

BEVERLEY URANIUM MINE

FOUR MILE BASELINE

VEGETATION SURVEY

Prepared for
Quasar Resources

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EXECUTIVE SUMMARY

A vegetation survey using the methods employed by the South Australian government in its state-wide biological surveys was carried out on an area along Four Mile Creek and its tributaries to the west of the Beverley Uranium Mine in April 2007. Seasonal conditions were very dry at the time of the survey and few ephemeral species were present. Twenty two permanent monitoring sites were set up in this area and these were allocated a local site number and an official Department for Environment and Heritage (DEH) photopoint number. Monitoring sites covered one hectare and a 100m x 4m Jessup Transect was also set up at each site.

Data from these sites were examined by means of the multivariate analysis techniques of ordination and classification. These analyses resulted in the description of three vegetation groups and these are similar to the main groups described for the mine area in the 1998 Environmental Impact Statement (EIS) report (Heathgate Resources, 1998) and confirmed by a survey of the Southern EL 3251 area in 2006. These groups are the Mitchell Grass plains with *Astrebla pectinata* and *Sclerolaena* spp., the minor watercourses with *Rhagodia spinescens* and several tall shrubs or low trees, and the major creek lines with *Eucalyptus camaldulensis* and *Melaleuca glomerata*.

Quantitative data from this survey were compared to other data collected during the Southern EL 3251 survey and results were consistent with the finding of that survey.

No species listed under the EPBC Act are known to occur at Beverley or in the study area. One threatened species, *Swainsona oligophylla*, which is listed as rare under the National Parks and Wildlife Act, 1972, is known to occur at Beverley, but was not recorded during the present survey. Two previously reported species, *Frankenia subteres* and *Swainsona murrayana*, are now considered to be based on misidentifications and neither was recorded during the present survey. Most of the threatened species that are known to occur in the general area are restricted to the Flinders Ranges and are not known to exist on the plains.

One proclaimed plant, *Tribulus terrestris*, has been recorded at Beverley. It is fairly common in the general area but is not recorded in all years and was not recorded during the present survey. Nineteen alien plant species have been recorded at Beverley and a further 10 are known to occur in the general area. None of these occurrences can be directly attributed to exploration or mining activities. Two species have been recorded at the Four Mile Bore since the 1998 EIS survey: this bore and its wetland pre-date any exploration and mining activities and it is not known whether the presence of these species is connected to these activities. Only two alien species were recorded during the current survey, both in the major creek vegetation association.

CONTENTS

Executive Summary	i
Introduction	5
Project Overview	5
Environmental Legislation	5
Brief and Objectives	5
Environmental Setting	6
Previous Vegetation Studies	7
Threatened Species	8
Overview	8
Results of Previous Surveys at Beverley	8
Threatened Ecological Communities.....	9
Naturalised Plants	10
Methods	11
Literature Review	11
Field Survey.....	11
Data Analysis.....	15
Limitations of this Survey	15
Results	16
General.....	16
Seasonal Conditions	16
General Health of the Vegetation	16
Disturbance at Monitoring Sites	17
One Hectare Quadrats.....	17
Vegetation Groups	17
Species Richness.....	22
Comparisons with Previous Surveys	23
Jessup Transects	26
Threatened Flora and Communities	28
Threatened Species Recorded During the Field Survey	28
Threatened Species Known to Occur in the General Area	28

Notes on individual species	29
Alien Flora	33
Proclaimed Species	34
Other Alien Species	36
Calculating the Significant Environmental Benefit Ratio.....	41
Conclusions.....	43
References.....	44
APPENDICES.....	64
Appendix A: Examples of Data Sheets	65
Appendix B: Voucher Numbers	69
Appendix C: Plant List for the Beverley Uranium Mine Site and Adjacent Areas	73
Appendix D: Main species in each vegetation group	80
Appendix E: Site Photographs.....	82

LIST OF TABLES

Table 1: Summary of Numbers of Threatened Species in Beverley Area.....	8
Table 2: Location and description of new monitoring sites.....	13
Table 3: Abundance scoring system used in this survey	15
Table 4: Cover values for <i>Astrebla pectinata</i> at Beverley Monitoring Sites.....	16
Table 5: Mean species richness for vegetation groups	18
Table 6: Mean species richness at annual vegetation monitoring sites	22
Table 7: Summary of Jessup Transect shrub counts for each vegetation group.....	26
Table 8: Summary of Jessup Transect shrub densities at each site.....	26
Table 9: Densities of the most common species in Jessup Transects	27
Table 10: Summary of likely occurrence of threatened plants in the survey area.....	29
Table 11: Alien species known, or likely, to occur in the Beverley area	35

LIST OF FIGURES

Figure 1: Location of Study Area Monitoring Sites	14
Figure 2: Ordination plot from the 2007 one hectare quadrat data.....	18
Figure 3: Ordination plot from the 2006 and 2007 one hectare quadrat data	20
Figure 4: Dendrogram obtained from classification of the one hectare quadrat data.	21
Figure 5: Comparison of species richness at 1 Ha quadrats in the 2006 and 2007 surveys	24

INTRODUCTION

Project Overview

Environmental Legislation

The key South Australian assessment documentation under the Mining Act is the Mining and Rehabilitation Plan (MARP). A report on the vegetation and flora of the project area provides information that is used when compiling the MARP. The South Australian National Parks and Wildlife Act 1972 (SA NPW Act) also applies here, particularly its Schedules covering threatened species, as does the Native Vegetation Act 1991 and its amendments. The Natural Resources Management Act 2004 has replaced many other Acts that were formerly relevant to various aspects of natural resource management in South Australia.

The main item of Commonwealth legislation that is relevant to Environmental Studies relating to areas surrounding the Beverley Uranium Mine is the Environment Protection and Biodiversity Conservation (EPBC) Act 1999. The Commonwealth Department of Environment and Heritage will determine that the project is a controlled action under the EPBC Act (controlling provisions: Nuclear Actions and Sections 18 and 18A listed threatened species and communities) and hence requires approval from the Commonwealth Minister for Environment and Heritage.

Brief and Objectives

The purpose of this study is to provide information on the vegetation and flora within the proposed Four Mile extension to the west of the existing operational mine at Beverley (see Figure 1). This included a baseline survey and assessment of the vegetation communities and flora species within this area. The survey design was planned so as to be compatible with other South Australian Department for Environment and Heritage biological surveys.

A field survey was to be carried out using the methodology of the Biological Survey of South Australia, with permanent numbered vegetation monitoring sites that conform to the standards of the SA DEH Biological Survey. In addition, Jessup Transects were to be set up to gather quantitative data on shrub densities at each monitoring site. These sites would then form the basis of an ongoing monitoring programme.

The location and extent of any threatened or significant species was to be recorded and assessed, as well as the distribution of any alien species.

Environmental Setting

The existing Beverley mine and the Four Mile extension are located on the Wooltana pastoral lease. Grazing of cattle for beef production has traditionally been the primary land use and this activity dates back to 1856 on Paralana Station, with sheep grazing on Wooltana Station from the same year (Heathgate Resources 1998).

The project is located on the edge of the Northern Flinders subregion of the Interim Biogeographic Regionalisation for Australia (IBRA) Flinders Lofty Block bioregion. The Murnpeowie subregion of the Stony Plains bioregion (Neagle 2003) lies further to the east.

The study area covered in this report (see Figure 1) is situated on a plain with *Astrebla pectinata* grassland and short-lived perennial forbs, particularly *Sclerolaena* spp. This plain is dissected by a large watercourse, the Four Mile Creek. Paralana Creek lies just to the south of the present study area. Both creeks support riparian woodland dominated by *Eucalyptus camaldulensis* and *Melaleuca* spp., particularly *Melaleuca glomerata*. Both creeks flow from the Flinders Ranges and drain into Lake Frome. Several smaller watercourses flow into these major creeks. The minor watercourses support shrubland or low woodland vegetation with *Melaleuca glomerata*, several *Acacia*, *Eremophila* and *Senna* species or sub-species and several small tree or tall shrub species.

Although the whole area has a history of heavy grazing (Heathgate Resources 1998), the eastern part of the survey area is close to the Four Mile Bore stock watering point and has therefore been subject to heavier grazing than areas that are more distant from water. There is a now defunct watering point towards the east of the area and stock grazing on the north-western parts probably watered at the Paralana hot springs, which are just outside the survey area on its western side. Past disturbance of the survey area has been mainly from grazing by domestic livestock and kangaroos, fence and track construction, and some limited off-road driving. The majority of the latter, prior to the current mining exploration activities, has been associated with stock mustering activities.

Previous Vegetation Studies

The 1998 Environmental Impact Statement (Heathgate Resources 1998) summarised the vegetation of the Beverley area as follows:

“The region generally has not had the level of examination of other parts of the South Australian arid zone (Lange and Fatchen, 1990). The best current reference is the recent SA Department of Environment and Natural Resources’ biological survey of the North Olary Plains (Playfair and Robinson, 1997), which includes the proposed development site but does not extend to equivalent landscapes flanking the Flinders Ranges to the north-east and south-west. Summary indications of vegetation, which can however be linked to landform, are given by Laut et al. (1975). To some extent, the absence of regional mapping to the south west of the development site is compensated by generalised mapping in Greenwood et al. (1989), derived in part from recorded vegetation and landform traverses along the North Flinders Ranges from Fatchen (1986).

Close and Williams (1982) undertook a biological survey in 1979 for the earlier mining proposals at Beverley. Additional vegetation survey was undertaken in 1996 as part of the current baseline studies, with some further reconnaissance since (Fatchen Environmental, 1998).”

This summary is still accurate, although a DEH biological survey of the Flinders Ranges (Brandle 2001), which does not cover the present survey area, has been completed since this was written. The most recent survey work in the Beverley area covered the vegetation of an area surrounding the Beverley Mine Lease (Badman 2006a), while other studies have been concerned with monitoring the effects of the current mining operation (Fatchen 1998, 2000, 2001, 2002; Badman 2004a, 2004b, 2005b, 2006b) and the rehabilitation of the Epic Gas Pipeline (Badman 2004c, 2005a, 2006c).

A list of all species known to occur in the Beverley area, including those from the April 2007 survey, is given in Appendix C.

Threatened Species

Overview

The Beverley Mine site lies within the Eastern Botanic Region (EA) as defined by Barker et al (2005). The eastern part of the Four Mile survey area is within this botanic region, but site FM15 (DEH photopoint 11120) and all those to the west (Figure 1) are within the Flinders Ranges Botanic Region (FR). The number of threatened species reported by Barker et al (2005) for these two regions is summarised in Table 1. This table clearly shows that many more threatened species occur in the Flinders Ranges Botanic Region than in the Eastern Botanic Region. In the Flinders Ranges, many species are restricted to the ranges themselves, particularly to damp areas in gullies and at higher elevations.

Table 1: Summary of Numbers of Threatened Species in Beverley Area

	FR	EA	FR + EA
Endangered	13	3	15
Vulnerable	32	12	39
Rare	87	35	98
Total	132	50	152

Results of Previous Surveys at Beverley

No species listed under the EPBC Act has been recorded at or near the Beverley Mine site.

Only one threatened species is currently known to occur in the immediate Beverley Mine area. This is *Swainsona oligophylla*, which is listed as rare under the South Australian National Parks and Wildlife Act, 1972. This species was recorded on three occasions in October 2005 and three voucher collections (F.J. Badman 11752, 11759 and 11767) were lodged with the State Herbarium of South Australia. These records followed good winter rainfall in 2005 (Badman 2005a, 2005b) and were from sites on the gibber plains, including in a small gully, and along the Epic Gas Pipeline. Soils ranged from clay to clay-loam and sandy clay-loam.

Another threatened species was listed by Heathgate Resources (1998) for the Beverley area. This is *Frankenia subteres*, which is listed as rare under the National Parks and Wildlife Act, 1972. The presence of this species at Beverley is based on a 1979 herbarium collection (L.D. Williams 10931) and subsequent reports are based on apparently un-vouchered collections. In 2004, the identity of *Frankenia* at Beverley was questioned by the present author and three herbarium collections (F.J. Badman 11389, 11422 and 11423) were later determined to be of the common *Frankenia serpyllifolia*. The genus *Frankenia* is currently being revised by Dr. Molly Whalen of Flinders University and the identity of many collections that have previously been placed in threatened species categories have been shown to be incorrect (DEH 2005). This includes the Williams collection from North Mulga, which is currently identified in the State Herbarium Database as "*Frankenia* sp." The South Australian Plant Mapper (Web Ref. 1) no longer shows any records of

Frankenia subteres to the east of the Flinders Ranges in South Australia, although there is one record from New South Wales.

The vulnerable *Swainsona murrayana* was also reported from Beverley by Fatchen Environmental (2002), but this was based on field identification of vegetative material and has never been confirmed by the collection of a voucher specimen. The report of this species at Beverley is now considered to be erroneous. There are no vouchered herbarium collections from anywhere near the Beverley Mine site, with the closest vouchered records being from Olary, Oodlawirra, Bagalowie and Black Rock Plain (Web Ref. 1), all well to the south of Beverley.

Melaleuca dissitiflora is a species with a restricted distribution (Heathgate Resources 1998), but is present throughout the Northern Flinders Ranges and also in the far north-west of the state (Web Ref. 1). It does not have a conservation rating (Barker et al. 2005) and its presence in large creeks flowing out of these ranges is not surprising. The fact that it originates from the Flinders Ranges was thought to explain why it was not found in the minor watercourses in the study area (Heathgate Resources 1998), which begin on the plains rather than in the ranges. However, it was found in one minor watercourse, at Site BEVEXP07, during the March 2006 survey (Badman 2006a) and this may represent a spread from the major creeks into the minor ones. In the Beverley area it is most common in watercourses close to the ranges.

Eucalyptus gillii is also mentioned by Heathgate Resources (1998) as a species with a relatively restricted distribution that could be affected by the possible removal of borrow material from the base of the Flinders Ranges. It is not known to occur on the plains and was not detected during either the 2006 (Badman 2006a) or April 2007 surveys.

Threatened Ecological Communities

The April 2007 study area does not include all or part of any threatened vegetation community as listed by Davies (1982) or Neagle (1995). No such community has been recorded during previous baseline surveys in the Beverley area (Heathgate Resources 1998, Badman 2006a).

Naturalised Plants

Following a dedicated weed survey, Badman (2005) listed a cumulative total of 18 introduced plant species at the Beverley Mine site. This represented only nine percent of the total species list at that time. The number of aliens recorded at Beverley has now increased to 19 but due to the recording of additional native species this now represent only seven percent of the total list of 263 species (Appendix C). This is well below the 10% listed by Badman (1995, 1999) as being a typical percentage of naturalised plants on South Australian arid zone plant lists that have been collated over several years. It is similar to the percentage of naturalised taxa (11%) derived from Barker et al (2005) for the Eastern Botanic Region, but well below the 20% figure derived from the same source for the Flinders Ranges Botanic Region. The low number for Beverley is surprising given the ease of access for seeds of alien species from the Flinders Ranges. It would seem likely that the number of introduced species recorded at Beverley is still below the number that is likely to be found in the future.

The incidence of naturalised plants in arid parts of South Australia is generally much lower than in higher rainfall areas to the south (Badman 1995, 1999) because the arid climate does not suit the mostly Mediterranean climate-adapted alien plant species that are found in northern parts of the State. Badman (1995) found that the alien flora of northern South Australia contained few long-lived perennials and that most of the naturalised plants in this area depend on cool-season rainfall. When summer-growing native perennial grasses are well established they can exclude the winter and spring growing alien species. Studies at Olympic Dam (Badman 1995, 2002) found that a suite of alien plants that became established in wetter areas around the town and mine did not spread into the surrounding countryside, even during very wet years. These studies also demonstrated two significant declines in the incidence of the most common alien species following years with well above average summer rainfall that allowed the establishment of perennial native grasses.

Although Olympic Dam has different soil types and topography to the Beverley Mine area, it has a similar climate and the effects of permanent water sources provided by the mine, e.g. sewage ponds and drains, is similar at both sites (Badman 2004b). However, the accommodation village at the Beverley mine has introduced far fewer alien species than the town of Roxby Downs because of the lack of domestic gardens and garden plants. The overall effect of additional operations outside the existing Beverley mine lease is therefore expected to have a lesser influence on the introduction of naturalised plants than did the Olympic Dam mine and the town of Roxby Downs.

METHODS

Literature Review

The literature review was largely restricted to the original Beverley Uranium Mine EIS (Heathgate Resources 1998) and subsequent reports produced on behalf of Heathgate Resources by the consultants Fatchen Environmental and Badman Environmental. Other sources were examined in relation to the distribution of threatened flora in the general area (Web Ref. 1) and the distribution of alien species (Web Ref. 1, Badman 1995, 1999). A review of literature covering the regional context of the vegetation at Beverley, particularly the work of Playfair and Robinson (1997), was covered by Heathgate Resources (1998) and was not repeated here.

Field Survey

Vegetation survey work was conducted under a South Australian Department for Environment and Heritage Permit to Undertake Scientific Research No. G24191 8 held by Dr F.J. Badman, 6 Griggs Drive, Athelstone 5076, SA.

All photopoints were marked with standard Biological Survey of South Australia numbered marker discs. Marker discs are located at the start of the Jessup Transect, which is usually located at the northern end of each transect. Photopoint numbers 11106 to 11127 were used. Sites were also given a shorter site number for use in annual spring monitoring of vegetation at the Beverley Mine. This monitoring will be carried out in 5m x 2m quadrats that will be compatible with and will supplement the annual vegetation monitoring already carried out at Beverley. These site numbers, the location of the 1 Hectare quadrats, the magnetic bearing from the photopoint peg to the end of the Jessup Transect and the structural formation of the vegetation at each site are given in Table 2.

Both the present survey and the March 2006 (Badman 2006a) survey of the Beverley mine expansion areas were carried out using the methodology of the Biological Survey of South Australia as described by Heard and Channon (1997), with a one hectare (100 m x 100 m) quadrat being used in this arid area rather than the 30 m x 30 m quadrat used in the agricultural areas of South Australia, as is standard practice by DEH. The survey is a continuation of an official DEH biological survey, designated "Number 546", which was begun in March 2005 (Badman 2006a).

A 100 m long Jessup Transect was also set up within the one hectare quadrat: this runs from the photopoint marker peg and was set up so as to divide the one hectare quadrat into two equal parts, extending for 50 m either side of the Jessup Transect. The 100 m long transect compensates for the natural "patchiness" (Stafford Smith and Morton 1990) of the vegetation in arid areas. Low shrubs are usually found in clusters, with large areas with no shrubs in between the clusters. Each transect usually passes through several shrub clusters, where these are present, and crosses several bare patches.

Areas of suitable vegetation were chosen for sampling based on vegetation type and landform. Ease of access was also considered, although some sites were set up away from any tracks so as to get coverage of the whole survey area. Sites were set up in suitable locations in order to more evenly sample the Four Mile area. Transects were

set up in a southerly direction from the photopoint peg wherever possible, so as to allow for photography at any time of the day.

Information on each species within the quadrat was recorded on a standard biological survey data sheet, together with other information on the physical description of the site, date, observers and seasonal conditions. Examples of blank data sheets are presented in Appendix A. Data recorded for each species include its cover abundance, growth form and whether it forms part of the overstorey, understorey or is an emergent species. Voucher specimens were collected for each species that was not collected in March 2006 (Badman 2006a) and these are reported here in Appendix B. A complete list of species recorded during the survey, together with other species known to occur in the area, is presented in family order in Appendix C.

Jessup Transects were devised by R.W. Jessup in the late 1940s (Jessup 1951). Initially he counted the number of shrubs over a fixed distance between his vehicle tracks, but the method has since been refined to sample a 100 m x 4 m quadrat and is widely used by the South Australian Department for Water, Land and Biodiversity Conservation for monitoring the condition of pastoral leases (Lay 2005). This method records the number of plants belonging to each long-lived perennial species in a quadrat 100 m long x 4 m wide, two metres on either side of a tape run between two steel star droppers. The dropper with the photopoint disc is at the start of the quadrat. Data are recorded for 10 m blocks on either side of the tape starting on the left-hand side, with juvenile plants recorded separately from adults. Juvenile plants are defined as those <10 cm in height with no woody stem (Lay 2005).

Searches for threatened species were carried out at all quadrats as part of the monitoring routine and opportunistically in other likely areas (see section on “Threatened Species and Communities).

Table 2: Location and description of new monitoring sites

Coordinates are AMG Zone 54. Datum is WGS84.

Coordinates are for the north end of the Jessup Transect: the photopoint disc is always at the (closest to) northern end of each transect. Discs are marked with the official DEH photopoint number: the Four Mile prefix number is given in this table.

Beverley Site No.	Photo-point Disc No.	North End		Bear-ing ¹	Structural Formation
		Easting	Northing		
FM01	11106	360982	6661440	176	Tall open shrubland
FM02	11107	359600	6661787	145	Tall shrubland
FM03	11108	359098	6662235	205	Low very open herbland
FM04	11109	360119	6664062	210	Low very open herbland
FM05	11110	358389	6663374	216	Low very open herbland
FM06	11111	358283	6664289	176	Low very open herbland
FM07	11112	358777	6664303	180	Low very open herbland
FM08	11113	358731	6665559	175	Low very open herbland
FM09	11114	357351	6666232	238	Low open woodland
FM10	11115	358536	6661671	200	Low open woodland
FM11	11116	357520	6661618	200	Low open woodland
FM12	11117	356214	6665227	180	Low very open herbland
FM13	11118	356105	6664811	178	Low very open woodland
FM14	11119	356664	6662981	180	Low very open herbland
FM15	11120	355646	6663108	198	Low open woodland
FM16	11121	355827	6662726	182	Low very open herbland
FM17	11122	354980	6662853	190	Tall open shrubland
FM18	11123	354155	6662223	166	Tall shrubland
FM19	11124	351530	6660280	180	Tall shrubland
FM20	11125	354065	6660785	180	Low open shrubland
FM21	11126	354855	6660538	156	Low very open herbland
FM22	11127	356476	6660156	176	Low very open shrubland

¹ Bearing is the direction of the end post of the Jessup Transect from the post with the photopoint disc. The Jessup Transect always divides the 1 Ha quadrat into two equal rectangles.

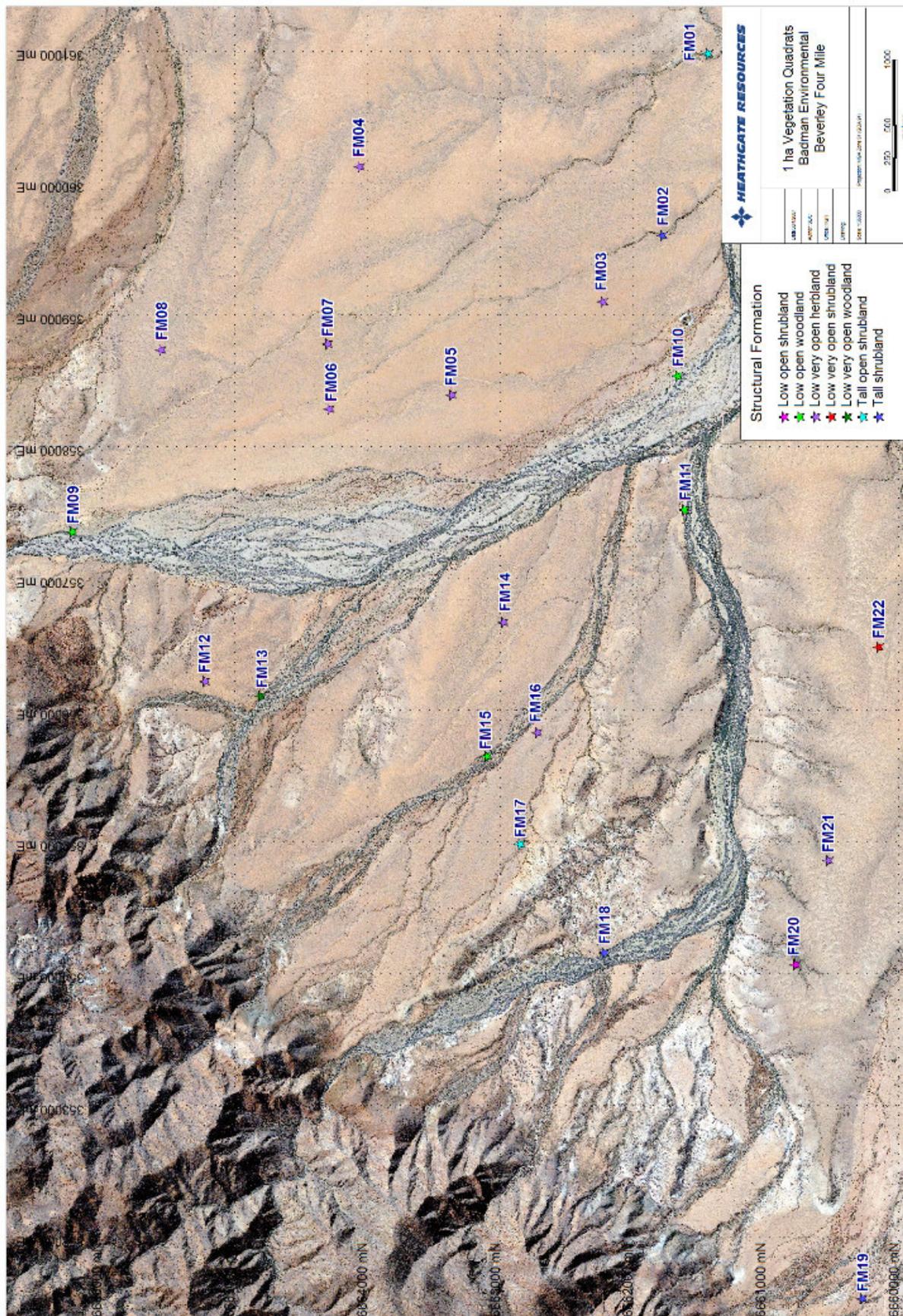


Figure 1: Location of Study Area Monitoring Sites

Data Analysis

The main data analysis tools used to examine the Beverley Four Mile data were ordination and classification. Ordination of the site data was carried out using the PC-Ord computer software package (McCune and Mefford 1999) and classification using the PATN software package (Belbin 1992).

Each species recorded in the field was entered on a standard Biological Survey data sheet (Appendix A) together with an abundance score. Scales used are a modified Braun-Blanquet system and these are given in Table 3. In practice, scores greater than 3 are seldom used in the South Australian arid zone and were not used during this survey. Most vegetation had a score of no greater than 2 at most sites during the April 2007 survey. Because the DEH scoring system contains letters as well as numbers, each score was given a numerical value for use in the analyses. These are shown in Table 3.

Table 3: Abundance scoring system used in this survey

Score	Explanation	Score used in analyses
N	Not many (1-10 plants and <5% cover)	1
T	Sparsely present; cover small (<5%)	2
1	Plentiful but of small cover (<5%)	3
2	Any number of individuals covering 2-25% of area	4
3	Any number of individuals covering 25-50% of area	5
4	Any number of individuals covering 50-75% of area	6
5	Any number of individuals covering >75% of area	7

Field determinations of voucher specimens were confirmed at the State Herbarium of South Australia and identifications corrected on the data sheets where necessary. These data were then entered into Excel spreadsheets prior to carrying out the analyses. Classification and ordination were then carried out for the one hectare quadrat data. Species with less than two records were removed from the dataset, so as to give a more robust analysis and to minimise the effects of uncommon species. This resulted in the removal of 32 species from the matrix.

Limitations of this Survey

The dry seasonal conditions since 2001 have resulted in the cover of *Astrebla pectinata* being at its lowest since monitoring started at the mine site in 1998 (Fatchen 1998). Subsequent vegetation monitoring has recorded increases in the biomass of this species, peaking in 2001 (Fatchen 2001), with an overall decline since that time (Badman 2006b). Few annual or ephemeral species were recorded during the present survey and many of these were present at only a single site and were therefore removed from the analyses. Those that were recorded were often identified from dead plants that remained in the ground. Species recorded during the survey are the core species of these vegetation associations and give a good indication of the basic composition of the various vegetation groups. They do not give an accurate indication of annuals and ephemerals that would be likely to occur following wetter seasonal conditions. In particular, there has not been a significant summer rainfall event since 2001 and there has been very limited growth and practically no recruitment of *Astrebla pectinata* during this period.

RESULTS

General

Seasonal Conditions

Seasonal conditions were very dry at the time of the April 2007 survey. *Astrebla pectinata*, which was the dominant species at many tableland sites in 1998 (Heathgate Resources 1998), requires summer rainfall to promote growth and recruitment and was present only as butts or as dry leaf material. This is due to a continuation of dry conditions and reductions in plant biomass at the mine site since 2001 (Badman 2006b). The decline in cover of this species at Beverley monitoring sites is detailed in Table 4. The effects of good winter rainfall in 2005, which resulted in the growth of many ephemeral species, did not persist once the hot weather of the summer of 2005-06 arrived (Badman 2006b).

Table 4: Cover values for *Astrebla pectinata* at Beverley Monitoring Sites

Source: Beverley Uranium Mine Annual Vegetation Monitoring Reports. Percentage cover values from tableland monitoring sites with *Astrebla pectinata*.

Site No	1998	2000	2001	2002	2003	2004	2005	2006	Mean
BU01	5.3	11.2	6.2	2.6	2.7	2.3	2.1	1.2	4.2
BU04	1.1	5.7		1.9	0.7	0.7	0.7	0.7	1.6
BU06	5.2	16.6	9.7	4.4	3.1	3.2	2.9	1.7	5.9
BU07	4.8	10.1	4.3	3.0	1.8	1.5	1.0	0.8	3.4
BU09	5.7	13.2	0	3.9	3.4	2.2	2.0	1.3	4.0
BU15	6.0	15.1	10.9	0	3.4	2.8	1.7	1.0	5.1
BU20	6.1	20.7	11.3	0	6.0	2.1	2.1	1.2	6.2
Mean	4.9	13.2	7.1	2.3	3	2.1	1.8	1.1	4.4

General Health of the Vegetation

Despite the dry seasonal conditions, most perennial vegetation was in fairly good condition at the time of the survey, although few of the shrub species were in a reproductive state. Most of the *Eucalyptus camaldulensis* trees along the major creek lines showed evidence of past leaf-loss, but there was a considerable amount of new leaf growth on almost all trees. *Eucalyptus camaldulensis* and the two *Melaleuca* spp. were mostly in bud or had mature fruits. The foliage of both tall and low shrubs was generally in good condition, although most species were not flowering or in fruit. Annual, ephemeral and many short-lived perennial species were generally not in an active growth state and most were identified from dead, dormant or vegetative material.

The condition of *Astrebla pectinata* in April 2007 continues to be of some concern. The lack of summer rainfall in recent years has resulted in a serious deterioration in the cover of this species (Table 4). Many plants have now reached the stage where they are present only as root material exposed on the surface of the ground. Some (or many) of these may have passed the point from which they will regenerate from this root material. This has been the case for at least the last three years, with the situation becoming worse each year. A significant summer rainfall event of at least 100mm and possibly more will be required to return this species to its former

dominance on the plains. The poor condition of this species has nothing to do with grazing or any mining or exploration related activities: from observation, the situation is the same across the whole of the plains between this part of the Flinders Ranges and Lake Frome. It is entirely due to lack of significant summer rainfall since 2000-2001.

Heathgate Resources (1998) referred to the heavy past grazing regime across the whole of this area and indicated that past grazing was heavier in some areas than it is at present. This was suggested as the reason for the high proportion of *Sclerolaena* spp. in the grasslands, rather than there being pure stands of *Astrebla pectinata*. They also pointed to the resilient nature of *Astrebla pectinata*, but there is always the possibility that the effects of the “State and Transition Model” (Westoby et al. 1989) could result in a different vegetation community becoming dominant if the lack of summer rainfall continues.

Disturbance at Monitoring Sites

Permanent monitoring sites were placed in what were thought to be the three main vegetation types: major creek lines, minor watercourses and on the open plains. They were placed in areas where there was minimal previous disturbance caused by human influences. Where there was evidence of previous impacts, these were mainly restricted to the effects of domestic grazing and a few vehicle tracks. Sites were placed so as to be at least one kilometre away from stock watering points. Where possible, sites were placed on the south side of existing roads or tracks for ease of access and so that photographs could be taken at any time of the day without the problem of morning or evening shadows.

One Hectare Quadrats

Vegetation Groups

An ordination plot of the April 2007 one hectare quadrat data is shown in Figure 2 and of the combined 2006 (Badman 2006a) and 2007 data in Figure 3. A dendrogram derived from classification of the 2007 data is presented in Figure 4. Three vegetation groups are identified in these figures, occurring at the Bray-Curtis 0.91 level of dissimilarity (Figure 4). This level of dissimilarity is slightly higher than the one used in the analysis of data from the March 2006 survey (Badman 2006a) and is thought to be a result of continuing dry conditions and reductions in species richness (Figure 4). The three groups relate closely to landform: to major creek lines, minor watercourses and open plains (tablelands). This is similar to the vegetation groups defined by Heathgate Resources (1998), with the exception that the 1998 report also identifies a group with dense vegetation in localised run-on areas, which is included here with Group 2 vegetation, and chenopod shrubland on outwash and sandplain. However, no data are presented by Heathgate Resources (1998) to explain how these groups were obtained. More groups can easily be obtained from the present data by reducing the cut-off point on the dendrogram (Figure 4).

The three-group option has been used because it is consistent with previous groupings of vegetation in this area and also because of the small number of sites that would have been present in some groups if a lower cut-off point had been used.

Mean abundance scores for plant species recorded in each group in April 2007 are shown in Appendix D. Mean species richness for each group is shown in Table 5. All further information on the species composition of the three groups given in this section concerns the findings of the April 2007 survey. More detailed comparisons between the results from the April 2007 and the March 2006 surveys are given in a later section of this report.

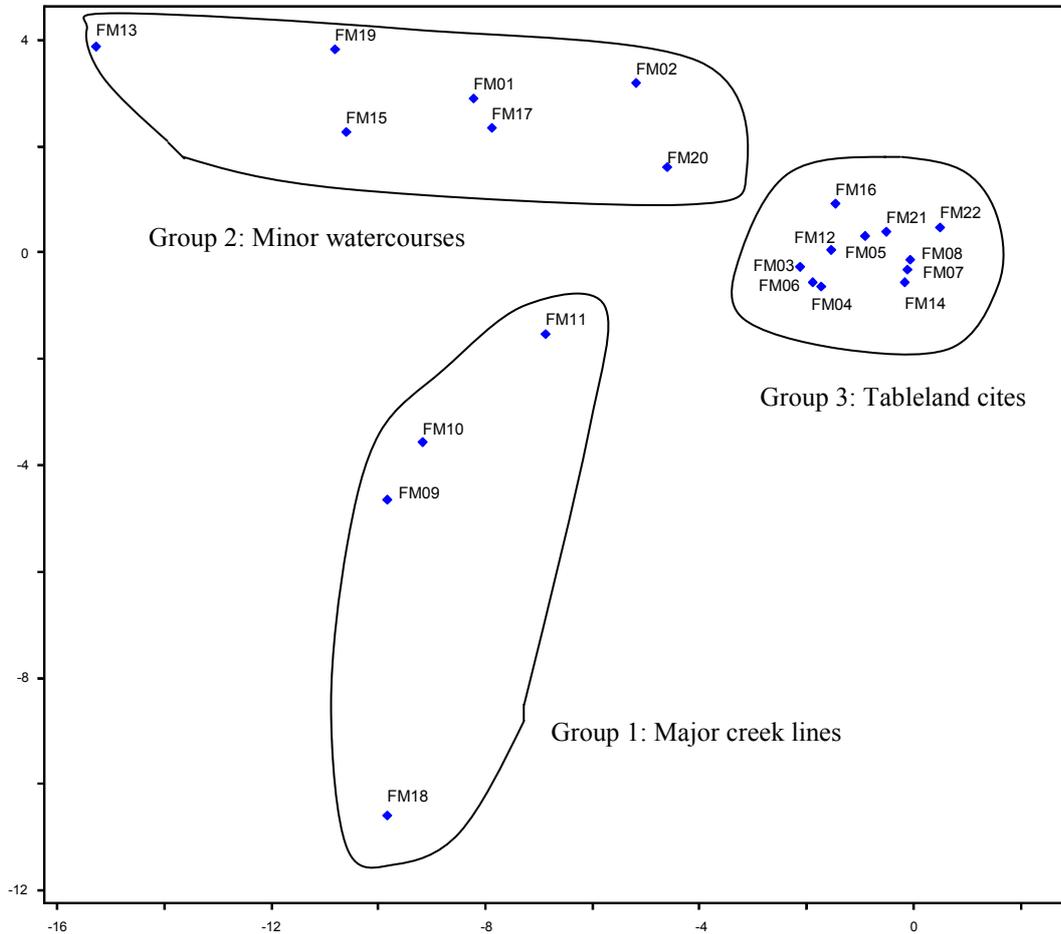


Figure 2: Ordination plot from the 2007 one hectare quadrat data

Table 5: Mean species richness for vegetation groups

Group Number	Number of Sites in Group	Mean Species Richness	Range
1	4	19.5	17-24
2	7	22.7	16-32
3	11	12.2	9-17

Group 1

Group 1 contains four sites along the major channels of Four Mile Creek and its tributaries. Overstorey vegetation is dominated by *Melaleuca glomerata* and *Eucalyptus camaldulensis*, which occur along the channel banks and on higher ground between the channels. The shrubs *Acacia tetragonophylla* and *Eremophila freelingii* dominate the mid storey. The grasses *Triodia irritans*, *Enteropogon ramosus* and *Aristida nitidula* are common in the understorey, together with the shrubs *Rhagodia spinescens* and *Enchylaena tomentosa* and the forbs *Ptilotus obovatus*, *Sclerolaena cuneata* and *S. diacantha*. The introduced *Sisymbrium erysimoides* was also found to be common here, although it was identified only from dead plants that had already shed their seeds. *Triodia irritans* decreases in abundance with distance from the ranges.

This group has high mean species richness, but not as high as the Group 2 sites (Table 5)

This is the only group where introduced species are amongst the most common species, although only two species, *Sisymbrium erysimoides* and *Acetosa vesicaria*, were recorded during the April 2007 survey and both species were represented only by dead plants. Neither was as common as it was in March 2006 (Badman 2006a). The higher incidence of introduced species in this group is due to their seeds being carried into the area with stream flows from the more suitable habitat in the Flinders Ranges.

Heathgate Resources (1998) listed several other grasses and *Scaevola collaris* as being present in this vegetation association, but these were absent at the time of the present survey.

Group 2

Group 2 contains seven sites situated along minor watercourses as well as some larger tributaries of Four Mile Creek.

Upper storey vegetation is dominated by the tall shrubs *Acacia tetragonophylla* and *Eremophila freelingii*, with *Santalum lanceolatum* also fairly common. *Eremophila duttonii* often occurs at the margins of the watercourses. The most common understorey species are *Enchylaena tomentosa*, *Ptilotus obovatus*, *Sclerolaena cuneata*, *S. longicuspis* and *Senna artemisioides* ssp. *sturtii*.

This group has the highest mean species richness of any of the groups described here, as well as having the highest individual species richness of any of the sites sampled in April 2007 (Table 5).

Only one introduced species, *Sisymbrium erysimoides*, was recorded in this group and it was less common here than in the larger watercourses.

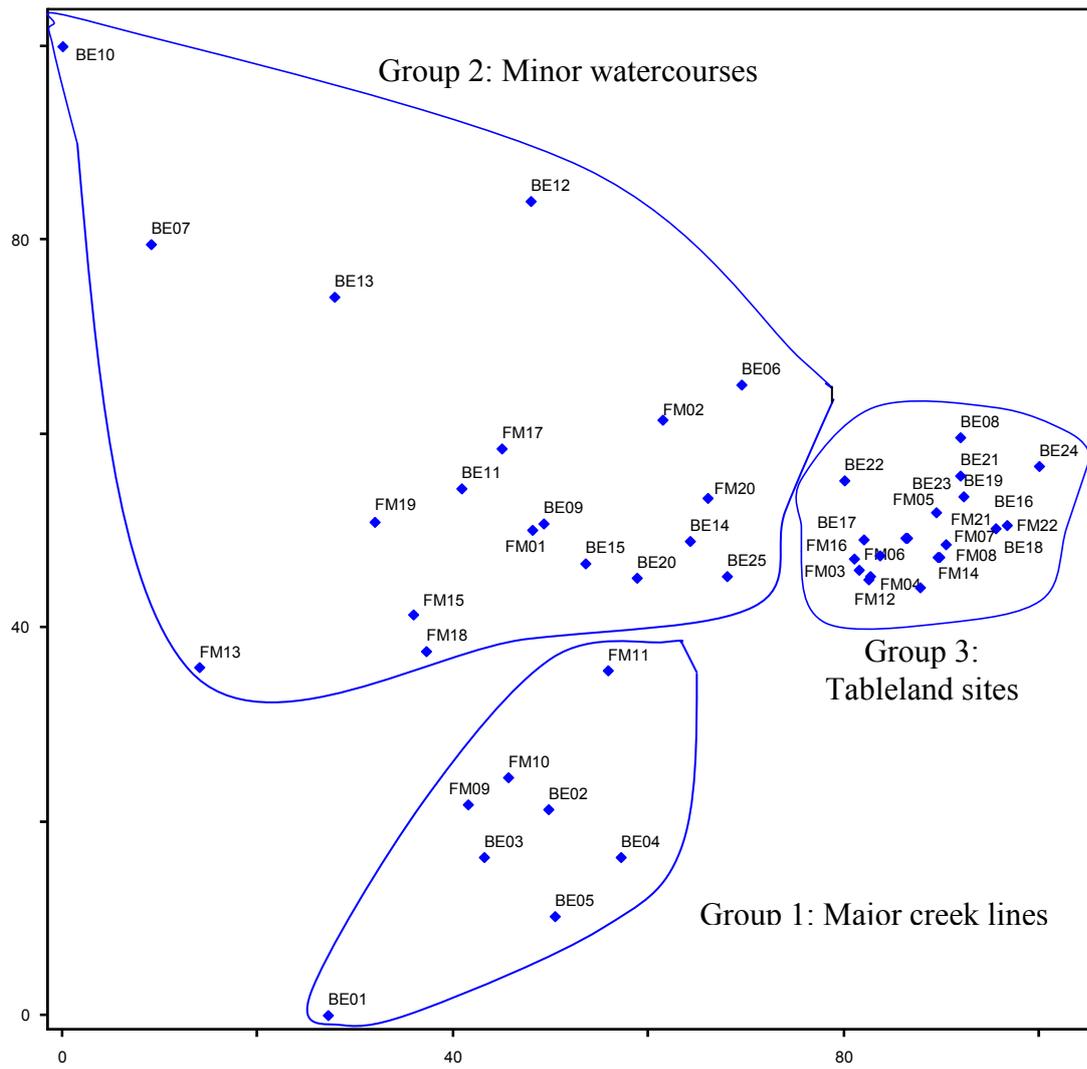


Figure 3: Ordination plot from the 2006 and 2007 one hectare quadrat data

Beverley Uranium Mine Four Mile Baseline Vegetation Survey

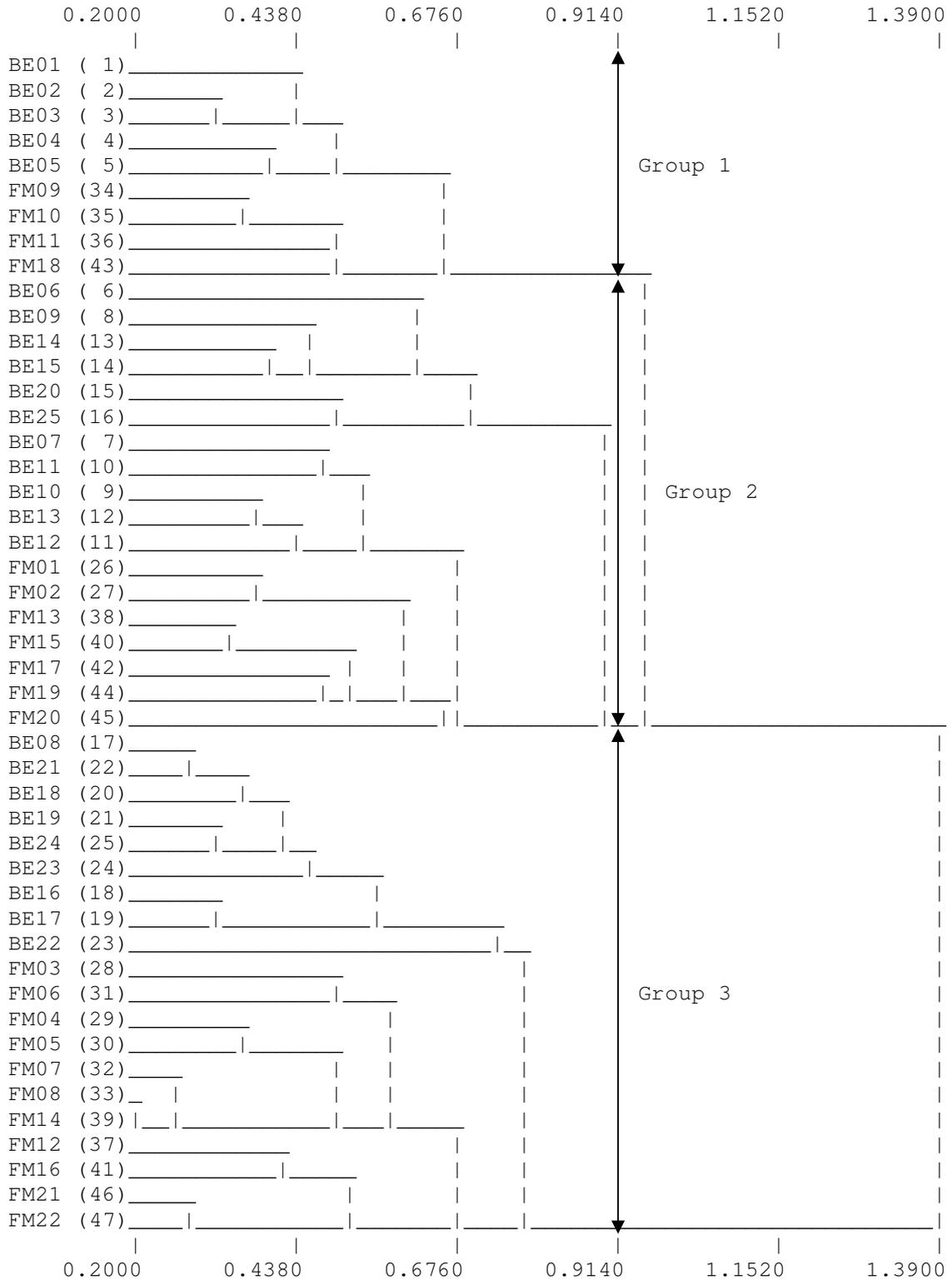


Figure 4: Dendrogram obtained from classification of the one hectare quadrat data

Sites from the March 2006 survey are prefixed “BE” and those from the April 2007 survey by “FM”.

Group 3

Group 3 contains all of the tableland sites. These sites form a much tighter group than the sites that make up the other two groups (Figure 2).

Very few shrubs occur at sites in this group and they are not sufficiently common to form a dominant part of the vegetation. Vegetation is dominated by *Sclerolaena* spp., particularly *S. divaricata*, *S. intricata* and *S. longicuspis*, with *S. ventricosa* also present at many sites. Other common species are *Neobassia proceriflora* and the herbs *Calotis hispidula*, *Daucus glochidiatus* and *Euphorbia stevenii*.

The summer-growing grass *Astrebla pectinata* should form the overstorey in this type of country (Fatchen 1998, 2001), but it has been in decline since peak cover values were recorded in 2000 (Table 4). It is now present only as scattered butts, with no leaf material recorded at any site in the April 2007 survey area. It is now unclear whether any of these butts will regenerate following suitably heavy summer rainfall, or whether it will need to regenerate from seed in the soil seedbank.

No introduced species were recorded in this group in April 2007.

This group had both the lowest mean species richness and the lowest species richness at an individual site in the April 2007 survey (Table 5).

Species Richness

Mean species richness and the range between all sites sampled during the April 2007 survey, are shown in Table 5. Species richness is highest at Group 2 sites and lowest at Group 3 sites.

For comparison, species richness at all annual vegetation monitoring sites from 1998-2005 is shown in Table 6. Values in Table 6 are all lower than those in Table 5 because of the small size of the quadrats used in the annual vegetation monitoring. The values recorded in April 2007 at Group 2 and Group 3 sites (Table 5), in a very dry season, are similar to those recorded in the best seasons in Table 6.

Table 6: Mean species richness at annual vegetation monitoring sites

Year	Group 1 Sites	Group 2 Sites	Group 3 Sites
1998	-	19.0	14.5
2000	-	18.0	17.6
2001	-	10.5	9.8
2002	4.0	3.3	5.1
2003	5.3	9.3	9.0
2004	4.0	4.7	5.5
2005	13.7	16.3	17.5
2006	4.5	9.4	9.5
All Years	6.4	11.3	11.1

There was no survey in 1999 and no data were collected from Group 1 sites from 1998-2001. Sample size was not the same in all years, with the majority of sites being in Group 3 vegetation. The mean for Group 1 sites is dragged down by the lack of data from the wetter years of 1998 and 2001 and by the small quadrat size and its location on the edge of the creek. High species richness in 2005 was caused by heavy winter rainfall.

Comparisons with Previous Surveys

The earliest survey reports were based on qualitative assessment of the vegetation. They have produced similar groupings of the vegetation, although with some differences in species composition caused mainly by differing climatic conditions at the time of preceding these surveys. The exception was the March 2006 Southern EL 3251 survey (Badman 2006a), which used the same methodology as the April 2007 survey.

The only other surveys in the Beverley area that have collected quantitative data are those associated with the mine itself. These commenced in 1998, although the methods used and data collected are not compatible with those used in the present survey. Data are collected from 2m x 5m quadrats for the annual mine vegetation surveys and while these data give a more accurate representation of the cover of each species, the species richness obtained by this method is far lower than that obtained from a one hectare quadrat. An ordination plot of all data collected from 1998 to 2005 was prepared by Badman (2006a) and this did not indicate any groups based on differences in vegetation composition. Two tails were evident and these included all sites from two different years, the wettest and driest years. All other relevés formed a single large group which included sites from all vegetation associations.

Quantitative data are also collected from 50m x 2m quadrats along the Epic Pipeline corridor. Data from 2003-2005 were also examined by Badman (2006a) and were found to be incompatible with data from the one hectare quadrats.

In 2001, a one hectare quadrat was established at the tableland monitoring site BU15 and this has been surveyed in each subsequent year. Data from this site were also analysed by Badman (2006a) and were found to fit well with other Group 3 sites.

It was expected (Badman 2006a) that the higher and lower areas of the plain would form separate vegetation groups, as indicated by Heathgate Resources (1998), but this was not the case in March 2006 or April 2007. It is not known whether this would be the case based on data collected following a significant summer rainfall event. Sites to the north of Four Mile Creek contained very little *Astrebla pectinata* in March 2006 and even less in April 2007 and were dominated by *Sclerolaena* spp. in both years. Heathgate Resources (1998) considered this to be a typical outcome of the degradation assigned to previous overgrazing by domestic stock. While this is almost certainly a factor, the role of the recent lack of summer rainfall has almost certainly been a contributing factor. Badman (2006b) reported that plant biomass in September 2005 was almost back to its 2001 levels, but the bulk of the biomass was made up of forbs, including mainly *Sclerolaena* spp., rather than *Astrebla pectinata* as it was in 2001.

Direct comparisons can be made between the March 2006 (Badman 2006a) and April 2007 surveys. Both were carried out under very dry seasonal conditions and used the same methodology. Conditions in April 2007 were slightly drier than in the previous year and this is reflected in mean species richness in the vegetation groups (Figure 4) and also in the fact that sites from the two years are in most cases slightly separated in the groups shown in Figure 3.

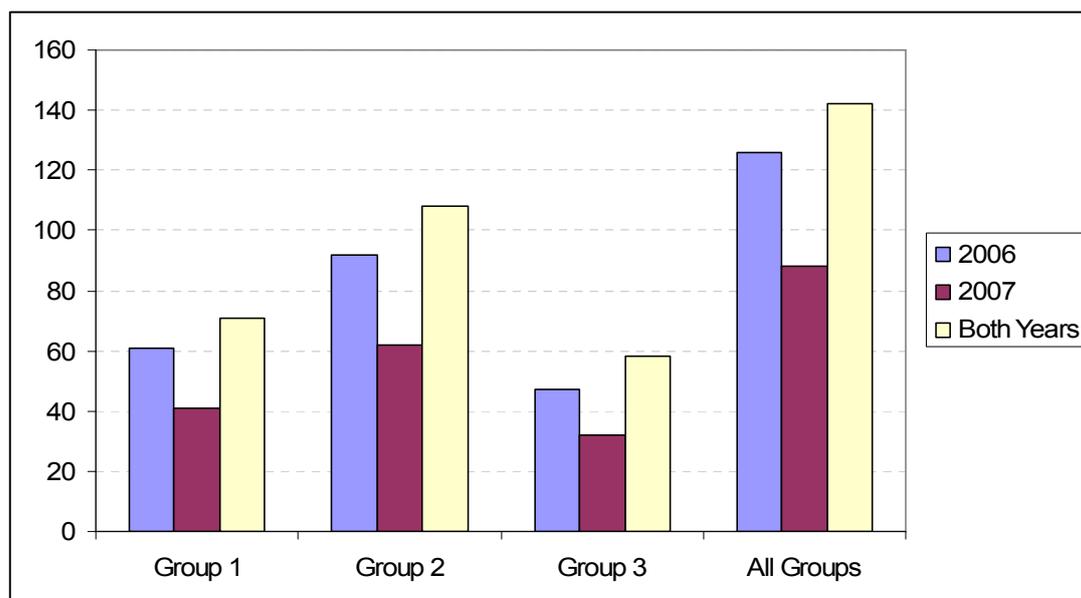


Figure 5: Comparison of species richness at 1 Ha quadrats in the 2006 and 2007 surveys

The value for “both years” is the sum of the species recorded during the two surveys, not the mean.

One noticeable difference between the vegetation of the plains as described by Heathgate Resources (1998) and the findings of both the March 2006 and the present survey was the complete lack of *Sclerolaena bicornis*. This species was listed as being “frequent” in this habitat by Heathgate Resources (1998), but has not been recorded in any of the subsequent surveys.

A puzzling finding of the March 2006 survey when compared to the original EIS survey (Heathgate Resources 1998) was the domination of the low shrub *Rhagodia spinescens* in Group 2 sites (Badman 2006a). This species was not mentioned by Heathgate Resources (1998) in their description of vegetation associated with secondary drainage. It was far less common at minor watercourse sites in April 2007. The only possible explanation for this is that minor watercourses are quite diverse in their vegetation composition and that different low shrubs dominate the understorey in different areas. This would also explain the much larger spread of sites in Figure 3 compared to the other two groups and also to the groups formed from the April 2007 data shown in Figure 2.

This is also likely to be the explanation for the varying abundance of *Maireana aphylla* found in different surveys. Heathgate Resources (1998) reported that it was the main low shrub species, although in March 2006 (Badman 2006a) it was far less common than *Rhagodia spinescens*. It was not amongst the 10 most common shrubs during the April 2007 survey (Table 9). Heathgate Resources (1998) mention *Rhagodia spinescens* only as an important component of the vegetation of the uppermost portion of the floodplain of Four Mile Creek, where it was found to be present in March 2006 but at much lower densities than in the minor watercourses. There is no obvious reason for this apparent change in vegetation composition: *Rhagodia spinescens* is a long-lived shrub, with a lifespan exceeding the period between these two surveys. It is inconceivable that such a dominant and obvious species could have been overlooked during the 1998 survey.

Eremophila latrobei was also reported from the higher plains areas (Heathgate Resources 1998), but this species was not recorded in either March 2006² or April 2007, nor in any other survey at Beverley since 2003. This species was reported from the area by Close and Williams (1982) and two voucher numbers are listed in their report. However, an electronic search of herbarium records (Web Ref. 1) failed to locate these collections and there are no herbarium records of this species east of the Flinders Ranges (Web Ref. 1). It is likely that the L.D. Williams collections were made in the ranges rather than on the plain.

Melaleuca dissitiflora is also more common in major creeks close to the ranges than it is in minor watercourses on the plains, where it is generally replaced by the dryland species *Melaleuca glomerata*.

The findings of the April 2007 survey highlight the variability of the vegetation of the watercourses in the Beverley area. The two most outlying sites in Group 1 and Group 2 (FM18 and FM13 respectively in Figure 2) are both located close to the Flinders Ranges. The Group 3 tableland sites in Figure 2 and Figure 3 show a much tighter grouping, i.e. less variability, than does either of the groups that include the watercourse sites.

The groupings of sites shown in Figure 3 indicate little overlap of the March 2006 and April 2007 sites. This is thought to be partly due to the drier conditions of April 2007, which resulted in lower mean species richness, and also to the more westerly location of all sites and their increased proximity to the ranges.

² The March 2006 survey used the standard DEH biological survey methodology, in which a voucher collection was made for every species encountered on the survey. All additional species recorded in April 2007 were also vouchered. The identity of these was then confirmed by taxonomists at the State Herbarium of South Australia.

Jessup Transects

A summary of data from the Jessup Transects is given in Table 7 and the summary results from each site are presented in Table 8. Table 9 shows the densities of the 10 most common species, overall and at each site.

Table 7: Summary of Jessup Transect shrub counts for each vegetation group

Group Number	Mean Shrub Numbers per 400m ² Quadrat			Total shrub density per hectare
	Adults	Juveniles	Total	
1	41	<1	41	1025
2	107	0	107	2675
3	2	<1	2	50
Mean	50	<1	50	1250

Table 8: Summary of Jessup Transect shrub densities at each site

Units are number of plants per 400m² quadrat

Site Number	DEH Photopoint	Group Number	Shrub Numbers		
			Adults	Juveniles	Total
FM01	11106	2	26	0	26
FM02	11107	2	52	0	52
FM03	11108	3	0	0	0
FM04	11109	3	0	0	0
FM05	11110	3	0	0	0
FM06	11111	3	0	0	0
FM07	11112	3	0	0	0
FM08	11113	3	0	0	0
FM09	11114	1	48	1	49
FM10	11115	1	21	0	21
FM11	11116	1	12	1	13
FM12	11117	3	0	0	0
FM13	11118	2	243	1	244
FM14	11119	3	0	0	0
FM15	11120	2	79	0	79
FM16	11121	3	0	0	0
FM17	11122	2	113	0	113
FM18	11123	1	80	0	80
FM19	11124	2	43	0	43
FM20	11125	2	192	0	192
FM21	11126	3	1	0	1
FM22	11127	3	22	0	22

Table 9: Densities of the most common species in Jessup TransectsUnits are the number of plants per 400m² quadrat. Sites with no shrubs have been omitted.

Site Number	Vegetation Group	<i>Abutilon halophilum</i>	<i>Acacia tetragonophylla</i>	<i>Enchylaena tomentosa</i>	<i>Eremophila duttonii</i>	<i>Eremophila freelingii</i>	<i>Maireana triptera</i>	<i>Melaleuca glomerata</i>	<i>Ptilotus obovatus</i>	<i>Rhagodia spinescens</i>	<i>Senna artemisioides sturtii</i>
FM01	2		3			15			6	2	
FM02	2		19			10			7	1	11
FM09	1			15				13	2	8	
FM10	1			5				4		11	
FM11	1			3				9	1		
FM13	2		14	36		22			138	9	16
FM15	2		1	15		11		11	37	1	
FM17	2		7	3	2	70	13				
FM18	1			45		4	1	23	1	1	
FM19	2		10	10	6	6				6	
FM20	2		6	2	8	162	12				
FM21	3	1									
FM22	3	22									

Little can be said about these results, other than that the minor watercourse sites in Group 2 contain the largest numbers of shrubs and that very few shrubs are present at the Group 3 tableland sites. In March 2006, two tableland sites had sufficient numbers of low shrubs so as to place them in vegetation Group 2 with the minor watercourse sites (Badman 2006a). This was not the case at any of the sites selected in April 2007, where all tableland sites formed a very compact grouping (Figure 2).

The greatest value of the Jessup Transects will be in allowing statistical analysis of changes in shrub numbers in future years.

THREATENED FLORA AND COMMUNITIES

The author of this report has had extensive experience with threatened species in the north of South Australia, both during field surveys over more than 25 years and as part of two desktop study projects for the South Australian Department for Environment and Heritage during 2005 and 2006 (DEH 2005, 2006). These projects have involved the preparation of Species Profiles and Threats (SPRAT) sheets for 110 threatened species in the South Australian Arid Lands.

The subject of threatened flora at Beverley was covered by Fatchen (1998) and Badman (2005) and all relevant information from these reports is repeated herein. Additional information is included that came to light during the 2005 and 2006 SPRAT projects (DEH 2005, 2006). Information on species that are known to occur in the general area is given below and is summarised in Table 10.

Some of the species listed in Table 10 and discussed below are ephemerals and are likely to be present only in very wet years and probably only for a short time. Some of these species are known in the general district from only one or two records and the chances of finding them during a survey carried out under dry seasonal conditions are practically non-existent. The rare *Swainsona oligophylla* was collected three times following significant winter rainfall in 2005 and these remain the only records from the Beverley area.

No species listed under the Commonwealth Environmental Protection and Biological Conservation (EPBC) Act has been reliably recorded in the Beverley area.

No threatened vegetation communities, as defined under Commonwealth legislation in the EPBC Act, or by Davies (1982) and Neagle (1995) for South Australia, are known to occur in the study area.

Frankenia subteres, which is listed as Vulnerable under the EPBC Act, was reported from the area during an earlier vegetation survey (Close and Williams 1982) but this record is now thought to be based on an incorrect identification. This species is listed as rare in South Australia and is known from numerous herbarium collections to the west of the survey area, particularly in the Flinders Ranges and around Leigh Creek and Copley. There are no confirmed records from the Beverley area or from east of the Flinders Ranges (DEH 2005, Web Ref. 1).

Threatened Species Recorded During the Field Survey

No threatened species were recorded during the April 2007 field survey. There is only one record of a threatened species that is supported by a voucher collection from the Beverley Mine area. This is *Swainsona oligophylla*, which is listed as Rare under the National Parks and Wildlife Act, 1992 and was recorded three times in a single year following significant winter rainfall. It has not been recorded from this area in any other year.

Threatened Species Known to Occur in the General Area

Threatened species that have been reliably recorded in the general vicinity of Beverley and in similar habitat, i.e. within about 100km, are listed in Table 10. Only those species whose presence is supported by herbarium voucher collections are included in

this list. Individual species are discussed below. Many other threatened species are present in the adjacent ranges, but will not be found at Beverley due to lack of suitable habitat. Some species that have been mentioned in early reports on the vegetation and flora of the Beverley area but which are not supported by voucher collections and whose habitat does not occur on the plains are not included here, although some were listed by Badman (2006a).

Table 10: Summary of likely occurrence of threatened plants in the survey area

Likelihood of occurring in this area is based on information from the South Australian Plant Mapper (Web Ref. 1).

Threatened species ratings

E	Endangered (SA NPW Act)
V	Vulnerable under the SA NPW Act
R	Rare under the SA NPW Act

Threatened species recorded within 100 km of the Beverley Mine site

Species	Famil y	EPB C Rati ng	St ate Ra tin g	Likeli hood of occurr ence
<i>Aristida arida</i>	Grami neae	Not rated	R	Possib le
<i>Austrodanthonia tenuior</i>	Grami neae	Not rated	R	Possib le
<i>Cladium procerum</i>	Cyper aceae	Not rated	R	Unlike ly
<i>Eremophila subfloccosa</i> ssp. "glandulosa"	Myop oracea e	Not rated	R	Unlike ly
<i>Orobanchaceae cernua</i> var. <i>australiana</i>	Oroba nchace ae	Not rated	R	Possib le
<i>Ranunculus sessiliflorus</i> var. <i>pilulifera</i>	Ranun culace ae	Not rated	V	Unlike ly
<i>Solanum eremophilum</i>	Solana ceae	Not rated	R	Possib le
<i>Swainsona oligophylla</i>	Legum inosae	Not rated	R	Recor ded 2005
<i>Swainsona procumbens</i>	Legum inosae	Not rated	V	Possib le
<i>Swainsona viridis</i>	Legum inosae	Not rated	V	Possib le
<i>Zygophyllum hybridum</i>	Zygop hyllac eae	Not rated	R	Possib le

Notes on individual species

Swainsona oligophylla

There are numerous records from the north and north-east of the state, with many from the Innamincka area, but no records from around Beverley (Web Ref. 1) prior to the three collections made in 2005. There is a record from the Epic Gas pipeline corridor near Erudina, well to the south of Beverley. This species was recorded in the one Hectare quadrat as monitoring site BU15 in September 2005 (collection number FJB 11752). This was the first and only record of any *Swainsona* sp. since monitoring of this quadrat commenced in March 2001. This species was rare at this site (1-10 plants in the 100 x 100 m quadrat). Two other collections of this species were subsequently made in 2005 (FJB 11759, 11767). It has not been recorded in subsequent years.

Aristida arida (no common name)

There are many records from the Gammon Ranges, which appears to be its stronghold in South Australia (DEH 2006). Although its preferred habitat is rocky places within the ranges, it has also been recorded along watercourses on the plains and in disturbed areas in other parts of the state (DEH 2006) and this is the reason it has been included here.

Austrodanthonia tenuior (Short-awn Wallaby-grass, Purplish Wallaby-grass)

There is a record from 30 km north-east of Wooltana, in rocky hills after floods (Web Ref. 1). It is possible that it could be found at Beverley, although the hills in this area are not as rugged as those to the north-east of Wooltana.

Cladium procerum (Leafy Twig-rush)

There is a herbarium voucher specimen from “The John Crossing” (Web Ref. 1), which is where Big John Creek crosses the Copley – Balcanoona Road just east of Nepabunna. There are no records from the plains so it is unlikely to be found at Beverley.

Eremophila subfloccosa ssp. “*glandulosa*” ms (Green-flower Emubush)

There are herbarium voucher collections from Balcanoona and South Tusk Hill (Web Ref. 1). This name is still in manuscript form and has yet to be formally published. It is unlikely that suitable habitat for this subspecies exists in the Beverley area.

Orobanche cernua var. *australiana* (Australian Broomrape)

There are several records from the general area, but none from the immediate vicinity of Beverley (Web Ref. 1). The closest herbarium voucher collections are from Big John Creek, 30 miles (50 km) south of Mt Hopeless, Murnpeowie and from Hamilton Creek near the junction of Salt Creek and Lake Callabonna. This species is parasitic on the roots of other plants and usually occurs along small watercourses in northern South Australia. There is a possibility that it could be found in this area in a good season.

Ranunculus sessiliflorus var. *pilulifera* (Annual Buttercup, Small-flower Buttercup)

The closest herbarium voucher collections to Beverley are from Moro Gorge, Mt John and Balcanoona Creek (Web Ref. 1). There are other records from further north, but this species is more common in southern parts of the state. The likelihood of it being found at Beverley is considered to be remote.

Solanum eremophilum (Rare Nightshade)

There is a herbarium voucher collection from Floods Creek (Web Ref. 1), which flows into Lake Frome to the east of Balcanoona. It is unlikely, but possible, that it could be found in the Beverley area. This is the only record in South Australia from north of the Port Pirie area.

Swainsona procumbens (Broughton Pea, Tatiara Pea)

The closest herbarium voucher collection is from near Lake Frome, to the south-east of Beverley (Web Ref. 1). It is possible that this species could be found at Beverley in a good season, although there are only four records in this state from north of Port Augusta.

Swainsona viridis (Creeping Darling Pea)

There is a herbarium voucher collection from Paralana Homestead (Web Ref. 1), which is now part of Wooltana Station³. All other nearby records are from the Gammon Ranges, although there are records from further north and south. There are no records from the plains east of the Gammon Ranges so it is unlikely that it would be found at Beverley.

³ The original Paralana Homestead was on the eastern edge of the ranges, about three kilometres south of the Paralana Hot Springs.

Zygophyllum hybridum

There are herbarium voucher collections from Mt Fitton, Benbonyathe Hill and Mt Clive, but no records from the plains to the east of the Gammon Ranges (Web Ref. 1). It is possible that it could be found in the Beverley area, although the lack of records from east of the ranges suggests that this is unlikely.

ALIEN FLORA

Alien species that are either known to exist in the Beverley area, or are considered likely to be found in the future, are listed in Table 11. This table also includes their status as listed by DWLBC (2005). No species listed as “very aggressive” by DWLBC (2005) are known or considered likely to occur in the Beverley area. The DWLBC definition of very aggressive is “*highly invasive in either disturbed or intact native vegetation. Spreads rapidly producing very dense stands and a blanket cover. Potential to eliminate native understorey species. Very difficult to control*”. All alien species recorded during the April 2007 survey were identified from dead standing plants, with no live alien plants seen during the survey.

Badman (1995) studied the spread of alien species at the Olympic Dam mine site and concluded that two distinct suites of alien plants were present there: those that had been in the area for 50-100 years or more, and plants that had come in after the establishment of the mine and town of Roxby Downs. The latter were restricted to wet areas such as drains and sewage ponds and had not spread into the surrounding country after more than a decade, a period which included two very wet years. These two suites are present at the Beverley Mine site, although the second suite is poorly represented because of the lack of on-site housing and domestic gardens. *Solanum nigrum* is the most obvious representative of this suite, although it was present in the district prior to any activities by Heathgate Resources. It has benefited from the availability of free water at drains on the mine lease (Badman 2004b). It was not recorded during the April 2007 survey, which did not include any such wet areas.

Polypogon monspeliensis and *Spergularia marina* (see comments below under these species) also belong in this category, although the presence of both species is the result of a pastoral bore rather than the mine. A third suite of alien plants appears to be present at Beverley: species that have been introduced to the area, and will probably continue to be introduced, by the large creeks that flow onto the plain from the Flinders Ranges. Heathgate Resources (1998) pointed to the fact that the majority of alien species were associated with drainage and the extra water subsidies that they provide. This was demonstrated by the higher incidence of introduced species at Group 1 sites compared to other vegetation groups during the March 2006 survey (Badman 2006a), as well as, to a lesser extent, during the April 2007 survey.

There still do not appear to be any introductions of new species that are a direct result of the mine or operations connected to it. Additional alien species that have been recorded since 1998 are all species that are already known from the Flinders Ranges. The two species present at Four Mile Bore, *Polypogon monspeliensis* and *Spergularia marina*, were first recorded in 2004, which was the first time the bore was surveyed by the present author (Badman 2004b). They were not reported by Heathgate Resources (1998). This bore predates any of the Heathgate Resources exploration and mining activities at this site, but it is not known whether these species were introduced by activities related to the mine, by stream flows from the ranges, by domestic stock after 1998, or whether they were overlooked during previous surveys.

Badman (1999) considered that at least 10% of the flora of the Lake Eyre basin is made up of introduced taxa (aliens). The ratio for Beverley is now well below this figure at 7 %.

The status of the species listed in Table 11 is discussed briefly below.

Proclaimed Species

Only one proclaimed species has been recorded in the Beverley area: this is *Tribulus terrestris*. Five other proclaimed species have been recorded in the general area, particularly in the nearby Flinders Ranges, and could be found at Beverley sometime in the future. These are:

Tribulus terrestris (Caltrop)

This species has been recorded in Beverley Uranium Mine monitoring quadrats in some years but has been absent in many others. This species is common in surrounding pastoral country following good rainfall.

Asphodelus fistulosus (Onion Weed)

This species had not yet been recorded in the Beverley area, but is common in the Flinders Ranges. It could be introduced to the area by water flows along Four Mile Creek or Paralana Creek. There is a nearby herbarium record from Frome Downs (Web Ref. 1).

Echium plantagineum (Salvation Jane)

This species had not yet been recorded in the Beverley area, but is common in the Flinders Ranges. It could be introduced to the area by water flows along Four Mile Creek or Paralana Creek. There are nearby herbarium records from Chambers Gorge and Martins Well (Web Ref. 1).

Emex australis (Three-corner Jack)

This species has yet to be recorded in the Beverley area, but is widely distributed in the Flinders Ranges. There is also a herbarium collection from Chambers Gorge (Web Ref. 1). It could be introduced to the Beverley area along one of the creeks from the ranges, or be brought in on vehicle tyres.

Marrubium vulgare (Horehound)

This species has yet to be recorded in the Beverley area, but is widely distributed in the Flinders Ranges. It could be introduced to the Beverley area along one of the creeks from the ranges, or by seeds in the coats of animals.

Xanthium spinosum (Bathurst Burr)

This species has yet to be recorded in the immediate Beverley area, but is widely distributed in the Flinders Ranges. It could be introduced to the Beverley area along one of the creeks from the ranges. There is a nearby record from North Mulga (Web Ref. 1) and it is most commonly associated with station dams in northern parts of South Australia.

Table 11: Alien species known, or likely, to occur in the Beverley area

DWLBC (2005b) Status:

P: Proclaimed species.

* Non-aggressive; generally only invade disturbed areas. Often widespread and abundant but not considered a serious threat to biodiversity unless present at very high densities.

** Aggressive; invasive in intact native vegetation with moderate potential to reduce native species diversity. Once present will persist and threaten native plant diversity. May produce dense stands, but can be controlled with sustained effort.

(P): Species not listed as proclaimed species by DWLBC (2005b), but listed as such by Barker et al. (2005).

Family	Species	Common Name	Known to occur	DWLBC (2005) Status
Polygonaceae	<i>Acetosa vesicaria</i>	Ruby Dock	Y	Not listed
Primulaceae	<i>Anagallis arvensis</i>	Scarlet Pimpernel	Y	**
Liliaceae	<i>Asphodelus fistulosus</i>	Onion Weed		Not listed (P)
Cruciferae	<i>Brassica tournefortii</i>	Long-fruited Wild-turnip		**
Cruciferae	<i>Carrichtera annua</i>	Ward's Weed		*
Gramineae	<i>Cenchrus ciliaris</i>	Buffel Grass	Y	**
Compositae	<i>Centaurea melitensis</i>	Maltese Cockspur	Y	**
Chenopodiaceae	<i>Chenopodium murale</i>	Nettle-leaf Goosefoot	Y	Not listed
Cucurbitaceae	<i>Citrullus colocynthis</i>	Colocynth		Not listed
Cucurbitaceae	<i>Citrullus lanatus</i>	Bitter Melon		*
Cucurbitaceae	<i>Cucumis myriocarpus</i>	Paddy Melon	Y	*
Gramineae	<i>Cynodon dactylon</i>	Couch-grass	Y	**
Solanaceae	<i>Datura leichhardtii</i>	Native Thorn-apple	Y	Not listed
Boraginaceae	<i>Echium plantagineum</i>	Salvation Jane		** P
Polygonaceae	<i>Emex australis</i>	Three-corner Jack		** P
Geraniaceae	<i>Erodium cicutarium</i>	Common Storks Bill		**
Boraginaceae	<i>Heliotropium curassavicum</i>	Smooth Heliotrope	Y	Not listed
Compositae	<i>Lactuca serriola</i>	Prickly Lettuce	Y	**
Malvaceae	<i>Malva parviflora</i>	Mallow		**
Labiatae	<i>Marrubium vulgare</i>	Horehound		** P
Solanaceae	<i>Nicotiana glauca</i>	Tree Tobacco		Not listed
Gramineae	<i>Polypogon monspeliensis</i>	Annual Beard-grass	Y	Not listed
Euphorbiaceae	<i>Ricinus communis</i>	Castor Oil Plant	Y	**
Labiatae	<i>Salvia verbenaca</i>	Wild Sage		**
Gramineae	<i>Schismus barbatus</i>	Arabian Grass	Y	Not listed
Cruciferae	<i>Sisymbrium erysimoides</i>	Hedge Mustard	Y	**
Cruciferae	<i>Sisymbrium irio</i>	London Rocket	Y	**
Solanaceae	<i>Solanum nigrum</i>	Black Nightshade	Y	**
Compositae	<i>Sonchus oleraceus</i>	Sow Thistle	Y	Not listed
Caryophyllaceae	<i>Spergularia marina</i> ⁴	Salt Sand-spurry	Y	Not listed
Zygophyllaceae	<i>Tribulus terrestris</i>	Caltrop	Y	** P
Compositae	<i>Xanthium spinosum</i>	Bathurst Burr		* P

⁴ See comment under this species.

Other Alien Species

Acetosa vesicaria (Rosy Dock)

This species was found to be common at Group 1 sites in March 2006 (Badman 2006a) and was sparsely present in April 2007. It was reported from the same type of country by Heathgate Resources (1998). One immature plant was found in the camp area in September 2004, but was not recorded in 2005. It is abundant in the Flinders Ranges and a continuing influx of seeds can be expected along major watercourses from the ranges. It has a broad but scattered distribution to the east of the Flinders Ranges (Web Ref. 1).

Anagallis arvensis (Blue Pimpernel)

This species is common in the Flinders Ranges (Web Ref. 1) and was reported from the Four Mile Creek by Heathgate Resources (1998). It was also collected opportunistically in Paralana Creek in 2005. Further introductions to the Beverley area can be expected along the Four Mile and Paralana Creeks.

Brassica tournefortii (Long-fruited Wild –turnip)

This species was reported from Four Mile Creek and Jenny Creek by Heathgate Resources (1998). It was not recorded during the April 2007 survey. Because of its preference for sandy habitats it is unlikely to occur at Beverley other than in sandy areas such as occur along the Four Mile and Paralana Creeks. Seeds could be introduced to the area along either of these creeks, but it is unlikely to dominate as it does in sandier country.

Carrichtera annua (Ward's Weed)

This species has a very broad distribution to the west and south of the Beverley area (Web Ref. 1), but has not yet been recorded at Beverley. Because this species has been so common in so many areas for over a Century, it is possible that it will not spread to Beverley under the present climatic conditions because either the soils or rainfall patterns do not suit it.

Cenchrus ciliaris (Buffel Grass)

This species was recorded during the 1979 biological survey (Close and Williams 1982), along Four Mile Creek (Heathgate Resources 1998) and along the banks of Paralana Creek during Epic Pipeline rehabilitation surveys (Badman 2005). This species has been widely planted for stock fodder by pastoralists in northern South Australia, but it is not known whether its occurrence in this area is accidental or deliberate.

Centaurea melitensis (Malta Thistle)

Recorded during the 1979 biological survey⁵ (Close and Williams 1982) and reported from Four Mile Creek (Heathgate Resources 1998) and again during the March 2006 survey (Badman 2006a). It is not common in this area, but there are numerous records from the Flinders Ranges (Web Ref. 1).

⁵ Williams listed *Centaurea solstitialis*, but this particular species is known in South Australia only from south of Port Augusta (Web Ref. 1) The widespread *C. melitensis* is the only member of this genus which is currently known from the botanical region containing the Beverley Mine.

Chenopodium murale (Nettle-leaf Goosefoot)

This species was recorded from watercourses during the 1979 biological survey (Close and Williams 1982), but has not been subsequently recorded in the Beverley area. It is most common at pastoral watering points and at sheep yards in northern South Australia and appears to benefit from the extra nutrients found at such places.

Citrullus colocynthis (Colocynth)

Not recorded during the 1979 biological survey (Close and Williams 1982), but reported by Heathgate Resources (1998).

Citrullus lanatus (Bitter Melon)

Not recorded during the 1979 biological survey (Close and Williams 1982), but it has since been recorded opportunistically as sparsely present in some watercourses, including the Four Mile Creek during the March 2006 survey (Badman 2006a). This perennial species is very common and widespread in northern South Australia (Web Ref. 1), particularly following late spring and summer rainfall.

Cucumis myriocarpus (Paddy Melon)

Recorded during the 1979 biological survey (Close and Williams 1982), it was also recorded along the drain at the main camp in 2005 (Badman 2006b).

Cynodon dactylon (Couch)

Found in a drain just outside the main gate to the process plant in 2004 and 2005 and also at the Four Mile Bore in both years (Badman 2004b, 2005b). Close and Williams (1982) also reported it from watercourses in the general area. This is a common species along drains and around water points throughout the surrounding pastoral country.

Datura leichhardtii (Native Thorn-apple)

One plant was found growing in a gully near the old camp site on the mine lease to the south of the Four Mile Bore in 2004 (Badman 2004b). Heathgate Resources (1998) reported a *Datura* sp. from Four Mile Creek, which was most likely referable to this species. There are numerous records from the Flinders Ranges (Web Ref. 1).

Erodium cicutarium (Common Storks Bill)

This widespread and common species has been recorded in the Flinders Ranges and at Frome Downs (Web Ref. 1). It is probably only a matter of time before it is recorded in the Beverley area, although it is likely to be found only following a significant rainfall event.

Heliotropium curassavicum (Smooth Heliotrope)

This species was recorded along Four Mile Creek during the 1979 biological survey (Close and Williams 1982) and there are other scattered records from the region (Web Ref. 1). It is common in good seasons in saline damp areas, including the margins of salt lakes, but is unlikely to occur in large numbers on or near the Beverley mine lease because of lack of suitable habitat.

Lactuca serriola (Prickly Lettuce)

This species was recorded during the 1979 biological survey (Close and Williams 1982), although reference to this record was omitted by Heathgate Resources (1998). It has not subsequently been recorded in the Beverley area. There are several scattered records from northern South Australia (Web Ref. 1), where it occurs in some watercourses and other damp areas.

Malva parviflora (Mallow)

This species was recorded during the December 2003 annual vegetation survey (Badman 2004a) and during the June 2004 Epic pipeline vegetation survey (Badman 2004b). There are several scattered herbarium records from the region, including one from Mulga Bore, and it is widespread in the Flinders Ranges (Web Ref. 1)

Nicotiana glauca (Tree Tobacco)

This species occurs throughout the Flinders Ranges (Web Ref. 1), but has yet to be found on the plains to the east of the ranges. Seeds could be introduced into the area along the large creeks emanating from the ranges, but this does not appear to have happened yet. However, there are records from north of Beverley, including from along the Strzelecki Track (Web Ref. 1).

Polypogon monspeliensis (Annual Beard-grass)

This species was recorded in wet mud at the Four Mile Bore in 2004 (Badman 2004b) and 2005 and in the drain from the camp kitchen in 2005 (Badman 2006b). This is a common species at many bore drain swamps and in some other permanently wet areas in northern South Australia, but most commonly throughout the Flinders Ranges and to the west of Lake Eyre (Web Ref. 1).

Ricinus communis (Castor Oil Plant)

This species was recorded along Four Mile Creek during the 1979 biological survey (Close and Williams 1982), but has not subsequently been recorded in this area. There are scattered records from the Flinders Ranges and from areas to the north-west, although most herbarium collections are from south of the Beverley area (Web Ref. 1).

Schismus barbatus (Arabian Grass)

This species has been recorded in mine lease monitoring quadrats in good seasons and also along the Epic Pipeline in 2004 and 2005. It was found to be common at Group 1 sites in March 2006 (Badman 2006a), but it was not recorded in April 2007. Heathgate Resources (1998) reported it as occurring “throughout”. It is widespread in the general area (Web Ref. 1) and is common on surrounding pastoral country following cool-season rainfall. Badman (2004c) found that it was sometimes more common on control sites than on disturbed areas along the Epic Gas Pipeline.

Sisymbrium erysimoides (Smooth Mustard)

This species was recorded by Close and Williams (1982) and in the drain from the camp kitchen in 2004 and 2005. It was frequently recorded at both Group 1 and Group 2 sites in March 2006 (Badman 2006a), but was much less common in April 2007. This is a common and widespread species in wet, shaded habitats, particularly along watercourses, throughout the pastoral country (Web Ref. 1).

Sisymbrium irio (London Rocket)

Not recorded during the 1979 biological survey (Close and Williams 1982), but reported from the Four Mile Creek by Heathgate Resources (1998). The dead material of *Sisymbrium* observed and collected along Four Mile Creek during the March 2006 survey did not appear to include this species (Badman 2006a).

Solanum nigrum (Black Nightshade)

This species was reported from Four Mile Creek by Heathgate Resources (1998). It was found at most places where water overflowed from the camp and process plant in September 2004, but was slightly less commonly in 2005 following a site environmental control campaign (Badman 2006b). It is found in similar habitats throughout much of the northern pastoral areas of South Australia, although there are few records from east of the northern Flinders Ranges (Web Ref. 1).

Sonchus oleraceus (Common Sow-thistle)

Heathgate Resources (1998) reported this species as occurring “throughout”. It was found in a drain just outside the main gate to the process plant and in the drain from the camp kitchen in 2004 and 2005. It was also found growing in the camp area and in and around the process plant in 2005 (Badman 2006b). This is a common species along drains and around water points throughout the pastoral country, although there are few herbarium records from east of the northern Flinders Ranges (Web Ref. 1). It was not recorded during the March 2006 survey (Badman 2006a), although it was opportunistically recorded at one place on the mine lease at that time.

Spergularia marina (Salt Sand-spurrey)

This species was recorded in wet mud at the Four Mile Bore in 2004 and was common there in 2005 (Badman 2006b). It is restricted in northern South Australia to wet areas such as bore drains and tank overflows. However, Barker et al. (2006) no longer list this species as being introduced. This genus is currently under revision and new species will probably be described, including one or more species that are considered to be native to Australia. At present there is no published key to aid in identification and all South Australian material for *Spergularia* is currently on loan for use in the revision.

Two other alien species have been reported from the Beverley area (Close and Williams 1982), but are now considered to be the result of misidentifications. These are:

Centaurium erythraea (Common Centaury)

Reported from the 1979 biological survey (Close and Williams 1982), but not recorded during later monitoring events. This record is well to the east and north of the accepted range of this species (Barker et al. 2005, Web Ref. 1).

Mentha spicata (Spearmint)

Reported from the 1979 biological survey (Close and Williams 1982), but not recorded during later monitoring events. This record is well to the north of the accepted range of this species (Barker et al. 2005, Web Ref. 1).

Other species that could possibly turn up in the Beverley area include *Avena barbata*, *Avena fatua*, *Bromus rubens*, *Chenopodium album* and *Salvia verbenaca*. The first three are grasses that would have been expected to have already entered the area from

the Flinders Ranges if they were going to do so, while the last is found throughout the southern Flinders Ranges, in southern parts of the state, and in sandy country further to the west.

CALCULATING THE SIGNIFICANT ENVIRONMENTAL BENEFIT RATIO

The vegetation of the Four Mile area is typical of the plains between the Flinders Ranges and Lake Frome. The vegetation of the plains on the Four Mile Lease (Group 3 sites) is also very similar to the vegetation of the present mine lease and the surrounding country that was surveyed in March 2006 (Badman 2006a). The vegetation of the minor watercourses on the Four Mile Lease is also very similar to minor watercourses on the present mine lease (Badman 2006a).

The report “*Guidelines for a Native Vegetation Significant Environmental Benefit Policy for the Minerals and Petroleum Industry*” (DWLBC 2005a) does not adequately address the condition of vegetation in arid areas such as the Beverley Mine site. The Guidelines place considerable emphasis on clearance of trees and the number and frequency of introduced species and are more appropriate where the native vegetation is remnant rather than intact but disturbed, as it is at Beverley. No trees have been cleared in the Beverley Mine site area, other than perhaps where a few may have been cleared or used for posts during past fence construction, and practically no introduced species are present in dry years and only a few species in good seasons. Even during wet years, the alien species that are present are mostly winter-growing annuals rather than perennial species and they never dominate the vegetation in this area. Vegetation has been modified by domestic grazing, particularly in close proximity to the Four Mile Bore and other stock watering points, but this modification cannot be quantified.

The temporary clearing of vegetation on the study area will have no impact on flora of listed conservation significance at the local, regional or state level. Vegetation clearance associated with the proposed development will affect only vegetation types that are common in the general area and over broader areas of the north of South Australia.

Existing impacts on native vegetation are mainly those associated with domestic grazing and also grazing by kangaroos. These cannot be quantified without considerable extra monitoring, although Badman (2004b, 2006b) demonstrated that the grazing effects of kangaroos inside the Beverley Mine Lease fence was equivalent to the grazing pressure of cattle outside the fence. Badman (2002) also found that total grazing pressure remains the same when domestic stock are removed from a mine lease because kangaroos and perhaps rabbits move in or increase in numbers to take advantage of the extra vegetation provided by the removal of domestic livestock.

When calculating the Significant Environmental Benefit (SEB) ratio (Table 1 in DWLBC 2005), the study area should probably be treated as having an 8:1 ratio, although past grazing practices are not taken into consideration under these guidelines. These guidelines are largely based on the findings of work in southern parts of the state and place too much emphasis on the incidence of, and domination by, alien species. Arid zone areas can be heavily disturbed without the introduction of sufficient weed species to form a dominant part of the vegetation (Badman 1995). The study area has probably been cleared of 10-50% of its original vegetation, including much of the original understorey, by cattle grazing. Heathgate Resources (1998) also indicated modifications to the understorey caused by overgrazing which have resulted in what were once pure stands of *Astrebla pectinata* now including a

significant component of *Sclerolaena divaricata*. These modifications would give the area a 4:1 SEB ratio except that the vegetation is not dominated by weeds and contains only one very aggressive weed species (*Sisymbrium erysimoides*) as listed in Appendix 4 of DWLBC (2005).

CONCLUSIONS

Seasonal conditions were very dry at the time of the survey and few ephemeral species were present. Analysis of data from 22 new one hectare monitoring sites, resulted in the description of three main vegetation groups and these are similar to the main groups described for the mine area in both the 1998 Environmental Impact Statement (EIS) report (Heathgate Resources, 1998) and the March 2006 report on EL3251 (Badman 2006a). These groups are the Mitchell Grass plains with *Astrebla pectinata* and *Sclerolaena* spp., the minor watercourses with *Rhagodia spinescens* and several tall shrubs or low trees, and the major creek lines with *Eucalyptus camaldulensis* and *Melaleuca* spp.

No species listed under the EPBC Act are known to occur at Beverley or in the study area. Only one threatened species, *Swainsona oligophylla*, which is listed as rare under the National Parks and Wildlife Act, 1972, is known to occur at Beverley. Two previously reported species, *Frankenia subteres* and *Swainsona murrayana*, are now considered to be based on misidentifications. Most of the threatened species that are known to occur in the general area are restricted to the Flinders Ranges and are not known to exist on the plains.

One proclaimed plant, *Tribulus terrestris*, has been recorded at Beverley. It is fairly common in the general area but is not recorded in all years. Nineteen alien plant species have now been recorded at Beverley and a further 10 are known to occur in the general area. None of these occurrences can be directly attributed to exploration or mining activities. Two species have been recorded at the Four Mile Bore since the 1998 EIS survey: this bore and its wetland pre-date any exploration and mining activities and it is not known whether the presence of these species is connected to these activities.

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APPENDICES

Appendix A: Examples of Data Sheets

Field Order	<i>BIOLOGICAL SURVEY of SA- BS207: Arid Rivers</i>				Office use only											
<table border="1" style="width: 100%; height: 20px;"> <tr> <td style="width: 25%;">Team No.</td> <td style="width: 25%;">Sequence No.</td> <td style="width: 25%;">Camp</td> <td style="width: 25%;">Site</td> </tr> </table>	Team No.	Sequence No.	Camp	Site	SA Department for Environment and Heritage				Patchid <input style="width: 100px;" type="text"/>							
Team No.	Sequence No.	Camp	Site													
VEGETATION PATCH/QUADRAT DATA																
Site id:	<table border="1" style="width: 100%; height: 20px;"> <tr> <td style="width: 25%;">Camp</td> <td style="width: 25%;">Site</td> <td style="width: 25%;">Quadrat / Patch</td> <td style="width: 25%;"></td> </tr> </table>			Camp	Site	Quadrat / Patch		Date	<table border="1" style="width: 100%; height: 20px;"> <tr> <td style="width: 20%;">DD</td> <td style="width: 20%;">MM</td> <td style="width: 20%;">YY</td> <td style="width: 20%;"></td> <td style="width: 20%;"></td> <td style="width: 20%;"></td> </tr> </table>		DD	MM	YY			
Camp	Site	Quadrat / Patch														
DD	MM	YY														
Observer:	<input style="width: 100%; height: 20px;" type="text"/>			Climatic Condition	<input type="checkbox"/> 1 = Wet - rainfall prior to survey, annuals. <input type="checkbox"/> 2 = Dry - vegetation dry, few annuals present.											
Vegetation Condition	<input type="checkbox"/>			1 = virtually no cover, 2 = undisturbed natural, 3 = disturbed natural, 4 = degraded natural, 5 = highly degraded												
LF = Life form:	T Trees > 30m	S Shrubs > 2m	H Hummock Grass	V Vines (twiners)												
	M Trees 15-30m	SA Shrubs 1.5-2m	GT Grass > 0.5m	MI Mistletoes												
	LA Trees 5-15m	SB Shrubs 1-1.5m	GL Grass < 0.5m	X Ferns												
	LB Trees < 5m	SC Shrubs 0.5-1m	J Herbaceous spp.	MO Mosses												
	KT Mallee tree form (>3m)	SD Shrubs 0-0.5m	VT Sedges > 0.5m	LI Lichens												
	KS Mallee shrub form (<3m)	P Mat plant (single plant)	VL Sedges < 0.5m													
AD = Flag the dominant/codominant species for Overstorey (up to 3 spp), Emergents (up to 3 spp) and Understorey (up to 5 spp) (O/E/U). *Note: an emergent species is defined as a species that emerges above the dominant overstorey and has a cover abundance of less than 2.																
CA: Cover Abundance scale adapted from Braun-Blanquet system. N = Not many (1-10 plants and <5%) \$ T = sparsely present; cover small (less than 5%) 1 = plentiful, but of small cover (less than 5%) 2 = any number of individuals covering 5-25% of area 3 = any number of individuals covering 25-50% of area 4 = any number of individuals covering 50-75% of area 5 = covering more than 75% of area				LS = Life stages: enter code where relevant to >10% of that species at site and if >10% of reproductive organs are at that stage. Enter seedlings always . V = vegetative R = regenerating D = dead/dormant B = budding F = flowering I = immature fruits M = mature fruits X = recently shed S = seedling												
\$ where large shrubs or trees are involved upgrade the category to reflect the cover rather than the number of individuals																
Species	Previous Voucher No	Voucher No	AD O/E/U	LF	CA	LS	Comments									
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																

Beverley Uranium Mine Four Mile Baseline Vegetation Survey

VEGETATION ASSOCIATION DESCRIPTION (PLA)

ASSEMBLAGE INFORMATION (VEGETATION STRUCTURAL SUMMARY) : (From highest to lowest stratum):

Life form height class LF / Canopy cover (d =70-100% / c =30-70% / i =10-30% / r =1-10%) (Muir 1977)

From observations of site, not plant list. Strike out life forms not present as a +/- consistent/identifiable 'layer' in vegetation.

T / _____ **KS** / _____ **SD** / _____ **VL** / _____ **X** / _____
M / _____ **S** / _____ **GT** / _____ **P** / _____ **MO** / _____
LA / _____ **SA** / _____ **GL** / _____ **J** / _____ **LI** / _____
LB / _____ **SB** / _____ **H** / _____ **V** / _____
KT / _____ **SC** / _____ **VT** / _____ **MI** / _____

SA STRUCTURAL FORMATION : (Overstorey structural category):

Check that all dominants (O, E, U) are entered in AD column on plant list.

Record the vegetation structure, using the adapted Forward & Robinson table (below), based on the cover and average height of the overstorey at the site.

Overstorey is the tallest stratum with a canopy cover of 5% or more (taller 'layers' of less than 5% are emergents), or the tallest layer where no layers attain 5% cover. If two different lifeforms are more or less codominant eg. a Mallee/Callitris mix, then use both combined to determine average height and cover, but select most prevalent or conspicuous to select a name. Canopy cover is based on projected foliage cover –refer to manual.

Life Form/Height Class	Projective Foliage Cover of Tallest Stratum			
	Dense (70-100%)	Mid-dense (30-70%)	Sparse (10-30%)	Very sparse (<10%)
Trees > 30m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland
Trees 10-30m	Closed forest	Open forest	Woodland	Open woodland
Trees 5-10m	Low closed forest	Low open forest	Low woodland	Low open woodland
Trees <5m	Very low closed forest	Very low open forest	Very low woodland	Very low open woodland
Mallee (>3m)	Closed mallee	Mallee	Open mallee	Very open mallee
Low Mallee (<3m)	Closed low mallee	Low mallee	Open low mallee	Very open low mallee
Shrubs > 2m	Tall closed shrubland	Tall shrubland	Tall open shrubland	Tall very open shrubland
Shrubs 1-2m	Closed shrubland	Shrubland	Open shrubland	Very open shrubland
Shrubs < 1m	Low closed shrubland	Low shrubland	Low open shrubland	Low very open shrubland
Mat plants	Closed mat plants	Mat plants	Open mat plants	Very open mat plants
Hummock grasses	Closed Hummock grassland	Hummock grassland	Open hummock grassland	Very open hummock grassland
Tussock grasses	Closed (tussock) grassland	(Tussock) grassland	Open (tussock) grassland	Very open (tussock) grassland
Sedges	Closed sedgeland	Sedgeland	Open sedgeland	Very open sedgeland
Herbs	Closed hermland	Hermland	Open hermland	Very open hermland
Ferns	Closed fernland	Fernland	Open fernland	Very open fernland

Upper Stratum Age Class (for dominant / codominant species) **Circle if present; Slash if absent** (Tree layer only)

Comments

seedling (<1m) **SE** _____
Sapling (juvenile) **SA** _____
Mature **MA** _____
Senescent **SN** _____
Hollows **HO** _____

OVERSTOREY MEASUREMENTS (OVE) (Dominant / co-dominant overstorey, including if shrubland; 10 estimates.

Eyeball the site in cross-section to distinguish the stratum and to determine the overstorey height range. For overstorey, measure 10 individuals or discrete foliage clumps of any species that occur in the broad lifeform category that corresponds to the structural description completed above. Broad lifeform categories include trees, mallees and shrubs. Include all individuals regardless of height, except where there is a recognisable height gap corresponding to a separate lower stratum. In circumstances where two lifeforms are codominant include measurements for both.

Canopy Type % Estimate average canopy type for overstorey species measured.

Overstorey Height (m)

--	--	--	--	--	--	--	--	--	--

VEGETATION COMMENTS (*VEG):

Crown Depth (m)

--	--	--	--	--	--	--	--	--	--

Canopy Diameter (m)

--	--	--	--	--	--	--	--	--	--

Gap (m)

--	--	--	--	--	--	--	--	--	--

SITE DATA SHEET		SURVEY NO.	<input style="width: 15px; height: 15px;" type="text"/> <input style="width: 15px; height: 15px;" type="text"/> <input style="width: 15px; height: 15px;" type="text"/>
SA Department for Environment and Heritage			
SITE DESCRIPTION		PATCHID	
Observer(s) <small>(3 initials)</small>			Office use only
Site ID	<input style="width: 15px; height: 15px;" type="text"/>	<input style="width: 15px; height: 15px;" type="text"/> <input style="width: 15px; height: 15px;" type="text"/> <input style="width: 15px; height: 15px;" type="text"/>	<input style="width: 15px; height: 15px;" type="text"/> <input style="width: 15px; height: 15px;" type="text"/>
	Reserve Type (CP,NP,RP,GR)	Reserve Code	Sequence
Reserve Name			
Map Code		Map Name	
		Altitude	
			m
Altitude Accuracy		1 = Surveyed height , 2 = Differential GPS , 3 = GPS , 4 = map contour	
AMG Zone		Easting	
Method		Datum	
	1 = map 2 = aerial photo digitised 3 = GPS 4 = differential GPS		1 = WGS84 2 = AGD84 3 = AGD66 4 = GDA94
		Reliability	
			1 =5-50m 2 =50-100m 3 =100-250m 4 =250-500m D =0-5m
Is Photopoint location marked ?	<input type="checkbox"/> Y/N	Marker	<input type="checkbox"/>
			1 = Wooden peg 5 = Steel Star Dropper 2 = Plastic peg 6 = Galvanised Dropper 3 = Poly Dropper 7 = Cement Plate 4 = F/glass Post 0 = none
Photopoint Disc	<input type="checkbox"/> Y/N	No. Allocated	
		Photopoint Direction	
			degrees from magnetic north
Please mark location of photopoint and tralines			
Location Comments: (optional - include Parcel/Plan eg Lot/ Deposited.Plan, Sec/Hundred)			

Beverley Uranium Mine Four Mile Baseline Vegetation Survey

PHYSICAL DESCRIPTION	
Landform Pattern <input style="width: 50px; height: 20px;" type="text"/>	ALF=aluvial fan, ALP=aluvial plain, SAN=sandplain, FLO=floodplain, PLA=plain, CON=consolidated dunefield, DUN=dunefield, PED=pediment, RIS=rises, PLT=plateau, LOW=low hills, HIL=hills, ESC=escarpment, MOU=mountains
Landform Element <input style="width: 50px; height: 20px;" type="text"/>	303=hill footslope, 304=talus, 305=aclove, 306=ridge, 321=gully, 322=gorge, 330=cliff, 331=cliff footslope, 340=scarp, 350=pediment, 360=rock outcrop (on hill), 400=stream channel, 402=stream bank, 403=stream bar, 410=levee, 420=channel bench, 430=terrace, 451=floodout, 452=back plain, 453=fan-alluvial, 455=scroll complex, 460=estuary, 500=lake, 510=saltlake, 520=swamp, 521=perched swamp, 530=terminal lake, 540=salt crust, 600=beach, 610=beach ridge, 620=fore dune, 630=lagoon, 710=cone, 720=crater, 730=marr, 740=ashplain, 760=tumulus, 811=open depression, 812=closed depression, 820=flat, 830=doline/sinkhole, 840=cave,
Site Slope <input style="width: 50px; height: 20px;" type="text"/>	degrees from horizontal
Site Aspect <input style="width: 50px; height: 20px;" type="text"/>	(degrees from North) N =360, no slope=0
Outcrop Cover <input style="width: 50px; height: 20px;" type="text"/>	9= none apparent, 1=<10%, 2=10-50%, 3=>50%
Outcrop Lithology <input style="width: 50px; height: 20px;" type="text"/>	110=calcrete/limestone, 120=sandstone, 130=siltstone, 140=shale, 160=laterite (ironstone), 220=quartzite, 230=gneiss, 240=schist, 310=quartz, 330=granite, 777=not identified
	Other: <input style="width: 150px; height: 20px;" type="text"/> (or subdominant)
Surface Strew Size <input style="width: 50px; height: 20px;" type="text"/>	9 = none apparent, 1 = pebble (5 - 50mm), 2 = cobble (51 - 250mm), 3 = boulder (250mm)
Surface Strew Cover <input style="width: 50px; height: 20px;" type="text"/>	9=nil, 1= <10%, 2=10-30%, 3=30-70%, 4=70-100%
Surface Strew Lithology <input style="width: 50px; height: 20px;" type="text"/>	110=calcrete/limestone, 120=sandstone, 130=siltstone, 140=shale, 160=laterite (ironstone), 220=quartzite, 230=gneiss, 240=shist, 310=quartz, 330=granite, 777=not identified
Surface Strew Comment	<input style="width: 100%; height: 20px;" type="text"/>
Soil Texture Class <input style="width: 50px; height: 20px;" type="text"/>	S = sand, LS = loamy sand, CS = clayey sand, SL = sandy loam, L = loam, ZL = silty loam, SCL = sandy clay loam, CL = clay loam, CLS = clay loam, sandy, ZCL = silty clay loam, LC = light clay, LMC = light med clay, MC = med. clay, MHC = med. heavy clay HC = heavy clay, P =peat
VISIT	
Observer(s) <input style="width: 150px; height: 20px;" type="text"/>	Date <input style="width: 100px; height: 20px;" type="text"/>
Fire Scars <input type="checkbox"/> Y/N	Year of last fire (if known) <input style="width: 50px; height: 20px;" type="text"/>
	Year certain ? <input type="checkbox"/> Y/N
Photopoint - not taken <input type="checkbox"/>	Taken - BSM Standard <input type="checkbox"/>
	Taken - other <input type="checkbox"/>
Bare Earth Estimate (% cover) <input style="width: 50px; height: 20px;" type="text"/>	Litter Estimate <input style="width: 50px; height: 20px;" type="text"/>
	Sighter distance <input style="width: 50px; height: 20px;" type="text"/>
Vegetation Patch/Quadrat Dimensions (m) <input style="width: 50px; height: 20px;" type="text"/>	X <input style="width: 50px; height: 20px;" type="text"/>
	Sighter Height <input style="width: 50px; height: 20px;" type="text"/>
Climatic Conditions <input type="checkbox"/>	Vegetation Condition <input type="checkbox"/>
(transfer from vegetation sheet)	(transfer from vegetation sheet)
	Camera Height <input style="width: 50px; height: 20px;" type="text"/>
Structural Formation <input style="width: 100%; height: 20px;" type="text"/>	
(transfer from vegetation sheet)	
Comments	<input style="width: 100%; height: 20px;" type="text"/>
*PHY Physical	<input style="width: 100%; height: 20px;" type="text"/>
*ERO Erosion	<input style="width: 100%; height: 20px;" type="text"/>
*DIS Disturbance	<input style="width: 100%; height: 20px;" type="text"/>
*VPR Vertebrates	<input style="width: 100%; height: 20px;" type="text"/>
*SOI Soil *PPP Photopoint	<input style="width: 100%; height: 20px;" type="text"/>

Appendix B: Voucher Numbers

All voucher collections have been deposited in the State Herbarium of South Australia.

Voucher numbers below 12269 are from the March 2006 survey (Badman 2006a).

* denotes introduced species.

Species	Collection Number(s) (F.J. Badman)
<i>Abutilon cryptopetalum</i>	11979
<i>Abutilon halophilum</i>	12030
<i>Abutilon leucopetalum</i>	12017, 12059, 12122
<i>Acacia aneura</i>	11783, 11784, 11785, 12292
<i>Acacia aneura</i> var. <i>tenuis</i>	12054
<i>Acacia ligulata</i>	12002
<i>Acacia oswaldii</i>	12065
<i>Acacia tetragonophylla</i>	12005, 12107
<i>Acacia victoriae</i>	12001, 12303
* <i>Acetosa vesicaria</i>	11991
<i>Actinobole uliginosum</i>	11762
<i>Alectryon oleifolius</i>	12058
<i>Amyema maidenii</i>	12295
<i>Amyema preissii</i>	12114
* <i>Anagallis arvensis</i>	11769
<i>Arabidella ?glaucescens</i>	12098
<i>Arabidella nasturtium</i>	11778
<i>Arabidella trisecta</i>	11779
<i>Aristida contorta</i>	12104
<i>Aristida nitidula</i>	11780, 11972, 12006, 12279
<i>Astrebla pectinata</i>	11985, 12029
<i>Astrebla pectinata</i>	12081
<i>Atriplex angulata</i>	12008, 12038
<i>Atriplex holocarpa</i>	12096
<i>Atriplex lindleyi</i>	11754
<i>Atriplex vesicaria</i>	12062
<i>Boerhavia dominii</i>	11990, 12018
<i>Brachiaria gilesii</i>	11408
<i>Brachyscome ciliaris</i> var. <i>lanuginosa</i>	11764, 12112
<i>Bulbine alata</i>	12043
<i>Callitris glaucophylla</i>	12300
<i>Calotis latiuscula</i>	12049
* <i>Cenchrus ciliaris</i>	11409
* <i>Centaurea melitensis</i>	11982
<i>Chamaesyce drummondii</i>	12045
<i>Chenopodium cristatum</i>	11763
* <i>Citrullus colocynthis</i>	11989
<i>Convolvulus</i> sp.	12015
<i>Convolvulus remotus</i>	11751
<i>Cymbopogon ambiguus</i>	11976
* <i>Datura leichhardtii</i>	11980
<i>Daucus glochidiatus</i>	12052
<i>Dichanthium sericeum</i> ssp. <i>sericeum</i>	11756
<i>Dichromochlamys dentatifolia</i>	11758, 12105
<i>Digitaria brownii</i>	12016, 12019
<i>Dissocarpus biflorus</i>	12084

Beverley Uranium Mine Four Mile Baseline Vegetation Survey

Species	Collection Number(s) (F.J. Badman)
<i>Dissocarpus paradoxus</i>	12020
<i>Dodonaea viscosa</i> ssp. <i>angustissima</i>	12290
<i>Einadia nutans</i>	11967
<i>Enchylaena tomentosa</i>	11786, 11966
<i>Enteropogon</i> sp.	11404, 11970, 12284
<i>Eragrostis australasica</i>	12090
<i>Eragrostis dielsii</i>	12088
<i>Eragrostis setifolia</i>	12035
<i>Eremophila duttonii</i>	12094
<i>Eremophila freelingii</i>	12000, 12028
<i>Eremophila longifolia</i>	12025, 12273
<i>Erodium carolinianum</i>	11749, 11765
<i>Eucalyptus camaldulensis</i>	11977, 12283
<i>Euphorbia stevenii</i>	11757, 12040, 12047
<i>Euphorbia tannensis</i> ssp. <i>eremophila</i>	11996
<i>Frankenia serpyllifolia</i>	11781, 12086
<i>Glossocardia bidens</i>	11775
<i>Glycine canescens</i>	12119
<i>Gnephosis arachnoidea</i>	12291
<i>Gnephosis eriocarpa</i>	12022
<i>Goodenia lunata</i>	11755
<i>Grevillea huegelii</i>	12285
<i>Hakea leucoptera</i>	12089
<i>Haloragis aspera</i>	12111
<i>Heliotropium asperrimum</i>	11770
<i>Heliotropium cunninghamii</i>	11776
<i>Hibiscus brachysiphonius</i>	11317, 12095
<i>Indigofera leucotricha</i>	12057, 12301
<i>Ixiochlamys</i> sp?	12011
<i>Ixiolaena leptolepis</i>	12037
<i>Lepidium phlebopetalum</i>	12048
<i>Lysiana exocarpi</i>	11974, 12026, 12270
<i>Maireana aphylla</i>	12064
<i>Maireana astrotricha</i>	12108
<i>Maireana campanulata</i>	12124
<i>Maireana coronata</i>	11760, 11768, 11771
<i>Maireana georgei</i>	12069
<i>Maireana pyramidata</i>	12070
<i>Maireana triptera</i>	12302
<i>Malacocera albolanata</i>	12085
<i>Malacocera tricornis</i>	12032
<i>Malvastrum americanum</i>	11986
<i>Melaleuca dissitiflora</i>	12056, 12298
<i>Melaleuca glomerata</i>	11969, 12010, 12060, 12274, 12282, 12287, 12293, 12297
<i>Minuria cunninghamii</i>	12125
<i>Mukia maderaspatana</i>	12067
<i>Neobassia proceriflora</i>	11965
<i>Neobassia proceriflora</i>	11318, 12034
<i>Nicotiana simulans</i>	11772, 11981
<i>Omphalolappula concava</i>	11782

Beverley Uranium Mine Four Mile Baseline Vegetation Survey

Species	Collection Number(s) (F.J. Badman)
<i>Osteocarpum acropterum</i> var. <i>acropterum</i>	12012
<i>Phyllanthus fuernrohrii</i>	12014
<i>Pimelea microcephala</i>	12024
<i>Pimelea simplex</i> ssp. <i>simplex</i>	12036, 12106, 12120
<i>Pittosporum angustifolium</i>	12027
<i>Plantago drummondii</i>	12042
<i>Plantago</i> sp.	12041
<i>Pluchea dentex</i>	11984
<i>Prostanthera striatiflora</i>	12299
<i>Pseudognaphalium luteoalbum</i>	11773
<i>Pterocaulon sphacelatum</i>	11999
<i>Ptilotus obovatus</i>	12004
<i>Rhagodia spinescens</i>	11402, 11975, 12003
<i>Rhodanthe floribunda</i>	12082
<i>Rhodanthe stricta</i>	12097
<i>Rhyncharrhena linearis</i>	12055, 12288
<i>Salsola kali</i>	11992
<i>Santalum lanceolatum</i>	12063
<i>Sarcostemma viminale</i> ssp. <i>australe</i>	12117
<i>Scaevola spinescens</i>	12066, 12073
* <i>Schismus barbatus</i>	11766, 11997
<i>Sclerolaena brachyptera</i>	12031
<i>Sclerolaena cuneata</i>	11998, 12009
<i>Sclerolaena decurrens</i>	12087
<i>Sclerolaena diacantha</i>	12079
<i>Sclerolaena intricata</i>	12044, 12278
<i>Sclerolaena lanicuspis</i>	12021, 12074, 12116
<i>Sclerolaena longicuspis</i>	11964
<i>Sclerolaena parallelicuspis</i>	11748, 11987, 12102
<i>Sclerolaena ventricosa</i>	12007, 12115
<i>Senecio lanibracteus</i>	12091
? <i>Senecio glossanthus</i>	12053
<i>Senecio</i> sp.	12099
<i>Senna artemisioides</i> ssp. <i>coriacea</i>	12071, 12272
<i>Senna artemisioides</i>	12277
<i>Senna artemisioides</i> ssp. <i>alicia</i>	12076
<i>Senna artemisioides</i> ssp. <i>artemisioides</i>	11995, 12294
<i>Senna artemisioides</i> ssp. <i>coriacea</i>	12050, 12110, 12275
<i>Senna artemisioides</i> ssp. <i>filifolia</i>	12113
<i>Senna artemisioides</i> ssp. <i>helmsii</i>	12072, 12100
<i>Senna artemisioides</i> ssp. <i>oligophylla</i>	12121, 12276
<i>Senna artemisioides</i> ssp. <i>petiolaris</i>	12078, 12109
<i>Senna artemisioides</i> ssp. <i>sturtii</i>	12075, 12080, 12101, 12271, 12286, 12296
<i>Senna phyllodinea</i>	12033, 12123
<i>Sida fibulifera</i>	12046, 12051, 12118
<i>Sida petrophila</i>	11971
<i>Sida trichopoda</i>	12083
* <i>Sisymbrium erysimoides</i>	11978
<i>Solanum chenopodium</i>	12092, 12280, 12289
<i>Solanum esuriale</i>	11774
<i>Solanum quadriloculatum</i>	11973, 12061

Beverley Uranium Mine Four Mile Baseline Vegetation Survey

Species	Collection Number(s) (F.J. Badman)
<i>Solanum sturtianum</i>	11968
* <i>Sonchus oleraceus</i>	12093
* <i>Spergularia marina</i>	11777
<i>Stenopetalum lineare</i>	11750, 12103
<i>Streptoglossa adscendens</i>	11400, 12039
<i>Swainsona oligophylla</i>	11752, 11759, 11767
<i>Swainsona phacoides</i>	11761
<i>Trachymene glaucifolia</i>	11983
<i>Tragus australianus</i>	12013
<i>Trianthema triquetra</i>	12126
<i>Trichanthodium skirrophorum</i>	11993
<i>Trichodesma zeylanicum</i>	11994, 12068
<i>Triodia irritans</i>	11988, 12281
<i>Tripogon loliiformis</i>	12077
<i>Zygophyllum ammophilum</i>	12023

Appendix C: Plant List for the Beverley Uranium Mine Site and Adjacent Areas

Sources: Williams (1979), Fatchen Environmental (2001, 2002), Badman (2006a), annual vegetation survey data, April 2007 Four Mile baseline survey.

Family/Species/genus	Common Name
ACANTHACEAE	
<i>Rostellularia adscendens</i> var. <i>pogonanthera</i>	Pink Tongues
AIZOACEAE	
<i>Glinus lotoides</i>	Hairy Carpet-weed
<i>Gunniopsis quadrifida</i>	Sturt's Pigface
<i>Trianthema triquetra</i>	Red Spinach
AMARANTHACEAE	
<i>Amaranthus grandiflorus</i>	Large-flower Amaranth
<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	Pink Mulla Mulla
<i>Ptilotus obovatus</i> var. <i>obovatus</i>	Silver Mulla Mulla
ASCLEPIADACEAE	
<i>Cynanchum floribundum</i>	Desert Cynanchum
<i>Rhyncharhena linearis</i>	Bush Bean
<i>Sarcostemma viminalis</i> ssp. <i>australe</i>	Caustic Bush
BORAGINACEAE	
<i>Heliotropium asperrimum</i>	Rough Heliotrope
<i>Heliotropium cunninghamii</i>	Bushy Heliotrope
* <i>Heliotropium curassavicum</i>	Smooth Heliotrope
<i>Omphalolappula concava</i>	Burr Stickseed
<i>Trichodesma zeylanicum</i>	Camel Bush
CAMPANULACEAE	
<i>Isotoma petraea</i>	Rock Isotome
<i>Wahlenbergia communis</i>	Tufted Bluebell
CAPPARACEAE	
<i>Capparis mitchellii</i>	Native Orange
CARYOPHYLLACEAE	
<i>Spergularia marina</i>	Salt Sand-spurrey
CASUARINACEAE	
<i>Casuarina pauper</i>	Black Oak
CHENOPODIACEAE	
<i>Atriplex angulata</i>	Fan Saltbush
<i>Atriplex holocarpa</i>	Pop Saltbush
<i>Atriplex lindleyi</i>	Balduo
<i>Atriplex lindleyi</i> ssp. <i>inflata</i>	Corky Saltbush
<i>Atriplex nummularia</i>	Old-man Saltbush
<i>Atriplex spongiosa</i>	Pop Saltbush
<i>Atriplex velutinella</i>	Sandhill Saltbush
<i>Atriplex vesicaria</i>	Bladder Saltbush

Family/Species/genus	Common Name
<i>Chenopodium cristatum</i>	Crested Goosefoot
<i>Chenopodium desertorum</i>	Desert Goosefoot
* <i>Chenopodium murale</i>	Nettle-leaf Goosefoot
<i>Chenopodium pumilio</i>	Clammy Goosefoot
<i>Dissocarpus biflorus</i> var. <i>biflorus</i>	Two-horn Saltbush
<i>Dissocarpus paradoxus</i>	Ball Bindyi
<i>Einadia nutans</i>	Climbing Saltbush
<i>Enchylaena tomentosa</i> var. <i>tomentosa</i>	Ruby Saltbush
<i>Eriochiton sclerolaenoides</i>	Woolly-fruit Bluebush
<i>Maireana aphylla</i>	Cotton-bush
<i>Maireana astrotricha</i>	Low Bluebush
<i>Maireana brevifolia</i>	Short-leaf Bluebush
<i>Maireana campanulata</i>	Bell-fruit Bluebush
<i>Maireana ciliata</i>	Hairy Fissure-plant
<i>Maireana coronata</i>	Crown Fissure-plant
<i>Maireana georgei</i>	Satiny Bluebush
<i>Maireana pyramidata</i>	Black Bluebush
<i>Malacocera albolanata</i>	Woolly Soft-horns
<i>Malacocera tricornis</i>	Goat-head Soft-horns
<i>Neobassia proceriflora</i>	Desert Glasswort
<i>Osteocarpum acropterum</i> var. <i>acropterum</i>	Tuberculate Bonefruit
<i>Rhagodia spinescens</i>	Spiny Saltbush
<i>Salsola kali</i>	Buckbush
<i>Sclerolaena bicornis</i>	Goat-head Bindyi
<i>Sclerolaena brachyptera</i>	Short-wing Bindyi
<i>Sclerolaena cuneata</i>	Tangled Bindyi
<i>Sclerolaena decurrens</i>	Green Bindyi
<i>Sclerolaena diacantha</i>	Grey Bindyi
<i>Sclerolaena divaricata</i>	Tangled Bindyi
<i>Sclerolaena intricata</i>	Tangled Bindyi
<i>Sclerolaena lanicuspis</i>	Spinach Bindyi
<i>Sclerolaena limbata</i>	Pearl Bindyi
<i>Sclerolaena longicuspis</i>	Long-spine Bindyi
<i>Sclerolaena obliquicuspis</i>	Oblique-spined Bindyi
<i>Sclerolaena parallelicuspis</i>	Western Bindyi
<i>Sclerolaena patenticuspis</i>	Spear-fruit Bindyi
<i>Sclerolaena ventricosa</i>	Salt Bindyi
COMPOSITAE	
<i>Actinobole uliginosum</i>	Flannel Cudweed
<i>Brachyscome ciliaris</i> var. <i>lanuginosa</i>	Woolly Variable Daisy
<i>Brachyscome lineariloba</i>	Hard-head Daisy
<i>Calotis cymbacantha</i>	Showy Burr-daisy
<i>Calotis hispidula</i>	Hairy Burr-daisy
<i>Calotis latiuscula</i>	Leafy Burr-daisy
<i>Calotis</i> sp.	Burr-daisy
* <i>Centaurea melitensis</i>	Malta Thistle
* <i>Centaurea solstitialis</i>	St Barnaby's Thistle
<i>Chrysocephalum apiculatum</i>	Common Everlasting
<i>Craspedia</i> sp.	
<i>Dichromochlamys dentatifolia</i>	
<i>Flaveria australasica</i>	Yellow Twin-stem
<i>Glossocardia bidens</i>	Native Cobbler's-pegs
<i>Gnephosis arachnoidea</i>	Spidery Button-flower

Family/Species/genus	Common Name
<i>Gnephosis eriocarpa</i>	Native Camomile
<i>Isoetopsis graminifolia</i>	Grass Cushion
<i>Ixiochlamys</i> sp.	
* <i>Lactuca serriola</i>	Prickly Lettuce
<i>Leiocarpa leptolepis</i>	Pale Plover-daisy
<i>Minuria cunninghamii</i>	Bush Minuria
<i>Minuria denticulata</i>	Woolly Minuria
<i>Minuria leptophylla</i>	Minnie Daisy
<i>Pluchea dentex</i>	Bowl Daisy
<i>Pluchea rubelliflora</i>	
<i>Pseudognaphalium luteoalbum</i>	Jersey Cudweed
<i>Pterocaulon sphacelatum</i>	Apple-bush
<i>Rhodanthe floribunda</i>	White Everlasting
<i>Rhodanthe microglossa</i>	Clustered Everlasting
<i>Rhodanthe moschata</i>	Musk Daisy
<i>Rhodanthe pygmaea</i>	Pigmy Daisy
<i>Rhodanthe stricta</i>	Slender Everlasting
<i>Rhodanthe uniflora</i>	Woolly Daisy
<i>Senecio glossanthus</i>	Annual Groundsel
<i>Senecio lanibracteus</i>	Inland Shrubby Groundsel
<i>Senecio magnificus</i>	Showy Groundsel
<i>Senecio odoratus</i>	Scented Groundsel
<i>Senecio quadridentatus</i>	Cotton Groundsel
* <i>Sonchus oleraceus</i>	Common Sow-thistle
<i>Streptoglossa adscendens</i>	Desert Daisy
<i>Trichanthodium skirrophorum</i>	Woolly Yellow-heads
<i>Vittadinia eremaea</i>	Desert New Holland Daisy
CONVOLVULACEAE	
<i>Convolvulus erubescens</i> complex	
<i>Convolvulus erubescens/remotus</i>	Native Bindweed
CRUCIFERAE	
<i>Arabidella glaucescens</i>	
<i>Arabidella nasturtium</i>	Yellow Cress
<i>Arabidella trisecta</i>	Shrubby Cress
<i>Lepidium oxytrichum</i>	Green Peppercress
<i>Lepidium phlebopetalum</i>	Veined Peppercress
<i>Menkea australis</i>	Fairy Spectacles
* <i>Sisymbrium erysimoides</i>	Smooth Mustard
<i>Stenopetalum lineare</i>	Narrow Thread-petal
CUCURBITACEAE	
* <i>Citrullus colocynthis</i>	Colocynth
* <i>Cucumis myriocarpus</i>	Paddy Melon
<i>Mukia maderaspatana</i>	Snake Vine
CUPRESSACEAE	
<i>Callitris glaucophylla</i>	White Cypress Pine
CYPERACEAE	
<i>Cyperus gymnocaulos</i>	Spiny Flat-sedge
<i>Cyperus</i> sp.	Flat-sedge
<i>Schoenoplectus litoralis</i>	Shore Club-rush

Family/Species/genus	Common Name
EUPHORBIACEAE	
<i>Chamaesyce drummondii</i>	
<i>Euphorbia australis</i>	Hairy Caustic Weed
<i>Euphorbia stevenii</i>	Bottletree Spurge
<i>Euphorbia tannensis</i> ssp. <i>eremophila</i>	Desert Spurge
<i>Phyllanthus lacunarius</i>	Lagoon Spurge
* <i>Ricinus communis</i>	Castor Oil Plant
FRANKENIACEAE	
<i>Frankenia serpyllifolia</i>	Thyme Sea-heath
GENTIANACEAE	
* <i>Centaurium erythraea</i>	Common Centaury
GERANIACEAE	
<i>Erodium carolinianum</i>	Clammy Heron's-bill
<i>Erodium</i> sp.	Heron's-bill/Crowfoot
GOODENIACEAE	
<i>Goodenia lunata</i>	Stiff Goodenia
<i>Goodenia</i> sp.	Goodenia
<i>Scaevola spinescens</i>	Spiny Fanflower
GRAMINEAE	
<i>Aristida contorta</i>	Curly Wire-grass
<i>Aristida latifolia</i>	Feather-top Wire-grass
<i>Aristida nitidula</i>	Brush Three-awn
<i>Astrebla lappacea</i>	Curly Mitchell-grass
<i>Astrebla pectinata</i>	Barley Mitchell-grass
<i>Austrostipa</i> sp.	Spear-grass
<i>Brachiaria gilesii</i>	Hairy-edged Arm-grass
* <i>Cenchrus ciliaris</i>	Buffel Grass
<i>Chloris pectinata</i>	Comb Windmill Grass
<i>Cymbopogon ambiguus</i>	Lemon-grass
* <i>Cynodon dactylon</i> var. <i>dactylon</i>	Couch
<i>Dactyloctenium radulans</i>	Button-grass
<i>Dichanthium sericeum</i> ssp. <i>sericeum</i>	Silky Blue-grass
<i>Digitaria ammophila</i>	Spider Grass
<i>Digitaria brownii</i>	Cotton Panic-grass
<i>Enneapogon avenaceus</i>	Common Bottle-washers
<i>Enneapogon caeruleus</i> var. <i>caeruleus</i>	Blue Bottle-washers
<i>Enneapogon polyphyllus</i>	Leafy Bottle-washers
<i>Enteropogon</i> sp.	Umbrella Grass
<i>Eragrostis australasica</i>	Cane-grass
<i>Eragrostis dielsii</i> var. <i>dielsii</i>	Mulka
<i>Eragrostis eriopoda</i>	Woollybutt
<i>Eragrostis setifolia</i>	Bristly Love-grass
<i>Eragrostis xerophila</i>	Knotty-butt Neverfail
<i>Eulalia aurea</i>	Silky Brown-top
<i>Leptochloa digitata</i>	Umbrella Cane-grass
<i>Leptochloa fusca</i> ssp. <i>muelleri</i>	Brown Beetle-grass
<i>Panicum decompositum</i> var. <i>decompositum</i>	Native Millet
* <i>Schismus barbatus</i>	Arabian Grass

Family/Species/genus	Common Name
<i>Setaria constricta</i>	Knotty-butt Paspalidium
<i>Sporobolus actinocladius</i>	Ray Grass
<i>Themeda triandra</i>	Kangaroo Grass
<i>Tragus australianus</i>	Small Burr-grass
<i>Triodia irritans complex</i>	Spinifex
<i>Tripogon loliiformis</i>	Five-minute Grass
<i>Triraphis mollis</i>	Purple Plume Grass
HALORAGACEAE	
<i>Haloragis aspera</i>	Rough Raspwort
LABIATAE	
<i>Teucrium racemosum</i>	Grey Germander
LEGUMINOSAE	
<i>Acacia aneura</i>	
<i>Acacia aneura</i> var. <i>tenuis</i>	Mulga
<i>Acacia ligulata</i>	Umbrella Bush
<i>Acacia oswaldii</i>	Umbrella Wattle
<i>Acacia tetragonophylla</i>	Dead Finish
<i>Acacia victoriae</i> ssp. <i>victoriae</i>	Elegant Wattle
<i>Crotalaria eremaea</i> ssp. <i>eremaea</i>	Downy Loose-flowered Rattle-pod
<i>Cullen australasicum</i>	Tall Scurf-pea
<i>Cullen</i> sp.	Scurf-pea
<i>Glycine canescens</i>	Silky Glycine
<i>Goodia medicaginea</i>	Western Golden-tip
<i>Indigofera leucotricha</i>	Silver Indigo
<i>Isotropis wheeleri</i>	Wheeler's Lamb-poison
<i>Lotus cruentus</i>	Red-flower Lotus
<i>Senna artemisioides</i> ssp. <i>alicia</i>	Desert Senna
<i>Senna artemisioides</i> ssp. <i>artemisioides</i>	Silver Senna
<i>Senna artemisioides</i> ssp. <i>coriacea</i>	Broad-leaf Desert Senna
<i>Senna artemisioides</i> ssp. <i>filifolia</i>	Fine-leaf Desert Senna
<i>Senna artemisioides</i> ssp. <i>helmsii</i>	Blunt-leaf Senna
<i>Senna artemisioides</i> ssp. <i>oligophylla</i>	Limestone Senna
<i>Senna artemisioides</i> ssp. <i>petiolaris</i>	
<i>Senna artemisioides</i> ssp. <i>sturtii</i>	Grey Senna
<i>Senna artemisioides</i> ssp. <i>zygophylla</i>	Twin-leaf Desert Senna
<i>Senna phyllodinea</i>	
<i>Swainsona oligophylla</i>	
<i>Swainsona phacoides</i>	Dwarf Swainson-pea
<i>Swainsona swainsonioides</i>	Downy Swainson-pea
<i>Templetonia egena</i>	Broombush Templetonia
<i>Trigonella suavissima</i>	Sweet Fenugreek
LILIACEAE	
<i>Bulbine alata</i>	Winged Bulbine-lily
LORANTHACEAE	
<i>Amyema preissii</i>	Wire-leaf Mistletoe
<i>Lysiana exocarpi</i> ssp. <i>exocarpi</i>	Harlequin Mistletoe
MALVACEAE	
<i>Abutilon halophilum</i>	Plains Lantern-bush

Family/Species/genus	Common Name
<i>Abutilon leucopetalum</i>	Desert Lantern-bush
<i>Gossypium sturtianum</i> var. <i>sturtianum</i>	Sturt's Desert Rose
<i>Hibiscus brachysiphonius</i>	Low Hibiscus
<i>Hibiscus krichauffianus</i>	Velvet-leaf Hibiscus
<i>Malva behriana</i>	Australian Hollyhock
<i>Malvastrum americanum</i> var. <i>americanum</i>	Malvastrum
<i>Sida corrugata</i>	Corrugated Sida
<i>Sida fibulifera</i>	Pin Sida
<i>Sida intricata</i>	Twiggy Sida
<i>Sida petrophila</i>	Rock Sida
<i>Sida phaeotricha</i>	Hill Sida
<i>Sida trichopoda</i>	High Sida
MYOPORACEAE	
<i>Eremophila duttonii</i>	Harlequin Emubush
<i>Eremophila freelingii</i>	Rock Emubush
<i>Eremophila latrobei</i> ssp. <i>glabra</i>	Crimson Emubush
<i>Eremophila longifolia</i>	Weeping Emubush
<i>Eremophila sturtii</i>	Turpentine Bush
<i>Myoporum montanum</i>	Native Myrtle
MYRTACEAE	
<i>Eucalyptus camaldulensis</i> var. <i>obtusa</i>	Northern River Red Gum
<i>Eucalyptus gillii</i>	Curly Mallee
<i>Eucalyptus intertexta</i>	Gum-barked Coolibah
<i>Melaleuca dissitiflora</i>	
<i>Melaleuca glomerata</i>	Inland Paper-bark
NYCTAGINACEAE	
<i>Boerhavia dominii</i>	Tar-vine
<i>Commicarpus australis</i>	Pink Gum-fruit
PITTOSPORACEAE	
<i>Pittosporum angustifolium</i>	Native Apricot
PLANTAGINACEAE	
<i>Plantago drummondii</i>	Dark Plantain
POLYGONACEAE	
* <i>Acetosa vesicaria</i>	Rosy Dock
<i>Muehlenbeckia florulenta</i>	Lignum
PORTULACACEAE	
<i>Portulaca oleracea</i>	Common Purslane
PRIMULACEAE	
* <i>Anagallis arvensis</i>	Pimpernel
PROTEACEAE	
<i>Hakea ednieana</i>	Flinders Ranges Corkwood
<i>Hakea leucoptera</i> ssp. <i>leucoptera</i>	Silver Needlewood
SANTALACEAE	
<i>Santalum lanceolatum</i>	Plumbush

Family/Species/genus	Common Name
SAPINDACEAE	
<i>Alectryon oleifolius</i> ssp. <i>canescens</i>	Bullock Bush
<i>Dodonaea viscosa</i> ssp. <i>angustissima</i>	Narrow-leaf Hop-bush
SOLANACEAE	
* <i>Datura leichhardtii</i>	Native Thorn-apple
<i>Nicotiana simulans</i>	Native Tobacco
<i>Nicotiana velutina</i>	Velvet Tobacco
<i>Solanum chenopodium</i>	Goosefoot Potato-bush
<i>Solanum coactiliferum</i>	Tomato-bush
<i>Solanum ellipticum</i>	Velvet Potato-bush
<i>Solanum esuriale</i>	Quena
* <i>Solanum nigrum</i>	Black Nightshade
<i>Solanum quadriloculatum</i>	Plains Nightshade
<i>Solanum sturtianum</i>	Sturt's Nightshade
THYMELAEACEAE	
<i>Pimelea microcephala</i> ssp. <i>microcephala</i>	Shrubby Riceflower
<i>Pimelea simplex</i> ssp. <i>simplex</i>	Desert Riceflower
<i>Pimelea trichostachya</i>	Spiked Riceflower
TYPHACEAE	
<i>Typha domingensis</i>	Narrow-leaf Bulrush
UMBELLIFERAE	
<i>Daucus glochidiatus</i>	Native Carrot
<i>Trachymene glaucifolia</i>	Blue Parsnip
ZYGOPHYLLACEAE	
* <i>Tribulus terrestris</i>	Caltrop
<i>Zygophyllum ammophilum</i>	Sand Twinleaf
<i>Zygophyllum apiculatum</i>	Pointed Twinleaf
<i>Zygophyllum prismatothecum</i>	Square-fruit Twinleaf

Appendix D: Main species in each vegetation group

Numbers in the columns are the sum of the scores for each species that were used for data analysis (Table 3) divided by the number of sites in that group. Only species with a score higher than 1 in at least one group at one monitoring event are shown.

Species	2006			2007			Both Years		
	Gp 1	Gp 2	Gp 3	Gp 1	Gp 2	Gp 3	Gp 1	Gp 2	Gp 3
<i>Abutilon leucopetalum</i>	0.60	0.75		1.00			0.78	0.47	
<i>Acacia aneura</i>		0.17			1.00			0.47	
<i>Acacia ligulata</i>	1.20			0.50			0.89		
<i>Acacia tetragonophylla</i>	0.60	1.00		1.50	3.14		1.00	1.79	
<i>Acacia victoriae</i>	0.40	1.83		0.50	0.57		0.44	0.89	
<i>Acetosa vesicaria</i>	2.00			0.75			1.44		
<i>Aristida nitidula</i>	1.40			1.50	0.43		1.44	0.16	
<i>Astrebla pectinata</i>	0.20	1.17	2.43	0.25	0.57	1.64	0.22	0.95	2.53
<i>Atriplex angulata</i>	0.40	1.33	1.43				0.22	0.84	0.63
<i>Boerhavia dominii</i>	0.80		0.29			1.00	0.44		0.16
<i>Calotis hispidula</i>	0.20	0.42	0.57	0.50	0.29	2.00	0.33	0.37	1.42
<i>Daucus glochidiatus</i>	0.50	0.57	0.48			1.27		0.32	1.53
<i>Dissocarpus paradoxus</i>	0.40	0.50	1.14	0.50		0.18	0.44	0.32	0.63
<i>Enchylaena tomentosa</i>	2.20	1.33		1.50	2.00		1.89	1.58	
<i>Enteropogon ramosus</i>	2.60	1.42		0.75	0.35		1.78	1.53	
<i>Eremophila duttonii</i>		1.00			1.71	1.00		1.26	0.53
<i>Eremophila freelingii</i>	0.40	1.58		1.50	3.86		0.89	2.42	
<i>Eucalyptus camaldulensis</i>	2.40	0.33		1.50	0.57		2.00	0.42	
<i>Euphorbia stevenii</i>		0.17	1.57			1.36		0.15	1.47
<i>Gnephosis arachnoidea</i>	0.40	1.58	0.57		1.14		0.22	1.42	0.22
<i>Lysiana exocarpi</i>	1.40	0.67		0.25	0.86		0.89	0.74	
<i>Maireana aphylla</i>		1.50	0.43		0.43			1.15	0.22
<i>Malacocera tricornis</i>		0.50	1.00					0.32	0.37
<i>Melaleuca dissitiflora</i>		0.75		0.75			0.33	0.47	
<i>Melaleuca glomerata</i>	4.20	0.50		4.25	1.14		4.22	0.74	
<i>Neobassia proceriflora</i>	0.60	1.17	1.43		0.14	1.82	0.33	0.79	1.68
<i>Nicotiana velutina</i>	1.60	0.25				1.18	0.89	0.16	0.69
<i>Pimelea simplex</i>		0.67	1.43		0.29	0.55		0.53	0.95
<i>Ptilotus obovatus</i>	0.40	1.42		1.25	2.29		0.78	1.74	
<i>Rhagodia spinescens</i>	1.60	3.00		1.50	1.14		1.56	2.32	
<i>Rhodanthe floribunda</i>		0.33	0.57			2.00		0.22	0.95
<i>Salsola kali</i>	2.20	1.83	2.14	1.00	0.57	1.18	1.67	1.37	1.58
<i>Santalum lanceolatum</i>		1.75		0.50	1.71		0.22	1.74	
<i>Sclerolaena brachyptera</i>		1.83	2.43		0.29	0.27		0.79	1.22
<i>Sclerolaena cuneata</i>	0.40	0.83		1.50	1.57	0.18	0.89	1.15	0.15
<i>Sclerolaena diacantha</i>	0.60	0.92		2.00			1.22	0.58	
<i>Sclerolaena divaricata</i>	0.60	0.58	2.86		0.71	2.00	0.33	0.63	2.37
<i>Sclerolaena intricata</i>			1.14		0.29	1.82		0.15	1.47
<i>Sclerolaena longicuspis</i>	0.60	0.83	0.86	0.25	2.57	2.00	0.44	1.47	1.15
<i>Sclerolaena ventricosa</i>	0.40	1.67	3.00		0.57	1.18	0.22	1.26	2.00
<i>Senecio glossanthus</i>					0.14	1.00		<0.1	0.58
<i>Senna artemisioides</i> ssp. <i>coriacea</i>		0.75	0.14	0.25	1.00		0.11	0.84	0.53
<i>Senna artemisioides</i> ssp. <i>sturtii</i>			0.42		1.57			0.84	

Beverley Uranium Mine Four Mile Baseline Vegetation Survey

Species	2006			2007			Both Years		
	Gp 1	Gp 2	Gp 3	Gp 1	Gp 2	Gp 3	Gp 1	Gp 2	Gp 3
<i>Sida petrophila</i>	0.60	0.25		1.25	0.86		0.89	0.47	
<i>Sisymbrium erysimoides</i>	2.20	0.83		2.00	0.86	1.00	2.11	0.84	0.53
<i>Solanum chenopodium</i>	0.60	0.17		1.00	1.00		0.78	0.47	
<i>Solanum ellipticum</i>	1.00	0.50		1.25	0.86		1.11	0.63	
<i>Triodia irritans</i>	0.40			1.50			0.89		

Appendix E: Site Photographs



Plate 1: DEH Photopoint No 11106 (Site FM01)



Plate 2: DEH Photopoint No 11107 (Site FM02)



Plate 3: DEH Photopoint No 11108 (Site FM03)



Plate 4: DEH Photopoint No 11109 (Site FM04)



Plate 5: DEH Photopoint No 11110 (Site FM05)



Plate 6: DEH Photopoint No 11111 (Site FM06)



Plate 7: DEH Photopoint No 11112 (Site FM07)



Plate 8: DEH Photopoint No 11113 (Site FM08)



Plate 9: DEH Photopoint No 1114 (Site FM09)



Plate 10: DEH Photopoint No 1115 (Site FM10)



Plate 11: DEH Photopoint No 11116 (Site FM11)



Plate 12: DEH Photopoint No 11117 (Site FM12)



Plate 13: DEH Photopoint No 11118 (Site FM13)



Plate 14: DEH Photopoint No 11119 (Site FM14)



Plate 15: DEH Photopoint No 11120 (Site FM15)



Plate 16: DEH Photopoint No 11121 (Site FM16)



Plate 17: DEH Photopoint No 11122 (Site FM17)



Plate 18: DEH Photopoint No 11123 (Site FM18)



Plate 19: DEH Photopoint No 11124 (Site FM19)



Plate 20: DEH Photopoint No 11125 (Site FM20)



Plate 21: DEH Photopoint No 11126 (Site FM21)



Plate 22: DEH Photopoint No 11127 (Site FM22)