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Minesite rehabilitation report

Oakleigh Mine, May 2008

Report Number 22223.27272

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Table of Contents

List of Tables

List of Figures

List of Appendices

1. Introduction

The hand-back of mining leases at the Oakleigh mine is conditional on the rehabilitation of the disturbed areas within the leases meeting a set of acceptance criteria for 'grazing outcome' rehabilitation sites. The agreed *Grazing Outcome Acceptance Criteria* are as follows:

- ***Acceptance Criteria 1:***

  Foliage projective cover (FPC) of monitoring rehabilitation sites is at or above 70% understorey FPC

- ***Acceptance Criteria 2:***

  Standing Dry Matter to be within ±10% of the analogue sites' production rate over a period of 12 months

- ***Acceptance Criteria 3:***

  Grazing species diversity on the mine rehabilitation sites to be on average within ±20% of the analogue site

- ***Acceptance Criteria 4:***

  Erosion rates of the mine rehabilitation areas, as determined by the Revised Universal Soil Loss Equation (RUSLE) (Renard et. al. 1994), to be within ±10% of the rates of the analogue site

This report provides an assessment of progress in respect to the above acceptance criteria at one rehabilitation site at Oakleigh mine. The particular site is known as Normanton Dump.

The analogue or reference site used for comparison with the rehabilitation site is an area of grazing land that currently supports a small number of beef cattle. This land is situated in Keates Road, Ashwell, and is described as lot 566, CH31740. The total area of the analogue site lot is 32.375 hectares. The analogue site is located approximately 3 kilometres west of the Normanton Dump rehabilitation site.

Land at the analogue was cleared of native vegetation at some considerable time in the past. The native vegetation at the site was most likely 'vine scrub' or 'dry rainforest' dominated by *Flindersia* spp. and *Ficus* spp., with emergent *Araucaria cunninghami.* Based on a derelict building on the site, the land has at some previous time been used as a dairy farm. Other evidence (*e.g*. landform and patterns of soil erosion and deposition) suggests that some portions of the site were cultivated at times, presumably to grow forage crops (for either dairy or beef cattle) or for dryland (non-irrigated) opportunity or 'cash' crops (*e.g*. grain or vegetable crops). In its current somewhat degraded condition, the analogue site would not be considered good quality grazing land. It is not however atypical of much of the older developed grazing land in the locality.

2. Methodology

2.1 Sampling sites

Sampling intensity at the rehabilitation site and the analogue site was based on:

- Historical sampling intensities,
- Statistical analysis of data from previous sampling at the sites, and
- In-field observation of the between sample variance within a rehabilitation site (*i.e.* increasing or decreasing the number of samples and sampling intensity if the between-sample variance is respectively high or low).

Individual sampling sites were selected on a judgemental basis at irregular intervals along a 'random walk' through each of the rehabilitation sites and the analogue site (the 'walk' was actually driven in a four-wheel drive vehicle). In total, some 34 sites were sampled over two days in early May 2008. The location of each of the sampling sites was determined using a Bullseye ™ dGPS and the relevant coordinates (UTM easting and northing values in AGD84 datum) were logged. The logged coordinates are shown overlain in the 1:100 000 topographic map in Figure 1 (*n.b.* AGD84 datum) and overlain on satellite images in Appendix A (*n.b.* MGA94 datum). A photograph of each sampling site is provided in Appendix B.

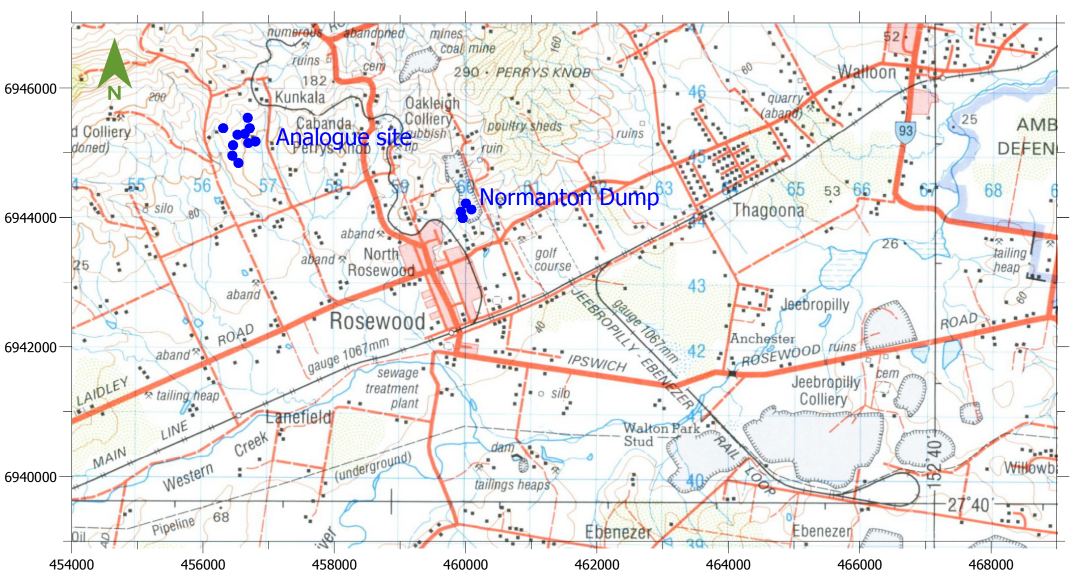

Figure 1: Part of the 1:100 000 Ipswich topographic mapsheet annotated to show the location of the 14 sampling sites (●)

Details of the number of sampling sites in each area and the resultant sampling intensity within the rehabilitation areas are provided in Table 1.

Table 1: Sampling intensities in rehabilitation areas and the analogue site

Area	Sampling sites	Sampling intensity
Analogue site	10	3.2 ha/site
Normanton Dump	4	3.0 ha/site

2.2 Vegetation sampling

2.2.1 Vegetative and total cover

Two point frame quadrats (one shown in Figure 2) were used to determine vegetative and total cover at each of the sampling sites.

Figure 2: Point frame quadrat used in vegetation sampling

Ten quadrats were placed at each sampling site. Placement of the point frame quadrats was undertaken by stepping a random number of paces forward, turning 90° and stepping a random number of paces to the side, and then placing the sampling quadrat at the tip of the foremost of the sampler's feet. This process was followed in sequence from the initial or previous sampling point, until the ten samples had been taken[1]. Random number sequences for the sampling were generated using an electronic calculator.

Cover was recorded in each quadrat on the basis of the first contact the individual points in the point frame quadrat made when lowered with either green (live) or dry (dead) vegetation, or with bare earth. Any green plant cover contacted was identified and the taxa recorded. Due to the seasonal conditions (very limited autumn rainfall and some early frosts) there were some difficulties in determining whether some of rather desiccated plant material was effectively live or dead.

2.2.2 Botanical composition of sward

The frequencies with which identifiable species were observed in the sampled point frame quadrats were recorded. Other taxa present at the rehabilitation and analogue sites, but not recorded in the sampled quadrats, were also noted.

Due to the seasonal conditions (*i.e.* dry weather and frost), there was considerable amount of senescent plant material present. This made accurate identification of taxa problematic, but not necessarily impossible.

[1] In effect this method resulted in the actual sampling taking place within plots with overall dimensions of approximately 50 m x 50 m or 0.25 ha (the actual area varying due the variance inherent the sets of 20 random numbers)

2.2.3 Standing vegetative dry matter

A visual assessment of standing dry matter was made at each sampling point.

To provide some degree of consistency with previous assessments, the standing dry matter assessment was made using the photo-standards in Hacker *et al*. (2005) and Condamine Alliance (2006). However, in this instance the observed level of standing dry matter was rated or scored using the ordinal scale shown in Table 2, rather than attempting to precisely estimate intermediate values from the interval based photo-standards (*e.g*. providing an estimated standing dry matter of precisely 550 kg/ha from a 300 – 600 kg/ha interval photo-standard). This ordinal rating approach was intended to provide more robust and repeatable assessment data.

Table 2: Ratings applied in assessing vegetation against the standing dry matter photo-standards

Rating	Standing dry matter
1	50 – 100 kg/ha
2	100 – 300 kg/ha
3	300 – 600 kg/ha
4	600 – 900 kg/ha
5	900 – 1 200 kg/ha
6	1 200 – 1 500 kg/ha
7	1 500 – 2 000 kg/ha
8	2 000 – 5 000 kg/ha
9	5 000 – 10 000 kg/ha
10	>10 000 kg/ha

2.3 Soil erosion variables

2.3.1 Slope gradient

The gradient of slopes at each sampling site was determined using a Suunto™ PM-5 handheld inclinometer.

2.3.2 Slope length

The length of the slope at each sampling point was visually estimated (to the nearest 10 – 20 metres).

2.3.3 Soil texture

Field assessment of soil texture class had been made at previous assessments and was not repeated at this assessment.

2.3.4 Cover

Estimates of soil cover are available from the vegetation assessment.

2.3.5 Canopy height

A visual estimate (±0.1 m) was made of the average canopy height at each sampling site. This information was solely for use in the Universal Soil Loss Equation calculations, rather than any direct ecological assessment.

2.4 Statistical analysis

Statistical data analysis for this assessment was undertaken using the STATISTICS® analytical software package (Analytical Software, 1996).

2.5 Terminology

For the purpose of this assessment the following terminology has been applied:

- Site – one of the rehabilitation sites or the analogue site;
- Sampling site – one of the locations selected for sampling within one of the *sites*; and
- Quadrat – one of the sampling units applied at a *sampling site*.

3. Results

3.1 Climatic conditions

3.1.1 Precipitation

Given the dominance of summer active species in the sward at both the rehabilitation and analogue sites, precipitation in the preceding summer will normally be a significant factor in respect to the yield of plant biomass, and associated variables such as plant cover.

Figure 3 provides a comparison for the Amberley Bureau of Meteorology station (40004) of the following:

- Monthly precipitation totals for the period May 2007 to April 2008, and
- The long-term mean values for that station in those same months.

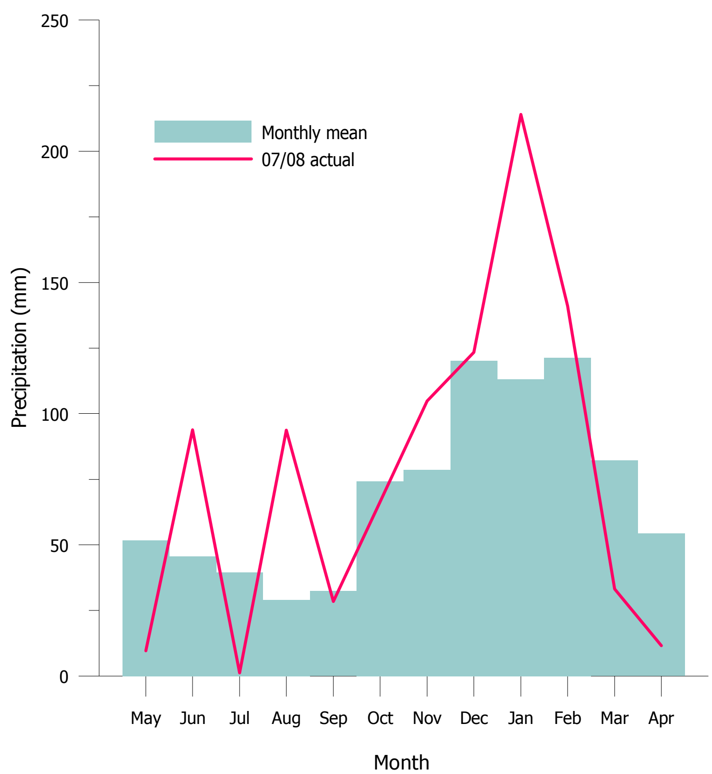

Figure 3: Comparison of monthly precipitation at Amberley between May 2007 and April 2008 and the long-term averages (1941 – 2008) for the corresponding months

From Figure 3 it can be seen that despite some very dry months over the previous 12 months (*e.g*. May & July 2007, and March & April 2008), monthly precipitation values have generally been above average; in some cases (*e.g*. January 2008) very much so. The total rainfall for the preceding 12 months was 921 mm. This approximates the 60th percentile value (*i.e*. the value is still exceeded in 40% of years).

3.1.2 Rainfall erosivity

Rainfall intensity in a 2 year average recurrence interval (ARI) 6 hour design storm at Rosewood is 11.9 mm/hr (Pilgrim, 2001). The corresponding value for the rainfall erosivity factor (R) in the SI version of the Universal Soil Loss Equation (USLE) is 3 061.

3.2 Vegetation

3.2.1 Species present

Table 3 provides a taxonomic list of the plants identified at the rehabilitation and analogue sites during this assessment.

Table 3: Species list for the rehabilitation and analogue sites (= present at sites, S = sampled at sites)

Species	Common name	Rehabilitation	Analogue
Aristida spp.	Wire grasses [native]		S
Bothriochloa decipiens	Pitted blue grass [native]	S	S
Chloris gayana	Rhodes grass	S	S
Dicanthium sp.	Blue grass [native]	S	S
Digitaria didactyla	Blue couch	S	S
Eragrostis spp.	Love grasses [native]	S	
Panicum maximum var. *trichoglume*	Green panic	S	S
Paspalum dilatatum	Paspalum		S
Rhynchelytrum repens	Red Natal grass		S
Seteria sphacelata	Seteria	S	
Acacia farnesiana	Prickly mimosa		S
Achyranthes aspera	Chaff flower		
Alchornea sp.	Native holly [native]		
Alternanthera pungens	Khaki weed		
Asclepias sp.	A balloon cotton	S	
Chenopodiaceae	Various chenopods [native]	S	S
Cirsium vulgare	Spear thistle		S
Conyza sp.	A fleabane		
Cyperus gracilis	Slender sedge [native]		S
Euphorbia drummondii	Asthma plant [native]		
Gomphrena celosioides	Gomphrena weed	S	
Lantana camara	Lantana [noxious]		
Macroptilium atropurpureum	Siratro	S	S
Macroptilium lathroides	Phasey bean		
Melia azedarach	White cedar [native]		
Opuntia spp.	Prickly & tree pears [noxious]		
Salsola sp.	A rolypoly [native]		
Sida cordifolia	Flannel weed		S
Sida rhombifolia	Sida retusa	S	
Verbena spp.	Verbena	S	
Verbena tenuisecta	Maynes pest	S	
Vigna sp.	A vigna [native]		S
Wahlenbergia sp.	Native bluebell [native]		

As in previous assessments there was more commonality in respect to the grass species observed at the rehabilitation and analogue sites, than there was in respect to the dicotyledonous species (refer Table 3). Some species, such as *Bothriochloa decipiens, Cirsium vulgare* and *Sida rhombifolia*, are somewhat ubiquitous in southeast Queensland and would be expected to occur at almost any site.

Some species, such as *Seteria sphacelata* are pasture plants likely to have been purposely sown at the rehabilitation site, and would not ordinarily be present in ‘unimproved’ grazing land in this locality.

Macroptilium atropurpureum is also a sown-pasture species, but has become naturalised in many areas in south-eastern Queensland. However this species is generally not persistent on land that is heavily stocked on a continuous or near-continuous basis (*i.e*. being a short-lived perennial species, rotational grazing, or temporary destocking during and immediately after flowering is normally required to allow seed-set and on-going recruitment in this species). The very limited representation of this species at the analogue sites may therefore be an indicator of suboptimal grazing management at this particular site.

Not all species shown in Table 3 were present in the sampled quadrats. These additional taxa were casual observations at either rehabilitation or analogue sites. The absence of these taxa from sampled quadrats would suggest they were either visually prominent or otherwise exceptional plant species, but were either present at very low densities throughout the sites; or restricted to very limited areas within the sites (*i.e*. areas too small to have a good chance of being represented in sample quadrats).

Those taxa that are endemic indigenous species[2] are identified in Table 3 by a superscript annotation (*i.e*. [native]). Similarly, those species listed as Class C1, C2 or C3 noxious weeds in Queensland are also identified (*i.e*. [noxious]). It should be noted that control of declared noxious weed species is a requirement of various state and local government laws. Technically a notice could be served on the landowner by a duly appointed weeds officer, requiring the removal of these weeds.

3.2.2 Species numbers

Table 4 shows the number of different taxa recorded in sampled plots at each site.

Table 4: Number of taxa recorded at each site

Site	Taxa
Normanton Dump	6
Analogue	15

The number of taxa recorded at the Normanton Dump was under half (40%) of those recorded at the analogue site. While it is commonly argued that sites with a greater number of species present are of more ecological value than sites with fewer, in an agricultural context a large diversity of species can be indicative of suboptimal conditions (or management) for the desirable crop or pasture species (*i.e*. species diversity can be indicative of a stressed agricultural system). Similarly, the comparatively smaller area sampled at Normanton Dump may also have impacted on these results.

It is noted that the numbers of taxa recorded in this assessment are less than half the numbers recorded at the Normanton Dump site in spring 2007, but similar to the numbers recorded in autumn 2007. This might suggest that the number of species varies with season and is not unexpected for a pasture swards dominated by summer-active species.

[2] Being indigenous does not necessarily imply these are ‘desirable’ species, as some can be indicative of degraded landscapes

3.2.3 Species diversity index

Species diversity at the various sites was assessed by applying the Shannon diversity index[3] (H') to frequency data for the analogue site and rehabilitation area (*i.e.* species presence or absence at every sampling site). The results are shown in Table 5, along with the values for a variant of the *t*-test (Zar, 1999) used to assess the statistical significance of differences between the indices for the rehabilitation area and that of the analogue site.

Table 5: Values for the Shannon diversity index and the *t*-test used to test for difference between analogue and rehabilitation sites

Site	H'	s^2_H	t	$t_{0.01(2),df}$
Normanton Dump	1.81	3.4×10^{-4}	35.6^{**}	2.58
Analogue	2.76	3.8×10^{-4}	—	

** = significant at P = 0.01

The values for H' in Table 5 are moderate to low (<3.0, >1.0). The index for the analogue site is the higher than the value for Normanton Dump (*i.e.* greater taxonomic diversity). The substantial value for the *t*-statistic in Table 5 indicate that the lower index value for the rehabilitation area differs significantly (at P = 0.01) from that of the analogue site.

[3] Sometimes referred to as the Shannon-Weaver or Shannon-Wiener index of diversity, a value of 0 represents total uniformity; there is no upper limit for very diverse populations – refer statistical texts such as Zar (1999) for the computational methods for the index

3.2.4 Foliage and total vegetative cover

Figure 4 shows the proportion of total vegetative cover[4] attributable to the following:

- Foliage of live monocotyledonous plants (grasses & sedges),
- Foliage of live dicotyledonous plants (herbs and forbs),
- Plant litter and dead foliage, and
- Bare ground.

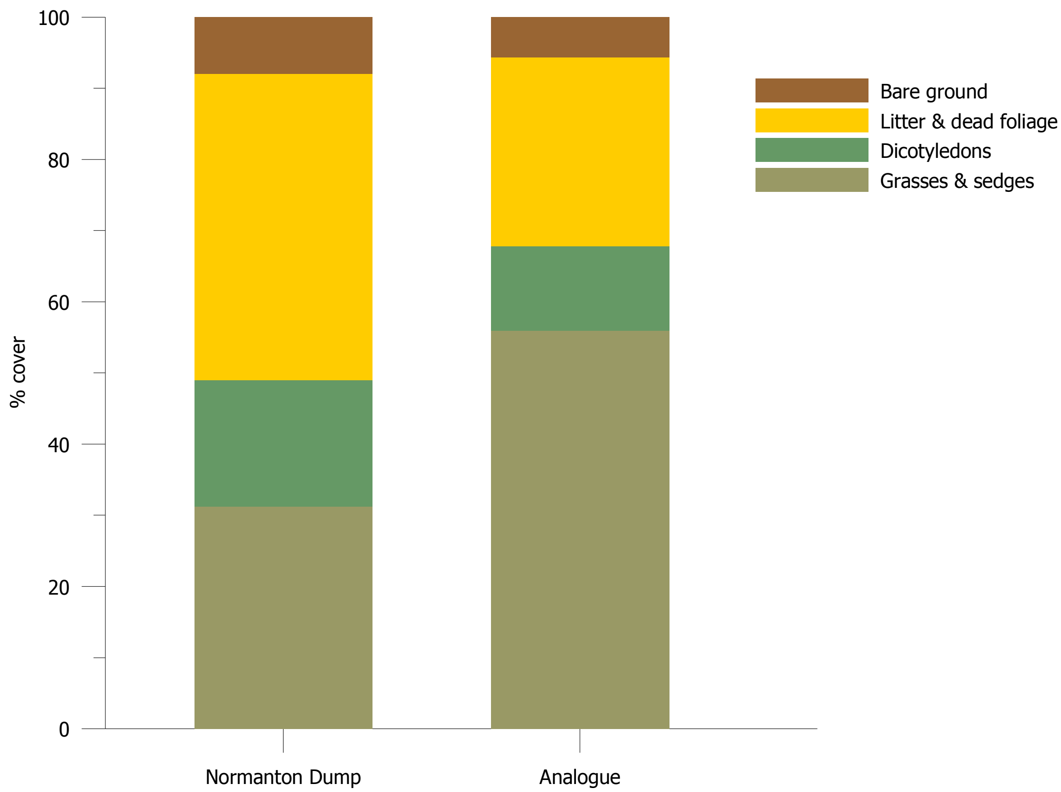

Figure 4: Mean proportions of total cover provided by live monocotyledonous and dicotyledonous plants, litter and dead foliage, and bare ground in the analogue and rehabilitation site

From Figure 4 it can be seen that:

- Grasses and sedges dominate the live component of the foliage cover at both the Normanton Dump and analogue sites, but the proportion of grasses and sedges was much greater at the analogue site than at Normanton Dump,
- There is a larger proportion of dicotyledonous plants at Normanton Dump than the analogue site,
- The proportions of litter and dead foliage was greatest at the Normanton Dump site,
- The proportion of bare ground was greatest at the Normanton Dump site, and
- Total vegetative cover exceeds 70% in all areas.

[4] 100% – % bare ground = total vegetative or protective cover (*i.e.* protects soil from erosion)

By way of further analysis of the cover data, Figure 5 provides a box and whisker plot[5] of total vegetative cover at individual sampling sites at the Normanton Dump and analogue sites.

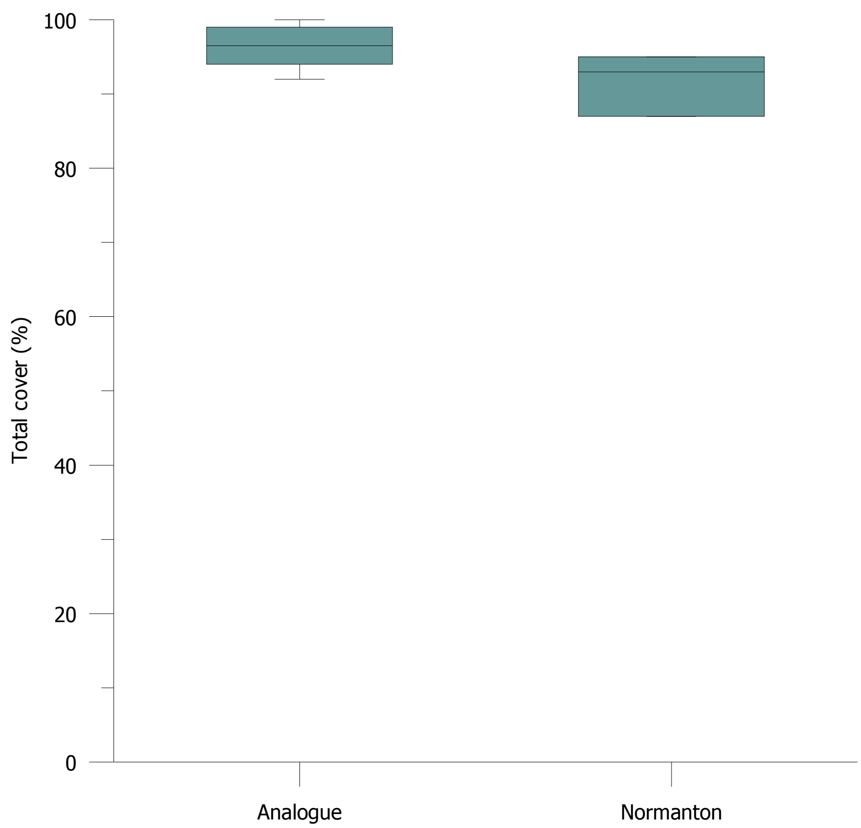

Figure 5: Box & whisker plot of total vegetative cover (live & dead material)

The percentile values plotted in Figure 5 indicate that:

- The median values for total cover (97% & 93% respectively) for the analogue and Normanton Dump sites are very similar to the mean values in Figure 4 (94% and 92% respectively),
- Like the mean values, the median values for all three sites also exceed 70% cover,
- There is not as much variability in the total cover data from the analogue site in comparison to the Normanton Dump site (which could be a function of the comparatively small sample size at Normanton Dump).

The above points are confirmed by a Kruskal-Wallis nonparametric analysis of variance (ANOVA) and a pair-wise comparison of the mean ranks for each site made using the *z*-statistic, the results of which are summarised in Table 6. These results show there is no statistical difference (at a 95% confidence interval) between the mean values for total cover at the Normanton Dump and analogue sites.

[5] Box & whisker plots provide the following:

- Maximum value,
- Minimum value,
- Median value (50th percentile or 'middle' value, as opposed to the arithmetic mean or average value plotted in Figure 4),
- Lower quartile value (or first quarter or 25th percentile value), and
- Upper quartile value (or third quarter or 75th percentile value).

Table 6: Results of Kruskal-Wallis nonparametric ANOVA applied to the total vegetative cover data

Site	Number of sites	Mean cover	Mean rank
Normanton Dump	4	92.0	4.38_a
Analogue	10	96.2	8.75_a
Total	**14**	**95.0**	**7.5**
Kruskal-Wallis statistic			**3.17^{ns}**

^{ns} = not significant at P < 0.05,
Mean ranks followed by same letter do not differ at P = 0.05

Figure 6 shows a box and whisker plot of the percentage cover provided by live foliage at the respective sites.

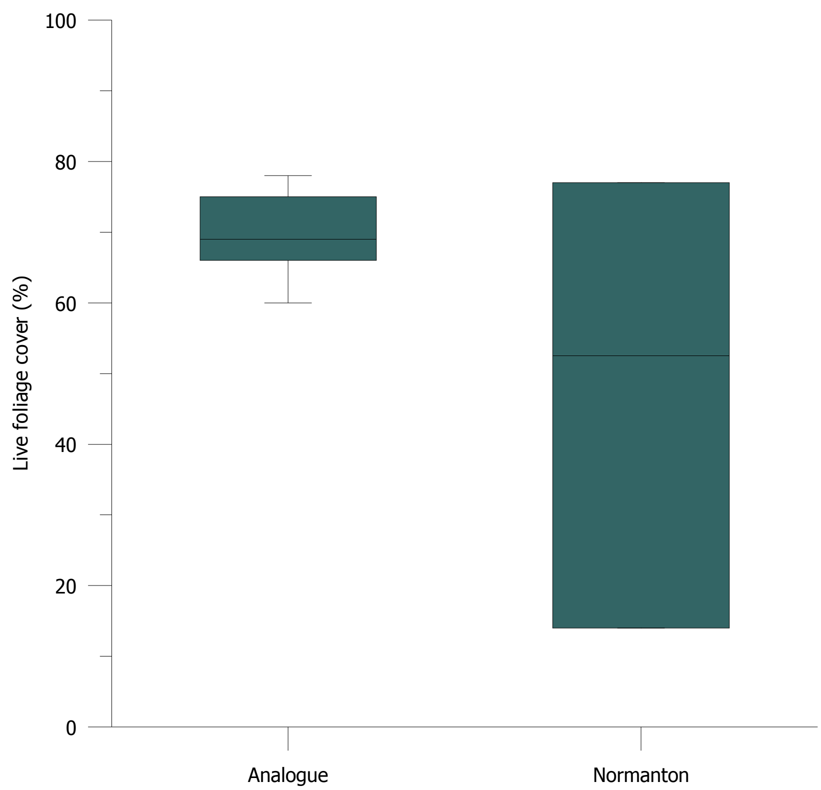

Figure 6: Box & whisker plot of live foliage cover

The median live foliage cover shown in Figure 6 is much less at the Normanton Dump site than at the analogue site (53% and 69% respectively). Also, the variability in live foliage cover at the Normanton Dump site was much greater than at the analogue site.

Nonetheless, a Kruskal-Wallis ANOVA and *z*-statistic pair-wise comparisons of mean ranks, as summarised in Table 7, shows that any apparent increase in the magnitude of the differences between the three sites was not sufficient to alter the previous relationships in terms of statistical significance (*i.e.* the live foliage cover values for the Normanton Dump and analogue sites do not differ significantly at P=0.05). The mean and median live foliage cover at neither of the sites exceeded the 70% threshold, although those of the analogue site (69.7% and 69.0% respectively) was only marginally less than 70%.

Table 7: Results of Kruskal-Wallis nonparametric ANOVA applied to the live foliage cover data

Site	Number of sites	Mean live foliage cover	Mean rank
Normanton Dump	4	49.0	6.1_a
Analogue	10	69.7	7.4_a
Total	**14**	**63.8**	**7.0**
Kruskal-Wallis statistic			**0.29^{ns}**

^{ns} = not significant at $P < 0.05$,
Mean ranks followed by same letter do not differ at $P = 0.05$

3.2.5 Pasture height

Figure 7 provides a box and whisker plot of the foliage height data for each site.

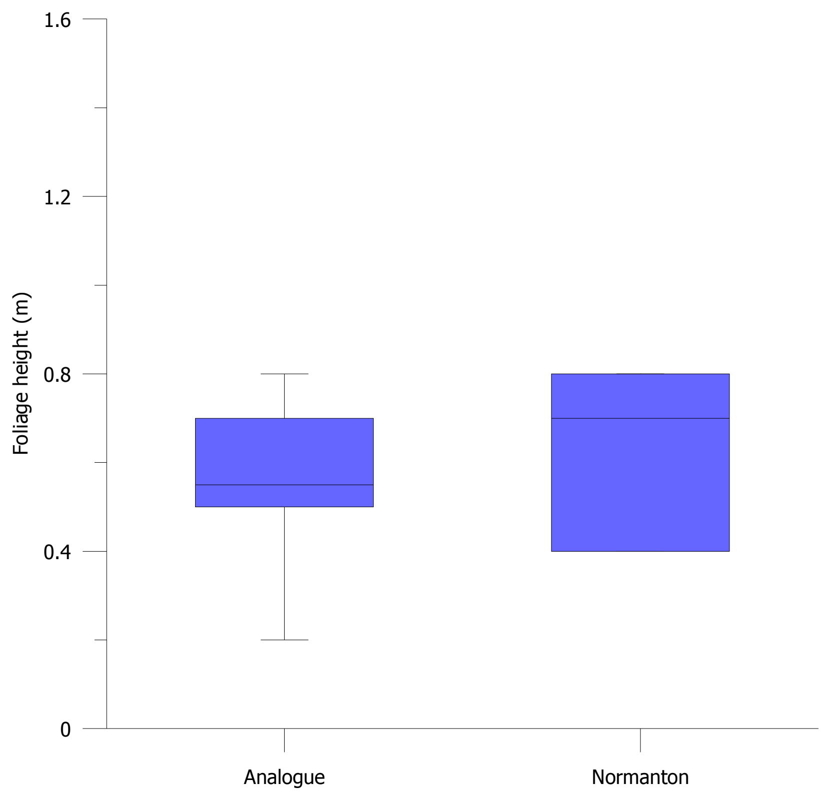

Figure 7: Box & whisker plot of foliage height

The foliage height data display slightly different trends to that of the other vegetation parameters, with the Normanton Dump site having a greater median foliage height than the analogue site. Despite the apparent differences in median values evident in Figure 7 , the results of the Kruskal-Wallis nonparametric ANOVA and pair-wise comparison of mean ranks provided in Table 8 indicate that the difference is not a statistically significant one.

Table 8: Results of Kruskal-Wallis nonparametric ANOVA applied to the foliage height data

Site	Number of sites	Mean height	Mean rank
Normanton Dump	4	0.65	9.0_a
Analogue	10	0.54	6.9_a
Total	**14**	**0.57**	**7.5**
Kruskal-Wallis statistic			**0.75^{ns}**

^{ns} = not significant at $P < 0.05$,
Mean ranks followed by same letter do not differ at $P = 0.05$

Foliage height might be expected to vary with the following:

- Soil physical and chemical variables (*e.g.* soil fertility, soil salinity, plant available water capacity, *etc.*), which would determine the amount of biomass produced,
- The habit of component species (*e.g.* low growing stoloniferous species, such as *Digitaria didactyla vs.* more erect species, such as *Panicum maximum* var. *trichoglume*), and
- Grazing pressure.

Casual observation at the time of this assessment would suggest that the last two factors (habit and grazing pressure) are the more important in this instance. At the time of assessment, it appeared as though the Normanton Dump site was not stocked, although it has been in the past, whilst the analogue site was.

3.2.6 Standing dry matter

Standing dry matter was assessed by applying a visual rating on an ordinal scale of 0 – 10 to vegetation at each sampling site (refer Section 2.2.3 for details).

Figure 8 shows the box and whisker plot of the visual scores of standing dry matter at each sampling site within the analogue and Normanton Dump site.

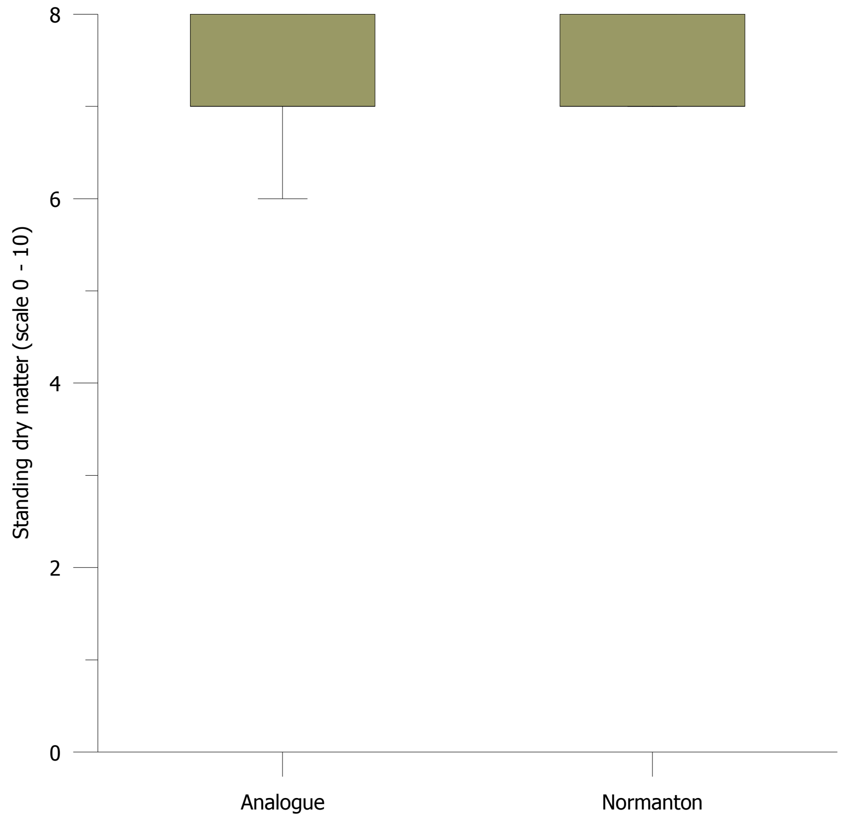

Figure 8: Box & whisker plot of standing dry matter scores (0 – 8) at the various sampling sites

Visually there appeared to be very little difference between the standing dry matter data for the two sites shown in Figure 8.

Again the standing dry matter data were analysed using the nonparametric Kruskal-Wallis ANOVA and the mean ranks for the two sites being subject to a pair-wise comparison made using the *z*-statistic. The summary results are shown in Table 9.

Table 9: Results of Kruskal-Wallis nonparametric ANOVA applied to the standing dry matter data

Site	Number of sites	Mean score	Mean rank
Normanton Dump	4	7.3	7.6_a
Analogue	10	7.2	7.5_a
Total	**14**	**7.2**	**7.5**
Kruskal-Wallis statistic			**0.007^{ns}**

^{ns} = not significant at P < 0.05,
Mean ranks followed by same letter do not differ at P = 0.05

From Table 9 it can be seen that the standing dry matter ratings for the two sites do not differ significantly.

3.3 Soil erosion

3.3.1 Revised Universal Soil Loss Equation

The Revised Universal Soil Loss Equation (RUSLE) was used to estimate annual soil loss from each sampling site in both rehabilitation areas and the analogue site. The RUSLE equation is given by:

$$A = R \times K \times LS \times P \times C$$

Where:
- A = average annual soil loss (t/ha/yr),
- R = rainfall erosivity factor (MJ.mm/ha.hr.yr),
- K = soil erodibility factor,
- LS = slope length factor,
- P = soil conservation practice factor,
- C = vegetation factor.

Algorithms used in determining for component variables R, K, LS, P and C in this assessment are those provided in Rosewell & Loch (2002), Lu *et al*. (2003) and Foster (2005). The values applied in these algorithms include specific data collected as per Section 2.3 of this report. Other input data, such as foliage and total cover, were obtained from the values generated in analyses undertaken for Section 3.2 of this report. Still other data were sourced from other sources, such as Noble (1996) and So *et al*. (2003).

Figure 9 provides a box and whisker plot of the annual soil loss estimates for each sampling point within each of the rehabilitation sites and the analogue site.

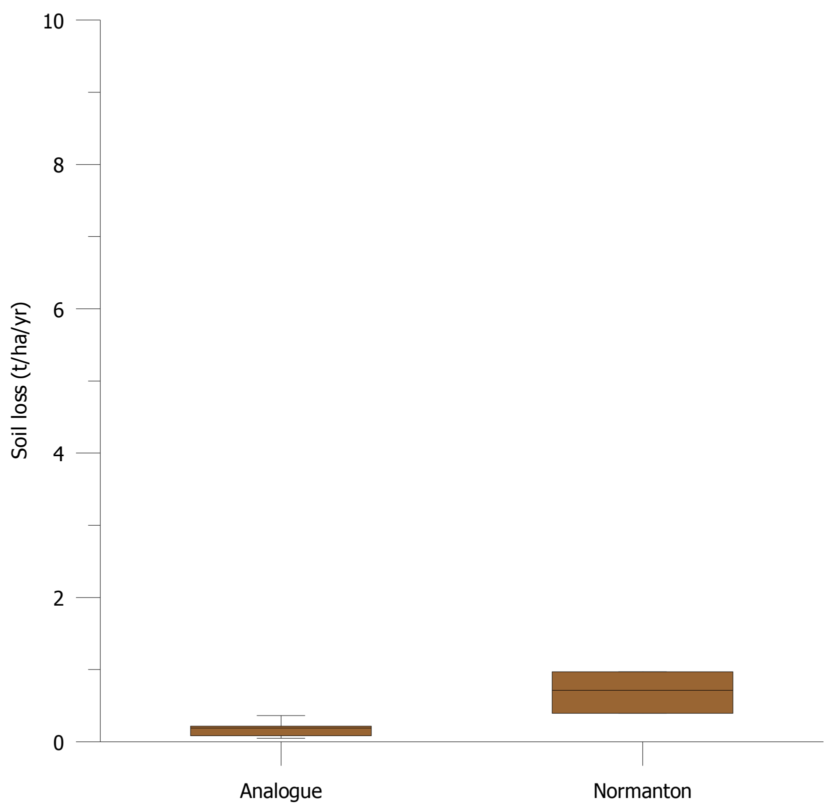

Figure 9: Box and whisker plot of the annual soil loss estimates at the various sites

As can be seen from Figure 9, Normanton Dump appears to suffer a higher rate of soil loss than does the analogue site..

The individual USLE soil loss estimates represented in Figure 9 were analysed using the nonparametric Kruskal-Wallis analysis of variance (ANOVA). Similarly, the mean rank for each site was then subjected to pair-wise comparison using the *z*-statistic. The results of these analyses are shown in Table 10.

Table 10: Results of Kruskal-Wallis nonparametric ANOVA applied to the USLE soil loss data

Site	Number of sites	Mean score	Mean rank
Normanton Dump	4	0.70	12.5_b
Analogue	10	0.18	5.5_a
Total	**14**	**0.33**	**7.5**
Kruskal-Wallis statistic			**8.04****

** = significant at P < 0.05,
Mean ranks followed by different letters differ at P = 0.05

Differences between then mean ranks shown in Table 10 suggest that the Normanton Dump has a statistically higher rate of soil loss than the analogue site, a finding which is consistent with previous assessments. This might suggest that despite improved seasonal conditions and pasture yield, little progress has been made in respect to *Assessment Criteria 4* (*i.e.* RUSLE estimates with ±10% of the analogue site). To investigate this further, the mean values for the component variables are shown in Table 11.

Table 11: Mean values for the applied variables in the RUSLE

Site	*R*	*K*	*LS*	*P*	*C*	*A*
Normanton Dump	3060	**0.062**	2.27	1.0	**0.003**	**0.70**
Analogue	3060	**0.025**	4.08	1.0	**0.001**	**0.18**

From Table 11 it is evident that despite longer and steeper slopes on the analogue site (and therefore a higher *LS* value), the greater sensitivity of the RUSLE equation to soil erodibility (*K*) and crop factor (*C*) values means that the estimates of soil loss at the Normanton Dump site are greater than at the analogue site.

The higher *K* value for the Normanton Dump site in Table 11 appear to be largely due to the soil texture and the soil organic carbon values that are being applied. In the case of both the rehabilitation and analogue sites, the values applied are not actual values. Rather they are composite values derived, in respect to the rehabilitation sites, for some limited soils data for spoil at the Oakleigh Mine; and in respect to the analogue site, typical values for natural soils that typically develop in similar contexts on the Walloon Coal Measures in the area – as provided in '*Understanding and managing soils in the Moreton region*' (Noble, 1996).

Soil sampling and analysis in both the rehabilitation and analogue sites might avoid the necessity of relying on these alternative sources of data, and thus provide more reliable and robust estimates of *K* values. Nonetheless given the relatively slow rate of pedogenesis, and the limited time for which the spoil has been vegetated (which strongly influences soil organic carbon levels), it is to be expected that any actual values for the rehabilitation and analogue site soils would still differ substantially (albeit possibly by a lesser magnitude).

Topdressing the spoil with some form of supplementary organic matter (*e.g*. compost made from feedlot manure, municipal green waste or sewage treatment plant biosolids) would help increase soil organic carbon levels at the rehabilitation sites. Such applications can be made at any time, not just at sowing, and can even be made on an ongoing basis.

It should be noted that despite the differences in RUSLE estimates seen in Table 10 and Table 11, rates of soil loss less than 1 t/ha/annum, would be considered acceptable for almost any grazed pasture site in southeast Queensland.

4. Conclusions

4.1 Compliance with acceptance criteria

4.1.1 Acceptance criteria 1

This criteria requires *foliage projective cover* to be greater than 70%.

There was not a statistical difference between the two sites (Normanton Dump and the analogue site) in total foliage cover, with both sites having mean and median total foliage covers greater than 70%. There was also no statistically significant difference between the sites in respect to live foliage projective cover either, however neither site had either a mean or median live foliage projective cover above the threshold value of 70%.

4.1.2 Acceptance criteria 2

To meet this criteria *standing dry matter* at a rehabilitation site has to be within ±10% of the analogue sites for a period of 12 months. Figure 10 shows the median standing dry matter for the period that dry matter estimates have been undertaken at Normanton Dump[6]. The median scores have been included to remain consistent with the approach used in other reports.

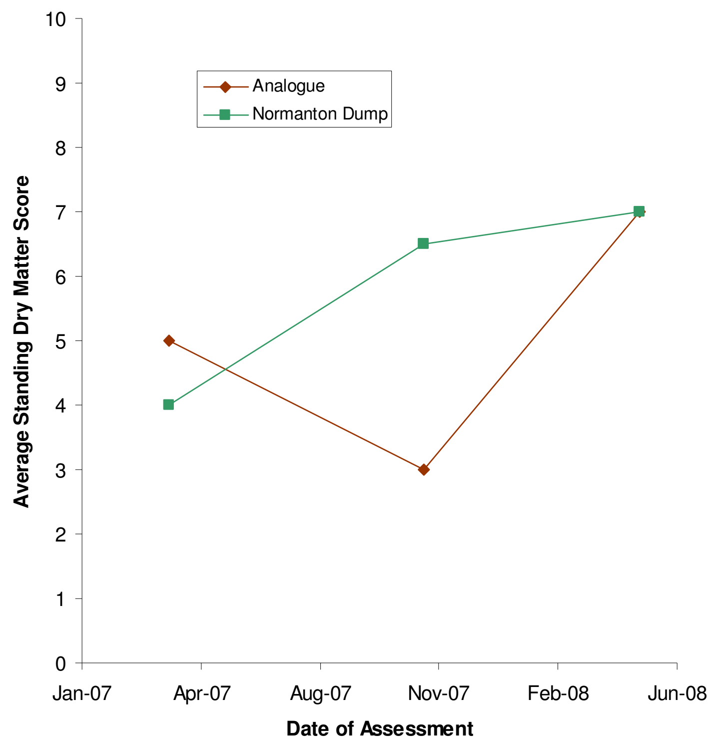

Figure 10: Trends in median standing dry matter scores (Nov 2005 – April 2008)

The effect on pasture productivity of varying seasonal conditions over the last 12 months (refer Figure 3, page 6) is evident in the median values for all sites plotted in Figure 10.

[6] Previous assessments conducted at the Analogue site have not been included, because there was no corresponding data collected from the Normanton Dump site.

It should also be obvious from Figure 10, that the acceptance criteria relating to standing dry matter has only been met in the most recent assessment at Normanton Dump. In the previous assessments (April and November 2007), the Normanton Dump site was -20% and +117% respectively different from the analogue site, thus not meeting the acceptance criteria of being ±10% of the analogue site for a period of 12 months, despite the Normanton Dump site having a higher ranking than the analogue in November 2007.

The possible reasons for this discrepancy include:

- The variable seasonal conditions that have occurred over the past 12 months (see above);
- The difference in grazing intensity that has been applied between the sites; and,
- Inherent difference in pasture productivity, which is impacted by *inter alia*: soil fertility, the pasture species present and their interactions with grazing animals.

4.1.3 Acceptance criteria 3

To comply with this acceptance criteria grazing *species diversity* in the rehabilitation sites has on average to be within ±20% of that at the analogue site.

This criteria was not met during this assessment, as the total number of taxa recorded at the Normanton Dump rehabilitation site was 60% lower than the corresponding value at the analogue site. Similarly, there was a significant difference between the two sites in the calculated Shannon Diversity Index, a more robust measure of species diversity.

The suitability of this criteria for measuring the sustainability of a grazing system is questionable, given that an increase in the total number of species generally reflects poor grazing management and a decline in the pasture's productivity.

4.1.4 Acceptance criteria 4

This criteria states that the soil erosion rates estimated using the RUSLE method from the Normanton Dump site must be within ±10%. This criteria has not been met in this assessment, as the Normanton Dump site had a higher estimated soil erosion rate than the analogue site. The potential reasons for this discrepancy and some suggestions to remedy the situation are present above in Section 3.3.1.

4.2 Constraints on achieving acceptance criteria

Please see E.A. Systems report "22222.27267 – Minesite Rehabilitation Report, Jeebropilly mine, May 2008" for a full description of the constraints on achieving the acceptance criteria. The same constraints can be applied currently to the Oakleigh mine, and it is not intended to expand upon them here. However, the same recommendations have been repeated below.

4.3 Recommendations

The following appear to warrant consideration:

- Obtaining a binding definition of *foliage projective cover* from the Queensland Environmental Protection Agency,
- Synchronising the grazing management of the rehabilitation and analogue sites such that similar grazing intensities and regimes apply,
- Undertaking soil sampling and analysis at the rehabilitation and analogue sites to better calibrate the RUSLE estimates, and
- Give consideration to either:
    a) Renegotiating the acceptance criteria to address a number of issues highlighted above, or
    b) Varying the requirements to allow the use of a more appropriate analogue site.

5. References

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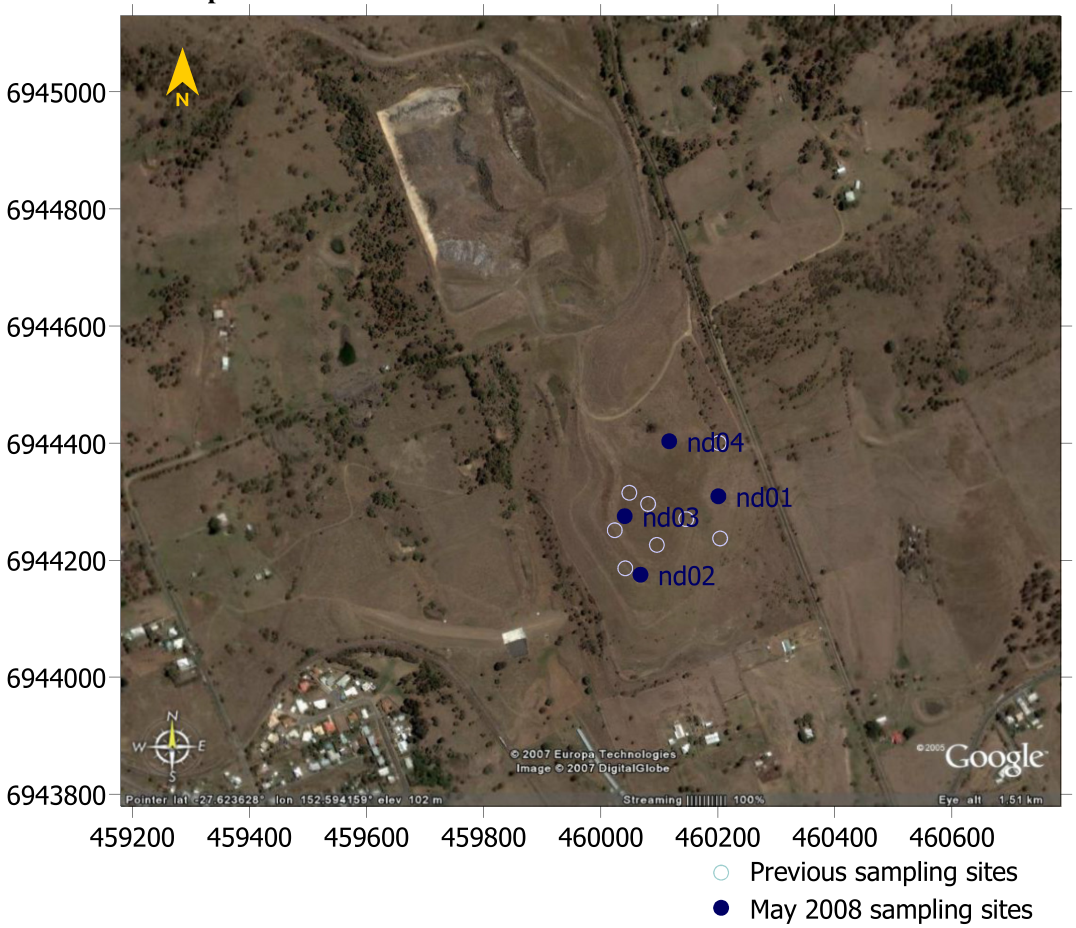
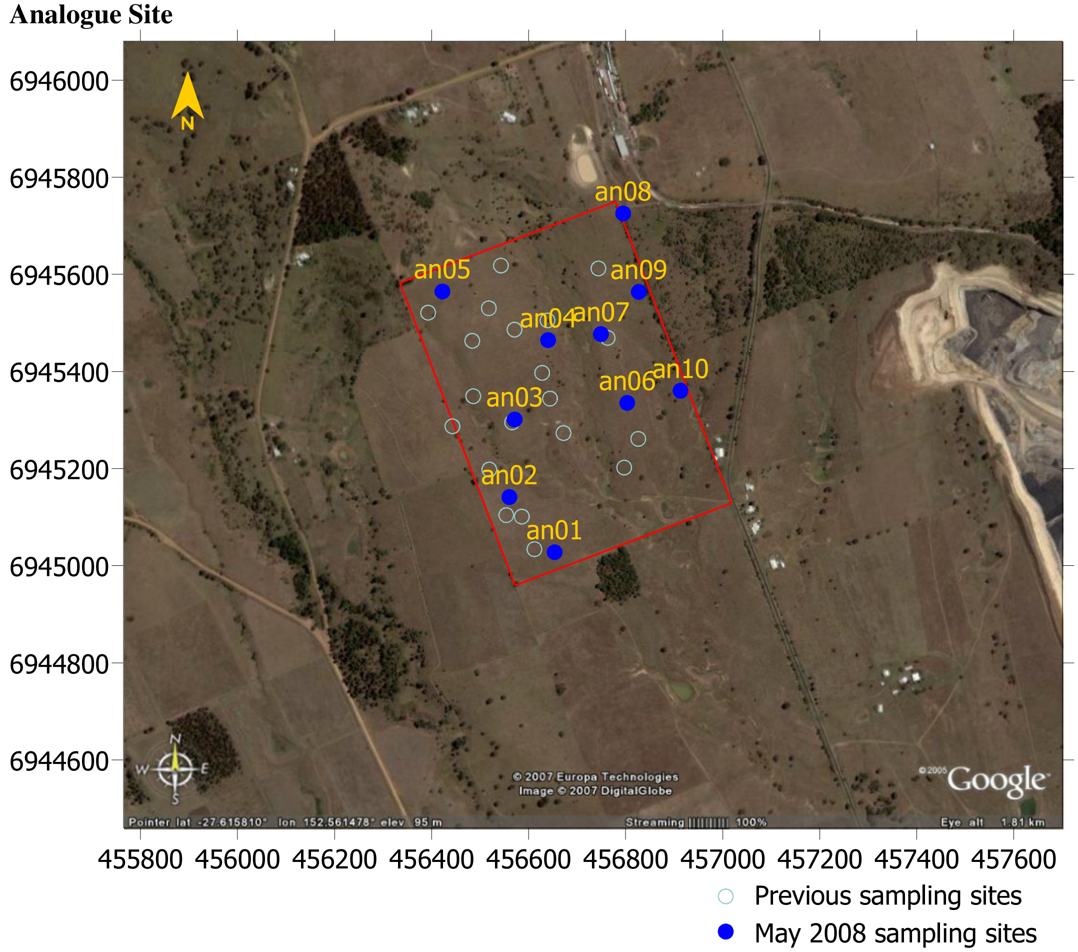
6. Appendices

Appendix A. Sampling site satellite images

Normanton Dump



Analogue Site



Appendix B. Sampling site photographs

Normanton Dump & Analogue Site, 6-7 May 2008

Analogue Sites


an01


an02


an03


an04


an05


an06

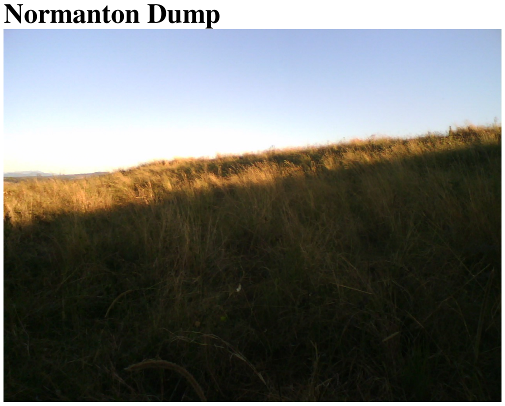

an07


an08

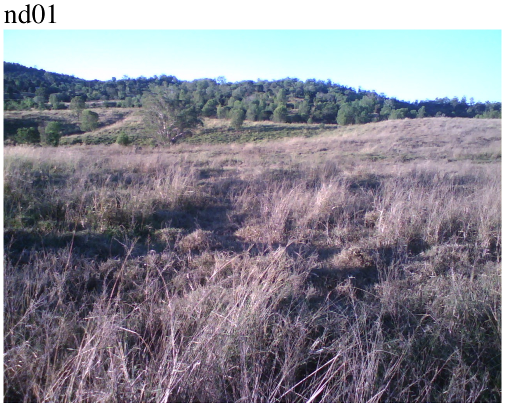

an09


an10

Normanton Dump


nd01


nd02


nd03


nd04