2023 CVO Rehabilitation Monitoring Report

for
Newcrest Mining Limited

Prepared by
DnA Environmental
May 2023

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Signed: 

Dr Donna Johnston
Restoration Ecologist
PhD, BAppSc (Hons) MEIANZ

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DnA Environmental
417 Mandurama Rd
Mandurama, NSW 2792

Ph/Fax: (02) 63 675 251
Mobile: 0408 221 922
donna@dnaenviro.com.au
ABN 19 607 392 634

Acknowledgements

Field work and associated reports have been undertaken by Dr Donna Johnston and Andrew Johnston from DnA Environmental. Since 2021, field surveys were undertaken by Andrew Johnston (DnA Environmental) and Ray Mjadwesch (Mjadwesch Environmental Service Support). Reports continue to be prepared by Dr Donna Johnston and Andrew Johnston.

Executive summary

Cadia Valley Operations (CVO) is one of Australia's largest gold mining operations and is 100 per cent owned by Newcrest. It is located approximately 25 kilometres from the city of Orange in central west New South Wales. Rehabilitation activities at the Cadia Valley Operations aim to generate safe and sustainable landforms at the mine site and on CHPL-owned land.

Final land use goals are broadly based on the pre-existing land uses within the Cadiangullong Creek Valley, with these being agriculture (predominantly grazing) with scattered paddock trees and woodland conservation. The pre-existing landform of undulating hills would be replicated through mine rehabilitation landforms so that these landforms are typical of the surrounding topography. Specific future post mining land use goals include:

- High quality agriculture (grazing) areas where there is a low risk of erosion, degradation and damage by grazing livestock using a species composition and carrying capacity similar to the surrounding agricultural areas.
- Woodland (conservation) to establish similar vegetation communities to the surrounding remnant woodlands and to increase the extent and connectivity of woodlands in the local area.

Other post-mining rehabilitation objectives will allow for future needs of the community through retaining key infrastructure where appropriate (pending future negotiations with regulatory bodies / community. Progressive rehabilitation of mining disturbed lands would be undertaken throughout the life of the Project, where practicable.

The 2023 rehabilitation monitoring program was undertaken by DnA Environmental on behalf of Newcrest Mining Limited, Cadia Valley Operations (CVO). The purpose of this report is to present the results of the ongoing annual rehabilitation monitoring program that first commenced in 2008. The monitoring program compares the progress of rehabilitated landforms towards fulfilling long-term land use objectives. This is done by comparing a selection of ecological performance targets or completion criteria against areas of remnant vegetation not impacted by mining activities that are representative of the final land use and vegetation assemblage (reference sites). It also aims to comply and be consistent with conditions specified within a range of approval documents and associated Management Plans and align with the regulatory guidelines whilst addressing the range of technical issues associated with mine rehabilitation.

The CVO monitoring project aimed to establish clearly defined, repeatable and consistent methodologies for monitoring changes in various aspects of ecosystem function, succession and long-term sustainability. Part of the process includes:

- Establishing a range of relevant reference sites to compare and track the progress and inherent ecosystem function of rehabilitation areas;
- Selecting a range of suitable reference sites that reflect the desired final land use, biodiversity targets, historical disturbances and local community expectations; and
- Undertaking a monitoring program that provides simple but informative and reliable information that indicates positive recovery trends or rapid detection of rehabilitation failure.

Previously, the process for monitoring and managing progression towards successful rehabilitation outcomes that are quantified by completion criteria which are applicable to each of the similar land management units within the mine site was detailed in the ESG3 MOP guidelines. The ESG3 MOP was used by the Department of Planning and Environment (DPE) to monitor the progress of mining and rehabilitation activities across the life of a mine. The Resources Regulator have since improved compliance and reporting requirements for rehabilitation which commenced on 2 July 2021.These new rehabilitation conditions replace existing rehabilitation and environmental management conditions on current leases. Subsequently previous MOPs have been replaced by the Rehabilitation Management Plan and associated Annual Rehabilitation Report and Forward Program for large

mines Codes of Practice. Many of the previous ESG3 guidelines are still however relevant to the current rehabilitation monitoring and reporting protocols. Rehabilitation Phases where the post mining land use is a native plant ecosystem according to these guidelines include:

1. Active Mining;
2. Decommissioning;
3. Landform Establishment;
4. Growth Medium Development;
5. Ecosystem and Land Use Establishment;
6. Ecosystem and Land Use Development; and
7. Rehabilitation Completion (sign off).

Reference sites are used to provide a range of ecological performance indicators or completion criteria against which rehabilitation progress can be compared and provide the ability to monitor ecological indicators of an existing natural ecosystem and changes in that ecosystem as a result of climatic variations and disturbance events (such as drought, fire, flood etc.). Reference sites are used as a benchmark for the final rehabilitated landscape and provide a time series record of ecosystem change and development. Since its inception the CVO monitoring program has adopted this process of comparing rehabilitation areas against reference sites in logical successional phases and has adapted the methodology with the various revisions of the Departments regulatory guidelines.

CVO Rehabilitation monitoring program

At CVO, the agreed post mining land use aims to establish a combination of grazing land and endemic woodland on final landforms and add value to the current vegetation corridor program of CVO farmland. Three main vegetation communities form the basis of the rehabilitation objectives and these include woodland (open woodland with grassy understorey), riparian woodlands and perennial pastures (exotic grassland suitable for grazing). Replicated sites representing each of these main community types (reference sites) were established to provide a range of ecological performance targets or completion criteria. Reference sites were spread out where possible to maximise the spatial distribution and subsequent variations in community composition across the local landscape and all are now situated on Cadia owned land.

At CVO, rehabilitation has been progressive since the inception of the monitoring program and subsequently the number of rehabilitation monitoring sites has typically changed over the years. A review of the monitoring program has been undertaken on numerous occasions prompting the need to simplify and refine the methodology without losing the heterogeneity of the local ecology and to align more adequately with the various changes in the various reporting guidelines. Major rehabilitation was undertaken on the main Waste Emplacements in 2008 (South Dump) and in 2014/2015 and 2018 (North and South Dump). Subsequently there have been some changes in the quantity, locations and frequency of monitoring of the rehabilitation sites.

Some of the older more stable rehabilitation sites are monitored on a three-year rotation, with these last being assessed in 2022 and some sites have been lost due to the recovery of benign waste rock material. This year the monitoring program included monitoring of three woodland reference sites and five rehabilitation sites on the South Dump and three rehabilitation sites on the North Dump.

The monitoring methodology is consistent with that used in previous years and includes a combination of Landscape Function Analyses (LFA) and an assessment of ecosystem characteristics using an adaptation of methodologies derived by the Biometric Assessment Method (BAM). Soil analyses and permanent transects and photo-points have been established to record changes in these attributes over time.

Data obtained from replicated reference sites are used to provide upper and lower ecological performance indicator limits or "completion criteria targets". Primary completion performance indicators are those chosen as completion criteria targets and rehabilitation sites should equal, exceed, or show positive trends towards those attributes of the reference sites. When these primary completion performance indicators have been met or are trending in the right direction, the sites should therefore theoretically be eligible for closure sign off. The range values of each ecological performance indicator are adapted annually to reflect climatic variations and local disturbance events.

Ecological monitoring has been undertaken in autumn in all monitoring years. Field work and associated reports have been undertaken by Dr Donna Johnston and Andrew Johnston from DnA Environmental. Since 2021, field surveys have been undertaken by Andrew Johnston (DnA Environmental) and Ray Mjadwesch (Mjadwesch Environmental Service Support) and this year were undertaken during 3rd - 6th April. Reports continue to be prepared by Dr Donna Johnston and Andrew Johnston.

Rainfall

The long-term annual average rainfall recorded at Orange Airport is 879 mm however below average annual rainfall was experienced during 2014 – 2019, with the exception of 2016 which provided temporary relief from the prolonged drought. The lowest annual rainfall was recorded for three consecutive years during 2017 to 2019 which was one of the worst droughts on record.

Since 2020, improved rainfall conditions have occurred with several extreme and unprecedented flood events occurring across the state with total annual rainfalls of 963 mm and 1076 mm in 2021 and 2022 respectively. From December 2022 to February 2023 rainfall was well below average, with these hot dry conditions followed by two months of above average monthly rainfall with 147 mm during the month of March alone. For the year to April 2023, 350 mm of rain was recorded compared to an average monthly total for the same period of 264mm.

Progress of the woodland rehabilitation sites

During the drought, there tended to be a declining trend in ecological function as a result of the prolonged dry seasonal conditions and simultaneous increase in grazing and disturbance by animals. Subsequently there was a decline in many performance indicators with these also being reflected in the range of woodland reference sites. Over the last few years, improved seasonal conditions have resulted in an increase in the diversity and abundance of the ground covers in most of the monitoring sites, therefore increasing the overall ecological function in the monitoring sites. At some sites such as South Dump 04, 07, 08 and 10 there continued to be small bare patches which have been slow to establish and disturbance by herbivores continued to cause localised bare patches. This year, there has been further overall improvement in the rehabilitation areas, however stability continued to be low in South Dump 05 and 07 and North Dump 03, and all rehabilitation sites had low infiltration and nutrient recycling capacity in comparison to the woodland reference sites. North Dump 02 was the most functional rehabilitation sites, while South Dump 07 was the least functional rehabilitation area.

There was an appropriate density of endemic woodland trees and mature shrubs (>5 cm dbh) in four of the eight rehabilitation sites compared to the reference sites this year. The majority of the tree populations were mature acacias, however, there were high rates of mortality in some sites. There was also an absence of eucalypts in South Dump 04 and all sites on the North Dump. The rehabilitation sites were too young to contain tree hollows or mistletoe, however reproductive structures were recorded across most areas.

There has been a declining trend in shrub densities (<5cm dbh) in most rehabilitation areas as individuals grow and are then recorded in tree population data. Many however have also died as a result of drought and/or natural senescence and most were typically species of acacia or *Cassinia sifton* which presently occur in much higher

numbers than are recorded in the local woodlands. The decline in coloniser species such as acacia and cassinia is expected to occur naturally as the rehabilitation areas develop. Rehabilitation sites on the South and North Dump had a relatively high diversity of endemic shrubs and juvenile trees with 3 - 16 different species with these typically containing a proportionately high density and diversity of acacias. Sites South Dump 05 and South Dump 10 also had some exotic *Rubus fruticosus* (Blackberry) and so did RfWood01, while *Crataegus monogyna* (Hawthorn) seedlings continue to be recorded in RWood05. While eucalypt densities were somewhat limited on rehabilitation areas, sites that did not presently contain any eucalypts included South Dump 04 and all three sites on the North Dump. In the rehabilitation areas, all height classes were represented however most individuals tended to be taller than 2.0m, indicating good growth and development.

This year all rehabilitation sites had a level of perennial ground cover comparable to the woodland reference sites and while exotic plants may have been more abundant than native species in most sites, all rehabilitation sites except South Dump 10 had a cover of native plants comparable to the RfWood02 reference site this year. All sites had a total floristic diversity similar to the reference sites, except native diversity was low in South Dump 10 and there were too many exotic species in North Dump 01.

The woodland reference sites were dominated by perennial grasses *Phalaris aquatica* (Phalaris) and *Rytidosperma racemosum* (Wallaby Grass) as well as exotic annuals *Bromus diandrus* (Great Brome) and in RfWood01, *Trifolium subterraneum* (Subterraneum Clover) was also relatively abundant. The composition of ground covers in rehabilitation areas was variable, however all sites were dominated by exotic species such as those recorded in the woodland reference sites, and/or other annual grasses such as *Vulpia muralis* (Rats-tail Fescue) and *Bromus molliformis* (Soft Brome). Site South Dump 10 remained very weedy with *Silybum marianum* (Variegated Thistle) providing the most ground cover this year.

In the rehabilitation sites, most had a composition of species comparable to the reference sites, however there continued to be an absence of eucalypt trees in South Dump 04 and all three sites on the North Dump. Numerous sites also had a low diversity of grasses and reeds, while South Dump 07 had a slightly low diversity of herbs.

On the South and North Dump, minor rilling that had been recorded in previous years has declined as ground covers became more established. Minor rilling continued to be recorded in South Dump 07 and North Dump 01 however these appear to be stabilising with increasing levels of ground cover.

The results of the soils analyses indicate that the rehabilitation areas typically had soil chemistry similar to the local reference sites and/or were close to recommended agricultural guidelines, with some exceptions. Soils were typically slightly acidic to neutral, non-saline and non-sodic and most were low in organic matter and had low Cation Exchange Capacity (CEC). In South Dump 05 and 08 however, the soils were strongly acidic.

The results of the soil analyses also indicate there are numerous elements which occur at elevated levels in the rehabilitation sites, however some such as sulfur, manganese, iron, copper and silicon and were also recorded at elevated levels in one or more of the woodland reference sites, suggesting they can occur at “naturally” high levels around the local area. However, copper was recorded in particularly high concentrations in South Dump 07 and sites on the North Dump. Iron was also recorded in high concentrations in South Dump 05 and 08.

In total, six Weeds of National Significance (WONS) and Priority weeds were recorded across the woodland monitoring sites and these were scattered in limited numbers cross a range of sites. No threatened species have been identified within the range of woodland monitoring sites.

Conclusion

While no rehabilitation site yet met all primary completion criteria, many sites had been demonstrating a significant increase in ecological function up until the drought that was experienced for three consecutive years during 2017 - 2019. Since 2020, improved seasonal conditions have resulted in an increase in the diversity and abundance of the ground covers in most of the monitoring sites, therefore also increasing the overall ecological function in the rehabilitation sites. This year, the results of Landscape Function Analyses (LFA) has shown there has been further overall improvement in the rehabilitation areas, however some sites had low stability and all rehabilitation sites had low infiltration and nutrient recycling capacity in comparison to the woodland reference sites. North Dump 02 was the most functional rehabilitation sites, while South Dump 07 was the least functional rehabilitation area.

A range of introduced species common to the local agricultural area, have successfully colonised large areas of rehabilitation and are playing a particularly important role in the ecological development, function and stability of the sites. Many annual weeds have become naturalised within the local area and some of the annual ground covers were clovers or medics which can be useful pasture species. All rehabilitation sites, except South Dump 10, had a similar native cover abundance and diversity to the woodland reference site RfWood02, however future rehabilitation should focus on establishing native ground covers where possible to ensure sustainability of the woodlands in the longer-term.

The woodland rehabilitation areas were dominated by acacias, with limited occurrence of eucalypts in most areas and no eucalypts were recorded at all in sites on the North Dump. There was high variability in the density of shrubs and/or juvenile trees however there has been a significant declining trend in acacias. The ongoing decline in mature acacia densities may have implications for the rehabilitation sites to meet completion targets into the future, especially due to the absence of or low density of long-lived eucalypt species. Areas identified as requiring rehabilitation intervention on the Northern Waste Rock Dump have undergone a program of in-fill planting during May and June, to address limited eucalypt densities.

While no formal survey for fauna is undertaken by DnA Environmental, a range of wildlife have been or were observed within rehabilitation areas and this year an earthworm was found in NorthDump01. Increased habitat such as large logs, fallen trees and rock piles would further enhance habitat on rehabilitation areas and the addition of perching sites would be beneficial.

Testing of waste rock materials and topsoils prior to application on rehabilitation areas should be an ongoing part of the progressive rehabilitation programs and regularly undertaken to ensure suitable substrates are used prior to spreading onto rehabilitation areas.

Follow up surveillance and control of priority weeds and WONS will continue to be required as part of the CVO land management plans and care should be undertaken to avoid spraying of non-target species. While grazing pressure has significant declined after the drought, feral and pest animal populations will also require ongoing monitoring.

Table of Contents

1 Introduction: 2023 CVO Rehabilitation monitoring report

1.1 Background

Cadia Valley Operations (CVO) is one of Australia's largest gold mining operations and is 100 per cent owned by Newcrest Mining Limited. It is located approximately 25 kilometres from the city of Orange in central west New South Wales and is 250 kilometres west of Sydney (http://www.newcrest.com.au/our-business/operations/cadia-nsw/).

CVO comprises three mines - the Cadia East underground panel cave mine which commenced commercial production on 1 January 2013, the Ridgeway underground mine (currently in care and maintenance) and the Cadia Hill open pit mine, currently operated as a tailings storage facility (TSF), identified as the Pit TSF. Cadia produces gold doré from a gravity circuit and gold-rich copper concentrates from a flotation circuit at Cadia. The gold doré is then refined at the Perth Mint and concentrates are piped to a dewatering plant at nearby Blayney and sent by rail to Port Kembla in New South Wales for export.

1.2 CVO Post mining land use objectives

Final land use goals are broadly based on the pre-existing land uses within the Cadiangullong Creek Valley being agriculture (predominantly grazing) with scattered paddock trees and woodland conservation (Newcrest 2013a, 2013b; Newcrest Mining Limited, 2020). The pre-existing landform of undulating hills would be replicated through mine rehabilitation landforms so that these landforms generally / reasonably blend in with surrounding topography.

Specific future post mining land use goals include:

- High quality agriculture (Grazing) areas were deemed to be sustainable and low risk of erosion, degradation, damage. Similar species composition and carrying capacity to surrounding areas.
- Woodland (conservation). Increasing the amount of conserved woodland in the district for future flora and fauna protection. Replacing / replicating Endangered Ecological Communities where applicable. Similar vegetation types / composition to surrounding / local remnant vegetation.
- Allowing for future needs of the community through retaining key infrastructure where appropriate (pending future negotiations with regulatory bodies / community). Considerations may include regional water reticulation network, future industrial use of the site, landfill (within Cadia Hill Pit), roads, power assets etc.

The overall rehabilitation goal is to generate enduring land value, including both ecological value (e.g. biological diversity and other environmental values) and agricultural value (i.e. the ability to produce agricultural goods). Rehabilitation activities at Cadia aim to generate safe and sustainable landforms at the mine site, CHPL-owned land and the region as a whole, by rehabilitating mine disturbed lands to:

- add value to the current vegetation corridor programme (ecological value);
- allow for the future land use of grazing, where appropriate and sustainable (agricultural value);
- retain areas that may be important for future industry and infrastructure needs; and
- provide safe and stable landforms and minimise any adverse potential impacts so that there is no future liability for Newcrest or the community.

1.3 Rehabilitation and land management strategy

The primary objectives of rehabilitation and revegetation of post-mining disturbance areas at Cadia are summarised in the following points:

- If possible, allow for future industrial use of site infrastructure and resources.
- Create safe and stable, sustainable and productive landforms which conform to the natural topography of the Cadia area.
- Ensure there is no future or residual liability from the site (e.g. from soil or water contamination) for Newcrest or the wider community;
- Create sustainable ecological and if applicable, production (agricultural) ecosystems which are comparable to local reference / analogue sites (Mine Closure Criteria) or similar vegetation associations.
- Increase areas (compared to pre-mining) of native woodland with a long term land use of conservation to increase overall habitat availability for native fauna.
- Rigorously assess any mine disturbed areas with a future land use for agriculture / grazing to ensure it remains a sustainable land use and will not be subject to degradation (erosion).
- Incorporate 'chain of ponds' concepts into riparian system restoration.
- Protect the wider environment from potential long-term environmental impacts (e.g. impacts from Acid and Metalliferous Drainage (AMD)) via best practice design and rehabilitation.
- Consult with future user groups and other stakeholders regarding post mining land use and rehabilitation objectives.
- Control weeds and pests to meet mine closure criteria.
- Prevent, control and repair areas of erosion.
- Manage bushfire fuels and plan for emergencies, taking into consideration conservation objectives.
- Maximise the harvesting of topsoil and clay resources.

CHPL would aim to provide a balanced rehabilitation outcome, recognising the alternative land uses that exist in the region and aiming to establish a combination of grazing land and indigenous woodland on final landforms.

Rehabilitation programmes would be adjusted over the life of the Project as necessary, based on the outcomes of research trials, community and regulatory consultation, regional infrastructure requirements and industry knowledge. Progressive rehabilitation would be undertaken throughout the life of the Project, where practicable.

1.4 CVO rehabilitation commitments

1.4.1 Primary mine disturbed areas

The following section provides a brief overview of the rehabilitation and mine closure considerations for the primary mine disturbed areas that are being progressively rehabilitated at CVO according to CVO Rehabilitation Management Plan (Newcrest 2022). Presently, two major areas of rehabilitation are progressively being rehabilitated and include the North Waste Rock Dump (NWRD) and the South Waste Rock Dump (SWRD). These are discussed in Sections 1.4.1.1 and 1.4.1.23, below, with rehabilitation over the NWRD completed, and the SWRD is being progressively rehabilitated. A map showing the conceptual final land use for these areas is provided in Figure 1-1.

1.4.1.1 North Waste Rock Dump (NWRD)

The NWRD was designed to the following standard:

- The NWRD would have maximum batter slopes of 1:3, with 15 to 20 metre (m) wide, step-back, reverse graded berms and rock lined drains;
- PAF material contained in the dump would be encapsulated by covering with 0.5 m of compacted clay or a HDPE liner followed by 2 to 3 m of non-acid forming (NAF) material;
- This would be covered by 20 to 30 centimetres (cm) of topsoil. Where possible topsoil will be used that has been stripped from an area with a consistent final land use;
- Drainage control structures would be installed where necessary, utilising 'chain of ponds' concepts where appropriate; and
- The North Waste Rock Dump would be revegetated with indigenous bushland species with a final land use of conservation.

1.4.1.2 South Waste Rock Dump (SWRD)

The SWRD has/will be constructed to the following standard:

- The revegetation objective for the SWRD is to provide woodland across the dump surface and batters with a final land use of woodland conservation;
- Selective encapsulation of PAF waste rock with a low permeability seal (compacted clay capping) followed by NAF material and topsoil;
- 20 to 30 centimetres (cm) of topsoil will be placed as the surface substrate. Where possible topsoil will be used that has been stripped from an area with a consistent final land use;
- Grading the final surface of the dump to blend in with the natural topography of the area, with an overall outer batter slope of 1:4 comprising 1:3 outer slopes and 15 to 20 m wide, step-back, reverse graded berms;
- Installation of rock lined drains and detention ponds to channel runoff safely to constructed outlet areas;
- Creation of additional habitat using trees cleared from disturbance areas supplemented with additional habitat structures targeting threatened and declining woodland species (e.g. nesting boxes, bat boxes, salvaged hollows etc);
- The woodland areas will be linked to other conservation areas in the Cadia Valley through the vegetation corridor programme;
- Rehabilitation trials would be conducted by CHPL to determine the best combination of techniques for the establishment of native woodland species (including soil treatments, seed mixes, sowing methods etc).

1.4.1.3 **SWRD Water Management**

The SWRD water management structures were design with the following considerations:

- The top surface of the South Waste Rock Dump would be designed with a slight dish shape that would generally drain towards the north. Rock lined channels would be installed along the northern edge of the top surface to provide a stable means for surface water runoff to drain from the top of the SWRD;
- On the batters of the dump, surface water runoff would flow perpendicularly down the slope to the toe of each batter where it would be re-directed by the 15 to 20 m wide reverse graded berms. The water would gradually flow short distances along the berms to rock lined channels which would be constructed at regular intervals down the faces of the batters. These channels would enable water from one berm to be channelled in a controlled manner down the face of the batter to the next berm and ultimately to the base of the dump;
- Rock lined channels would be used at the base of the dump to direct runoff into natural creek lines, the surface of the NTSF, or the Rodds Creek Water Holding Dam;
- Drainage control structures would utilise 'chain of ponds' concepts where appropriate; and
- The existing sediment ponds and leachate collection ponds downstream of the dump would be retained until the revegetated surface of the dump is stable and the runoff water quality is acceptable.

1.4.2 **Guiding principles**

The following guiding principles will be implemented for the Mine Disturbed Landscape (Newcrest 2013a, 2013b).

- Rehabilitation for the post mining land use of woodland, forest or native communities to use:
    - A range of indigenous species (trees, shrubs, grasses, forbs, and aquatic species where applicable);
    - Seed that has been locally collected; and
    - A range of species to provide diversity (including structural diversity) consistent with the target vegetation association (based on soil type, aspect, slope and adjacent (or pre-existing) communities).
- Rehabilitation for the post mining land use of agriculture / grazing to use:
    - Predominantly perennial species (supplemented with annual species as required such as legumes etc);
    - Ranges of native and / or introduced pasture species where suitable; and
    - Scattered paddock trees to match the surrounding agricultural landscape.
- Species will be selected based on the target vegetation community and derived from vegetation survey species lists from a similar community type or monitoring reference site. (Refer to Appendix B Cadia East Environmental Assessment (CHPL 2009));
- Where possible, attempt to re-create communities consistent with local Endangered Ecological Communities (EEC);
- The recovery and use of habitat and rehabilitation resources from remnant areas destined for clearance / subsidence should be maximised to enhance the success and colonisation of rehabilitated sites;
- Locally uncommon species from remnant areas or species that are difficult to propagate should be re-located / re-planted prior to approved clearing;

- Native seed to be collected from within 50km of mine lease boundary or within an acceptable distribution radius;
- Where possible immediately re-spread harvested topsoil to take advantage of seed banks and soil biota and to reduce damage to soil structure through rehandling;
- Utilise topsoil from areas with a similar post mining land use to take advantage of available seed banks; and
- Undertake annual monitoring of rehabilitation sites and compare a range of parameters against selected reference sites.

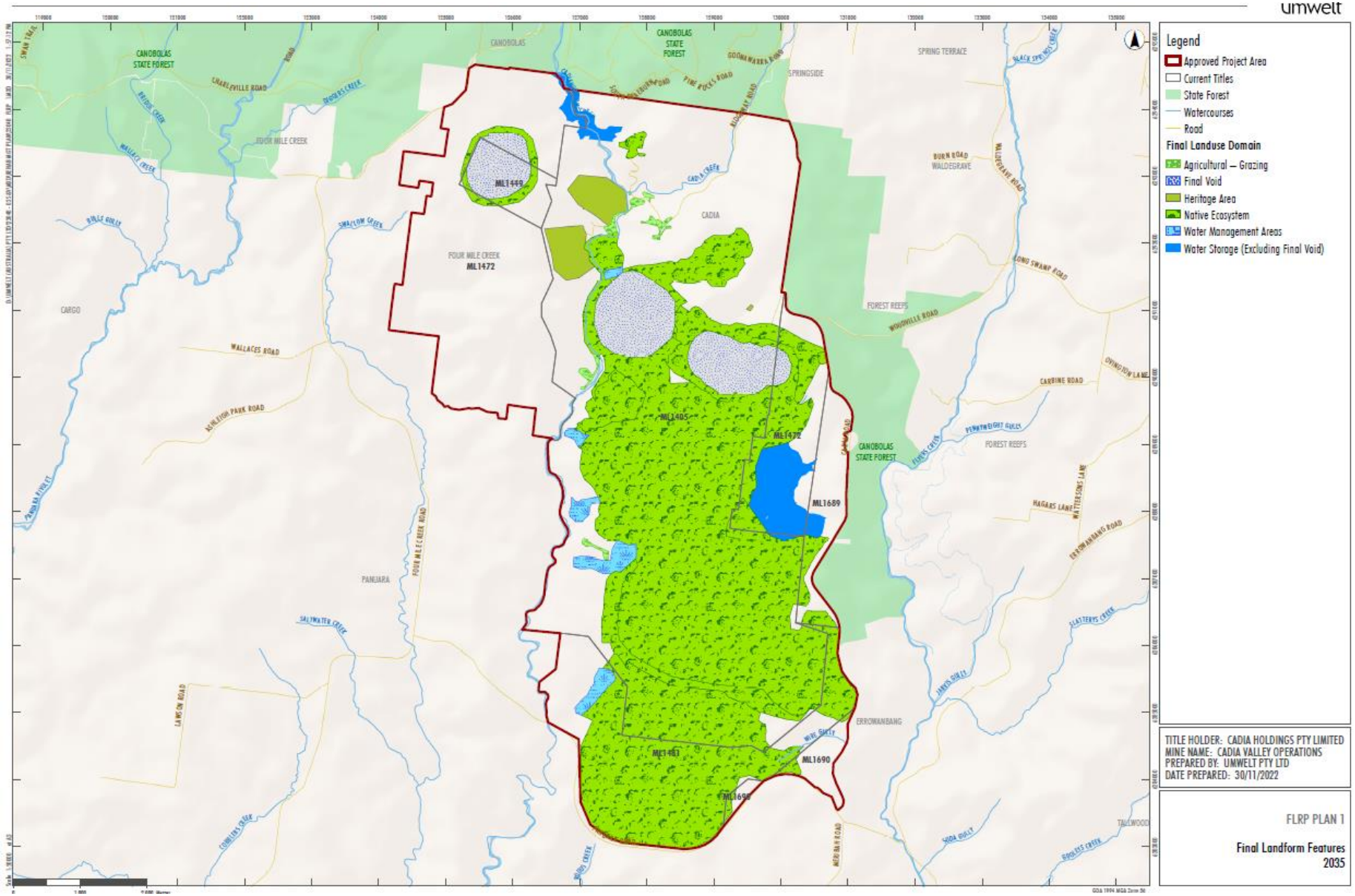


Figure 1-1. Conceptual final land use of mine disturbed areas (RMP 2022)

1.4.3 Vegetation corridor program.

1.4.3.1 Aim of CVO Vegetation Corridor Program

The aim of the CVO Vegetation Corridor Program is to generate enduring land value, including both ecological and agricultural value. This aim will be achieved through meeting the following objectives throughout the life of the plan (Newcrest 2013b):

- Conserve and enhance areas of isolated remnant vegetation;
- Link significant areas of remnant vegetation;
- Provide habitat for native fauna;
- Allow the movement of genetic material between flora and fauna populations; and
- Increase the sustainability and biodiversity of CVO farms and environs.

1.4.3.2 Considerations for Vegetation Corridors

The following considerations will be taken into account when planning and implementing the Vegetation Corridor Program. Figure 1-2 shows the status of the Vegetation Corridor Program (Newcrest 2013b). Figure 1-3 shows how the Vegetation Corridor Program aligns with the proposed mine site rehabilitation concepts to extend corridor linkages across Newcrest owned land (Newcrest 2013b).

- Existing viable remnants should be protected wherever possible;
- Protection is to extend to all strata and native life forms including trees, shrubs, grasses, other herbs and forbs, ground litter, fungi, logs etc;
- Existing remnants should be enlarged or connected by revegetating with the appropriate indigenous species in the landscape;
- Ensure revegetation areas are of sufficient size (nominally >5ha or > 100m wide) where possible to maximise sustainability and biodiversity outcomes;
- Revegetation areas should provide a wide range of habitat features and provide specific habitat for threatened and locally significant fauna species;
- Rehabilitation planning should recognise that physiographic and topographic controls as well as land use objectives may make some areas better suited to pasture and agriculture;
- Rehabilitation planning would be conducted in consultation with the Community Consultative Committee (CCC) and key government stakeholder agencies (e.g. NSW Office of Environment and Heritage (OEH) (Formally NSW Department of Environment, Climate Change and Water), NSW Department of Trade and Investment, Regional Infrastructure and Services (formally Industry & Investment (I&I NSW) and NSW Office of Water (NOW)), and Councils through the AEMR process;
- Rehabilitation planning should be recognised as a dynamic activity requiring stakeholder consultation, the conduct of trials and design studies and the preparation of appropriate management plans prior to implementation;
- Allow for the protection and enhancement of threatened species, communities and locally significant species; and
- Planning for rehabilitation works will take into consideration livestock movement, stock water access, farm operational needs and future mining projects.

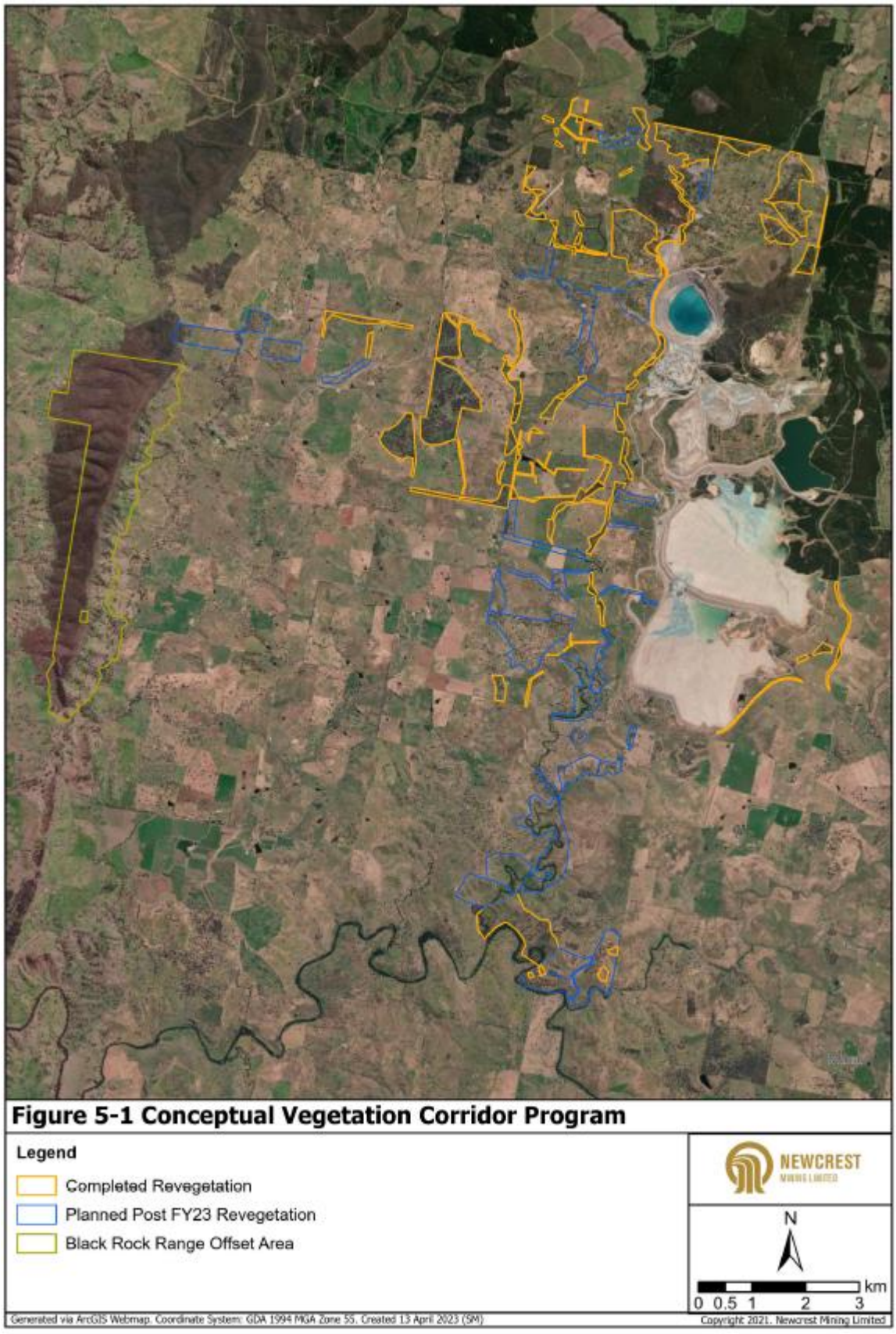


Figure 1-2. Vegetation Corridor Program (RMP 2022).

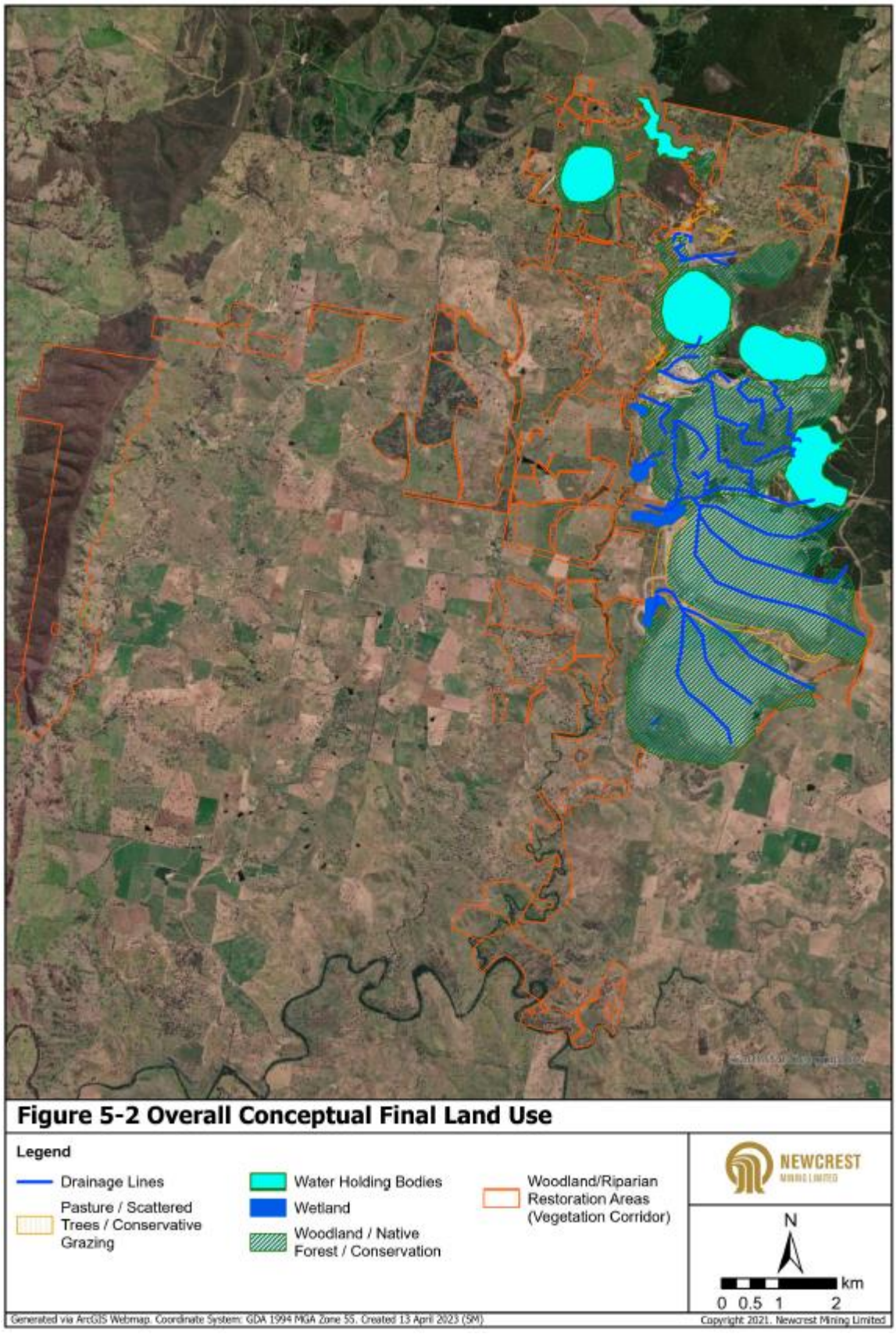


Figure 1-3. Vegetation Corridor Program and how it aligns with the mine site rehabilitations concepts (RMP 2022).

1.5 Management Plans

1.5.1 Mining Operation Plans

In NSW, mining operations were previously carried out in accordance with a Mining Operations Plan (MOP) that had been approved by the NSW Department of Planning & Environment (DPE) (formerly NSW Trade and Investment - Division of Resources and Energy). The MOP was a tool used by DPE to monitor the progress of mining and rehabilitation activities across the life of a mine (NSW T&I 2013). The MOP was intended to fulfil the function of both a rehabilitation plan and a mine closure plan, where it should document the long-term mine closure principles and outcomes whilst outlining the proposed rehabilitation activities during the MOP term (NSW T&I 2013).

ESG3: Mining Operations Plan (MOP) Guidelines, September 2013 (ESG3) detailed a process for monitoring and managing progression towards successful rehabilitation outcomes (NSW T&I 2013). The Guidelines required industry to identify and provide measurable data and demonstrate that proposed rehabilitation outcomes are achievable and realistic within a given timeframe. The requirement for more targeted information strengthened the capacity of the Department to regulate rehabilitation and environmental performance and more accurately determine rehabilitation security liabilities (NSW T&I 2013).

1.5.2 RMP Code of Practice 2018

The Resource Regulators have since improved compliance and reporting requirements for rehabilitation through an amendment to the Regulation under the Mining Act 1992, known as the rehabilitation reforms, which prescribes new mining lease conditions relating to rehabilitation and sets clear, achievable and enforceable requirements for rehabilitation. The Regulation commenced on 2 July 2021. The new standard rehabilitation conditions will apply to all new mining leases issued from this date. For mining leases that were in force before this date, the conditions apply for large mines1 on 2 July 2022 and for small mines on 2 July 2023. These new rehabilitation conditions will replace existing rehabilitation and environmental management conditions on current leases.

Subsequently previous MOPs have been replaced by the Rehabilitation Management Plan and Associated Annual rehabilitation Report and Forward Program for large mines Codes of Practice (NSW DPE 2021). Many of the previous ESG3 guidelines are still however relevant to the current rehabilitation monitoring and reporting protocols.

1.5.3 Rehabilitation phases

Successful rehabilitation of a mine site has been conceptually described in terms of logical steps or phases and are to be made applicable to each of the similar land management units or domains. It is recognised that most domains will require a different rehabilitation methodology to achieve the intended post-mining land use (NSW T&I 2013; NSW DPE 2018). Rehabilitation Phases where the post mining land use is a native plant ecosystem according to the previous guidelines and RMP 'Form and Way' documents include:

1. Active Mining;
2. Decommissioning;
3. Landform Establishment;
4. Growth Medium Development;
5. Ecosystem and Land Use Establishment;
6. Ecosystem and Land Use Development; and
7. Rehabilitation Completion (sign Off).

1.5.4 Performance Indicators

To satisfy regulatory conditions, performance measures, indicators and associated performance/completion criteria that are appropriate to the location and relevant to the stated rehabilitation goals and objectives must be presented for each land management unit or domain. The application of the ecological performance data during the Decommissioning phase (Phase 1) are not considered applicable within the presentation of the ecological data obtained within the CVO rehabilitation monitoring program. Subsequently, the ecological performance criteria which are consolidated into Key Performance Indicator (KPI) tables are only represented within Rehabilitation Phases 3 (Landform establishment) to Phase 6 (Ecosystem and Land Use Development).

Data from reference sites provide suitable target values of key biophysical parameters, vegetation structures and diversity and habitat complexity. It provides the ability to monitor both success against true values of an existing ecosystem and the effects of climatic variations and disturbance events (such as fire, flooding, drought etc.). The reference site can be used as the target outcome of the final rehabilitated landscape and a time series record of ecosystem change or development can be obtained. By comparing data with reference sites, it is possible to see if the rehabilitation or disturbed site is developing adequately. All completion criteria at a given site should be within critical threshold values if ecosystem rehabilitation is to be judged successful (NSW T&I 2013).

1.6 Completion criteria and key performance indicators

At CVO, a range of KPI's have been determined and are quantified by data obtained from replicated reference sites which are representative of the agreed final land use. All ecological performance indicators are quantified by range values measured annually (or three-year monitoring cycle) from these reference sites which form an *upper* and *lower* KPI target. The same ecological performance indicators are measured in the rehabilitation sites and these should equal or exceed these values or demonstrate an increasing trend.

These KPIs have been further separated into "*Primary performance indicators*" and "*Secondary performance indicators"*. Primary performance indicators are those chosen as essential completion criteria targets and have been identified as those that will satisfy requirements specifically identified within the EIS, MOP and relevant Rehabilitation Management Plans and in particular the final land use and any relevant conditions of consent relating to vegetation type, specific use of species and condition for example.

Secondary performance indicators are those that would be desirable to achieve but will not necessarily have an influence on relinquishment requirements. Therefore, please note that not all Performance Indicators are set as primary completion criteria targets.

2 CVO rehabilitation monitoring program

2.1 Primary objectives

The primary objective of the CVO rehabilitation monitoring program has been to compare the progress of rehabilitated landforms and revegetated conservation areas towards fulfilling long-term land use objectives by comparing a selection of ecological targets or completion criteria against unmined areas of remnant vegetation (reference sites) that are representative of the final land use and vegetation assemblage. This originally involved developing a set of completion criteria consistent with CVOs Landscape Management Plan (CPHL 2009), Rehabilitation Strategy (Newcrest Mining Ltd 2013a), Land and Biodiversity Management Plan (Newcrest 2013b), community expectations as well as relevant NSW legislation, policies and best practice guidelines (NSW I&I 2010, NSW T&I 2012, NSW T&I 2013, NSW Department of Planning 2018) and current Rehabilitation Management Plan (2022).

The primary objectives in establishing completion criteria is to establish clearly defined, repeatable and consistent methodologies for monitoring changes in various aspects of ecosystem stability, recovery and long-term sustainability. Part of this process includes:

- Establishing a range of relevant reference sites to compare and track the progress of rehabilitation areas and inherent ecosystem function;
- Selecting a range of suitable reference sites that reflect the desired final land use, biodiversity targets and local community expectations; and
- Undertaking monitoring programs that provide simple but informative and reliable information that indicates positive recovery trends or rapid detection of rehabilitation failure.

2.2 Establishing suitable reference sites

Three main vegetation community types were identified as being rehabilitated onto mining disturbed areas or CVO farmland areas and included:

- Grassy woodland;
- Introduced pastures; and
- Riparian woodlands.

All reference sites have been subjected to some form of prior disturbance, in particular clearing for agriculture and livestock grazing and all woodland sites were regrowth, with some invasion from introduced species. These sites, despite their disturbance history were typical of the local area and help set realistic rehabilitation targets and provide a benchmark for transitional processes that can be expected or that are presently occurring in the rehabilitation areas.

Data obtained from these reference sites quantified the range of key ecological performance indicators and resulting completion criteria. The reference sites were spread out where possible to maximise the spatial distribution and subsequent variations in community composition across the local landscape and all are now situated on Cadia owned land. Current reference sites include:

- Three grassy woodlands;
- Two riparian woodlands; and
- Two exotic pastures.

2.3 General description of the reference sites

2.3.1 Grassy woodland reference sites

The grassy woodlands were comprised of low various densities of *E. albens* (White Box) or *E. melliodora* trees but *E. blakelyi* (Blakely's Red Gum), *E. macrorhyncha* (Red Stringybark), *E. bridgesiana* (Apple Box) and/or *E. goniocalyx* (Bundy Box) may also have been present. Scattered old growth trees were present as well as younger regrowth and some relatively recent natural eucalypt recruitment was present in all sites. There was an absence of a shrub layer in two sites however in the other woodland site, there were some scattered *Acacia dealbata* (Silver Wattle) and *A. implexa* (Hickory) and eucalypt regeneration was present. There may also have been occasional exotic shrubs in some woodland areas *(i.e. Rubus fruticosus* (Blackberry), *Rosa rubiginosa* (Sweet Briar). The understoreys were usually dominated by native perennial grasses and common native forbs and all sites contained a high cover of leaf litter. There were also scattered exotic annuals and pockets of exotic grasses or weeds especially in old stockcamp areas.

2.3.2 Riparian woodland reference sites

The two riparian woodland sites were quite different to each other, but both were characteristically open grassy woodland. One site was comprised of scattered old growth trees of *E. camaldulensis* (River Red Gum)*, E. melliodora* and *E. bridgesiana* (Apple Box) and had an understorey dominated by *Phalaris aquatica* (*Phalaris*) and *Dactylis glomerata (Cocksfoot)* with patches of introduced annual grasses and native grass and herbs. The second site was also comprised of scattered old growth trees dominated by *E. viminalis* (Ribbon Gum)*, E. melliodora* and *E. bridgesiana* and a relatively intact and diverse native grassy understorey and contained some patches of shrubs including *Acacia melanoxylon* (Blackwood) and *A. dealbata*. Both sites however contained various noxious weeds and floods waters continue to alter the stream morphology.

2.3.3 Introduced pasture reference sites

The two introduced pasture sites were dominated by *Phalaris aquatica* and contained various combinations of other pasture species such as *Dactylis glomerata* (Cocksfoot), *Lolium* sp. (Ryegrass) and *Trifolium* species (Clovers). At RfPast03, *Puccinellia stricta* (Australian Saltmarsh Grass) was also very abundant. These sites are intermittently grazed by sheep and cattle but both sites contained very high ground cover levels and had very few weeds.

2.4 CVO Rehabilitation monitoring sites

At CVO, rehabilitation has been progressive since the inception of the monitoring program and subsequently the number of rehabilitation monitoring sites has changed over the years. Major rehabilitation was undertaken on the main Waste Emplacements in 2008 (South Dump) and in 2014/2015 (North and South Dump). The rehabilitation monitoring sites were considered to be representative of the rehabilitation area as a whole or were similar to and representative of other areas of rehabilitation.

Sites South Dump 01,02, 03 and 06 are no longer assessed due to their association with the recovery of benign waste rock material. Access to South Dump 09 was difficult this year due to nearby heavy machinery and was also not assessed due to safety risks. Due to the significant development of the woodland rehabilitation in most areas of the South Dump, some sites may be placed on a two to three year rotation. Some of the older more

stable farmland and riparian revegetation sites are also monitored on a three-year rotation, with these last being assessed in 2022.

2.5 Summary and location of the monitoring sites

Table 2-1 shows a summary of the monitoring sites assessed as part of the CVO monitoring program, including the general locality, year of establishment, community type and frequency of monitoring. Figure 2-1 shows the location of the reference and rehabilitation monitoring sites. GPS coordinates and other site-specific information is provided in Appendix 1.

Table 2-1. Summary of the monitoring sites.

Site type	Vegetation community	Site name	Rehabilitation method	Year est.	3 year monitoring rotation	2016	2017	2018	2019	2020	2021	2022	2023
Reference site	Woodland - Ashleigh Park	RfWood01	-	2008		1	1	1	1	1	1	1	1
	Woodland - Bundarra	RfWood02	-	2008		1	1	1	1	1	1	1	1
	~~Woodland - CVO Access Rd~~	~~RWood04~~	~~-~~	~~2015~~		~~1~~	~~1~~	~~1~~	~~subsidence~~	~~subsidence~~	~~subsidence~~		
	Woodland - Cadiangullong Dam	RWood05	-	2008		1	1	1	1	1	1	1	1
	Pasture - Bundarra	RfPast01	-	2008	☑ 2019	1			1				
	Pasture - Willunga	RfPast03	-	2008	☑ 2019	1			1				
	Riparian - Bakers Shaft	RrRip02	-	2008	☑ 2022	1			1			1	
	Riparian - Cadiangullong Ck CVO	RrRip03	-	2008	☑ 2022	1			1			1	
	Total reference sites					**8**	**4**	**4**	**8**	**3**	**3**	**5**	**3**
Rehabilitation sites	Woodland	Ashleigh Park	Direct Seeded Farmland	2008	☑ 2022	1			1			1	
	~~Woodland~~	~~South Dump 01~~	~~Aerial seeding + tubestock planting~~	~~2008~~	NA	1		1	1			NA	
	~~Woodland~~	~~South Dump 02~~	~~Aerial seeding + tubestock planting~~	~~2008~~	NA	1		1	1			NA	
	~~Woodland~~	~~South Dump 03~~	~~Aerial seeding + tubestock planting~~	~~2010~~	NA	1		1	1			NA	
	Woodland	WillungaDS01	Direct seeded farmland	2008	☑ 2022	1			1			1	
	Woodland	WillungaDS02	Direct seeded farmland	2008	☑ 2022	1			1			1	
	Riparian woodland	Cadiangullong Creek	Direct seeded farmland	2008	☑ 2022	1			1			1	
	Riparian woodland	Creek Diversion	Tubestock planting	2008	☑ 2022	1			1			1	
	Woodland	North Dump 01	Aerial seeding	2014		1	1	1	1	1	1	1	1
	Woodland	North Dump 02	Aerial seeding	2014		1	1	1	1	1	1	1	1
	Woodland	North Dump 03	Aerial seeding	2014		1	1	1	1	1	1	1	1
	Woodland	South Dump 04	Aerial seeding	2014		1	1	1	1	1	1		1
	Woodland	South Dump 05	Aerial seeding	2014		1	1	1	1	1	1		1
	~~Woodland~~	~~South Dump 06~~	~~Aerial seeding~~	~~2014~~		~~1~~	~~1~~	~~1~~	~~subsidence~~	~~subsidence~~	~~subsidence~~		
	Woodland	South Dump 07	Aerial seeding	2016		1	1	1	1	1	1		1
	Woodland	South Dump 08	Aerial seeding	2016		1	1	1	1	1	1		1
	~~Woodland~~	~~South Dump 09~~	~~Aerial seeding~~	~~2016~~		1	1	1	1	1	1		Not accessible
	Woodland	South Dump 10	Seeded	2018					1	1	1	1	1
	Total rehabilitation monitoring sites					**17**	**9**	**16**	**17**	**9**	**9**	**9**	**8**
Total sites						**25**	**13**	**16**	**25**	**12**	**12**	**14**	**11**

Figure 2-1. Map of the CVO monitoring sites.

3 Rehabilitation monitoring methodology

The primary objective of the CVO rehabilitation monitoring program was to establish an annual rehabilitation monitoring program and develop set of completion criteria that complies and is consistent with conditions specified within a range of approval documents and conditions and associated CVO Management Plans including the CVO Rehabilitation Strategy (CVO 2013) and CVO Land and Biodiversity – Landscape Management Plan (CVO 2013). It has also been amended to align with the Rehabilitation and Environmental Management Plan (REMP) Guidelines (NSW I&I 2010) and the NSW Departments ESG3 MOP guidelines (NSW T&I 2012, 2013) and new RMP Code of Practice (2018).

The monitoring methods adopted to obtain completion targets included a combination Landscape Function Analyses (LFA; CSIRO Tongway & Hindley 1996), accredited soil analyses and an assessment of ecosystem diversity and habitat values using an adaptation of methodologies derived from the Biometric Manual (Gibbons *et al* 2005, DECCW 2011). The methodology used for undertaking the monitoring has been provided in "Rehabilitation monitoring methodology and determination of completion criteria" (DnA Environmental 2011) and have been referenced in previous monitoring reports.

Ecological monitoring has been undertaken in autumn in all monitoring years. Field work and associated reports have been undertaken by Dr Donna Johnston and Andrew Johnston from DnA Environmental. Since 2021, field surveys have been undertaken by Andrew Johnston (DnA Environmental) and Ray Mjadwesch (Mjadwesch Environmental Service Support) and this year were undertaken during 3 - 6th April 2023.

3.1 Amendments

In 2022r, inclusions were made to the KPI tables regarding tree and mature shrub density (> 5 cm dbh), and shrub and juvenile tree density (< 5cm dbh) targets. These included segregating the population(s) into:

- The density of eucalypts;
- The density of acacias;
- The density of other endemic shrubs;
- The density of weeds; and
- The percentage of eucalypts.

3.2 Limitations

3.2.1 Species identification

In some cases, there may have been a lack of critical features and/or reproductive structures (due to heavy grazing or browsing, new germinants etc) that may be required for the positive identification of some plant genera, and therefore some species may have only been identified to the genera level.

Where species names have been changed and/or updated and/or plants may have been previously misidentified, corrections according to PlantNet have been applied where possible. In most cases these occurrences are unlikely to have an impact on the meeting of completion targets.

4 Rainfall

Total annual and monthly rainfall averages recorded at CVO from 2014 to the end of April 2023 compared to long term monthly averages recorded at Orange Airport are provided in Figure 4-1 and Figure 4-2. The long term annual average rainfall recorded at Orange Airport is 889 mm. The graph indicates that, with the exception of 2016, 2020 - 2022, annual rainfall was well below average the expected annual rainfall since 2014. The lowest annual rainfall was recorded for three consecutive years during 2017 - 2019, with annual total rainfall ranging from 417 – 496 mm respectively, with these being less than or only slightly more than half the expected rainfall.

Despite the apparently low rainfall activity in the early monitoring years, monthly averages indicate there has also been high variability and erratic rainfall activity over these years. During January and February 2021, rainfall was close to the expected averages, however below average rainfall occurred March – June, with almost no rain at all falling in April. Improved rainfall conditions were experienced for the remainder of the year, with 222 mm being recorded in November causing widespread flooding. In 2021, a total of 963 mm was recorded.

High rainfall periods were also recorded into January 2022, followed by limited rain in February and March just prior to the monitoring event last year. Above average rainfall causing widespread flooding was experienced again, with a total rainfall of 1076mm recorded for the year. From December 2022 to February this year rainfall was well below average, with these hot dry conditions followed by two months of above average monthly rainfall with 147 mm during the month of March alone. For the year to April 2023, 350 mm of rain was recorded compared to an average monthly total for the same period of 264mm.

Subsequently there have been extremes in climatic conditions, with floods in 2016 followed by three consecutive years of drought which has typically been reflected in the monitoring data. Over the last three years there have several flood events and overall improved growing conditions resulting in a reduction in grazing and disturbance by animals and extensive plant growth and increased levels of ground cover.

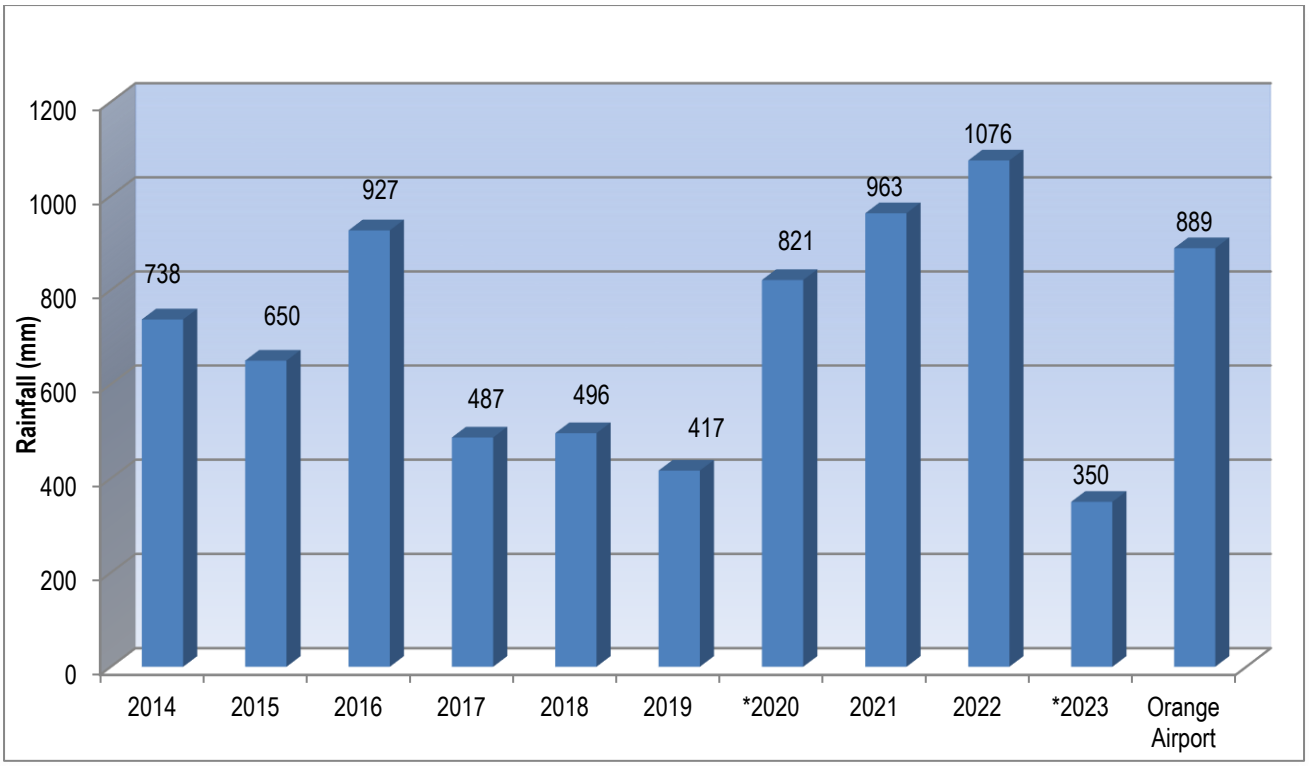


Figure 4-1. Annual average rainfall recorded at Cadia Valley Operations 2014 - April 2023 compared to long term monthly averages recorded at Orange Airport. (*2023 Jan – April rainfall).

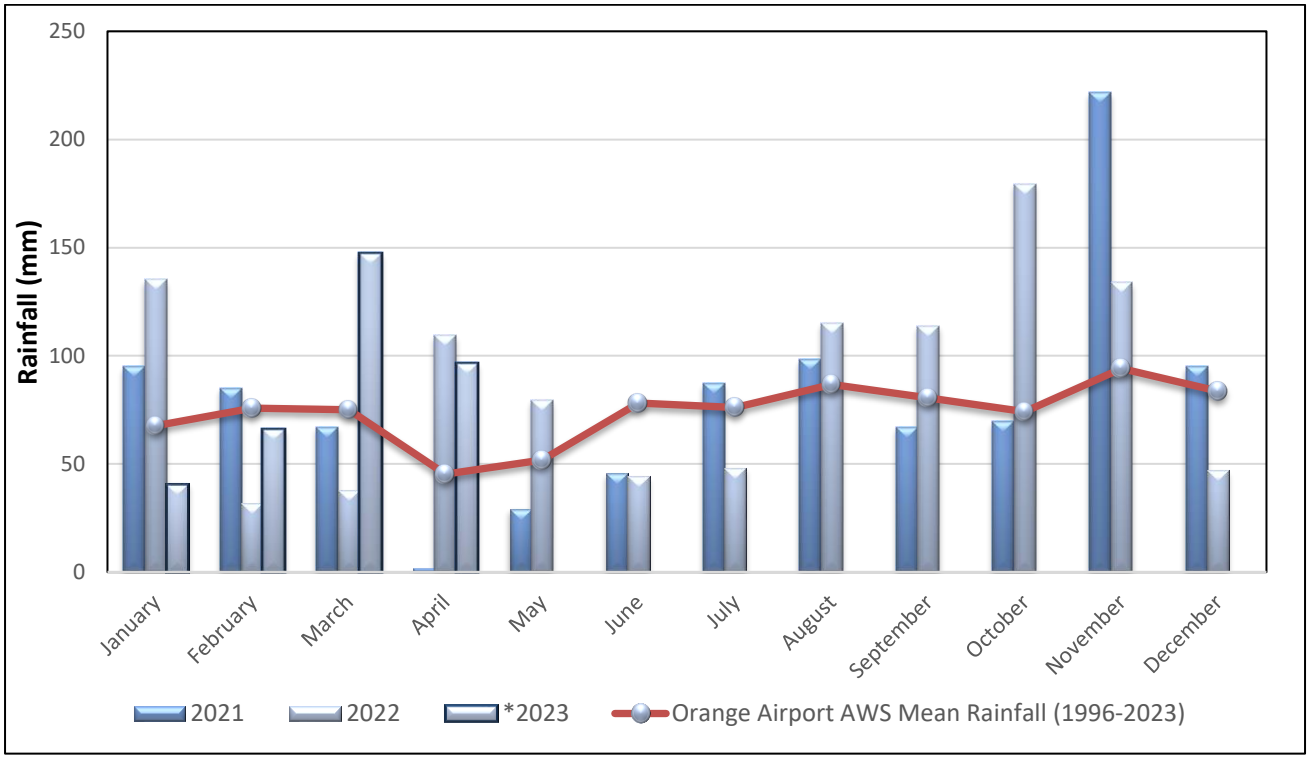


Figure 4-2. Average monthly rainfall recorded at Cadia Valley Operations January 2021 – April *2023 compared to long term monthly mean rainfall recorded at Orange Airport.

5 Results: Woodland monitoring sites

5.1 Permanent photo-points

5.1.1 Woodland reference sites

Table 5-1 provides a series of photographs taken from a permanent photo-point along the vegetation transect 2014 – 2023. Photos from numerous years have been excluded for ease of presentation of the increasing quantity of data. The GPS co-ordinates and other site-specific information of the reference sites are provided in Appendix 1.

Table 5-1. General description and permanent photo-point along the vegetation transect in the reference monitoring sites 2014 - 2023.

Site	2014	2020	2022	2023
RfWood01: "Ashleigh Park"				
RfWood02: "Bundarra"				

Site	2014	2020	2022	2023
RWood05: Cadiangullong Dam				

5.1.2 Woodland rehabilitation sites

Table 5-2 provides a photograph taken from the permanent monitoring point along the vegetation transect of rehabilitation sites established on the South and North Dumps from 2014 to 2023. North Dump 03 and South Dump 08 are relatively flat, while the remainder are on slopes. Sites South Dump 04 and 05 and North Dump 01, 02 and 03 were aerial seeded during November 2013 with a blend of native trees and shrubs and exotic pasture species. Sites on the North Dump were over sown with Japanese Millet while sites on the South Dump were over sown with Cereal Rye, Couch, Cocksfoot, Phalaris, Subterranean Clover, Perennial Ryegrass and the native grass *Bothriochloa macra* (Redgrass). In October 2015, sites South Dump 04 and 05 were cross ripped and re-seeded to reduce the compaction layer. Sites South Dump 07, 08 and 09 were also aerial sown in February 2015 with a mix of endemic native, shrubs and ground cover species. South Dump 10 was sown in February 2018. General descriptions and photo from the permanent photo-point of the farmland revegetation monitoring sites 2008 – 2023 is provided in Table 5-3. GPS co-ordinates and other site-specific information of the rehabilitation sites are provided in Appendix 1.

Table 5-2. Permanent photo-points of the woodland rehabilitation monitoring sites on the south and north dumps 2014 - 2023.

Site	2014	2018	2020	2021	2023
South Dump 04					
South Dump 05					

Site	2014	2018	2020	2021	2023
South Dump 07	N/A				
South Dump 08	N/A				
South Dump 10	N/A				

Site	2014	2018	2020	2021	2023
North Dump 01					
North Dump 02					
North Dump 03					

5.1.3 Farmland woodland revegetation monitoring sites: 2022

Farmland monitoring sites are monitored on a three-year rotation and were last assessed in 2022.

Table 5-3. Photo-points of farmland woodland revegetation monitoring sites 2008 - 2022.

Site	2008	2012	2016	2019	2022
Ashleigh Park 01					
Willunga DS01					
Willunga DS02					

5.2 Ecological trends and performance against a selection of ecological performance indicators

The following section provides a summary of the ecological trends and performance of woodland rehabilitation sites against a selection of performance indicators obtained from the three woodland reference sites.

In terms of data analyses, the majority of young rehabilitation sites were established and first assessed in 2014. Data obtained prior to 2014 from the older sites has been omitted from the report for ease of presentation. For early reference of data obtained from these older rehabilitation sites please refer to 2009 – 2016 CVO annual rehabilitation monitoring reports (DnA Environmental 2009 – 2016).

5.2.1 Landscape Function Analyses

5.2.1.1 Landscape Organisation Index

A patch is an area within an ecosystem where resources such as soil and litter tend to accumulate, while areas where resources are mobilised and transported away are referred to as interpatches. Landscape Organisation Indices (LOI) are calculated by the length of the patches divided by the length of the transect to provide an index or percent of the transect which is occupied by functional patch areas (Tongway and Hindley 2004).

The woodland reference sites were characterised by having a mature tree canopy and in two sites, there was a well-developed, decomposing leaf litter layer and a sparse cover of native perennial forbs and grasses. The other sites tended to have much more dominant perennial grass cover. The extended dry conditions during 2017 - 2019 caused a reduction in perennial ground covers and increased disturbances by animals has created some bare interpatch areas in RfWood01 and RfWood02, thus lowering LOIs in these sites. Since 2020, the improved seasonal conditions resulted in a significant increase in the diversity and abundance of the ground covers, with 100% functional patch area continuing to be recorded in the woodland reference sites (Figure 5-1).

All rehabilitation sites established on the South Dump and North Dump had previously demonstrated a significant increase in functional patch area (Figure 5-1). Despite the loss of many of the original troughs and banks due to erosive processes in numerous sites, there tended to be a concurrent increase in plant and litter covers. During 2017 - 2019 however, prolonged dry conditions and increased grazing and disturbance by animals resulted in a deterioration of functional patch area in all rehabilitation sites.

In early 2020, the effects of the drought, heavy grazing and increased erosion was recorded in several rehabilitation areas and two of the reference sites. In the majority of rehabilitation sites however increased patch area was recorded largely due to the relatively recent germination of annual plant covers. The ongoing favourable seasonal conditions have continued to result in increased ground cover and resultant functional patch areas. This year LO ranged from 75 - 100%. Three sites South Dump 07, South Dump 04 and South Dump 08 had high levels of LO but did not quite meet 100% completion targets this year.

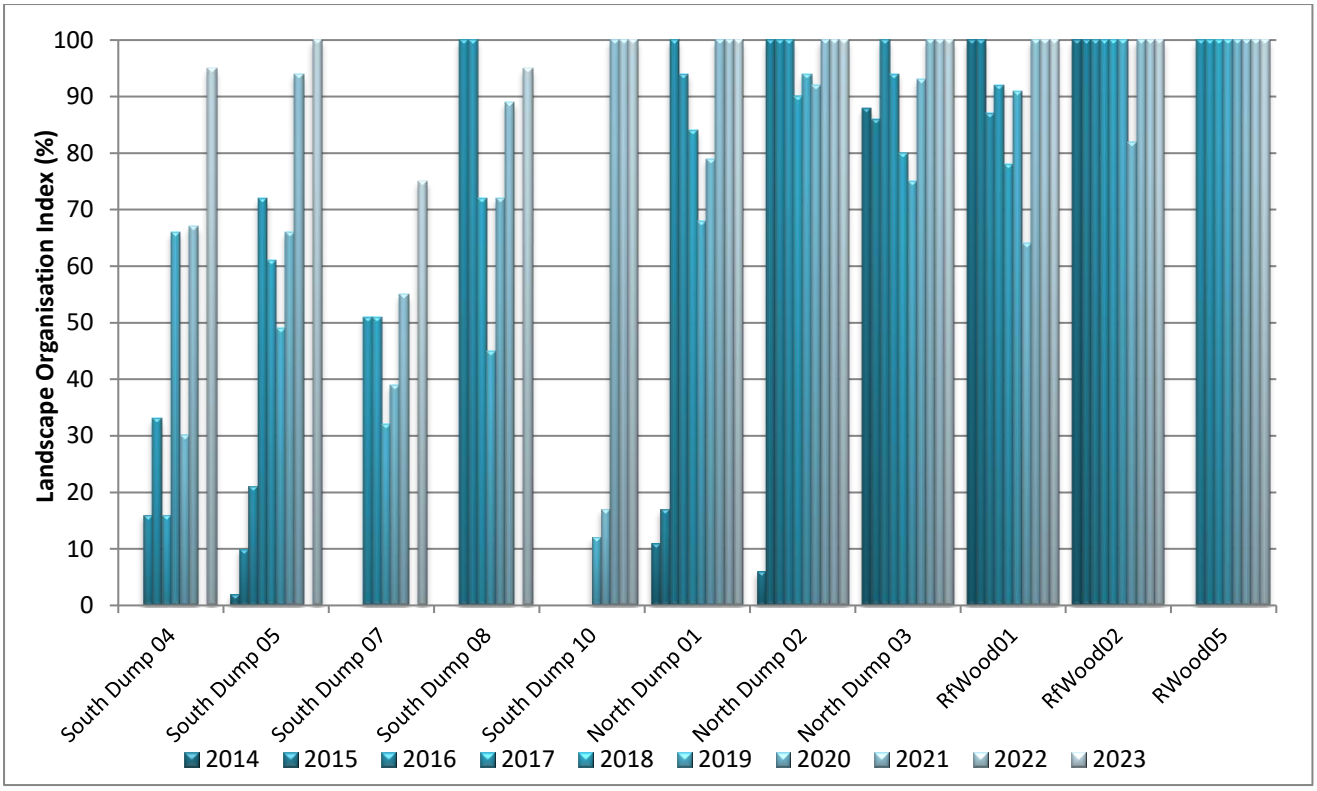


Figure 5-1. Landscape Organisation Indices recorded in the woodland monitoring sites.

5.2.1.2 **Soil surface assessments**

5.2.1.2.1 Stability

Changes in stability in the various woodland reference sites have tended to fluctuate according to seasonal conditions and total grazing pressure and these have been variable between sites. Most sites tended to have a lower stability during the drought 2017 – 2019 however these have since increased as a result of the improved seasonal conditions. This year, however, perennial grasses had become tall and rank in RWood02, thus slightly lowering the stability in this site, while increased stability was recorded in the remaining two sites. The resultant stability range this year was 69.5 – 74.4 (Figure 5-2).

Stability in the rehabilitation areas has varied significantly, as a result of the way the landform was constructed combined with the ongoing effects of drought and animal disturbance. While some sites were relatively slow to develop, all sites on the South Dump have increased in stability since 2021, due to improved seasonal conditions although some sites may still be subjected to grazing and disturbances by animals. This year stability across the five sites were similar to each other and ranged from 66.8 – 69.9.

On the North Dump rehabilitation area, annual weeds have become well colonised and all three sites had a well-developed and mostly stable annual plant/litter layer and scattered perennial ground covers were becoming established. Grazing by herbivores continued to be evident in some areas, where there continued to be small bare patches mostly on the top of old rip lines where some isolated erosion may have occurred. Stability on the North Dump ranged from 68.5 – 71.5. Compared to the reference sites, rehabilitation sites South Dump 05, 07 and North Dump 03 had a marginally low stability this year.

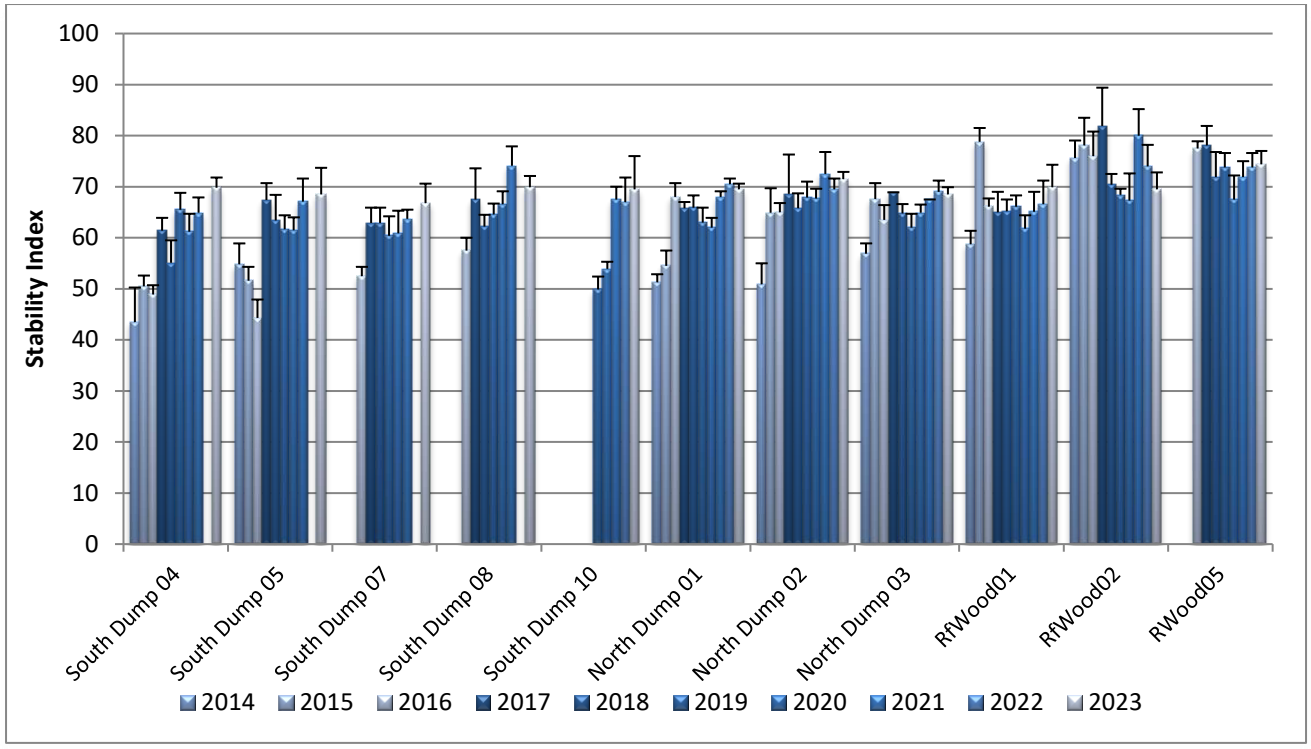


Figure 5-2 LFA stability indices recorded in the woodland monitoring sites.

5.2.1.2.2 Infiltration

The LFA infiltration indices recorded in the woodland reference sites ranged from 56.7 – 66.0, with a marginal reduction being recorded in RWood02 (Figure 5-3). All rehabilitation sites had improved infiltration capacity over the last few years, except South Dump 10 where animal disturbance was high and perennial ground cover was limited and had become tall and rank. All rehabilitation sites continued to have a lower infiltration capacity compared to the reference sites and this year ranged from 35.5 (South Dump 07) to 52.4 (North Dump 02).

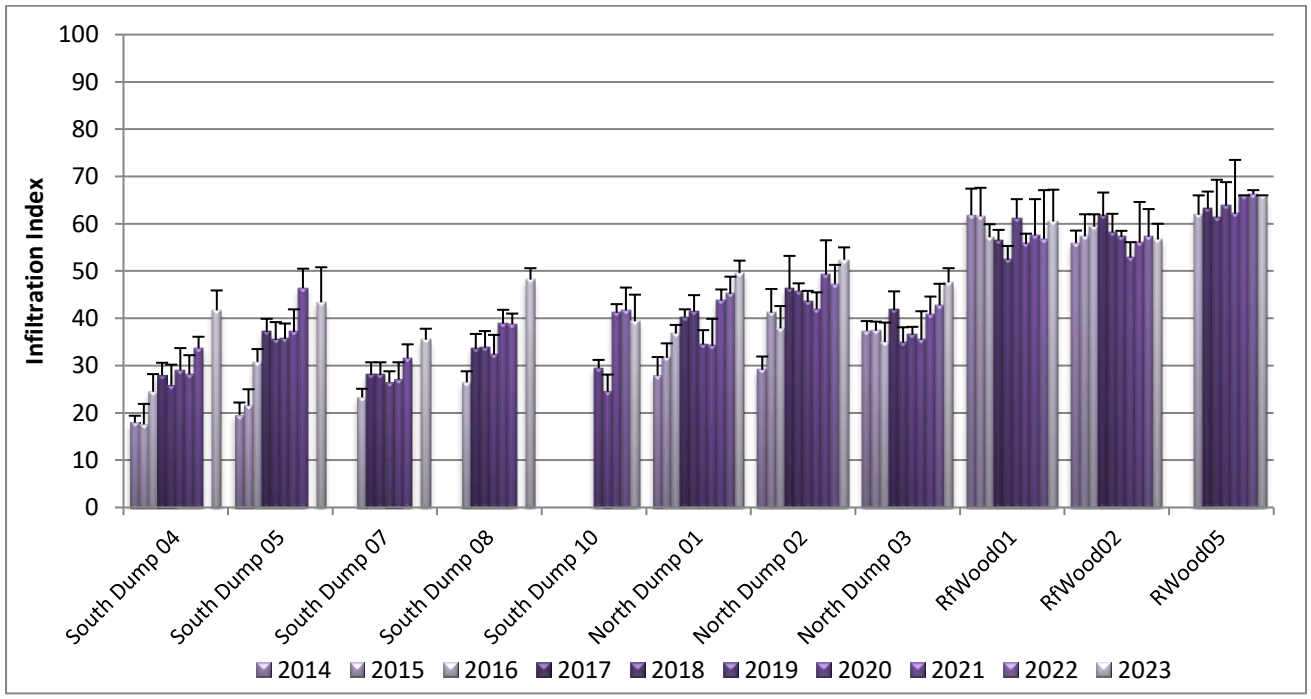


Figure 5-3. LFA infiltration indices recorded in the woodland monitoring sites.

5.2.1.2.3 Nutrient recycling

The nutrient recycling indices followed similar trends as infiltration capacity of the sites. They also tended to be influenced by the increase levels of perennial canopy and ground cover, litter cover and decomposition as well as cover provided by cryptogams. This year there was little change in nutrient recycling indices for the woodland reference sites and ranged from 54.3 – 64.1 (Figure 5-4). Despite improved levels of nutrient recycling, all rehabilitation sites had lower nutrient recycling capacity compared to the woodland reference sites and ranged from 35.5 (South Dump 07) to a high of 52.4 (North Dump 02).

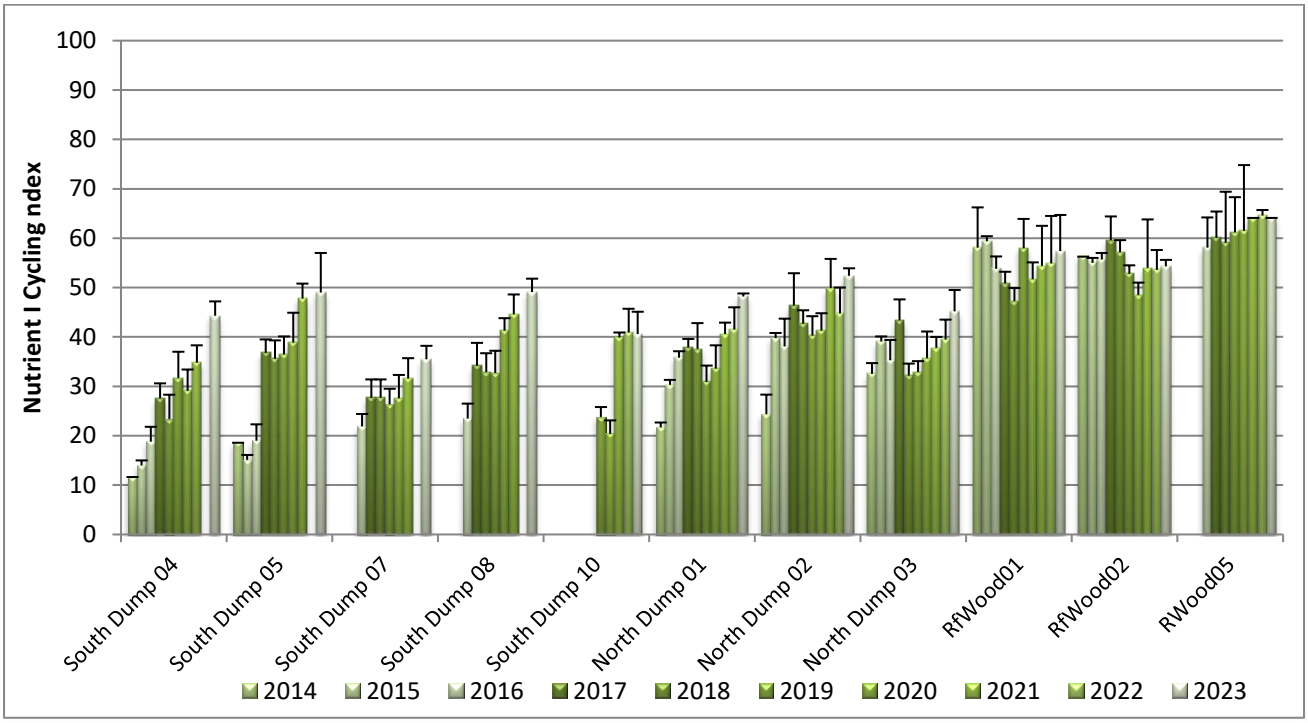


Figure 5-4 LFA nutrient recycling indices recorded in the woodland monitoring sites.

5.2.1.2.4 Most functional sites

The sum of the LFA stability, infiltration and nutrient recycling components provides an indication of the most functional to least functional monitoring site recorded in 2023 (Figure 5-5). The maximum score possible is 300.

The woodland reference site RWood05 continued to be the most ecologically functional and continued to have a sum of scores 205, followed by the remaining two reference sites with scores of 188 and 181. North Dump 02 was the most functional rehabilitation sites with a total sum of scores of 176, with many of the remaining rehabilitation areas being functionally similar to each other with scores ranging from 167 – 156. The least developed sites included South Dump 10 with a score of 150, while South Dump 07 was the least functional rehabilitation area with a score of 138.

Examples of the substrates and vegetation covers in the woodland monitoring sites this year have been illustrated in Table 5-4.

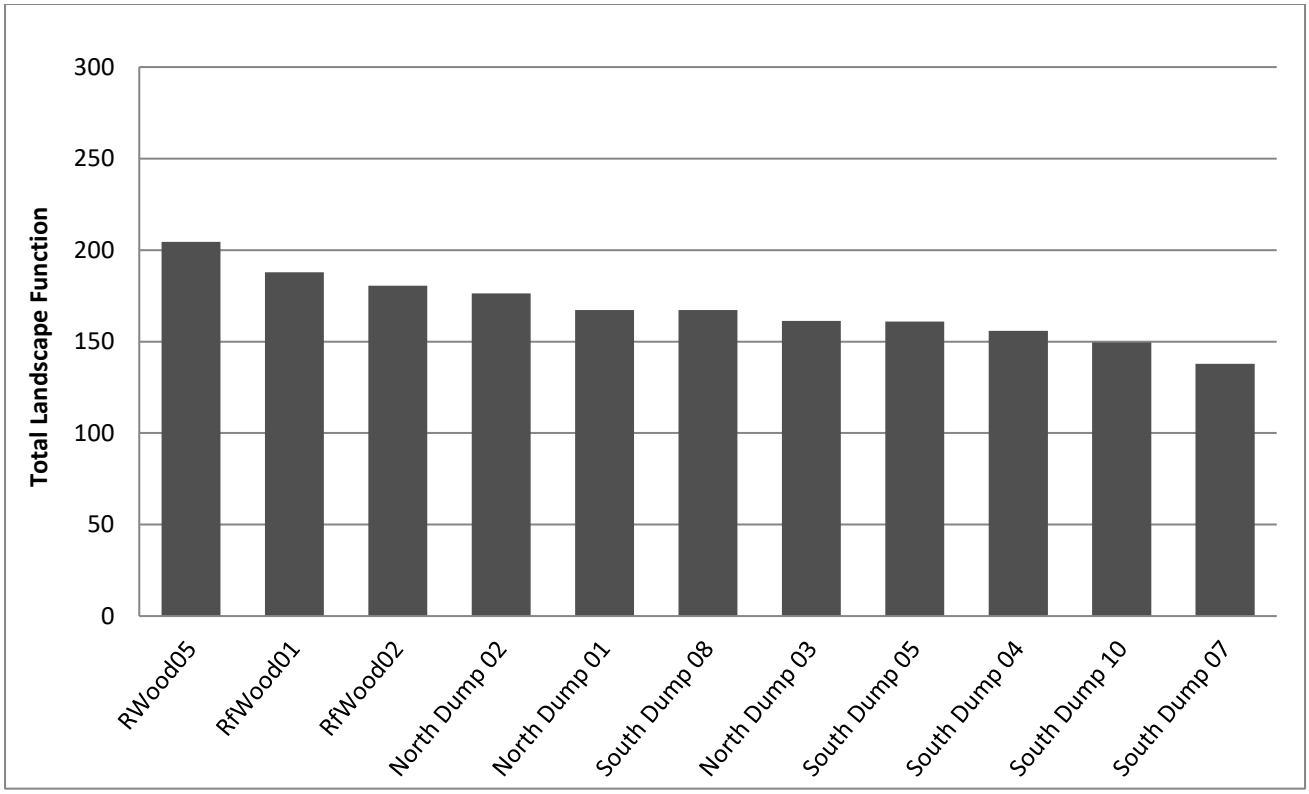
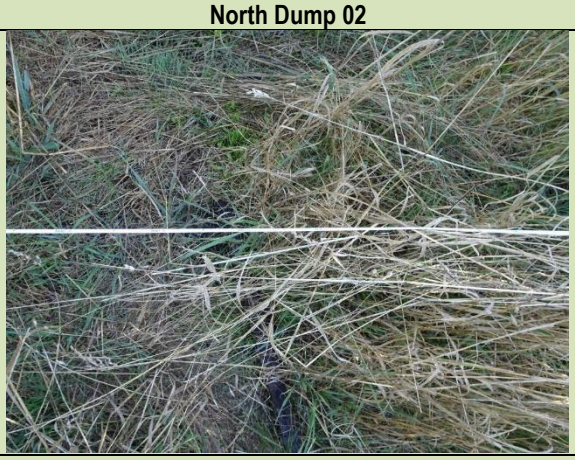
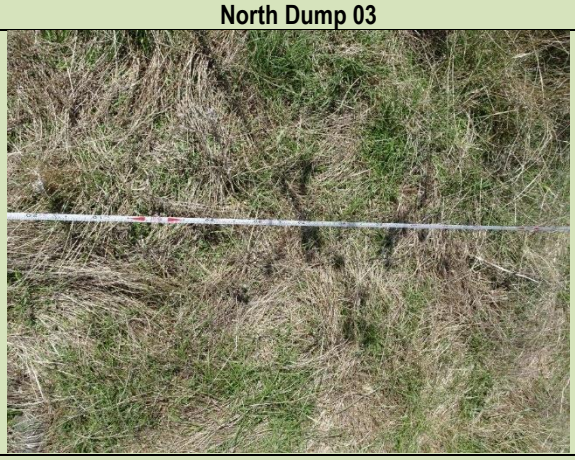


Figure 5-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2023.

Table 5-4. Examples of the different ground covers in the woodland monitoring sites in 2023.

South Dump04	South Dump05
	
South Dump07	**South Dump08**
	

South Dump 10	North Dump 01
	
North Dump 02	**North Dump 03**
	
RfWood01	**RfWood02**
	
RWood05(1)	**RWood05(2)**
	

5.2.2 Tree and mature shrub populations

5.2.2.1 Density

The total density of live trees and mature shrubs (>5cm dbh) recorded in the woodland reference sites was highly variable with a further increase in density recorded in RWood01 and RWood05 this year, as saplings had grown. The resultant tree densities were 8 – 37 trees per 50 x 20m (0.1 ha) plot, equating to a stem density of 80 – 370 trees per hectare (Figure 5-6).

There continues to be an absence of trees and mature shrubs in the younger rehabilitation site South Dump 10 and there has been no change in North Dump 03 with 1 individual. While tree and mature shrub densities have increased in North Dump 01 and North Dump 02 they remained low with 4 – 20 individuals. In the remaining rehabilitation sites on the South Dump, there were 7- 26 individuals. Sites South Dump 05, 07, 08 and North Dump 02 had densities that were comparable to the woodland reference sites this year.

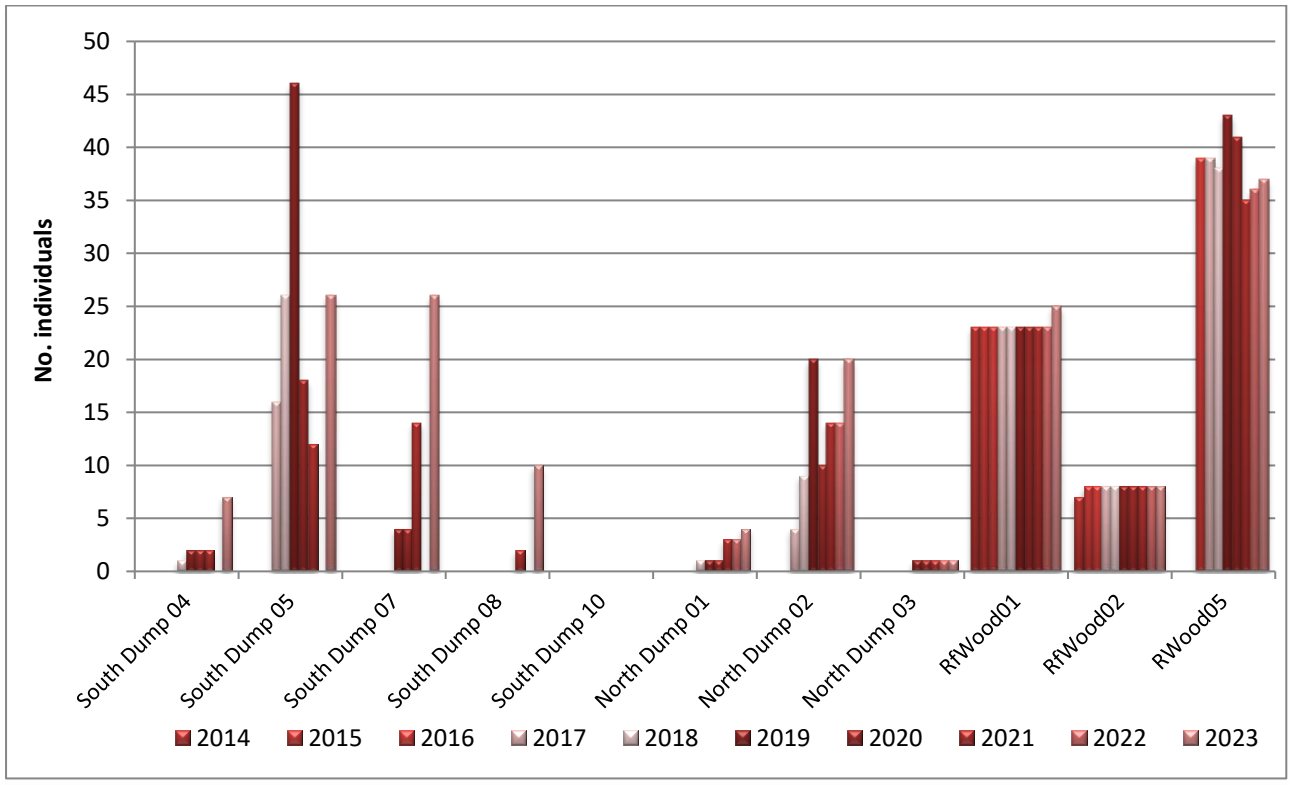


Figure 5-6. Tree and mature shrub densities (>5cm dbh) in the woodland monitoring sites.

5.2.2.2 Composition

The composition of the tree and mature shrub populations is highly variable across the range of sites, with eucalypts being the dominant species in the woodland reference sites and providing 95 – 100% of individuals at these sites. In the mine rehabilitation areas where mature individuals were recorded, eucalypts provided 60 – 85% of the population in two sites South Dump 07 and 08, with the remainder being mature acacias (Figure 5-7).

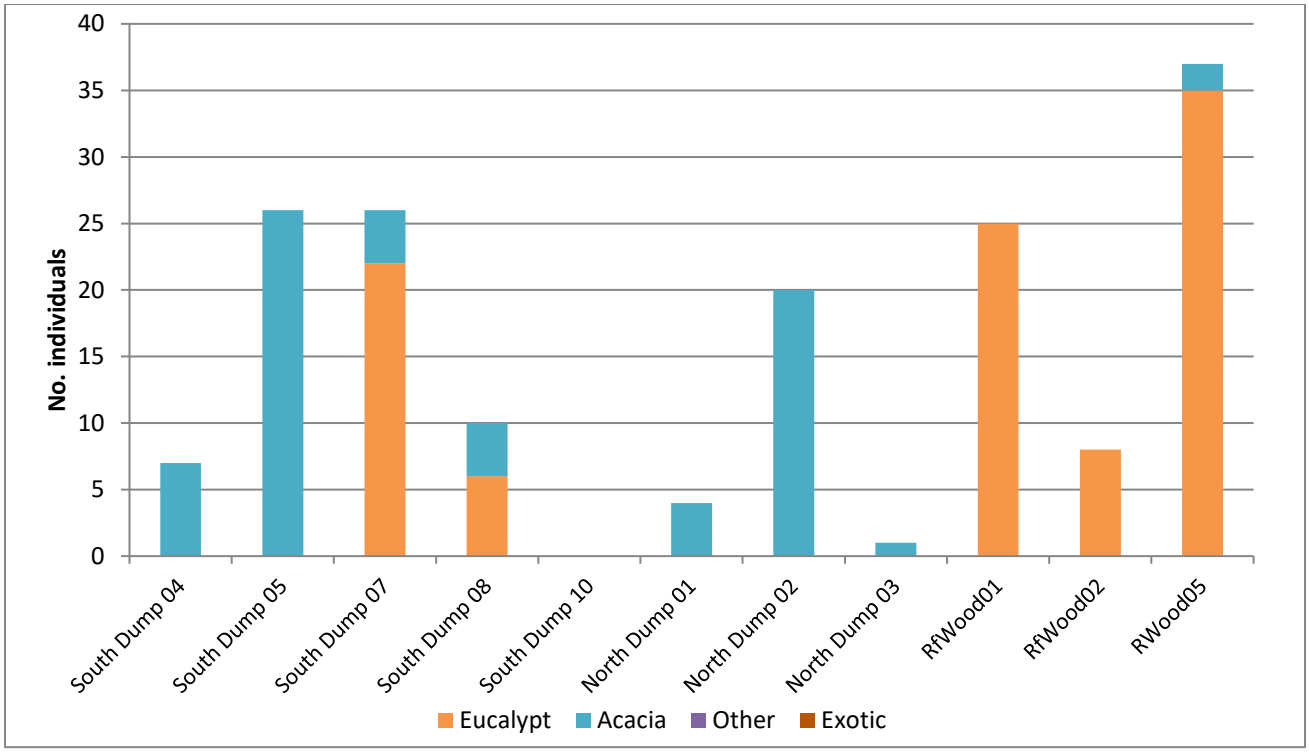


Figure 5-7. Composition of the tree and mature shrub populations in 2023.

5.2.2.3 **Condition**

The average dbh recorded in the reference sites ranged from 26 – 70 cm with the smallest being 7 cm and the largest 95 cm. Trunk diameter in rehabilitation sites on the North Dump ranged from 5 – 13 cm, with the average being 8 - 9 cm (Table 5-5). On the South Dump tree diameters were 8 – 15 cm on average with some being up to 20 cm at South Dump 04.

Trees and mature shrubs in the woodland reference sites were predominantly in good to moderate health this year however, a small number were stressed in RfWood01 and RWood05 and 8 – 18% were stags [dead]. In the reference sites 40 – 78% of the tree population contained reproductive structures such as buds, flowers or fruits (Table 5-5). RfWood02 contained tree hollows (>5cm) with 44% of the tree population bearing suitable habitat hollows respectively, while fewer were recorded in the remaining two sites. Mistletoe was not recorded in any site.

In sites on the North Dump, most individuals were also in good to moderate health, however 25% were in a state of advanced dieback in North Dump 01, while 33% had died in North Dump 02. The rehabilitation sites were too young to contain tree hollows or mistletoe, however reproductive structures (buds) were recorded in North Dump 02 and 03. In sites on the South Dump, all individuals were in good to moderate health, however 55% of the mature acacias had died in South Dump 05 and 7% were dead in South Dump 07. All individuals had reproductive structures.

5.2.2.4 **Species**

In the reference sites, the tree populations were comprised of 1 – 4 species of tree and mature shrubs (Table 5-5). The most dominant species were *Eucalyptus melliodora* (Yellow Box), *E. albens* (White Box) and *E. goniocalyx* (Bundy Box), with *E. macrorhyncha* (Red Stringybark), *E. bridgesiana* (Apple Box), *Acacia dealbata* (Silver Wattle) and *A. implexa* (Hickory) typically occurring in fewer numbers.

The rehabilitation sites on the South and North Dump typically had tree populations comprised only of mature *A. dealbata.* Additional species recorded include *Acacia implexa* (Hickory), *A. filicifolia* (Fern-leaved Wattle), *A. penninervis* (Mountain Hickory), *Eucalyptus goniocalyx* (Bundy Box), *E. albens* (White Box) and/or *E. bridgesiana* Apple Box).

Table 5-5. Trunk diameters and condition of the trees and mature shrubs in the woodland monitoring sites in 2023.

Site Name	No species	Average dbh (Cm)	Max dbh (cm)	Min dbh (cm)	Total trees	No. with multiple limbs	% Live trees	% Healthy	% Medium Health	% Advanced Dieback	% Dead	% Mistletoe	% Flowers / fruit	%. Trees with hollows
South Dump 04	1	15	20	8	7	3	100	71	29	0	0	0	100	0
South Dump 05	3	8	16	5	58	6	45	24	21	0	55	0	14	0
South Dump 07	4	11	18	6	28	6	93	79	14	0	7	0	21	0
South Dump 08	4	8	10	5	10	0	100	60	40	0	0	0	20	0
South Dump 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Dump 01	1	9	13	5	4	3	100	50	25	25	0	0	0	0
North Dump 02	1	8	11	5	30	4	67	20	47	0	33	0	40	0
North Dump 03	1	9	9	9	1	0	100	0	100	0	0	0	100	0
RfWood01	**2**	**33**	**91**	**8**	**25**	**10**	**92**	**60**	**28**	**4**	**8**	**0**	**72**	**4**
RfWood02	**1**	**70**	**95**	**31**	**9**	**1**	**89**	**56**	**33**	**0**	**11**	**0**	**78**	**44**
RWood05	**4**	**26**	**76**	**7**	**45**	**12**	**82**	**11**	**60**	**11**	**18**	**0**	**40**	**9**

5.2.3 Shrubs and juvenile trees

5.2.3.1 **Density**

The density of shrubs and/or juvenile trees (<5cm dbh) recorded in the woodland reference sites was highly variable with only 3 – 4 individuals recorded in RfWood01 and RfWood02, while more seedlings were recorded in RWood05 this year with 142 seedlings. The density of shrubs and/or juvenile trees (<5cm dbh) recorded in the woodland rehabilitation sites was also highly variable between sites with 8 - 317 individuals on the South Dump, while there were 152 - 296 individuals on the North Dump. Despite having shown a declining trend over the past few years, all rehabilitation sites had more shrubs and juvenile trees than the reference sites (Figure 5-8, Table 5-6).

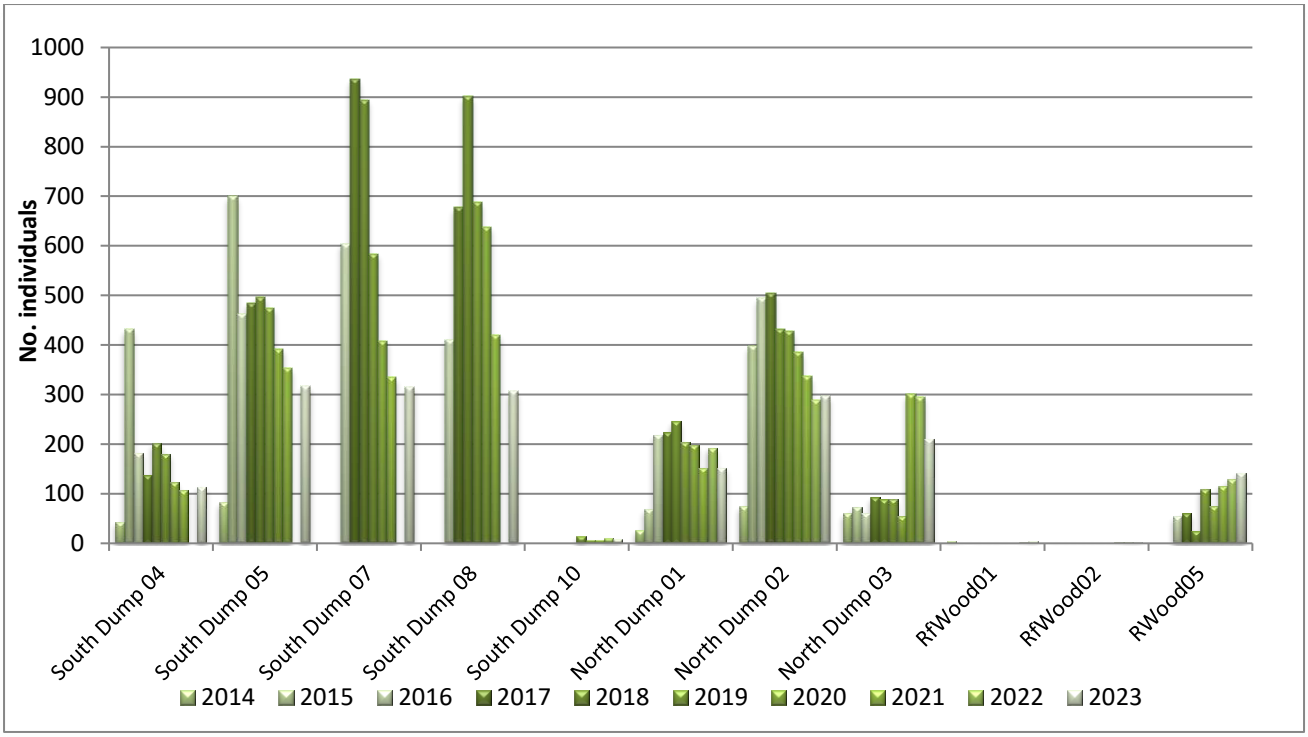


Figure 5-8. Population densities of shrubs and juvenile trees recorded in the woodland monitoring sites.

5.2.3.2 **Composition**

The composition of the shrub and juvenile tree populations is highly variable across the range of sites, with limited eucalypt seedlings in two reference sites this year. In the rehabilitation sites, the vast majority of individuals were acacias, however some sites also had volunteer *Cassinia Sifton* (Sifton Bush). Sites South Dump 05 and South Dump 10 also had some exotic *Rubus fruticosus* (Blackberry) and so did RfWood01, while *Crataegus monogyna* (Hawthorn) seedlings continue to be recorded in RWood05 (Figure 5-7).

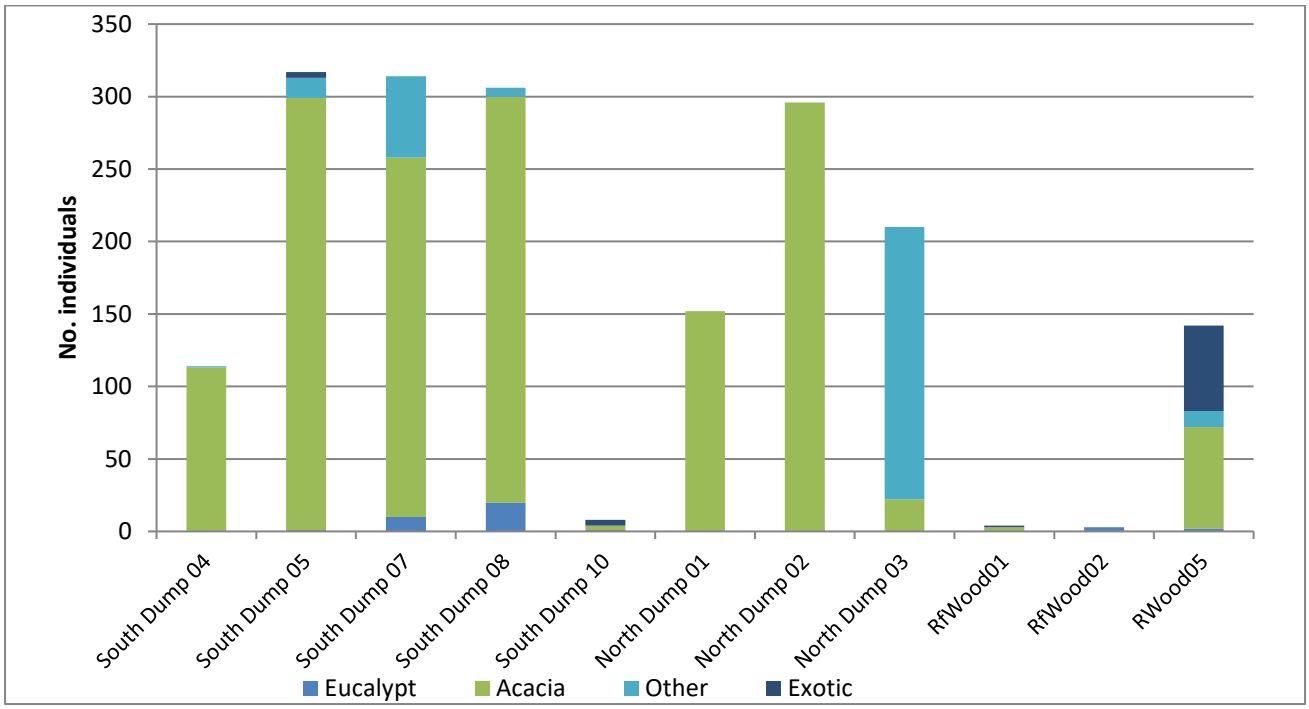


Figure 5-9. Composition of the shrub and juvenile tree populations in 2023.

5.2.3.3 **Diversity**

In the reference sites with juvenile trees and shrubs there were 1 – 9 species. The most common shrubs and juvenile tree species in the woodland reference site were *A. dealbata, A. decora, Cassinia sifton [arcuata], A. implexa* and *Brachychiton populneus* (Kurrajong) and/or juvenile *E. albens or E. goniocalyx.* There were also numerous exotic shrubs in RWood05 including *Crataegus monogyna* (Hawthorn), *Ligustrum lucidum* (Privet), *Rubus fruticosus* (Blackberry) and *Rosa rubiginosa* (Sweet Briar) which collectively comprised 42% of the shrub population.

The rehabilitation sites on the South and North Dump had a relatively high diversity of shrubs and juvenile trees with 3 - 16 different species with these typically containing a proportionately high density and diversity of acacias. On the North and South Dump, *A. buxifolia* tended to be the most abundant species followed by *A. dealbata* and *A. vestita*. Other occasional species may have included *A. spectabilis* (Mudgee Wattle), *A. genistifolia* (Early Wattle), *A. verniciflua* (Varnish Wattle), *A. penninervis* (Mountain Hickory), *A. decora* (Western Golden Wattle), *A. filicifolia* (Fern leaved Wattle), *A. melanoxylon* (Blackwood), *A. paradoxa* (Kangaroo Thorn) and volunteers of Cassinia *sifton. O*ther occasional species may have included *Daviesia leptophylla, Leptospermum continentale, Hakea sp., Pultenaea sp.* and the native vine *Hardenbergia violacea* (Happy Wanderer). Eucalypts were recorded more frequently in South Dump 07 and 08, with common species being juvenile *Eucalyptus albens, E. goniocalyx, E. bridgesiana, E. melliodora* and *E. polyanthemos* (Red Box).

Eucalyptus viminalis (Ribbon Gum), *E. dives* (Broad-leaved Peppermint) and *E. macrorhyncha* have also been previously recorded in sites that are no longer assessed. While eucalypt densities were somewhat limited on rehabilitation areas, sites that did not presently contain eucalypts included South Dump 04 and all three sites on the North Dump.

Table 5-6. Shrubs and juvenile trees recorded in each height class in the woodland monitoring sites in 2023.

Site Name	0-0.5m	0.5-1.0m	1.0-1.5m	1.5-2.0m	>2.0m	Total	No. species	% endemic
South Dump 04	9	9	17	45	34	114	6	100
South Dump 05	6	2	10	38	261	317	10	99
South Dump 07	8	14	58	108	126	314	11	100
South Dump 08	26	56	106	74	44	306	16	100
South Dump 10	5	2	0	0	1	8	3	50
North Dump 01	17	6	27	61	41	152	4	100
North Dump 02	4	12	20	110	150	296	4	100
North Dump 03	35	135	27	11	2	210	4	100
RfWood01	**4**	**0**	**0**	**0**	**0**	**4**	**3**	**75**
RfWood02	**1**	**1**	**0**	**1**	**0**	**3**	**1**	**100**
RWood05	**66**	**39**	**34**	**2**	**1**	**142**	**9**	**58**

5.2.3.4 **Height class**

In the reference sites, most seedlings tended to be less than 0.5m in height and almost all were less than 1.5m. In the rehabilitation areas, all height classes were represented however most individuals tended to be taller than 2.0m, indicating good growth and development (Table 5-6, Figure 5-10).

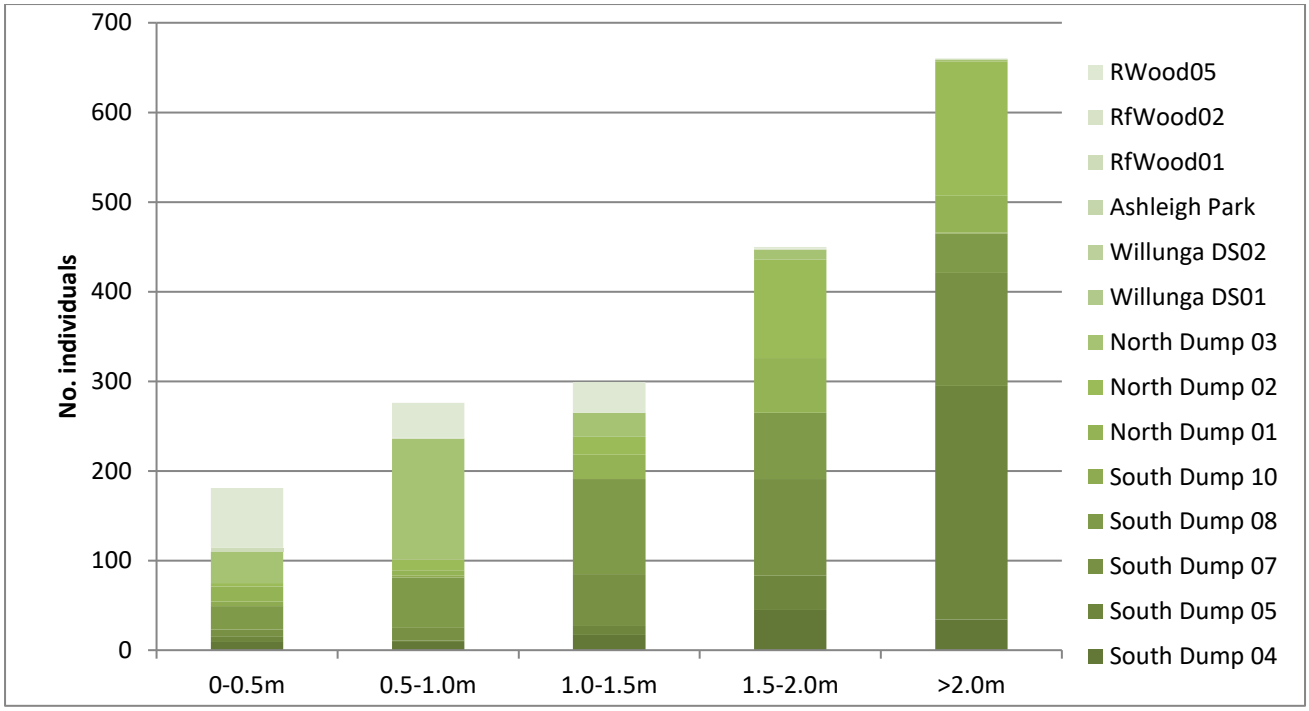


Figure 5-10. Number of individuals within the five height classes.

5.2.4 Total ground cover

Total ground cover is a combination of leaf litter, annual plants, cryptogams, rocks, logs and live perennial plants (<0.5m in height). All monitoring sites had improved levels of ground cover this year, with 99 – 100 % being recorded in the reference sites. There was 80 – 99.5% cover in sites on the South Dump, while there was 96 – 99% cover on the North Dump. Small bare patches from macropod disturbance and/or camps may have reduced ground cover in some sites (Figure 5-11).

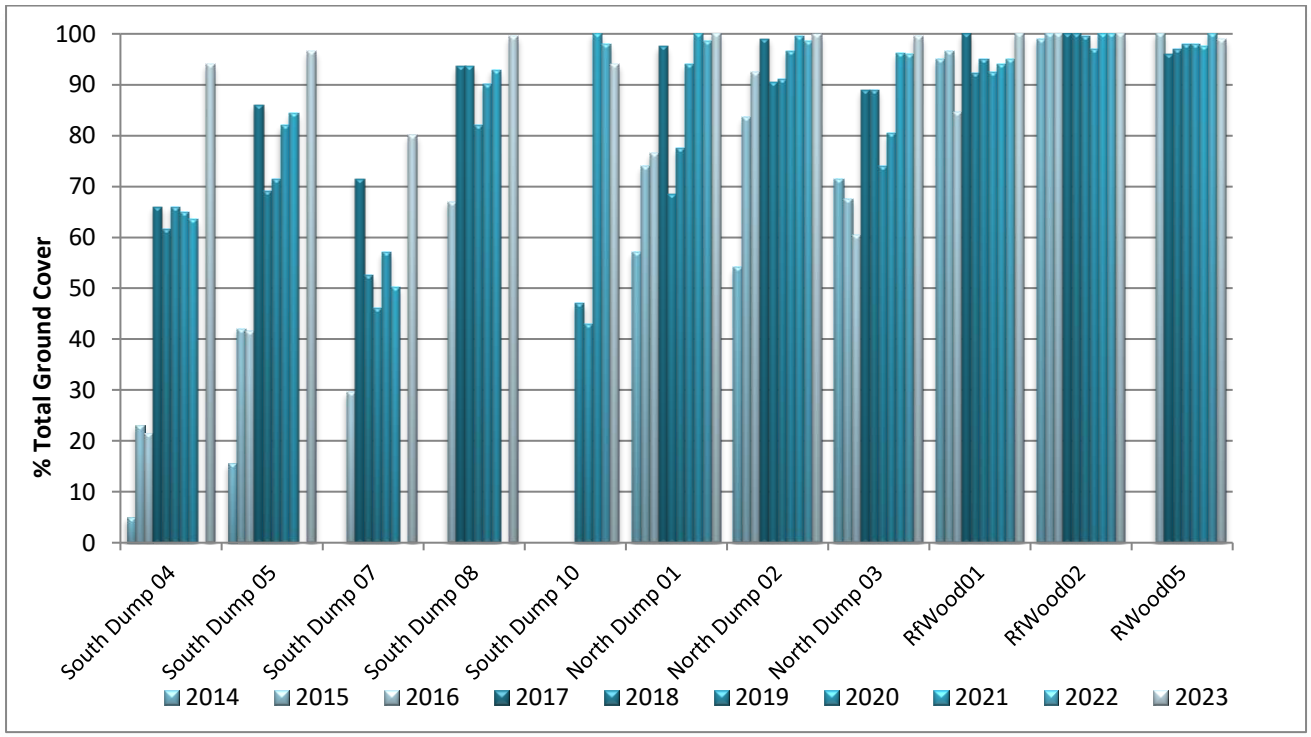


Figure 5-11. Total ground cover recorded in the woodland monitoring sites.

5.2.5 Structural composition

This year, ground cover in the reference were more similar to each other and all were dominated by dead leaf litter (65 - 72%) and contained a sparse scattering of annual (3 – 21%) and perennial (7 - 24%) ground covers. In two sites there was a small amount of cover from fallen branches and in RfWood02 there continued to be a rocky outcrop providing additional rock cover. Cryptogam cover was absent due to the high levels of plant and litter covers (Figure 5-12).

In rehabilitation sites, dead litter provided 38 – 75% ground cover, while perennial ground covers or low hanging shrubs provided 11 – 29% cover. Annual plant cover was highly variable and ranged from 2 (South Dump 05) – 50% (North Dump 01), while some sites had scattered rocks. Cryptogams were low in abundance in most sites.

The three woodland reference sites had 25 – 40% mature canopy cover (>6.0 m) but typically there was limited foliage cover recorded in the lower height classes, a characteristic feature of open grassy woodland communities. In the rehabilitation areas, establishing tree and shrub seedlings provided some foliage cover 0.5 – 2.0 m in height in all sites. There was also some cover 2.0 – 4.0m tall in the older sites on the South Dump and in North Dump 02.

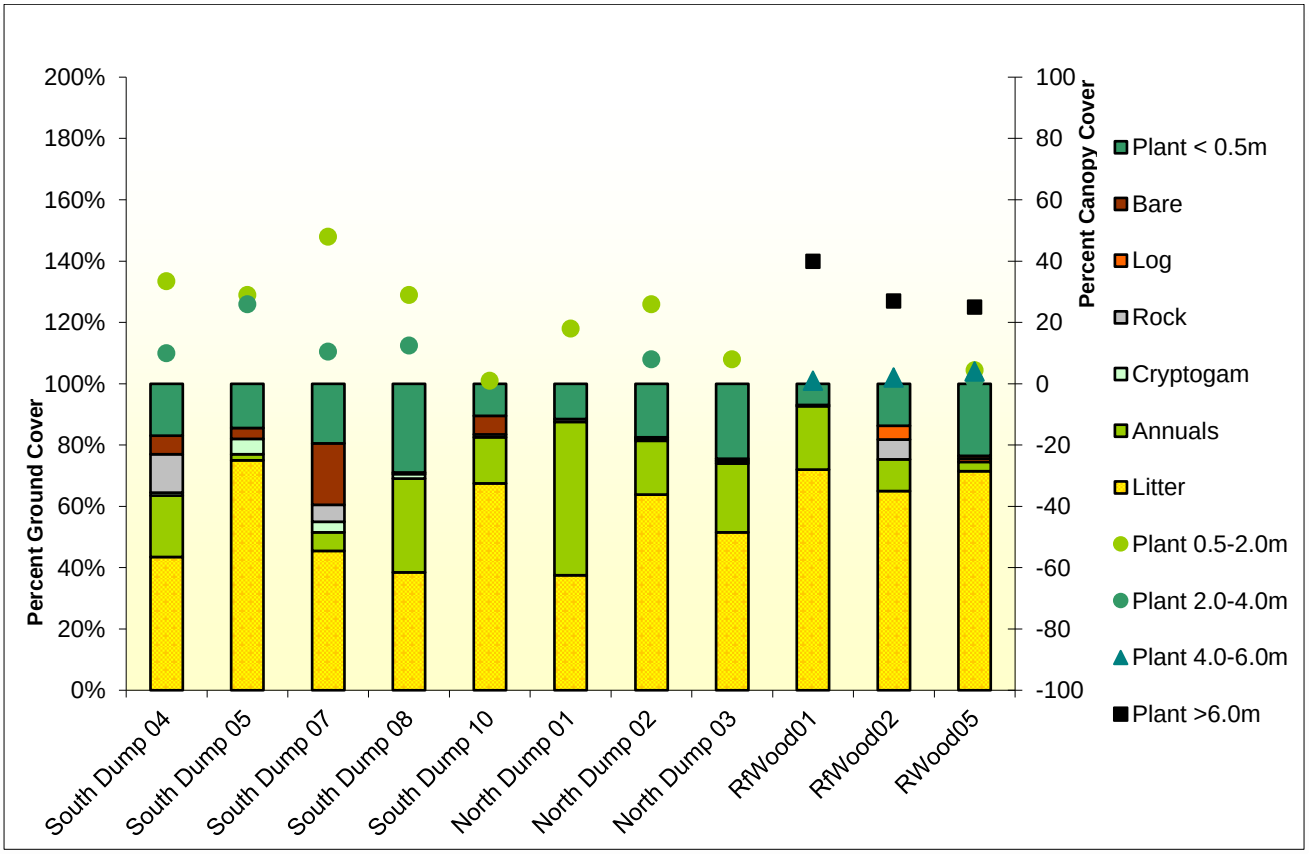


Figure 5-12. Average percent ground cover and projected foliage cover recorded in the woodland monitoring sites in 2023.

5.2.6 Floristic Diversity

There has been no consistent change in total species diversity across the range of monitoring sites, however the level of diversity has tended to fluctuate with the seasonal conditions and degree of grazing intensity. In the rehabilitation areas floristic diversity may also be associated with the successional development and/or management intervention of the area. This year there was increased diversity in RfWood01, a minor reduction in

RfWood02 and little change in RWood05 with a total of 21 – 60 plant species recorded in the 0.1 ha woodland site monitoring quadrats (Figure 5-13). Native species were more common in two sites where there were 9 – 22 species, while in RWood02, exotic species were more common and a total of 12 – 24 exotics were recorded across the three sites (Figure 5-14).

In sites on the South Dump, diversity had increased in some and decreased in others where a total of 31 – 56 species were recorded. There were 15 – 34 native species (Figure 5-14) and 11 – 24 exotic species (Figure 5-15). On the North Dump there were 28 – 40 species. Of these 9 – 11 were native and 19 – 29 were exotic. All sites except South Dump 10 had an acceptable diversity of native species compared to the reference sites, while all sites except North Dump 01 had an acceptable diversity of exotic species. A comprehensive list of flora species recorded in the monitoring sites is provided in Appendix 2.

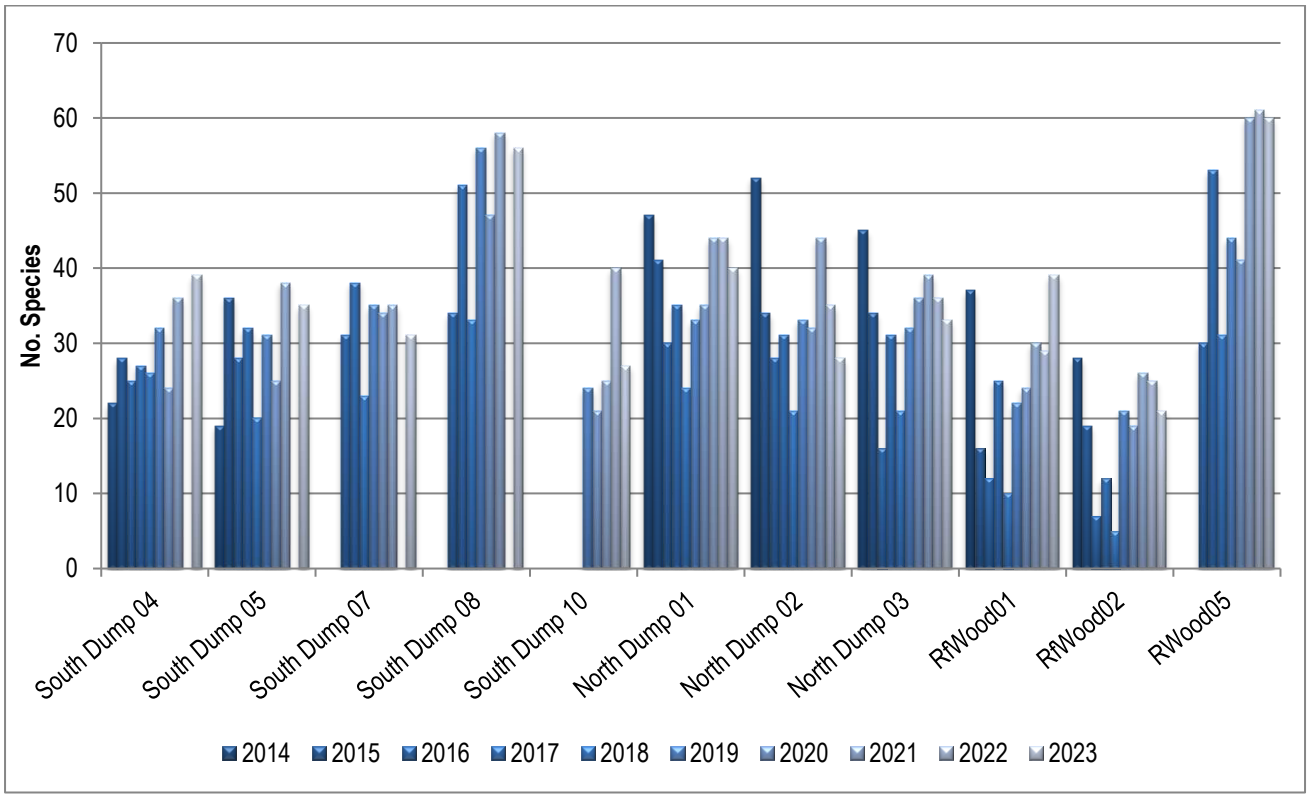


Figure 5-13. Total species diversity recorded in the woodland sites.

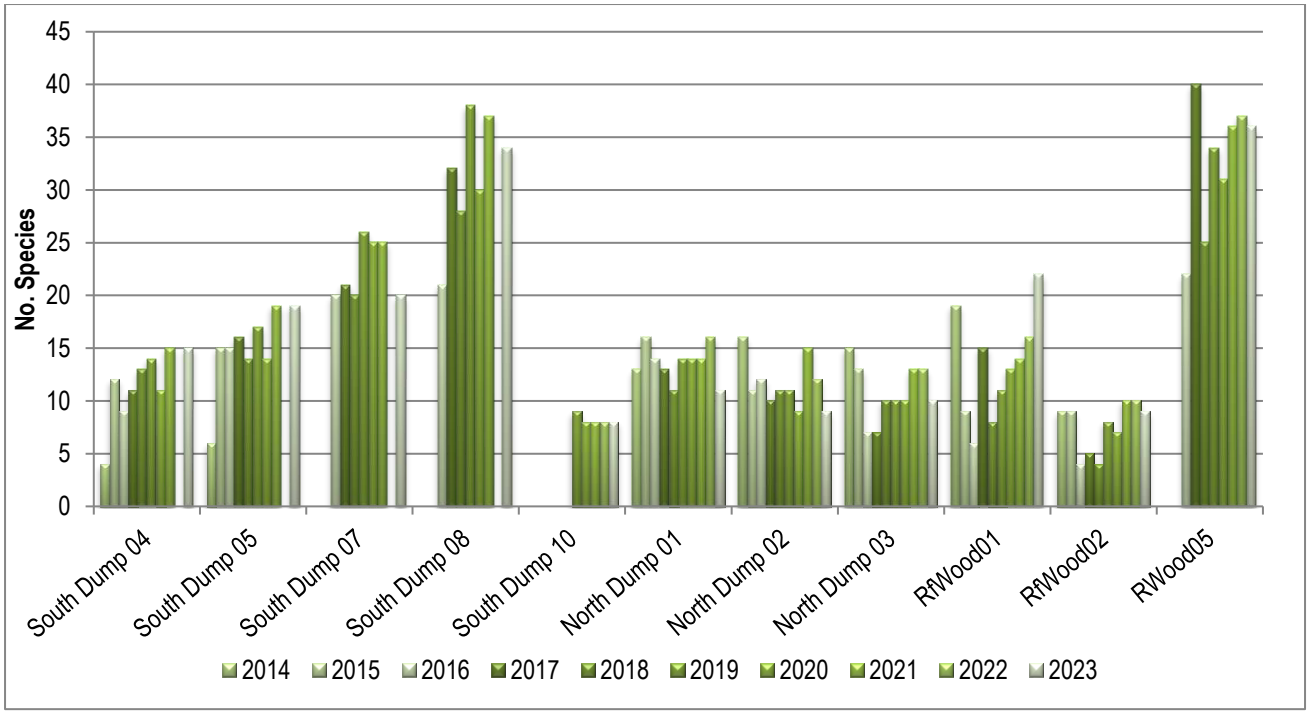


Figure 5-14. Native species diversity recorded in the woodland monitoring sites.

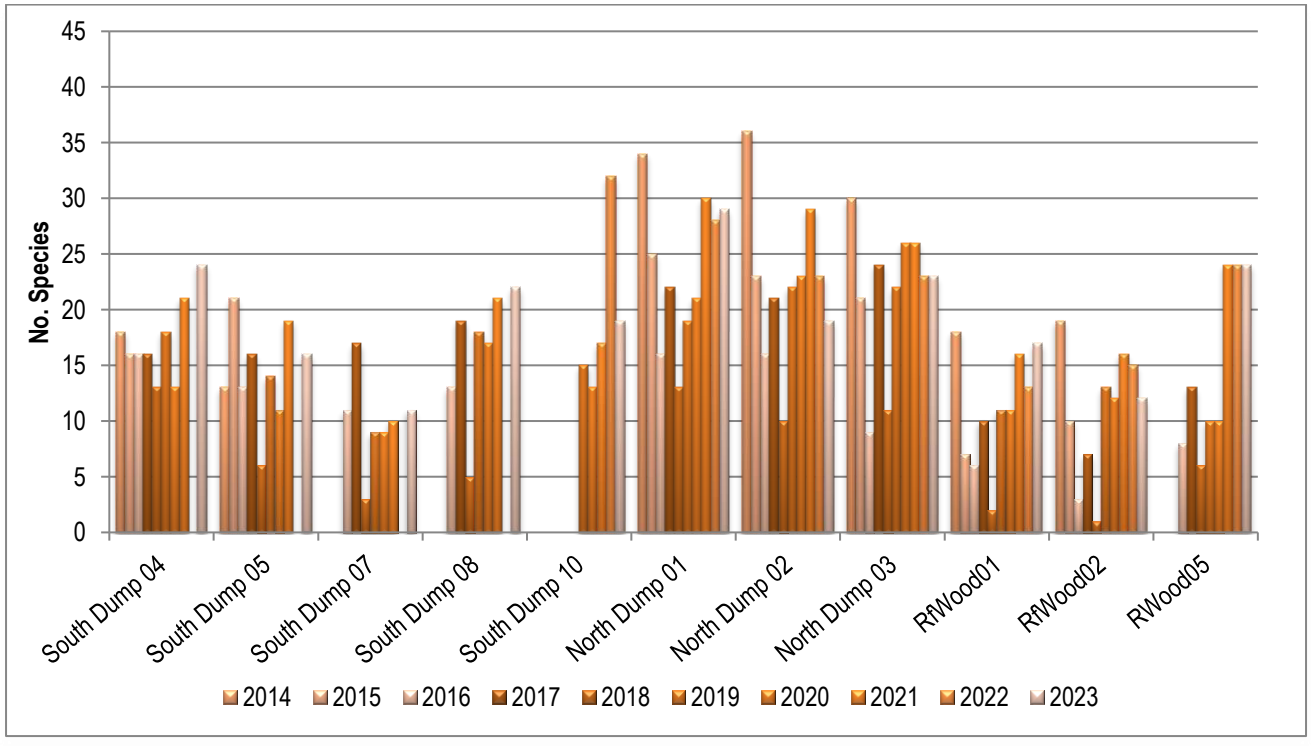


Figure 5-15. Exotic species diversity recorded in the woodland monitoring sites.

5.2.7 Native ground cover abundance

Native ground cover abundance is an additional ecological indicator which provides a measure of the cover abundance of the native vegetation and an indication of the overall weediness of the sites (Figure 5-16). Similarly, to the floristic diversity data, the proportionate ground cover provided by native plants has also been strongly influenced by the seasonal conditions and degree of grazing pressure. Dry conditions usually result in the lower abundance of exotic annual plants thus tending to increase the cover provided by live native perennial species.

This year, there has been a decrease in the proportion of native plant cover in the reference sites where native plants provided 18 - 72% of the live plant cover.

The abundance of native ground cover has also tended to decrease in the rehabilitation site this year where there was 10 – 78% native plant cover on the South Dump, where the least native cover was recorded in South Dump 10. On the North Dump native plants provided 23 – 38% cover. While exotic plants may have been more abundant in most sites, all rehabilitation sites, except South Dump 10 had an acceptable cover of native plants compared to the RfWood02 reference sites this year.

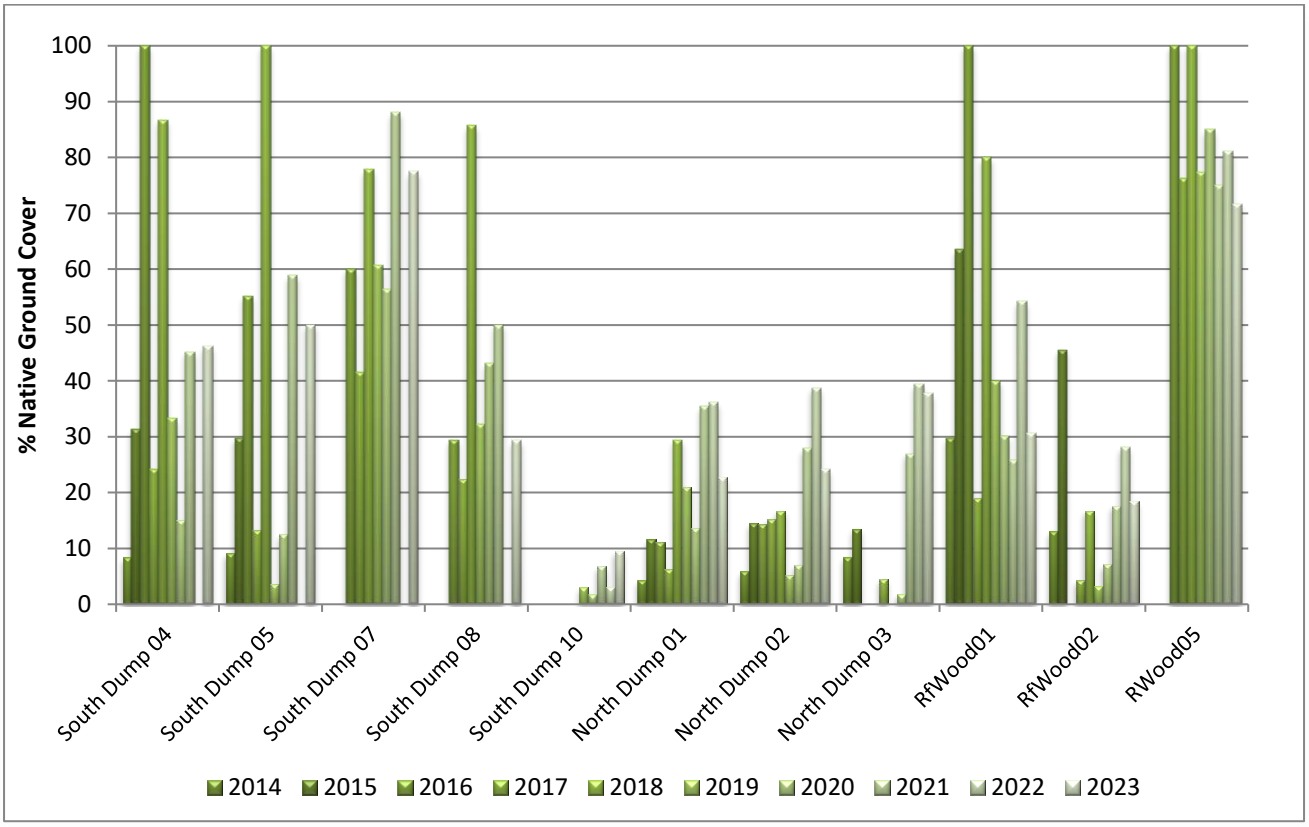


Figure 5-16. Native cover abundance recorded in the woodland monitoring sites.

5.2.8 Most common species

The most common species, those that were recorded in at least six of the eight woodland rehabilitation sites in 2023 is given in Table 5-7. The exotic species *Avena fatua* (Wild Oats), *Modiola caroliniana* (Red-flowered Mallow) and *Phalaris aquatica* (Phalaris) were recorded in all rehabilitation sites and so were the native perennials *Oxalis perennans* (Yellow Wood-sorrel) and *Rytidosperma racemosum* (Wallaby Grass).

Other common species included exotics such as *Bromus diandrus* (Great Brome), *Conyza bonariensis* (Fleabane), *Rumex acetosella* (Sheep Sorrel), *R. crispus* (Curled Dock), *Sonchus oleraceus* (Milk Thistle) and *Trifolium subterraneum* (Subterraneum Clover). Other common natives included *Acacia buxifolia*, *A. vestita*, *A. dealbata*, *Geranium solanderi* (Native Geranium) and *Senecio quadridentatus* (Cotton Fireweed). Many of these common species were also recorded in at least one of the woodland reference sites, reflecting their natural distribution within the local area, while others may have been sown as part of the rehabilitation program. A comprehensive list of species recorded in all woodland monitoring sites in 2023 has been included in Appendix 2.

Table 5-7. The most common species recorded in the woodland rehabilitation sites in 2023 and their occurrence in the woodland reference sites.

exotic	Scientific Name	Common Name	Habit	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total	RfWood01	RfWood02	RWood05
*	*Avena fatua*	Wild Oats	g	1	1	1	1	1	1	1	1	8		1	
*	*Modiola caroliniana*	Red-flowered Mallow	h	1	1	1	1	1	1	1	1	8			
	Oxalis perennans	Yellow Wood-sorrel	h	1	1	1	1	1	1	1	1	8	1	1	1
*	*Phalaris aquatica*	Phalaris	g	1	1	1	1	1	1	1	1	8		1	
	Rytidosperma racemosum	Wallaby Grass	g	1	1	1	1	1	1	1	1	8	1	1	1
	Acacia buxifolia	Box-leaved Wattle	s	1	1	1	1	1	1	1		7			
	Acacia vestita	Boree	s	1	1	1	1	1	1	1		7			
*	*Bromus diandrus*	Great Brome	g	1	1		1	1	1	1	1	7	1	1	1
*	*Conyza bonariensis*	Fleabane	h	1		1	1	1	1	1	1	7	1		1
	Acacia dealbata	Silver Wattle	s	1	1	1	1	1	1			6	1		1
	Geranium solanderi	Native Geranium	h	1	1	1	1	1			1	6	1	1	1
*	*Rumex acetosella*	Sheep Sorrel	h	1	1	1	1	1		1		6	1		1
*	*Rumex crispus*	Curled Dock	h	1	1	1		1		1	1	6			
	Senecio quadridentatus	Cotton Fireweed	h	1		1	1	1		1	1	6	1	1	1
*	*Sonchus oleraceus*	Milk Thistle	h	1	1		1	1	1		1	6	1		
*	*Trifolium subterraneum*	Subterraneum Clover	h	1		1	1		1	1	1	6	1		

Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; c = cactus

5.2.9 Most abundant species

The most abundant species recorded in each of the rehabilitation monitoring sites this year are provided in Table 5-8. The most abundant species were those that collectively summed to a Braun-Blanquet total of 10 or more from the five replicated samples along the vegetation transect. The maximum score that can be obtained by any one species is 30.

The woodland reference sites were dominated by perennial grasses *Phalaris aquatica* (Phalaris) and *Rytidosperma racemosum* (Wallaby Grass) as well as exotic annuals *Bromus diandrus* (Great Brome) and in RfWood01 *Trifolium subterraneum* (Subterraneum Clover) was also relatively abundant. The composition of the rehabilitation areas was variable however all sites were dominated by exotic species such as those recorded in the woodland reference sites, and/or other annual grasses such as *Vulpia muralis* (Rats-tail Fescue) and *Bromus molliformis* (Soft Brome). Site South Dump 10 remained very weedy with *Silybum marianum* (Variegated Thistle) providing the most ground cover this year. Species and their abundance cover recorded at the individual sites is provided in Appendix 3.

Table 5-8. The most abundant species recorded in the woodland monitoring sites in 2023.

exotic	Scientific Name	Common Name	Habit	South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03	RfWood01	RfWood02	RWood05
*	*Bromus diandrus*	Great Brome	g	10								16	16	
*	*Phalaris aquatica*	Phalaris	g		14			12		15			15	
	Rytidosperma racemosum	Wallaby Grass	g			10						11		16
*	*Trifolium subterraneum*	Subterraneum Clover	h				15		21		17	11		
*	*Vulpia muralis*	Rats-tail Fescue	g				14							
*	*Silybum marianum*	Variegated Thistle	h					12						
*	*Bromus molliformis*	Soft Brome	g						12	10				

5.2.10 **Vegetation composition**

The composition of the vegetation as categorised by eight different growth forms is given in Figure 5-17, with these being highly variable between the sites. The reference sites were comprised by a high diversity of herbs with 10 - 32 species followed by grasses with 9 – 13 species. There were 1 – 4 species of tree and while one site had no shrubs, there were 3 - 8 different shrubs in the other two sites. There were 1 - 3 reed species however there were no sub-shrubs, vines or ferns.

In the rehabilitation sites, most sites had a composition that was comparable to the reference sites however there continued to be an absence of tree species in South Dump 04 and all three sites on the North Dump. Numerous sites also had a low diversity of grasses and reeds, while South Dump 07 had a slightly low diversity of herbs.

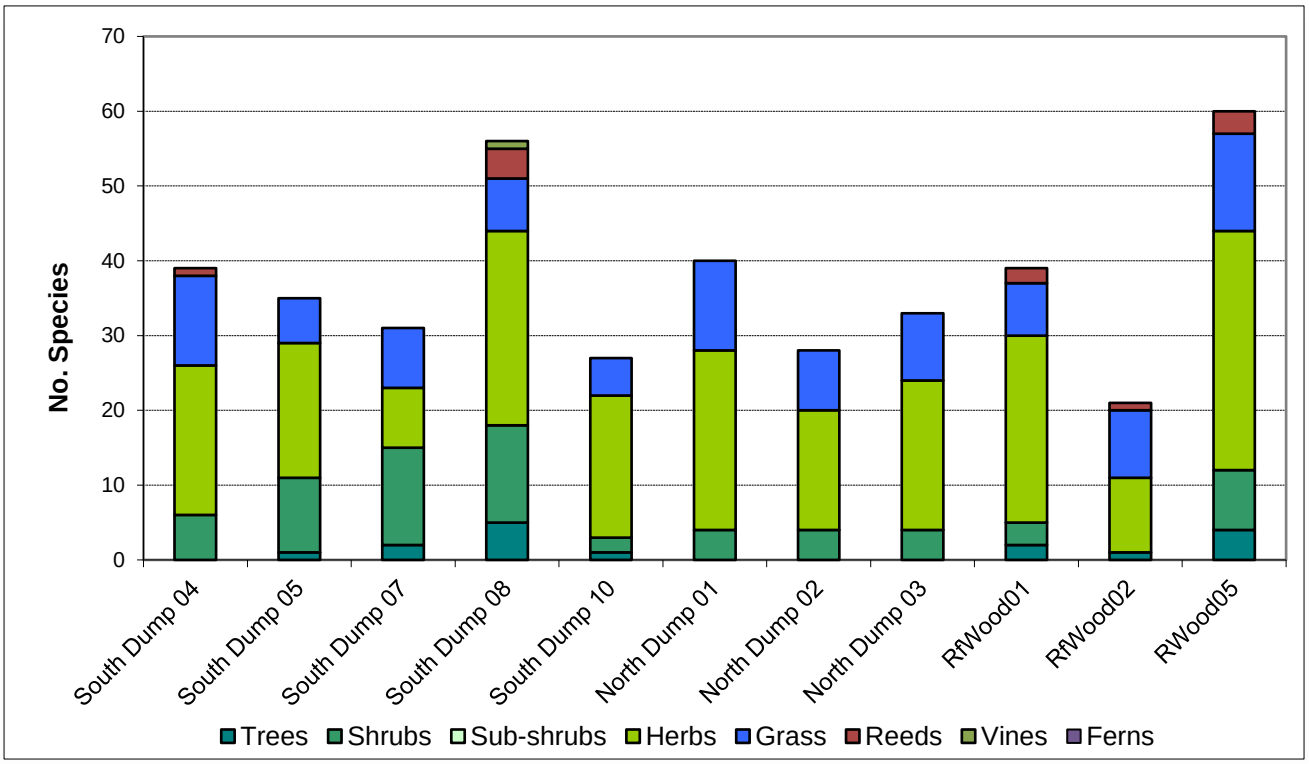


Figure 5-17. Vegetation composition of the woodland monitoring sites in 2023.

5.2.11 **Rill Assessment**

On the South and North Dump, minor rilling that has been recorded in previous years declined as ground covers became more established. Minor rilling continued to be recorded in South Dump 07 and North Dump 01 (Figure 5-18) however these appear to be stabilising with increased levels of ground cover.

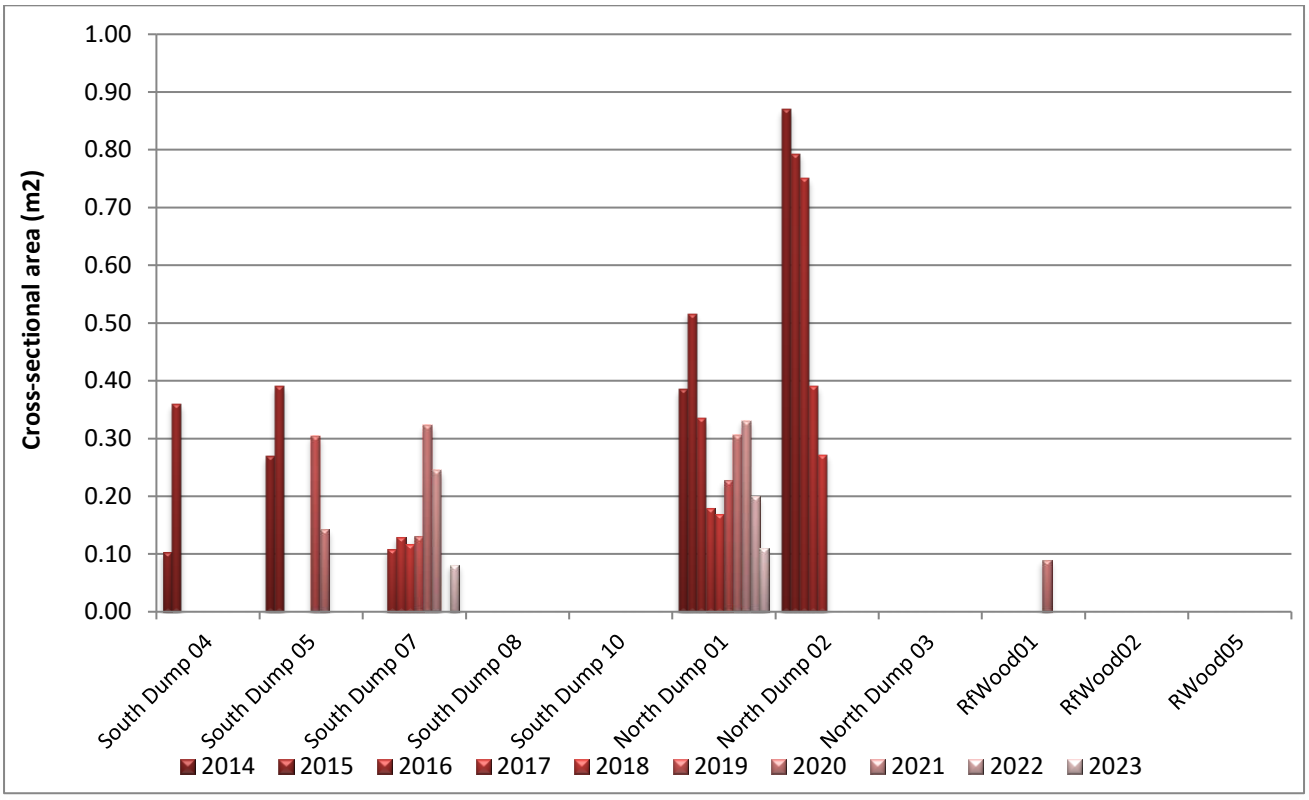


Figure 5-18. Sum of the cross-sectional area of the rills recorded in the woodland monitoring sites.

5.2.12 **Soil Analyses**

The following section provides the results of a select range of key soil characteristics. The full soil analyses report as provided by the NATA accredited laboratory is provided in Appendix 4.

5.2.12.1 **pH**

Figure 5-19 shows the pH recorded in the woodland rehabilitation sites compared to the woodland reference sites and "desirable" range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. The data indicates that there has been no consistent change in soil pH (1:5 water) across the range of woodland monitoring sites with most changes being minor and probably associated with inherent variations in the soils and random sampling techniques. This year the woodland reference sites had soil pH which ranged 6.2 – 7.1 indicating the soils in the local woodlands continue to be slightly acidic to neutral and within desirable agricultural levels (Bruce & Rayment 1982). Most rehabilitation sites had soil pH within this range or were within acceptable agricultural levels. In South Dump 05 and 08 however, pH was 5.4 and 5.5 respectively and strongly acidic.

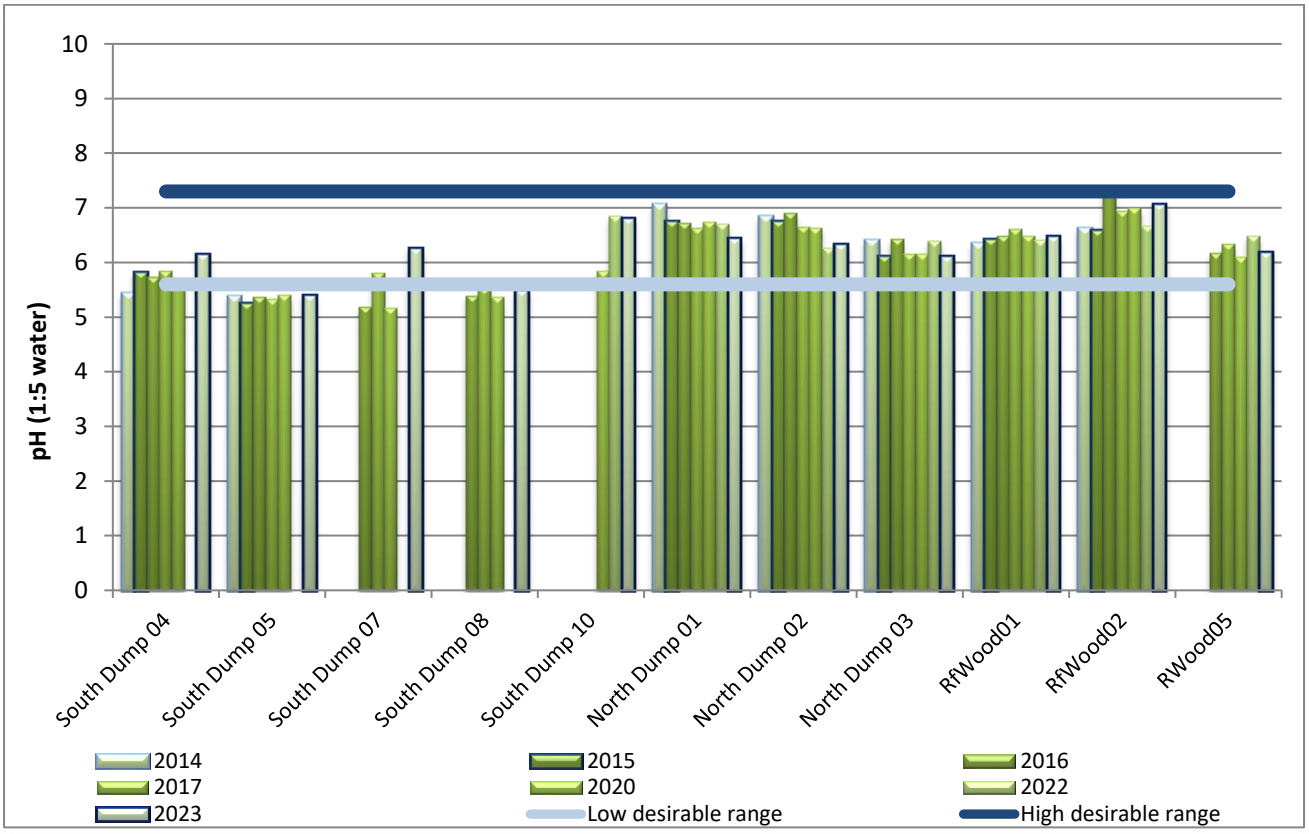


Figure 5-19. Soil pH recorded in the rehabilitation sites compared to the woodland reference sites and desirable agricultural range.

5.2.12.2 Conductivity

Figure 5-20 shows the Electrical Conductivity (EC) recorded in the rehabilitation sites compared to the woodland reference sites and "desirable" range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. There has been no consistent trend in the changes in Electrical Conductivity (EC) across the range of reference sites and in 2016 there was an unexplained and significant increase in EC was recorded in RfWood02. This year EC recorded in the reference sites ranged from 0.056 – 0.132 dS/cm and continued to be classified as non-saline (Slavich & Petterson 1993).

EC in some of the rehabilitation sites was very high when the sites were first established, however EC has shown a decreasing trend, or at least have declined from initial levels. This year, EC ranged from 0.032 - 0.098 dS/cm with all rehabilitation areas having acceptable EC levels and non saline soils.

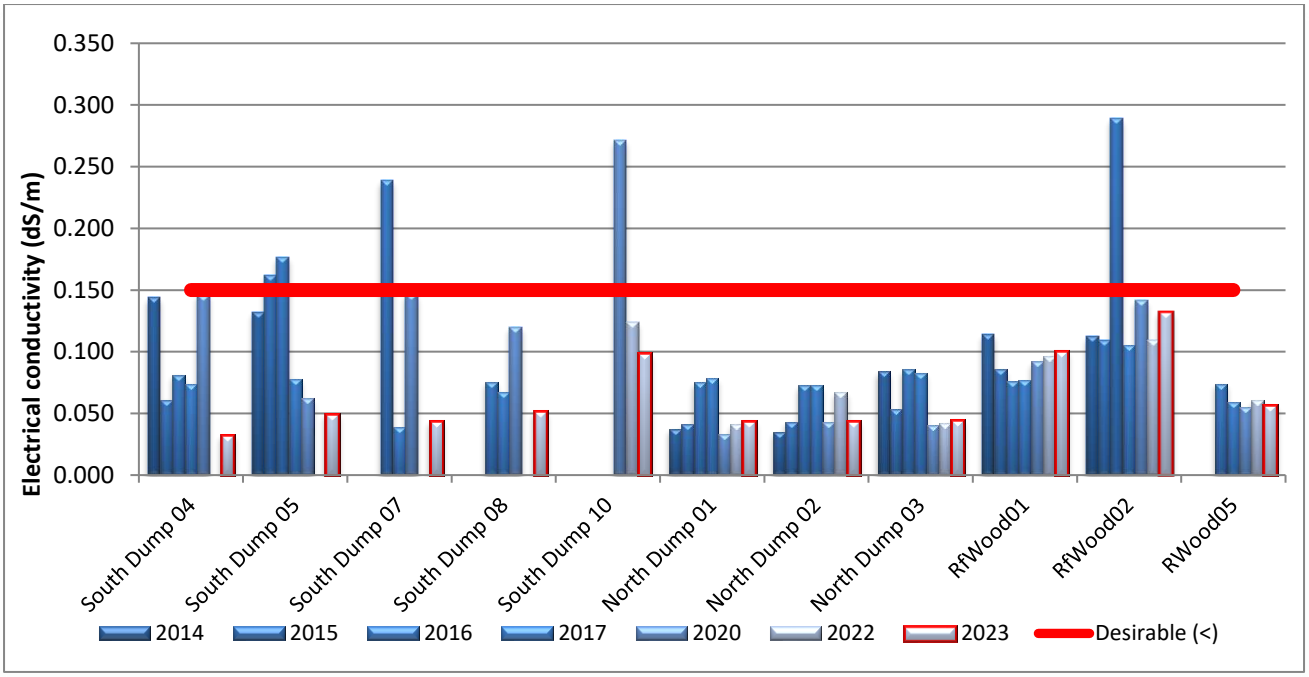


Figure 5-20. Electrical Conductivity recorded in the rehabilitation sites compared to the woodland reference sites and desirable agricultural levels.

5.2.12.3 Organic Matter

Organic Matter (OM) levels recorded in the woodland reference sites have been quite variable between sites as well as over the years probably as a result of natural changes in soil characteristics. This year OM in the reference sites remained very high with 7.5 – 11.0% OM (Figure 5-21). In the mine rehabilitation areas, soil OM remained low despite some marginal increases being recorded in most areas with OM ranging from 2.0 – 4.0%.

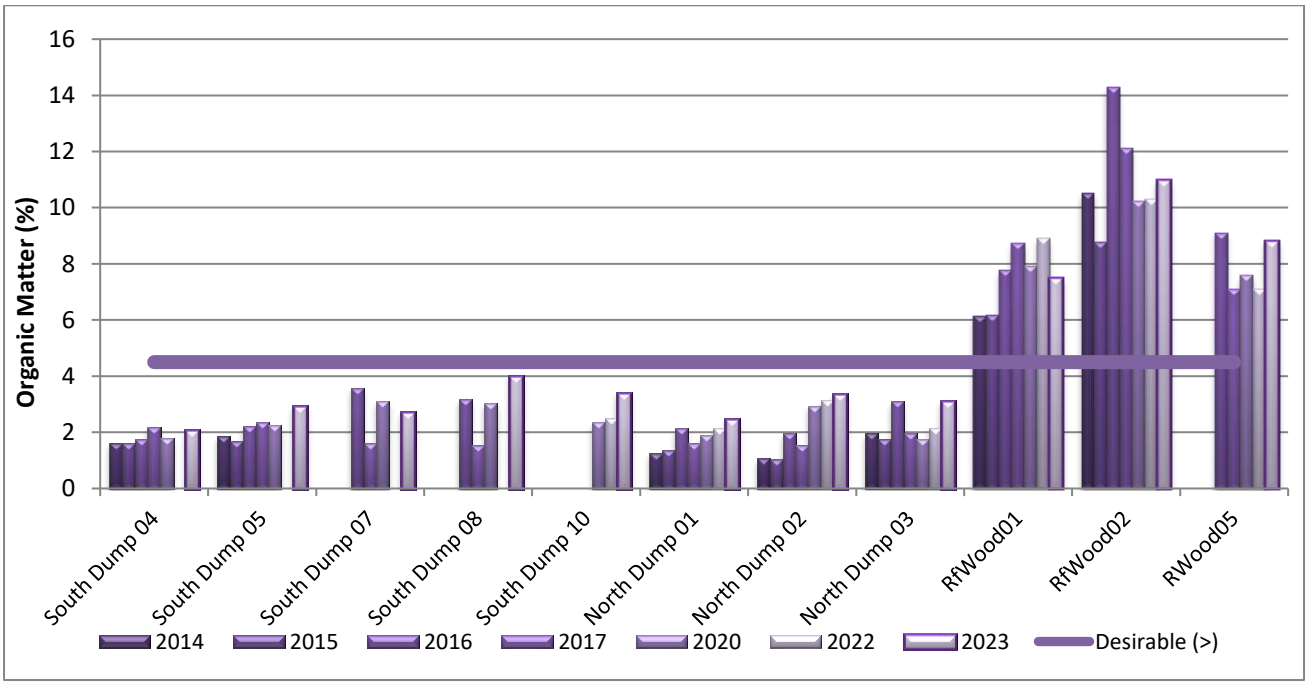


Figure 5-21. Organic Matter concentrations recorded in the rehabilitation sites compared to the woodland reference sites and desirable agricultural levels.

5.2.12.4 Phosphorous

There has been no consistent change in Phosphorous (P) levels across the range of woodland monitoring sites, with there being little significant change being recorded over the past few years. This year P concentrations ranged from 12 - 26 mg/kg in the reference sites and remained lower than desirable agricultural levels. Several rehabilitation sites on the South Dump (South Dump 04, 05, 07) continued to have low P concentrations of 11 – 14 mg/kg. While P was also low in South Dump 10 and North Dump 01, 02 and 03 compared to agricultural levels, most rehabilitation sites had acceptable P concentrations and were comparable to or higher than the local woodlands. South Dump 08 was an exception with P concentrations exceeding agricultural levels with 72 mg/kg (Figure 5-22).

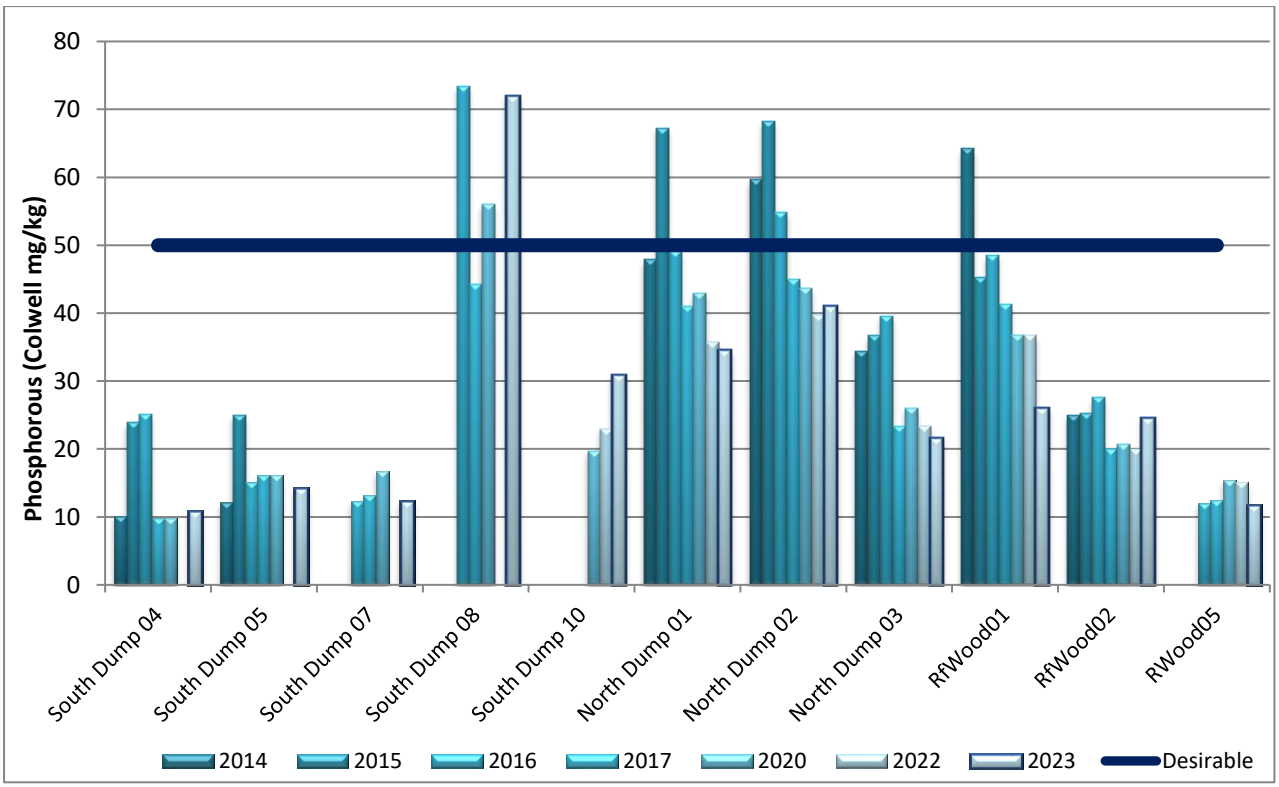


Figure 5-22. Phosphorous (Colwell) concentrations recorded in the rehabilitation sites compared to the woodland reference sites and desirable agricultural levels.

5.2.12.5 Nitrate

Nitrate (N) levels are often highly variable and have not shown any consistent trend across the range of sites, however N concentrations were often very high when the rehabilitation sites were first established with these having significantly declined since then. This year the woodland reference sites had N ranging from 1.2 – 10.9 mg/kg in, with N levels remaining slightly lower than the agricultural threshold this year (Figure 5-23). N concentrations in most of the rehabilitation sites remained relatively low with 0.8 – 5.6 mg/kg, with most sites except South Dump 07 having N concentrations comparable to the local woodlands. In South Dump 10 however, N remained high with 14.2 mg/kg and close to desirable agricultural levels.

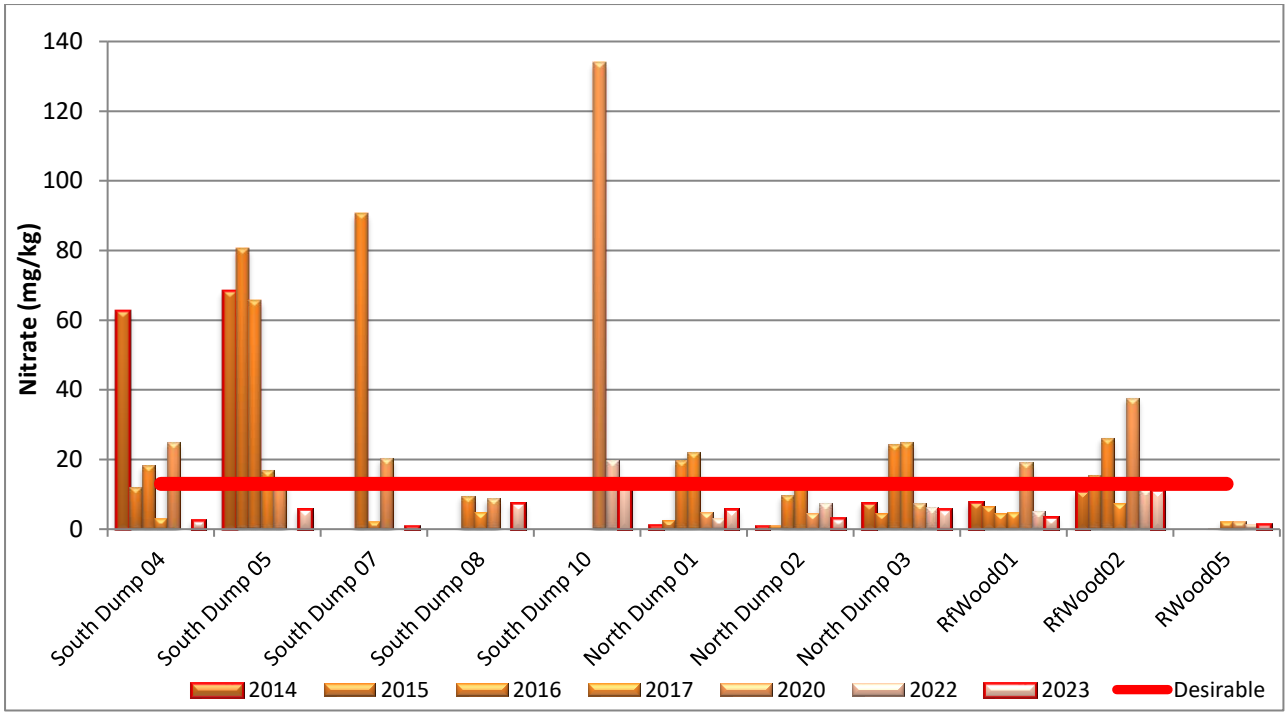


Figure 5-23. Nitrate concentrations recorded in the rehabilitation sites compared to the woodland reference sites and desirable agricultural levels.

5.2.12.6 Cation Exchange Capacity

Cation Exchange Capacity (CEC) is the capacity of the soil to hold the major cations (Calcium, Magnesium, Sodium and Potassium) and is also a measure of the potential fertility of the soil. There was no consistent trend in changes in CEC across the range of monitoring sites but in the reference sites CEC was highly variable between sites and ranged from 14.8 – 32.9 cmol+/Kg, with RfWood02 continuing to far exceed the desirable level (Figure 5-24). All rehabilitation sites on the South Dump had slightly lower and ranged from 6.9 – 11.8 cmol+/Kg, while on the North Dump CECs ranged from 12.2 – 16.5 cmol+/.

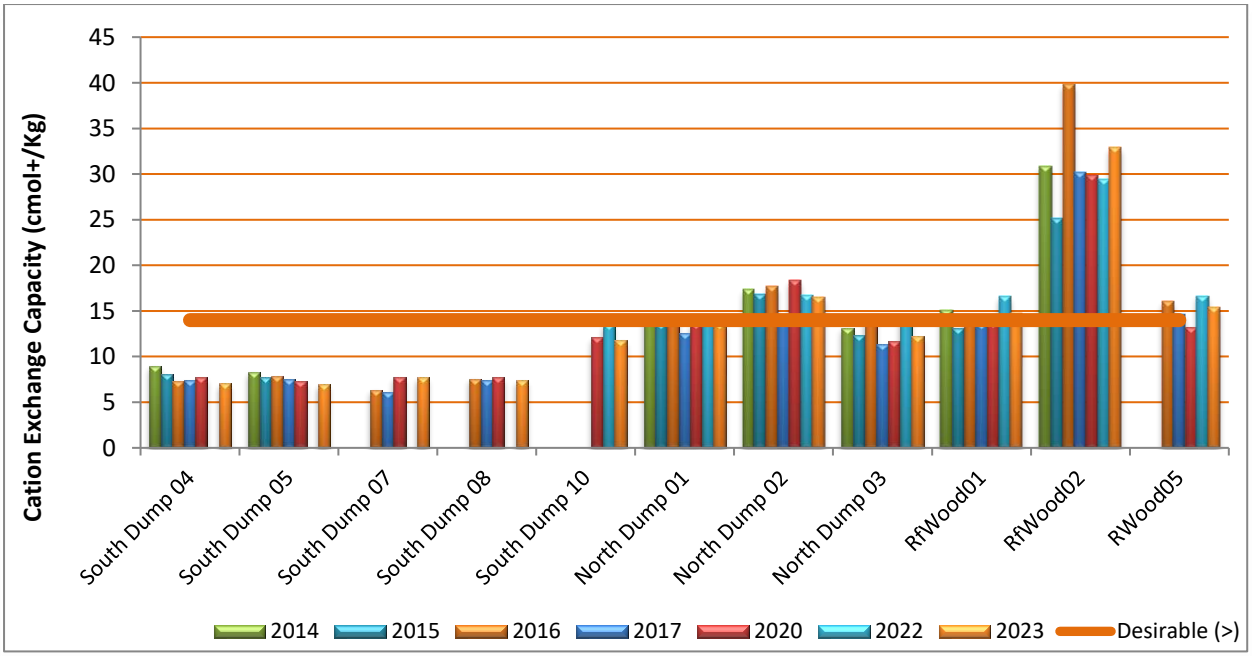


Figure 5-24. Cation Exchange Capacity recorded in the woodland rehabilitation sites compared to the upper and lower values from the woodland reference sites and desirable agricultural levels.

5.2.12.7 Exchangeable Sodium Percentage

Sodicity refers to a significant proportion of Sodium in the soil compared to other cations with soil considered to be sodic when there is sufficient sodium to interfere with its structural stability which often interferes with plant growth. Sodic soils tend to suffer from poor soil structure including hard soil, hardpans, surface crusting and rain pooling on the surface, which can affect water infiltration, drainage, plant growth, cultivation and site accessibility. This year the data indicate that ESP in all monitoring sites has further declined with ESP in the woodland reference remaining very low with 0.2 – 0.3% and non-sodic (Figure 5-25). In the rehabilitation sites, ESP was also very low and ranged from 0.3 – 0.7% this year.

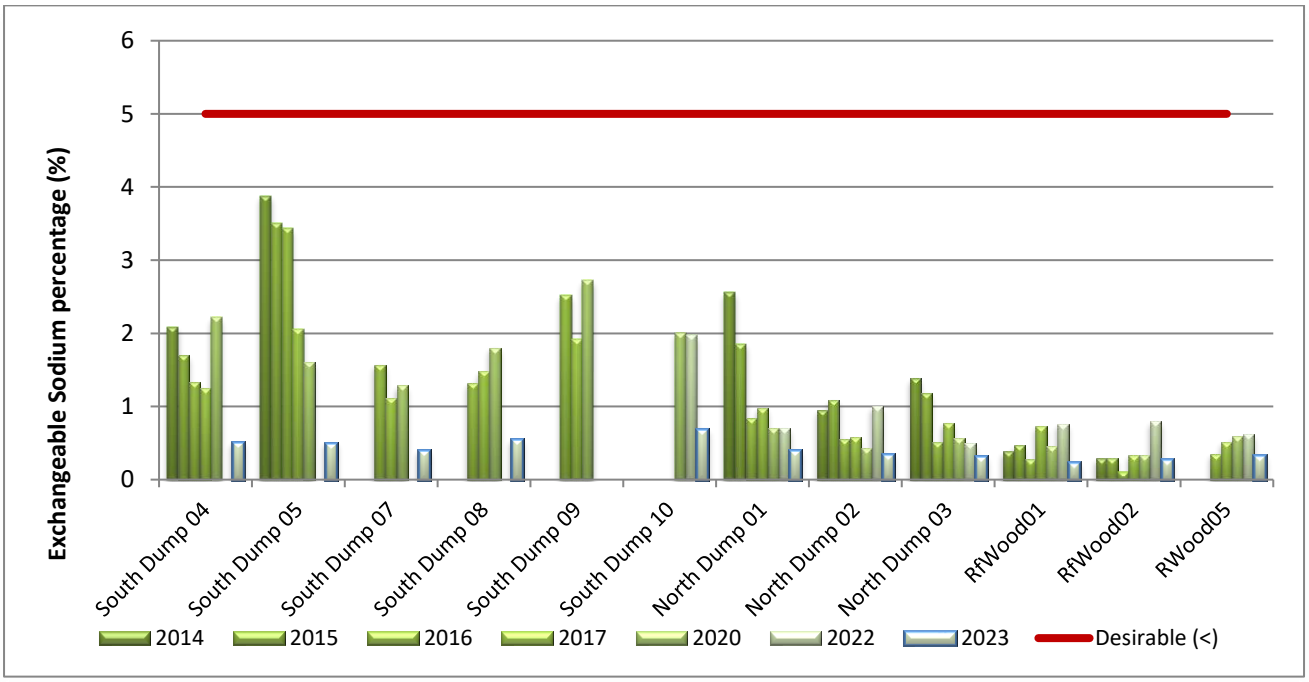


Figure 5-25. ESP recorded in the rehabilitation sites compared to the woodland reference sites and desirable agricultural levels.

5.3 Woodland rehabilitation site performance towards meeting ecological performance indicators

Table 5-9 indicates the performance of the woodland rehabilitation monitoring sites against the range of primary and secondary ecological performance indicators recorded in the woodland reference sites in 2023. The performance indicators have been presented in order of rehabilitation phases and ecosystem succession, beginning with Phase 2 Landform establishment and stability (Orange) followed by Phase 3 Growth Medium Development (Brown), Phase 4 Ecosystem & Land Use Establishment (Green) and ending with Phase 5 Ecosystem & Land Use Development (Blue).

Rehabilitation sites meeting or exceeding the range values of the reference sites have been identified with a shaded colour box and have therefore been deemed to meet the ecological targets. In the case of "growth medium development", upper and lower soil property indicators are also based on results obtained from the respective reference sites. In some cases, the site may not fall within ranges based on these data but may be within "desirable" levels as prescribed by the agricultural industry. If this scenario occurs, the rehabilitation site has been identified using a striped shaded box to indicate that it falls within "desirable agricultural" ranges but does not fall within specified completion criteria targets using the adopted methodology.

Table 5-9. Performance of the woodland rehabilitation monitoring sites against primary and secondary ecological performance indicators in 2023.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
Performance indicators are quantified by the range of values obtained from replicated reference sites assessed in 2023							Ashleigh Park	Bundarra	CVO Cadiangullong	Lower KPI	Upper KPI	2023							
Phase 2: Landform Establishment and Stability	**Landform slope, gradient**	Landform suitable for final land use and generally compatible with surrounding topography and final landform design	Slope	Landform is generally compatible within the context of the local topography and final landform design.		Degrees (<18°)	10	14	12	10	14	18	18	16	0	17	14	15	2
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Number of gullies or rills >0.3m in width or depth in a 50m transect are limited and stabilising		No.	0	0	0	0	0	0	0	1	0	0	2	0	0
			Cross-sectional area of rills		Provides an assessment of the extent of soil loss due to gully and rill erosion and that it is limited and/or is stabilising	m^2	0	0	0	0	0	0	0	0.081	0	0	0.110	0	0
Phase 3: Growth Medium Development	**Soil chemical, physical properties and amelioration**	Soil properties are suitable for the establishment and maintenance of selected vegetation species	pH	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry		pH (5.6-7.3)	6.5	7.1	6.2	6.2	7.1	6.2	5.4	6.3	5.5	6.8	6.4	6.3	6.1
			EC		Electrical Conductivity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	< dS/m (<0.150)	0.100	0.132	0.056	0.056	0.132	0.032	0.049	0.043	0.051	0.098	0.043	0.043	0.044
			Organic Matter	Organic Matter levels are typical of that of the surrounding landscape, increasing or fall within desirable ranges provided by the agricultural industry		% (>4.5)	7.5	11.0	8.8	7.5	11.0	2.0	2.9	2.7	4.0	3.4	2.5	3.3	3.1
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		mg/kg (50)	25.9	24.5	11.7	11.7	25.9	10.8	14.2	12.2	71.8	30.8	34.4	41.0	21.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	mg/kg (>12.5)	3.4	10.9	1.2	1.2	10.9	2.4	5.6	0.8	7.4	14.2	5.6	3.0	5.5
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg (>14)	14.8	32.9	15.4	14.8	32.9	7.1	6.9	7.7	7.4	11.8	13.7	16.5	12.2
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	% (<5)	0.2	0.3	0.3	0.2	0.3	0.5	0.5	0.4	0.5	0.7	0.4	0.3	0.3
Phase 4: Ecosystem & Land Use Establishment	**Landscape Function Analysis (LFA): Landform stability and organisation**	Landform is stable and performing as it was designed to do	LFA Stability	The LFA stability index provides an indication of the sites stability and is comparable to or trending towards that of the local remnant vegetation		%	69.9	69.5	74.4	69.5	74.4	69.8	68.5	66.8	69.9	69.5	69.5	71.5	68.5
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and is comparable to that of the local remnant vegetation		%	100	100	100	100	100	95	100	75	95	100	100	100	100
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation	Diversity of shrubs and juvenile trees		The diversity of shrubs and juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation.	species/area	3	1	9	1	9	6	10	11	16	3	4	4	4
				The percentage of shrubs and juvenile trees with a stem diameter < 5cm dbh which are local endemic species, and these percentages are comparable to the local remnant vegetation		% population	75	100	58	58	100	100	99	100	100	50	100	100	100

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RfWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			Total species richness	The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation		No./area	39	21	60	21	60	39	35	31	56	27	41	28	33
			Native species richness		The total number of live native plant species provides an indication of the native plant diversity of the site and that it is greater than or comparable to the local remnant vegetation	>No./area	22	9	36	9	36	15	19	20	34	8	11	9	10
			Exotic species richness		The total number of live exotic plant species provides an indication of the exotic plant diversity of the site and that it is less than or comparable to the local remnant vegetation	<No./area	17	12	24	12	24	24	16	11	22	19	29	19	23
			Ratio of native to exotic species		The ratio of live native species compared to live exotic plant species provides an indication of the relative native species richness of the site and that it is more than or comparable to the local remnant vegetation	>	1.3	0.8	1.5	0.8	1.5	0.6	1.2	1.8	1.5	0.4	0.4	0.5	0.4
	Vegetation density	Vegetation contains a density of species comparable to that of the local remnant vegetation	Density of shrubs and juvenile trees (< 5cm dbh)		The total density of shrubs and/or juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation	No./area	4	3	142	3	142	114	317	314	306	8	152	296	210
				The density of eucalypts is comparable to the local remnant vegetation		No./area	0	3	2	0	3	0	1	10	20	1	0	0	0
				The density of acacias is comparable to the local remnant vegetation		No./area	3	0	70	0	70	113	298	248	138	3	152	296	22
				The density of other endemic shrubs is comparable to the local remnant vegetation		No./area	0	0	11	0	11	1	14	56	148	0	0	0	188

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
				The density of exotic / non endemic species is comparable to the local remnant vegetation		<No./area	1	0	59	0	59	0	4	0	0	4	0	0	0
				The percentage of eucalypts is comparable to the local remnant vegetation		% population	0	100	1	0	100	0	0.3	3	7	13	0	0	0
					The total density of endemic shrubs and/or juvenile trees (< 5cm) is comparable to the local remnant vegetation	No./area	3	3	83	3	83	114	313	314	306	4	152	296	210
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation	Trees	The number of tree species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	2	1	4	1	4	0	1	2	5	1	0	0	0
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	3	0	8	0	8	6	10	13	13	2	4	4	4
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0	0	0	0	0
			Herbs		The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	25	10	32	10	32	20	18	8	26	19	24	16	20
			Grasses	The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	7	9	13	7	13	12	6	8	7	5	12	8	9

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RfWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			Reeds		The number of reed, sedge or rush species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	2	1	3	1	3	1	0	0	4	0	0	0	0
			Vines		The number of vines or climbing species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	1	0	0	0	0
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0	0	0	0	0
			Aquatic		The number of aquatic plants comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0	0	0	0	0
Phase 5: Ecosystem & Land Use Development	**Landscape Function Analysis (LFA): Landform function and ecological performance**	Landform is ecologically functional and performing as it was designed to do	LFA Infiltration	LFA infiltration index provides an indication of the sites infiltration capacity and is comparable to or trending towards that of the local remnant vegetation		%	60.5	56.7	66.0	56.7	66.0	41.7	43.4	35.5	48.2	39.4	49.6	52.4	47.6
			LFA Nutrient recycling	LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and is comparable to or trending towards that of the local remnant vegetation		%	57.4	54.3	64.1	54.3	64.1	44.3	49.0	35.5	49.1	40.6	48.2	52.4	45.2
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Litter cover		Percent ground cover provided by dead plant material is comparable to that of the local remnant vegetation	%	72.0	65.0	71.5	65	72.0	44	75	46	39	68	38	63.8	51.5
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	20.6	10.3	3.0	3	20.6	20	2	6	31	15	50	18	22.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			Cryptogam cover		Percent ground cover provided by cryptogams (e.g. mosses, lichens) is comparable to that of the local remnant vegetation	%	0	0	0	0	0	1	5	4	2	1	0	0	1
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	7	0	0	6.5	13	0	6	0	0	1	1	1
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	1	5	1	1	4.5	0	0	0	0	0	0	1	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	0	0	1	0	1	6	4	20	1	6	0	0	1
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (<0.5m in height) is comparable to that of the local remnant vegetation		%	6.9	13.7	23.5	7	23.5	17	15	20	29	11	12	18	25
			Total Ground Cover	Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of the local remnant vegetation		%	100	100	99	99	100	94	97	80	100	94	100	100	100
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance	The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has more than or an equal number of native species as the local remnant vegetation		> species/m^2	2	1	4	0.6	4.4	2.4	2	3	1.8	0.4	1.8	1	1.4

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			Exotic understorey abundance		The abundance of exotic species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has less than or an equal number of exotic species as the local remnant vegetation	< species/m^2	3.4	2.0	2.2	2.0	3.4	3.6	2.4	1.2	5	3.4	5	3.2	2.8
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5m tall	The percent ground cover abundance of native species (<0.5m) compared to exotic species is comparable to that of the local remnant vegetation		%	30.6	18.4	71.7	18.4	71.7	46.2	50	77.5	29.3	9.5	22.7	24.1	37.7
	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation	shrubs and juvenile trees 0 - 0.5m in height	The number of shrubs or juvenile trees <0.5m in height provides an indication of establishment success and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	4	1	66	1	66	9	6	8	26	5	17	4	35
			shrubs and juvenile trees 0.5 - 1m in height		The number of shrubs or juvenile trees 0.5-1m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	1	39	0	39	9	2	14	56	2	6	12	135
			shrubs and juvenile trees 1 - 1.5m in height		The number of shrubs or juvenile trees 1-1.5m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	0	34	0	34	17	10	58	106	0	27	20	27

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	0	1	2	0	2	45	38	108	74	0	61	110	11
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees >2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	0	1	0	1	34	261	126	44	1	41	150	2
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	0	0	5	0	4.5	33.5	29	48	29	1	18	26	8
			Foliage cover 2 - 4m	Projected foliage cover provided by perennial plants in the 2 - 4m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	0	0	1	0	1	10	26	10.5	12.5	0	0	8	0
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	1	2	4	1	4	0	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			Foliage cover >6m	Projected foliage cover provided by perennial plants >6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	40	27	25	25	40	0	0	0	0	0	0	0	0
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to the local remnant vegetation	Tree diversity		The diversity of trees or shrubs with a stem diameter >5cm is comparable to the local remnant vegetation	species/area	2	1	4	1	4	1	3	4	4	0	1	1	1
				The percentage of maturing trees and shrubs with a stem diameter >5cm dbh which are local endemic species, and these percentages are comparable to the local remnant vegetation		% endemic	100	100	100	100	100	100	100	100	100	0	100	100	100
	Tree density	Vegetation contains a density of maturing tree and shrub species comparable to the local remnant vegetation	Tree and mature shrub density (> 5 cm dbh)		The total density of live trees and/or mature shrubs with a stem diameter > 5cm is comparable to that of the local remnant vegetation	No./area	25	8	37	8	37	7	26	26	10	0	4	20	1
				The density of eucalypts is comparable to that of the local remnant vegetation		No./area	25	8	35	8	35	0	0	22	6	0	0	0	0
				The density of acacias is comparable to the local remnant vegetation		No./area	0	0	2	0	2	7	26	4	4	0	4	20	1

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
				The density of other endemic species is comparable to the local remnant vegetation		No./area	0	0	0	0	0	0	0	0	0	0	0	0	0
				The density of exotic / non endemic species is comparable to the local remnant vegetation		<No./area	0	0	0	0	0	0	0	0	0	0	0	0	0
				The percentage of eucalypts is comparable to the local remnant vegetation		% population	100	100	95	95	100	0	0	85	60	0	0	0	0
			Average dbh		Average tree diameter of the tree population provides a measure of age, (height) and growth rate and that it is trending towards that of the local remnant vegetation.	cm	33	70	26	26	70	15	8	11	8	0	9	8	9
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees		The percentage of the tree population which are live individuals, and that the percentage is comparable to the local remnant vegetation	% population	92	89	82	82	92	100	45	93	100	0	100	67	100
			Healthy trees	The percentage of the tree population which are in healthy condition and that the percentage is comparable to the local remnant vegetation		% population	60	56	11	11	60	71	24	79	60	0	50	20	0
			Medium health		The percentage of the tree population which are in a medium health condition and that the percentage is comparable to the local remnant vegetation	% population (if greater than dieback)	28	33	60	28	60	29	21	14	40	0	25	47	100

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators	Secondary Performance Indicators	Unit of measurement	RfWood01 2023	RfWood02 2023	RWood05 2023	2023 Woodland ecosystem range		South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03
			Advanced dieback		The percentage of the tree population which are in a state of advanced dieback and that the percentage is comparable to the local remnant vegetation	% population	4	0	11	0	11	0	0	0	0	0	25	0	0
			Dead Trees		The percentage of the tree population which are dead (stags), and that the percentage is comparable to the local remnant vegetation	% population	8	11	18	8	18	0	55	7	0	0	0	33	0
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is comparable to the local remnant vegetation	% population	0	0	0	0	0	0	0	0	0	0	0	0	0
			Flowers/fruit: Trees	The presence of reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of the local remnant vegetation		% population	72	78	40	40	78	100	14	21	20	0	0	40	100
			Hollows		The presence of hollows provides evidence that the ecosystem is maturing, and can provide habitat resources comparable to that of the local remnant vegetation	% population	4	44	9	4	44	0	0	0	0	0	0	0	0

6 Elevated soil test results

The full results of the soil analysis are provided in Appendix 4 with a summarised version highlighting elevated results provided in Table 6-1. The indicative fertility guidelines are based on Albrecht and Reams concepts for achieving ideal soil fertility in clay loam soils. Further detail can be found in the "End notes" of the Soil Analyses results (Appendix 4).

Rehabilitation sites which appear to have elevated levels compared to the indicative guidelines have been highlighted to provide a general indication of how much an element or heavy metal may exceed these guidelines. The colour coding used when comparing against these recommended guidelines is as follows: Green = slightly elevated; Yellow = high; Red = very high; Brown = significantly high; Purple = excessive.

The results indicate there are numerous elements which occur at elevated levels in the rehabilitation sites, however some such as Sulfur, Manganese, Iron, Copper and Silicon and were also recorded at elevated levels in one or more of the woodland reference sites, suggesting they can occur at "naturally" high levels around the local area. Copper was however recorded in particularly high concentrations in site South Dump 07 and sites on the North Dump. Iron was also recorded in high concentrations in South Dump 05 and 08.

Table 6-1. Summarised soil analyses highlighting elevated test results in the monitoring sites in 2023.

	Site	South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03	RfWood01	RfWood02	RWood05	*Medium Soil Clay Loam*
Parameter	**Method reference**	N9663/4	N9663/5	N9663/6	N9663/7	N9663/8	N9663/1	N9663/2	N9663/3	N9663/9	N9663/10	N9663/11	Indicative guidelines - refer to Notes 6 and 8
Sulfur (mg/kg S)	**Inhouse S37 (KCl)	10.0	9.4	12	16	14	6.3	9.9	11	10	14	8.1	*8.0*
Manganese (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	16	25	7.0	20	16	15	11	17	31	34	31	*22*
Iron (mg/kg)		44	105	69	161	64	50	73	58	91	49	52	*22*
Copper (mg/kg)		3.9	3.2	20	6.5	4.5	23	30	13	0.79	5.9	1.8	*2.0*
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	30	37	31	28	51	58	64	49	43	60	50	*45*
Total Zinc (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	24	29	35	21	28	59	73	49	24	50	46	*20–50 Zn*
Total Iron (mg/kg)		30,597	33,743	34,516	45,058	19,510	51,858	59,073	52,446	17,237	36,907	63,498	*1000–50 000 Fe*
Total Copper (mg/kg)		35	31	136	100	70	217	270	137	14	87	46	*20–50 Cu*
Total Molybdenum (mg/kg)		0.96	1.0	2.8	1.3	0.76	2.9	3.5	2.2	0.58	0.47	0.41	*0.5–3.0 Mo*

Green = slightly elevated; Yellow = high; Red = very high; Brown = significantly high; Purple = excessive.

7 Priority weeds

This year, Weeds of National Significance (WONS) and listed Priority weeds of the Central Tablelands (NSW DPI 2022) or weeds included under the NSW general biosecurity duty recorded in the woodland monitoring sites are provided in Table 7-1. In total six WONS and Priority weeds were recorded across the woodland monitoring sites, and these were scattered in limited numbers cross a range of sites.

Table 7-1. WONS and Priority weeds recorded at CVO in 2023.

Scientific Name	Common Name	Habit	RfWood01	RfWood02	RWood05	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total
Crataegus monogyna	Hawthorn	s			1									1
Hypericum perforatum	St. John's Wort	h							1			1		2
Ligustrum lucidum	Large-leaved Privet	s			1									1
Nassella trichotoma	Serrated Tussock	g				1	1		1					3
Rubus fruticosus	Blackberry	s	1		1					1			1	4
Solanum sisymbriifolium	Sticky Nightshade	h		1										1

8 Threatened flora

No threatened species have been identified within the range of monitoring sites.

9 Conclusion

While no rehabilitation site yet met all primary completion criteria, many sites had been demonstrating a significant increase in ecological function up until the drought that was experienced for three consecutive years during 2017 - 2019. During the drought, there tended to be a declining trend in ecological function, as a result of the prolonged dry seasonal conditions and simultaneous increase in grazing and disturbance by animals, with a decline in many performance indicators also being reflected in the range of woodland reference sites. Over the last few years, improved seasonal conditions have resulted in an increase in the diversity and abundance of the ground covers in most of the monitoring sites, therefore also increasing the overall ecological function in the rehabilitation sites. This year, there has been further overall improvement in the rehabilitation areas, however stability continued to be low in South Dump 05 and 07 and North Dump 03, and all rehabilitation sites had low infiltration and nutrient recycling capacity in comparison to the woodland reference sites.

The woodland reference site RWood05 continued to be the most ecologically functional site and continued to have a sum of scores 205, followed by the remaining two reference sites with scores of 188 and 181. North Dump 02 was the most functional rehabilitation sites with a total sum of scores of 176, with many of the remaining rehabilitation areas being functionally similar to each other with scores ranging from 167 – 156. The least developed sites included South Dump 10 with a score of 150, while South Dump 07 was the least functional rehabilitation area with a score of 138.

The drought conditions over three consecutive years was not conducive to significant developments during the early successional development of the rehabilitation areas, however many areas maintained or even slightly improved in ecological function largely due to the establishment of voluntary ground covers. Many volunteer species are exotic annual plants that have successfully colonised large areas of rehabilitation via establishment from the soil seed bank and these have been playing a particularly important role in the ecological development, function and stability of the sites due to the provision of protective ground cover and development of the litter layers, which lead to increased stability and coherency of the soil profile. Many annual weeds have become naturalised within the local area and some of the annual ground covers were clovers or medics which can be useful pasture species and have also been recorded in the range of reference sites.

Exotic ground covers are prevalent across the local agricultural lands and subsequently all rehabilitation sites, except South Dump 10, had a similar native cover abundance and diversity to the woodland reference site RfWood02. Despite meeting a variety of these targets, future rehabilitation should focus on establishing native ground covers where possible, as perennial pasture species are highly competitive and have the potential to limit tree and shrub seed germination and establishment in the short-term and restrict natural regeneration and sustainability of the woodlands in the longer-term. This limitation can be observed across the local landscape where natural tree regeneration is limited across vast areas of farmland that have “improved exotic pastures”.

The woodland rehabilitation areas were dominated by acacias, with limited occurrence of eucalypts in most areas except South Dump 07 and 08, and no eucalypts were recorded at all in sites on the North Dump. There was high variability in the density of shrubs and/or juvenile trees however there has been a significant declining trend. While in some cases, some individuals may have grown and were now recorded as mature trees, the majority have been drought mortalities and/or had reached the end of their life span (natural senescence). The potential for the ongoing decline in mature acacia densities may also have implications for the rehabilitation sites to meet completion targets into the future, especially due to the absence of or low density of long-lived eucalypt species. Areas identified as requiring rehabilitation intervention on the Northern Waste Rock Dump have undergone a program of in-fill planting during May and June, to address limited eucalypt densities. Sites that continue to have limited eucalypt establishment may require additional rehabilitation intervention via reseeding or tubestock planting to ensure appropriate eucalypt densities become established in the longer-term.

A range of other primary performance indicators that have not yet been achieved were primarily related to the lack of a mature tree population and targets associated with a mature canopy structure. Additional habitat attributes such as tree hollows and mistletoe were also not present due to the relative immaturity of individuals, however most of the acacias have been capable of reproducing and many were presently developing buds. In addition, it will be critical that eucalypts become established within the rehabilitation areas on the South and North Dump where they are currently absent, to provide the range of additional habitat benefits in the longer-term.

While no formal survey for fauna is undertaken by DnA Environmental, a range of wildlife have been or were observed within the rehabilitation areas and this year an earthworm was found in North Dump 01! Increased habitat such as large logs, fallen trees and rock piles would further enhance rehabilitation sites. Additional perching sites could also be made available by erecting mature eucalypts that have been cleared for mining, upside down (i.e. tree roots provide the new dead tree canopy) in appropriate locations across the rehabilitation areas. Large rocky outcrops could also be constructed. These practices have been undertaken with very successful outcomes in the Hunter Valley. Birds using the perching sites assist rehabilitation outcomes by introducing native plant seed (especially those with fleshy drupes) that may not otherwise colonise large rehabilitation areas. A range of other wildlife may also assist with the natural dispersal of seeds, create germination niches and micro-sites and assist with nutrient recycling across the wider rehabilitation areas. They may however also distribute weeds and harbour pest animals.

Testing of waste rock materials and topsoils prior to application on rehabilitation areas should be an ongoing part of the progressive rehabilitation programs and regularly undertaken to ensure suitable substrates are used prior to spreading onto rehabilitation areas. Ongoing soil testing is likely to identify any changes in soil chemistry that may adversely affect the establishment of protective ground cover and/or development and sustainability of wider rehabilitation areas.

Priority weeds and WONS are being actively controlled through an ongoing weed management program and ongoing control will be required as part of the CVO land management plans. Particular care should be undertaken to avoid spraying of non-target species. There has been an increasing abundance of weeds, especially *Rubus fruticosu*s (Blackberry) in numerous sites, and previous monitoring has indicated *Salix* species (Willows) were becoming increasingly more dominant in the Creek Diversion channel. While grazing pressure has significant declined after the drought, feral and pest animal populations will also require ongoing monitoring and control.

In summary, recommendations include:

- Implement a well-defined seed collection strategy to ensure local endemic species diversity and availability;
- Sowing and establishment of native grasses and sterile cover crops only in future rehabilitation programs;
- Refine species mixes and adjust sowing rates to maximise eucalypt establishment from seed;
- Re-seeding and/or infill tubestock planting in sites that continue to have limited eucalypt establishment;
- Increasing wildlife habitat using large logs, fallen trees and rock piles;
- Erecting upside-down trees that have been cleared for mining (i.e. tree roots provide the new dead tree canopy) for use as additional perching (and nesting) sites where possible;
- Ongoing testing of waste rock materials and topsoils prior to and after application onto rehabilitation areas;
- Application of weed free hay to stabilise and accelerate the development of any areas with minor rilling and/or erosion or are slow to establish;
- Follow up surveillance and control of priority weeds and WONS, including *Rubus fruticosus* and Salix species (Willows) which appear to be increasing in abundance along the Creek Diversion Channel.
- Ongoing monitoring and control of feral and pest animal populations.

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Appendix 1. Monitoring site location data

GPS co-ordinates and other site-specific information for the reference sites.

Site Reference	LFA Start	LFA Finish	LFA slope°	LFA bearing°	Veg transect start	Veg transect finish	Veg transect bearing°
RfWood01 (Ashleigh Park)	55680871 6295705	55680880 6295718	10	30 NE	55680875 6295715	55680903 6295677	120 SE
RfWood02 (Bundarra)	55683151 6290452	55683159 6290441	14	145 SE	55683154 6290447	55683114 6290436	236 NW
RWood04 (CVO access) (Right - left transect)	55687596 6296337	55687589 6296351	10	310 W	55687591 6296345	55687554 6296316	220 SW
RWood05 (CVO Cadiangullong Dam)	55 684994 6298928	55 685013 6298922	12	94	55 685005 6298924	55 684987 6298876	184 S
RfPast01 (Bundarra)	55 683406 6290780	55 683423 6290790	10	45 NE	55 683415 6290785	55 683439 6290742	140 SE
RfPast03 (Willunga)	55 687926 6298533	55 687911 6298546	8	300 NW	55 687918 6298540	55 687948 6298579	25 N
RrRip02 (Bakers Shaft)	55 686614 6279287	55 686622 6279263	10	170 S	55 686622 6279272	55 686573 62792710	260 W
RrRip03 (CVO Cadiang Ck)	55 685302 6298471	55 685314 6298478	14	44	55 685306 6298475	55 685327 6298431	140 SE

GPS co-ordinates and other site-specific information for the rehabilitation monitoring sites.

Site	LFA Start	LFA Finish	LFA slope°	LFA bearing°	Veg transect start	Veg transect finish	Veg transect bearing°
Ashleigh Park 01	55 680874 6294881	55 680864 6294899	5	320 NW	55 680887 6294887	55 680873 6294904	320 NW
South Dump 01	55 685304 6294460	55 685308 6294478	22	351 N	55 685307 6294468	55 685353 6294467	79 E
South Dump 02	55 685118 6294354	55 685108 6294369	17	302 NW	55 685113 6294362	55 685146 6294401	33 NE
South Dump 03	55685250 6293838	55685231 6293838	18	245W	55685240 6293838	55685239 6293886	348 NW
South Dump 04	55686455 6293539	55686453 6293524	18	173S	55686454 6293535	686407 6293533	264 W
South Dump 05	55687089 6294032	687108 6294029	18	88E	687100 6294032	687092 6293982	175 S

Site	LFA Start	LFA Finish	LFA slope°	LFA bearing°	Veg transect start	Veg transect finish	Veg transect bearing°
South Dump 06	687551 6294645	55687570 6294653	1	231SW	55687561 6294649	55687579 6294603	144 SE
South Dump 07	55686973 6294252	55686991 6294252	16	76 E	55686983 6294254	55686981 6294200	168 S
South Dump 08	55686632 6293878	55686643 6293860	0	142 SE	55686638 6293868	55686594 6293845	232 SW
South Dump 09	55685920 6294044	55685900 6294046	16	260 W	55685911 6294045	55685915 6294096	350 N
South Dump 10	55684896 6293929	55684878 6293915	17	216 SW	55684888 6293919	55684853 6293957	305 NW
North Dump 01	55686596 6296978	55686582 6296967	14	217SW	55686589 6296973	55686555 6297013	307 NW
North Dump 02	55686375 6296954	55686362 6296942	15	220SW	55686369 6296947	55686339 6296986	309 NW
North Dump 03	55687148 6297228	55687130 6297227	1	260W	55687139 6297226	55687139 6297277	350 N
Willunga DS01	55 687586 6298689	55 687579 6298710	6	320 NW	55 687601 6298700	55 687568 6298737	320 NW
Willunga DS02	55 687266 6208927	55 687260 6298910	10	180 S	55 687248 6298929	55 872473 6298883	182 S
Cadiangullong Creek	55 684249 6294028	55 684242 6294015	5	180 S	55 684244 6294017	55 684199 6294037	275 W
Creek Diversion	55 685350 6297515	55 685346 6297501	8	165 S	55 685346 6297511	55 685296 6297506	257 W

Appendix 2. Flora species recorded in the woodland and riparian monitoring sites 2023

*Note: "1" denotes the presence of that species at a particular site and is not a measure of cover abundance.
Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; p = parasite

Family	exotic	Annual/ perennial	Scientific Name	Common Name	Habit	RfWood01	RfWood02	RWood05	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total
Amaranthaceae	*	A	*Amaranthus powellii*	Powell's Amaranth	h						1						1
Apiaceae		A	*Daucus glochidiatus*	Australian Carrot	h	1											1
Araliaceae		P	*Hydrocotyle laxiflora*	Stinking Pennywort	h			1									1
Asteraceae	*	A	*Bidens subalternans*	Greater Beggars Tick	h							1			1		2
Asteraceae	*	A	*Carduus tenuiflorus*	Winged Slender Thistle	h			1									1
Asteraceae	*	A	*Carthamus lanatus*	Saffron Thistle	h				1		1	1				1	4
Asteraceae		P	*Cassinia sifton [arcuata]*	Sifton Bush	s			1			1	1	1	1	1		6
Asteraceae	*	A	*Centaurea solstitialis*	St Barnaby's Thistle	h										1		1
Asteraceae	*	P	*Chondrilla juncea*	Skeleton Weed	h	1			1	1	1						4
Asteraceae	*	A	*Cirsium vulgare*	Spear Thistle	h	1	1	1		1			1			1	6
Asteraceae	*	A	*Conyza bonariensis*	Fleabane	h	1		1	1		1	1	1	1	1	1	9
Asteraceae		A	*Cymbonotus lawsonianus*	Bear's Ear	h	1											1
Asteraceae	*	A	*Dittrichia graveolens*	Stinkwort	h								1				1
Asteraceae		P	*Euchiton involucratus*	Star Cudweed	h			1									1
Asteraceae		A	*Euchiton sphaericus*	Japanese Cudweed	h										1		1
Asteraceae	*	A	*Hypochaeris glabra*	Smooth Catsear	h						1						1
Asteraceae	*	P	*Hypochaeris radicata*	Flatweed	h	1		1			1	1	1		1		6
Asteraceae	*	A	*Lactuca serriola*	Prickly Lettuce	h	1	1	1				1					4
Asteraceae		A	*Senecio hispidulus*	Hill Fireweed	h			1									1
Asteraceae		P	*Senecio prenanthoides*	A Fireweed	h			1									1
Asteraceae		P	*Senecio quadridentatus*	Cotton Fireweed	h	1	1	1	1		1	1	1		1	1	9
Asteraceae	*	A	*Silybum marianum*	Variegated Thistle	h		1		1	1						1	4

Family	exotic	Annual/ perennial	Scientific Name	Common Name	Habit	RfWood01	RfWood02	RWood05	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total
Asteraceae	*	A	*Sonchus asper*	Prickly Sowthistle	h				1							1	2
Asteraceae	*	A	*Sonchus oleraceus*	Milk Thistle	h	1			1	1		1	1	1		1	7
Asteraceae	*	P	*Taraxacum officinale*	Dandelion	h	1											1
Asteraceae		P	*Vittadinia cuneata*	Fuzzweed	h							1					1
Asteraceae		P	*Vittadinia gracilis*	A Fuzzweed	h										1		1
Asteraceae		A	*Xerochrysum viscosum*	Sticky Everlasting	h	1											1
Boraginaceae		P	*Cynoglossum australe*	Australian Hounds Tounge	h			1									1
Boraginaceae	*	A	*Echium plantagineum*	Paterson's Curse	h				1			1		1	1	1	5
Boraginaceae	*	A	*Echium vulgare*	Vipers Bugloss	h				1	1	1	1			1		5
Brassicaceae	*	A	*Lepidium africanum*	Peppercress	h										1	1	2
Brassicaceae	*	A	*Sisymbrium officinale*	Hedge Mustard	h											1	1
Brassicaceae	*	A	*Sisymbrium sp.*	A Mustard	h	1											1
Campanulaceae		P	*Wahlenbergia communis*	Tufted Bluebell	h	1									1		2
Campanulaceae		P	*Wahlenbergia luteola*	Australian Bluebell	h	1											1
Caryophyllaceae	*	A	*Petrorhagia nanteuilii*	Proliferous Pink	h	1		1	1	1	1						5
Caryophyllaceae	*	A	*Stellaria media*	Chickweed	h		1										1
Chenopodiaceae	*	A	*Chenopodium album*	Fat Hen	h				1								1
Convolvulaceae		P	*Dichondra repens*	Kidney Weed	h	1		1		1							3
Cyperaceae		P	*Carex inversa*	Knob Sedge	r	1	1	1							1		4
Cyperaceae	*	P	*Cyperus eragrostis*	Umbrella Sedge	r										1		1
Fabaceae (Faboideae)		P	*Daviesia leptophylla*	Slender Bitter-Pea	s										1		1
Fabaceae (Faboideae)		P	*Glycine clandestina*	Climbing Glycine	h			1									1
Fabaceae (Faboideae)		A	*Grona [Desmodium] varians*	Slender Tick-trefoil	h			1					1				2
Fabaceae (Faboideae)		P	*Hardenbergia violacea*	Happy Wanderer	v										1		1
Fabaceae (Faboideae)		P	*Pultenaea spinosa*	Spiny Bush-pea	s										1		1

Family	exotic	Annual/ perennial	Scientific Name	Common Name	Habit	RfWood01	RfWood02	RWood05	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total
Fabaceae (Faboideae)	*	A	*Trifolium angustifolium*	Narrow-leaf Clover	h							1		1	1		3
Fabaceae (Faboideae)	*	A	*Trifolium arvense*	Haresfoot Clover	h										1		1
Fabaceae (Faboideae)	*	A	*Trifolium glomeratum*	Clustered Clover	h										1		1
Fabaceae (Faboideae)	*	P	*Trifolium repens*	White Clover	h			1									1
Fabaceae (Faboideae)	*	A	*Trifolium sp.*	A Clover	h			1									1
Fabaceae (Faboideae)	*	A	*Trifolium subterraneum*	Subterraneum Clover	h	1			1		1	1		1	1	1	7
Fabaceae (Faboideae)	*	A	*Vicia sativa*	Common Vetch	h			1	1	1							3
Fabaceae (Mimosoideae		P	*Acacia filicifolia*	Fern-leaved Wattle	s								1		1		2
Fabaceae (Mimosoideae)		P	*Acacia buxifolia*	Box-leaved Wattle	s				1	1	1	1	1	1	1		7
Fabaceae (Mimosoideae)		P	*Acacia dealbata*	Silver Wattle	s	1		1	1	1	1	1	1	1			8
Fabaceae (Mimosoideae)		P	*Acacia decora*	Western Golden Wattle	s	1						1	1			1	4
Fabaceae (Mimosoideae)		P	*Acacia decurrens*	Early black Wattle	s									1	1		2
Fabaceae (Mimosoideae)		P	*Acacia genistifolia*	Early Wattle	s								1	1	1		3
Fabaceae (Mimosoideae)		P	*Acacia implexa*	Hickory	s			1				1	1	1	1		5
Fabaceae (Mimosoideae)		P	*Acacia melanoxylon*	Blackwood	s									1			1
Fabaceae (Mimosoideae)		P	*Acacia paradoxa*	Kangaroo Thorn	s				1				1	1	1		4
Fabaceae (Mimosoideae)		P	*Acacia penninervis*	Mountain Hickory	s									1	1		2
Fabaceae (Mimosoideae)		P	*Acacia spectabilis*	Mudgee Wattle	s					1							1
Fabaceae (Mimosoideae)		P	*Acacia verniciflua*	Varnish Wattle	s									1	1		2
Fabaceae (Mimosoideae)		P	*Acacia vestita*	Boree	s				1	1	1	1	1	1	1		7
Gentaniaceae	*	A	*Centaurium erythraea*	Common Centaury	h			1				1		1			3
Geraniaceae		P	*Geranium solanderi*	Native Geranium	h	1	1	1	1	1	1	1	1			1	9
Haloragaceae		P	*Gonocarpus tetragynus*	Raspwort	h										1		1
Hypericaceae		P	*Hypericum gramineum*	Small St. John's Wort	h			1							1		2
Hypericaceae	*	P	*Hypericum perforatum*	St. John's Wort	h							1			1		2

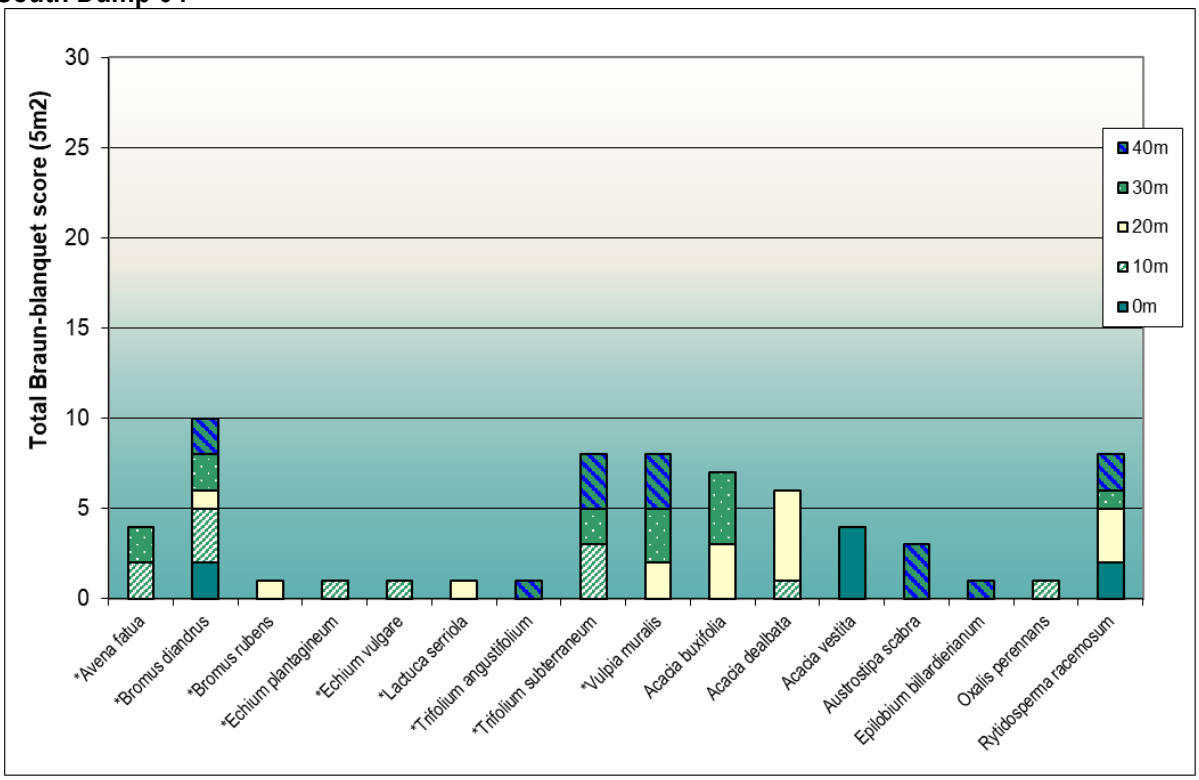
Family	exotic	Annual/ perennial	Scientific Name	Common Name	Habit	RfWood01	RfWood02	RWood05	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total
Juncaceae		P	*Juncus aridicola*	Tussock Rush	r										1		1
Juncaceae		P	*Juncus subsecundus*	A Rush	r							1			1		2
Juncaceae		P	*Juncus usitatus*	A Rush	r	1		1									2
Juncaceae		P	*Luzula flaccida*		r			1									1
Lamiaceae	*	P	*Marrubium vulgare*	Horehound	h	1	1		1	1	1		1				6
Lamiaceae		P	*Scutellaria humilis*	Dwarf Scullcap	h			1									1
Lomandraceae		P	*Lomandra multiflora*	Many-flowered Mat-rush	h			1									1
Lythraceae		A	*Lythrum hyssopifolia*	Hyssop Loosestrife	h								1				1
Malaceae	*	P	*Crataegus monogyna*	Hawthorn	s			1									1
Malvaceae	*	A	*Malva parviflora*	Small-flowered Mallow	h											1	1
Malvaceae	*	A	*Modiola caroliniana*	Red-flowered Mallow	h				1	1	1	1	1	1	1	1	8
Myrtaceae		P	*Eucalyptus albens*	White Box	t		1						1	1	1		4
Myrtaceae		P	*Eucalyptus blakelyi*	Blakely's Red Gum	t	1										1	2
Myrtaceae		P	*Eucalyptus bridgesiana*	Apple Box	t										1		1
Myrtaceae		P	*Eucalyptus goniocalyx*	Bundy Box	t			1						1	1		3
Myrtaceae		P	*Eucalyptus macrorhyncha*	Red Stringybark	t			1									1
Myrtaceae		P	*Eucalyptus melliodora*	Yellow Box	t	1		1							1		3
Myrtaceae		P	*Eucalyptus polyanthemos*	Red Box	t										1		1
Myrtaceae		P	*Leptospermum continentale*	Prickly Tea-tree	s										1		1
Oleaceae	*	P	*Ligustrum lucidum*	Large-leaved Privet	s			1									1
Onagraceae		P	*Epilobium billardierianum*	Willow Herb	h	1		1	1	1		1	1		1		7
Oxalidaceae		P	*Oxalis perennans*	Yellow Wood-sorrel	h	1	1	1	1	1	1	1	1	1	1	1	11
Plantaginaceae	*	A	*Plantago lanceolata*	Ribwort	h			1	1		1					1	4
Poaceae	*	P	*Agrostis stolonifera*	Creeping Bent Grass	g							1					1
Poaceae		P	*Anthosachne [Elymus] scabra*	Common Wheatgrass	g	1		1						1			3

Family	exotic	Annual/ perennial	Scientific Name	Common Name	Habit	RfWood01	RfWood02	RWood05	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total
Poaceae		P	*Austrostipa scabra*	Speargrass	g	1					1	1		1			4
Poaceae		P	*Austrostipa sp.*	A Speargrass	g		1		1								2
Poaceae	*	A	*Avena fatua*	Wild Oats	g		1		1	1	1	1	1	1	1	1	9
Poaceae	*	A	*Briza minor*	Shivery Grass	g			1									1
Poaceae	*	A	*Bromus diandrus*	Great Brome	g	1	1	1	1	1		1	1	1	1	1	10
Poaceae	*	A	*Bromus molliformis*	Soft Brome	g	1	1	1	1	1	1	1					7
Poaceae	*	A	*Bromus rubens*	Red Brome	g							1					1
Poaceae		P	*Cynodon dactylon*	Couch	g								1				1
Poaceae	*	A	*Cynosurus echinatus*	Rough Dog's Tail	g			1	1		1						3
Poaceae	*	P	*Dactylis glomerata*	Cocksfoot	g		1	1	1	1	1						5
Poaceae		P	*Dichelachne micrantha*	Shorthair Plumegrass	g			1									1
Poaceae		P	*Echinopogon ovatus*	Forest Hedgehog Grass	g			1									1
Poaceae	*	A	*Hordeum leporinum*	Barley Grass	g				1		1						2
Poaceae	*	P	*Lolium perenne*	Perennial Ryegrass	g				1			1					2
Poaceae		P	*Microlaena stipoides*	Weeping Rice-grass	g	1	1	1							1	1	5
Poaceae	*	P	*Nassella trichotoma*	Serrated Tussock	g				1	1		1					3
Poaceae	*	P	*Pennisetum clandestinum*	Kikuyu Grass	g								1				1
Poaceae	*	P	*Phalaris aquatica*	Phalaris	g		1		1	1	1	1	1	1	1	1	9
Poaceae		P	*Poa sieberiana*	Fine-leaf Tussock	g			1							1		2
Poaceae		P	*Rytidosperma erianthum*	Hill Wallaby Grass	g			1									1
Poaceae		P	*Rytidosperma racemosum*	Wallaby Grass	g	1	1	1	1	1	1	1	1	1	1	1	11
Poaceae		P	*Rytidosperma richardsonii*	Wallaby Grass	g							1					1
Poaceae		P	*Rytidosperma sp.*	Wallaby Grass	g									1			1
Poaceae		P	*Sporobolus creber*	Western Rat's-tail Grass	g						1						1
Poaceae	*	A	*Vulpia muralis*	Rats-tail Fescue	g	1	1	1	1	1		1		1	1		8

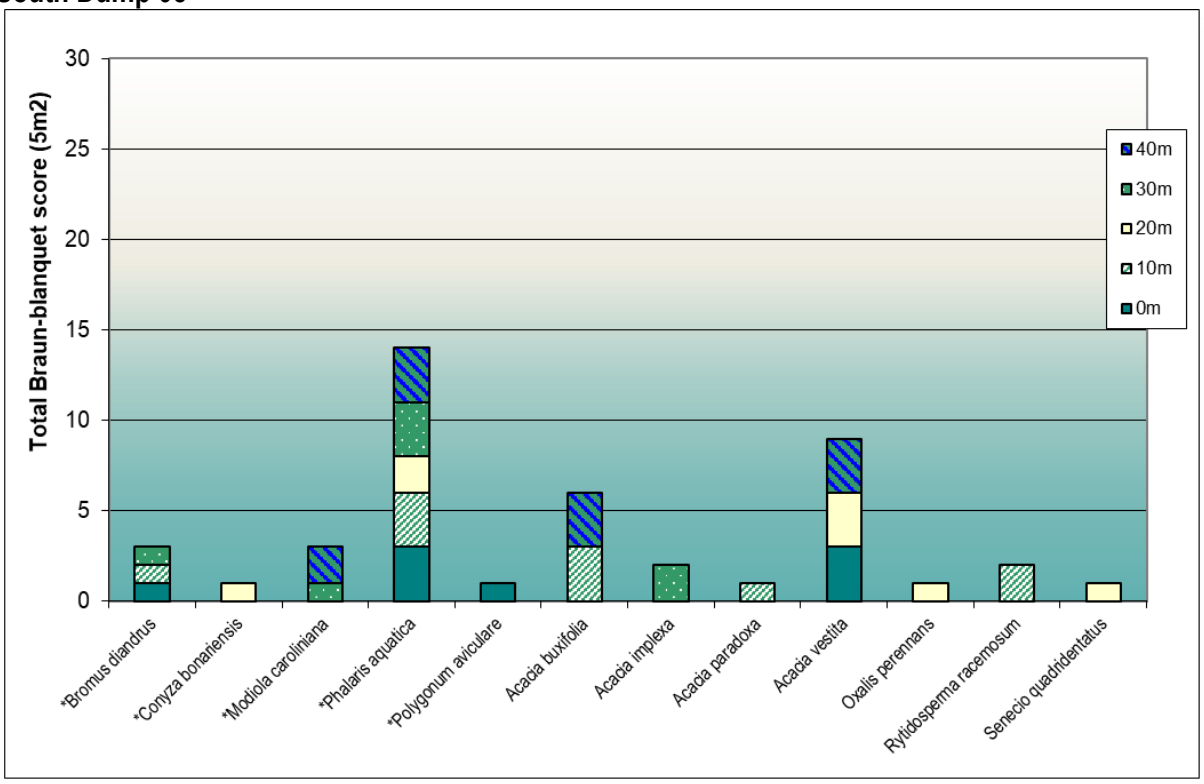
Family	exotic	Annual/ perennial	Scientific Name	Common Name	Habit	RfWood01	RfWood02	RWood05	NthDump01	NthDump02	NthDump03	SthDump04	SthDump05	SthDump07	SthDump08	SthDump10	Total
Polygonaceae	*	A	*Polygonum aviculare*	Wireweed	h				1				1		1		3
Polygonaceae	*	P	*Rumex acetosella*	Sheep Sorrel	h	1		1	1	1	1	1	1		1		8
Polygonaceae		P	*Rumex brownii*	Swamp Dock	h	1		1	1						1	1	5
Polygonaceae	*	P	*Rumex crispus*	Curled Dock	h				1	1	1		1		1	1	6
Primulaceae	*	A	*Lysimachia [Anagallis] arvensis*	Scarlet Pimpernel	h					1							1
Proteaceae		P	*Grevillea ramosissima*	Fan Grevillea	s									1			1
Proteaceae		P	*Hakea decurrens*	A Needlewood	s									1			1
Resedaceae	*	P	*Reseda luteola*	Weld	h						1						1
Rosaceae		P	*Acaena echinata*	Sheeps Burr	h	1											1
Rosaceae		P	*Acaena novae-zelandiae*	Biddy-biddy	h			1									1
Rosaceae		P	*Acaena ovina*	Sheep's Burr	h			1									1
Rosaceae		P	*Acaena sp.*	Sheep's Burr	h								1				1
Rosaceae	*	P	*Rosa rubiginosa*	Sweet Briar	s			1									1
Rosaceae	*	P	*Rubus fruticosus*	Blackberry	s	1		1					1			1	4
Rosaceae		P	*Rubus parvifolius*	Native Raspberry	s			1									1
Solanaceae	*	A	*Solanum nigrum*	Blackberry Nightshade	h	1	1	1			1	1	1				6
Solanaceae	*	A	*Solanum sisymbriifolium*	Sticky Nightshade	h		1										1
Sterculiaceae		P	*Brachychiton populneus*	Kurrajong	t			1									1
Verbenaceae	*	P	*Verbena bonariensis*	Purpletop	h			1	1		1					1	4
Verbenaceae	*	P	*Verbena litoralis*	Coastal Verbena	h										1		1

Appendix 3: Species cover abundance at individual rehabilitation monitoring sites in 2023

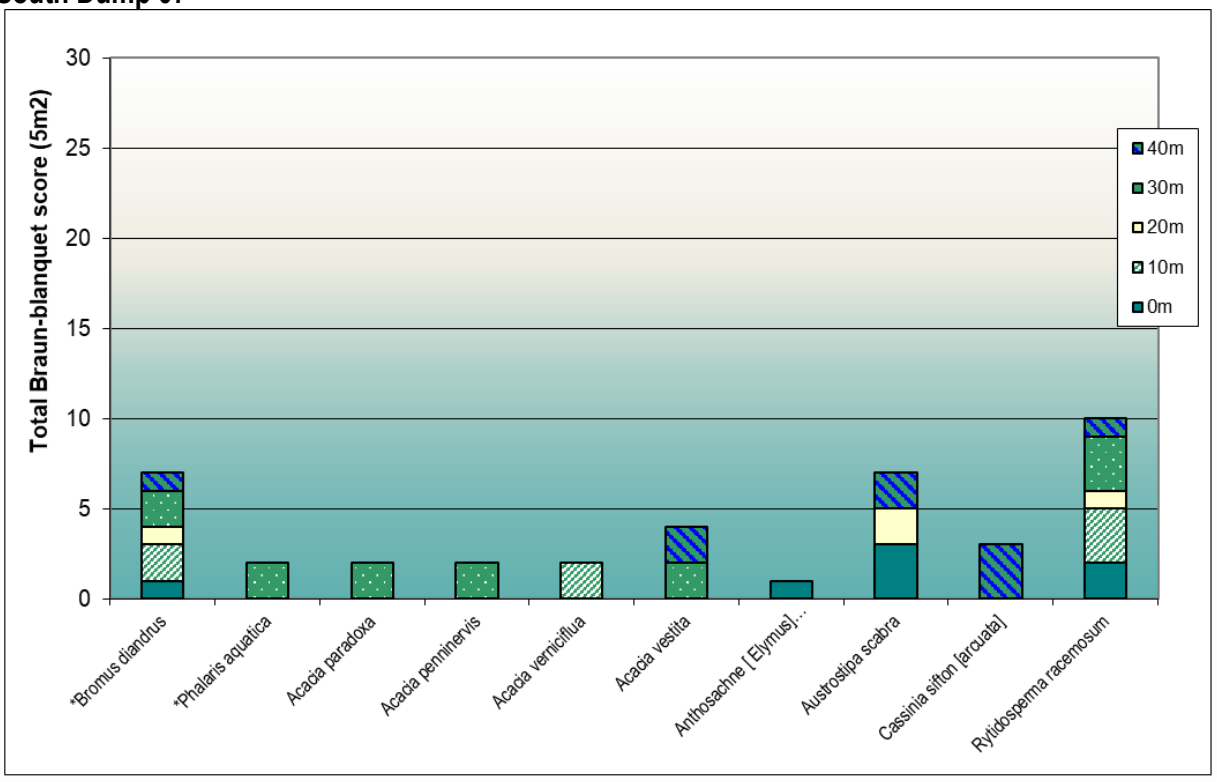
South Dump 04



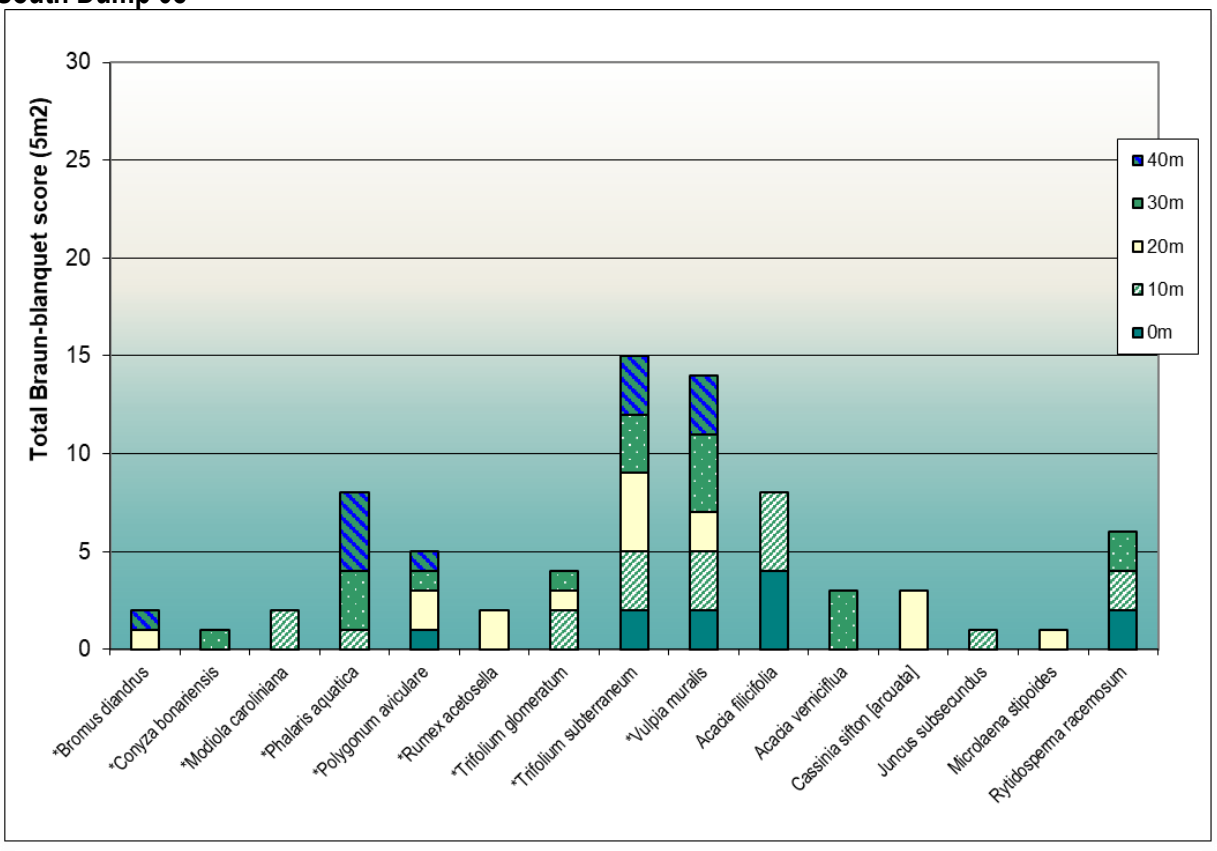
South Dump 05



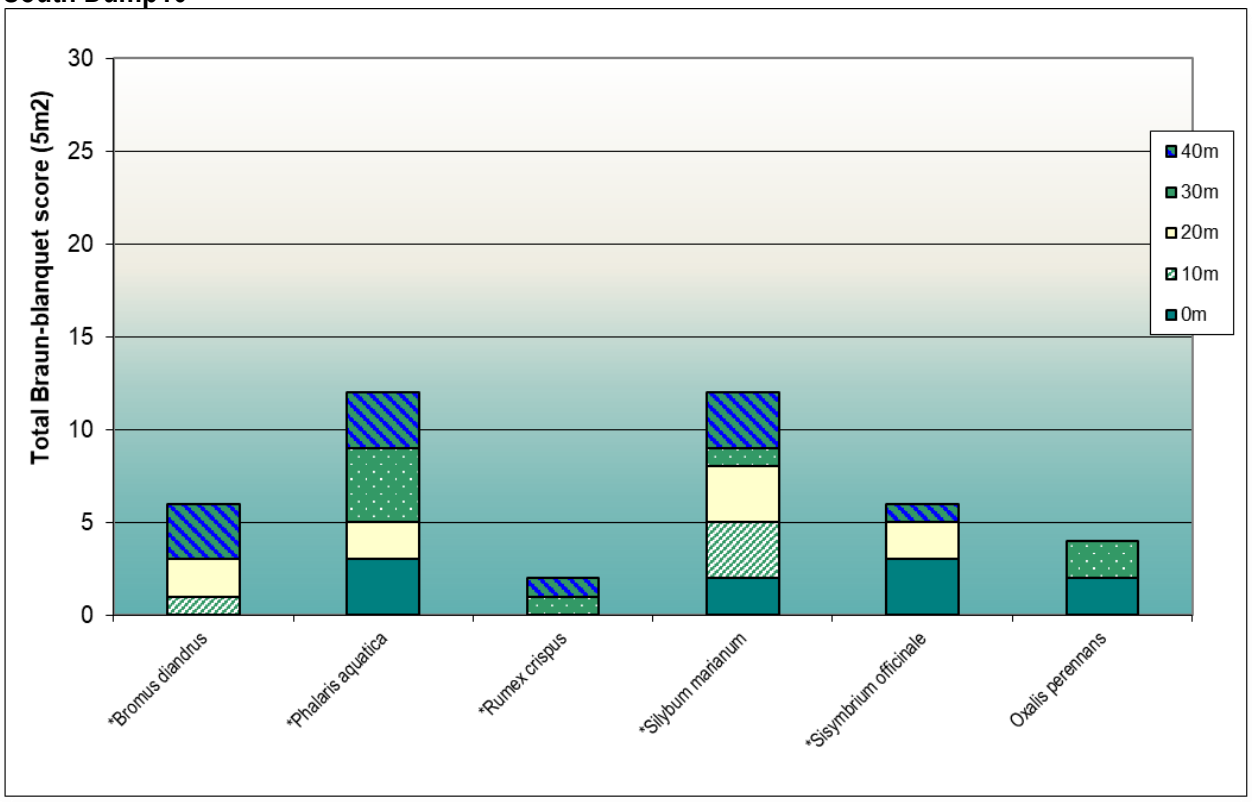
South Dump 07



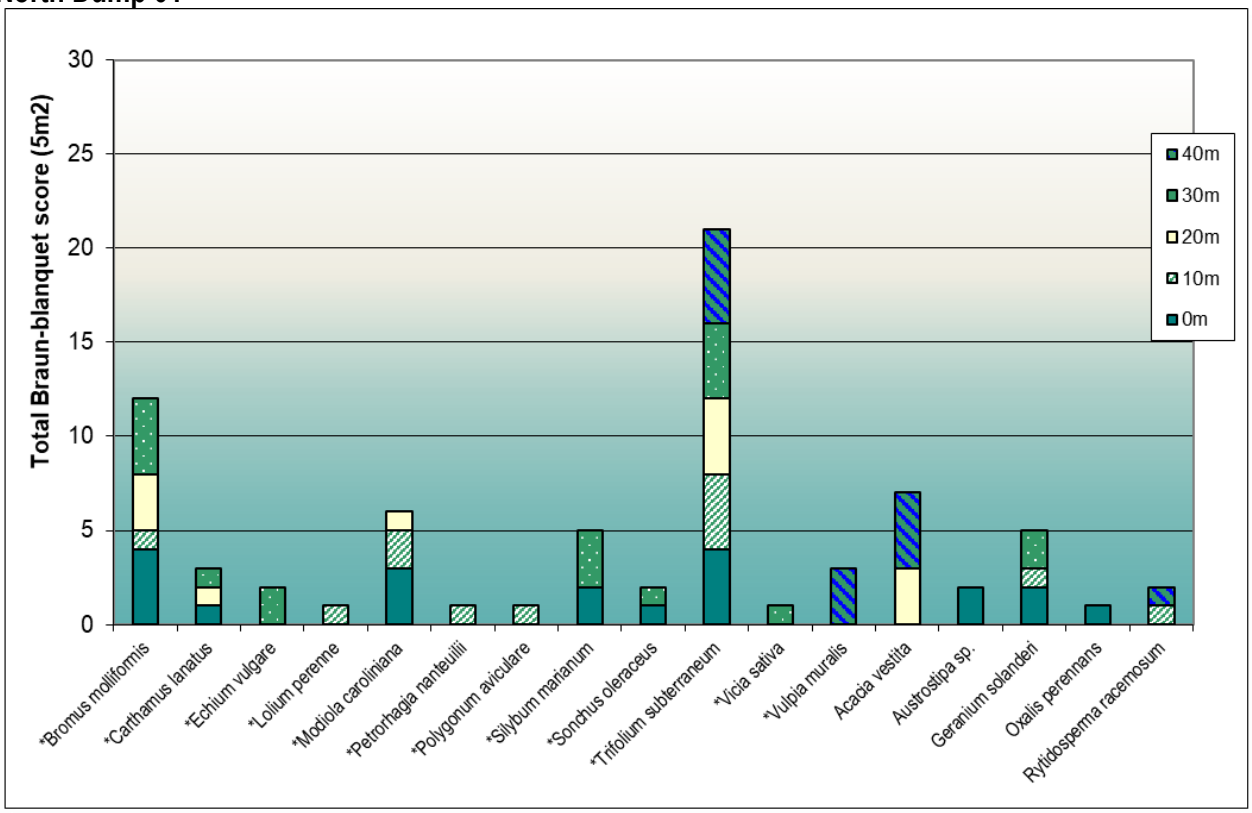
South Dump 08



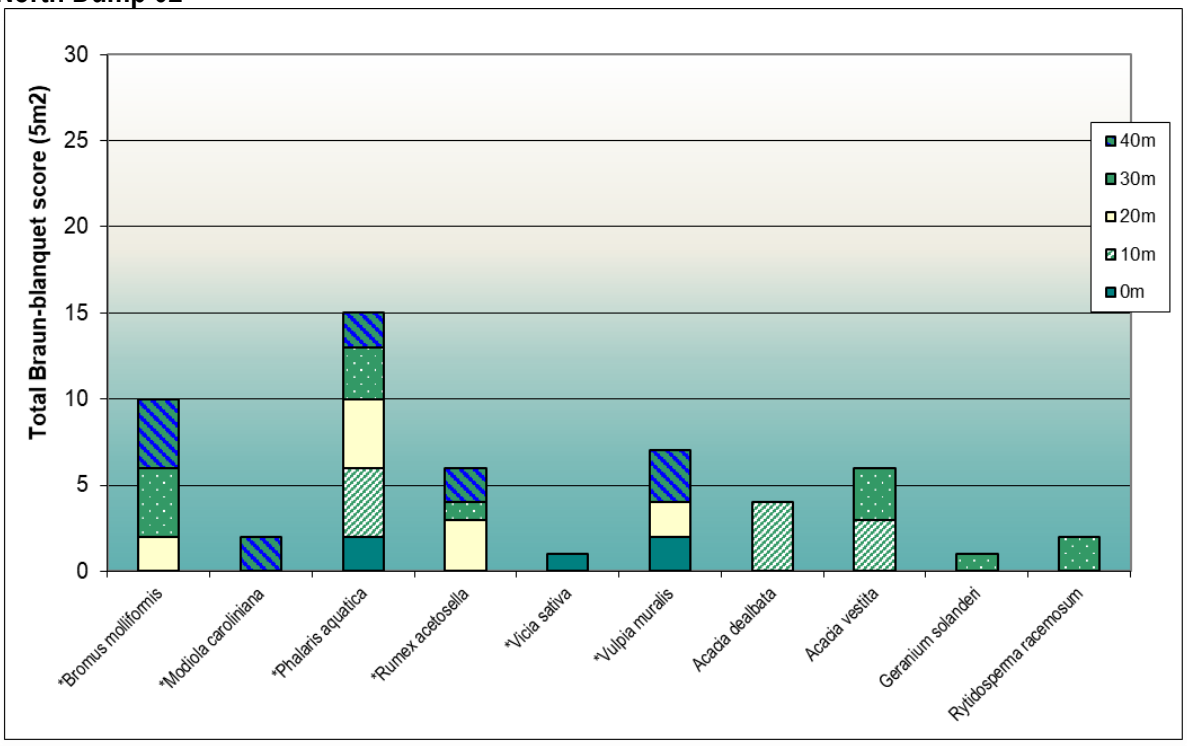
South Dump10



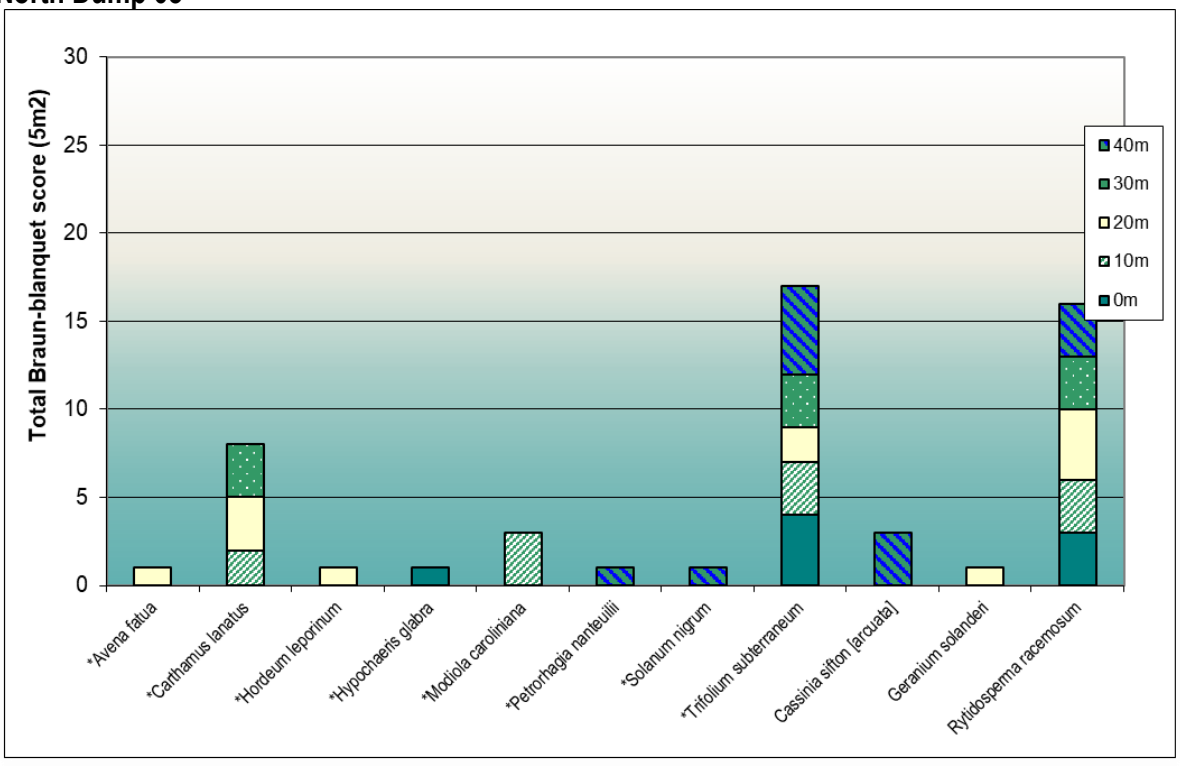
North Dump 01



North Dump 02



North Dump 03



Appendix 4: Agricultural Soil Analysis Report

11 samples supplied by DnA Environmental on 14/04/2023. Lab Job No.N9663

			Site	South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03	RWood01	RWood02	RWood05	Heavy Soil *Clay*	Medium Soil *Clay Loam*	Light Soil *Loam*	Sandy Soil *Loamy Sand*
	Parameter		Method reference	N9663/4	N9663/5	N9663/6	N9663/7	N9663/8	N9663/1	N9663/2	N9663/3	N9663/9	N9663/10	N9663/11	Indicative guidelines - refer to Notes 6 and 8			
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	539	371	635	409	829	933	940	801	996	2,482	1,047	1150	750	375	175
	Soluble Magnesium (mg/kg)			191	219	141	182	197	329	384	288	293	424	315	160	105	60	25
	Soluble Potassium (mg/kg)			71	109	93	115	327	92	99	111	218	237	134	113	75	60	50
	Soluble Phosphorus (mg/kg)			<1	<1	<1	1.4	2.9	1.5	1.6	1.3	6.3	5.0	2.7	15	12	10	5.0
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	2.1	3.0	3.7	33	7.7	6.6	9.3	5.3	17	6.3	3.8	45[note 5]	30[note 5]	24[note 5]	20[note 5]
			**Rayment & Lyons 2011 - 9B2 (Colwell)	11	14	12	72	31	34	41	21	26	25	12	80	50	45	35
			**Inhouse S3A (Bray 2)	4.9	6.5	15	63	18	16	26	15	31	15	6.2	90[note 5]	60[note 5]	48[note 5]	40[note 5]
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	2.4	5.6	0.82	7.4	14	5.6	3.0	5.5	3.4	11	1.2	15	13	10	10
	Ammonium Nitrogen (mg/kg N)			0.78	1.8	2.4	3.0	7.4	2.6	2.2	2.1	13	6.6	7.6	20	18	15	12
	Sulfur (mg/kg S)			10.0	9.4	12	16	14	6.3	9.9	11	10	14	8.1	10.0	8.0	8.0	7.0
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.15	5.40	6.26	5.48	6.81	6.44	6.33	6.10	6.47	7.07	6.19	6.5	6.5	6.3	6.3
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.032	0.049	0.043	0.051	0.098	0.043	0.043	0.044	0.100	0.132	0.056	0.200	0.150	0.120	0.100
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.0	2.9	2.7	4.0	3.4	2.5	3.3	3.1	7.5	11	8.8	> 5.5	>4.5	> 3.5	> 2.5
	Exchangeable Calcium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	4.4	3.2	5.6	3.7	7.7	8.8	10	7.9	10	26	11	15.6	10.8	5.0	1.9
		(kg/ha)		1,996	1,447	2,502	1,673	3,443	3,970	4,660	3,533	4,607	11,804	4,863	7000	4816	2240	840
		(mg/kg)		891	646	1,117	747	1,537	1,772	2,080	1,577	2,057	5,270	2,171	3125	2150	1000	375

			Site	South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03	RRWood01	RRWood02	RWood05	***Heavy Soil*** *Clay*	***Medium Soil*** *Clay Loam*	***Light Soil*** *Loam*	***Sandy Soil*** *Loamy Sand*
	Exchangeable Magnesium	**($cmol_+/kg$)**		2.1	2.6	1.6	2.2	2.3	4.2	5.5	3.6	3.4	5.2	3.8	*2.4*	*1.7*	*1.2*	*0.60*
		(kg/ha)		576	707	437	609	635	1,144	1,486	977	921	1,421	1,034	*650*	*448*	*325*	*168*
		(mg/kg)		257	315	195	272	284	511	663	436	411	634	462	*290*	*200*	*145*	*75*
	Exchangeable Potassium	**($cmol_+/kg$)**		0.40	0.55	0.44	0.65	1.7	0.53	0.59	0.60	1.0	1.3	0.68	*0.60*	*0.50*	*0.40*	*0.30*
		(kg/ha)		352	486	385	568	1,461	463	520	527	876	1,103	594	*526*	*426*	*336*	*224*
		(mg/kg)		157	217	172	254	652	207	232	235	391	493	265	*235*	*190*	*150*	*100*
	Exchangeable Sodium	**($cmol_+/kg$)**		<0.065	<0.065	<0.065	<0.065	0.08	<0.065	<0.065	<0.065	<0.065	0.09	<0.065	*0.3*	*0.26*	*0.22*	*0.11*
		(kg/ha)		<33	<33	<33	<33	42	<33	<33	<33	<33	45	<33	*155*	*134*	*113*	*57*
		(mg/kg)		<15	<15	<15	<15	19	<15	<15	<15	<15	20	<15	*69*	*60*	*51*	*25*
	Exchangeable Aluminium	**($cmol_+/kg$)**	**Inhouse S37 (KCl)	<0.01	0.41	0.03	0.55	0.03	0.01	<0.01	0.02	0.07	0.04	0.04	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		1.2	82	6.7	111	6.7	2.3	<1	4.9	15	7.2	7.4	*121*	*101*	*73*	*30*
		(mg/kg)		<1	37	3.0	49	3.0	1.0	<1	2.2	6.7	3.2	3.3	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen	**($cmol_+/kg$)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.05	0.13	0.03	0.16	<0.01	0.04	0.05	0.03	<0.01	<0.01	0.02	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		1.2	2.8	<1	3.5	<1	<1	1.0	<1	<1	<1	<1	*13*	*11*	*8*	*3*
		(mg/kg)		<1	1.3	<1	1.6	<1	<1	<1	<1	<1	<1	<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) ($cmol_+/kg$)		**Calculation: Sum of Ca,Mg,K,Na,Al,H ($cmol_+/kg$)	7.1	6.9	7.7	7.4	12	14	17	12	15	33	15	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)		**Base Saturation Calculations - Cation $cmol_+/kg$ / ECEC x 100	63	46	72	51	65	65	63	65	70	80	70	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)			30	37	21	30	20	31	33	30	23	16	25	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)			5.7	8.0	5.7	8.8	14	3.9	3.6	4.9	6.8	3.8	4.4	*3.0*	*3.5*	*5.2*	*9.1*

	Site	South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03	RfWood01	RfWood02	RWood05	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
Sodium - ESP (%)		0.5	0.5	0.4	0.5	0.7	0.4	0.3	0.3	0.2	0.3	0.3	*1.5*	*1.8*	*2.9*	*3.3*
Aluminium (%)		0.1	5.9	0.4	7.5	0.3	0.1	0.0	0.2	0.5	0.1	0.2	*6.0*	*7.1*	*10.5*	*12.1*
Hydrogen (%)		0.8	1.8	0.4	2.1	0.0	0.3	0.3	0.3	0.1	0.0	0.2				
Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium ($cmol_+/kg$)	2.1	1.2	3.5	1.7	3.3	2.1	1.9	2.2	3.0	5.0	2.9	*6.5*	*6.4*	*4.2*	*3.2*
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	<0.5	0.80	2.2	0.54	1.8	1.7	2.0	1.4	2.2	3.1	0.70	*6.0*	*5.0*	*4.0*	*3.0*
Manganese (mg/kg)		16	25	7.0	20	16	15	11	17	31	34	31	*25*	*22*	*18*	*15*
Iron (mg/kg)		44	105	69	161	64	50	73	58	91	49	52	*25*	*22*	*18*	*15*
Copper (mg/kg)		3.9	3.2	20	6.5	4.5	23	30	13	0.79	5.9	1.8	*2.4*	*2.0*	*1.6*	*1.2*
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.41	0.51	0.40	0.42	0.60	0.39	0.41	0.40	0.60	0.72	0.50	*2.0*	*1.7*	*1.4*	*1.0*
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	30	37	31	28	51	58	64	49	43	60	50	*50*	*45*	*40*	*35*
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.2	1.7	1.6	2.3	1.9	1.4	1.9	1.8	4.3	6.3	5.0	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
Total Nitrogen (%)		0.10	0.12	0.10	0.15	0.16	0.12	0.15	0.15	0.27	0.37	0.25	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	12	14	16	16	12	12	12	12	16	17	20	*10–12*	*10–12*	*10–12*	*10–12*
Basic Texture	**Inhouse S65	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	..	..	..	..
Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	..	..	..	..
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	20	31	28	33	63	28	28	28	64	84	36	..	..	..	..
Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	1,030	765	1,791	1,139	2,136	2,493	2,934	2,269	3,423	13,487	3,507	*1000–10 000 Ca*			
Total Magnesium (mg/kg)		1,434	1,412	1,103	1,619	1,200	4,245	5,145	3,008	1,516	3,166	2,521	*500–5000 Mg*			
Total Potassium (mg/kg)		1,098	1,211	820	1,652	1,702	1,162	1,272	1,214	1,569	1,978	1,356	*200–2000 K*			
Total Sodium (mg/kg)		<50	<50	<50	55	<50	52	59	54	70	65	52	*100–500 Na*			

	Site	South Dump 04	South Dump 05	South Dump 07	South Dump 08	South Dump 10	North Dump 01	North Dump 02	North Dump 03	RWood01	RWood02	RWood05	Heavy Soil *Clay*	Medium Soil *Clay Loam*	Light Soil *Loam*	Sandy Soil *Loamy Sand*
Total Sulfur (mg/kg)		195	128	319	713	213	109	701	184	269	421	220	*100–1000 S*			
Total Phosphorus (mg/kg)		281	254	368	1,066	338	611	724	575	464	490	412	*400–1500 P*			
Total Zinc (mg/kg)		24	29	35	21	28	59	73	49	24	50	46	*20–50 Zn*			
Total Manganese (mg/kg)		537	528	323	571	1,032	770	561	600	773	1,393	1,342	*200–2000 Mn*			
Total Iron (mg/kg)		30,597	33,743	34,516	45,058	19,510	51,858	59,073	52,446	17,237	36,907	63,498	*1000–50 000 Fe*			
Total Copper (mg/kg)		35	31	136	100	70	217	270	137	14	87	46	*20–50 Cu*			
Total Boron (mg/kg)		<2	<2	<2	2.9	3.4	<2	<2	<2	7.9	15	5.3	*2–50 B*			
Total Silicon (mg/kg)		761	817	1,052	1,298	1,292	551	508	751	1,890	2,248	1,619	*1000–3000 Si*			
Total Aluminium (mg/kg)		10,012	10,394	9,694	12,688	9,546	14,153	15,221	14,420	7,824	19,131	12,739	*2000–50 000 Al*			
Total Molybdenum (mg/kg)		0.96	1.0	2.8	1.3	0.76	2.9	3.5	2.2	0.58	0.47	0.41	*0.5–3.0 Mo*			
Total Cobalt (mg/kg)		14	10	6.3	8.8	16	20	24	21	7.8	28	36	*5–50 Co*			
Total Selenium (mg/kg)		<0.5	<0.5	<0.5	2.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	*0.1–2.0 Se*			
Total Cadmium (mg/kg)		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	*<1 Cd*			
Total Lead (mg/kg)		13	13	12	11	11	11	11	13	11	9.8	8.2	*2–200 Pb*			
Total Arsenic (mg/kg)		7.4	4.2	8.0	35	6.4	9.2	9.9	9.5	16	3.7	4.5	*1–50 As*			
Total Chromium (mg/kg)		28	22	17	55	21	34	37	37	9.4	24	61	*5–1000 Cr*			
Total Nickel (mg/kg)		12	12	6.2	11	9.9	16	16	19	5.0	15	13	*5–500 Ni*			
Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.14	<0.1	<0.1	<0.1	*< 0.2 Hg*			
Total Silver (mg/kg)		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	*.. Ag*			

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.*CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer SCU.edu.au/eal/t&cs).
17. This report was issued on 21/04/2023.

Quality Checked: Kris Saville
Agricultural Co-Ordinator