TERRESTRIAL ECOSYSTEMS

# Baseline Monitoring of Rehabilitation Programs

## Alcoa's Bauxite Mining Areas

Prepared for: Alcoa of Australia Ltd

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# EXECUTIVE SUMMARY

Alcoa of Australia Ltd (Alcoa) operates bauxites mines in the Huntly and Willowdale areas east of Pinjarra in the Western Australian Jarrah Forest. Alcoa is progressively rehabilitating mined areas once the local resources have been exhausted. The primary objective of Alcoa's bauxite mine rehabilitation program is to return a self-sustaining Jarrah Forest ecosystem after mining. This includes re-establishing populations of all faunal groups and species in densities and distributions required for maintaining forest biodiversity and ecosystem function.

Alcoa has established 12 long-term monitoring sites for vertebrate fauna. Three of the sites are in unmined habitat, and three of the sites are in areas rehabilitated 5, 10 and 15 years ago. It is proposed that the vertebrate fauna at these sites would be periodically monitored (e.g. every 5 years) to enable judgements to be made about the extent to which rehabilitated areas were progressing on a trajectory towards the recreation of functional ecosystems, as determined by the terrestrial vertebrate fauna assemblage, like that in the unmined areas. Outcomes from these monitoring surveys would inform planning for future rehabilitation programs and where appropriate taking corrective action in existing rehabilitated areas.

Terrestrial Ecosystems has undertaken the baseline survey, which will be the first of the long-term monitoring surveys. These survey data indicated that the three unmined sites selected as analogue climax communities for the rehabilitation areas are not similar, and there are appreciable differences among the fauna assemblages within aged classes of rehabilitation. Based on the available data, there are two alternative conclusions that can be reached about succession of rehabilitated areas along a trajectory to an analogue climax community:

- differences among the unmined areas makes it difficult to determine what is the target climax community, and it is possible there are other alternative Jarrah Forest communities that have not been sampled that would better represent climax communities that will eventuate in rehabilitated areas; or
- rehabilitation programs are not of sufficient quality to enable the mammal, reptile and amphibian assemblages in unmined area to recolonise rehabilitated areas within a 15-year period sufficiently to clearly indicate they are on a trajectory toward establishing analogue climax communities.

The preliminary data collected in this survey would suggest that conservation significant species are in the unmined areas, but not the rehabilitated areas. If further investigation indicates that this was the case, then a focus on the long-term preservation of conservation significant species, and in particular their use of rehabilitation areas should be a priority.

No foxes were recorded during the camera trapping program and only a single feral cat was recorded, however, the area surveyed was very limited when viewed in the context of the extent of Jarrah Forest managed by Alcoa. Feral pigs were abundant in a localised area and are known to cause environmental damage. It is suggested that Alcoa implement a program to manage feral pest species likely to be impact on ecosystems, and in particular conservation significant species.

It is suggested that this monitoring program is reviewed before the survey is repeated, with particular attention to:

- the fauna target(s) as represented by the rehabilitation trajectory and intended climax community(ies);
- survey design (i.e. location of analogue sites);
- use of camera traps to determine presence vs relative abundance or conservation significant fauna; and
- value-for-money of surveys, when compared with the alternative uses of these resources to achieve a similar objective(s) (e.g. the long-term preservation of conservation significant species, and in particular their use of rehabilitation areas).

# 1. INTRODUCTION

## 1.1 BACKGROUND

Alcoa of Australia Ltd (Alcoa) operates the Huntly and Willowdale bauxite mines east of Pinjarra in Western Australian on mineral lease ML1SA. The Huntly mine was established in 1972 and is located near Dwellingup and supplies bauxite ore to the Kwinana and Pinjarra refineries, as well as other clients. The Huntly mine currently includes locations at Myara, McCoy and Karnet. The Willowdale mine was established in 1984 and is located near Wagerup and supplies bauxite ore to the Wagerup refinery, as well as other clients. The Willowdale mine currently includes locations at Larego, Orion and Arundel.

The primary objective of Alcoa's bauxite mine rehabilitation program is to return a self-sustaining jarrah forest ecosystem after mining. This includes re-establishing populations of all faunal groups and species in densities and distributions required for maintaining forest biodiversity and ecosystem function. To ensure this objective is met, Alcoa established a long-term fauna monitoring program in 1991. This program characterises and monitors the key fauna of the areas in which Alcoa operates and assesses the impact of mining on these species.

## 1.2 SUCCESSION

Grant (2006) indicated that Alcoa's objective for its rehabilitation programs was to establish self-sustaining jarrah forest ecosystems. Grant (2006) went on to indicate that '*restored native ecosystems may be different in structure to the surrounding native ecosystems, but there should be confidence that they will change with time along with, or toward the structure and composition of the surrounding area*' and '*should be capable of withstanding disturbances such as fire or grazing*'. It has been presumed that this object is still applicable.

Primary succession is defined here as a process of change in the species structure of an ecological community over time from an assemblage that commences on barren or highly disturbed land to the climax community. This can be diagrammatically represented as shown in Plate 1.

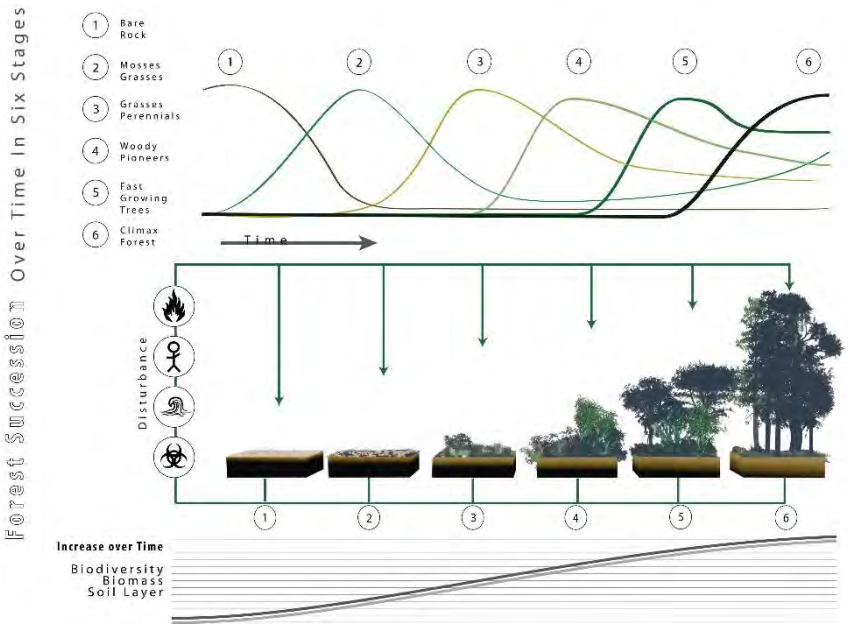



**Plate 1. Conceptual diagram of primary succession**

taken from https://commons.wikimedia.org/wiki/File:Forest_succession_depicted_over_time.png

During the very early stages, very few terrestrial vertebrate species will colonise the area due to a lack of suitable habitat and higher levels of predation because of a lack of cover and retreat sites. Once the vegetation, invertebrates and microbial activity move through the succession stages and additional habitat niches open up, then more species can colonise the rehabilitated areas. In some cases, the abundance of early colonisers (i.e. pioneers) will be reduced due to competition and changing habitat conditions. Rehabilitated areas will cycle through many iterations of this process and along the way, species abundance typically increases, and the various species reach population levels suitable for the habitat and resources available, until such time it becomes a climax community.

Vertebrate fauna are only a part of the primary succession process and their progress from pioneering species toward a climax community is interrelated with the vegetation, fungi, microbial and invertebrate community development. Within broad boundaries, the trajectory in rehabilitated areas should be apparent in monitoring data (Plate 2).

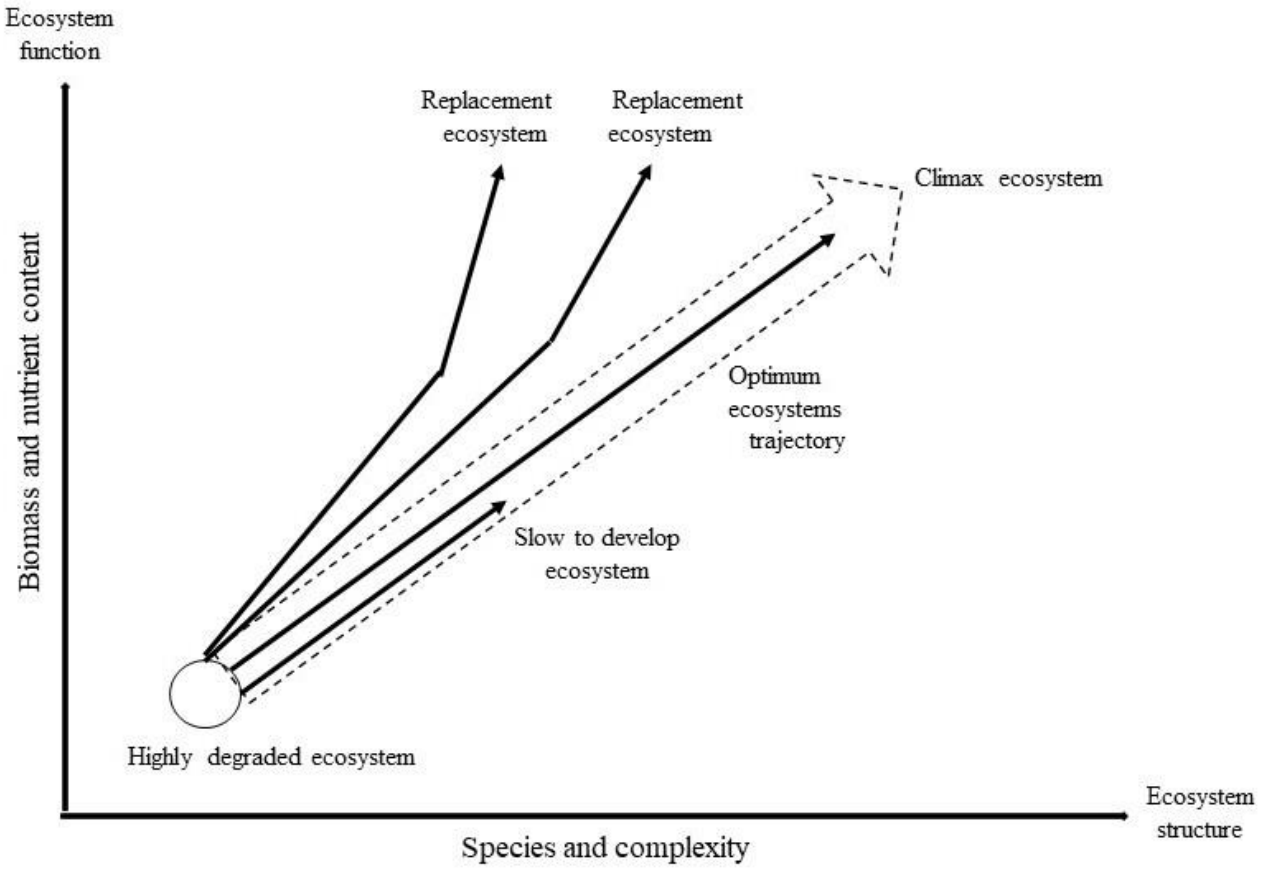



**Plate 2. Primary succession trajectory(taken from: Bradshaw 1984)**

Anderson et al. (2022) and Cross et al. (2019, 2021) argued that fauna have very often been forgotten in considering rehabilitation success with the focus on soils and vegetation. Anderson et al. (2022) went on to suggest a framework for incorporating fauna into the restoration process, and in doing so, identified the following five key criteria for effective faunal standards:

- appropriate reference ecosystem [analogue site(s)];
- faunal taxa to be considered;
- attributes of these taxa to be measured;
- acceptable level of similarity with reference conditions; and
- sampling methodology that is sufficiently robust to provide reliable comparative data.

## 1.3 OBJECTIVE

Alcoa's intention was to establish long-term monitoring sites for vertebrate fauna in unmined areas, and areas rehabilitated 5, 10 and 15-years ago. It was proposed that the vertebrate fauna at these sites would be periodically monitored to enable judgements to be made about the extent to which rehabilitated areas were progressing on a trajectory towards the recreation of functional ecosystems, like that in the unmined areas. Outcomes from these monitoring surveys would inform planning for future rehabilitated areas and where appropriate corrective action in existing rehabilitated areas.

Here we provide a description of the methods used to collect vertebrate fauna data, the results of the baseline monitoring program, discussion of the results and a commentary on the program and a suggested way forward.

# 2. METHODS

## 2.1 PIT-TRAPPING PROGRAM

Twelve sites in the Jarrah Forest (Figures 1 and 2) were established by Alcoa (Plates 16-39). This included three unmined analogue sites, three sites that were rehabilitated in 2007 (i.e. 15-years old), three sites that were rehabilitated in 2012 (i.e. 10-years old) and three sites that were rehabilitated in 2017 (i.e. 5-years old; Appendix A).

At each site there were four near parallel drift fences 30m long with approximately 25cm of flywire above the ground. Along each drift fence there were three 20L PVC buckets, three PVC 150mm diameter pipes that were 400mm deep and buried directly under the flywire drift fence. Three pair of funnels traps were deployed either side of the drift fence and three aluminium box traps were set approximately 10m to the side of the drift fence (Plate 3). Buckets used as pit-traps had holes and styrene sheets in the bottom to provide captured fauna protection from unfavourable environmental conditions. These traps targeted small mammals, reptiles and amphibians.

The location of trapping sites is shown in Figures 2-14 and the coordinates are provided in Appendix B. Traps were opened on 9 January and closed on 21 January 2023.

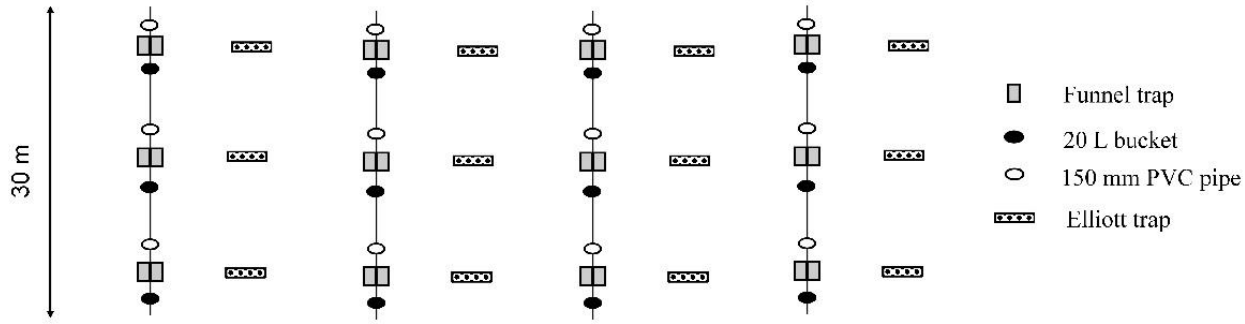



**Plate 3. Trapping site layout**

## 2.2 CAGE TRAPPING PROGRAM

Eighty cage traps (Plate 4) targeting Chuditch (*Dasyurus hallucatus*) were deployed adjacent to gravel tracks where Alcoa believed that there may have been Chuditch. Trapping sites were selected by Alcoa on the basis that one was inside the mine perimeter and comprised a variety of levels of disturbance (i.e. rehabilitation of various ages and remnant vegetation), and the other was outside the mine perimeter in unmined forest (Figures 18-21).

Cages were baited with raw chicken necks which were replaced every three days or as required. Traps were opened on 8 January and closed on 20 January 2023 at locations were Chuditch had previously been reported. Camera traps targeted the medium and large mammals, but any fauna recorded were reported.



**Plate 4. Baited cage trap**

## 2.3 CAMERA TRAPS

Twenty-four camera traps (Reconyx HC600) were deployed in the denser vegetation targeting Quokka (*Setonix brachyurus*) and Quenda (*Isoodon fusciventer*; Figures 15-17). Each camera trap had a non-reward lure (Plate 5) placed ~3-4m in front of the camera trap (Plate 6) in the detection zone. Lures were a mixture of peanut butter, rolled oats and sardines topped up with mullie oil. Traps were deployed on 8 January and retrieved on 20 January 2023.



**Plate 5. Non-reward lure**



**Plate 6. Mounted camera trap**

## 2.4 INVERTEBRATE SAMPLING

Each trapping site was searched for invertebrates for one hour by two people for the following taxonomic groups: isopods, diplopods, opiliones, scorpions, mygalomorph spiders and pseudoscorpions. Specimens were preserved in ethanol but not identified. In addition, specimens from these taxonomic groups caught in pit and funnel traps were also collected and preserved. All specimens were given to Alcoa for identification and analysis.

## 2.5 DATA ANALYSIS

The diversity for the trapped fauna assemblage can be measured in numerous ways (Hayek and Buzas 1997, Magurran 2004). The four most common attributes are species richness, evenness, a single diversity score and relative abundance. These metrics are interrelated and there are a diverse number of analytical tools available to quantify these metrics and similarity among the trapped assemblages for each site.

### 2.5.1 Principal component analysis

A principal component analysis (PCA) is used to reduce the complexity of large datasets by transforming a large dataset of variables into a smaller one that contains most of the information. PCAs were calculated (StatistiXL) for all survey site-based trapping data (i.e. excluding cage and camera trap data), to determine the extent to which vertebrate fauna assemblages were similar/different among sites. Eigenvalues >1 are typically used to determine the components that are useful, and for each component a percentage of its contribution to displaying the attributes of larger data set provides useful information about the importance of each component.

It should be expected that if succession processes were advancing along an expected trajectory, then, survey sites should be grouped in the PCAs based according to the period of rehabilitation (i.e. unmined, 15-years, 10-years and 5-years) using the most significant principal components (i.e. PCAs 1 and 2).

### 2.5.2 Similarity

If having established that there were differences among the trapped fauna assemblages at each site, and if rehabilitation and succession were advancing along an expected trajectory, then the extent to which the trapped fauna assemblages were similar is of interest. Ideally, the three unmined analogue sites should be more similar to each other than to the rehabilitation sites, and rehabilitation site similarity should be greatest among rehabilitation aged class sites.

The Morisita-Horn similarity index was used to compare similarity among combinations of trapped fauna assemblages at each site. The quantitative Morisita-Horn similarity index was selected because it is not strongly influenced by either species richness or sample size (Wolda 1981) and it was recommended by Magurran (2004). Readers should, however, be aware that it is heavily influenced by the abundance of the most abundant species. The Morisita-Horn similarity index was calculated using Species, Diversity and Richness software (Pisces Conservation Ltd 2010).

### 2.5.3 Species richness and relative abundance

The actual number of species caught at each trapping site is one measure of species richness and is directly related to the trapping effort and number of individuals caught. Had the trapping effort been extended and more individuals caught, then it is likely the number of species caught at each site would increase (Colwell and Coddington 1994, Magurran 2004). Species richness and abundance was calculated using Species, Diversity and Richness software IV (Pisces Conservation Ltd 2010).

It should be expected that the unmined sites would have the highest number of species and species abundance, and as rehabilitation sites progress along an expected succession trajectory, then species richness would increase, however, abundance for many species will rise and fall based on the available habitat and competition among species.

### 2.5.4 Evenness

Smith and Wilson (1996), supported by Magurran (2004), reported their measure of evenness (Evar) to be the most satisfactory overall. Species, Diversity and Richness software IV software (Pisces Conservation Ltd 2010) was used to calculate the Smith and Wilson method of determining evenness. It is unknown how evenness is related to fauna assemblages in rehabilitated sites.

### 2.5.5 Diversity

Fisher's alpha (also known as Log series diversity) was used to measure diversity because of its good discriminating ability and low sensitivity to sample size (Kempton and Taylor 1974, Magurran 1988, Hayek and Buzas 1997). Other more commonly used diversity indices were also calculated.

Log series diversity, Shannon-Wiener and Simpson's indices were calculated using Species, Diversity and Richness IV software (Pisces Conservation Ltd 2010).

# 3. RESULTS

All vertebrate fauna caught in pit, funnel and aluminium box traps are shown in Table 1.

**Table 1. Trapping data results**

| | | Survey site status | Unmined | Unmined | Unmined | 15-year rehabilitation | 15-year rehabilitation | 15-year rehabilitation | 10-year rehabilitation | 10-year rehabilitation | 10-year rehabilitation | 5-year rehabilitation | 5-year rehabilitation | 5-year rehabilitation | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Family** | **Species** **Survey sites** | **1** | **2** | **3** | **7** | **8** | **12** | **4** | **5** | **6** | **9** | **10** | **11** | |
| Amphibian | Limnodynastidae | *Heleioporus eyrei* | | | 2 | | | | | | | | | | 2 |
| | | *Heleioporus inornatus* | 1 | | | | | | | | | | | | 1 |
| | Myobatrachidae | *Crinia georgiana* | | 2 | | | | | 1 | | | 1 | | | 4 |
| Mammal | Burramyidae | *Cercartetus concinnus* | 3 | 2 | 1 | 23 | 13 | 8 | 3 | | 12 | | | 1 | 66 |
| | Dasyuridae | *Antechinus flavipes* | | 1 | 14 | 5 | 1 | 4 | 11 | 7 | 2 | 2 | 2 | | 49 |
| | | *Sminthopsis gilberti* | | | 1 | 2 | 1 | 2 | 5 | | 1 | 2 | 1 | 2 | 17 |
| | Muridae | *Mus musculus* | | | | | | | | 1 | 1 | 6 | | 5 | 13 |
| Reptile | Agamidae | *Pogona minor* | | | | 3 | 1 | | | 2 | 2 | | | 1 | 9 |
| | Carphodactylidae | *Underwoodisaurus milii* | 2 | 2 | | | | | | 2 | | 1 | 3 | 3 | 13 |
| | Diplodactylidae | *Diplodactylus lateroides* | | 1 | | 1 | 1 | | | | 1 | 2 | 6 | 1 | 13 |
| | | *Diplodactylus polyophthalmus* | | | | 1 | | | 1 | | | | | 1 | 3 |
| | Elapidae | *Suta gouldii* | | | | 1 | | | | | 1 | | | | 2 |
| | | *Suta nigriceps* | 1 | | | | | | | 3 | | | | | 4 |
| | Gekkonidae | *Christinus marmoratus* | | | | | | | | | | | | 1 | 1 |
| | Pygopodidae | *Lialis burtonis* | | | | | | | | | 1 | | | | 1 |
| | Scincidae | *Acritoscincus trilineatus* | | 7 | 2 | 9 | 6 | 9 | 1 | 12 | 9 | | 1 | 3 | 59 |
| | | *Cryptoblepharus buchananii* | 3 | 7 | 2 | | | | | | | 1 | | | 13 |
| | | *Egernia napoleonis* | 13 | 5 | 1 | | | | | 1 | | | | | 20 |
| | | *Hemiergis initialis* | 2 | 4 | | | 2 | 2 | | 5 | | | | | 15 |
| | | *Lerista distinguenda* | 11 | 15 | 11 | 3 | 4 | | | 3 | 6 | 1 | | | 54 |
| | | *Lerista elegans* | | 1 | | 1 | | | | 3 | | | | | 5 |
| | | *Menetia greyii* | 3 | | 1 | 4 | 4 | | 2 | 1 | 3 | 1 | 6 | 7 | 32 |
| | | *Morethia obscura* | 14 | 13 | 2 | 7 | 7 | 4 | 4 | 6 | 9 | 9 | 1 | 4 | 80 |
| | | *Tiliqua rugosa* | | | | | 1 | | | | | | | | 1 |
| | Typhlopidae | *Anilios australis* | | 5 | | | 1 | | | 1 | 1 | | | | 8 |
| | | Total | 53 | 65 | 37 | 60 | 42 | 29 | 28 | 47 | 49 | 26 | 20 | 29 | 485 |

Of interest, a single *Morelia imbricata* was recorded on one of the tracks while undertaking the survey (Plate 7).



**Plate 7. Carpet python**

Vertebrate fauna caught in cage traps are shown in Table 2.

**Table 2. Fauna caught in a cage traps**

| Taxa | Family | Species | Trap numbers | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 12C | 13C | 1C | 28C | 41C | 42C | 44C | 45C | 47C | 50C | 57C | 59C | 61C | 63C | 68C | 6C | 74C | 76C | 78C | Total |
| Mammal | Dasyuridae | *Dasyurus geoffroii* | | | | | 1 | 1 | 1 | 1 | | | | | 1 | 1 | | | 1 | 3 | 2 | 12 |
| | Peramelidae | *Isoodon fusciventer* | | | | | | | | | | | 1 | | | | 1 | | | | | 2 |
| | Tachyglossidae | *Tachyglossus aculeatus* | | | 1 | | | | | | | | | | | | | | | | | 1 |
| Reptile | Scincidae | *Tiliqua rugosa* | | | | | | | | | | 1 | 1 | | | | | | | | | 2 |
| | Varanidae | *Varanus gouldii* | | 1 | | 1 | | 1 | 1 | 1 | 1 | | | 1 | | 1 | | | | | | 8 |
| | | *Varanus rosenbergi* | 1 | 1 | | 1 | | | | | | 1 | | | | | | 3 | | | | 7 |
| | | Total | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 1 | 3 | 2 | 32 |

Vertebrate fauna caught by trap type are shown in Table 3.

## Table 3. Vertebrate fauna recorded by trap type

| Taxa | Family | Species | Aluminium box trap | Bucket | Funnel | Pipe | Cage trap - Large | Total |
|---|---|---|---|---|---|---|---|---|
| Amphibian | Limnodynastidae | *Heleioporus eyrei* | | 2 | | | | 2 |
| | | *Heleioporus inornatus* | | 1 | | | | 1 |
| | Myobatrachidae | *Crinia georgiana* | | 3 | | 1 | | 4 |
| Mammal | Burramyidae | *Cercartetus concinnus* | | 28 | | 38 | | 66 |
| | Dasyuridae | *Antechinus flavipes* | 21 | 4 | 5 | 19 | | 49 |
| | | *Dasyurus geoffroii* | | | | | 12 | 12 |
| | | *Sminthopsis gilberti* | | 8 | | 9 | | 17 |
| | Muridae | *Mus musculus* | 7 | | 1 | 5 | | 13 |
| | Peramelidae | *Isoodon fusciventer* | | | | | 2 | 2 |
| | Tachyglossidae | *Tachyglossus aculeatus* | | | | | 1 | 1 |
| Reptile | Agamidae | *Pogona minor* | | 5 | 1 | 3 | | 9 |
| | Carphodactylidae | *Underwoodisaurus milii* | | 2 | 5 | 6 | | 13 |
| | Diplodactylidae | *Diplodactylus lateroides* | | 6 | 4 | 3 | | 13 |
| | | *Diplodactylus polyophthalmus* | | 1 | 1 | 1 | | 3 |
| | Elapidae | *Suta gouldii* | | | 2 | | | 2 |
| | | *Suta nigriceps* | | 1 | 3 | | | 4 |
| | Gekkonidae | *Christinus marmoratus* | | | | 1 | | 1 |
| | Pygopodidae | *Lialis burtonis* | | | 1 | | | 1 |
| | Scincidae | *Acritoscincus trilineatus* | | 20 | 28 | 11 | | 59 |
| | | *Cryptoblepharus buchananii* | | 1 | 1 | 11 | | 13 |
| | | *Egernia napoleonis* | 1 | 3 | 13 | 3 | | 20 |
| | | *Hemiergis initialis* | | 9 | 2 | 4 | | 15 |
| | | *Lerista distinguenda* | | 22 | 3 | 29 | | 54 |
| | | *Lerista elegans* | | 5 | | | | 5 |
| | | *Menetia greyii* | | 15 | | 17 | | 32 |
| | | *Morethia obscura* | | 21 | 38 | 21 | | 80 |
| | | *Tiliqua rugosa* | | | 1 | | 2 | 3 |
| | Typhlopidae | *Anilios australis* | | 2 | 2 | 4 | | 8 |
| | Varanidae | *Varanus gouldii* | | | | | 8 | 8 |
| | | *Varanus rosenbergi* | | | | | 7 | 7 |
| | | Total | 29 | 159 | 111 | 186 | 32 | 517 |

Vertebrate fauna recorded by camera traps are shown in Table 4.

**Table 4. Camera trap results**

| | | | Camera trap numbers | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Taxa | Family | Species | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 | CM10 | CM11 | CM12 | CM13 | CM14 | CM15 | CM16 | CM17 | CM18 | CM19 | CM20 | CM21 | CM22 | CM23 | CM24 |
| Bird | Artamidae | *Strepera versicolor* | 1 | | | | | | | | | | | | | 1 | 1 | | | | | | | | | |
| | Casuariidae | *Dromaius novaehollandiae* | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| | Columbidae | *Phaps elegans* | 2 | | | 1 | | | | | | | | | 1 | | | | | | | | | | | |
| Mammal | Dasyuridae | *Antechinus flavipes* | | | | | | | | | | | 1 | | 1 | | | | | | | | | | | |
| | | *Dasyurus geoffroii* | | | | | | | | | | | | | | | 1 | 1 | | | | | | | | |
| | Felidae | *Felis catus* | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| | Macropodidae | *Macropus fuliginosus* | 1 | | 1 | 2 | | 1 | | 1 | | | 1 | | 3 | 1 | 3 | 2 | | 2 | 2 | 1 | | 1 | 1 | 1 |
| | | *Notamacropus irma* | | | | | | | | | | | 1 | 1 | 2 | | | | | | | | | | | |
| | | *Setonix brachyurus* | | | | | | | | | 1 | 1 | 1 | 2 | 1 | | | | | | | | | | | |
| | Muridae | *Mus musculus* | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Rattus rattus* | 1 | | 1 | | | | | 1 | | | | | | 1 | | | | | | 1 | | | | |
| | Peramelidae | *Isoodon fusciventer* | | | | | | | | | | 1 | | | | | | | 1 | 1 | | | | 1 | | 1 |
| | Suidae | *Sus scrofa* | 1 | 1 | 2 | | 4 | 3 | 1 | 2 | | | | | | | | | | | | | | | | |
| | Tachyglossidae | *Tachyglossus aculeatus* | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | |
| Reptiles | Varanidae | *Varanus rosenbergi* | 1 | | | | | | | | | | | | | | | | | | | | | | | |

## 3.1 SIMILARITY AMONG SURVEY SITES

Survey site similarity (or difference) was determined using two metrics; PCA and Morisita-Horn similarity index.

For the PCA analysis, the PCAs 1 and PCAs 2, and PCAs 1 and PCAs 3 are plotted, and the eigenvalues and percent variance accounted by these PCAs are shown in Table 5.

**Table 5. Percent variance and eigenvalues for the PCA**

| Value | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 | PC 6 | PC 7 | PC 8 | PC 9 | PC 10 | PC 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Eigenvalue | 5.94 | 4.18 | 3.22 | 2.80 | 2.24 | 1.83 | 1.51 | 1.23 | 1.09 | 0.56 | 0.42 |
| % of Variance | 23.76 | 16.73 | 12.86 | 11.21 | 8.96 | 7.33 | 6.03 | 4.91 | 4.35 | 2.22 | 1.66 |
| Cum. % | 23.76 | 40.48 | 53.34 | 64.56 | 73.51 | 80.84 | 86.86 | 91.77 | 96.12 | 98.34 | 100.00 |

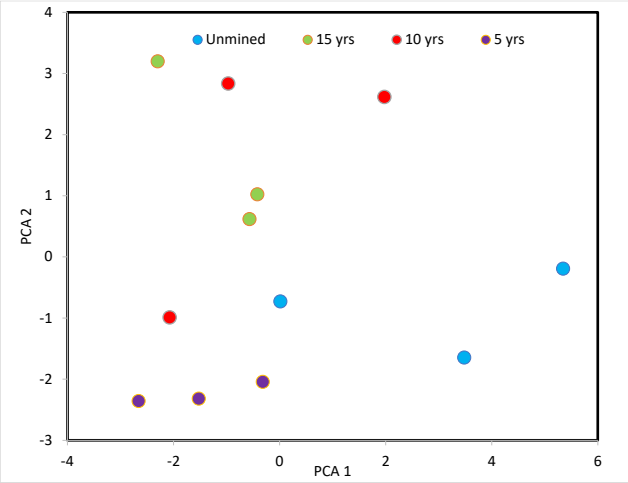



**Chart 1. PCAs 1 and 2**

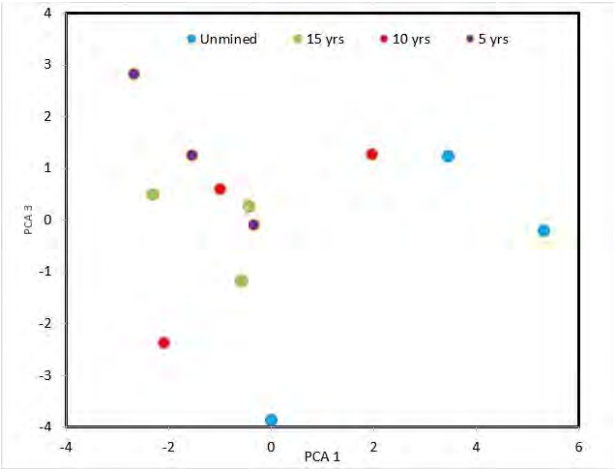



**Chart 2. PCAs 1 and 3**

The Morisita-Horn index provides an indication of the similarity of the fauna assemblage among sites (Table 6).

**Table 6. Morisita-Horn index for 12 sites**

| | Sites | 2 | 3 | 7 | 8 | 12 | 4 | 5 | 6 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sites | | Unmined | Unmined | 15 | 15 | 15 | 10 | 10 | 10 | 5 | 5 | 5 |
| 1 | Unmined | **0.814** | 0.410 | 0.344 | 0.500 | 0.269 | 0.232 | 0.378 | 0.540 | 0.547 | 0.177 | 0.344 |
| 2 | Unmined | | 0.523 | 0.383 | 0.565 | 0.427 | 0.236 | 0.613 | 0.659 | 0.521 | 0.147 | 0.317 |
| 3 | Unmined | | | 0.330 | 0.317 | 0.368 | 0.710 | 0.513 | 0.404 | 0.290 | 0.226 | 0.116 |
| 7 | 15-years | | | | **0.947** | **0.864** | 0.500 | 0.439 | **0.904** | 0.276 | 0.229 | 0.388 |
| 8 | 15-years | | | | | **0.830** | 0.418 | 0.506 | **0.960** | 0.392 | 0.282 | 0.487 |
| 12 | 15-years | | | | | | 0.568 | 0.707 | **0.844** | 0.304 | 0.180 | 0.364 |
| 4 | 10-years | | | | | | | 0.486 | 0.438 | 0.459 | 0.352 | 0.316 |
| 5 | 10-years | | | | | | | | 0.619 | 0.396 | 0.265 | 0.432 |
| 6 | 10-years | | | | | | | | | 0.466 | 0.258 | 0.512 |
| 9 | 5-years | | | | | | | | | | 0.331 | 0.645 |
| 10 | 5-years | | | | | | | | | | | 0.634 |

*Cells in bold have a similarity greater than 0.75

## 3.2 SPECIES ABUNDANCE AND DIVERSITY

Species richness, Shannon Wiener index, Simpsons D index, Fishers' Alpha index and Smith and Wilsons B index are provided for each survey site and for all sites combined in Table 7.

## Table 7. Diversity and abundance index scores

| | Site # | Species richness | Shannon Wiener | Simpsons' D | Fishers' Alpha | Smith and Wilson B |
|---|---|---|---|---|---|---|
| **Unmined** | 1 | 10 | 1.91 | 5.86 | 3.64 | 0.54 |
| **Unmined** | 2 | 13 | 2.22 | 8.19 | 4.89 | 0.56 |
| **Unmined** | 3 | 10 | 1.75 | 4.44 | 4.50 | 0.55 |
| **15-years** | 7 | 12 | 1.98 | 5.32 | 4.51 | 0.52 |
| **15-years** | 8 | 12 | 2.07 | 6.78 | 5.61 | 0.56 |
| **15-years** | 12 | 6 | 1.63 | 5.21 | 2.30 | 0.79 |
| **10-years** | 4 | 8 | 1.74 | 5.04 | 3.74 | 0.62 |
| **10-year** | 5 | 13 | 2.26 | 8.79 | 5.95 | 0.64 |
| **10-year** | 6 | 13 | 2.13 | 7.44 | 5.78 | 0.54 |
| **5-years** | 9 | 10 | 1.92 | 6.02 | 5.95 | 0.67 |
| **5-years** | 10 | 7 | 1.69 | 5.59 | 3.83 | 0.67 |
| **5-years** | 11 | 11 | 2.15 | 9.23 | 6.46 | 0.70 |
| **All** | | 25 | 2.62 | 10.72 | 5.59 | 0.30 |

# 4. DISCUSSION

## 4.1 PIT, FUNNEL AND ALUMINIUM BOX TRAPS

It was anticipated that there would be similarity among the unmined sites in the vertebrate fauna assemblage and this would be reflected in a clustering of these sites in the graph of PCA 1 and PVA 2 (Chart 1) or PCA 1 and PCA 3 (Chart 2), which is not the case. The similarity index score for unmined sites 1 and 2 is relatively high (i.e. 0.81) but for sites 1 and 3 (i.e. 0.41), and 2 and 3 (0.52) there are differences. The most obvious differences were abundance of *Antechinus flavipes* (Plate 8), lower number of *Morethia obscura*, and less species and less individuals at unmined site 3 when compared with unmined sites 1 and 2.

*Cryptoblepharus buchananii*, *Egernia napoleonis* and *Lerista distinguenda* are species likely to be present and characterise climax assemblages, and should become evident as the rehabilitation programs progress. In this situation, their abundance appears uneven in the analogue sites and only *Lerista distinguenda* displays the anticipated pattern. If all unmined sites had a similar vertebrate fauna assemblage, then these data could collectively be used as the succession trajectory climax community, but given the differences, it begs the question if other unmined sites in the northern Jarrah forest were surveyed, then how different would they be to the existing three unmined survey sites. The vertebrate data in Appendix C (excluding volant species) indicates that there are numerous other species (particularly skinks) that have been recorded in the broader Jarrah Forest that were not caught in the three unmined survey sites.

Rehabilitation sites that are 5-years old provide a good grouping on PCA 2 when compared with the other groups, but had a similar dispersed grouping on PCA 1, and the similarly index suggests sites 9 and 11, and 10 and 11 are more closely aligned than sites 9 and 10. Pioneering colonising species are the *Mus musculus*, *Menetia greyii* and *Morethia obscura* and species richness of 7-11 is less than for older rehabilitated sites.

Rehabilitation sites that are 10-years old show an increase in species richness for two sites (i.e.13, 13 and 8), with sites well spread on PCA 1, but two sites are reasonably similar of PCAs 2 and 3 (Charts 1 and 2). The Morisita-Horn similarity index scores were low, reflecting the information provided by the PCAs. Small mammals are starting to colonise the 10-year rehabilitation sites, with an abundance of *Cercartetus concinnus* (Plate 9) at one site, which almost certainly reflects the abundance of suitable flowering plants. *Pogona minor* is a recognised early colonising reptile (Thompson and Thompson 2003, Thompson and Thompson 2007a) and *Acritoscincus trilineatus, Morethia obscura* and *Lerista distinguenda* were relatively abundant at two of the sites and widespread throughout the Jarrah Forest. As widely foraging species they have a greater propensity to colonise new areas than species with defined home ranges and high site fidelity.



**Plate 8. Mardo**



**Plate 9. Western pygmy possum**

Two of the rehabilitation sites that are 15-years old had a species richness of 12 and the other site had 6 recorded species, and this is reflected in the diversity scores. Two of these 15-year old sites grouped on PCA 1 and PCA 2 (Chart 1). A different two 15-years old rehabilitation sites also grouped closely on PCA 3 and also with two unmined sites (Chart 2).

These data might suggest it was more than one or two species contributing to the difference between unmined and 15-year old rehabilitation sites in the vertebrate fauna assemblage. *Cercartetus concinnus* were abundant at two sites and *Acritoscincus trilineatus* and *Morethia obscura* were abundant at all three sites. In the Goldfields we have observed substantial seasonal variability in the catch rate of *Cercartetus concinnus*, but the reason is not clear (Thompson 2004).

## 4.2 TRAP TYPES

Aluminium box traps mostly caught *Antechinus flavipes* and *Mus musculus*, and buckets, pipes and funnel traps caught most reptiles. Because buckets, pipes and funnel traps also caught *Antechinus flavipes* and *Mus musculus,* the aluminium box traps inflated the number of these two species caught in the trapping programs in the 12 survey sites compared with other species that did not enter these traps. As shown by Thompson and Thompson (2007b) bucket and pipe pit-traps are far superior at catching small mammals compared with funnel traps, and overall, pipe pit-traps recorded more individuals than bucket pit-traps followed by funnel traps (Table 3). Because various trap types catch a different suite of vertebrate fauna, each trap type introduces a bias into the dataset when analysed using diversity, similarity and PCA methods.

## 4.3 CAGE TRAPS

Cage traps were deployed to target terrestrial vertebrate fauna unlikely to be caught in pit, funnel and aluminium box traps, and were placed at locations where Chuditch had previously been recorded. The use of chicken necks as bait, restricted the range of animals likely to be caught to mostly carnivores, but it was noted that two Quenda were caught, but they are often caught using sardines. Twelve Chuditch were caught in baited cage traps (i.e. #41, 42, 44, 45, 61, 63, 74, 76 and 78). Cage traps 44, 61, 63, 74, 76 and 78 were all in unmined areas, and traps 41 and 42 were in areas rehabilitated in 2004 (i.e. 18 years old). Although cage traps were not deployed across all rehabilitation areas, these data might suggest that Chuditch are mostly confined to unmined and old rehabilitation areas. Placing cage traps in a wider range of aged rehabilitation areas would provide a better indication of their use of rehabilitated areas. The use of selective trapping sites indicated that Chuditch were present in the mined Jarrah Forest, but no indication of their relative abundance nor preferred habitats, which would be useful data if conservation programs for this species were to be planned and implemented.

## 4.4 CAMERA TRAPS

Camera traps target the larger vertebrate species and those unlikely to be caught in other types of traps. The Western Grey Kangaroo is clearly abundant in the areas that camera traps were deployed, and because of their large home ranges, they are likely to be widespread in the Jarrah Forest. Only two Chuditch (Plate 10) were recorded compared to 12 in cage traps, but this difference is probably largely due to where camera and cage traps were deployed. Quenda (Plate 13) were recorded in two of the three camera trapping locations. The Western Brush Wallaby (Plate 12) was recorded in one of the camera trapping areas (i.e. camera #11, 12 and 13). Quokkas (Plate 11) were recorded in one of the three camera trapping areas (i.e. #9, 10, 11, 12, 13).

Of concern was the abundance of pigs recorded by camera traps (#1, 2, 3, 5, 6, 7, 8) and these were all in the same location. One pig had an ear tag (Plate 15) suggesting that pig-hunters were using this pig in some type of competition to capture a 'marked' pig.




**Plate 10. Chuditch**




**Plate 11. Quokkas**




**Plate 12. Western Brush Wallaby**




**Plate 13. Quenda**

## 4.5 CONSERVATION SIGNIFICANT SPECIES

Two conservation significant species (*Setonix brachyurus* and *Dasyurus geoffroii*) and two priority species (*Notamacropus irma* and *Isoodon fusciventer*) were recorded in the survey. The Quokka and Western Brush Wallaby were in the same area, and one of the Quenda records was in this area, but most were in another area. Given that both *Setonix brachyurus* and *Dasyurus geoffroii* are listed as vulnerable under Commonwealth and State conservation legislation, where resources are available these species should be given a higher priority for protection and long-term conservation than the more abundant species that are widespread in the Jarrah Forest.

## 4.6 PEST AND PREDATOR SPECIES

A single feral cat (Plate 14) was recorded, and of concern it was in the area where Quokkas were recorded. No foxes were recorded, but a small number of Black Rats were recorded on camera traps but not in cage traps, possibly because of the bait used in these traps, and House Mice were caught in aluminium box, pipe and funnel traps. Pigs (Plate 15) are progressively becoming widespread in the Jarrah Forest and are considered a pest species because of the environmental damage they do particularly around creeks and in the denser vegetation. Pigs can also do significant damage to water courses and introduce disease into drinking water catchments. There is an obvious need to reduce or eliminate pigs from the Alcoa managed Jarrah Forest.




**Plate 14. Feral cat**




**Plate 15. Pig with ear tag**

# 5. SUMMARY AND CONCLUSIONS

The survey data indicated that the three unmined sites selected as analogue climax communities for the rehabilitation areas are not similar, and there are appreciable differences among the fauna assemblages within aged classes of rehabilitation.

## 5.1 SUCCESSION AND ON TARGET TO A CLIMAX FAUNA COMMUNITY

Based on the available data, there are two alternative conclusions that can be reached about succession of rehabilitated areas along a trajectory to a climax community:

- differences among the unmined areas makes it difficult to determine what is the target climax community, and it is possible there are other alternative Jarrah Forest communities that have not been sampled that would better represent climax communities that will eventuate in rehabilitated areas; or
- rehabilitation programs are not of sufficient quality to enable the mammal, reptile and amphibian assemblages in unmined area to recolonise rehabilitated areas within a 15-year period sufficient to clearly indicate they are on a trajectory toward establishing analogue climax communities.

If there is no one target climax community valid for all rehabilitation areas because the vertebrate fauna assemblage in the Alcoa mined Jarrah forest is variable, then the current survey methodology is unlikely to provide evidence that the fauna assemblages in the rehabilitated areas are within the expected trajectory to reach the analogue climax community. This issue can be partially addressed by redesigning the survey protocol and placing 'unmined' analogue survey sites in the unmined areas immediately adjacent to the rehabilitation areas. Given that the vertebrate fauna are most likely to colonise rehabilitation sites from the adjacent areas, this approach would provide the maximum opportunity for the vertebrate fauna assemblages in rehabilitated areas to be within expected trajectories toward climax communities. Variation from the expected trajectory would then most probably be a consequence of an inappropriate habitat (e.g. soils, vegetation and microbial activity, etc) in the rehabilitated areas instead of high variability in the analogue undisturbed site. Investigating and adjusting habitats in existing and future rehabilitation areas would be an obvious future task.

## 5.2 CONSERVATION SIGNIFICANT SPECIES

The presence of conservation significant species within the Jarrah forests that are being mined by Alcoa warrants attention. When mining in the area is completed there will remain many unmined areas, and with time many of the mined areas, irrespective of how they were rehabilitated will be progressing toward self-sustaining functional ecosystems, albeit possibly different to that which existed before mining. The scant data collected in this survey would suggest that conservation significant species are in higher densities in the unmined areas, compared to the rehabilitated areas. If further investigation confirms that this was the case, then a focus on the long-term preservation of conservation significant species, and in particular their use of rehabilitation areas should be a priority. This may mean developing a better understanding of the location and abundance of *Setonix brachyurus*, *Dasyurus geoffroii*, *Notamacropus irma* and *Isoodon fusciventer* in the general mining area and putting in place appropriate targeted management and monitoring regimes for these species.

## 5.3 PEST SPECIES

It was pleasing not to record foxes during the camera trapping program and only a single feral cat, however, the area surveyed was very limited when viewed in the context of the extent of Jarrah Forest managed by Alcoa. Foxes and feral cats are significant predators on our native vertebrate fauna (Catling 1988, Woinarski et al. 2018, Murphy et al. 2019, Woolley et al. 2019, Woinarski et al. 2020, Woolley et al. 2020, Fleming et al. 2021, Woinarski et al. 2021) and are implicated in the decline or extinction of many of the critical weight range mammals, and in many circumstances are having a long-term greater impact on the vertebrate fauna

assemblage than the mining operations. Therefore, resources allocated to feral cat and fox management may provide better long-term outcomes than spending huge resources on fine-turning rehabilitation programs to achieve analogue climax communities. A better understanding and appreciation of foxes and feral cats in the Alcoa mining areas is an obvious starting point for implementing management programs.

The localised abundance of feral pigs is of concern. Feral pigs are known to cause serious damage to ecosystems, biodiversity, fauna habitats, water sources and agricultural assets (National Feral Pig Action Plan Steering Group 2021), and in addition, they pose a biosecurity and disease risk to Australia. Alcoa is urged to develop and implement a feral pig management program within the Jarrah Forest under its stewardship.

## 5.4 REPEATING THIS SURVEY

To understand whether rehabilitated areas are moving along an established trajectory toward an analogue climax vertebrate fauna community, requires an understanding of what constitutes the climax vertebrate fauna community and the trajectory. Monitoring is then undertaken so that existing rehabilitated areas might be amended where that is feasible and planning for new areas is adjusted based on experience and monitoring results.

If Alcoa are not achieving the desired fauna outcomes, then it may have to revisit its rehabilitation programs which are probably tuned to its completion criteria that are largely based on the abundance of eucalypt stems in rehabilitated areas (Australian Government 2016) and may not be particularly focussed on recreating suitable fauna habitat.

It is suggested that this monitoring program is reviewed before the survey is repeated, with particular attention to:

- the fauna target(s) as represented by the rehabilitation trajectory and intended climax community(ies);
- survey design (e.g. location of analogue sites);
- use of camera traps to determine presence vs relative abundance or conservation significant fauna; and
- value-for-money of surveys, when compared with the alternative uses of these resources to achieve a similar objective(s) (e.g. the long-term preservation of conservation significant species, and in particular their use of rehabilitation areas).

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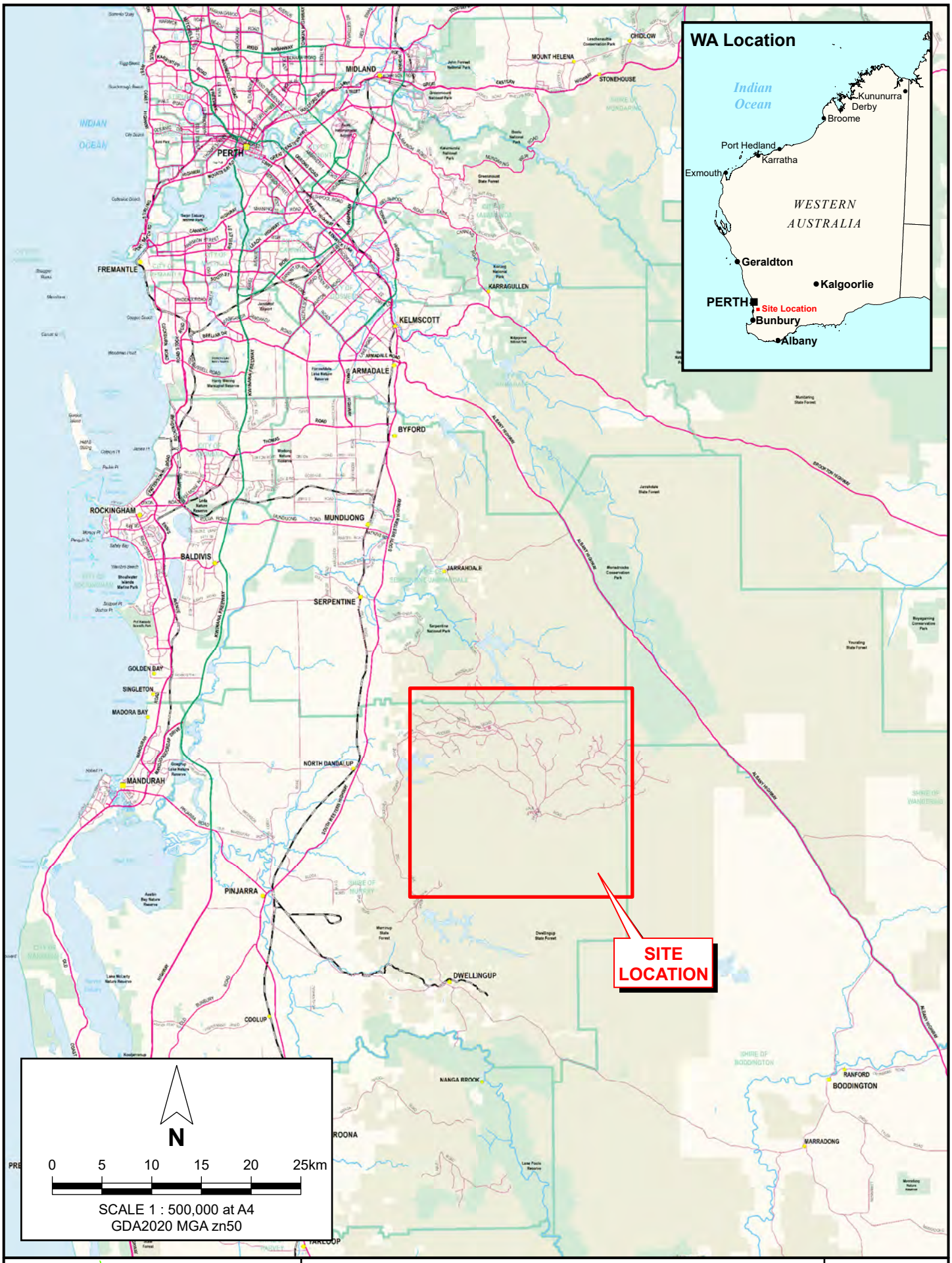
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# Figures

**Baseline Monitoring of Rehabilitation Programs**
**Alcoa's Bauxite Mining Areas**






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PINPOINT CARTOGRAPHICS (08) 9562 7136

TERRESTRIAL ECOSYSTEMS

Alcoa of Australia Ltd
BASELINE MONITORING OF REHABILITATION PROGRAMS
IN ALCOA'S BAUXITE MINING AREAS

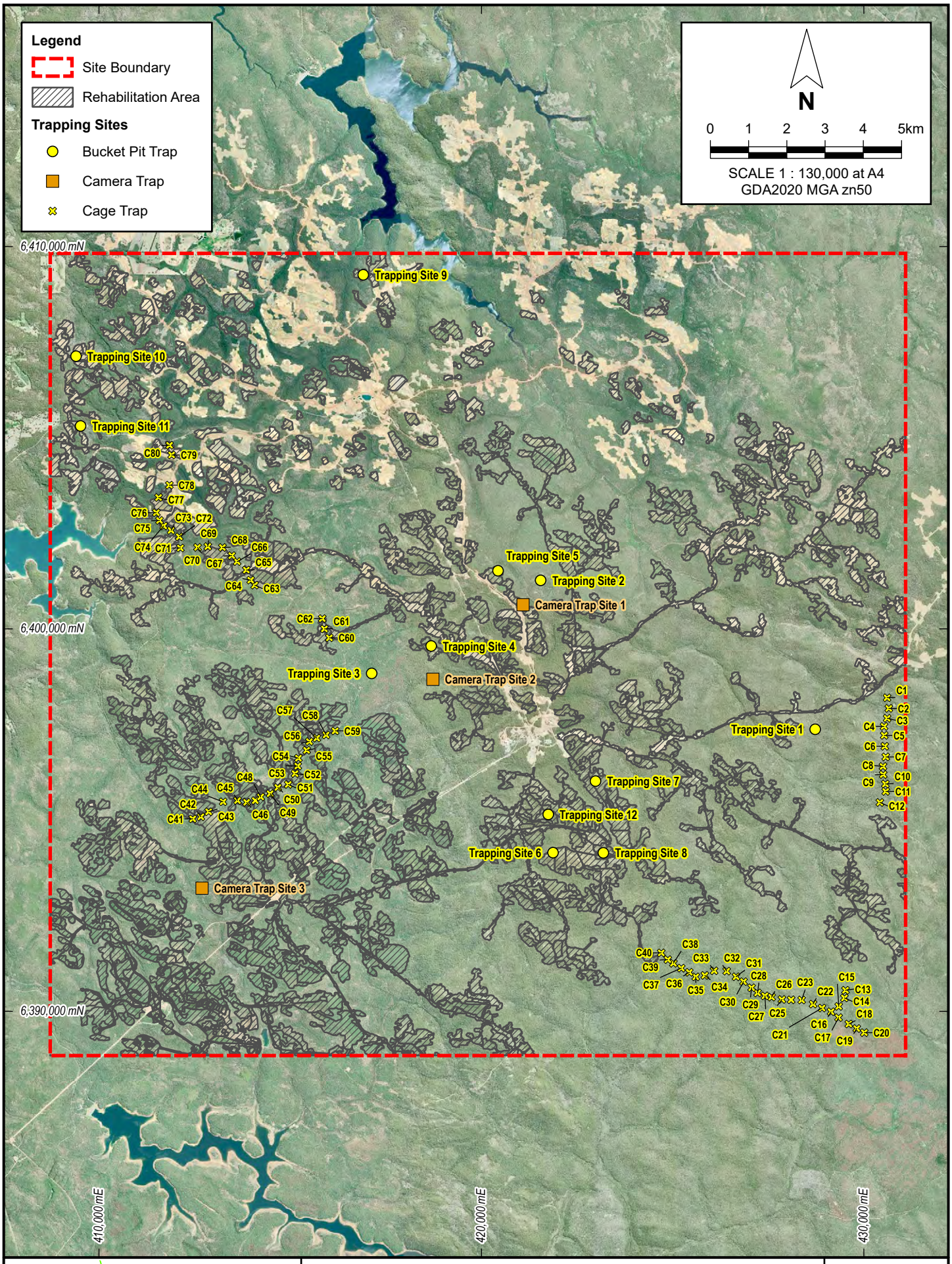
**Figure 1**

## REGIONAL LOCATION

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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TERRESTRIAL ECOSYSTEMS

Alcoa of Australia Ltd
BASELINE MONITORING OF REHABILITATION PROGRAMS
IN ALCOA'S BAUXITE MINING AREAS

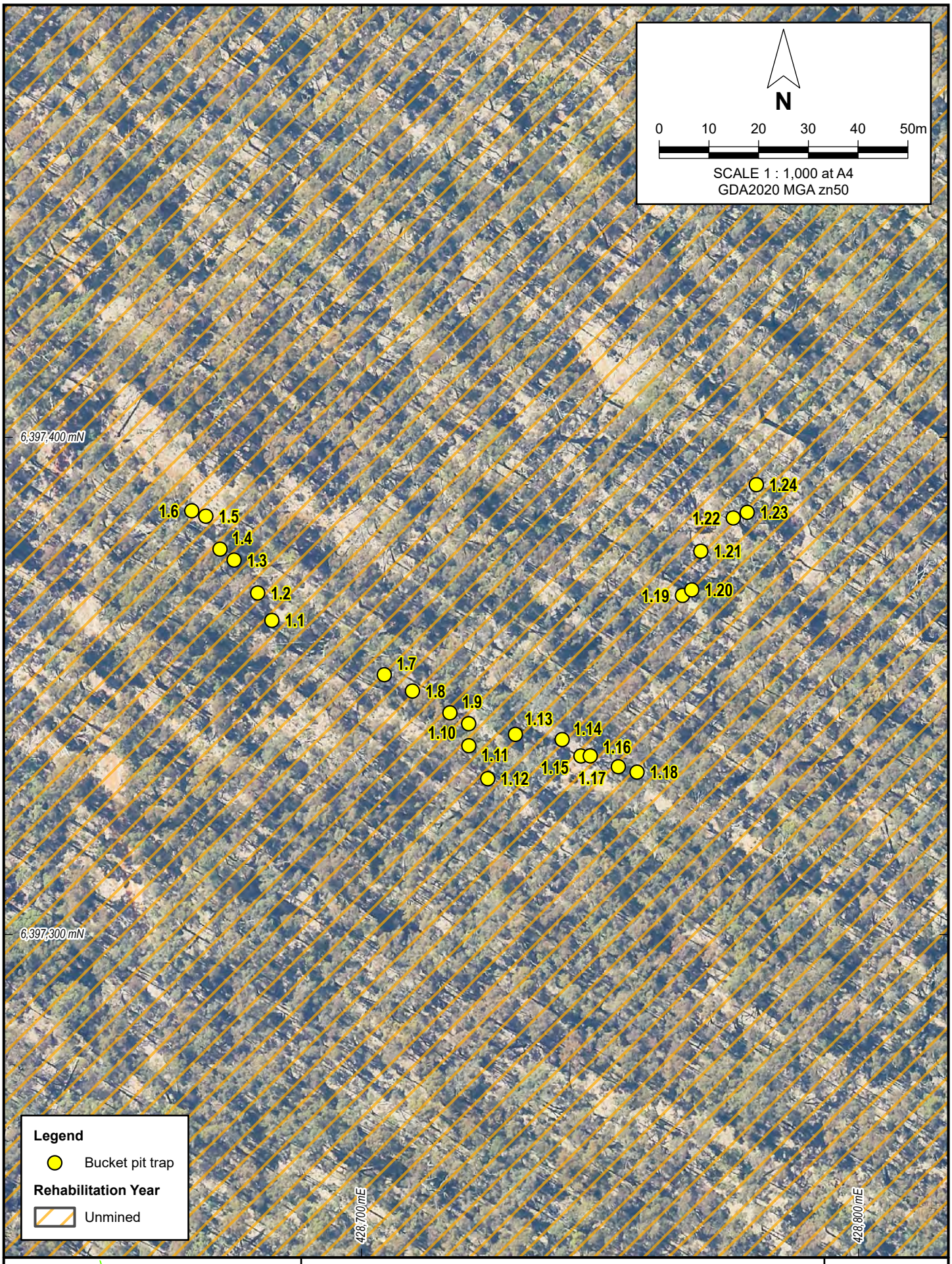
**PROJECT AREA**

**Figure 2**

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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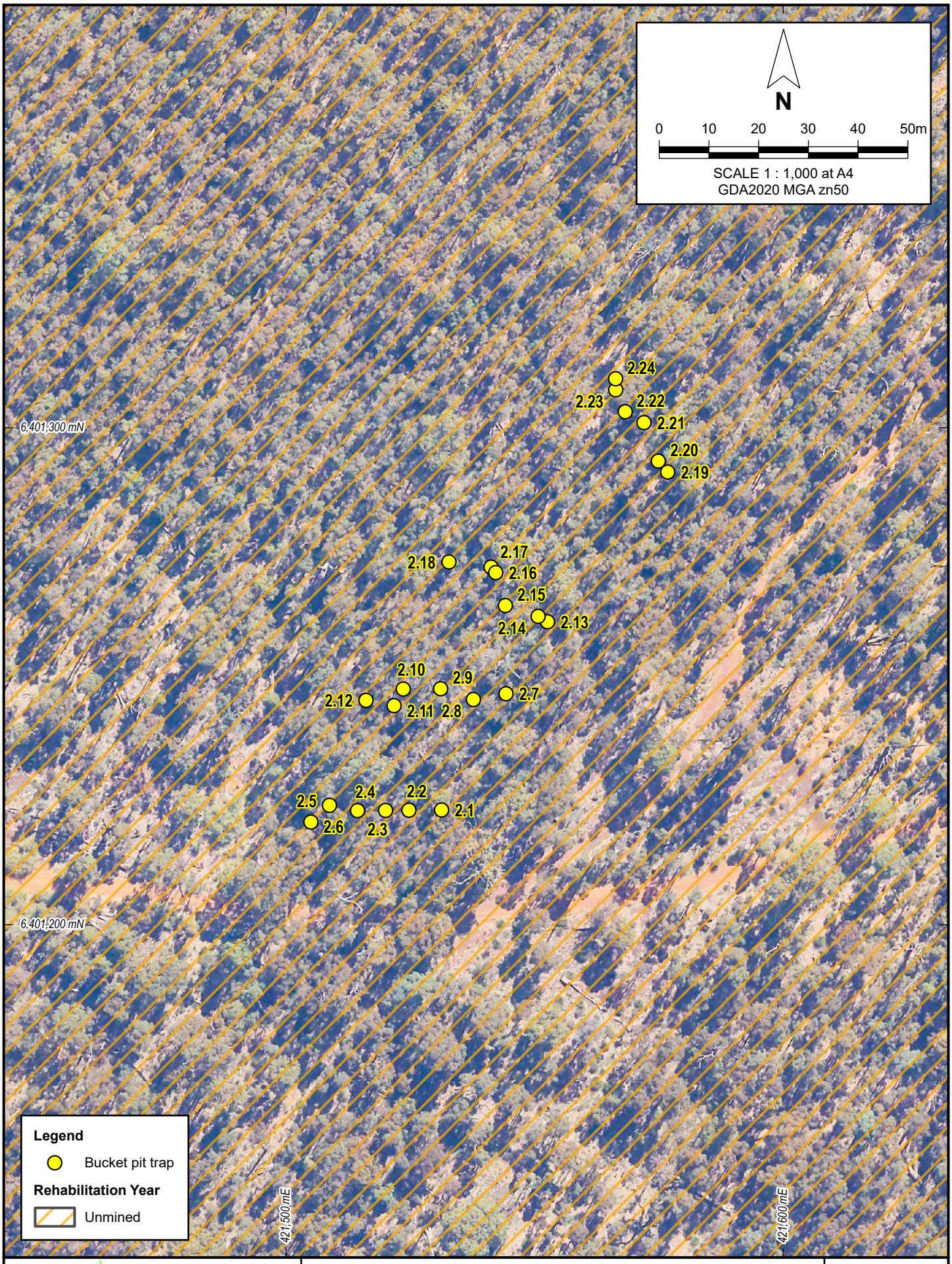
**Figure 3**

## PIT TRAP LOCATIONS - TRAP SITE 1

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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IN ALCOA'S BAUXITE MINING AREAS

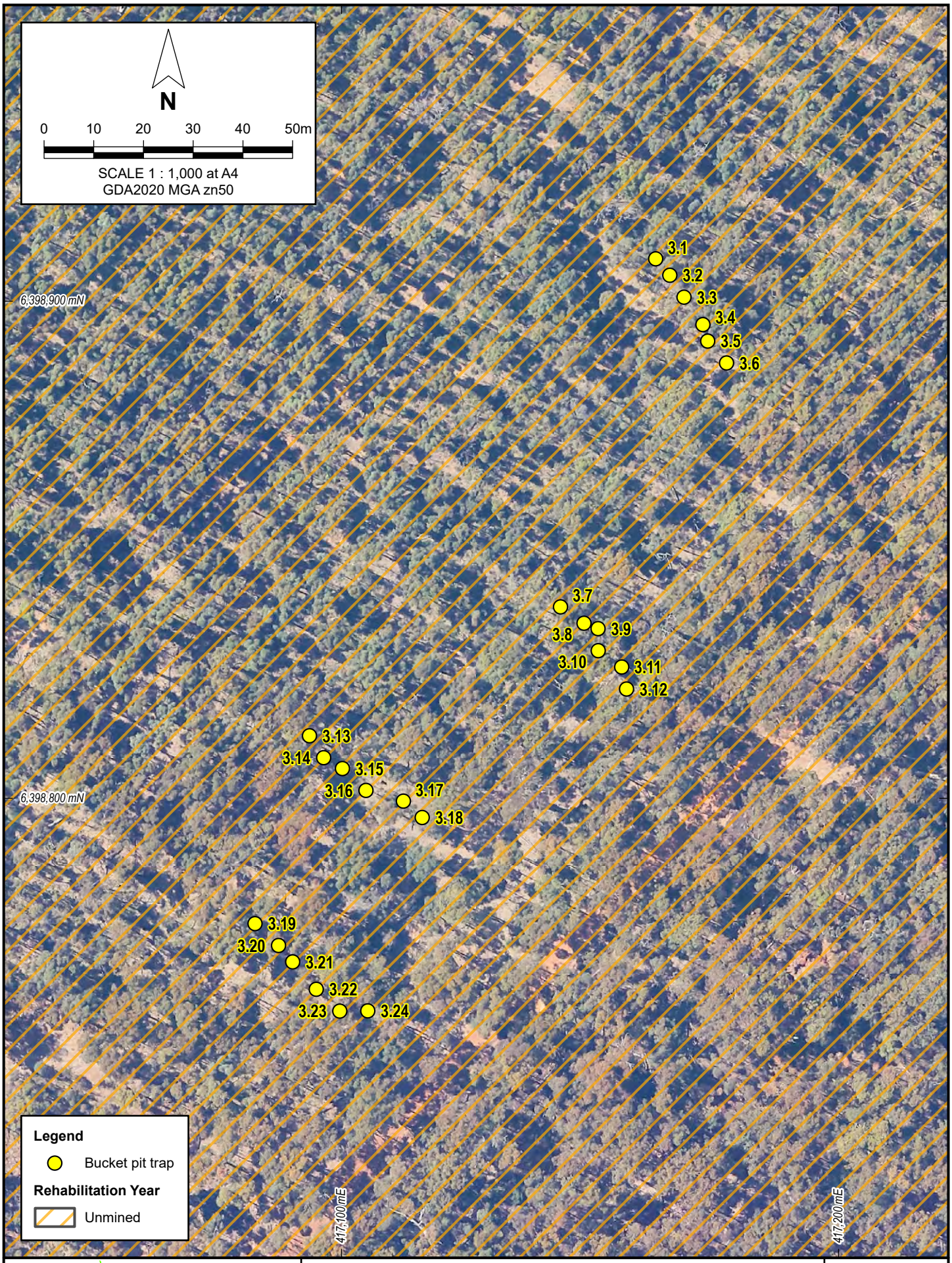
**Figure 4**

## PIT TRAP LOCATIONS - TRAP SITE 2

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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IN ALCOA'S BAUXITE MINING AREAS

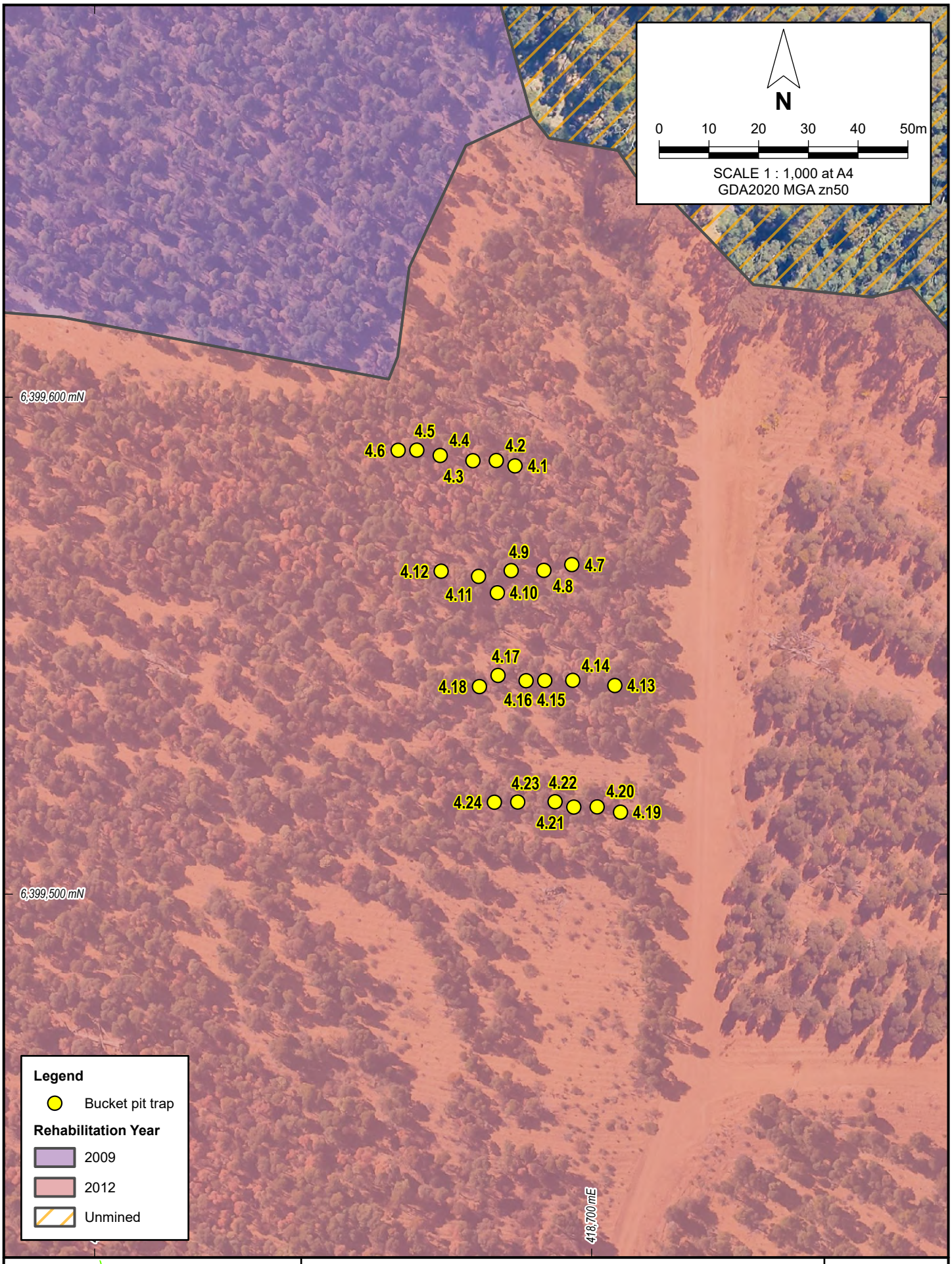
**Figure 5**

## PIT TRAP LOCATIONS - TRAP SITE 3

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

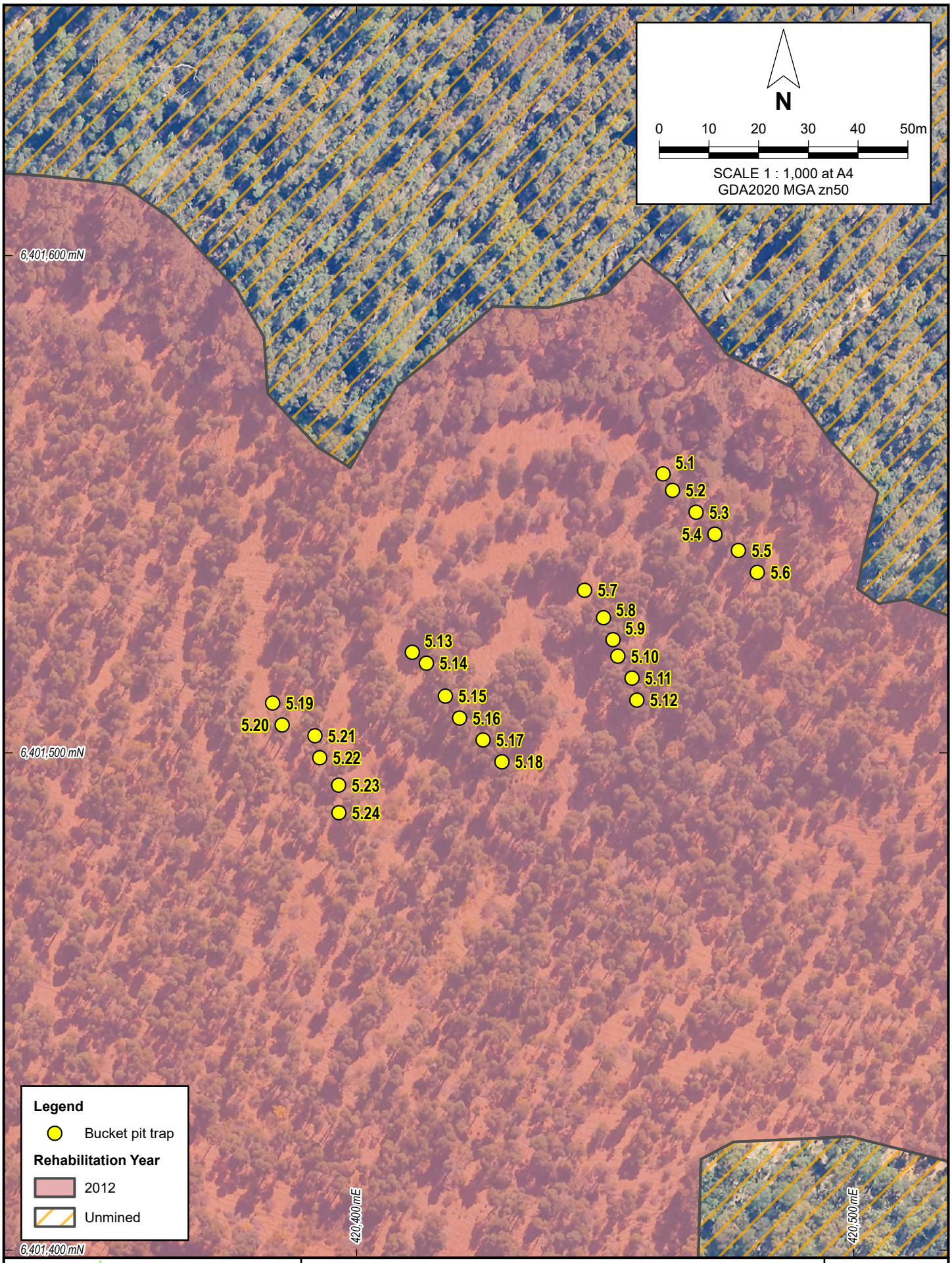
**Figure 6**

## PIT TRAP LOCATIONS - TRAP SITE 4

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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IN ALCOA'S BAUXITE MINING AREAS

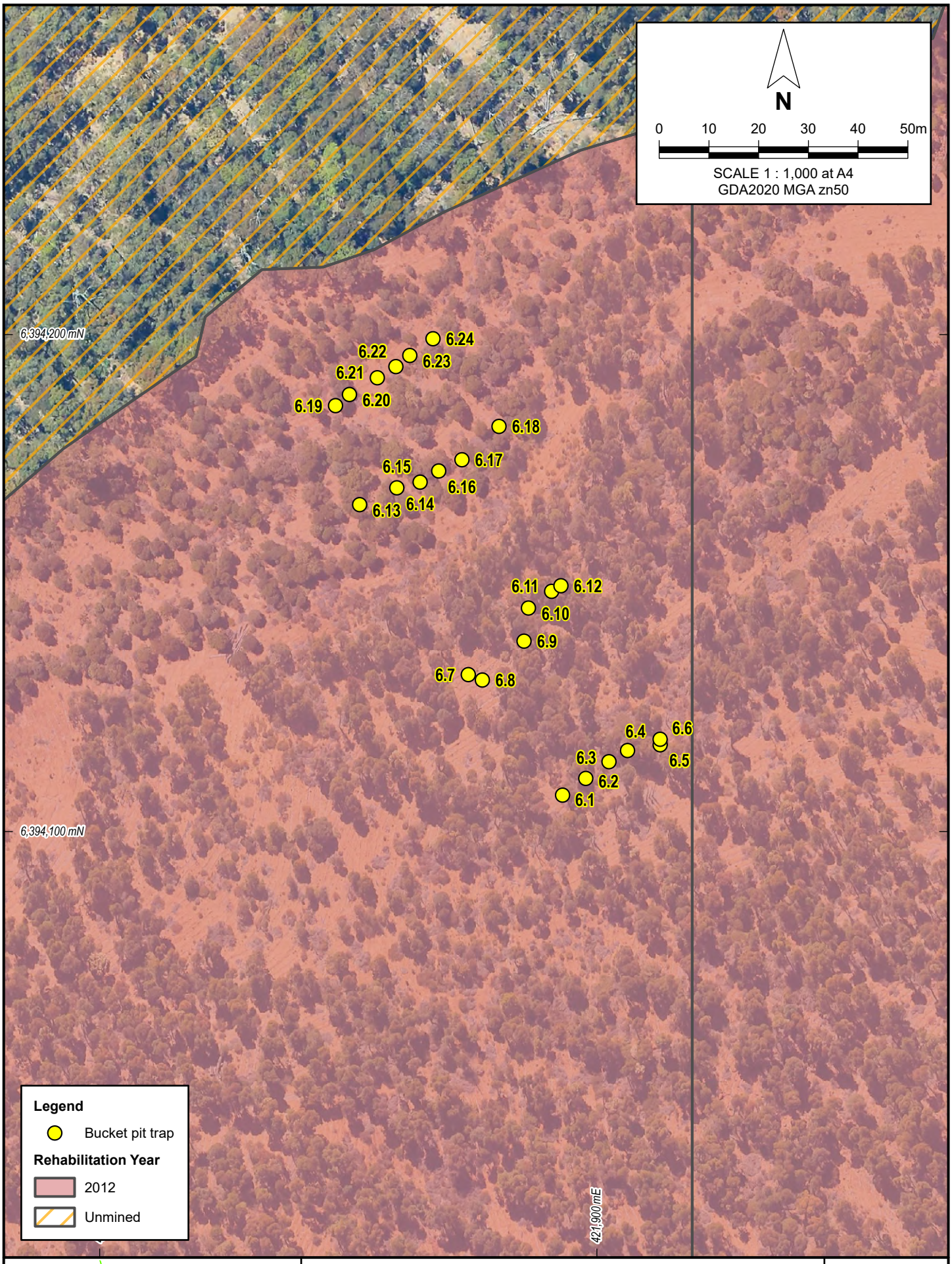
**PIT TRAP LOCATIONS - TRAP SITE 5**

**Figure 7**

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




PINPOINT CARTOGRAPHICS (08) 9562 7136 2022-0087.mxd

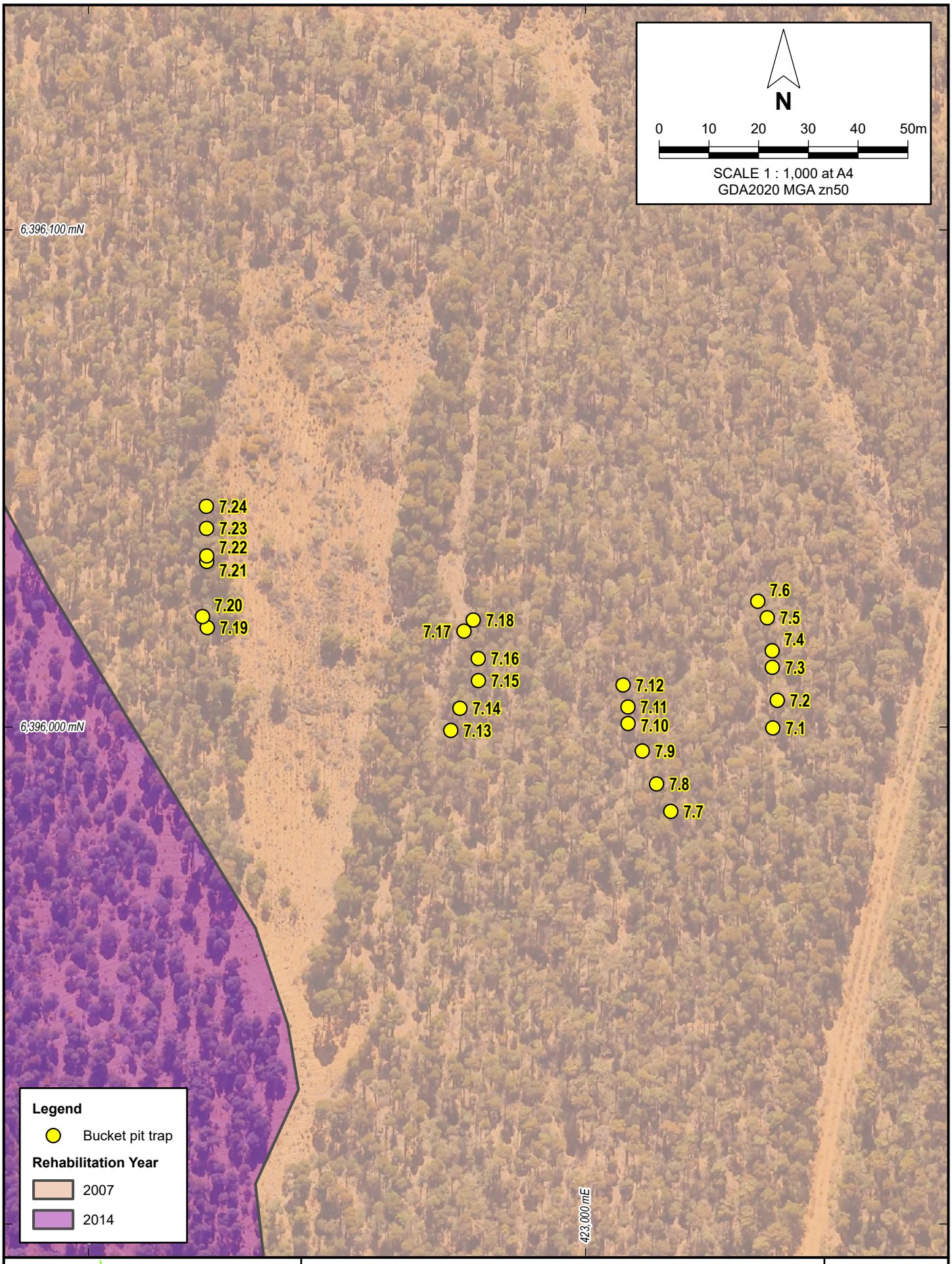
TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

**Figure 8**

## PIT TRAP LOCATIONS - TRAP SITE 6

Drawn: S. Thompson | Date: 30 May 2023 | Job: 2022-0087




PINPOINT CARTOGRAPHICS (08) 9562 7136 2022-0087.mxd

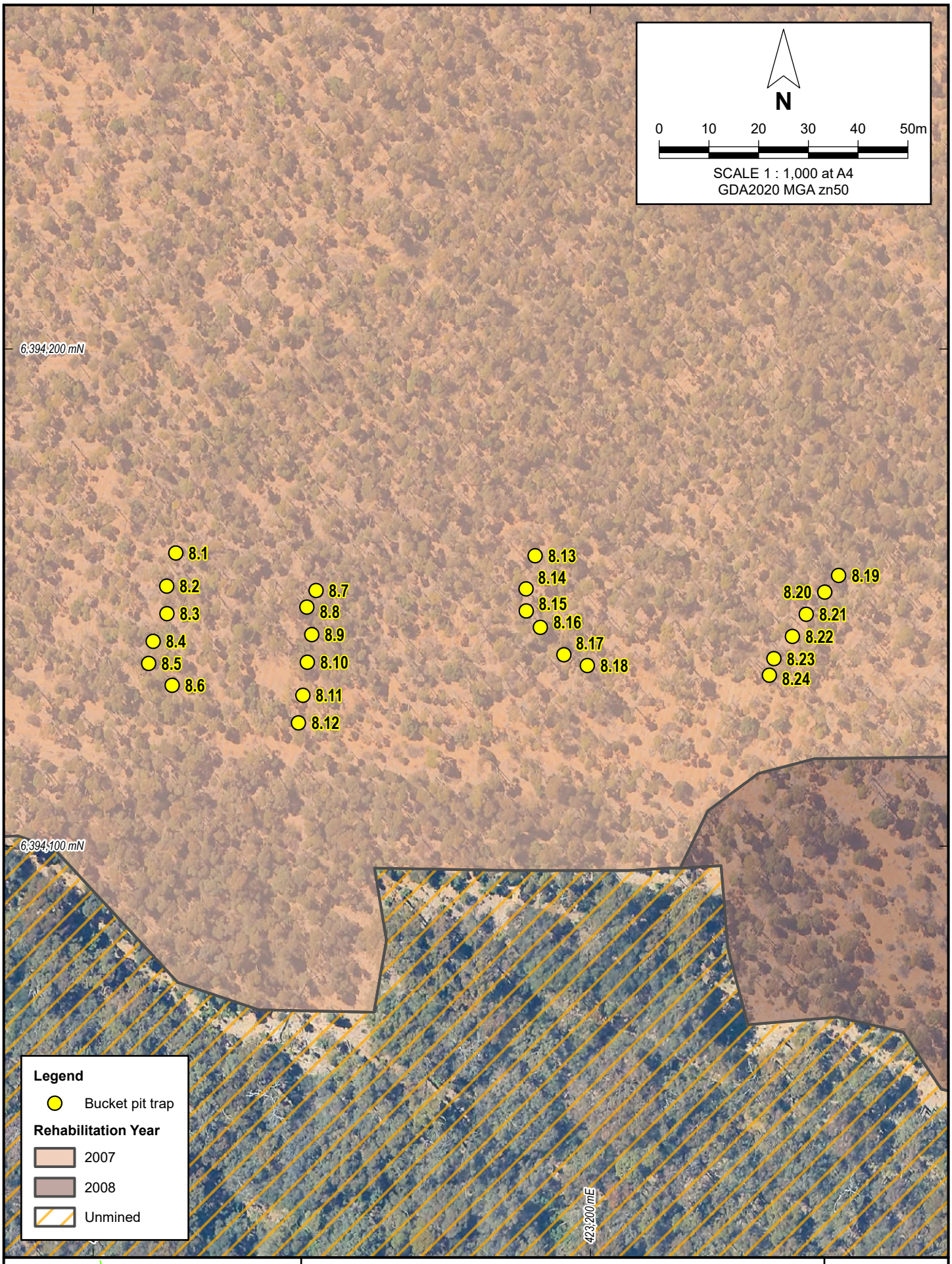
TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

**Figure 9**

## PIT TRAP LOCATIONS - TRAP SITE 7

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PINPOINT CARTOGRAPHICS (08) 9562 7136 2022-0087.mxd

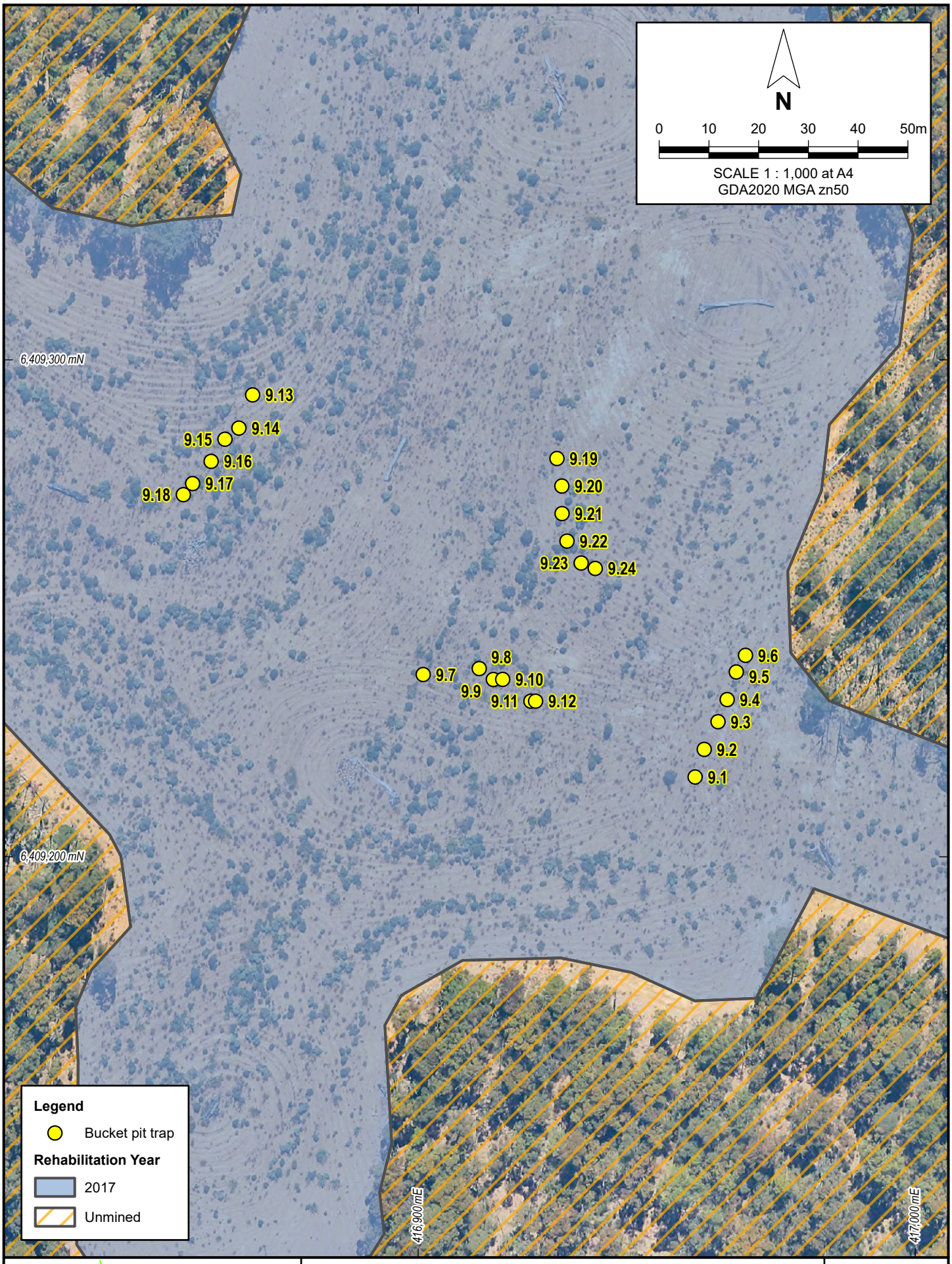
TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

**Figure 10**

## PIT TRAP LOCATIONS - TRAP SITE 8

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TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

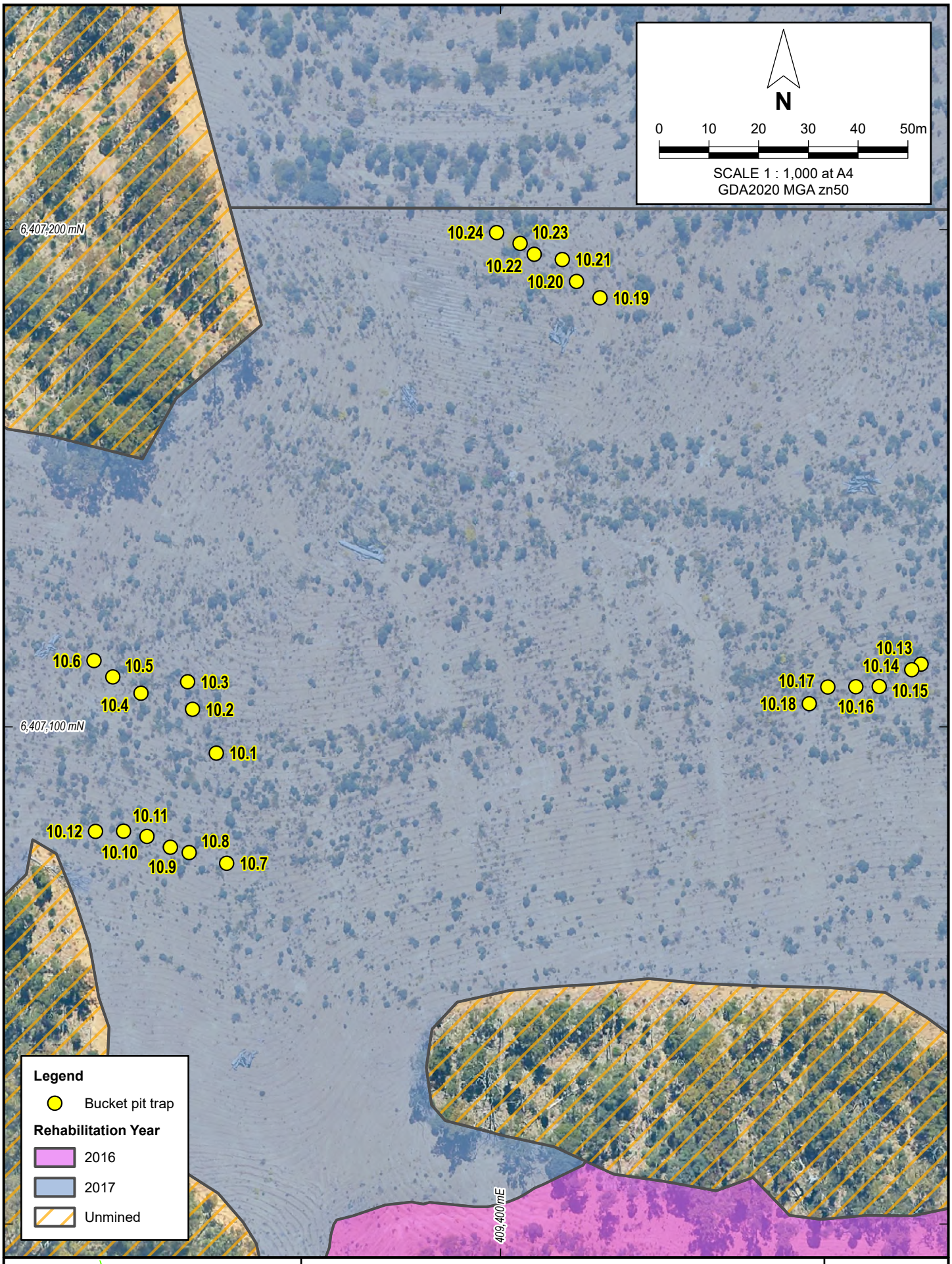
**Figure 11**

## PIT TRAP LOCATIONS - TRAP SITE 9

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Date: 30 May 2023

Job: 2022-0087




2022-0087.mxd

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TERRESTRIAL ECOSYSTEMS

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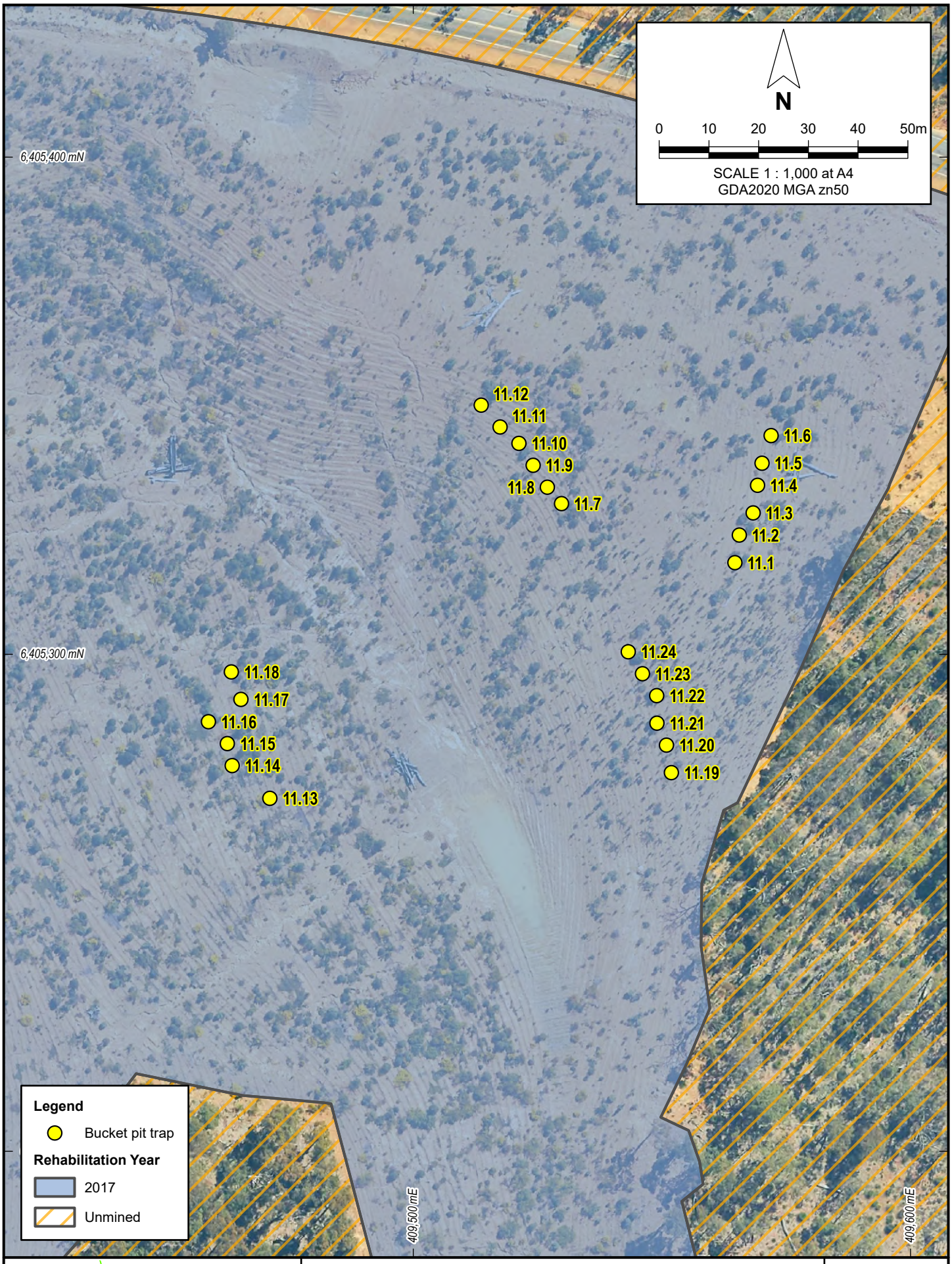
**Figure 12**

## PIT TRAP LOCATIONS - TRAP SITE 10

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Date: 30 May 2023

Job: 2022-0087




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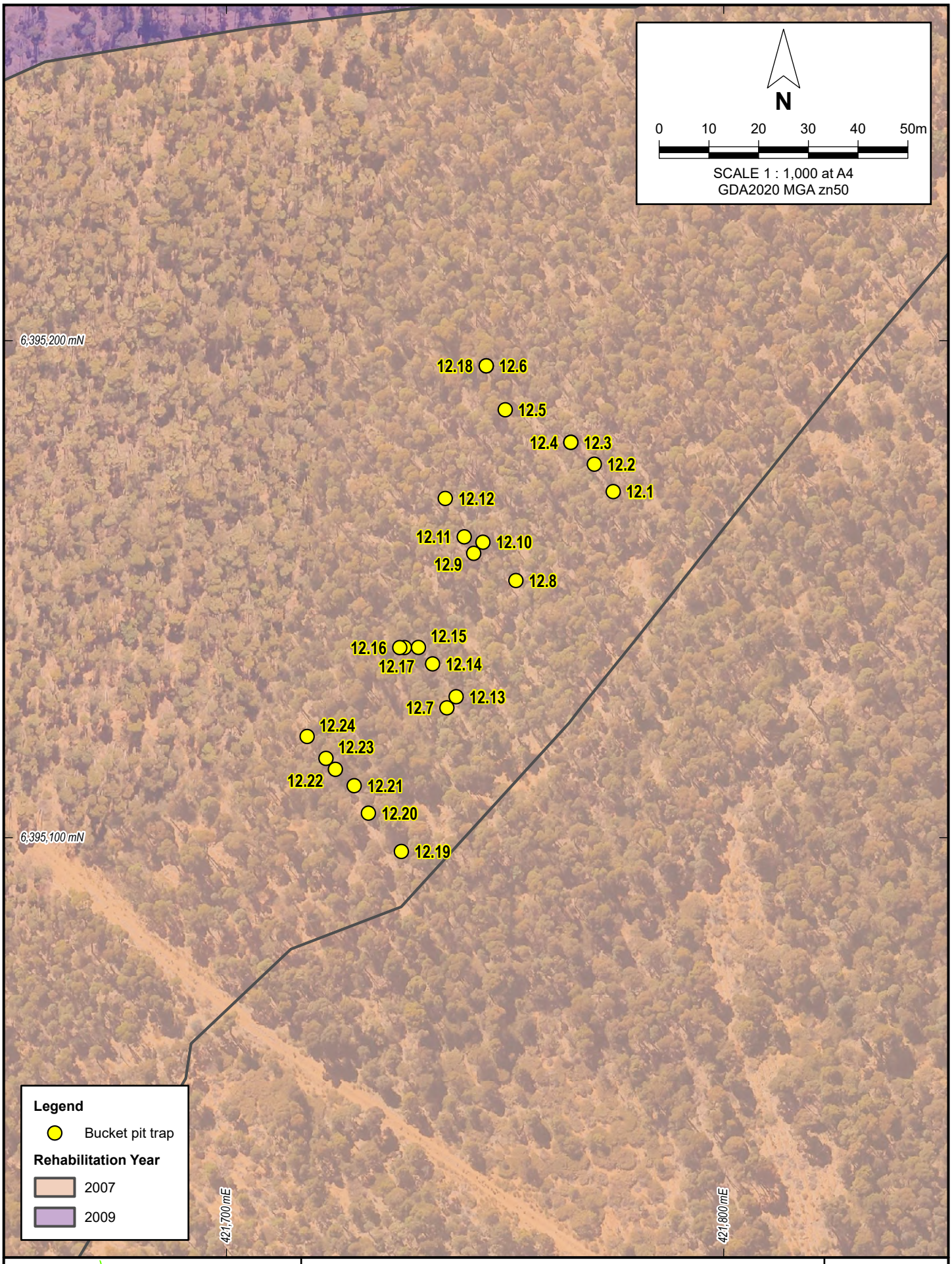
**Figure 13**

## PIT TRAP LOCATIONS - TRAP SITE 11

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

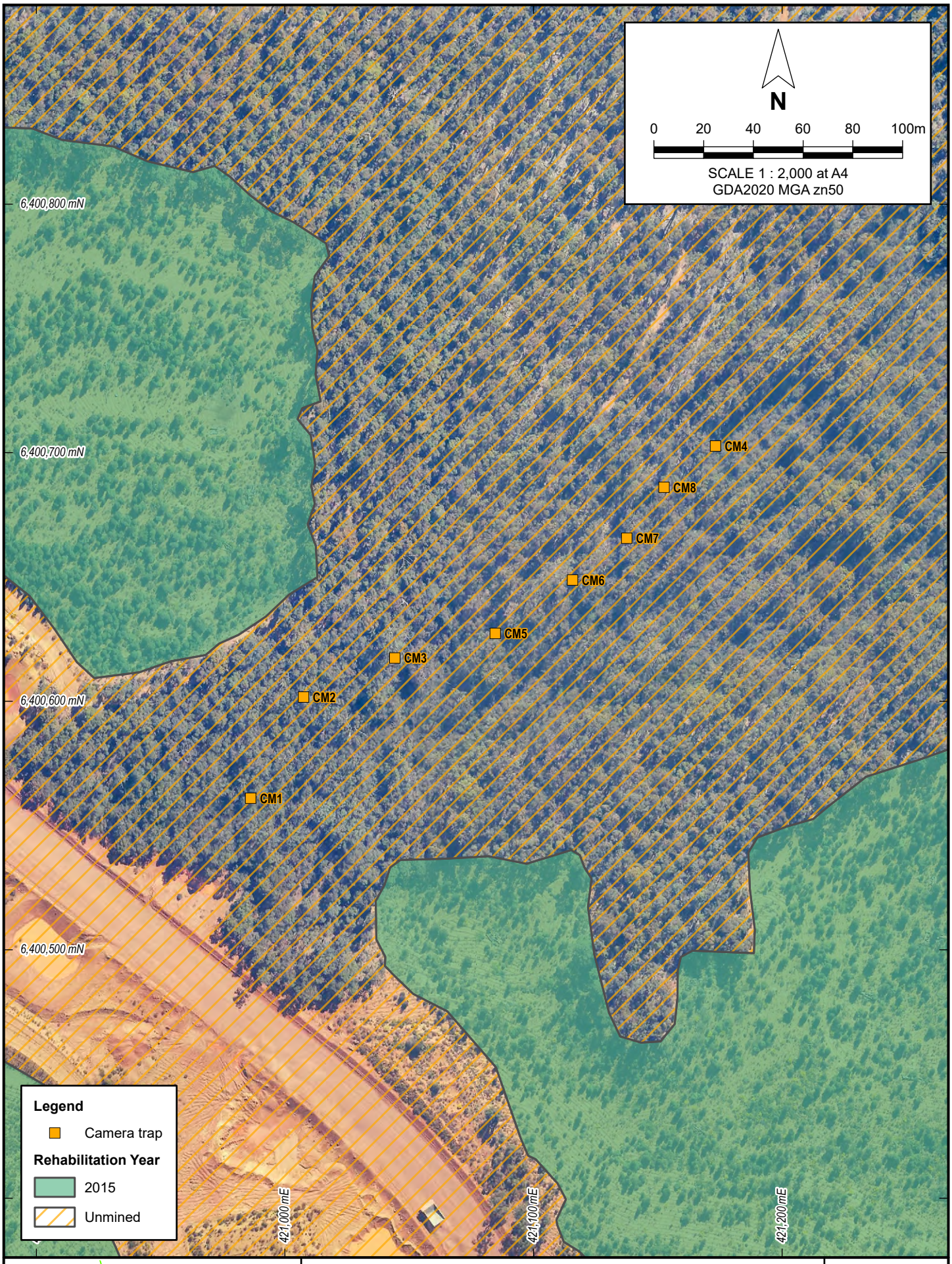
**Figure 14**

## PIT TRAP LOCATIONS - TRAP SITE 12

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




PINPOINT CARTOGRAPHICS (08) 9562 7136 2022-0087.mxd

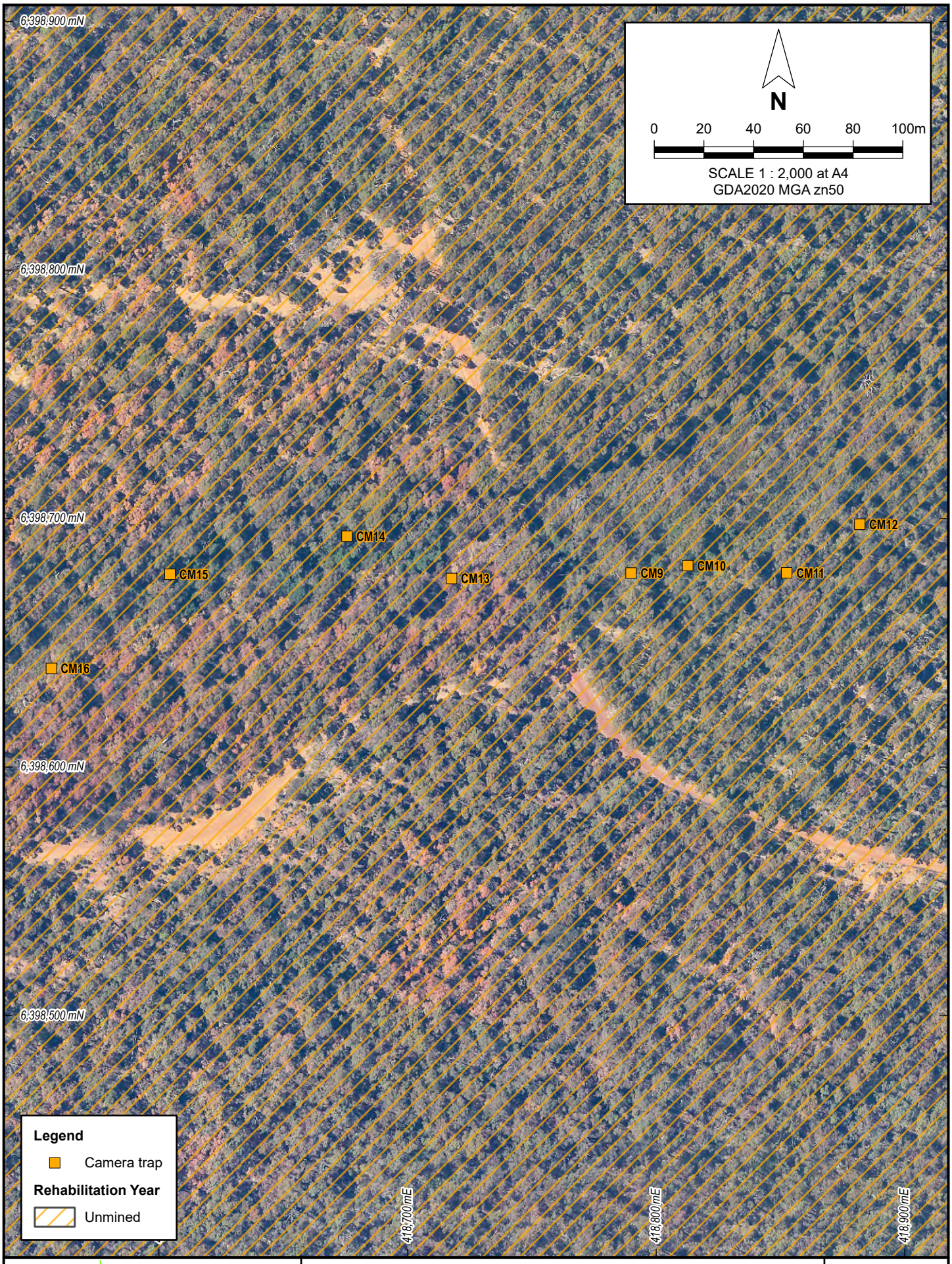
TERRESTRIAL ECOSYSTEMS

Alcoa of Australia Ltd
BASELINE MONITORING OF REHABILITATION PROGRAMS
IN ALCOA'S BAUXITE MINING AREAS

**Figure 15**

## CAMERA TRAP LOCATION - SITE 1

Drawn: S. Thompson | Date: 30 May 2023 | Job: 2022-0087




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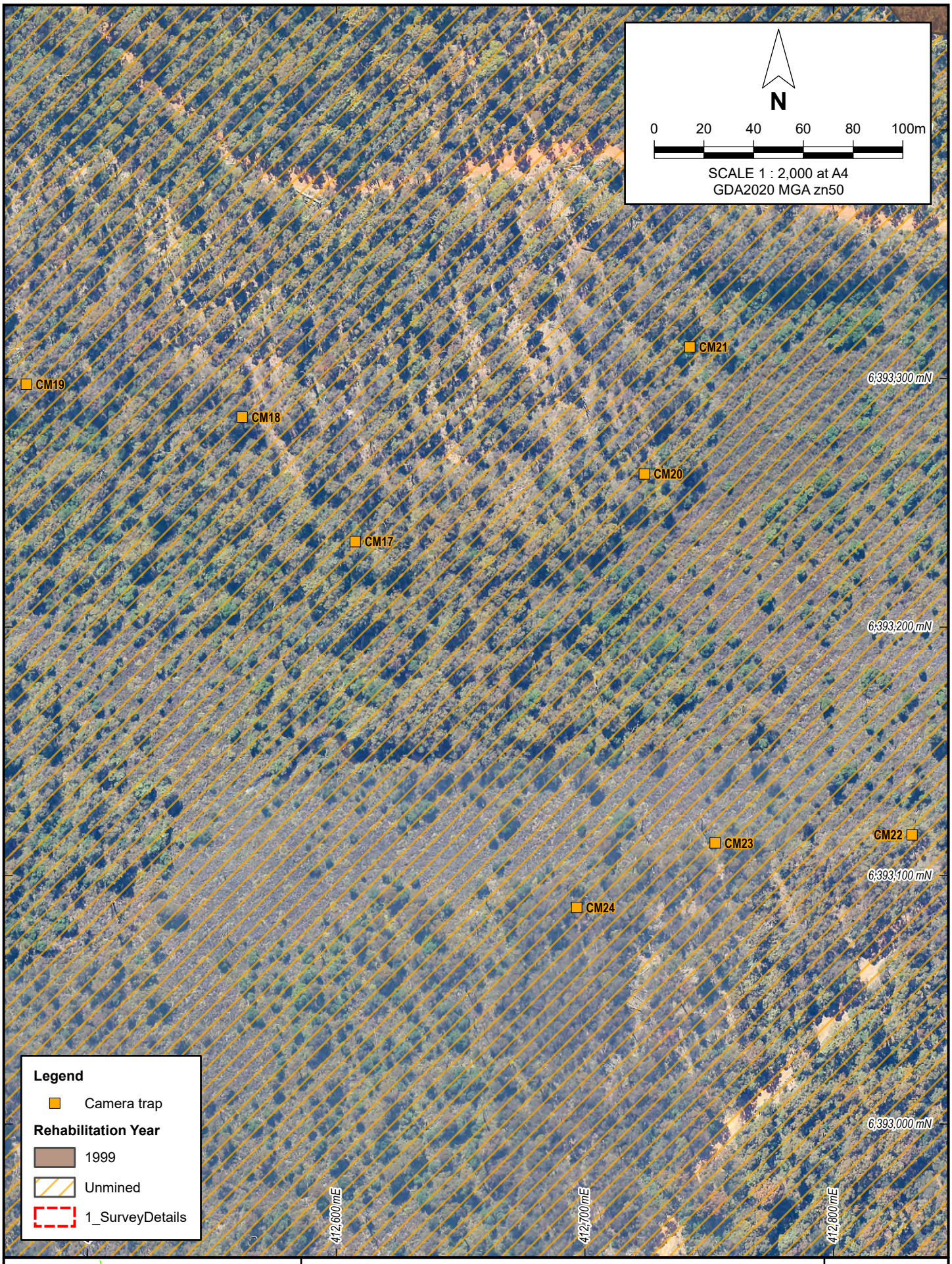
TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

**Figure 16**

## CAMERA TRAP LOCATION - SITE 2

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IN ALCOA'S BAUXITE MINING AREAS

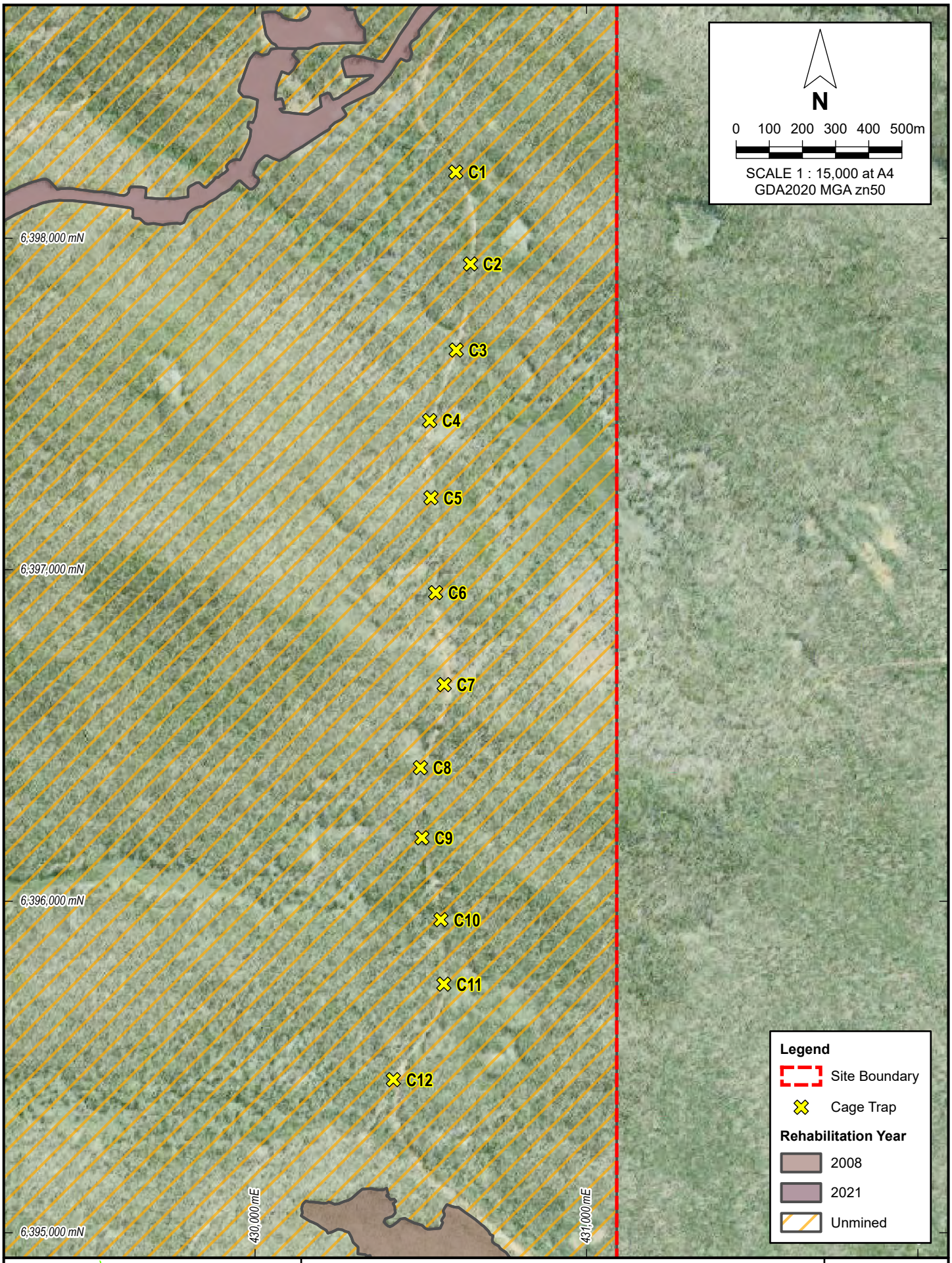
**Figure 17**

## CAMERA TRAP LOCATION - SITE 3

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087




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TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

**CAGE TRAPS - SITE 1**

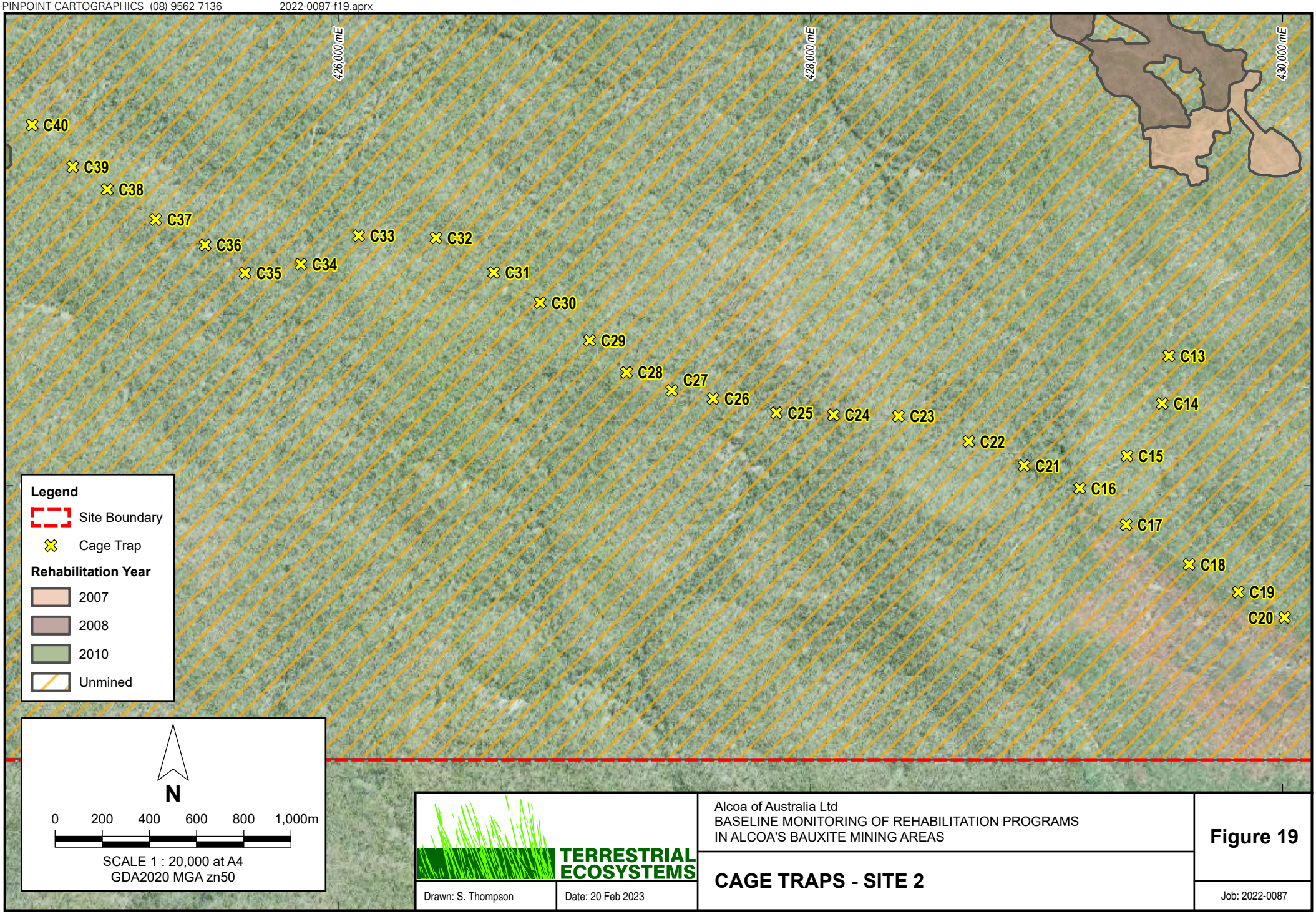
**Figure 18**

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087

PINPOINT CARTOGRAPHICS (08) 9562 7136 2022-0087-f19.aprx




TERRESTRIAL ECOSYSTEMS

Drawn: S. Thompson

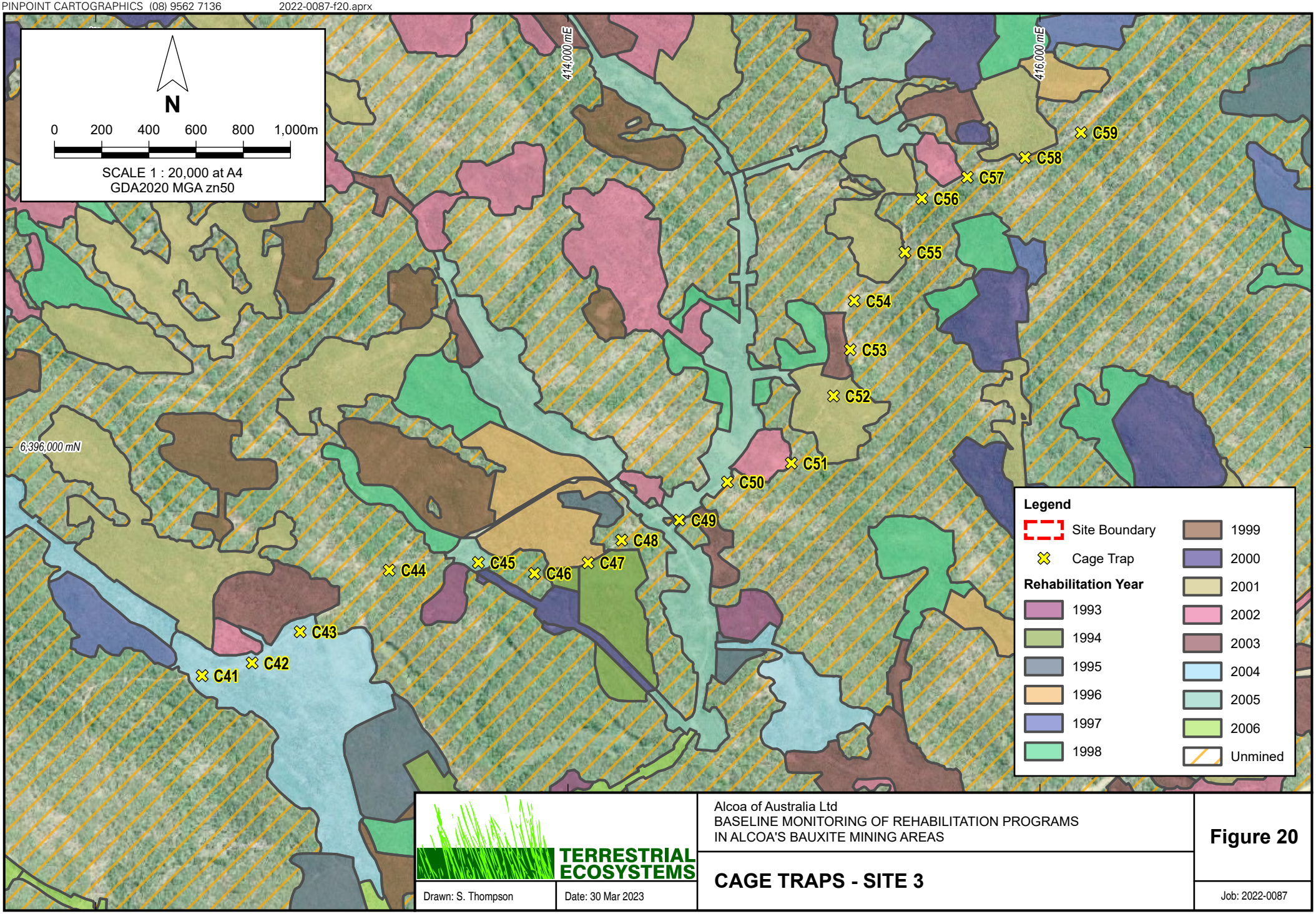
Date: 20 Feb 2023

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IN ALCOA'S BAUXITE MINING AREAS

# CAGE TRAPS - SITE 2

**Figure 19**

Job: 2022-0087




TERRESTRIAL ECOSYSTEMS

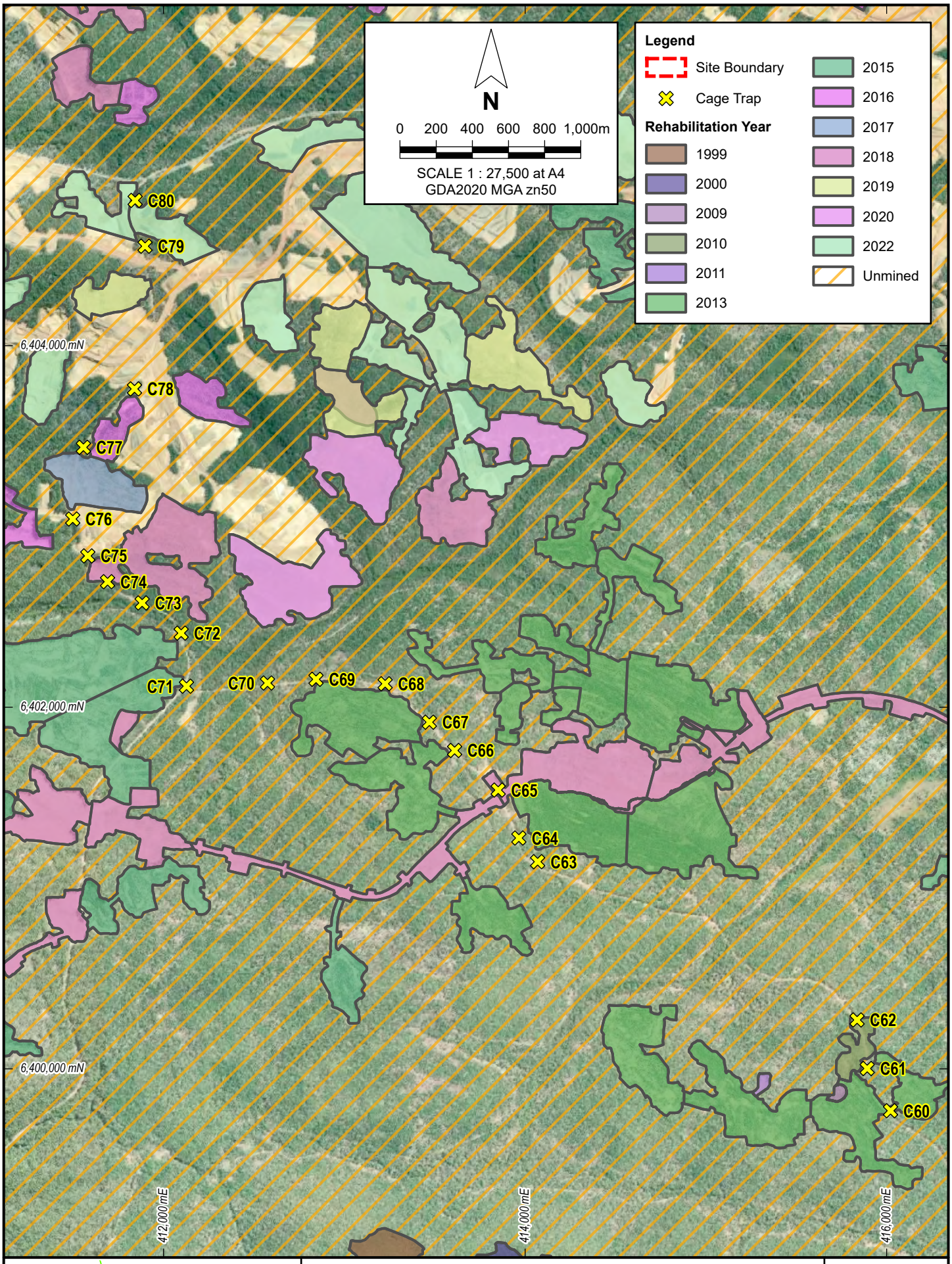
Drawn: S. Thompson | Date: 30 Mar 2023

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**CAGE TRAPS - SITE 3**

**Figure 20**

Job: 2022-0087




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TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS

**Figure 21**

## CAGE TRAPS - SITE 4

Drawn: S. Thompson

Date: 30 May 2023

Job: 2022-0087

# Appendix A.
# Images of trapping sites

**Baseline Monitoring of Rehabilitation Programs**
**Alcoa's Bauxite Mining Areas**





**Plate 16. Site 1 unmined**



**Plate 17. Site 1 unmined**



**Plate 18. Site 2 unmined**



**Plate 19. Site 2 unmined**



**Plate 20. Site 3 unmined**



**Plate 21. Site 3 unmined**



**Plate 22. Site 4 10-year rehabilitation**



**Plate 23. Site 4 10-year rehabilitation**



**Plate 24. Site 5 10-year rehabilitation**



**Plate 25. Site 5 10-year rehabilitation**



**Plate 26. Site 6 10-year rehabilitation**



**Plate 27. Site 6 10-year rehabilitation**



**Plate 28. Site 7 15-year rehabilitation**



**Plate 29. Site 7 15-year rehabilitation**



**Plate 30. Site 8 15-year rehabilitation**



**Plate 31. Site8 15-year rehabilitation**



**Plate 32. Site 9 5-year rehabilitation**



**Plate 33. Site 9 5-year rehabilitation**



**Plate 34. Site 10 5-year rehabilitation**



**Plate 35. Site 10 5-year rehabilitation**



**Plate 36. Site 10 5-year rehabilitation**



**Plate 37. Site 10 5-year rehabilitation**



**Plate 38. Site 10 15-year rehabilitation**



**Plate 39. Site 10 15-year rehabilitation**

# Appendix B.
# Trapping site coordinates

**Baseline Monitoring of Rehabilitation Programs**
**Alcoa's Bauxite Mining Areas**



**Table 8. Trap site coordinates and opening and closing dates**

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| **Pit and funnel traps** | | | | |
| 1.A | 428680 | 6397362 | 9/1/2023 | 21/1/2023 |
| 1.B | 428703 | 6397351 | 9/1/2023 | 21/1/2023 |
| 1.C | 428729 | 6397339 | 9/1/2023 | 21/1/2023 |
| 1.D | 428763 | 6397366 | 9/1/2023 | 21/1/2023 |
| 2.A | 421553 | 6401260 | 9/1/2023 | 21/1/2023 |
| 2.B | 421576 | 6401290 | 9/1/2023 | 21/1/2023 |
| 2.C | 421531 | 6401223 | 9/1/2023 | 21/1/2023 |
| 2.D | 421544 | 6401247 | 9/1/2023 | 21/1/2023 |
| 3.A | 417176 | 6398886 | 9/1/2023 | 21/1/2023 |
| 3.B | 417156 | 6398820 | 9/1/2023 | 21/1/2023 |
| 3.C | 417115 | 6398794 | 9/1/2023 | 21/1/2023 |
| 3.D | 417104 | 6398755 | 9/1/2023 | 21/1/2023 |
| 4.A | 418660 | 6399587 | 9/1/2023 | 21/1/2023 |
| 4.B | 418668 | 6399563 | 9/1/2023 | 21/1/2023 |
| 4.C | 418676 | 6399540 | 9/1/2023 | 21/1/2023 |
| 4.D | 418679 | 6399517 | 9/1/2023 | 21/1/2023 |
| 5.A | 420382 | 6401508 | 9/1/2023 | 21/1/2023 |
| 5.B | 420410 | 6401518 | 9/1/2023 | 21/1/2023 |
| 5.C | 420455 | 6401509 | 9/1/2023 | 21/1/2023 |
| 5.D | 420479 | 6401534 | 9/1/2023 | 21/1/2023 |
| 6.A | 421911 | 6394117 | 9/1/2023 | 21/1/2023 |
| 6.B | 421891 | 6394147 | 9/1/2023 | 21/1/2023 |
| 6.C | 421879 | 6394180 | 9/1/2023 | 21/1/2023 |
| 6.D | 421866 | 6394197 | 9/1/2023 | 21/1/2023 |
| 7.A | 422922 | 6396018 | 9/1/2023 | 21/1/2023 |
| 7.B | 422976 | 6396020 | 9/1/2023 | 21/1/2023 |
| 7.C | 423016 | 6395981 | 9/1/2023 | 21/1/2023 |
| 7.D | 423033 | 6396023 | 9/1/2023 | 21/1/2023 |
| 8.A | 423113 | 6394130 | 9/1/2023 | 21/1/2023 |
| 8.B | 423140 | 6394123 | 9/1/2023 | 21/1/2023 |
| 8.C | 423198 | 6394134 | 9/1/2023 | 21/1/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| 8.D | 423235 | 6394132 | 9/1/2023 | 21/1/2023 |
| 9.A | 416954 | 6409214 | 9/1/2023 | 21/1/2023 |
| 9.B | 416922 | 6409229 | 9/1/2023 | 21/1/2023 |
| 9.C | 416934 | 6409256 | 9/1/2023 | 21/1/2023 |
| 9.D | 416851 | 6409271 | 9/1/2023 | 21/1/2023 |
| 10.A | 409342 | 6407093 | 9/1/2023 | 21/1/2023 |
| 10.B | 409343 | 6407071 | 9/1/2023 | 21/1/2023 |
| 10.C | 409483 | 6407111 | 9/1/2023 | 21/1/2023 |
| 10.D | 409398 | 6407197 | 9/1/2023 | 21/1/2023 |
| 11.A | 409470 | 6405269 | 9/1/2023 | 21/1/2023 |
| 11.B | 409550 | 6405274 | 9/1/2023 | 21/1/2023 |
| 11.C | 409528 | 6405328 | 9/1/2023 | 21/1/2023 |
| 11.D | 409563 | 6405316 | 9/1/2023 | 21/1/2023 |
| 12.A | 421738 | 6395132 | 9/1/2023 | 21/1/2023 |
| 12.B | 421743 | 6395166 | 9/1/2023 | 21/1/2023 |
| 12.C | 421751 | 6395192 | 9/1/2023 | 21/1/2023 |
| 12.D | 421715 | 6395118 | 9/1/2023 | 21/1/2023 |
| Camera traps | | | | |
| CM1 | 420985 | 6400559 | 8/01/2023 | 20/01/2023 |
| CM2 | 421006 | 6400600 | 8/01/2023 | 20/01/2023 |
| CM3 | 421043 | 6400615 | 8/01/2023 | 20/01/2023 |
| CM4 | 421151 | 6400684 | 8/01/2023 | 20/01/2023 |
| CM5 | 421136 | 6400664 | 8/01/2023 | 20/01/2023 |
| CM6 | 421114 | 6400647 | 8/01/2023 | 20/01/2023 |
| CM7 | 421083 | 6400625 | 8/01/2023 | 20/01/2023 |
| CM8 | 421172 | 6400701 | 8/01/2023 | 20/01/2023 |
| CM9 | 418788 | 6398676 | 8/01/2023 | 20/01/2023 |
| CM10 | 418811 | 6398679 | 8/01/2023 | 20/01/2023 |
| CM11 | 418851 | 6398676 | 8/01/2023 | 20/01/2023 |
| CM12 | 418880 | 6398696 | 8/01/2023 | 20/01/2023 |
| CM13 | 418716 | 6398674 | 8/01/2023 | 20/01/2023 |
| CM14 | 418674 | 6398691 | 8/01/2023 | 20/01/2023 |
| CM15 | 418603 | 6398676 | 8/01/2023 | 20/01/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| CM16 | 418555 | 6398638 | 8/01/2023 | 20/01/2023 |
| CM17 | 412606 | 6393232 | 8/01/2023 | 20/01/2023 |
| CM18 | 412561 | 6393283 | 8/01/2023 | 20/01/2023 |
| CM19 | 412474 | 6393296 | 8/01/2023 | 20/01/2023 |
| CM20 | 412722 | 6393260 | 8/01/2023 | 20/01/2023 |
| CM21 | 412741 | 6393311 | 8/01/2023 | 20/01/2023 |
| CM22 | 412830 | 6393114 | 8/01/2023 | 20/01/2023 |
| CM23 | 412751 | 6393111 | 8/01/2023 | 20/01/2023 |
| CM24 | 412695 | 6393085 | 8/01/2023 | 20/01/2023 |
| Cage traps | | | | |
| **C1** | 430604 | 6398198 | 8/01/2023 | 18/1/2023 |
| **C2** | 430648 | 6397921 | 8/01/2023 | 18/1/2023 |
| **C3** | 430605 | 6397661 | 8/01/2023 | 18/1/2023 |
| **C4** | 430525 | 6397448 | 8/01/2023 | 18/1/2023 |
| **C5** | 430529 | 6397215 | 8/01/2023 | 18/1/2023 |
| **C6** | 430543 | 6396929 | 8/01/2023 | 18/1/2023 |
| **C7** | 430569 | 6396652 | 8/01/2023 | 18/1/2023 |
| **C8** | 430497 | 6396401 | 8/01/2023 | 18/1/2023 |
| **C9** | 430502 | 6396189 | 8/01/2023 | 18/1/2023 |
| **C10** | 430559 | 6395942 | 8/01/2023 | 18/1/2023 |
| **C11** | 430568 | 6395748 | 8/01/2023 | 18/1/2023 |
| **C12** | 430416 | 6395460 | 8/01/2023 | 18/1/2023 |
| **C13** | 429517 | 6390549 | 8/01/2023 | 18/1/2023 |
| **C14** | 429488 | 6390347 | 8/01/2023 | 18/1/2023 |
| **C15** | 429339 | 6390125 | 8/01/2023 | 18/1/2023 |
| **C16** | 429138 | 6389988 | 8/01/2023 | 18/1/2023 |
| **C17** | 429336 | 6389833 | 8/01/2023 | 18/1/2023 |
| **C18** | 429602 | 6389666 | 8/01/2023 | 18/1/2023 |
| **C19** | 429811 | 6389548 | 8/01/2023 | 18/1/2023 |
| **C20** | 430007 | 6389440 | 8/01/2023 | 18/1/2023 |
| **C21** | 428903 | 6390083 | 8/01/2023 | 18/1/2023 |
| **C22** | 428668 | 6390187 | 8/01/2023 | 18/1/2023 |
| **C23** | 428371 | 6390293 | 8/01/2023 | 18/1/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| **C24** | 428095 | 6390299 | 8/01/2023 | 18/1/2023 |
| **C25** | 427853 | 6390307 | 8/01/2023 | 18/1/2023 |
| **C26** | 427585 | 6390368 | 8/01/2023 | 18/1/2023 |
| **C27** | 427410 | 6390402 | 8/01/2023 | 18/1/2023 |
| **C28** | 427218 | 6390478 | 8/01/2023 | 18/1/2023 |
| **C29** | 427061 | 6390614 | 8/01/2023 | 18/1/2023 |
| **C30** | 426852 | 6390774 | 8/01/2023 | 18/1/2023 |
| **C31** | 426655 | 6390902 | 8/01/2023 | 18/1/2023 |
| **C32** | 426410 | 6391048 | 8/01/2023 | 18/1/2023 |
| **C33** | 426082 | 6391058 | 8/01/2023 | 18/1/2023 |
| **C34** | 425837 | 6390937 | 8/01/2023 | 18/1/2023 |
| **C35** | 425601 | 6390900 | 8/01/2023 | 18/1/2023 |
| **C36** | 425432 | 6391018 | 8/01/2023 | 18/1/2023 |
| **C37** | 425222 | 6391127 | 8/01/2023 | 18/1/2023 |
| **C38** | 425017 | 6391254 | 8/01/2023 | 18/1/2023 |
| **C39** | 424871 | 6391350 | 8/01/2023 | 18/1/2023 |
| **C40** | 424699 | 6391527 | 8/01/2023 | 18/1/2023 |
| **C41** | 412449 | 6395031 | 8/01/2023 | 18/1/2023 |
| **C42** | 412661 | 6395085 | 8/01/2023 | 18/1/2023 |
| **C43** | 412864 | 6395217 | 8/01/2023 | 18/1/2023 |
| **C44** | 413242 | 6395477 | 8/01/2023 | 18/1/2023 |
| **C45** | 413619 | 6395510 | 8/01/2023 | 18/1/2023 |
| **C46** | 413857 | 6395464 | 8/01/2023 | 18/1/2023 |
| **C47** | 414084 | 6395509 | 8/01/2023 | 18/1/2023 |
| **C48** | 414226 | 6395605 | 8/01/2023 | 18/1/2023 |
| **C49** | 414471 | 6395690 | 8/01/2023 | 18/1/2023 |
| **C50** | 414674 | 6395851 | 8/01/2023 | 18/1/2023 |
| **C51** | 414945 | 6395931 | 8/01/2023 | 18/1/2023 |
| **C52** | 415124 | 6396216 | 8/01/2023 | 18/1/2023 |
| **C53** | 415194 | 6396412 | 8/01/2023 | 18/1/2023 |
| **C54** | 415211 | 6396619 | 8/01/2023 | 18/1/2023 |
| **C55** | 415426 | 6396824 | 8/01/2023 | 18/1/2023 |
| **C56** | 415498 | 6397052 | 8/01/2023 | 18/1/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| **C57** | 415691 | 6397143 | 8/01/2023 | 18/1/2023 |
| **C58** | 415935 | 6397226 | 8/01/2023 | 18/1/2023 |
| **C59** | 416172 | 6397331 | 8/01/2023 | 18/1/2023 |
| **C60** | 416020 | 6399766 | 8/01/2023 | 18/1/2023 |
| **C61** | 415891 | 6399999 | 8/01/2023 | 18/1/2023 |
| **C62** | 415835 | 6400268 | 8/01/2023 | 18/1/2023 |
| **C63** | 414068 | 6401144 | 8/01/2023 | 18/1/2023 |
| **C64** | 413964 | 6401275 | 8/01/2023 | 18/1/2023 |
| **C65** | 413850 | 6401540 | 8/01/2023 | 18/1/2023 |
| **C66** | 413609 | 6401759 | 8/01/2023 | 18/1/2023 |
| **C67** | 413469 | 6401915 | 8/01/2023 | 18/1/2023 |
| **C68** | 413224 | 6402128 | 8/01/2023 | 18/1/2023 |
| **C69** | 412842 | 6402153 | 8/01/2023 | 18/1/2023 |
| **C70** | 412574 | 6402132 | 8/01/2023 | 18/1/2023 |
| **C71** | 412126 | 6402114 | 8/01/2023 | 18/1/2023 |
| **C72** | 412096 | 6402408 | 8/01/2023 | 18/1/2023 |
| **C73** | 411880 | 6402575 | 8/01/2023 | 18/1/2023 |
| **C74** | 411689 | 6402693 | 8/01/2023 | 18/1/2023 |
| **C75** | 411580 | 6402835 | 8/01/2023 | 18/1/2023 |
| **C76** | 411496 | 6403039 | 8/01/2023 | 18/1/2023 |
| **C77** | 411555 | 6403436 | 8/01/2023 | 18/1/2023 |
| **C78** | 411838 | 6403759 | 8/01/2023 | 18/1/2023 |
| **C79** | 411896 | 6404549 | 8/01/2023 | 18/1/2023 |
| **C80** | 411841 | 6404802 | 8/01/2023 | 18/1/2023 |

# Appendix C. Vertebrate Fauna Recorded in Biological Surveys in the Region

**Baseline Monitoring of Rehabilitation Programs**
**Alcoa's Bauxite Mining Areas**



| | | Surveys | A | B | | C | | | | | | | D | | E | | | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family | Species | Common name | | South | North | Site 3 | Site 6 | Site 4 | Site 7 | Site 5 | Site 9 | Site 8 | Plot 5 | Plot 6 | Unknown | Lease | | |
| Amphibians | | | | | | | | | | | | | | | | | | |
| Limnodynastidae | *Heleioporus barycragus* | Hooting Frog | X | | | | | | | | | | | | | | | |
| | *Heleioporus eyrei* | Moaning Frog | X | 2 | | | | | | | | | | | | | | |
| | *Heleioporus inornatus* | Whooping Frog | X | 2 | | 1 | 1 | | | | | | | | | | | |
| | *Limnodynastes dorsalis* | Western Banjo Frog | X | | | | | 1 | | | | | | | | | | |
| | *Neobatrachus pelobatoides* | Humming Frog | X | | | | | | | | | | | | | | | |
| Myobatrachidae | *Crinia georgiana* | Quacking Frog | X | 2 | 2 | 5 | 4 | 3 | 4 | 1 | | | 2 | | | | | |
| | *Crinia glauerti* | Glauert's Frog | X | | 2 | 2 | | | | | | | | | 2 | | | |
| | *Crinia insignifera* | Sin-bearing Froglet | X | | | | | | | | | | | | | | | |
| | *Crinia pseudinsignifera* | Bleating Froglet | X | | 2 | | | | | | | | | | | | | |
| | *Geocrinia leai* | Lea's Frog | X | | 2 | | 8 | | | 5 | | | | | 1 | | | |
| | *Pseudophryne guentheri* | Gunther's Toadlet | X | 2 | | | | | | | | | | | | | | |
| Pelodryadidae | *Litoria adelaidensis* | Slender Tree Frog | X | 2 | 2 | | | | | | | | | | 1 | | | |
| | *Litoria moorei* | Motorbike Frog | | | 2 | | | | | | | | | | | | | |
| Reptiles | | | | | | | | | | | | | | | | | | |
| Agamidae | *Ctenophorus ornatus* | Ornate Crevice Dragon | X | 2 | 2 | | | | | | 1 | | | | | | | |
| | *Pogona minor* | Western Bearded Dragon | X | 2 | 2 | | | | | | | | | | | | | |
| Carphodactylidae | *Underwoodisaurus milii* | Barking Gecko | X | | | | | | | | | | | | | | | |
| Diplodactylidae | *Diplodactylus lateroides* | Speckled Stone Gecko | X | | | | | | | | | | | | | | | |
| | *Diplodactylus polyophthalmus* | Spotted Sand Plain Gecko | X | 2 | 2 | | | | | | | | | | | | | |
| Diplodactylidae | *Oedura marmorata* | Marbled Velvet Gecko | | 2 | 2 | | | | | | | | | | | | | |
| Elapidae | *Acanthophis antarcticus* | Southern Death Adder | X | | | | | | | | | | | | | | | |
| | *Notechis scutatus* | Tiger Snake | X | 2 | 2 | | | | | | | | | | 1 | | | |
| | *Suta gouldii* | Gould's Snake | X | 2 | 2 | | | | | | | | | | | | | |
| | *Suta nigriceps* | Short-tailed Snake | X | | 2 | | | | | | | | | | | | | |
| | *Pseudonaja affinis* | Dugite | X | | 2 | | | | | | | | | | | | | |
| Gekkonidae | *Christinus marmoratus* | Marbled Gecko | X | | | | | | | | | | | | | | | |
| | *Gehyra variegata* | Variegated Gehyra | X | | | | | | | | | | | | | | | |
| Pygopodidae | *Aprasia parapulchella* | Pink-tailed Worm-lizard | | | | 1 | | | | | | | | | | | | |
| | *Aprasia pulchella* | Pretty Worm-lizard | X | 2 | 2 | | | | | | | | | | | | | |
| | *Aprasia repens* | Southwest Sandplain Worm Lizard | X | | | | | | | | | | | | | | | |
| | *Lialis burtonis* | Burton's Legless Lizard | X | 2 | 2 | | | | | | | | | | | | | |
| | *Pygopus lepidopodus* | Common Scaly-foot | | 2 | | | | | | | | | | | | | | |
| Pythonidae | *Morelia spilota* | Carpet Python | X | | | | | | | | | | | | | | | |
| Scincidae | *Acritoscincus trilineatus* | Western Three-lined Skink | X | 2 | 2 | | | | | | | | | | | | | |
| | *Cryptoblepharus buchananii* | Buchanan's Snake-eyed Skink | X | 2 | 2 | | | | | 1 | | | | 6 | 1 | | | |
| | *Ctenotus delli* | Dell's Ctenotus | X | 2 | 2 | | | | | | | | 6 | | | | | |
| | *Ctenotus impar* | Odd-stripped Ctenotus | | 2 | | | | | | | | | | | | | | |
| | *Ctenotus labillardieri* | Common South-west Ctenotus | X | 2 | 2 | | | 2 | 1 | | | | | | 2 | | | |
| | *Egernia kingii* | King's Skink | X | 2 | 2 | | 2 | | | | | | | | | | | |
| | *Egernia napoleonis* | Southwestern Crevice Skink | X | 2 | 2 | 1 | 1 | 3 | | | | | | | 2 | | | |
| | *Hemiergis initialis* | South-western Earless Skink | X | 2 | 2 | | | 4 | 2 | | | | 6 | | 1 | | | |
| | *Lerista distinguenda* | South-western Orange-tailed Slider | X | 2 | 2 | | | | 2 | | | | 2 | | | | | |
| | *Lerista elegans* | West Coast Four-toed Lerista | X | | | | | | | | | | | | | | | |
| | *Liopholis pulchra* | South-western Rock-skink | X | | | | | | | | | | | | | | | |
| | *Lissolepis luctuosa* | Western Mourning Skink | X | 2 | 2 | | | | | | | | | | | | | |
| | *Menetia greyii* | Common Dwarf Skink | X | 2 | 2 | | | | | | | | | | 1 | | | |
| | *Morethia obscura* | Shrubland Pale-flecked Morethia | X | 2 | 2 | 2 | | 3 | 5 | | | | 4 | | 1 | | | |
| | *Tiliqua rugosa* | Bobtail | X | 2 | 2 | | 2 | | | | | 3 | | | | | | |
| Typhlopidae | *Anilios australis* | Austral Blind Snake | X | 2 | | | | | | | | | | | | | | |
| Varanidae | *Varanus gouldii* | Gould's Goanna | X | 2 | | | | | | | | | | | | | | |
| | *Varanus rosenbergi* | Heath Monitor | | | | | 1 | | | | | | | | | | | |
| Mammals | | | | | | | | | | | | | | | | | | |
| Tachyglossidae | *Tachyglossus aculeatus* | Short-beaked Echidna | | 2 | 2 | | | | | | | | | | 4 | | | |
| Suidae | *Sus scrofa* | Pig | | 2 | | | | | | | | | | | 2 | | | |
| Canidae | *Vulpes vulpes* | Red Fox | | | | | | | | | | | | | 1 | | | |
| Dasyuridae | *Sminthopsis fulinginosa* | Grey-bellied Dunnart | X | | | | | | | | | | | | | | | |
| Molossidae | *Austronomus australis* | White-striped Freetail Bat | | 2 | 2 | | | | | | | | | | | | | |
| | *Mormopterus planiceps* | Southern Free-tail Bat | X | 2 | | | | | | | | | | | | | | |
| Vespertilionidae | *Chalinolobus gouldii* | Gould's Wattled Bat | X | 2 | | | | | | | | | | | | | | |
| | *Chalinolobus morio* | Chocolate Wattled Bat | X | | 2 | | | | | | | | | | | | | |
| | *Falsistrellus mackenziei* | Western False Pipistrelle | | | | | | | | | | | | | | | | 2 |
| | *Nyctophilus geoffroyi* | Lesser Long-eared Bat | X | 2 | | | | | | | | | | | | | | |

| | | Surveys | A | B | | C | | | | | | | D | | E | | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family | Species | Common name | | South | North | Site 3 | Site 6 | Site 4 | Site 7 | Site 5 | Site 9 | Site 8 | Plot 5 | Plot 6 | Unknown | Lease | |
| | *Nyctophilus holtorum* | Holt's Long-eared Bat | X | | 2 | | | | | | | | | | | | |
| | *Nyctophilus major* | Greater Long-eared Bat | X | | | | | | | | | | | | | | |
| | *Vespadelus regulus* | Southern Forest Bat | X | 2 | 2 | | | | | | | | | | | | |
| Dasyuridae | *Antechinus flavipes* | Yellow-footed Antechinus | X | 2 | 2 | | | | 2 | | | | 50 | 58 | | | |
| | *Dasyurus geoffroii* | Chuditch | X | | | | | | | | | | | | | | |
| | *Sminthopsis gilberti* | Gilbert's Dunnart | X | 2 | | | | | | | | | | | | | |
| Burramyidae | *Cercartetus concinnus* | Southwestern Pygmy Possum | X | | | | | | | | | | | | | | |
| Macropodidae | *Macropus fuliginosus* | Western Grey Kangaroo | X | 2 | 2 | | | | | | | | | | 6 | | |
| | *Notamacropus irma* | Western Brush Wallaby | X | 2 | 2 | | | | | | | | | | 1 | | 2 |
| | *Setonix brachyurus* | Quokka | X | | | | | | | | | | | | | | |
| Phalangeridae | *Trichosurus vulpecula* | Common Brushtail Possum | | | | | | | | | | | 4 | 6 | | | |
| Tarsipedidae | *Tarsipes rostratus* | Honey Possum | X | | | | | | | | | | | | | | |
| Leporidae | *Oryctolagus cuniculus* | Rabbit | X | | | | | | | | | | | | 2 | | |
| Peramelidae | *Isoodon fusciventer* | Quenda | X | 2 | 2 | | | | | | | | 6 | 2 | 4 | | 2 |
| Muridae | *Mus musculus* | House Mouse | | 2 | 2 | | | | | | | | | | | | |
| | *Rattus rattus* | Black Rat | X | | | 1 | | | | | | 1 | | | | | |

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DETECTION DOG

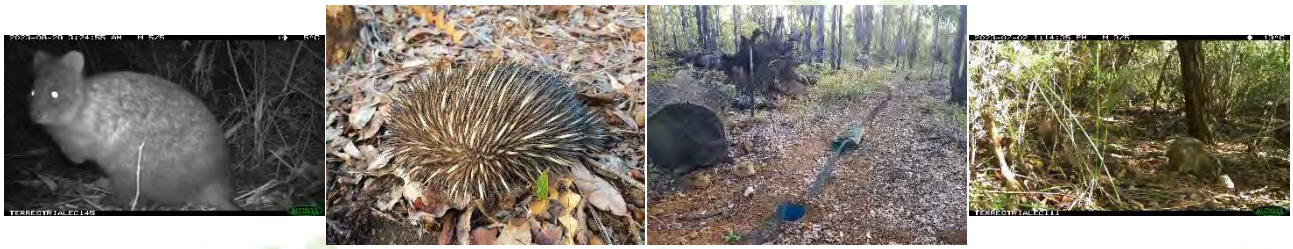
TERRESTRIAL ECOSYSTEMS

# Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas

## Winter Survey

Prepared for: Alcoa of Australia Ltd

Version 1. October, 2023





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# EXECUTIVE SUMMARY

Alcoa of Australia Ltd (Alcoa) has operated bauxite mines at Huntly and Willowdale east of Pinjarra in Western Australian since the 1970s. Once mining sites are no longer required, then they are rehabilitated with native vegetation. Alcoa has committed to monitoring the extent to which there is a progression toward the re-establishment of vertebrate fauna assemblages in these rehabilitated areas like that in selected analogue sites.

This is a report on the results of the second monitoring program. The first survey was undertaken in January 2023, and the results of the January and June-July 2023 surveys are compared and discussed. Comment and recommendations are provided on how Alcoa might enhance its program of establishing near-natural vertebrate fauna assemblages in rehabilitated areas.

# 1. INTRODUCTION

## 1.1 BACKGROUND

Alcoa of Australia Ltd (Alcoa) operates the Huntly and Willowdale bauxite mines east of Pinjarra in Western Australian on mineral lease ML1SA. The Huntly mine was established in 1972 and is located near Dwellingup and supplies bauxite ore to the Kwinana and Pinjarra refineries, as well as other clients. The Huntly mine currently includes locations at Myara, McCoy and Karnet. The Willowdale mine was established in 1984 and is located near Wagerup and supplies bauxite ore to the Wagerup refinery, as well as other clients. The Willowdale mine currently includes locations at Larego, Orion and Arundel.

The primary objective of Alcoa's bauxite mine rehabilitation program is to return a self-sustaining jarrah forest ecosystem after mining. This includes re-establishing populations of all faunal groups and species in densities and distributions required for maintaining forest biodiversity and ecosystem function. To ensure this objective is met, Alcoa established a long-term fauna monitoring program in 1991. This program characterises and monitors the key fauna of the areas in which Alcoa operates and assesses the impact of mining on these species.

## 1.2 SUCCESSION

Grant (2006) indicated that Alcoa's objective for its rehabilitation programs was to establish self-sustaining jarrah forest ecosystems. Grant (2006) went on to indicate that '*restored native ecosystems may be different in structure to the surrounding native ecosystems, but there should be confidence that they will change with time along with, or toward the structure and composition of the surrounding area*' and '*should be capable of withstanding disturbances such as fire or grazing*'. It has been presumed that this object is still applicable.

Primary succession is defined here as a process of change in the species structure of an ecological community over time from an assemblage that commences on barren or highly disturbed land to the climax community. This can be diagrammatically represented as shown in Plate 1.

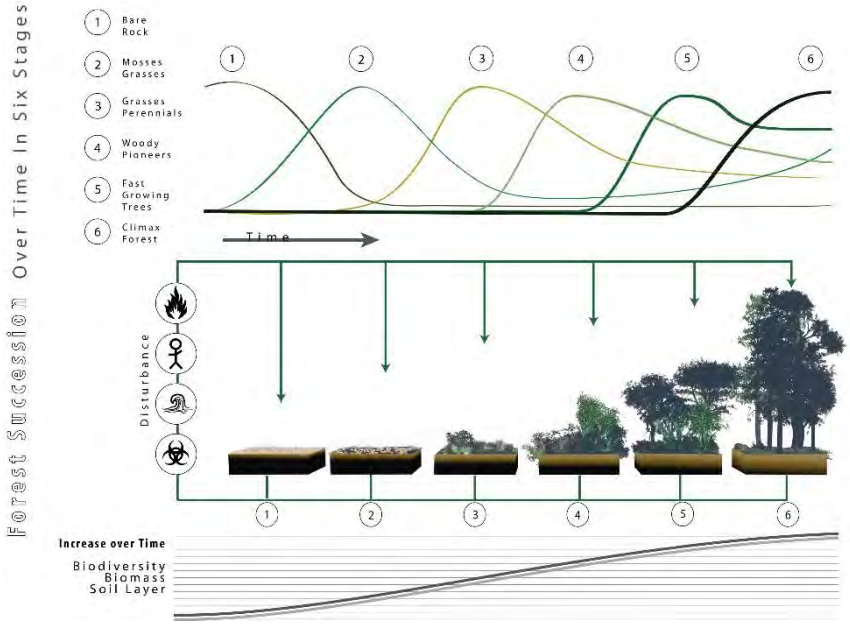



**Plate 1. Conceptual diagram of primary succession**

During the very early stages, very few terrestrial vertebrate species will colonise the area due to a lack of suitable habitat and there are likely to be higher levels of predation because of a lack of cover and retreat sites. Once the vegetation, invertebrates and microbial activity move through the succession stages and additional habitat niches become available, then more species can colonise the rehabilitated areas. In some cases, the abundance of early colonisers (i.e. pioneers) will be reduced due to competition and changing habitat conditions. Rehabilitated areas will cycle through many iterations of this process and along the way, species abundance typically increases, and the various species reach population levels suitable for the habitat and resources available, until such time it becomes a climax community.

Vertebrate fauna are only a part of the primary succession process and their progress from pioneering species toward a climax community is interrelated with the vegetation, fungi, microbial and invertebrate community development. Within broad boundaries, the trajectory in rehabilitated areas should be apparent in monitoring data (Plate 2).

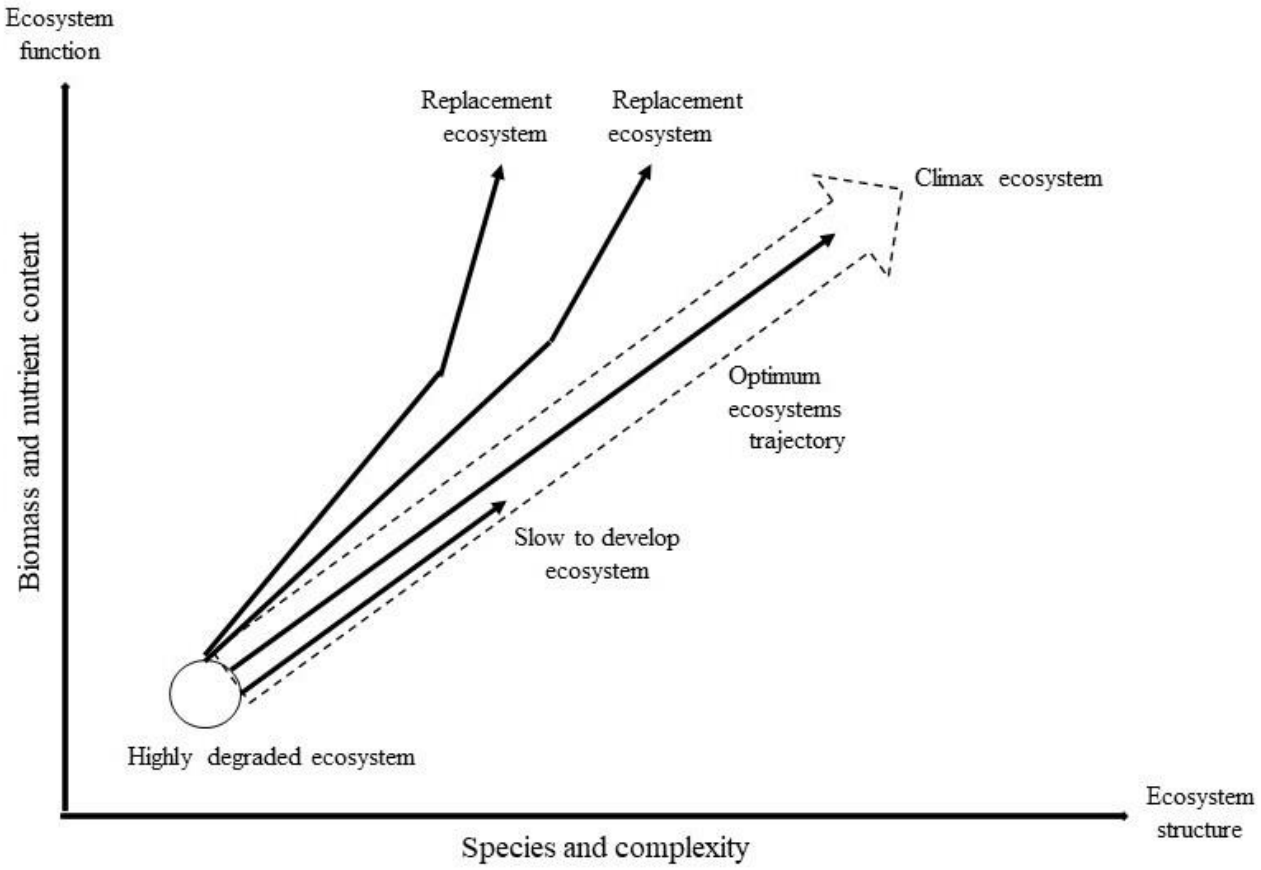



**Plate 2. Primary succession trajectory(taken from: Bradshaw 1984)**

Anderson et al. (2022) and Cross et al. (2019, 2021) argued that fauna have very often been forgotten in considering rehabilitation success with the focus on soils and vegetation. Anderson et al. (2022) went on to suggest a framework for incorporating fauna into the restoration process, and in doing so, identified the following five key criteria for effective faunal standards:

- appropriate reference ecosystem [analogue site(s)];
- faunal taxa to be considered;
- attributes of these taxa to be measured;
- acceptable level of similarity with reference conditions; and
- sampling methodology that is sufficiently robust to provide reliable comparative data.

## 1.3 OBJECTIVE

Alcoa's intention was to establish long-term monitoring sites for vertebrate fauna in unmined areas, and areas rehabilitated 5, 10 and 15-years ago. It was proposed that the vertebrate fauna at these sites would be periodically monitored to enable judgements to be made about the extent to which rehabilitated areas were progressing on a trajectory towards the recreation of functional ecosystems, like that in the unmined areas. Outcomes from these monitoring surveys would inform planning for future rehabilitated areas and where appropriate corrective action in existing rehabilitated areas.

Here we provide a description of the methods used to collect vertebrate fauna data, the results of the baseline monitoring program in winter, discussion of the results, a commentary on the program and a suggested way forward.

# 2. METHODS

The survey methodology adopted was identical to that implemented in the January 2023 monitoring survey.

## 2.1 PIT-TRAPPING PROGRAM

Twelve sites in the Jarrah Forest (Figures 1 and 2) were established by Alcoa (Plates 21-44). This included three unmined analogue sites, three sites that were rehabilitated in 2007 (i.e. 15-years old), three sites that were rehabilitated in 2012 (i.e. 10-years old) and three sites that were rehabilitated in 2017 (i.e. 5-years old).

At each site there were four near parallel drift fences 30m long with approximately 25cm of flywire above the ground. Along each drift fence there were three 20L PVC buckets, three PVC 150mm diameter pipes that were 400mm deep (Plate 4) and buried mid-line along the flywire drift fence. Three pair of funnels traps were deployed either side of the drift fence and three aluminium box traps were set approximately 10m to the side of the drift fence (Plate 5). Buckets used as pit-traps had holes and styrene sheets in the bottom to provide captured fauna protection from unfavourable environmental conditions. These traps targeted small mammals, reptiles and amphibians.

The location of trapping sites is shown in Figures 2-14 and the coordinates are provided in Appendix B. Traps were opened on 27 June and closed on 9 July 2023.

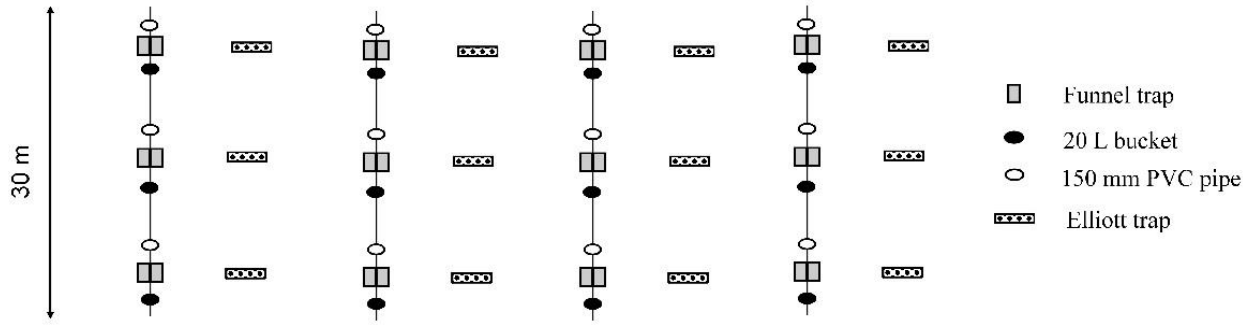



**Plate 3. Trapping site layout**



**Plate 4. Pit-fall trap on a drift fence**



**Plate 5. Pair of funnel traps on a drift fence**

## 2.2 CAGE TRAPPING PROGRAM

Eighty cage traps (Plate 6) targeting Chuditch (*Dasyurus geoffroii*) were deployed adjacent to gravel tracks where Alcoa believed that there may have been Chuditch. Trapping sites were selected by Alcoa on the basis that some were inside the mining area and comprised a variety of levels of disturbance (i.e. rehabilitation of various ages and remnant vegetation), and the others were outside the mine perimeter in unmined forest (Figures 18-21).

Cage traps were baited with raw chicken necks which were replaced every three days or as required. Cage traps were set up on 26 June and removed on 8 July 2023.



**Plate 6. Baited cage trap**

## 2.3 CAMERA TRAPS

Camera traps targeted the medium and large mammals, but any fauna recorded were reported.

Twenty-four camera traps (Reconyx HC600) were deployed in the denser vegetation targeting Quokka (*Setonix brachyurus*) and Quenda (*Isoodon fusciventer*; Figures 15-17). Each camera trap had a non-reward lure (Plate 7) placed ~3-4m in front of the camera trap (Plate 8) in the detection zone. Lures were a mixture of peanut butter, rolled oats and sardines topped up with mullie oil. Camera traps were deployed on 26 June and retrieved on 8 July 2023.



**Plate 7. Non-reward lure**



**Plate 8. Mounted camera trap**

## 2.4 INVERTEBRATE SAMPLING

Each trapping site was searched for invertebrates for one hour by two people for the following taxonomic groups: isopods, diplopods, opiliones, scorpions, mygalomorph spiders and pseudoscorpions. Specimens were preserved in ethanol but not identified. In addition, specimens from these taxonomic groups caught in pit and funnel traps were also collected and preserved. All specimens were given to Alcoa for identification and analysis.

## 2.5 DATA ANALYSIS

There were insufficient individual animals caught at the trapping sites to undertake any meaningful analysis. Some comparisons between what was caught and recorded in the January and July 2023 surveys has been provided in the discussion. All animal identifications were done by field staff.

## 2.6 STAFF

The field work was undertaken by Dr James Barr, Tom Raymond, Brody Altus, Stelleena Mackay, Mitch Plozza and Isaac Cable. Dr Graham Thompson drafted the report and it was reviewed by Dr Scott Thompson before being submitted to Alcoa for comment and review. As an EIANZ Certified Environmental Practitioner [CEnvP (Ecology Specialist)], Scott is appropriately qualified to sign off on the final report.

# 3. RESULTS

## 3.1 WEATHER

Compared with the January 2023 survey period, the June-July trapping was much cooler (Table 1). There was only one day of very light rain in January, whereas it rained on 12 days during the June-July survey period, although rain was light on many days.

**Table 1. Weather data for the January and the June-July surveys (BOM ID 94620 Dwellingup)**

| Date | Min. T° | Max. T° | Max. rainfall | Date | Min. T° | Max. T° | Max. rainfall |
|---|---|---|---|---|---|---|---|
| 7/1/2023 | 12.6 | 27.1 | 0 | 25/6/2023 | 6.2 | 11.9 | 4.4 |
| 8/1/2023 | 12.4 | 30.8 | 0 | 26/6/2023 | 3 | 12.9 | 0.2 |
| 9/1/2023 | 14.3 | 36.5 | 0 | 27/6/2023 | -0.9 | 15.2 | 0 |
| 10/1/2023 | 18.9 | 35.5 | 0.8 | 28/6/2023 | 2.1 | 14.0 | 0.2 |
| 11/1/2023 | 17.1 | 29.1 | 0 | 29/6/2023 | 1 | 14.8 | 0 |
| 12/1/2023 | 13.6 | 31.9 | 0 | 30/6/2023 | -0.2 | 15.0 | 0 |
| 13/1/2023 | 13.8 | 27.5 | 0 | 1/7/2023 | -0.1 | 15.8 | 0.2 |
| 14/1/2023 | 11.9 | 28.5 | 0 | 2/7/2023 | 0.8 | 16.9 | 0.2 |
| 15/1/2023 | 11.5 | 31.8 | 0 | 3/7/2023 | 6 | 15.4 | 6.4 |
| 16/1/2023 | 13.4 | 25.2 | 0 | 4/7/2023 | 7.5 | 12.7 | 37.0 |
| 17/1/2023 | 9.8 | 26.6 | 0 | 5/7/2023 | 7.7 | 12.7 | 17.8 |
| 18/1/2023 | 11.9 | 30.0 | 0 | 6/7/2023 | 6.2 | 14.6 | 2.8 |
| 19/1/2023 | 13.1 | 33.8 | 0 | 7/7/2023 | 9.1 | 15.6 | 5.0 |
| 20/1/2023 | 16.2 | 35.5 | 0 | 8/7/2023 | 7.8 | 17.0 | 5.2 |
| 21/1/2023 | 18.8 | 38 | 0 | 9/7/2023 | 8.5 | 16.9 | 0.2 |

## 3.2 TRAPPING RESULTS

The location of trapping sites is shown in Figures 1-21 in the appendices. All vertebrate fauna caught in pit, funnel and aluminium box traps are shown in Table 2.

**Table 2. Trapping data results**

| | | Survey site status | Unmined | Unmined | Unmined | 15-year rehabilitation | 15-year rehabilitation | 15-year rehabilitation | 10-year rehabilitation | 10-year rehabilitation | 10-year rehabilitation | 5-year rehabilitation | 5-year rehabilitation | 5-year rehabilitation | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Family** | **Species** **Survey sites** | **1** | **2** | **3** | **7** | **8** | **12** | **4** | **5** | **6** | **9** | **10** | **11** | |
| Frogs | Myobatrachidae | *Crinia georgiana* | | 9 | 5 | | 7 | | 8 | 8 | 4 | 36 | 26 | 6 | 109 |
| | | *Crinia insignifera* | | | | | | | | | | | 1 | | 1 |
| | Pelodryadidae | *Litoria adelaidensis* | | | | | | | | | | | 1 | | 1 |
| Mammals | Dasyuridae | *Antechinus flavipes* | 4 | 11 | 2 | | 3 | 8 | 2 | 1 | 6 | | | | 37 |
| | | *Sminthopsis* sp. | 2 | | | | | | 1 | | | | 1 | 1 | 5 |
| | Burramyidae | *Cercartetus concinnus* | | | | | | | | | 1 | | | | 1 |
| | Muridae | *Mus musculus* | | | | 1 | | | | | | | 2 | 1 | 4 |
| Reptiles | Scincidae | *Cryptoblepharus buchananii* | | | | | | | | | | | 1 | | 1 |

We are unsure of the identity of the *Sminthopsis* spp. and an individual has been lodged with the Western Australian Museum for identification.

## 3.3 CAGE TRAP RESULTS

Vertebrate fauna caught in cage traps are shown in Table 3.

**Table 3. Fauna caught in a cage traps**

| | | | Trap numbers | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Unmined | Reh. 2004 | Reh. 2004 | Reh. 2005 | Unmined | Unmined | Unmined | Reh. 2005 | Reh. 2001 | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined |
| **Taxa** | **Family** | **Species** | **18C** | **42C** | **43C** | **45C** | **47C** | **48C** | **49C** | **50C** | **52C** | **53C** | **54C** | **5C** | **60C** | **67C** | **68C** | **69C** | **70C** | **72C** | **73C** | **76C** | **77C** | **78C** |
| Mammals | Dasyuridae | *Dasyurus geoffroii* | 1 | 3 | 6 | 1 | 2 | 1 | 2 | 2 | 4 | | 1 | | 1 | 1 | | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| | Tachyglossidae | *Tachyglossus aculeatus* | | | | | | | | | | 1 | | 2 | | | | | | | | | | |
| | Peramelidae | *Isoodon fusciventer* | | | | | | | | | 1 | | | | | | 1 | | | | | | | |

Thirteen of the 17 female (33 in total) Chuditch had 3-5 pouch young and one Chuditch was a recapture.



**Plate 9. Echidna**



**Plate 10. Buchanan's Snake-eyed Skink**



**Plate 11. Dunnart**



**Plate 12. Chuditch pouch young**



**Plate 13. Releasing a Chuditch**



**Plate 14. Chuditch in a trap**

## 3.4 RESULTS BY TRAP TYPE

Vertebrate fauna caught by trap type are shown in Table 4.

**Table 4. Vertebrate fauna recorded by trap type**

| Taxa | Family | Species | Aluminium box trap | Bucket pit trap | Cage trap | Funnel | Pipe pit trap |
|---|---|---|---|---|---|---|---|
| Frogs | Myobatrachidae | *Crinia georgiana* | | 70 | | 9 | 30 |
| | Pelodryadidae | *Litoria adelaidensis* | | | | 1 | |
| Mammals | Dasyuridae | *Antechinus flavipes* | 30 | 3 | | 1 | 3 |
| | | *Dasyurus geoffroii* | | | 33 | | |
| | | *Sminthopsis* sp. | | 1 | | | 4 |
| | Burramyidae | *Cercartetus concinnus* | | | | | 1 |
| | Tachyglossidae | *Tachyglossus aculeatus* | | | 3 | | |
| | Peramelidae | *Isoodon fusciventer* | | | 2 | | |
| | Muridae | *Mus musculus* | 1 | 1 | | | 2 |

| Taxa | Family | Species | Aluminium box trap | Bucket pit trap | Cage trap | Funnel | Pipe pit trap |
|---|---|---|---|---|---|---|---|
| Reptiles | Scincidae | *Cryptoblepharus buchananii* | | | | | 1 |
| Total | | | 31 | 75 | 38 | 11 | 41 |

## 3.5 CAMERA TRAPPING RESULTS

Vertebrate fauna recorded by camera traps are shown in Table 5.

**Table 5. Camera trap results**

| | | | Camera trap numbers | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined | Unmined |
| Taxa | Family | Species | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 | CM10 | CM11 | CM12 | CM13 | CM14 | CM15 | CM16 | CM17 | CM18 | CM19 | CM20 | CM21 | CM22 | CM23 | CM24 |
| Bird | Alcedinidae | *Dacelo novaeguineae** | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| | Acanthizidae | *Sericornis frontalis* | 1 | 2 | | 1 | 2 | 1 | | 1 | 2 | | | | | | | | | | | | | | | |
| | Maluridae | *Malurus elegans* | 1 | 2 | | 1 | 2 | 1 | 1 | 3 | | | | | | 1 | | | | | | | | | | |
| | | *Malurus* sp. | | | | | | | | | | | | | 3 | | | | | | | | | | | |
| | | *Malurus splendens* | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| | Pachycephalidae | *Pachycephala pectoralis* | | | | | | | | | | 1 | | | | | | | | | | | | | | |
| | Rhipiduridae | *Rhipidura albiscapa* | | 2 | | | 1 | | | | | 1 | | | | | | | | | | | | | | |
| Mammals | Suidae | *Sus scrofa** | | | | | | | | | | | 1 | | | | | 1 | | | | | | | | |
| | Dasyuridae | *Antechinus flavipes* | | 1 | 1 | 1 | 2 | 2 | 2 | 1 | | | | 1 | 2 | 1 | 1 | | | | | | | | | 1 |
| | | *Dasyurus geoffroii* | | | | | | | | | 1 | 2 | 1 | 1 | 1 | 1 | | 2 | | | | | | | | |
| | | *Sminthopsis* sp. | | | 1 | | | | | | | | | | | | | | | | | | | | | |
| | Macropodidae | *Macropus fuliginosus* | | | | | | | | | | | | | | | | | | 1 | | | 1 | | | |
| | | *Setonix brachyurus* | | | | | | | | | | 3 | 2 | 2 | 2 | 3 | | | | | | | | | | |
| | Peramelidae | *Isoodon fusciventer* | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | | 1 | | 1 | 1 | 1 | 1 | 1 | | 2 |
| | Muridae | *Mus musculus** | 1 | 1 | | 1 | 1 | | | | | | 1 | | 1 | 2 | 1 | 1 | | | 1 | | 1 | 1 | | |
| | | *Rattus rattus** | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | | | | | | | | | | | 1 | | 1 | 1 | 1 | |

* non-native species

One Fairywren was unable to be identified, and as indicated above, the *Sminthopsis* spp. has been lodged with the Western Australian Museum for identification.



**Plate 15. Chuditch**



**Plate 16. Quenda**



**Plate 17. Black Rats**



**Plate 18. Quokkas**



**Plate 19. Quokka**



**Plate 20. Pig**

In addition, two *Hemiergis initialis* were observed near trapping site 3, and a *Crinia insignifera* near trapping site 10 during the collection of invertebrates, and *Notamacropus irma* were recorded between cages 68-69, two *Sus scrofa* were recorded between trapping sites 3 and 4, and another was recorded crossing the road near the entry to Alcoa Myara mine site.

# 4. DISCUSSION

## 4.1 PIT, FUNNEL AND ALUMINIUM BOX TRAPS

The pit, funnel and aluminium box trapping program predominantly caught frogs in the June-July 2023 survey period, and in particular *Crinia georgiana* (Quacking Frog), and most of these captures were in the rehabilitation sites. Many fewer frogs were caught during the January 2023 survey period, which was expected because it was hotter and there had been much less rain in the summer period.

Forty- nine *Antechinus flavipes* (Yellow-footed Antechinus) were caught in the January survey compared to 37 in the June-July survey, which was similar, but 66 *Cercartetus concinnus* (Western Pygmy Possum) were caught in the January survey compared with one in the June-July survey period. Thompson (2004) similarly recorded large variations in the capture of *C. concinnus* in pit-traps in the Goldfields, and this is probably due to the abundance of nectar producing plants that are flowering at the time and the ambient temperature. In cold weather, *C. concinnus* enters torpor and if found it is typically curled up in a ball and immobile. Based on the data recorded in the January 2023 survey, these pygmy possums are present in most of the survey sites, but the June-July survey indicates that they are only caught when they move around.

*Antechinus flavipes* was predominantly caught in the older rehabilitated areas and unmined area in both the January and June-July surveys. This species is probably one of the early colonisers, as it is a mobile and a widely foraging dasyurid.

The capture of a single reptile in the trapping program (i.e. *Cryptoblepharus buchananii*; Buchanan's Snake-eyed Skink) is typical of what occurs in cold weather, as most of the small reptiles that warm up quickly and are active during winter have very small home ranges and therefore are less likely to be trapped, and the larger reptiles are generally inactive and therefore not caught.

Like the January survey, most of the *Mus musculus* (House Mouse) caught in the June-July survey were in the more recent rehabilitation areas being mobile and early colonisers (Thompson and Thompson 2007).

Overall, there was insufficient data to draw any conclusions about patterns of succession from the pit, funnel and aluminium box trapping data.

**Table 6. Comparison of trapping results for the January and June-July 2023 surveys**

| | | Survey site status | Unmined | | Unmined | | Unmined | | 15-year rehabilitation | | 15-year rehabilitation | | 15-year rehabilitation | | 10-year rehabilitation | | 10-year rehabilitation | | 10-year rehabilitation | | 5-year rehabilitation | | 5-year rehabilitation | | 5-year rehabilitation | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Family** | **Species** **Survey sites** | **1** | | **2** | | **3** | | **7** | | **8** | | **12** | | **4** | | **5** | | **6** | | **9** | | **10** | | **11** | | | |
| | | | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul | Jan | Jul |
| Amphibian | Limnodynastidae | *Heleioporus eyrei* | | | | | 2 | | | | | | | | | | | | | | | | | | | | 2 | |
| | | *Heleioporus inornatus* | 1 | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| | Myobatrachidae | *Crinia georgiana* | | | 2 | 9 | | 5 | | | | 7 | | | 1 | 8 | | 8 | | 4 | 1 | 36 | | 26 | | 6 | 4 | 109 |
| | | *Crinea insignifera* | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 |
| | Pelodryadidae | *Litoria adelaidensis* | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 |
| Mammal | Burramyidae | *Cercartetus concinnus* | 3 | | 2 | | 1 | | 23 | | 13 | | 8 | | 3 | | | | 12 | 1 | | | | | 1 | | 66 | 1 |
| | Dasyuridae | *Antechinus flavipes* | | 4 | 1 | 11 | 14 | 2 | 5 | | 1 | 3 | 4 | 8 | 11 | 2 | 7 | 1 | 2 | 6 | 2 | | 2 | | | | 49 | 37 |
| | | *Sminthopsis gilberti* | | | | | 1 | | 2 | | 1 | | 2 | | 5 | | | | 1 | | 2 | | 1 | | 2 | | 17 | |
| | | *Sminthopsis* sp. | | 2 | | | | | | | | | | | | 2 | | | | | | | | 1 | | 1 | | |
| | Muridae | *Mus musculus* | | | | | | | | 1 | | | | | | | 1 | | 1 | | 6 | | | 2 | 5 | 1 | 13 | 4 |
| Reptile | Agamidae | *Pogona minor* | | | | | | | 3 | | 1 | | | | | | 2 | | 2 | | | | | | 1 | | 9 | |
| | Carphodactylidae | *Underwoodisaurus milii* | 2 | | 2 | | | | | | | | | | | | 2 | | | | 1 | | 3 | | 3 | | 13 | |
| | Diplodactylidae | *Diplodactylus lateroides* | | | 1 | | | | 1 | | 1 | | | | | | | | 1 | | 2 | | 6 | | 1 | | 13 | |
| | | *Diplodactylus polyophthalmus* | | | | | | | 1 | | | | | | 1 | | | | | | | | | | 1 | | 3 | |
| | Elapidae | *Suta gouldii* | | | | | | | 1 | | | | | | | | | | 1 | | | | | | | | 2 | |

| | | Survey site status | Unmined | | Unmined | | Unmined | | 15-year rehabilitation | | 15-year rehabilitation | | 15-year rehabilitation | | 10-year rehabilitation | | 10-year rehabilitation | | 10-year rehabilitation | | 5-year rehabilitation | | 5-year rehabilitation | | 5-year rehabilitation | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Suta nigriceps* | 1 | | | | | | | | | | | | | | 3 | | | | | | | | | | 4 | |
| | Gekkonidae | *Christinus marmoratus* | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | |
| | Pygopodidae | *Lialis burtonis* | | | | | | | | | | | | | | | | | 1 | | | | | | | | 1 | |
| | Scincidae | *Acritoscincus trilineatus* | | | 7 | | 2 | | 9 | | 6 | | 9 | | 1 | | 12 | | 9 | | | | 1 | | 3 | | 59 | |
| | | *Cryptoblepharus buchananii* | 3 | | 7 | | 2 | | | | | | | | | | | | | | 1 | | | 1 | | | 13 | 1 |
| | | *Egernia napoleonis* | 13 | | 5 | | 1 | | | | | | | | | | 1 | | | | | | | | | | 20 | |
| | | *Hemiergis initialis* | 2 | | 4 | | | | | | 2 | | 2 | | | | 5 | | | | | | | | | | 15 | |
| | | *Lerista distinguenda* | 11 | | 15 | | 11 | | 3 | | 4 | | | | | | 3 | | 6 | | 1 | | | | | | 54 | |
| | | *Lerista elegans* | | | 1 | | | | 1 | | | | | | | | 3 | | | | | | | | | | 5 | |
| | | *Menetia greyii* | 3 | | | | 1 | | 4 | | 4 | | | | 2 | | 1 | | 3 | | 1 | | 6 | | 7 | | 32 | |
| | | *Morethia obscura* | 14 | | 13 | | 2 | | 7 | | 7 | | 4 | | 4 | | 6 | | 9 | | 9 | | 1 | | 4 | | 80 | |
| | | *Tiliqua rugosa* | | | | | | | | | 1 | | | | | | | | | | | | | | | | 1 | |
| | Typhlopidae | *Anilios australis* | | | 5 | | | | | | 1 | | | | | | 1 | | 1 | | | | | | | | 8 | |

## 4.2 CAGE TRAPS

Many more *D. geoffroii* (Chuditch) were caught in June-July (i.e. 33) than January 2023 (i.e. 12). Pouch young (i.e. 3-5) were present in 13 of the 17 females caught. If conditions were suitable, and most of the pouched young survived to join the adult population, then there would be a doubling of the population.

The number of *Isoodon fusciventer* (Quenda) caught in cage traps was the same for both survey periods (i.e. 2), with three *Tachyglossus aculeatus* (Echidna) being caught in the June-July survey and one in the January survey.

## 4.3 CAMERA TRAPS

Many more *Sus scrofa* (feral pigs) were recorded during the January survey than the June-July survey. This variability is almost certainly due to the pigs mobility and preference for wetter areas. In the summer months the pigs might prefer the cooler wetter creek areas but disperse more widely during winter as the wetter areas are more common. As was the case for the cage trapping program, many more *D. geoffroii* were recorded in the June-July period compared with the January period. The copulating period for *D. geoffroii* had mostly finished and it might be expected that there would be a die-off of the adult male cohort before summer.

Of interest is the huge variation in the number of *Macropus fuliginosus* (Western Grey Kangaroo) recorded by camera traps, with two recorded in the June-July survey and 24 in the January survey. *Macropus fuliginosus* is patchy and obviously moves around the Jarrah forest, and the same is probably true for *Notamacropus irma* (Western Brush Wallaby) which were recorded on camera traps in January and not at all in the June-July survey period. These macropods may also favour the cooler wetter environments which were the targeted areas for camera trapping and spatially restricted in summer.

Many more *I. fusciventer* were recorded in the June-July (i.e. 20) survey than in the January (i.e. 5) survey, and there is a similar pattern for *Setonix brachyurus* (Quokka) with 12 recorded in the June-July survey and six recorded in the January survey. As with the larger macropods (e.g. *M. fuliginosus*) both of these mammals are quite mobile, and camera trapping surveys can indicate presence, but unless there is a specific method of identifying individuals (i.e. body fur pattern), then they are not a good measure of abundance.

## 4.4 WINTER VS SUMMER SURVEY

Ambient weather conditions had a notable impact on the surface activity of reptiles, with many fewer reptiles recorded during the cooler months than during the summer. This pattern was expected as it is also evident at other localities such as the Goldfields (Thompson 2004, Thompson and Thompson 2005). Many mammal species activity patterns are less affected by weather so there is less temporal variation in the trapping data, but species that enter torpor (e.g. *C. concinnus*) can be less active during the cold weather, and are therefore less likely to be trapped.

## 4.5 SPATIAL AND TEMPORAL VARIATIONS

One of the most significant outcomes of the comparison of two monitoring surveys undertaken (i.e. January and June-July 2023) is the appreciable spatial and temporal variation in the vertebrate fauna assemblage (see species and abundance variation in Table 6). The PCAs for the January survey (Charts 1 and 2) indicate appreciable variability within trapping sites for the unmined and the three categories of rehabilitation. If there was sufficient data for the June-July survey (which there isn't), then a similar spread among PCA scores for similar aged habitats is also likely to be recorded. This indicates the degree of spatial variability.

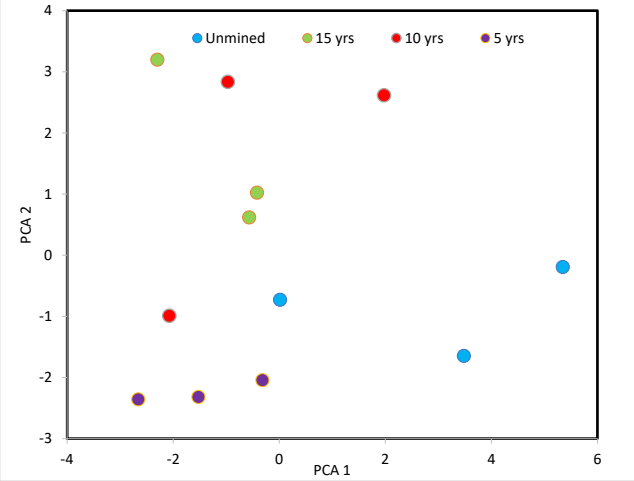



**Chart 1. PCAs 1 and 2**

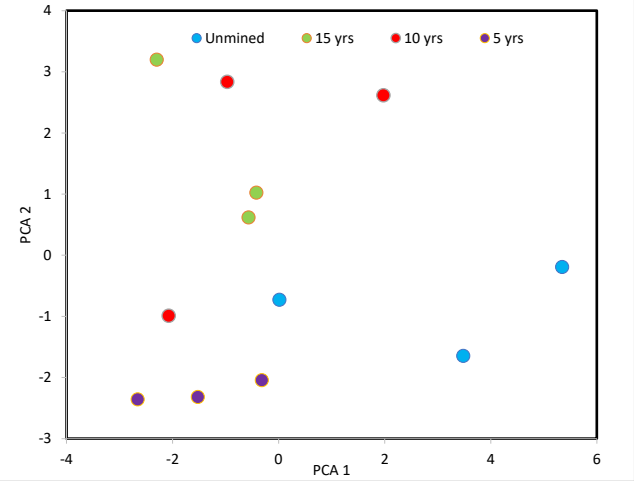



**Chart 2. PCAs 1 and 3**

Differences in the vertebrate fauna assemblage recorded using pit and funnel traps, cage traps and camera traps between the January and June-July surveys indicate very notable differences (see Table 6). Many of these differences are to be expected because of the variation in weather conditions (e.g. low reptile numbers during the winter survey period) and the mobility of species (e.g. camera trapping records for *M. fuliginosus* and *N. irma*). Therefore, comparison among capture records for different survey periods of the year are likely to provide spurious results if used for the purposes of monitoring succession over numerous years. However, it was not Alcoa's intention to compare the summer and winter results, rather to get a better appreciation of the vertebrate species in the various areas.

## 4.6 COMMENT

The high-level objective of these monitoring surveys is to mitigate potential impacts of bauxite mining on the vertebrate fauna in the northern Jarrah forest. Measuring outcomes of rehabilitation programs is an important part of this process, as it enables Alcoa to amend and fine-tune its rehabilitation programs, and to indicate to the environmental regulators and other stakeholders the success or otherwise of its rehabilitation programs in recreating self-sustaining, functional ecosystems.

Based on the data accumulated during the January 2023 survey, the current monitoring program requires adjustment, as the analogue sites for the rehabilitated areas appear not to be appropriate given the spatial variability in the vertebrate fauna assemblages in the unmined, and possibly older rehabilitated sites of the northern Jarrah forest. Given that it is the fauna assemblages in the unmined areas adjacent to the rehabilitated sites that are the primary source populations for the colonising fauna species in the rehabilitated areas, analogue survey sites should be near these areas. This will obviously require new survey sites to be established.

Many of the vertebrate fauna caught and recorded in the monitoring program are common, widespread and abundant, and given the mosaic disturbance pattern undertaken by Alcoa to mine bauxite in the northern Jarrah forest, the mining program is unlikely to threaten any of these common species. However, the northern Jarrah forest mining area is home to numerous threatened species (i.e. *S. brachyurus*, *D. geoffroii*, *I. fusciventer* and *N. irma*) and also home to a few feral vertebrate pest species (*Vulpes vulpes* (fox), *Felis catus* (cat), *S. scrofa*, *Rattus rattus* (Black Rat) and *M. musculus*). The fox is a known serious predator of *S. brachyurus*, *D. geoffroii* and *I. fusciventer* and the pigs are destroying habitat and ecosystems that that are crucial to the survival of these same species. Other than anecdotal information, little is known about the spatial distribution of *S. brachyurus*, *D. geoffroii*, *I. fusciventer, V. vulpes* and *S. scrofa* in the northern Jarrah forest areas mined by Alcoa. It is suggested that Alcoa focus on increasing the local population of threatened species and a reduction in the feral predators, as this will also have positive outcomes for the other native fauna in the Jarrah forest.

The camera and cage trapping program in June-July 2023 provided useful information about the abundance of these threatened species in selected areas, but the pit, funnel and aluminium box trapping program caught too few animals to be a useful monitoring tool.

The cage trapping programs targeted *D. geoffroii*, and they were also recorded in the camera trapping program. Cage trapping involves a stress on the animals, and it should therefore be avoided unless there is no other alternative to obtaining the same robust data. In this situation, camera traps can record the presence of Chuditch, and given that they have a unique spot pattern, most can be individually identified and therefore a cage trapping program would not be required. A few Quenda were caught in the cage trapping program, but the bait used was not very suitable for this species; Quenda were also recorded on camera traps. It is therefore suggested that cage traps are not used in future trapping programs, and an individual Chuditch identification program is used in its place based on a broader camera trapping network.

## 4.7 RECOMMENDATIONS

It is recommended that:

- the analogue sites for the rehabilitation areas be relocated to the unmined areas adjacent to the rehabilitated areas that are being monitored;
- the summer (i.e. January) surveys are used in the monitoring of rehabilitated and unmined areas only using pit, funnel and aluminium box traps;
- a program is developed to increase the population of *S. brachyurus*, *D. geoffroii* and *I. fusciventer* in mining areas, and in rehabilitated areas. This program will initially focus on identifying the location and abundance of these species and areas of *V. vulpes* and *S. scrofa* activity with a view to developing a long-term conservation plan that will increase the population of these threatened species; and
- the cage trapping program targeting Chuditch be replaced with camera trapping and a spot recognition analysis to determine relative abundance across the areas.

# 5. REFERENCES


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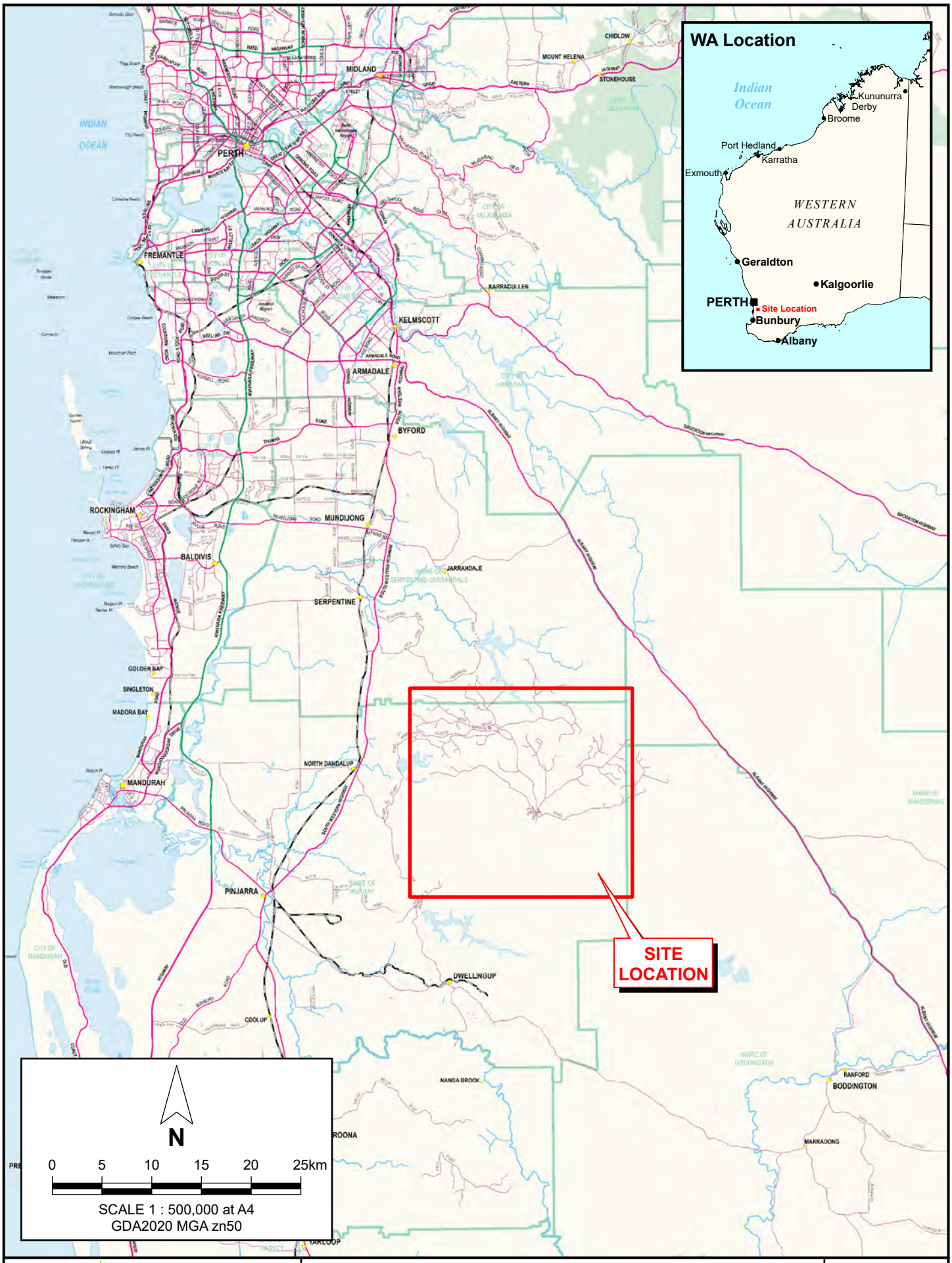
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# Figures

**Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas**
**Winter Survey**






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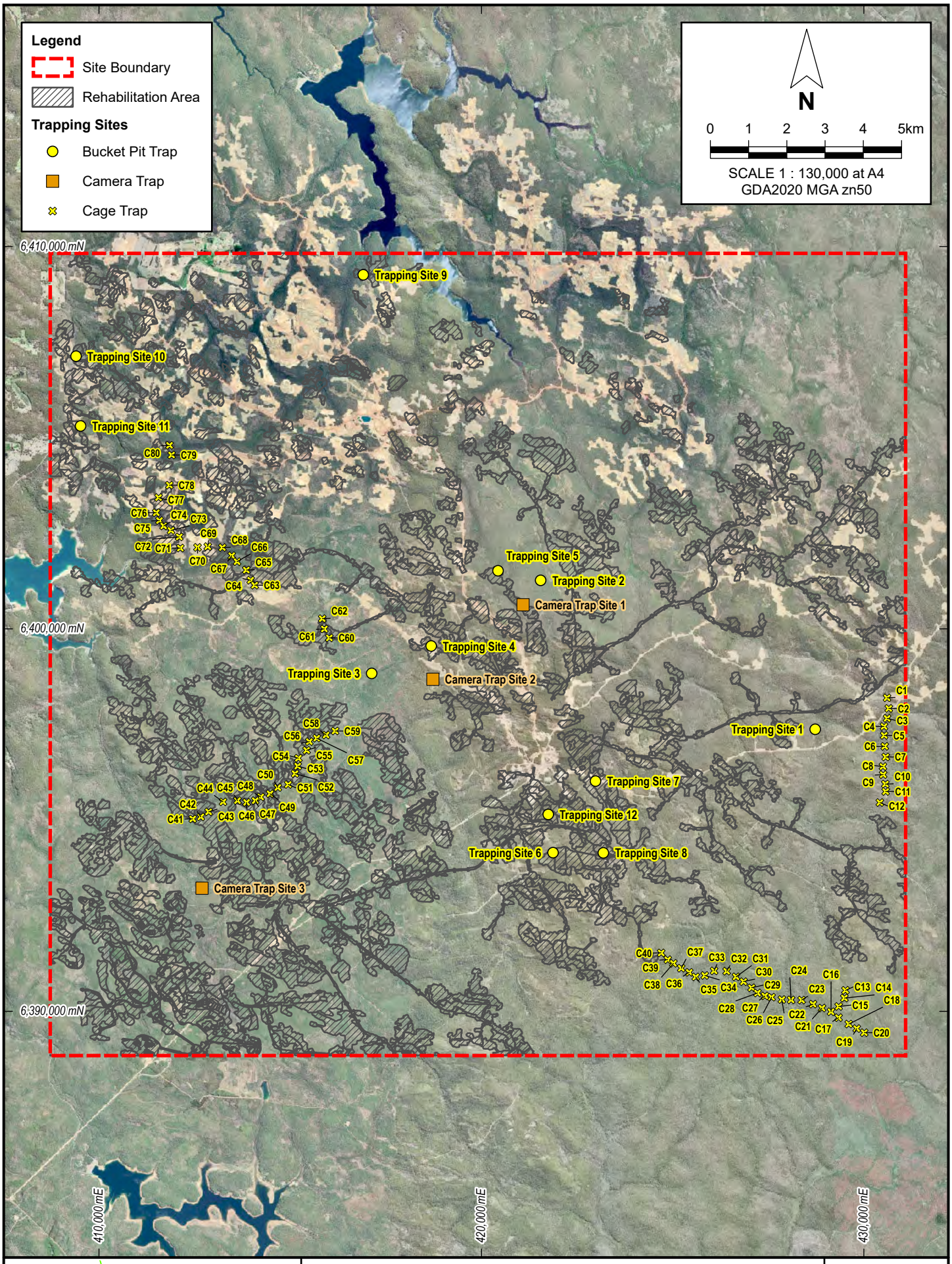
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**Figure 1**

## REGIONAL LOCATION

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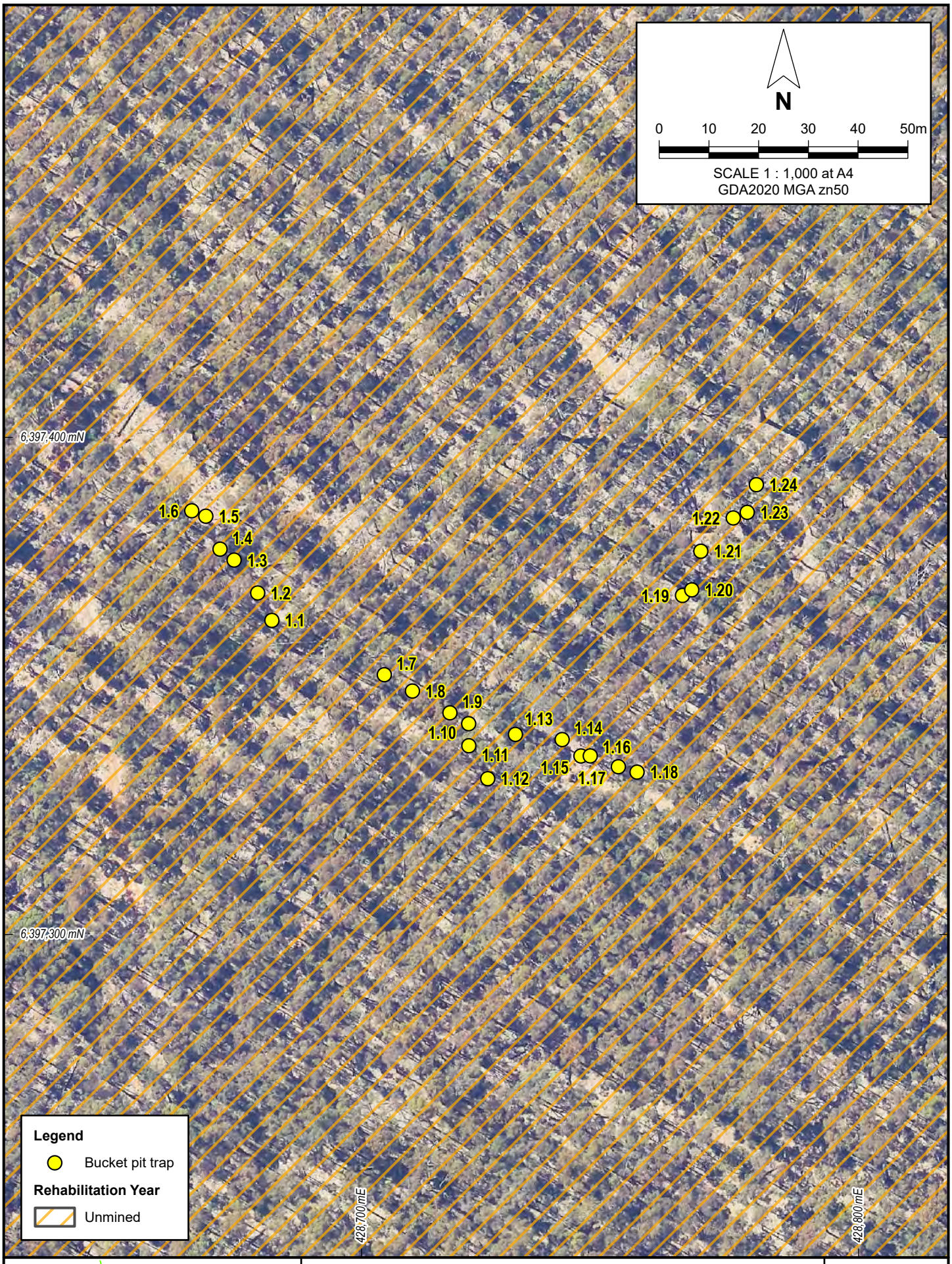
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**PROJECT AREA**

**Figure 2**

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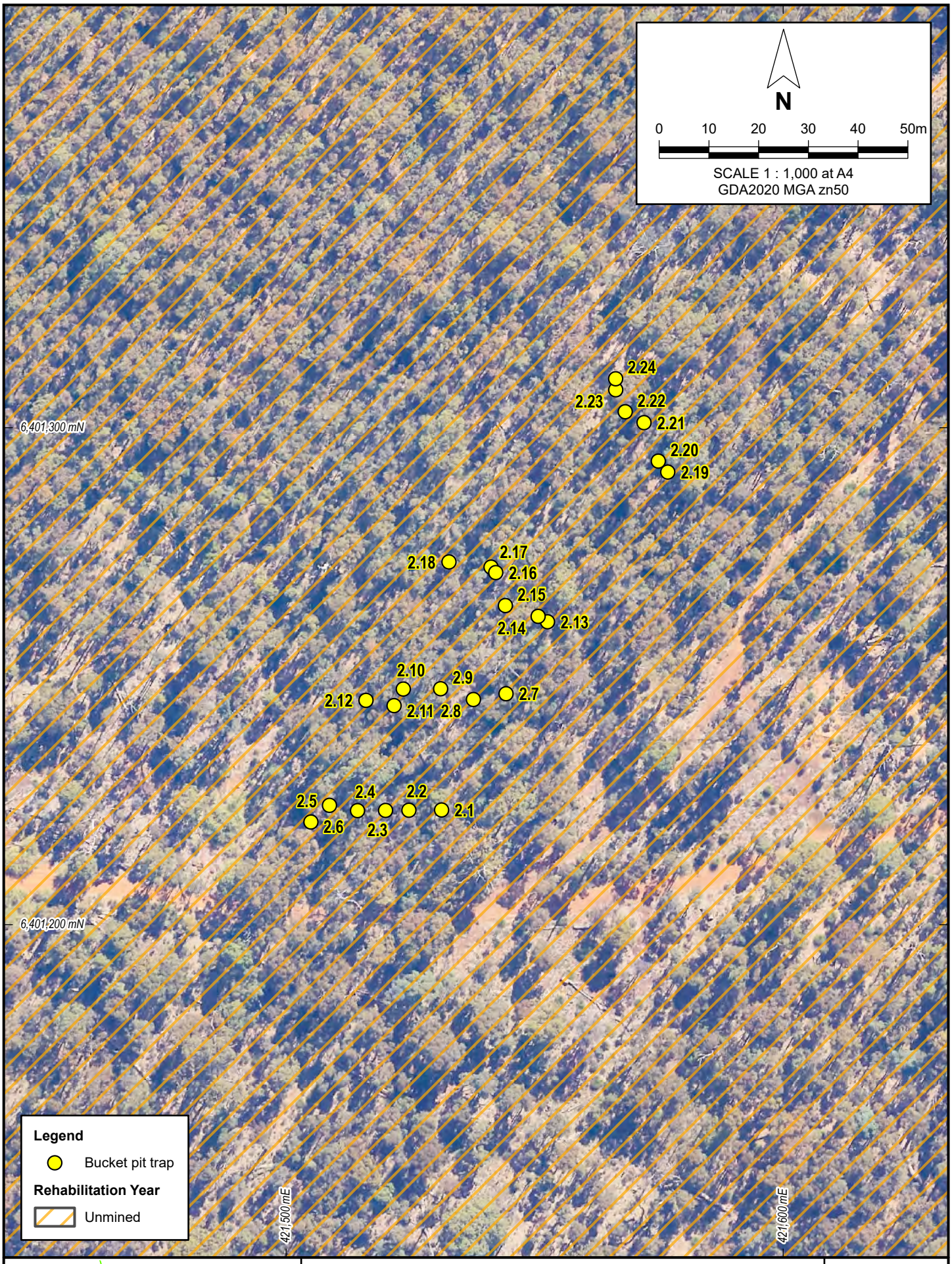
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**PIT TRAP LOCATIONS - TRAP SITE 1**

**Figure 3**

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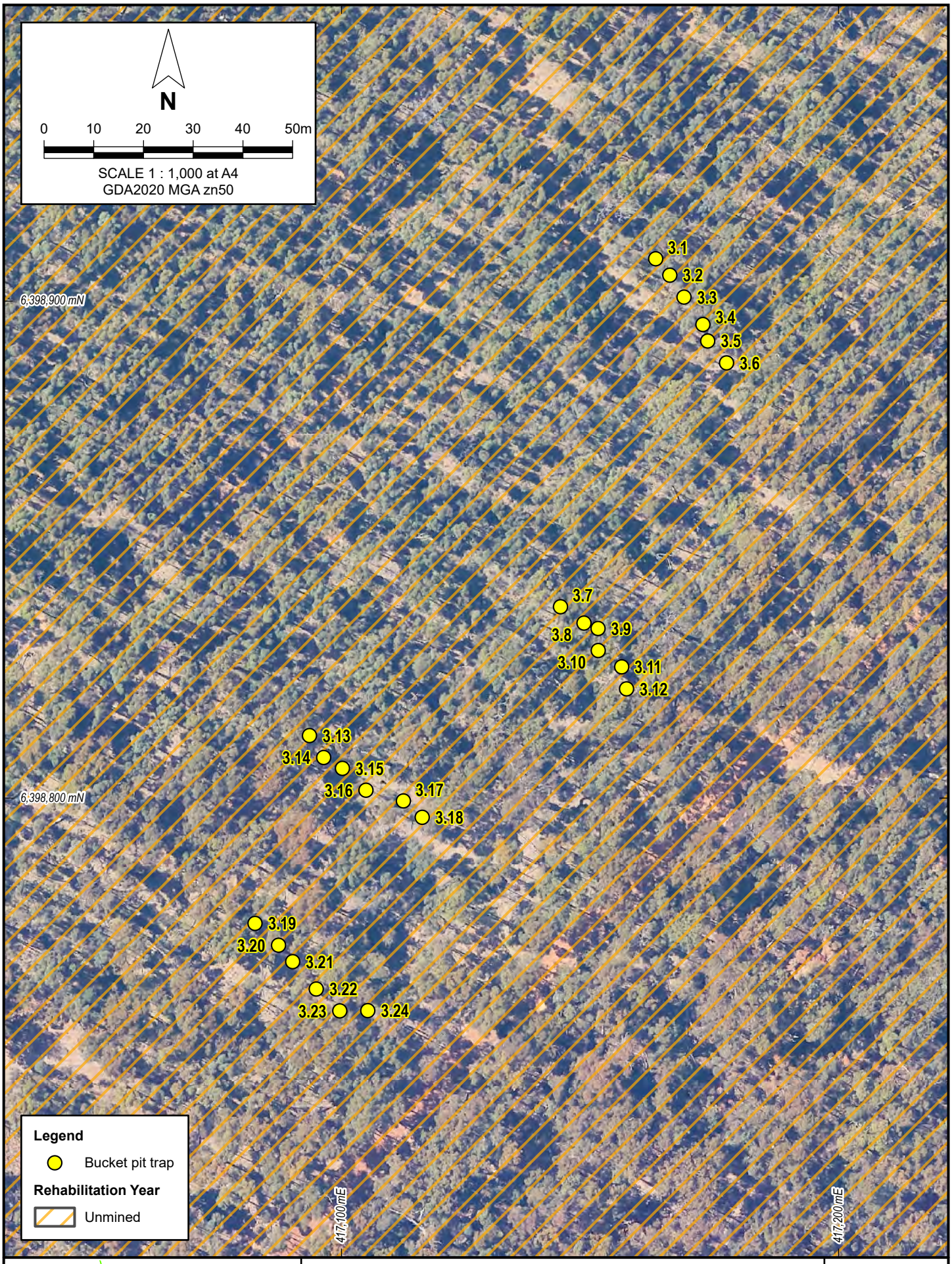
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**Figure 4**

## PIT TRAP LOCATIONS - TRAP SITE 2

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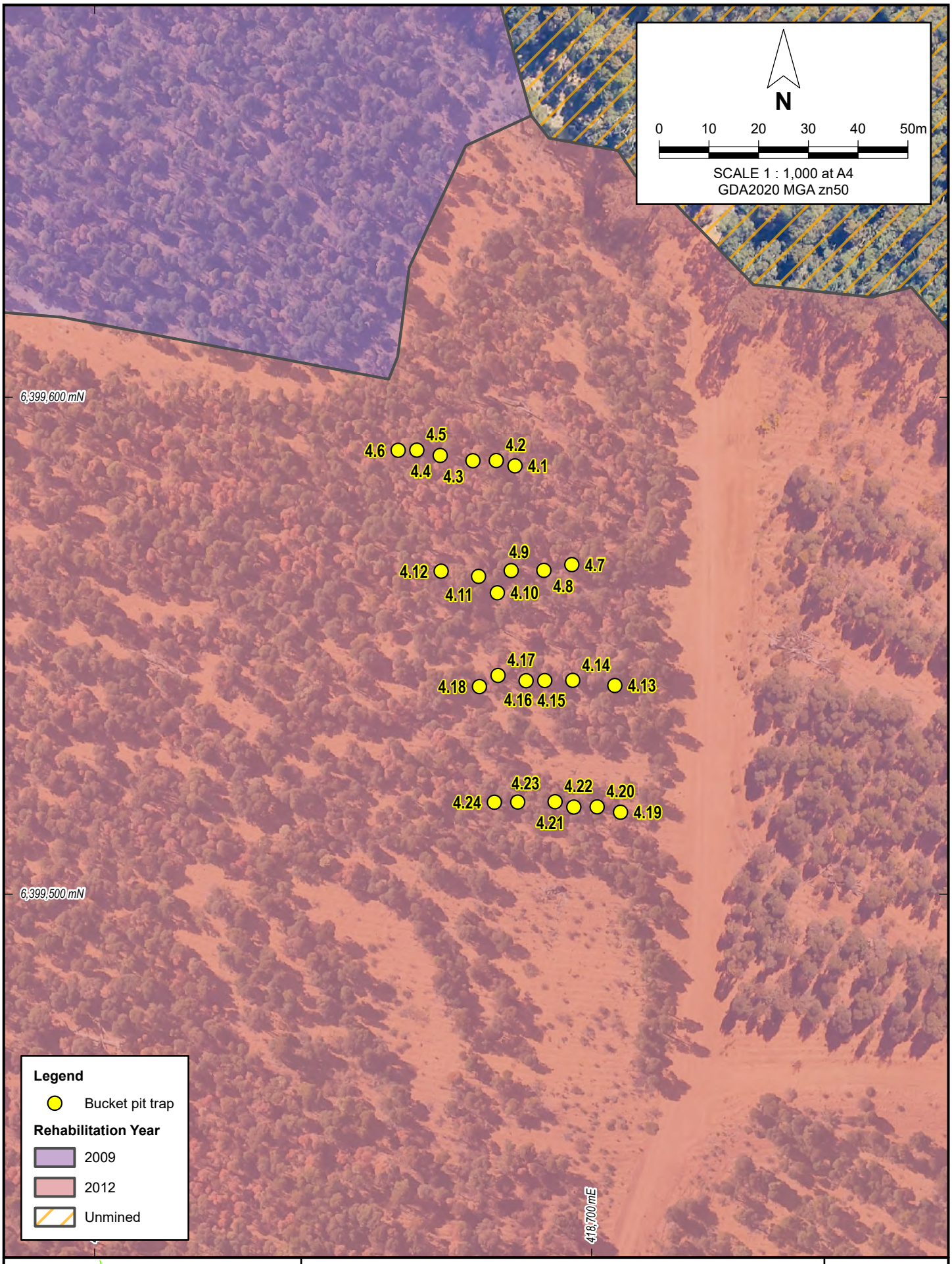
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**PIT TRAP LOCATIONS - TRAP SITE 3**

**Figure 5**

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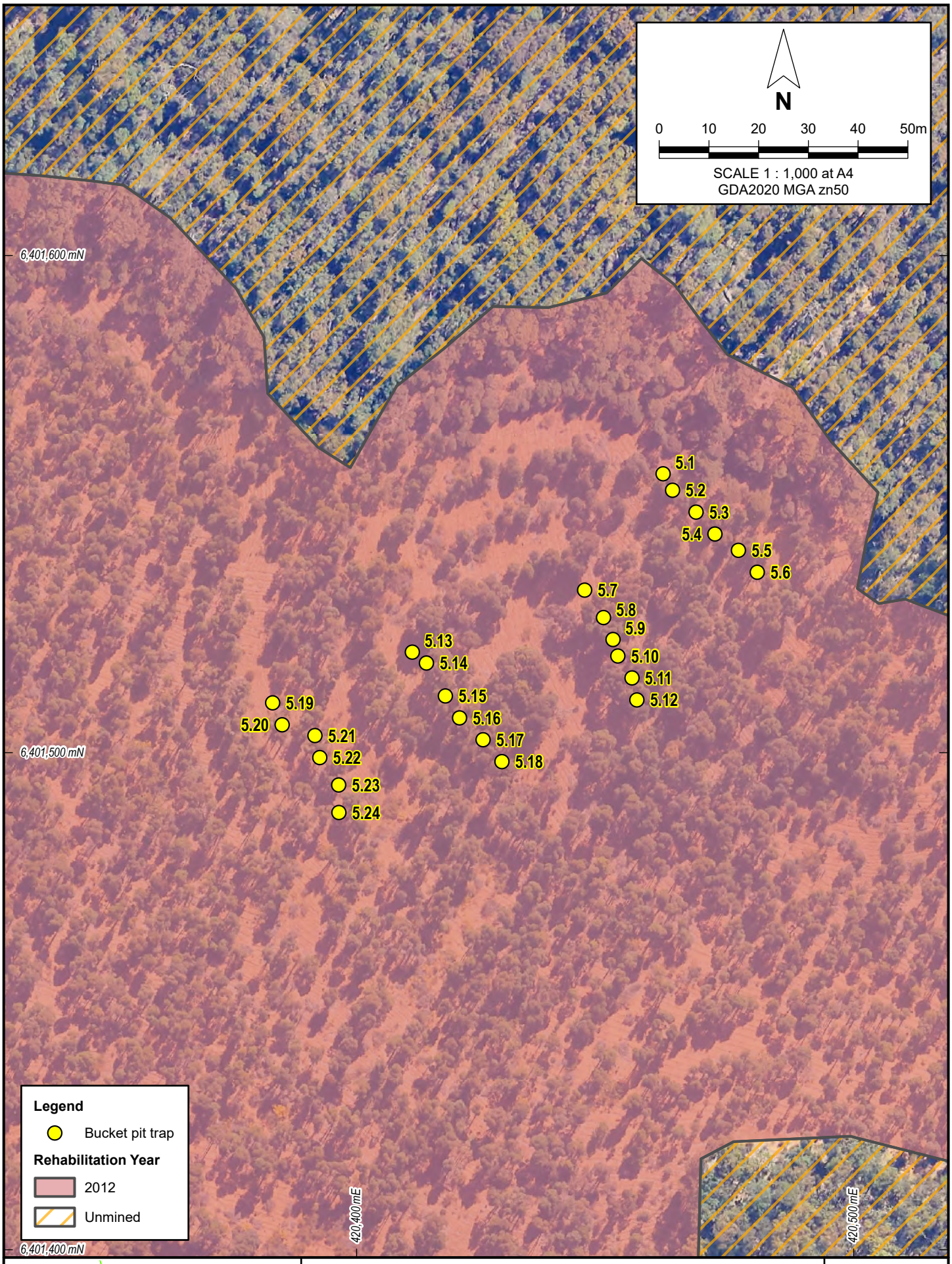
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**PIT TRAP LOCATIONS - TRAP SITE 4**

**Figure 6**

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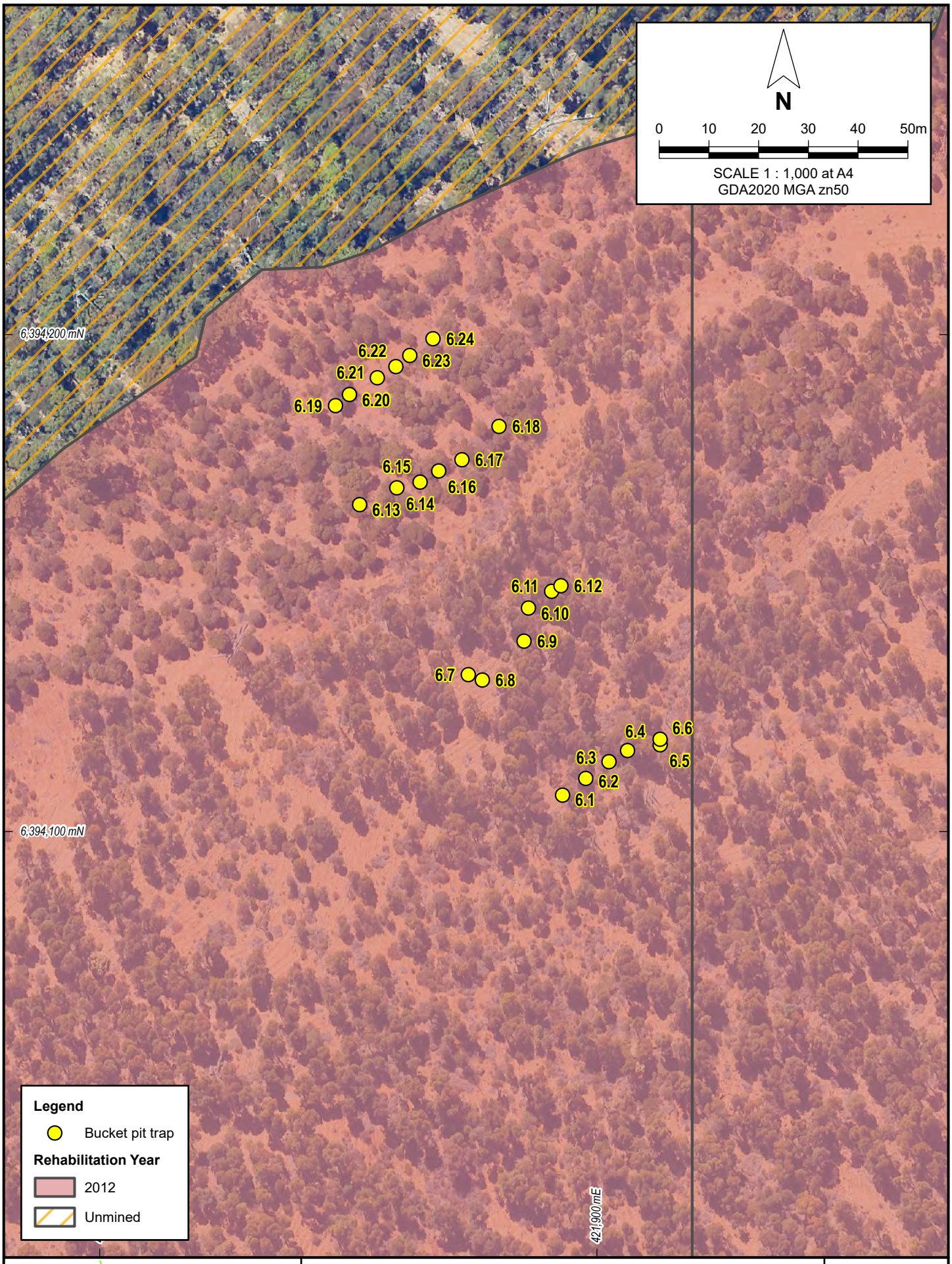
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**Figure 7**

## PIT TRAP LOCATIONS - TRAP SITE 5

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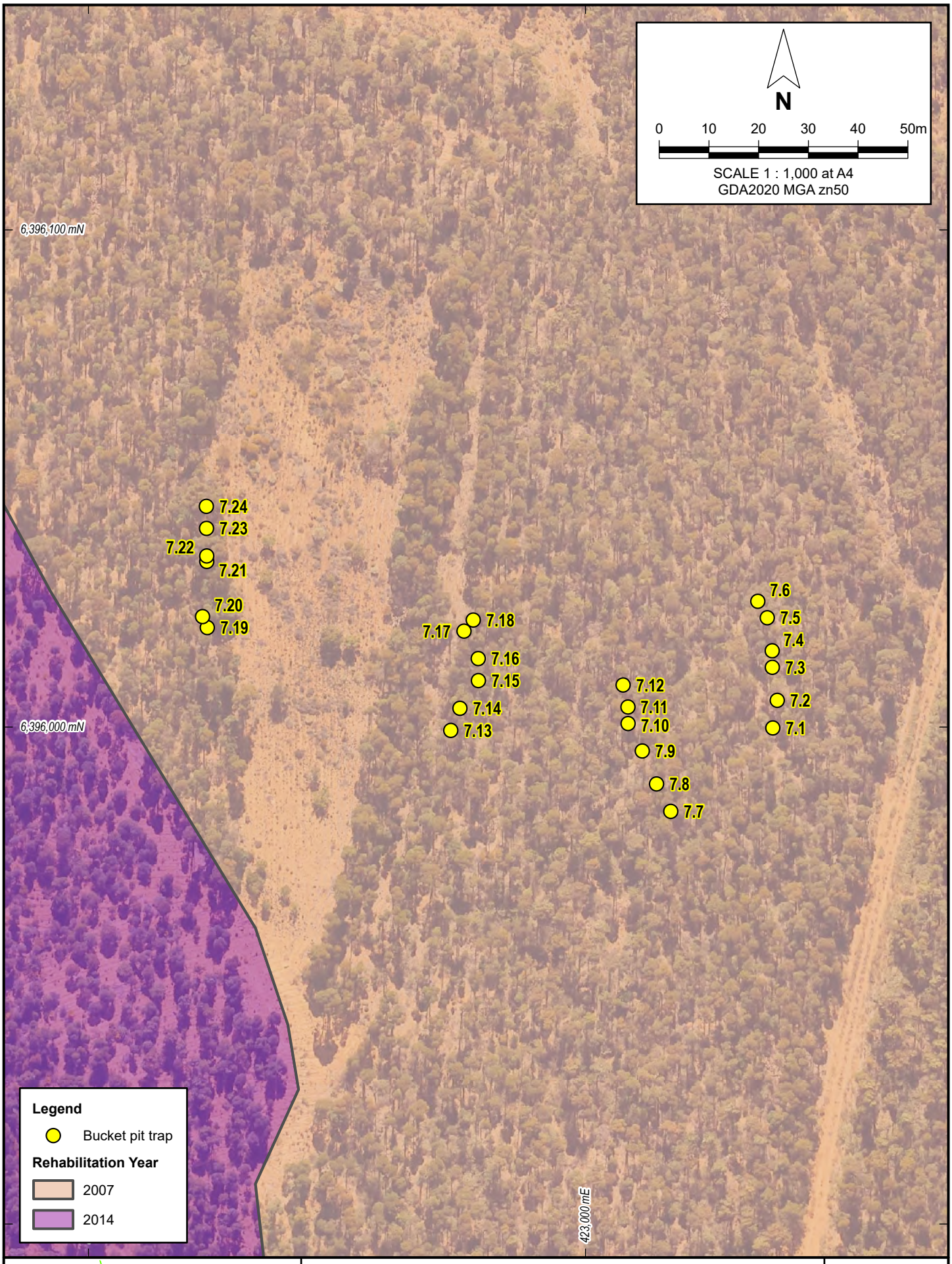
**Figure 8**

## PIT TRAP LOCATIONS - TRAP SITE 6

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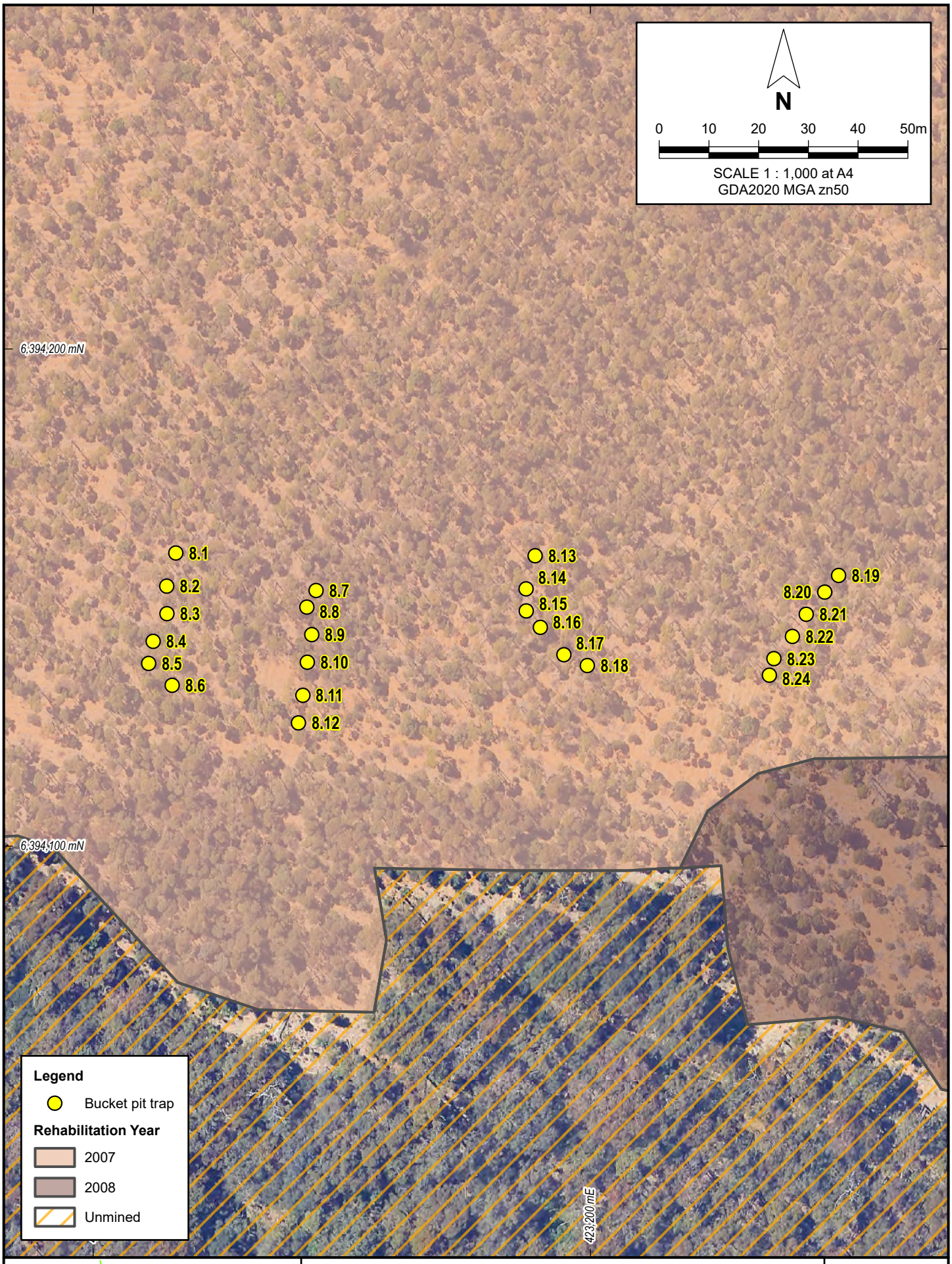
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**PIT TRAP LOCATIONS - TRAP SITE 7**

**Figure 9**

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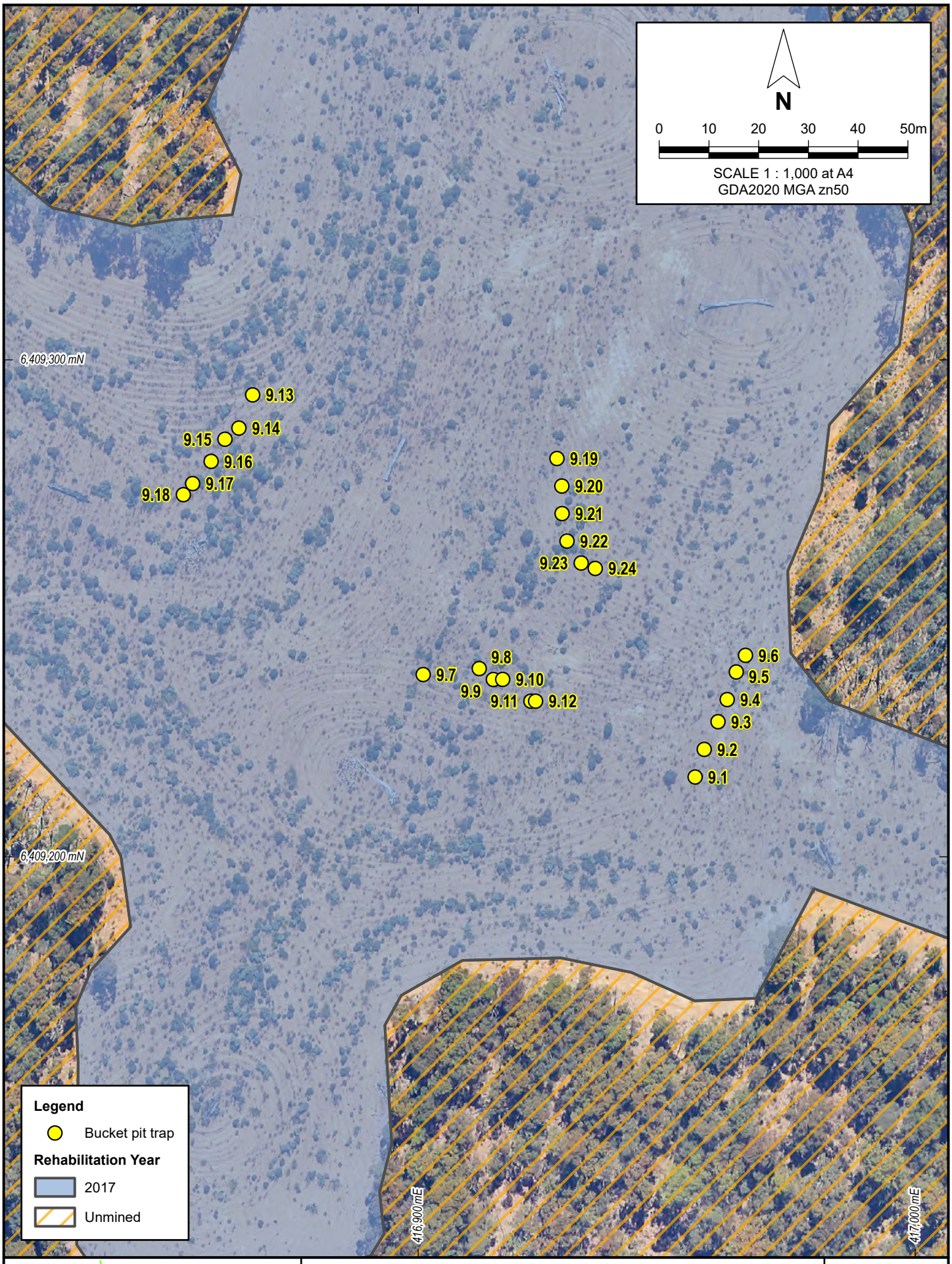
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**PIT TRAP LOCATIONS - TRAP SITE 8**

**Figure 10**

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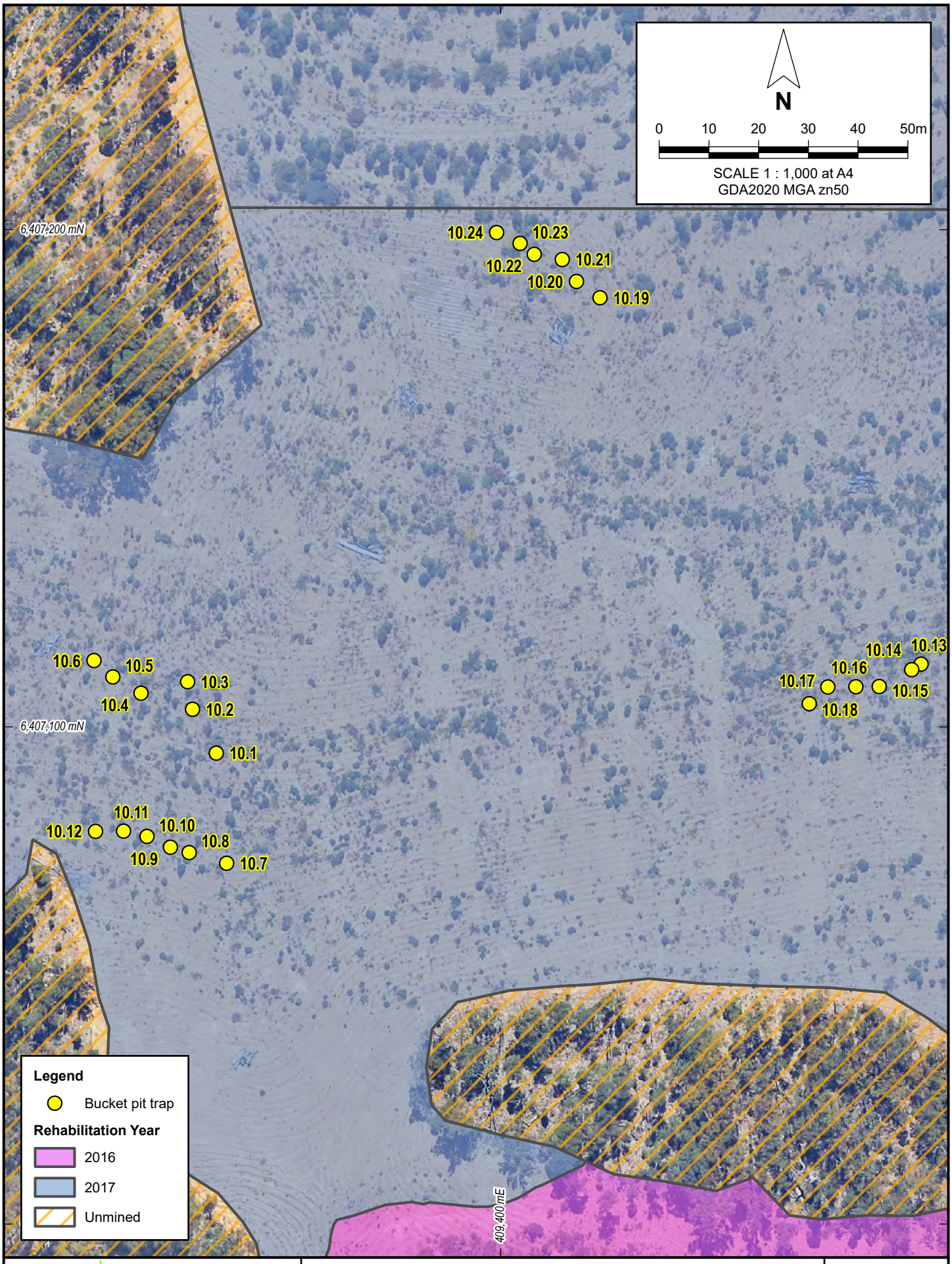
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**Figure 11**

## PIT TRAP LOCATIONS - TRAP SITE 9

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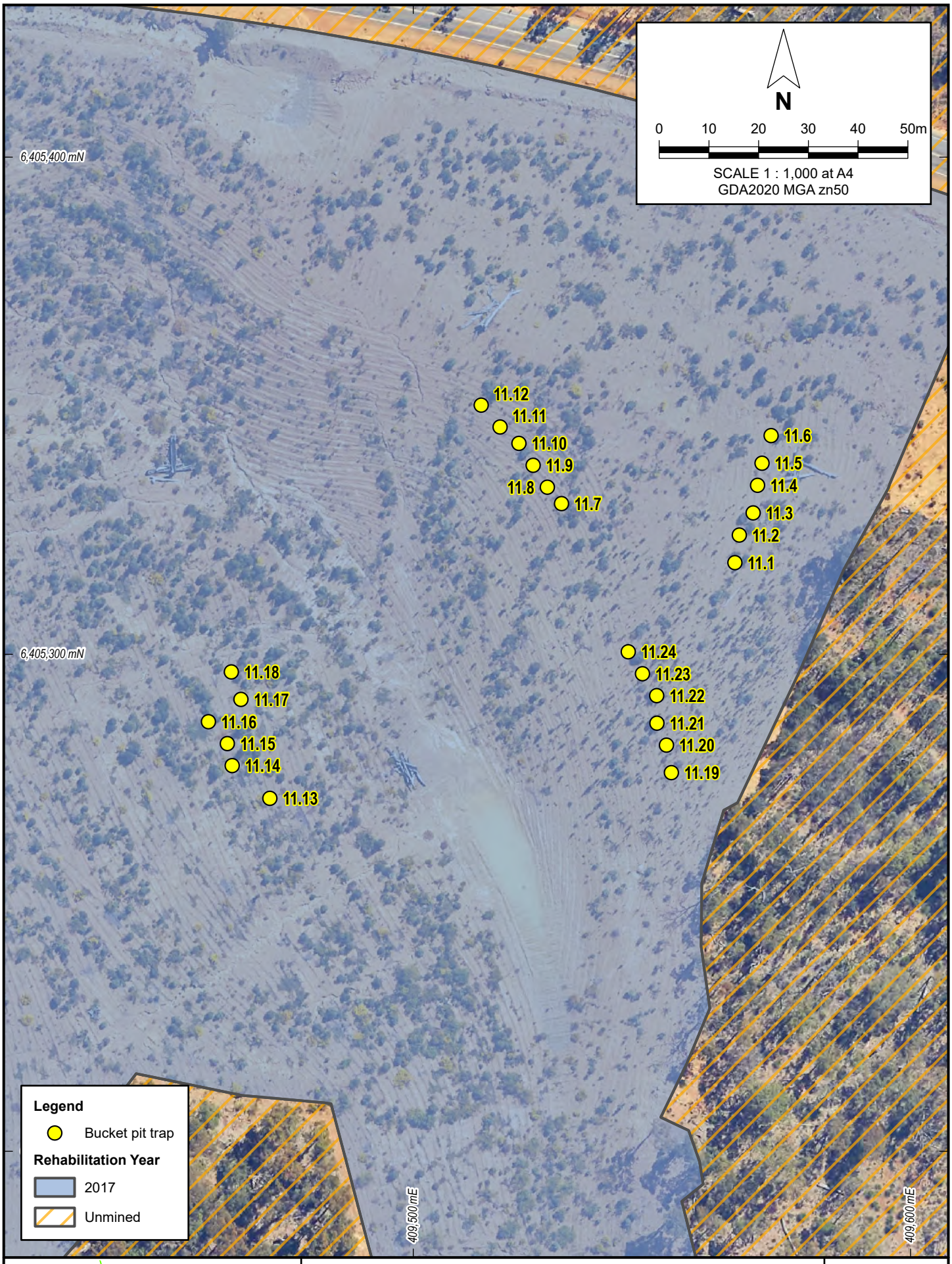
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**Figure 12**

## PIT TRAP LOCATIONS - TRAP SITE 10

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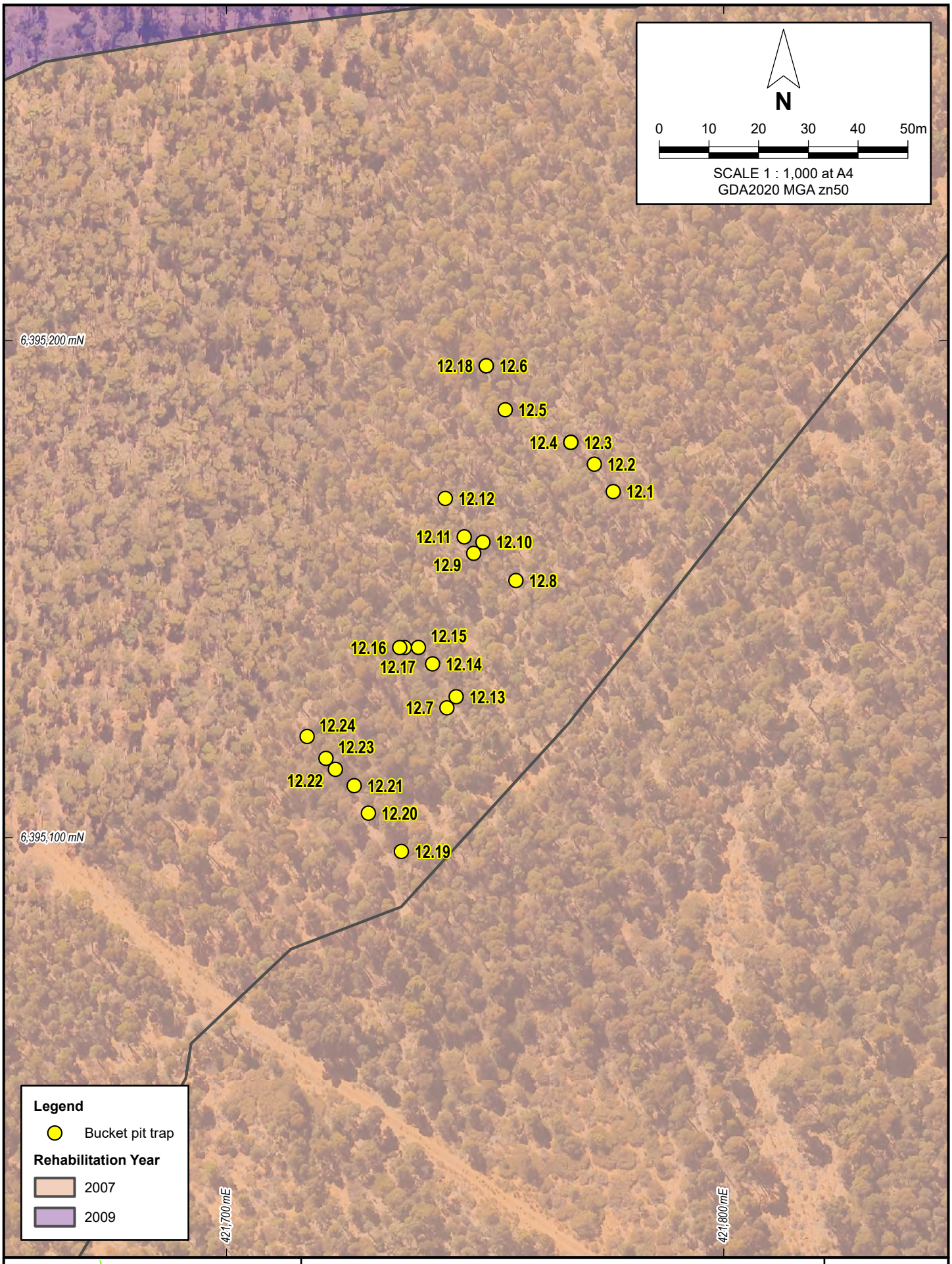
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**Figure 13**

## PIT TRAP LOCATIONS - TRAP SITE 11

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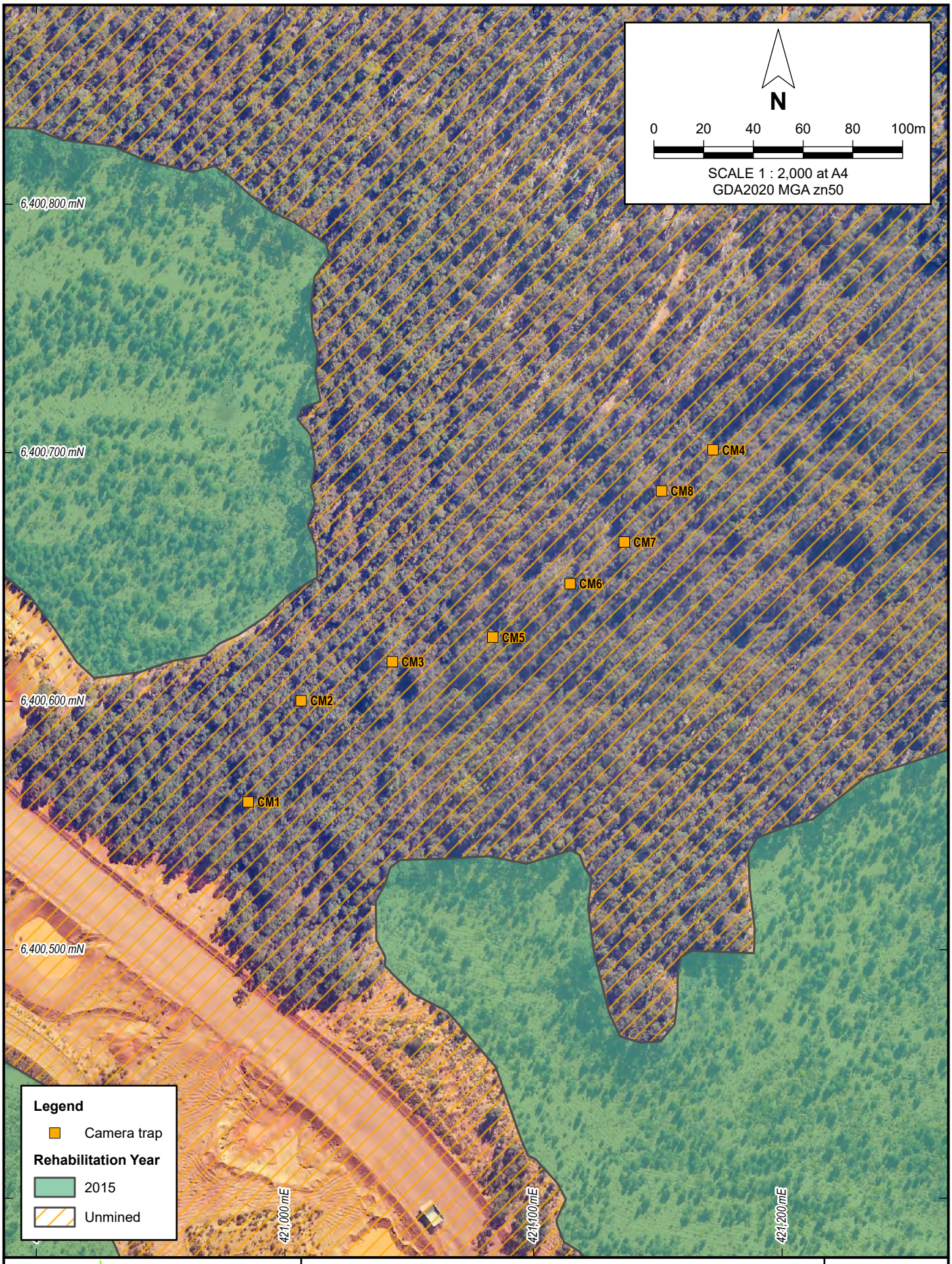
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**Figure 14**

## PIT TRAP LOCATIONS - TRAP SITE 12

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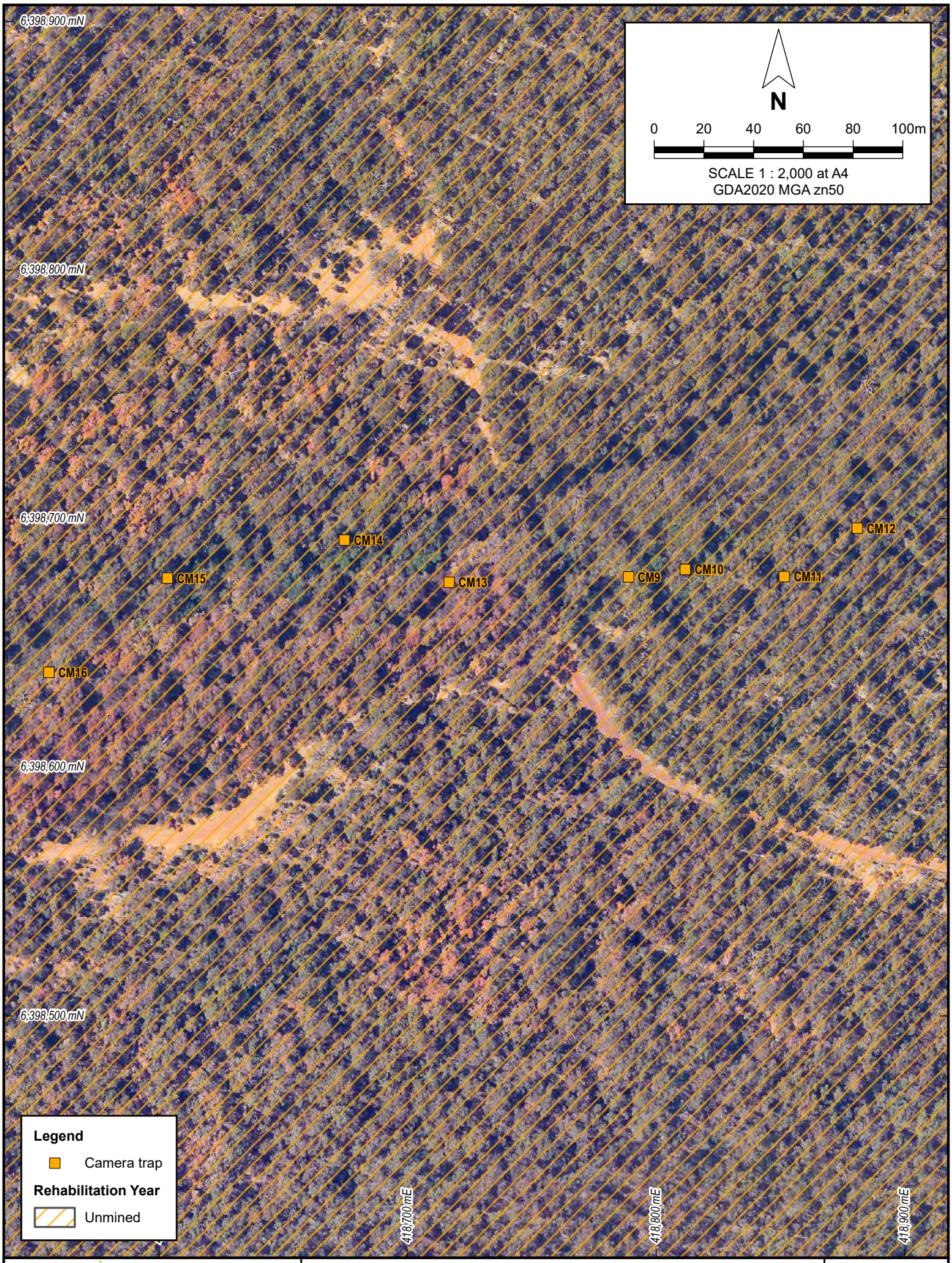
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**Figure 15**

## CAMERA TRAP LOCATION - SITE 1

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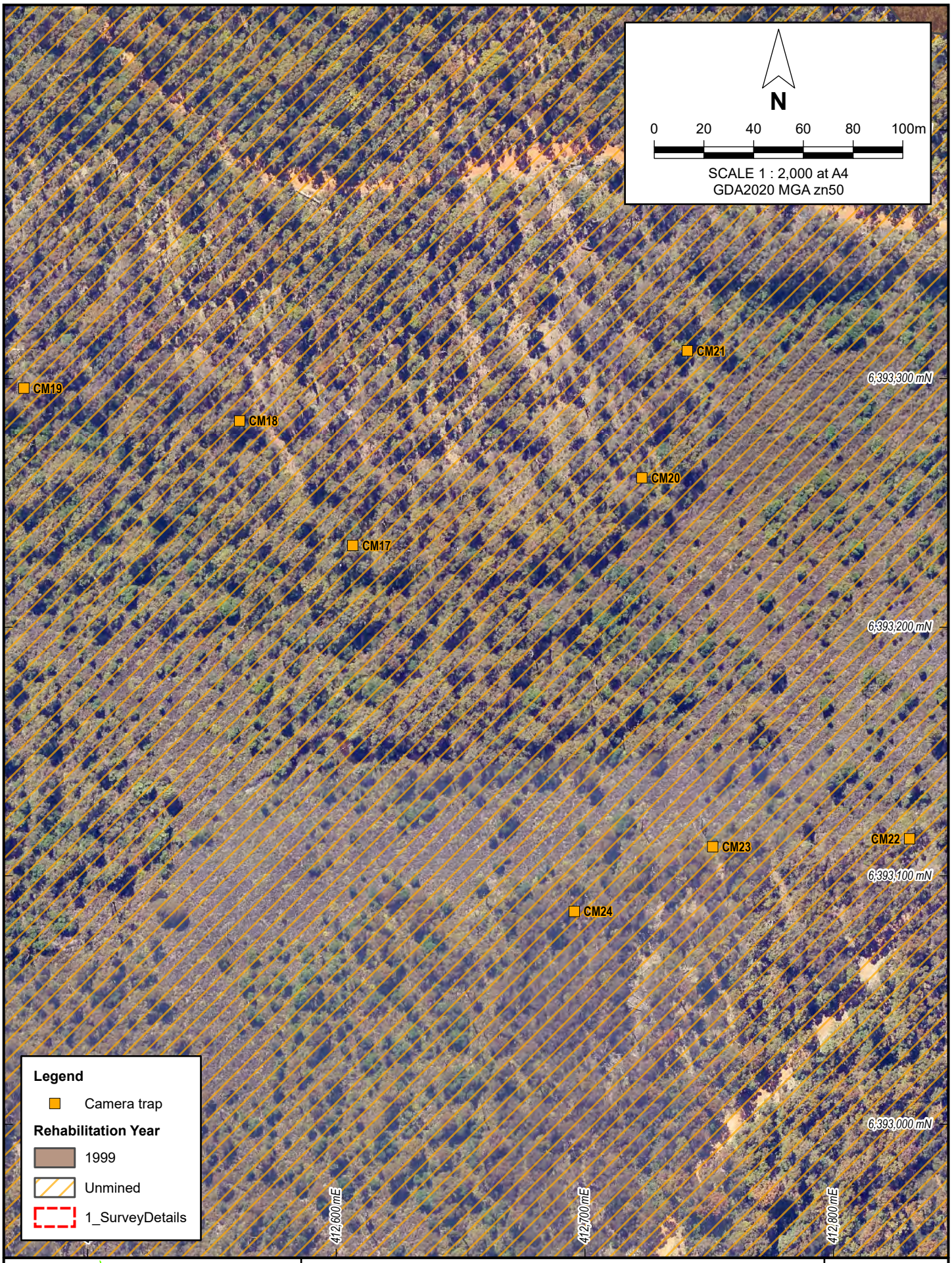
**Figure 16**

## CAMERA TRAP LOCATION - SITE 2

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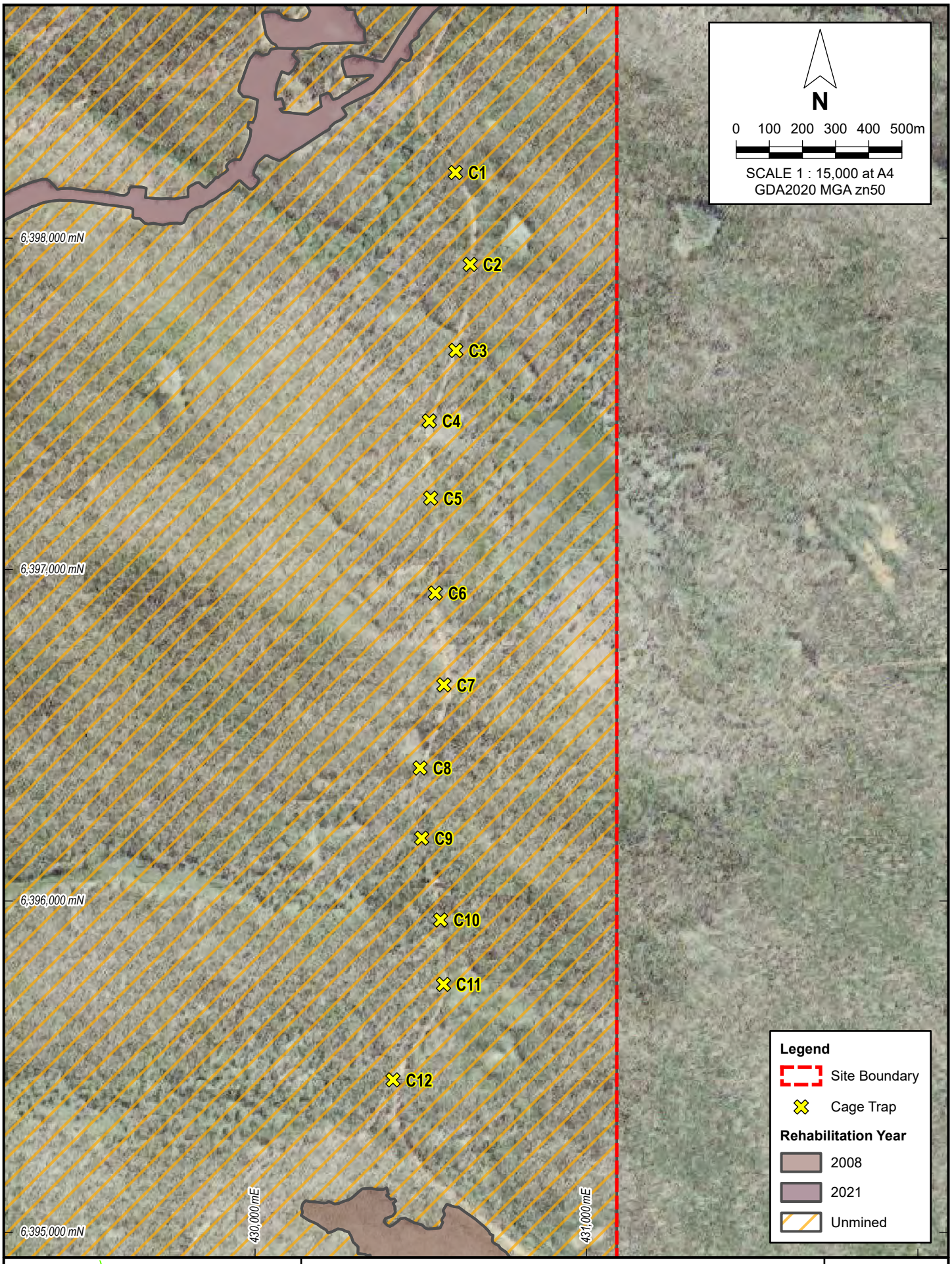
**Figure 17**

## CAMERA TRAP LOCATION - SITE 3

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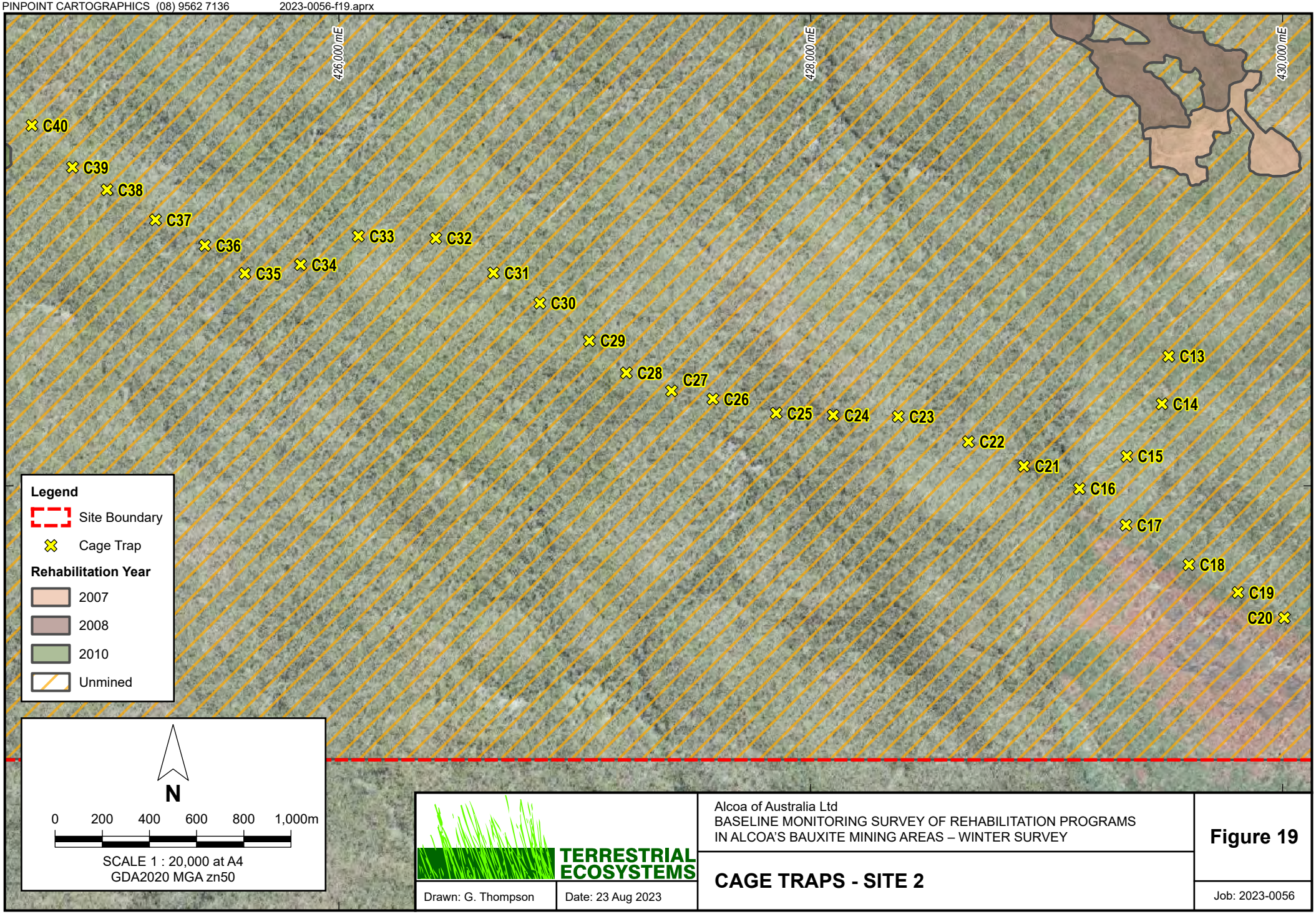
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**CAGE TRAPS - SITE 1**

**Figure 18**

Job: 2023-0056

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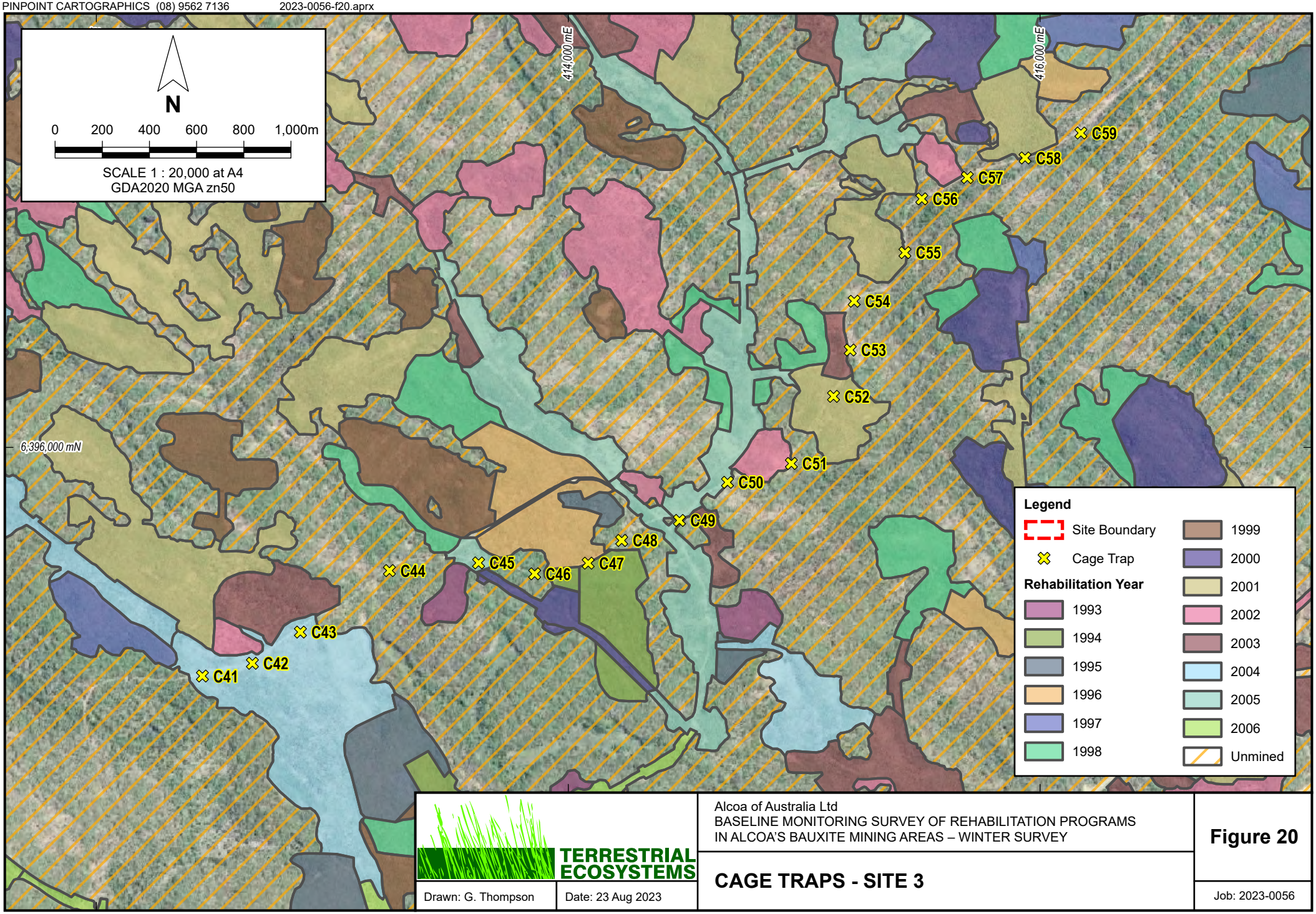
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## CAGE TRAPS - SITE 2

**Figure 19**

Job: 2023-0056

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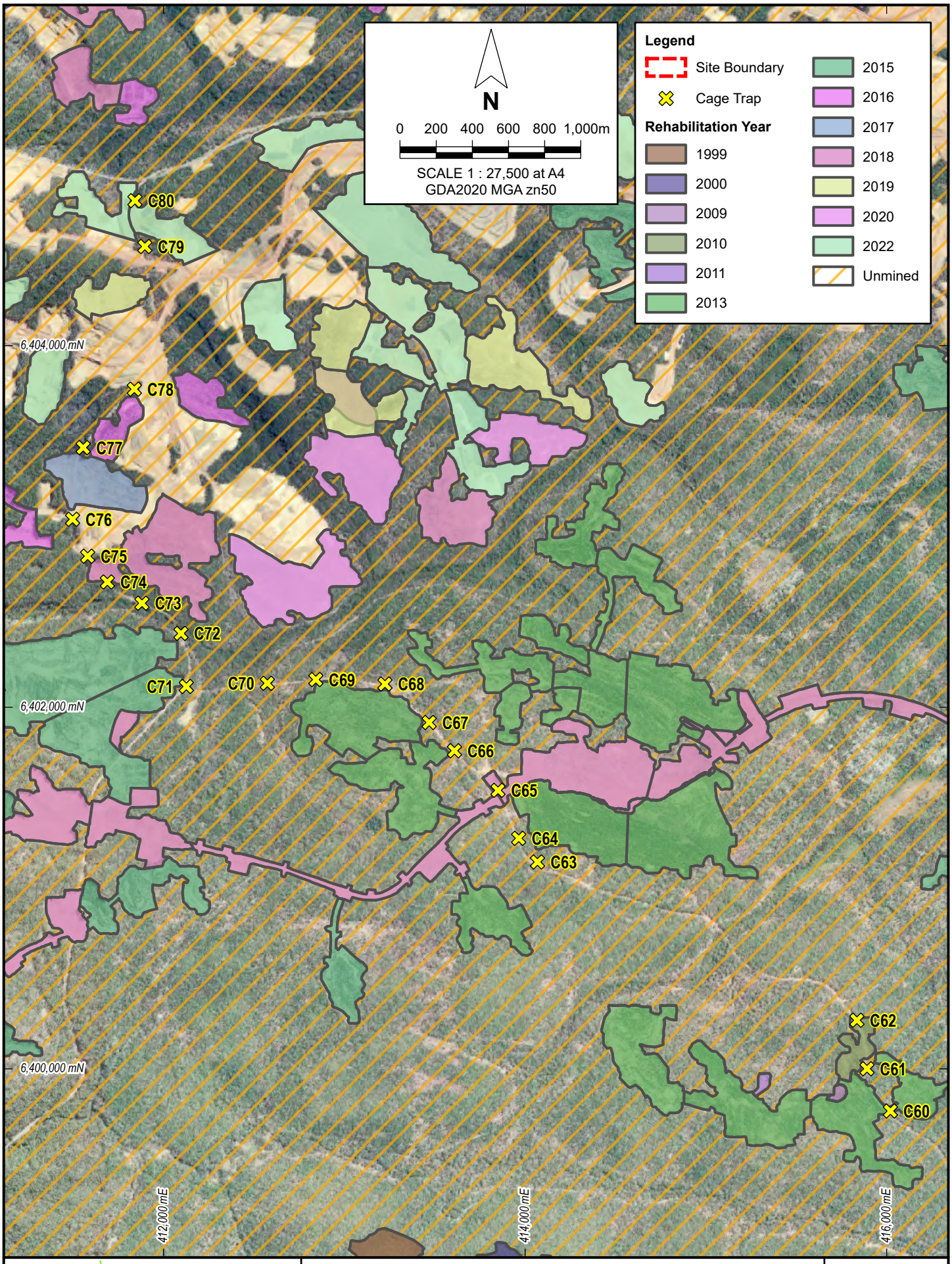
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## CAGE TRAPS - SITE 3

**Figure 20**

Job: 2023-0056




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Date: 23 Aug 2023

Alcoa of Australia Ltd
BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

**CAGE TRAPS - SITE 4**

**Figure 21**

Job: 2023-0056

# Appendix A.
# Site habitat images

**Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas**
**Winter Survey**





**Plate 21. Site 1 Unmined**



**Plate 22. Site 1 Unmined**



**Plate 23. Site 2 unmined**



**Plate 24. Site 2 unmined**



**Plate 25. Site 3 unmined**



**Plate 26. Site 3 unmined**



**Plate 27. Site 7 15-year rehabilitation**



**Plate 28. Site 7 15-year rehabilitation**



**Plate 29. Site 8 15-year rehabilitation**



**Plate 30. Site 8 15-year rehabilitation**



**Plate 31. Site 12 15-year rehabilitation**



**Plate 32. Site 12 15-year rehabilitation**



**Plate 33. Site 4 10-year rehabilitation**



**Plate 34. Site 4 10-year rehabilitation**



**Plate 35. Site 5 10-year rehabilitation**



**Plate 36. Site 5 10-year rehabilitation**



**Plate 37. Site 6 10-year rehabilitation**



**Plate 38. Site 6 10-year rehabilitation**



**Plate 39. Site 9 5-year rehabilitation**



**Plate 40. Site 9 5-year rehabilitation**



**Plate 41. Site 10 5-year rehabilitation**



**Plate 42. Site 10 5-year rehabilitation**



**Plate 43. Site 11 5-year rehabilitation**



**Plate 44. Site 11 5-year rehabilitation**

# Appendix B.
# Trapping site coordinates

**Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas**
**Winter Survey**



## B.1 TRAP LOCATIONS (GDA 94, ZONE 50)

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| **Pit and funnel traps** | | | | |
| 1.A | 428680 | 6397362 | 27/6/2023 | 9/7/2023 |
| 1.B | 428703 | 6397351 | 27/6/2023 | 9/7/2023 |
| 1.C | 428729 | 6397339 | 27/6/2023 | 9/7/2023 |
| 1.D | 428763 | 6397366 | 27/6/2023 | 9/7/2023 |
| 2.A | 421553 | 6401260 | 27/6/2023 | 9/7/2023 |
| 2.B | 421576 | 6401290 | 27/6/2023 | 9/7/2023 |
| 2.C | 421531 | 6401223 | 27/6/2023 | 9/7/2023 |
| 2.D | 421544 | 6401247 | 27/6/2023 | 9/7/2023 |
| 3.A | 417176 | 6398886 | 27/6/2023 | 9/7/2023 |
| 3.B | 417156 | 6398820 | 27/6/2023 | 9/7/2023 |
| 3.C | 417115 | 6398794 | 27/6/2023 | 9/7/2023 |
| 3.D | 417104 | 6398755 | 27/6/2023 | 9/7/2023 |
| 4.A | 418660 | 6399587 | 27/6/2023 | 9/7/2023 |
| 4.B | 418668 | 6399563 | 27/6/2023 | 9/7/2023 |
| 4.C | 418676 | 6399540 | 27/6/2023 | 9/7/2023 |
| 4.D | 418679 | 6399517 | 27/6/2023 | 9/7/2023 |
| 5.A | 420382 | 6401508 | 27/6/2023 | 9/7/2023 |
| 5.B | 420410 | 6401518 | 27/6/2023 | 9/7/2023 |
| 5.C | 420455 | 6401509 | 27/6/2023 | 9/7/2023 |
| 5.D | 420479 | 6401534 | 27/6/2023 | 9/7/2023 |
| 6.A | 421911 | 6394117 | 27/6/2023 | 9/7/2023 |
| 6.B | 421891 | 6394147 | 27/6/2023 | 9/7/2023 |
| 6.C | 421879 | 6394180 | 27/6/2023 | 9/7/2023 |
| 6.D | 421866 | 6394197 | 27/6/2023 | 9/7/2023 |
| 7.A | 422922 | 6396018 | 27/6/2023 | 9/7/2023 |
| 7.B | 422976 | 6396020 | 27/6/2023 | 9/7/2023 |
| 7.C | 423016 | 6395981 | 27/6/2023 | 9/7/2023 |
| 7.D | 423033 | 6396023 | 27/6/2023 | 9/7/2023 |
| 8.A | 423113 | 6394130 | 27/6/2023 | 9/7/2023 |
| 8.B | 423140 | 6394123 | 27/6/2023 | 9/7/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| 8.C | 423198 | 6394134 | 27/6/2023 | 9/7/2023 |
| 8.D | 423235 | 6394132 | 27/6/2023 | 9/7/2023 |
| 9.A | 416954 | 6409214 | 27/6/2023 | 9/7/2023 |
| 9.B | 416922 | 6409229 | 27/6/2023 | 9/7/2023 |
| 9.C | 416934 | 6409256 | 27/6/2023 | 9/7/2023 |
| 9.D | 416851 | 6409271 | 27/6/2023 | 9/7/2023 |
| 10.A | 409342 | 6407093 | 27/6/2023 | 9/7/2023 |
| 10.B | 409343 | 6407071 | 27/6/2023 | 9/7/2023 |
| 10.C | 409483 | 6407111 | 27/6/2023 | 9/7/2023 |
| 10.D | 409398 | 6407197 | 27/6/2023 | 9/7/2023 |
| 11.A | 409470 | 6405269 | 27/6/2023 | 9/7/2023 |
| 11.B | 409550 | 6405274 | 27/6/2023 | 9/7/2023 |
| 11.C | 409528 | 6405328 | 27/6/2023 | 9/7/2023 |
| 11.D | 409563 | 6405316 | 27/6/2023 | 9/7/2023 |
| 12.A | 421738 | 6395132 | 27/6/2023 | 9/7/2023 |
| 12.B | 421743 | 6395166 | 27/6/2023 | 9/7/2023 |
| 12.C | 421751 | 6395192 | 27/6/2023 | 9/7/2023 |
| 12.D | 421715 | 6395118 | 27/6/2023 | 9/7/2023 |
| Camera traps | | | | |
| CM1 | 420969 | 6400570 | 26/06/2023 | 9/07/2023 |
| CM2 | 421001 | 6400591 | 26/06/2023 | 9/07/2023 |
| CM3 | 421069 | 6400626 | 26/06/2023 | 9/07/2023 |
| CM4 | 421158 | 6400680 | 26/06/2023 | 9/07/2023 |
| CM5 | 421193 | 6400728 | 26/06/2023 | 9/07/2023 |
| CM6 | 421213 | 6400731 | 26/06/2023 | 9/07/2023 |
| CM7 | 421168 | 6400702 | 26/06/2023 | 9/07/2023 |
| CM8 | 421136 | 6400657 | 26/06/2023 | 9/07/2023 |
| CM9 | 418789 | 6398679 | 26/06/2023 | 9/07/2023 |
| CM10 | 418901 | 6398694 | 26/06/2023 | 9/07/2023 |
| CM11 | 418989 | 6398723 | 26/06/2023 | 9/07/2023 |
| CM12 | 418750 | 6398714 | 26/06/2023 | 9/07/2023 |
| CM13 | 418828 | 6398753 | 26/06/2023 | 9/07/2023 |
| CM14 | 418857 | 6398770 | 26/06/2023 | 9/07/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| CM15 | 418685 | 6398687 | 26/06/2023 | 9/07/2023 |
| CM16 | 418592 | 6398667 | 26/06/2023 | 9/07/2023 |
| CM17 | 412297 | 6393542 | 26/06/2023 | 9/07/2023 |
| CM18 | 412360 | 6393411 | 26/06/2023 | 9/07/2023 |
| CM19 | 412550 | 6393205 | 26/06/2023 | 9/07/2023 |
| CM20 | 412633 | 6393199 | 26/06/2023 | 9/07/2023 |
| CM21 | 412695 | 6393235 | 26/06/2023 | 9/07/2023 |
| CM22 | 412840 | 6393138 | 26/06/2023 | 9/07/2023 |
| CM23 | 412790 | 6393121 | 26/06/2023 | 9/07/2023 |
| CM24 | 412669 | 6393084 | 26/06/2023 | 9/07/2023 |
| Cage traps | | | | |
| **C1** | 430604 | 6398198 | 26/06/2023 | 9/07/2023 |
| **C2** | 430648 | 6397921 | 26/06/2023 | 9/07/2023 |
| **C3** | 430605 | 6397661 | 26/06/2023 | 9/07/2023 |
| **C4** | 430525 | 6397448 | 26/06/2023 | 9/07/2023 |
| **C5** | 430529 | 6397215 | 26/06/2023 | 9/07/2023 |
| **C6** | 430543 | 6396929 | 26/06/2023 | 9/07/2023 |
| **C7** | 430569 | 6396652 | 26/06/2023 | 9/07/2023 |
| **C8** | 430497 | 6396401 | 26/06/2023 | 9/07/2023 |
| **C9** | 430502 | 6396189 | 26/06/2023 | 9/07/2023 |
| **C10** | 430559 | 6395942 | 26/06/2023 | 9/07/2023 |
| **C11** | 430568 | 6395748 | 26/06/2023 | 9/07/2023 |
| **C12** | 430416 | 6395460 | 26/06/2023 | 9/07/2023 |
| **C13** | 429517 | 6390549 | 26/06/2023 | 9/07/2023 |
| **C14** | 429488 | 6390347 | 26/06/2023 | 9/07/2023 |
| **C15** | 429339 | 6390125 | 26/06/2023 | 9/07/2023 |
| **C16** | 429138 | 6389988 | 26/06/2023 | 9/07/2023 |
| **C17** | 429336 | 6389833 | 26/06/2023 | 9/07/2023 |
| **C18** | 429602 | 6389666 | 26/06/2023 | 9/07/2023 |
| **C19** | 429811 | 6389548 | 26/06/2023 | 9/07/2023 |
| **C20** | 430007 | 6389440 | 26/06/2023 | 9/07/2023 |
| **C21** | 428903 | 6390083 | 26/06/2023 | 9/07/2023 |
| **C22** | 428668 | 6390187 | 26/06/2023 | 9/07/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| **C23** | 428371 | 6390293 | 26/06/2023 | 9/07/2023 |
| **C24** | 428095 | 6390299 | 26/06/2023 | 9/07/2023 |
| **C25** | 427853 | 6390307 | 26/06/2023 | 9/07/2023 |
| **C26** | 427585 | 6390368 | 26/06/2023 | 9/07/2023 |
| **C27** | 427410 | 6390402 | 26/06/2023 | 9/07/2023 |
| **C28** | 427218 | 6390478 | 26/06/2023 | 9/07/2023 |
| **C29** | 427061 | 6390614 | 26/06/2023 | 9/07/2023 |
| **C30** | 426852 | 6390774 | 26/06/2023 | 9/07/2023 |
| **C31** | 426655 | 6390902 | 26/06/2023 | 9/07/2023 |
| **C32** | 426410 | 6391048 | 26/06/2023 | 9/07/2023 |
| **C33** | 426082 | 6391058 | 26/06/2023 | 9/07/2023 |
| **C34** | 425837 | 6390937 | 26/06/2023 | 9/07/2023 |
| **C35** | 425601 | 6390900 | 26/06/2023 | 9/07/2023 |
| **C36** | 425432 | 6391018 | 26/06/2023 | 9/07/2023 |
| **C37** | 425222 | 6391127 | 26/06/2023 | 9/07/2023 |
| **C38** | 425017 | 6391254 | 26/06/2023 | 9/07/2023 |
| **C39** | 424871 | 6391350 | 26/06/2023 | 9/07/2023 |
| **C40** | 424699 | 6391527 | 26/06/2023 | 9/07/2023 |
| **C41** | 412449 | 6395031 | 26/06/2023 | 9/07/2023 |
| **C42** | 412661 | 6395085 | 26/06/2023 | 9/07/2023 |
| **C43** | 412864 | 6395217 | 26/06/2023 | 9/07/2023 |
| **C44** | 413242 | 6395477 | 26/06/2023 | 9/07/2023 |
| **C45** | 413619 | 6395510 | 26/06/2023 | 9/07/2023 |
| **C46** | 413857 | 6395464 | 26/06/2023 | 9/07/2023 |
| **C47** | 414084 | 6395509 | 26/06/2023 | 9/07/2023 |
| **C48** | 414226 | 6395605 | 26/06/2023 | 9/07/2023 |
| **C49** | 414471 | 6395690 | 26/06/2023 | 9/07/2023 |
| **C50** | 414674 | 6395851 | 26/06/2023 | 9/07/2023 |
| **C51** | 414945 | 6395931 | 26/06/2023 | 9/07/2023 |
| **C52** | 415124 | 6396216 | 26/06/2023 | 9/07/2023 |
| **C53** | 415194 | 6396412 | 26/06/2023 | 9/07/2023 |
| **C54** | 415211 | 6396619 | 26/06/2023 | 9/07/2023 |
| **C55** | 415426 | 6396824 | 26/06/2023 | 9/07/2023 |

| Trap # | Easting | Northing | Date opened | Date closed |
|---|---|---|---|---|
| **C56** | 415498 | 6397052 | 26/06/2023 | 9/07/2023 |
| **C57** | 415691 | 6397143 | 26/06/2023 | 9/07/2023 |
| **C58** | 415935 | 6397226 | 26/06/2023 | 9/07/2023 |
| **C59** | 416172 | 6397331 | 26/06/2023 | 9/07/2023 |
| **C60** | 416020 | 6399766 | 26/06/2023 | 9/07/2023 |
| **C61** | 415891 | 6399999 | 26/06/2023 | 9/07/2023 |
| **C62** | 415835 | 6400268 | 26/06/2023 | 9/07/2023 |
| **C63** | 414068 | 6401144 | 26/06/2023 | 9/07/2023 |
| **C64** | 413964 | 6401275 | 26/06/2023 | 9/07/2023 |
| **C65** | 413850 | 6401540 | 26/06/2023 | 9/07/2023 |
| **C66** | 413609 | 6401759 | 26/06/2023 | 9/07/2023 |
| **C67** | 413469 | 6401915 | 26/06/2023 | 9/07/2023 |
| **C68** | 413224 | 6402128 | 26/06/2023 | 9/07/2023 |
| **C69** | 412842 | 6402153 | 26/06/2023 | 9/07/2023 |
| **C70** | 412574 | 6402132 | 26/06/2023 | 9/07/2023 |
| **C71** | 412126 | 6402114 | 26/06/2023 | 9/07/2023 |
| **C72** | 412096 | 6402408 | 26/06/2023 | 9/07/2023 |
| **C73** | 411880 | 6402575 | 26/06/2023 | 9/07/2023 |
| **C74** | 411689 | 6402693 | 26/06/2023 | 9/07/2023 |
| **C75** | 411580 | 6402835 | 26/06/2023 | 9/07/2023 |
| **C76** | 411496 | 6403039 | 26/06/2023 | 9/07/2023 |
| **C77** | 411555 | 6403436 | 26/06/2023 | 9/07/2023 |
| **C78** | 411838 | 6403759 | 26/06/2023 | 9/07/2023 |
| **C79** | 411896 | 6404549 | 26/06/2023 | 9/07/2023 |
| **C80** | 411841 | 6404802 | 26/06/2023 | 9/07/2023 |


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