Appendix 1

Wonarah Phosphate Project: Acid Forming Characteristics of Waste Rock Composite Samples from the Arruwurra Prospect and Main Zone and Low Grade Ore

Prepared by:

ENVIRONMENTAL GEOCHEMISTRY INTERNATIONAL PTY LTD

81A College Street, Balmain, NSW 2041 Australia
Telephone: (61-2) 9810 8100 Facsimile: (61-2) 9810 5542
Email: egi@geochemistry.com.au
ACN 003 793 486 ABN 12 003 793 486

For:

COFFEY NATURAL SYSTEMS PTY LTD

Level 1, 203 Greenhill Road
Wayville SA, 5034
Ph (08) 7221 3574

October 2009

Document No. 1751/874

Wonarah Phosphate Project

ACID FORMING CHARACTERISTICS OF WASTE ROCK COMPOSITE SAMPLES FROM THE ARRUWURRA PROSPECT AND MAIN ZONE AND LOW GRADE ORE
FINAL

Contents

List of Tables (after text)

List of Figures

List of Appendices (after tables)

1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Coffey Natural Systems Pty Ltd on behalf of Minemakers Australia Pty Ltd to carry out geochemical characterisation of composite waste rock samples from the Wonarah Phosphate Project in the Northern Territory. The project consists of two deposits, Main Zone and Arruwurra, with mining likely to begin with the Arruwurra Prospect. Testing of samples from the Wonarah Phosphate Project was undertaken in two separate stages. The first consisting of samples from the Arruwurra Prospect and the second consisting of samples from the Main Zone together with low-grade ore (from both deposits).

The objectives of the testing program were to:

- Determine the acid-forming characteristics of the samples;
- Evaluate the acid rock drainage (ARD) potential of the materials;
- Assess the availability of acid neutralising capacity (ANC) within the materials; and.
- Determine the elemental composition and enrichment of elements of environmental concern.

This report presents the results and findings of the geochemical test work conducted on all the samples.

2.0 Sample Description and Test Programme

The samples were provided in two batches with the first consisting of 47 composite waste rock samples from the Arruwurra Prospect (received by EGi on the 19th March 2009). The second batch comprised of 51 composite waste rock samples from the Main Zone and 20 low-grade ore samples (from both deposits), which was received by EGi on the 28th July 2009.

The composite waste rock samples were prepared on site using the following criteria:

- Sample holes selected to cover spatial and depth variation in geological units within the mining area.
- All lithological units within the mining area to be represented in the composite samples.
- Individual samples included in each composite should not transcend across different lithological boundaries or across different holes.
- Where possible for each hole, 4 composites should be made from overburden and 1 composite made from basement material. Composites should comprise no greater than 5 m intervals combined together.

- Composite samples should be about 1.5 to 2 kg each.

Upon receipt of samples, a 200 g split was sent to Sydney Environmental and Soil Laboratory (SESL) to pulverise to -75µm.

The testing program was as follows:

- Total sulphur analysis (all samples);
- Acid neutralising capacity (ANC) determination (all samples);
- $pH_{1:2}$ and $EC_{1:2}$ on water extracts (all Arruwurra Prospect samples, selected samples from the Main Zone and selected low grade ore samples);
- Single addition net acid generation (NAG) testing (all Arruwurra Prospect samples, selected samples from the Main Zone and selected low grade ore samples);
- Acid buffering characteristic curve (ABCC) testing (selected samples from the Arruwurra Prospect);
- Multi-element scans on liquors (selected samples from both batches); and
- Multi-element scans on solids (selected samples from both batches).

Samples from the second batch were selected for $pH_{1:2}$ and $EC_{1:2}$ and single addition NAG testing as results from testing of the Arruwurra Prospect samples indicated that waste rock would not be problematic with respect to ARD and metal leaching and it was expected that samples from the second batch would have similar characteristics.

Water extracts for pH, EC and multi-element scans on liquors were carried out on the as received samples. All other test work was carried out on pulverised samples.

Leco total sulphur assays were carried out by SESL, multi-element scans on solids were conducted by Australian Laboratory Services (ALS) in Brisbane and multi-element scans on water extracts was conducted by ALS in Sydney. All other analyses were carried out by EGi.

A general description of the pH/EC, total S, ANC and NAG test methods is included in Appendix A.

3.0 Results

3.1 Arruwurra Prospect

The geochemical test results of the Arruwurra Prospect composites are presented in Table 1 and comprise pH and EC of water extracts, total S, MPA, ANC, NAPP, ANC/MPA ratio and single addition NAG.

3.1.1 pH and EC

The $pH_{1:2}$ and $EC_{1:2}$ tests were carried out by equilibrating as received solid sample in deionised water for approximately 16 hours at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

All samples tested had a circum-neutral $pH_{1:2}$ ranging from 6.7 to 8.5 and correspondingly low electrical conductivities ($EC_{1:2}$) of 0.1 to 0.7 dS/m, indicating that the samples were non-saline to slightly saline.

3.1.2 Acid-Base Account and Net Acid Generation (NAG)

The acid-base and net acid generation (NAG) test results for the samples are presented in Table 1.

The results show that all samples had a low total S content ranging from <0.01 to 0.1%S, with the majority of the samples having a value <0.05%S. The acid neutralising capacities (ANC's) of the samples were variable, ranging from 3 to 848 kg H_2SO_4/t. About 40% of the samples had moderate to high ANC values greater than 20 kg H_2SO_4/t.

All the samples have a negative net acid producing potential (NAPP[1]) varying from -3 to -848 kg H_2SO_4/t.

The NAPP value is used in conjunction with single addition net acid generation (NAG) test results to geochemically classify samples in relation to their ARD potential. Samples are classified as barren, non-acid forming (NAF), potentially acid forming (PAF) and uncertain (UC) according to the following characteristics:

- Barren: Total S ≤ 0.05%S and ANC ≤ 5 kg H_2SO_4/t.
- NAF: Non-Acid Forming. NAPP negative and NAGpH greater than or equal to 4.5.
- PAF: Potentially Acid Forming. NAPP positive and NAGpH less than 4.5.
- UC: Uncertain. Conflicting NAPP and NAG results (i.e., NAPP positive and NAGpH greater than 4.5 or NAPP negative and NAGpH less than 4.5).

1 The net acid producing potential (NAPP) is a theoretical calculation that represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is expressed in units of kg H_2SO_4/t and is calculated as follows:

$$NAPP = MPA - ANC$$

Where MPA = Maximum potential acidity (total %S x 30.6 = MPA in units of kg H_2SO_4/t)
ANC = Acid Neutralising Capacity

The single addition NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals present. Both acid generation and acid neutralisation occur simultaneously during the NAG test, hence the end result represents a direct measurement of the net amount of acid generated.

Figure 1a is an ARD classification plot showing the pH after reaction with hydrogen peroxide (NAGpH) and the NAPP of the samples and Figure 1b is the same as Figure 1a, except with an expanded NAPP scale. Potentially acid forming (PAF), non-acid forming (NAF) and uncertain (UC) classification domains are indicated.

The results show that the samples have a negative NAPP and NAGpH greater than 4.5 and plot in the top left hand quadrant. These samples are classified as non-acid forming (NAF). About 30% of the samples are further classified as barren as they have a total S content < 0.1%S and ANC ≤ 5 kg H_2SO_4/t and are thus barren with respect to acid generation and neutralisation.

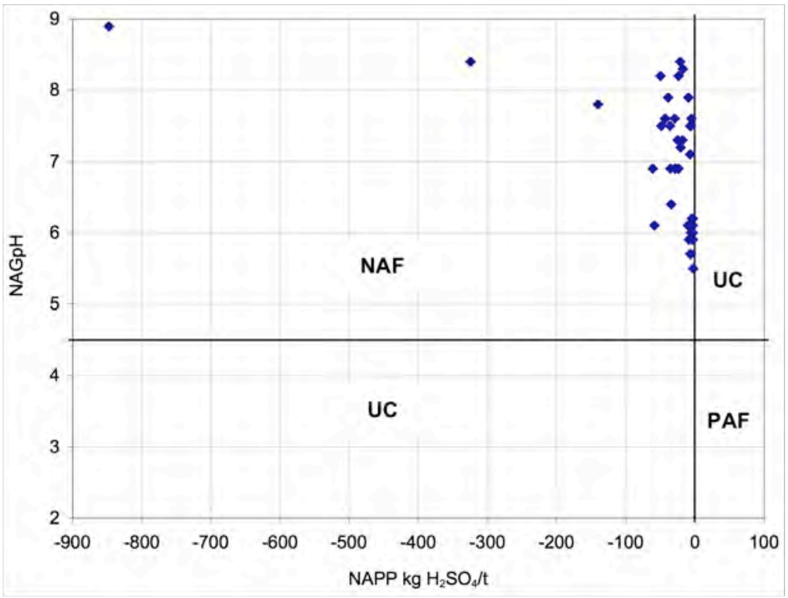


Figure 1a: ARD classification plot of composite samples – Arruwurra Prospect.

Three samples have a NAPP value less than -100 kg H_2SO_4/t. These include composite 4, with a NAPP of -848 kg H_2SO_4/t, composite 5 with a NAPP of -325 kg H_2SO_4/t and composite 6 with a NAPP of -140 kg H_2SO_4/t. These three samples are carbonates and described as dolomite, calcrete and phosphatic carbonate, respectively. They have high ANC values and negligible total S contents ranging from 0.01 to 0.04%S.

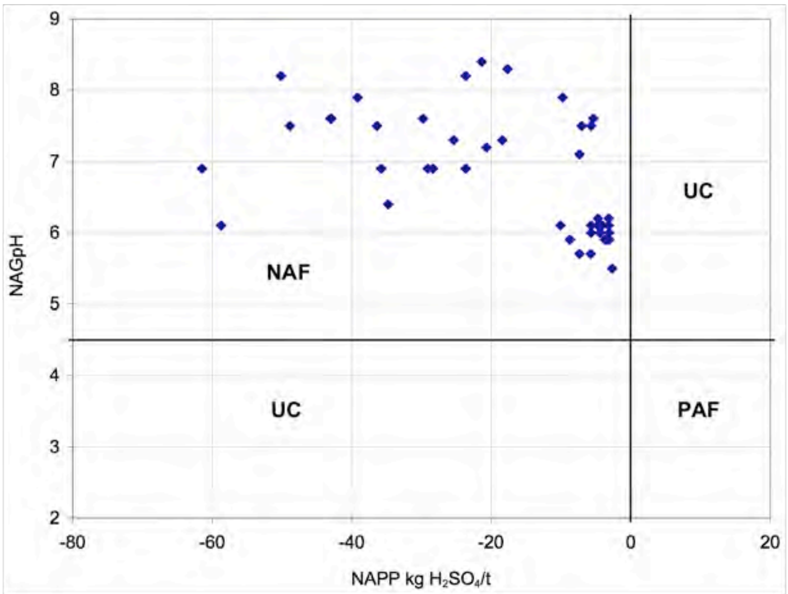


Figure 1b: Same as for Figure 1a, but with expanded NAPP scale.

3.1.3 ABCC Results

An acid buffering characteristic curve (ABCC) is produced by slow titration of a sample with acid, and provides an indication of the relative reactivity of the measured ANC. The acid buffering of a sample to pH 4 can be used as an estimate of the proportion of readily available ANC. Calcite, dolomite, ferroan dolomite and siderite standard curves are also plotted for reference. Calcite and dolomite readily dissolve in acid and exhibit strongly buffered pH curves in the ABCC test, rapidly dropping once the ANC value is reached. The siderite standard provides very poor acid buffering, exhibiting a very steep pH curve in the ABCC test. Ferroan dolomite is between siderite and dolomite in acid buffering availability.

Three samples (Composite 5, 30 and 42) were selected to undergo ABCC testing and had ANC values of 326, 26 and 52 kg H_2SO_4/t, respectively. The samples were selected to encompass the range in ANC values that were observed in the results. The results are presented in Figures 2 to 4.

Figure 2 presents the curve for Composite 5, which plots between the dolomite and ferroan dolomite standard curves. The sample has a strong initial pH plateau above pH 6 and has a readily available ANC, which is about 60% of the measured ANC of the sample. The results indicate that the ANC of this sample is dominated by dolomitic and ferroan dolomitic minerals with about 50% fast reacting.

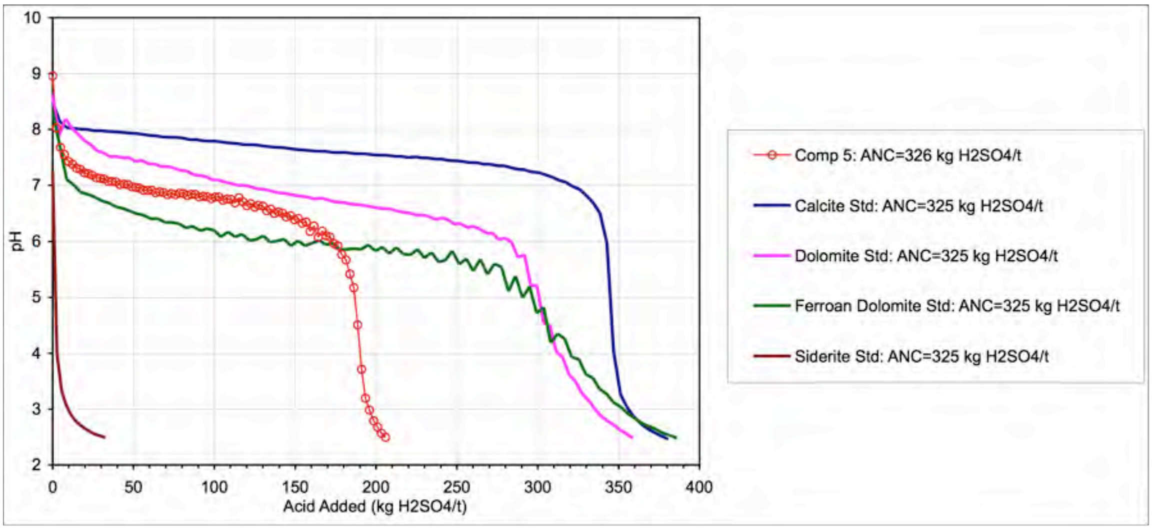


Figure 2: Acid buffering characteristic curve of composite 5, with ANC close to 325 kg H_2SO_4/t. Carbonate standard curves are included for reference.

Figures 3 and 4 present the ABCC plots for Composite 30 and 42, respectively. Both curves decrease rapidly from the beginning of the test and plot close to the siderite standard curve. The results indicate that the ANC of these two samples was ineffective and only about 10% of the measured ANC was readily available. The shapes of the curves suggest that the ANC of the samples is dominated by siderite. Siderite is known to cause interference with the standard ANC test (caused by incomplete oxidation of ferrous iron released during the ANC digest), resulting in overestimation of effective acid buffering.

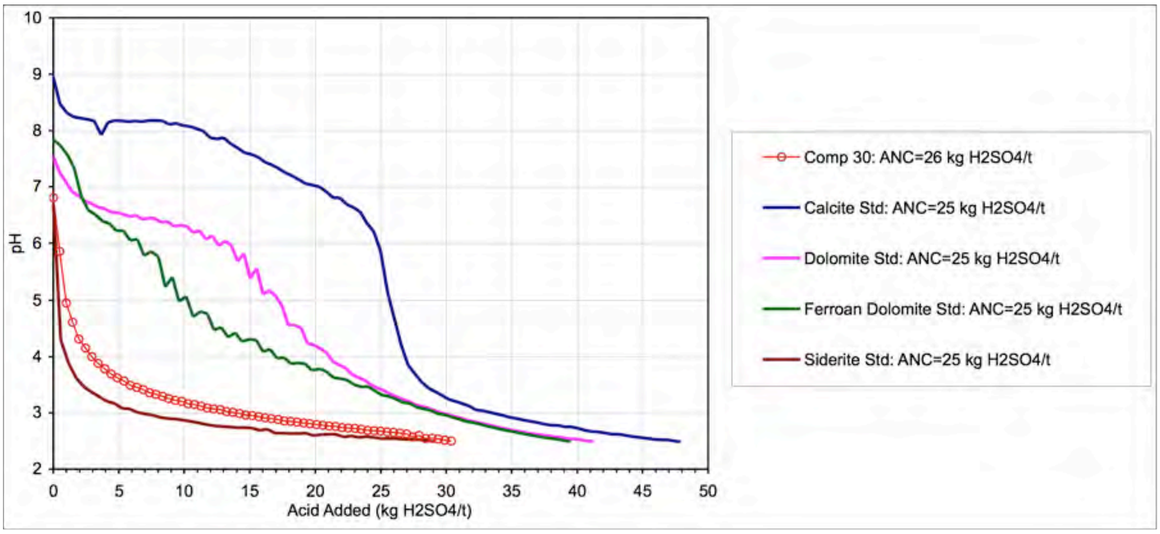


Figure 3: Acid buffering characteristic curve of composite 30, with ANC close to 25 kg H_2SO_4/t. Carbonate standard curves are included for reference.

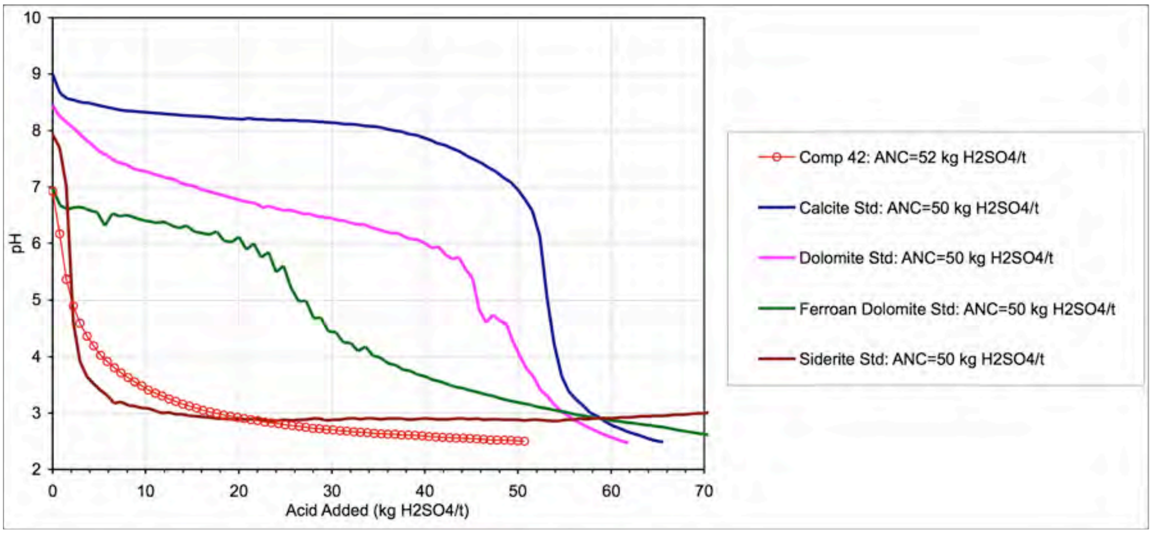


Figure 4: Acid buffering characteristic curve of composite 42, with ANC close to 50 kg H_2SO_4/t. Carbonate standard curves are included for reference.

Overall, ABCC testing indicates that in materials represented by Composite 5, 30 and 42, a large proportion of the ANC would not be available to neutralise pyrite generated acidity and hence the NAPP value can not be relied on to indicate the ARD risk. However, due to the low total S content and high NAGpH, all samples are classified as NAF and the lack of effective ANC would only be a concern if higher sulphide material were encountered.

3.1.4 Element Enrichment and Solubility

Multi-element scans were conducted on 8 samples and the elements included in the multi-element testing program were:

> Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, Hg, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Se, Sn, Sr, Th, Ti, Tl, U, V, W and Zn.

Geochemical Abundance Indices (GAIs) were also calculated for each element. The GAI compares the actual concentration of an element in a sample with the median abundance in the selected reference material (world soil[2] concentrations used in this report) for that element. The main purpose of the GAI is to provide an indication of any elemental enrichment that may be of environmental importance. The GAI for an element is calculated as follows:

$$GAI = \log_2 [\, C / (1.5*S) \,]$$

where C is the concentration of the element in the sample and S is the median soil content for that element. The GAI are truncated to integer increments (0 through to 6,

---

[2] References for median soil data were: (1) Bowen, H.J.M. (1997) Environmental Chemistry of the Elements. Academic Press, London. (2) Berkman, D.A. (1976) Field Geologists' Manual, The Australian Institute of Mining and Metallurgy, Parkville, Victoria, Australia

respectively) where a GAI of 0 indicates the element is present at a concentration similar to, or less than, median soil abundance and a GAI of 6 indicates approximately a 100-fold, or greater, enrichment above median soil abundance. The enrichment ranges for the GAI are as follows:

Little or No Enrichment
GAI=0 < 3 times median soil

Slightly Enrichment
GAI=1 3 to <6 times median soil
GAI=2 6 to <12 times median soil

Significant Enrichment
GAI=3 12 to <24 times median soil
GAI=4 24 to <48 times median soil
GAI=5 48 to <96 times median soil
GAI=6 ≥ 96 times median soil

The multi-element results and geochemical abundance indices are presented in Tables 2 and 3, respectively. The results show that phosphorous (P) is significantly enriched in many samples with concentrations exceeding 5% P. Beryllium (Be) is significantly enriched in 7 of the 8 samples and Ca, Cu, Ce, Tl and U are significantly enriched in 1 or 2 of the samples. Although the GAI for Be exceeds 3 relative to median soil concentrations, the actual concentrations are not enriched compared to mean crustal abundance (2.6 mg/kg) and is unlikely to be a concern. The enrichment of P is to be expected given the mineralogy of the deposit.

The potential for dissolution and leaching of enriched elements is the main environmental concern during mining operations. To evaluate element solubility, the same samples that underwent multi-element scans on solids also underwent multi-element analyses of water extracts to provide an indication of the immediate solubility of these enriched elements as well as other environmentally important elements.

The results are presented in Table 4 and show only low concentrations of dissolved constituents. Phosphorous shows very low solubility with concentrations less than the detection limit of 1 mg/l in all samples. Na, Cl and SO_4 are the main ions in solution and there is some solubility of F. Fluorine (F) is typically associated with phosphate and leaching of F would be expected. The results indicate that routine water quality monitoring programmes should include F.

3.2 Main Zone

The acid forming characteristics of the Main Zone composite waste rock samples are presented in Table 5. A total of 51 samples were included in the program. All samples were assayed for total S and ANC and selected samples assayed for pH, EC, single addition NAG and multi-element scans on solids and water extracts.

3.2.1 pH & EC

Twelve (12) samples were selected for $pH_{1:2}$ and $EC_{1:2}$ testing. The samples were selected to encompass a range in total S and ANC values observed in the samples.

The samples had a circum-neutral $pH_{1:2}$ ranging from 7.1 to 7.7. The corresponding electrical conductivities ranged from 0.09 to 0.15 dS/m, indicating that the samples were non-saline.

3.2.2 Acid-Base Accounting and Net Acid Generation (NAG)

The total S contents of the composite waste rock samples was low, ranging from <0.01 to 0.13%S. More than two thirds of the samples had a value that was less than or equal to 0.05%S.

The acid neutralising capacity (ANC) of the composites ranged from 0 to 19 kg H_2SO_4/t, with about three quarters of the samples having a value less than or equal to 5 kg H_2SO_4/t. The samples had a net acid producing potential (NAPP) ranging from -19 to 2 kg H_2SO_4/t, with the majority of the samples having a value close to zero.

Twelve (12) samples, which had total S contents ≥ 0.04%S, were selected for single addition NAG testing. The results show that all samples had a NAGpH > 4.5. Eight of the samples have a positive NAPP value close to zero and are classified as uncertain (UC). However, it is unlikely that these samples will be acid generating, therefore the samples are further classified as UC (NAF), i.e., uncertain but likely to be non-acid forming. The remaining four samples that were NAG tested have a negative NAPP value and are classified as NAF.

Table 5 shows that overall about 50% of the samples (29 of 51) are classified as barren with respect to acid generation and have total S of less than or equal to 0.05%S and ANC less than 5 kg H_2SO_4/t. Of the remaining 22 samples, 18 are classified UC (NAF) and 4 are classified NAF. No samples were classified as PAF.

Based on the samples provided, these results indicate that ARD will not be an issue for the Main Zone waste rock.

3.2.3 Element Enrichment and Solubility

Multi-element composition and geochemical abundance indices (GAI) of selected solids samples from the Main Zone are presented in Tables 6 and 7, respectively. A description of the GAI was presented in Section 3.1.4.

The results show that phosphorus (P) is significantly enriched in 3 of the 12 samples tested, however, concentrations are not as high as in the Arruwurra Prospect. Beryllium (Be) is significantly enriched in 5 of the samples when compared with the median soil concentrations. However, similar to the Arruwurra Prospect samples, the actual concentrations are not enriched compared to mean crustal abundance (2.6 mg/kg) and are unlikely to be a concern. Ag, Cd, Mg, Mn, Pb, U and Zn were significantly enriched in 1 or 2 of the samples as identified on Table 7

Water extractions were performed to determine the solubility of these elements and other environmentally important constituents. The results are presented in Table 8 and show that the majority of the elements are at low concentrations or below the detection limit.

Phosphorous shows low solubility with concentrations at or less than the detection limit of 1 mg/l, except for sample 31 with a concentration of 4 mg/l. There is some solubility of F, which is expected as fluorine is typically associated with phosphate, with concentrations ranging from 0.2 to 2.0 mg/l. Ten (10) of the samples had F concentrations in the range of 1 to 2 mg/l.

One sample, composite 16, also had a high concentration of Mn (1.26 mg/l). This sample was significantly enriched in Mn having a GAI of 4. Fe (0.36 mg/l) and Zn (0.17 mg/l) are also slightly soluble in this sample.

As for the Arruwurra Prospect, it is recommended that F is included in routine water quality monitoring programmes.

3.3 Low Grade Ore

Twenty low-grade ore samples were provided for geochemical testing and the acid forming characteristics of the samples is presented in Table 9. The samples are labelled as Comp No. 52 to 71. All the samples underwent total S and ANC testing and selected samples were assayed for pH, EC, single addition NAG and multi-element scans on solids and water extracts.

3.3.1 pH & EC

$pH_{1:2}$ and $EC_{1:2}$ was conducted on eight selected samples (4 from the Arruwurra Prospect and 4 from the Main Zone), which covered a range in total S and ANC values. The results show that the low grade ore samples had a circum-neutral to alkaline pH ranging from 7.2 to 7.9.

The electrical conductivities of the selected samples were low, ranging from 0.09 to 0.15 dS/m, indicating that the samples were non-saline.

3.3.2 Acid-Base Accounting and Net Acid Generation (NAG)

The low grade ore samples had low total S contents, which varied from 0.03 to 0.19%S, with the majority of the samples having a value less than 0.1%S. The acid neutralising capacity (ANC) of the samples was moderate, ranging from 14 to 28 kg H_2SO_4/t.

All the samples had a negative NAPP value and high ANC/MPA ratios indicating a high factor of safety for prevention of acid generation.

Eight (8) samples were selected for single addition NAG testing. The results show that the samples had a NAGpH greater than 4.5 confirming the non-acid forming (NAF) nature of the low grade ore samples.

Table 9 shows that all low grade ore samples from the Arruwurra Prospect and Main Zone are classified as NAF.

3.3.3 Element Enrichment and Solubility

The multi-element composition and geochemical abundance indices (GAI) of selected solids samples is presented in Tables 10 and 11, respectively. The results show that Be and P are highly enriched in all the samples with Ca and U significantly enriched in half of the samples. Phosphorous (P) enrichment is to be expected given the mineralogy of the deposit. In addition, Ag, Co, Pb and Sr are enriched in 1 of he Main Zone samples.

The enrichment of P, Ca, Be and U is typical of phosphate ores. As expected, P is highly enriched in the low grade ore and although Be is also significantly enriched, the actual concentrations only slightly exceed the typical range in soils (0.1 to 15 mg/kg[3]) in 1 of 8 samples.

The enrichment of uranium is also typical of phosphate deposits. The average content of U in rock phosphate is 120 mg/kg[3], which is greater than the maximum concentration of 63 mg/kg determined in the Main Zone and Arruwurra low grade ore samples.

As for the waste rock samples, water extractions were conducted to determine the solubility of environmentally important elements and the results are presented in Table 12. The results show only low concentrations of dissolved constituents with Ca and Na the main cations and Cl and SO_4 the main anions. Phosphorous has low solubility with concentrations being less than or equal to 2 mg/l. There is some solubility of F in the low-grade ore samples with concentrations ranging from 0.4 to 2.5 mg/l.

Ba was slightly soluble in sample 53 from the Arruwurra Prospect, having a concentration of 0.6 mg/l. The remaining elements were at low concentrations or below the detection limit.

4.0 Summary and Recommendations

Geochemical characterisation of composite waste rock samples from the Arruwurra Prospect and Main Zone, and low-grade ore from both deposits has shown that materials

[3] István Pais and J. Benton Jones, Jr. (1997), *The Handbook of Trace Elements.* St Lucie Press, Boca Raton Fl, USA.

represented by the samples will not be problematic with respect to ARD. All samples tested were classified as non-acid forming (NAF) and about 40% of the waste rock composites were also barren with respect to S and ANC contents, having a total S less than or equal to 0.05%S and ANC less than or equal to 5 kg H_2SO_4/t.

The average total S and ANC of samples are presented in Table 13. The average total S contents of waste rock composites from the Arruwurra Prospect and Main Zone were the same, while the average ANC of the waste rock from the Arruwurra Prospect was almost an order of magnitude higher than in the Main Zone samples.

Table 13 shows that the Arruwurra Prospect and Main Zone low-grade ore samples had similar average total S contents that were slightly higher than waste rock composites and similar ANC values.

Table 13: Average total S, ANC and NAPP of composite waste rock and low grade ore samples.

Sample Type	Deposit	Total S (%)	ANC (kg H_2SO_4/t)
Waste Rock	Arruwurra Prospect	0.03	46
	Main Zone	0.03	5
Low Grade Ore	Arruwurra Prospect	0.09	25
	Main Zone	0.07	19

Elemental analysis of selected waste rock composites indicated that P and Be were significantly enriched (i.e. GAI $\geq$3) in most samples from the Arruwurra Prospect and Main Zone. Phosphorous (P) enrichment is to be expected given the mineralogy of the deposit and although Be was enriched when compared against median soil concentrations (0.3 mg/kg), the actual concentrations were not enriched compared to mean crustal abundance (2.6 mg/kg). Other elements showing significant enrichment in 1 or 2 of the samples were Ag, Ca, Cd, Cu, Mg, Pb, Tl, U and Zn.

Testing showed that all the low grade ore samples were significantly enriched in Be and P and half of the samples were also significantly enriched in Ca and U. The actual concentration of U in the low grade ore is lower than typically observed in rock phosphate ore.

Water extractions carried out on waste rock and low grade ore samples indicated only low solubility of dissolved constituents and that the majority of the environmentally significant elements were either at low concentrations or below the detection limit. Phosphorous showed very low solubility with the concentrations being close to or less than the detection limit of 1 mg/l. There was some solubility of F in the samples. Fluorine (F) is typically associated with phosphate and leaching of F would be expected in these samples.

Overall, the results of the current investigation indicated that ARD will not be a concern for the Wonarah Phosphate Project. However, there are some elements that occur at elevated concentrations in waste rock and low grade ore. Although their solubilities are expected to be low, it is recommended that PO_4, F and Be, be included in site water quality monitoring programmes.

Table 1: Acid forming characteristics of composite waste rock samples from the Arruwurra Prospect.

Composite Number	Hole No.	Lithology	Depth (m)		Interval (m)	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
			From	To				Total %S	MPA	ANC	NAPP	ANC/MPA Ratio	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
1	WNRC009	mudstone	5	9	4.0	7.6	0.112	0.02	1	5	-4	8	6.0	0	8	NAF (Barren)
2	WNRC009	silty mudstone	9	12	3.0	8.3	0.216	0.01	0	5	-5	16	6.1	0	9	NAF (Barren)
3	WNRC009	silty mudstone	12	17	5.0	7.5	0.146	0.01	0	6	-6	20	6.0	0	8	NAF
4	WNRC009	dolomite	26	32	6.0	8.3	0.104	0.01	0	848	-848	2771	8.9	0	0	NAF
5	WNRC013	calcrete	1	4	3.0	8.2	0.156	0.04	1	326	-325	266	8.4	0	0	NAF
6	WNRC013	phosphatic carbonate	4	9	5.0	7.8	0.152	0.03	1	141	-140	154	7.8	0	0	NAF
7	WNRC089	muddy siltstone	3	6	3.0	7.7	0.232	0.04	1	11	-10	9	7.9	0	0	NAF
8	WNRC089	phosphatic muddy siltstone	6	11	5.0	8.1	0.214	0.07	2	51	-49	24	7.5	0	0	NAF
9	WNRC089	basaltic sediments	14	16	2.0	8.0	0.211	0.06	2	41	-39	22	7.9	0	0	NAF
10	WNRC089	basalt	16	20	4.0	7.8	0.176	0.01	0	18	-18	59	8.3	0	0	NAF
11	WNRC090	ferricrete	1	3	2.0	7.6	0.189	0.02	1	6	-5	10	7.6	0	0	NAF
12	WNRC090	siltstone	3	8	5.0	7.5	0.259	<0.01	0	6	-6	20	6.1	0	9	NAF
13	WNRC091	siltstone/mudstone	4	8	4.0	6.8	0.166	<0.01	0	9	-9	29	5.9	0	9	NAF
14	WNRC091	mudstone/siltstone	8	12	4.0	7.6	0.179	0.02	1	4	-3	7	5.9	0	9	NAF (Barren)
15	WNRC091	mudstone	20	24	4.0	8.3	0.181	<0.01	0	24	-24	78	6.9	0	0	NAF
16	WNRC091	basalt	24	27	3.0	7.8	0.192	0.01	0	21	-21	69	7.2	0	0	NAF
17	WNRC094	aeolian sand	0	4	4.0	6.7	0.215	0.01	0	3	-3	10	5.5	0	9	NAF (Barren)
18	WNRC094	siltstone	5	10	5.0	7.9	0.176	0.02	1	5	-4	8	6.0	0	9	NAF (Barren)
19	WNRC094	siltstone	10	14	4.0	8.2	0.236	0.03	1	4	-3	4	6.0	0	9	NAF (Barren)
20	WNRC094	phosphatic siltstone	15	20	5.0	8.4	0.213	0.03	1	44	-43	48	7.6	0	0	NAF
21	WNRC094	basalt	25	28	3.0	7.6	0.248	0.02	1	22	-21	36	8.4	0	0	NAF
22	WNRC197	pisolitic	2	4	2.0	8.3	0.376	0.01	0	6	-6	20	7.5	0	0	NAF
23	WNRC197	mudstone-siltstone	4	8	4.0	8.2	0.276	0.01	0	5	-5	16	6.1	0	9	NAF (Barren)
24	WNRC197	mudstone c chert	8	12	4.0	8.1	0.311	0.03	1	4	-3	4	5.9	0	10	NAF (Barren)
25	WNRC197	cherty sandstone	12	14	2.0	7.8	0.198	0.03	1	11	-10	12	6.1	0	6	NAF
26	WNRC197	basalt	21	25	4.0	8.4	0.416	0.02	1	19	-18	31	7.3	0	0	NAF
27	WNRC203	mudstone c chert	3	7	4.0	7.7	0.321	0.03	1	5	-4	5	6.1	0	7	NAF (Barren)
28	WNRC203	mudstone c chert	7	11	4.0	8.2	0.412	0.06	2	5	-3	3	6.2	0	7	NAF
29	WNRC203	chert sandstone	11	14	3.0	7.5	0.329	0.06	2	5	-3	3	6.1	0	6	NAF
30	WNRC203	phosphatic mudstone	14	17	3.0	8.4	0.407	0.02	1	26	-25	42	7.3	0	0	NAF
31	WNRC203	weathered basalt	19	24	5.0	7.7	0.311	<0.01	0	24	-24	78	8.2	0	0	NAF

Table 1: Acid forming characteristics of composite waste rock samples from the Arruwurra Prospect.

Composite Number	Hole No.	Lithology	Depth (m)		Interval (m)	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
			From	To				Total %S	MPA	ANC	NAPP	ANC/MPA Ratio	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
32	WNRC210	mudstone	3	8	5.0	6.8	0.276	<0.01	0	5	-5	16	6.2	0	7	NAF (Barren)
33	WNRC210	mudstone	8	12	4.0	7.8	0.356	<0.01	0	4	-4	13	5.9	0	10	NAF (Barren)
34	WNRC210	cherty sandstone and mudstone	12	16	4.0	8.5	0.281	0.04	1	37	-36	30	6.9	0	0	NAF
35	WNRC210	mudstone c chert	16	19	3.0	7.9	0.198	0.04	1	36	-35	29	6.4	0	6	NAF
36	WNRC210	weathered basalt	22	25	3.0	7.8	0.235	0.02	1	29	-28	47	6.9	0	0	NAF
37	WNRC212	mudstone	1	4	3.0	7.7	0.324	0.02	1	37	-36	60	7.5	0	0	NAF
38	WNRC212	mudstone-siltstone	4	8	4.0	8.2	0.276	0.02	1	8	-7	13	7.1	0	0	NAF
39	WNRC212	mudstone-siltstone	8	12	4.0	6.9	0.319	0.03	1	30	-29	33	6.9	0	0	NAF
40	WNRC212	cherty sandstone and mudstone	12	15	3.0	7.5	0.415	0.10	3	46	-43	15	7.6	0	0	NAF
41	WNRC217	ferricrete	1	3	2.0	6.9	0.266	0.03	1	8	-7	9	7.5	0	0	NAF
42	WNRC217	mudstone	3	8	5.0	7.8	0.346	0.06	2	52	-50	28	8.2	0	0	NAF
43	WNRC217	mudstone c chert	8	11	3.0	7.9	0.309	0.04	1	60	-59	49	6.1	0	10	NAF
44	WNRC252	mudstone	4	9	5.0	8.3	0.235	0.04	1	31	-30	25	7.6	0	0	NAF
45	WNRC252	mudstone>siltstone	9	14	5.0	6.7	0.616	0.05	2	63	-61	41	6.9	0	0	NAF
46	WNRC252	mudstone-siltstone	14	19	5.0	6.8	0.529	0.04	1	7	-6	6	5.7	0	11	NAF
47	WNRC252	palaeoregolith/weathered basalt	30	34	4.0	6.9	0.721	0.02	1	8	-7	13	5.7	0	8	NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF-LC = PAF - lower capacity
UC = Uncertain Classification
(expected classification in brackets)

Table 2: Multi-element composition of selected solids samples (mg/kg except where shown) - Arruwurra Prospect.

Element	Detection Limit	Composite Number / Hole ID / Lithology							
		5	8	13	21	25	40	42	45
		WNRC013	WNRC089	WNRC091	WNRC094	WNRC197	WNRC212	WNRC217	WNRC252
		calcrete	phosphatic muddy siltstone	siltstone/ mudstone	basalt	cherty sandstone	cherty sandstone and mudstone	mudstone	mudstone> siltstone
Ag	0.02	0.18	0.36	0.19	0.12	0.55	0.33	0.38	0.42
Al	0.01%	2.73%	5.61%	5.55%	6.78%	3.70%	3.82%	6.47%	2.12%
As	0.2	2	1.2	2	6.5	2.3	3.5	3.7	4
Ba	10	730	1550	520	230	500	210	780	160
Be	0.05	1.44	4.21	3.04	6.91	3.44	6.71	9.52	4.54
Bi	0.01	0.15	0.3	0.2	0.07	0.12	0.16	0.23	0.1
Ca	0.01%	9.18%	6.39%	0.12%	0.99%	0.20%	16.25%	3.83%	13.30%
Cd	0.02	0.12	0.31	<0.02	0.29	<0.02	0.42	0.12	0.63
Co	0.1	5	5.1	1.6	51.4	1.3	15.2	31.5	6.1
Cr	1	28	43	48	49	65	61	113	27
Cu	0.2	26.4	51.4	11.7	309	29	72.1	83.8	22.3
Fe	0.01%	0.73%	0.40%	0.47%	9.03%	0.45%	0.65%	0.51%	0.84%
Ga	10	10	10	10	10	10	10	10	<10
Hg	0.01	0.011	0.024	0.007	0.031	0.01	0.052	0.027	0.013
K	0.002%	0.54%	0.82%	1.24%	2.54%	0.34%	0.21%	0.18%	0.44%
La	10	30	30	40	20	30	40	40	10
Mg	0.002%	0.36%	0.52%	0.36%	0.73%	0.16%	0.22%	0.41%	0.14%
Mn	1.0	315	334	40	1330	20	472	1220	148
Mo	0.1	0.84	0.31	0.17	0.66	3.39	1.39	2.06	0.9
Na	0.002%	0.03%	0.09%	0.04%	0.05%	0.05%	0.11%	0.10%	0.04%
Ni	1.0	15.1	10.6	7.7	89.9	8.6	21.3	15.8	21.5
P	20	9390	29000	850	3530	1710	>50000	24500	>50000
Pb	2.0	44.4	135.5	35.2	22.7	70.7	57.8	123.5	18.1
S	0.001%	0.05%	0.07%	0.02%	0.02%	0.04%	0.12%	0.06%	0.05%
Sb	0.05	1.08	0.57	0.61	0.49	0.29	0.61	0.47	0.37
Sc	1	9	13	10	35	19	10	28	11
Se	0.01	2.2	2.3	1.3	1.9	2.5	2.6	4.3	1.4
Sn	0.1	1.5	2.5	3	1.3	1.2	1	2.3	1.1
Sr	0.05	79	112	190	55	328	150	735	66
Th	0.2	7	10.7	12	5.7	7.4	6.8	9.7	6.3
Ti	0.01%	0.14%	0.26%	0.26%	0.55%	0.12%	0.07%	0.23%	0.04%
Tl	0.02	0.18	0.41	0.33	1.08	0.13	0.2	1.93	0.2
U	0.01	2.6	11.6	3.3	2.6	4.7	12.1	13.1	24.1
V	2.0	43	68	80	292	53	64	62	56
W	0.1	1.3	2	2	1.2	2.4	1	2.2	0.9
Zn	1.0	66	38	19	205	39	52	22	99

< element at or below analytical detection limit.

Table 3: Geochemical abundance indices (GAI) of selected solids samples - Arruwurra Prospect.

Element	Median Soil Abundance*	Sample Number							
		5	8	13	21	25	40	42	45
		WNRC013	WNRC089	WNRC091	WNRC094	WNRC197	WNRC212	WNRC217	WNRC252
		calcrete	phosphatic muddy siltstone	siltstone/ mudstone	basalt	cherty sandstone	cherty sandstone and mudstone	mudstone	mudstone> siltstone
Ag	0.05	1	2	1	1	3	2	2	2
Al	7.1%	-	-	-	-	-	-	-	-
As	6	-	-	-	-	-	-	-	-
Ba	500	-	1	-	-	-	-	-	-
Be	0.3	2	3	3	4	3	4	4	3
Bi	0.2	-	-	-	-	-	-	-	-
Ca	1.5%	2	2	-	-	-	3	1	3
Cd	0.35	-	-	-	-	-	-	-	-
Co	8	-	-	-	2	-	-	1	-
Cr	70	-	-	-	-	-	-	-	-
Cu	30	-	-	-	3	-	1	1	-
Fe	4.0%	-	-	-	1	-	-	-	-
Ga	20	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-
La	40	-	-	-	-	-	-	-	-
Mg	0.5%	-	-	-	-	-	-	-	-
Mn	1000	-	-	-	-	-	-	-	-
Mo	1.2	-	-	-	-	1	-	-	-
Na	0.5%	-	-	-	-	-	-	-	-
Ni	50	-	-	-	-	-	-	-	-
P	800	3	5	-	2	1	>5	4	>5
Pb	35	-	1	-	-	-	-	1	-
S	0.07%	-	-	-	-	-	-	-	-
Sb	1	-	-	-	-	-	-	-	-
Sc	7	-	-	-	2	1	-	1	-
Se	0.4	2	2	1	2	2	2	3	1
Sn	4	-	-	-	-	-	-	-	-
Sr	250	-	-	-	-	-	-	1	-
Th	9	-	-	-	-	-	-	-	-
Ti	0.50%	-	-	-	-	-	-	-	-
Tl	0.2	-	-	-	2	-	-	3	-
U	2	-	2	-	-	1	2	2	3
V	90	-	-	-	1	-	-	-	-
W	1.5	-	-	-	-	-	-	-	-
Zn	90	-	-	-	1	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 4: Chemical composition of water extracts of selected samples - Arruwurra Prospect.

Parameter		Detection Limit	Composite Number / Hole ID / Lithology							
			5	8	13	21	25	40	42	45
			WNRC013	WNRC089	WNRC091	WNRC094	WNRC197	WNRC212	WNRC217	WNRC252
			calcrete	phosphatic muddy siltstone	siltstone/ mudstone	basalt	cherty sandstone	cherty sandstone and mudstone	mudstone	mudstone> siltstone
pH		0.01	8.1	8.3	6.7	7.5	7.9	7.6	7.6	6.8
EC	dS/m	0.01	0.149	0.219	0.161	0.251	0.21	0.429	0.355	0.626
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.80	0.67	3.93	0.96	0.36	0.12	0.20	0.22
As	mg/l	0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001
B	mg/l	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	mg/l	0.001	0.115	0.054	0.106	0.019	0.037	0.022	0.030	0.006
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/l	1	19	6	3	6	3	12	8	2
Cd	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	1	3	56	16	23	48	63	97	7
Co	mg/l	0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	0.001	0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.001	<0.001
Cu	mg/l	0.001	0.003	0.002	0.004	0.013	0.004	0.002	0.002	0.002
F	mg/l	0.1	2.4	2.9	1.1	0.8	1.1	2.1	2.2	2.6
Fe	mg/l	0.05	0.23	0.17	0.52	0.48	0.36	0.09	<0.05	0.36
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	8	5	7	6	6	6	4	5
Mg	mg/l	1	2	3	2	5	4	5	7	2
Mn	mg/l	0.001	0.010	0.004	0.031	0.075	0.008	0.001	0.004	0.004
Mo	mg/l	0.001	0.001	<0.001	<0.001	<0.001	0.004	0.003	0.003	0.001
Na	mg/l	1	2	57	16	19	26	35	59	9
Ni	mg/l	0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
P	mg/l	1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/l	0.001	0.001	<0.001	0.003	0.002	<0.001	<0.001	<0.001	<0.001
SO_4	mg/l	1	12	26	10	39	16	17	25	10
Sb	mg/l	0.001	0.006	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/l	0.1	7.5	6.9	7.7	9.3	4.6	5.4	7.1	3.0
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sr	mg/l	0.001	0.044	0.041	0.046	0.054	0.079	0.116	0.092	0.017
Th	mg/l	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/l	0.005	<0.005	<0.005	0.050	0.013	0.006	<0.005	<0.005	<0.005

< element at or below analytical detection limit.

Table 5: Acid forming characteristics of waste rock composite samples from the Main Zone.

Comp. No.	Hole No.	Lithology	Depth (m)		Interval (m)	$pH_{1:2}$	$EC_{1:2}$ (dS/m)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
			From	To				Total %S	MPA	ANC	NAPP	ANC/MPA Ratio	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
1	WNRC295	aeolian sand	0	3	3.0			<0.01	0	1	-1	3.3				NAF (Barren)
2	WNRC295	silty mudstone	5	10	5.0			0.03	1	1	0	1.1				NAF (Barren)
3	WNRC295	cherty sandstone	22	27	5.0	7.3	0.107	0.04	1	0	1	0.0	5.1	0	12	UC (NAF)
4	WNRC295	cherty sandstone/mudstone	30	35	5.0			0.02	1	1	0	1.6				NAF (Barren)
5	WNRC295	mudstone c chert	44	48	4.0			0.03	1	14	-13	15.3				UC (NAF)
6	WNRC313	mudstone/siltstone	4	9	5.0			0.01	0	1	-1	3.3				NAF (Barren)
7	WNRC313	mudstone/siltstone	12	17	5.0			<0.01	0	1	-1	3.3				NAF (Barren)
8	WNRC313	cherty sandstone and mudstone	25	30	5.0			0.02	1	0	1	0.0				NAF (Barren)
9	WNRC313	mudstone/siltstone c chert	36	40	4.0	7.4	0.114	0.02	1	3	-2	4.9				NAF (Barren)
10	WNRC313	weathered basalt	51	54	3.0			<0.01	0	18	-18	58.8				UC (NAF)
11	WNRC326	pisolitic regolith	0	3	3.0			<0.01	0	1	-1	3.3				NAF (Barren)
12	WNRC326	cherty/ferruginous silty mudstone	8	13	5.0			0.04	1	4	-3	3.3				NAF (Barren)
13	WNRC326	cherty mudstone	17	22	5.0			0.04	1	1	0	0.8				NAF (Barren)
14	WNRC326	weakly phosphatic mudstone	27	31	4.0	7.5	0.092	0.04	1	9	-8	7.4				UC (NAF)
15	WNRC326	weakly phosphatic c breccia	44	49	5.0			0.05	2	12	-10	7.8	5.6	0	10	NAF
16	WNRC326	cherty mudstone	49	53	4.0	7.6	0.121	0.13	4	12	-8	3.0	7.8	0	0	NAF
17	WNRC346	silcrete breccia	0	5	5.0			<0.01	0	1	-1	3.3				NAF (Barren)
18	WNRC346	siltstone-sandstone	7	12	5.0			0.01	0	1	-1	3.3				NAF (Barren)
19	WNRC346	mudstone-siltstone	13	18	5.0	7.7	0.146	0.07	2	0	2	0.0	5.2	0	12	UC (NAF)
20	WNRC346	mudstone-cherty sandstone	20	25	5.0			0.03	1	1	0	1.1				NAF (Barren)
21	WNRC346	phosphatic mudstone	41	46	5.0			0.02	1	14	-13	22.9				UC (NAF)
22	WNRC372	ferruginous silty mudstone	6	11	5.0			0.02	1	1	0	1.6				NAF (Barren)
23	WNRC372	mudstone	11	16	5.0	7.2	0.109	0.05	2	1	1	0.7	5.8	0	10	UC (NAF)
24	WNRC372	mudstone	16	21	5.0			0.03	1	1	0	1.1				NAF (Barren)
25	WNRC372	mudstone and cherty sandstone	26	31	5.0			<0.01	0	1	-1	3.3				NAF (Barren)
26	WNRC372	weakly phosphatic mudstone	42	46	4.0			0.02	1	16	-15	26.1				UC (NAF)
27	WNRC389	muddy siltstone	4	9	5.0			0.02	1	2	-1	3.3				NAF (Barren)
28	WNRC389	mudstone with chert sandstone	13	18	5.0			0.04	1	1	0	0.8				NAF (Barren)
29	WNRC389	mudstone with minor siltstone	19	24	5.0			0.03	1	1	0	1.1				NAF (Barren)
30	WNRC389	phosphatic cherty mudstone	25	27	2.0	7.4	0.111	0.10	3	6	-3	2.0	5.2	0	15	NAF

Table 5: Acid forming characteristics of waste rock composite samples from the Main Zone.

Comp. No.	Hole No.	Lithology	Depth (m)		Interval (m)	$pH_{1:2}$	$EC_{1:2}$ (dS/m)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
			From	To				Total %S	MPA	ANC	NAPP	ANC/MPA Ratio	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
31	WNRC389	weakly phosphatic chert breccia	33	38	5.0	7.1	0.131	0.08	2	15	-13	6.1	5.6	0	11	NAF
32	WNRC389	phosphatic mudstone	38	41	3.0			0.05	2	18	-16	11.8				UC (NAF)
33	WNRC418	silcrete breccia	0	5	5.0			<0.01	0	1	-1	3.3				NAF (Barren)
34	WNRC418	mudstone with minor siltstone	10	15	5.0	7.3	0.124	0.07	2	1	1	0.5	4.9	0	14	UC (NAF)
35	WNRC418	mudstone with minor chert	17	22	5.0			0.05	2	1	1	0.7	5.0	0	15	UC (NAF)
36	WNRC418	mudstone-siltstone	22	28	6.0			0.02	1	1	0	1.6				NAF (Barren)
37	WNRC418	clay-rich phosphatic mudstone	42	45	3.0			0.04	1	14	-13	11.4				UC (NAF)
38	WNRC429	mudstone	9	14	5.0			0.04	1	1	0	0.8				NAF (Barren)
39	WNRC429	mudstone with minor chert	22	27	5.0	7.2	0.122	0.06	2	1	1	0.5	5.1	0	14	UC (NAF)
40	WNRC429	mudstone with minor chert	37	42	5.0			0.02	1	1	0	1.6				NAF (Barren)
41	WNRC429	weathered basalt	53	58	5.0			<0.01	0	19	-19	62.1				UC (NAF)
42	WNRC481	ferruginous silcrete	0	3	3.0	7.5	0.088	0.01	0	1	-1	3.3				NAF (Barren)
43	WNRC481	silty mudstone	7	12	5.0			0.03	1	1	0	1.1				NAF (Barren)
44	WNRC481	silty-mudstone c cherty sandstone	19	24	5.0			0.05	2	1	1	0.7	5.0	0	17	UC (NAF)
45	WNRC481	mudstone	30	35	5.0			0.03	1	1	0	1.1				NAF (Barren)
46	WNRC481	cherty phosphatic mudstone	48	51	3.0			0.02	1	15	-14	24.5				UC (NAF)
47	WNRC532	silcrete breccia	2	6	4.0			<0.01	0	2	-2	6.5				NAF (Barren)
48	WNRC532	mudstone c minor cherty sandstone	6	11	5.0			0.02	1	1	0	1.6				NAF (Barren)
49	WNRC532	silty mudstone	15	20	5.0			0.04	1	1	0	0.8				NAF (Barren)
50	WNRC532	cherty mudstone	25	30	5.0			0.05	2	1	1	0.7	5.4	0	11	UC (NAF)
51	WNRC532	weathered basalt	55	59	4.0	7.4	0.125	<0.01	0	13	-13	42.5				UC (NAF)

KEY

MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF-LC = PAF - lower capacity
UC = Uncertain Classification
(expected classification in brackets)

Table 6: Multi-element composition of selected solids samples (mg/kg except where shown) - Main Zone.

Element	Detection Limit	Composite Number/ Hole ID/ Lithology											
		3	9	14	16	19	23	30	31	34	39	42	51
		WNRC295	WNRC313	WNRC326	WNRC326	WNRC346	WNRC372	WNRC389	WNRC389	WNRC418	WNRC429	WNRC481	WNRC532
		cherty sandstone	mudstone/silt stone c chert	weakly phosphatic mudstone	cherty mudstone	mudstone-siltstone	mudstone	phosphatic cherty mudstone	weakly phosphatic chert breccia	mudstone with minor siltstone	mudstone with minor chert	ferruginous silcrete	weathered basalt
Ag	0.02	0.11	0.43	0.26	0.23	0.03	<0.01	1.69	0.38	0.03	0.05	0.23	0.04
Al	0.01%	4.10%	4.70%	2.50%	4.05%	5.52%	4.84%	5.77%	3.92%	3.54%	2.97%	3.74%	7.17%
As	0.2	1.1	0.9	1.9	12.6	0.6	3.5	3.7	2.2	0.3	0.8	7.7	0.3
Ba	10	280	420	360	880	580	330	940	280	660	330	450	150
Be	0.05	1.51	7.55	4.34	4.38	1.74	2.15	11.30	5.26	1.10	1.42	1.15	1.14
Bi	0.01	0.13	0.20	0.10	0.22	0.13	0.12	0.33	0.14	0.04	0.06	0.17	0.06
Ca	0.01%	0.10%	0.51%	1.17%	1.06%	0.11%	0.08%	1.82%	8.57%	0.09%	0.11%	0.03%	0.52%
Cd	0.02	0.04	0.05	0.13	4.45	<0.02	<0.02	0.07	1.17	<0.02	<0.02	<0.02	0.37
Co	0.1	2.2	18.5	17.8	26.6	0.5	0.9	0.8	5.9	0.4	1.0	2.9	48.5
Cr	1	35	37	21	55	23	30	42	41	21	18	127	31
Cu	0.2	17.5	37.7	29.4	85.0	2.1	3.2	44.2	44.5	6.1	9.8	12.3	142.5
Fe	0.01%	0.33%	0.38%	0.39%	2.83%	0.32%	0.36%	0.57%	0.94%	0.30%	0.27%	5.16%	5.94%
Ga	10	8.50	12.35	6.54	14.15	14.80	12.45	13.70	9.44	8.19	6.93	13.55	17.75
Hg	0.01	0.007	0.007	0.007	0.052	0.006	<0.005	0.097	0.014	<0.005	0.005	0.009	0.032
K	0.002%	0.37%	0.97%	0.46%	0.78%	0.55%	0.59%	0.73%	0.66%	0.34%	0.42%	0.13%	2.44%
La	10	46	58	27	26	79	58	104	28	55	32	20	16
Mg	0.002%	0.07%	0.17%	0.09%	0.41%	0.10%	0.11%	0.12%	0.18%	0.06%	0.08%	0.04%	5.21%
Mn	1.0	15	177	325	18100	18	43	26	185	8	28	73	905
Mo	0.1	0.91	0.49	1.03	2.81	0.40	0.21	1.15	1.94	0.13	0.53	0.99	0.27
Na	0.002%	0.03%	0.04%	0.03%	0.05%	0.03%	0.04%	0.04%	0.04%	0.03%	0.03%	0.02%	0.04%
Ni	1.0	11.1	7.1	14.6	135.5	3.3	5.1	4	13.9	3.8	5.4	13.1	88.5
P	20	1370	5520	7630	4470	1670	1110	23300	43400	1330	1370	150	830
Pb	2.0	30	51	44	455	17	9	482	243	8	8	32	7
S	0.001%	0.05%	0.02%	0.05%	0.02%	0.08%	0.06%	0.13%	0.09%	0.07%	0.05%	0.03%	0.01%
Sb	0.05	0.41	0.19	0.25	2.05	0.41	0.38	1.34	0.97	0.18	0.24	0.52	<0.05
Sc	1	5.7	22.0	7.1	12.1	7.1	7.0	31.3	13.1	6.5	15.1	6.8	38.3
Se	0.01	1	1	<1	1	1	1	3	1	1	1	1	1
Sn	0.1	2.3	1.9	1.4	2.4	4.6	4.2	3.5	1.8	2.1	2.2	2.1	1.3
Sr	0.05	326	506	450	43	534	323	1690	673	729	450	59	25
Th	0.2	15.1	10.3	4.4	9.7	20.4	17.2	13.9	10.4	17.2	8.7	8.0	5.0
Ti	0.01%	0.21%	0.14%	0.10%	0.26%	0.39%	0.35%	0.23%	0.15%	0.17%	0.19%	0.32%	0.58%
Tl	0.02	0.13	0.35	0.69	0.87	0.14	0.18	0.31	0.30	0.11	0.18	0.13	0.36
U	0.01	5.2	16.7	6.0	4.8	5.3	3.6	50.4	21.8	4.1	3.3	1.4	1.1
V	2.0	29	68	49	232	31	60	68	90	26	23	119	234
W	0.1	1.6	1.2	1.2	2.4	1.9	1.8	1.8	2.2	1.2	1.3	1.6	0.7
Zn	1.0	27	30	66	1120	7	8	76	112	8	12	11	472

< element at or below analytical detection limit.

Table 7: Geochemical abundance indices (GAI) of selected solids samples - Main Zone.

Element	Median Soil Abundance*	Composite Number/ Drill Hole/ Lithology											
		3	9	14	16	19	23	30	31	34	39	42	51
		WNRC295	WNRC313	WNRC326	WNRC326	WNRC346	WNRC372	WNRC389	WNRC389	WNRC418	WNRC429	WNRC481	WNRC532
		cherty sandstone	mudstone/siltstone c chert	weakly phosphatic mudstone	cherty mudstone	mudstone-siltstone	mudstone	phosphatic cherty mudstone	weakly phosphatic chert breccia	mudstone with minor siltstone	mudstone with minor chert	ferruginous silcrete	weathered basalt
Ag	0.05	1	**3**	2	2	-	-	**4**	2	-	-	2	-
Al	7.1%	-	-	-	-	-	-	-	-	-	-	-	-
As	6	-	-	-	-	-	-	-	-	-	-	-	-
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-
Be	0.3	2	**4**	**3**	**3**	2	2	**5**	**4**	1	2	1	1
Bi	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Ca	1.5%	-	-	-	-	-	-	-	2	-	-	-	-
Cd	0.35	-	-	-	**3**	-	-	-	1	-	-	-	-
Co	8	-	1	1	1	-	-	-	-	-	-	-	2
Cr	70	-	-	-	-	-	-	-	-	-	-	-	-
Cu	30	-	-	-	1	-	-	-	-	-	-	-	2
Fe	4.0%	-	-	-	-	-	-	-	-	-	-	-	-
Ga	20	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-	-	-	-	-
La	40	-	-	-	-	-	-	1	-	-	-	-	-
Mg	0.5%	-	-	-	-	-	-	-	-	-	-	-	**3**
Mn	1000	-	-	-	**4**	-	-	-	-	-	-	-	-
Mo	1.2	-	-	-	1	-	-	-	-	-	-	-	-
Na	0.5%	-	-	-	-	-	-	-	-	-	-	-	-
Ni	50	-	-	-	1	-	-	-	-	-	-	-	-
P	800	-	2	**3**	2	-	-	**4**	**5**	-	-	-	-
Pb	35	-	-	-	**3**	-	-	**3**	2	-	-	-	-
S	0.07%	-	-	-	-	-	-	-	-	-	-	-	-
Sb	1	-	-	-	-	-	-	-	-	-	-	-	-
Sc	7	-	1	-	-	-	-	2	-	-	1	-	2
Se	0.4	1	1	1	1	1	1	2	1	1	1	1	1
Sn	4	-	-	-	-	-	-	-	-	-	-	-	-
Sr	250	-	-	-	-	1	-	2	1	1	-	-	-
Th	9	-	-	-	-	1	-	-	-	-	-	-	-
Ti	0.50%	-	-	-	-	-	-	-	-	-	-	-	-
Tl	0.2	-	-	1	2	-	-	-	-	-	-	-	-
U	2	1	2	1	1	1	-	**4**	**3**	-	-	-	-
V	90	-	-	-	1	-	-	-	-	-	-	-	1
W	1.5	-	-	-	-	-	-	-	-	-	-	-	-
Zn	90	-	-	-	**3**	-	-	-	-	-	-	-	2

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 8: Chemical composition of water extracts of selected waste rock composite samples from the Main Zone.

Parameter		Detection Limit	Composite Numer/ Hole ID/ Lithology											
			3	9	14	16	19	23	30	31	34	39	42	51
			WNRC295	WNRC313	WNRC326	WNRC326	WNRC346	WNRC372	WNRC389	WNRC389	WNRC418	WNRC429	WNRC481	WNRC532
			cherty sandstone	mudstone/ siltstone c chert	weakly phosphatic mudstone	cherty mudstone	mudstone-siltstone	mudstone	phosphatic cherty mudstone	weakly phosphatic chert breccia	mudstone with minor siltstone	mudstone with minor chert	ferruginous silcrete	weathered basalt
pH		0.01	7.3	7.4	7.5	7.6	7.7	7.2	7.4	7.1	7.3	7.2	7.5	7.4
EC	dS/m	0.01	0.107	0.114	0.092	0.121	0.146	0.109	0.111	0.131	0.124	0.122	0.088	0.125
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.50	0.24	0.29	0.54	0.32	0.14	0.45	0.97	0.52	0.60	0.24	0.43
As	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
B	mg/l	0.05	0.68	<0.05	<0.05	<0.05	<0.05	0.28	<0.05	<0.05	<0.05	<0.05	0.31	<0.05
Ba	mg/l	0.001	0.009	0.016	0.010	0.067	0.006	0.035	0.008	0.016	0.010	0.008	0.046	0.010
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/l	1	<1	6	2	5	<1	7	<1	9	<1	<1	<1	2
Cd	mg/l	0.0001	0.0001	<0.0001	<0.0001	0.0007	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	1	8	13	22	14	6	24	14	13	6	6	5	12
Co	mg/l	0.001	<0.001	<0.001	0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	0.001	<0.001	<0.001	<0.001	0.007	<0.001	<0.001	<0.001	0.001	0.001	0.001	<0.001	<0.001
Cu	mg/l	0.001	0.008	0.002	0.004	0.014	0.003	0.001	0.006	0.009	0.002	0.004	0.002	0.003
F	mg/l	0.1	0.6	2.0	1.0	1.0	1.1	2.0	1.3	1.6	1.0	1.4	0.2	1.0
Fe	mg/l	0.05	<0.05	<0.05	<0.05	0.36	<0.05	<0.05	<0.05	0.17	0.05	0.06	<0.05	<0.05
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	3	2	5	6	2	3	5	5	2	2	2	4
Mg	mg/l	1	<1	2	2	4	<1	3	<1	1	<1	<1	<1	1
Mn	mg/l	0.001	0.005	0.007	0.032	1.26	0.012	0.003	0.002	0.01	0.002	0.003	0.006	0.011
Mo	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001
Na	mg/l	1	7	12	12	14	6	19	7	8	7	8	6	10
Ni	mg/l	0.001	<0.001	<0.001	<0.001	0.018	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
P	mg/l	1	<1	1	<1	<1	<1	<1	<1	4	<1	<1	<1	<1
Pb	mg/l	0.001	<0.001	0.002	0.001	0.008	<0.001	<0.001	0.002	0.007	<0.001	<0.001	<0.001	<0.001
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/l	0.05	8.79	4.53	12.8	3.84	31.6	3.84	11.4	3.01	3.21	2.64	4.82	16.4
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO_4	mg/l	1	7	6	7	11	<1	14	9	11	3	2	3	5
Sr	mg/l	0.001	0.019	0.030	0.025	0.012	0.006	0.070	0.015	0.050	0.012	0.023	0.014	0.021
Th	mg/l	0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Zn	mg/l	0.005	0.02	<0.005	0.013	0.174	0.006	<0.005	0.008	0.018	0.005	0.006	0.007	0.005

< element at or below analytical detection limit.

Table 9: Acid forming characteristics of low-grade ore from the Arruwurrua Prospect and Main Zone.

Comp. No.	Hole No.	Deposit	Lithology	Depth (m)		Interval (m)	$pH_{1:2}$	$EC_{1:2}$ (dS/m)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
				From	To				Total %S	MPA	ANC	NAPP	ANC/MPA Ratio	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
52	WNRC210	Arruwurra Prospect	non-DSO phosphorite	15	18	3.0			0.03	1	16	-15	17.4				UC (NAF)
53	WNRC211		non-DSO phosphorite	12	16	4.0	7.8	0.092	0.09	3	24	-21	8.7	6.1	0	7	NAF
54	WNRC217		non-DSO phosphorite	8	10	2.0			0.05	2	27	-25	17.6				UC (NAF)
55	WNRC218		non-DSO phosphorite	14	18	4.0			0.07	2	26	-24	12.1				UC (NAF)
56	WNRC219		non-DSO phosphorite	9	13	4.0	7.2	0.129	0.15	5	28	-23	6.1	7.2	0	0	NAF
57	WNRC226		non-DSO phosphorite	4	9	5.0			0.09	3	28	-25	10.2				UC (NAF)
58	WNRC227		non-DSO phosphorite	13	17	4.0	7.9	0.146	0.11	3	25	-22	7.4	7.4	0	0	NAF
59	WNRC726		non-DSO phosphorite	10	12	2.0			0.14	4	25	-21	5.8	5.9	0	12	NAF
60	WNRC752		non-DSO phosphorite	7	11	4.0			0.10	3	25	-22	8.2				UC (NAF)
61	WNRC756		non-DSO phosphorite	9	11	2.0	7.2	0.096	0.04	1	24	-23	19.6				UC (NAF)
62	WNRC290	Main Zone	non-DSO phosphorite	32	34	2.0			0.06	2	23	-21	12.5				UC (NAF)
63	WNRC313		non-DSO phosphorite	40	42	2.0	7.5	0.117	0.07	2	23	-21	10.7	5.7	0	10	NAF
64	WNRC326		non-DSO phosphorite	31	35	4.0	7.6	0.124	0.03	1	22	-21	24.0				UC (NAF)
65	WNRC330		non-DSO phosphorite	38	41	3.0			0.04	1	28	-27	22.9				UC (NAF)
66	WNRC337		non-DSO phosphorite	30	32	2.0			0.09	3	15	-12	5.4	5.6	0	10	NAF
67	WNRC345		non-DSO phosphorite	37	39	2.0			0.06	2	14	-12	7.6				UC (NAF)
68	WNRC346		non-DSO phosphorite	29	31	2.0	7.6	0.099	0.19	6	14	-8	2.4	5.3	0	12	NAF
69	WNRC408		non-DSO phosphorite	30	38	8.0			0.06	2	15	-13	8.2				UC (NAF)
70	WNRC477		non-DSO phosphorite	44	47	3.0			0.07	2	23	-21	10.7				UC (NAF)
71	WNRC533		non-DSO phosphorite	41	43	2.0	7.7	0.087	0.05	2	16	-14	10.5	7.2	0	0	NAF

KEY

MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming
UC = Uncertain Classification
(expected classification in brackets)

Table 10: Multi-element composition of selected low grade ore samples (mg/kg except where shown).

Element	Detection Limit	Composite Number/ Hole ID/ Lithology							
		Arruwurra Prospect				**Main Zone**			
		53	56	58	61	63	64	68	71
		WNRC211	WNRC219	WNRC227	WNRC756	WNRC313	WNRC326	WNRC346	WNRC533
		non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite
Ag	0.02	0.26	0.33	0.28	0.30	0.79	0.17	0.36	0.33
Al	0.01%	1.61%	1.97%	1.07%	3.19%	2.70%	2.32%	7.91%	2.77%
As	0.2	5.0	5.0	5.0	5.0	9.0	5	0.9	7.0
Ba	10	170	280	240	120	140	210	1060	910
Be	0.05	4.06	6.15	4.40	4.58	9.87	6.24	27.70	12.50
Bi	0.01	0.06	0.07	0.04	0.13	0.17	0.13	0.16	0.10
Ca	0.01%	11.15%	19.30%	18.05%	17.90%	14.05%	16.70%	6.84%	18.85%
Cd	0.02	0.49	0.34	0.59	0.86	1.84	1.58	0.63	2.51
Co	0.1	20.1	15.0	14.8	2.6	2.6	5.7	1.8	87.8
Cr	1	23	30	16	35	27	71	81	55
Cu	0.2	31.4	18.4	33.9	19.9	53.5	18.5	26.8	47.4
Fe	0.01%	0.16%	0.31%	0.28%	0.19%	0.29%	0.27%	0.42%	0.64%
Ga	10	3.53	5.33	2.63	6.84	7.90	6.1	13.15	8.29
Hg	0.01	0.016	0.024	0.034	0.014	0.017	0.02	0.034	0.031
K	0.002%	0.22%	0.20%	0.15%	0.31%	0.55%	0.32%	0.62%	0.29%
La	10	20	46	20	25	55	47.3	81	39
Mg	0.002%	0.10%	0.15%	0.08%	0.22%	0.11%	0.06%	0.08%	0.11%
Mn	1.0	268	599	1040	98	101	191	84	2510
Mo	0.1	0.42	0.73	1.47	0.24	0.30	1.65	0.84	0.92
Na	0.002%	0.07%	0.14%	0.09%	0.05%	0.06%	0.03%	0.05%	0.06%
Ni	1.0	5.5	7.9	5.7	7	4.6	24	3.6	61.1
P	20	>50000	>50000	>50000	>50000	>50000	>50000	>50000	>50000
Pb	2.0	78	126	44	100	345	82.3	93	106
S	0.001%	0.08%	0.16%	0.09%	0.03%	0.06%	0.03%	0.14%	0.05%
Sb	0.05	0.17	0.15	0.09	0.25	0.24	0.4	0.54	0.51
Sc	1	3.8	8.0	5.5	10.0	10.4	13	50.5	41.2
Se	0.01	<1	1	1	1	1	1	3	2
Sn	0.1	0.5	0.8	0.5	1.1	1.3	1.2	2.5	1.5
Sr	0.05	81	244	125	47	162	332	2200	1670
Th	0.2	2.8	3.5	2.4	6.0	6.7	6.5	16.7	6.5
Ti	0.01%	0.02%	0.02%	0.02%	0.04%	0.05%	0.02%	0.14%	0.06%
Tl	0.02	0.12	0.26	0.19	0.17	0.20	0.29	0.36	0.97
U	0.01	8.7	9.9	8.7	18.8	21.5	15.9	62.7	54.1
V	2.0	26	30	33	34	43	37	45	109
W	0.1	0.6	0.7	0.5	0.9	0.9	1.2	1.6	1.6
Zn	1.0	20	30	66	23	76	153	124	275

< element at or below analytical detection limit.

Table 11: Geochemical abundance indices (GAI) of selected low grade ore samples.

Element	Median Soil Abundance*	Composite Number/ Hole ID/ Lithology							
		Arruwurra Prospect				**Main Zone**			
		53	56	58	61	63	64	68	71
		WNRC211	WNRC219	WNRC227	WNRC756	WNRC313	WNRC326	WNRC346	WNRC533
		non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite
Ag	0.05	2	2	2	2	**3**	1	2	2
Al	7.1%	-	-	-	-	-	-	-	-
As	**6**	-	-	-	-	-	-	-	-
Ba	**500**	-	-	-	-	-	-	-	-
Be	0.3	**3**	**4**	**3**	**3**	**4**	**4**	**6**	**5**
Bi	0.2	-	-	-	-	-	-	-	-
Ca	1.5%	2	**3**	**3**	**3**	**3**	**3**	2	**3**
Cd	0.35	-	-	-	1	2	2	-	2
Co	**8**	1	-	-	-	-	-	-	**3**
Cr	**70**	-	-	-	-	-	-	-	-
Cu	**30**	-	-	-	-	-	-	-	-
Fe	4.0%	-	-	-	-	-	-	-	-
Ga	**20**	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-
La	**40**	-	-	-	-	-	-	-	-
Mg	0.5%	-	-	-	-	-	-	-	-
Mn	**1000**	-	-	-	-	-	-	-	1
Mo	1.2	-	-	-	-	-	-	-	-
Na	0.5%	-	-	-	-	-	-	-	-
Ni	**50**	-	-	-	-	-	-	-	-
P	**800**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Pb	**35**	1	1	-	1	**3**	1	1	1
S	0.07%	-	1	-	-	-	-	-	-
Sb	1	-	-	-	-	-	-	-	-
Sc	**7**	-	-	-	-	-	-	2	2
Se	0.4	1	1	1	1	1	1	2	2
Sn	**4**	-	-	-	-	-	-	-	-
Sr	**250**	-	-	-	-	-	-	**3**	2
Th	**9**	-	-	-	-	-	-	-	-
Ti	0.50%	-	-	-	-	-	-	-	-
Tl	0.2	-	-	-	-	-	-	-	2
U	2	2	2	2	**3**	**3**	2	**4**	**4**
V	**90**	-	-	-	-	-	-	-	-
W	1.5	-	-	-	-	-	-	-	-
Zn	**90**	-	-	-	-	-	-	-	1

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 12: Chemical composition of water extracts of selected low-grade ore samples.

Parameter		Detection Limit	Composite Numer/ Hole ID/ Lithology							
			Aruwurra Prospect				**Main Zone**			
			53	56	58	61	63	64	68	71
			WNRC211	WNRC219	WNRC227	WNRC756	WNRC313	WNRC326	WNRC346	WNRC533
			non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite	non-DSO phosphorite
pH		0.01	7.8	7.2	7.9	7.2	7.5	7.6	7.6	7.7
EC	dS/m	0.01	0.092	0.129	0.146	0.096	0.117	0.124	0.099	0.087
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.01	0.16	0.09	0.05	0.28	0.27	0.26	0.32
As	mg/l	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
B	mg/l	0.05	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	mg/l	0.001	0.565	0.030	0.056	0.027	0.011	0.004	0.002	0.052
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/l	1	11	8	7	7	7	5	2	<1
Cd	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	1	94	35	20	15	19	7	5	7
Co	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/l	0.001	0.002	0.001	0.001	0.001	0.002	0.009	0.004	0.002
F	mg/l	0.1	1.9	1.4	2.5	2.1	2.5	1.2	1.2	0.4
Fe	mg/l	0.05	<0.05	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	7	3	4	2	<1	5	3	2
Mg	mg/l	1	8	4	3	2	2	1	<1	<1
Mn	mg/l	0.001	<0.001	0.002	0.002	0.009	0.001	0.003	0.003	0.006
Mo	mg/l	0.001	0.003	0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Na	mg/l	1	70	24	17	13	18	8	6	6
Ni	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
P	mg/l	1	<1	<1	<1	<1	2	2	<1	<1
Pb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.006	0.001	<0.001
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/l	0.05	7.87	4.59	4.03	3.36	6.53	7.46	8.38	4.65
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO_4	mg/l	1	60	23	8	8	4	7	<1	4
Sr	mg/l	0.001	0.185	0.103	0.065	0.041	0.03	0.006	0.005	0.013
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/l	0.005	0.013	<0.005	<0.005	<0.005	<0.005	0.005	0.006	0.006

< element at or below analytical detection limit.

APPENDIX A

Assessment of Acid Forming Characteristics

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to assess the acid forming characteristics of mine waste materials. The most widely used methods are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the potential acidity and the acid neutralising capacity, respectively. The difference between the potential acidity and the acid neutralising capacity value is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Potential Acidity

The potential acidity that can be generated by a sample is calculated from an estimate of the pyrite (FeS_2) content and assumes that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

Based on the above reaction, the potential acidity of a sample containing 1 %S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). The pyrite content estimate can be based on total S and the potential acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

$$\text{MPA (kg } H_2SO_4\text{/t)} = \text{(Total \%S)} \times 30.6$$

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating. The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulphide-sulphur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

Acid Neutralising Capacity (ANC)

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

The NAPP is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, an ANC/MPA ratio of 2 or more signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage.

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure A-1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

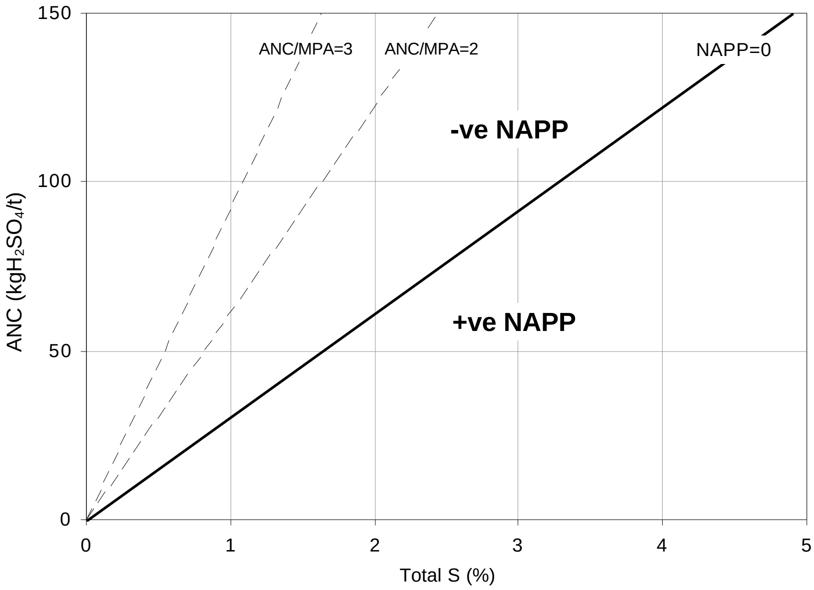


Figure A-1: Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. The end result represents a direct measurement of the net amount of acid generated by the sample. The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The four main NAG test procedures currently used by EGi are the single addition NAG test, the sequential NAG test, the kinetic NAG test, and the extended boil and calculated NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 ml of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the NAGpH and NAG capacity are measured.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at between pH 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (i.e. 2.5 g of sample is reacted two or more times with 250 ml aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials[1] such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides. Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

The extended boil and calculated NAG tests can be used to account for the relative proportions of pyrite derived acidity and organic acidity in a given NAG solution, thus providing a more reliable measure of the acid forming potential of a sample. The procedure involves two steps to differentiating pyritic acid from organic derived acid:

Extended Boil NAG	decompose the organic acids and hence remove the influence of non-pyritic acidity on the NAG solution.
Calculated NAG	calculate the net acid potential based on the balance of cations and anions in the NAG solution, which will not be affected by organic acid.

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 3-4 hours. After the boiling step the solution is cooled and the pH measured. An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure. To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and Cl, from which a calculated NAG value is determined[2].

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4). The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

The calculated NAG value is the amount of acid neutralised subtracted from the amount of acid generated. A positive value indicates that the sample has excess acid generation and is likely to be PAF, and a zero or negative value indicates that the sample has excess neutralising capacity and is likely to be NAF.

---

[1] Stewart, W., Miller, S., Thomas, J.E., and Smart R. (2003), 'Evaluation of the Effects of Organic Matter on the Net Acid Generation (NAG) Test', in *Proceedings of the Sixth International Conference on Acid Rock drainage (ICARD), Cairns, 12-18th July 2003*, 211-222.

[2] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008.

Sample Classification

The acid forming potential of a sample is classified on the basis of the acid-base and NAG test results into one of the following categories:

- Barren;
- Non-acid forming (NAF);
- Potentially acid forming (PAF); and
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but for hard rock mines it generally applies to materials with a total sulphur content ≤ 0.1 %S and an ANC ≤ 5 kg H_2SO_4/t.

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and the final NAG pH ≥ 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

Figure A-2 shows the format of the classification plot that is typically used for presentation of NAPP and NAG data. Marked on this plot are the quadrats representing the NAF, PAF and UC classifications.

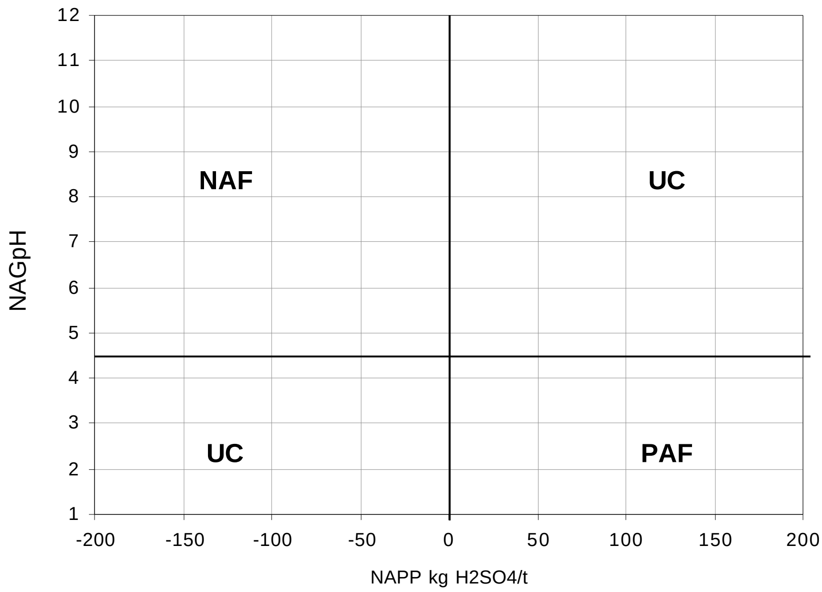


Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. These data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.

Appendix 2

Surface Water Management

REPORT ON

SURFACE WATER MANAGEMENT

WONARAH PHOSPHATE PROJECT

Prepared for

Minemakers Limited

Level 2, 34 Colin Street

WEST PERTH, WA 6005

Report Distribution

No. Copies

3	Minemakers Ltd. (electronic copies enclosed)
1	Groundwater Resource Management Pty Ltd

J090004R02(Final) October 2009

EXECUTIVE SUMMARY

Minemakers Australia Pty Ltd (MML) have undertaken a Bankable Feasibility Study (BFS) for their Wonarah Project in the Barkly Tablelands region of Northern Territory. MML has commissioned Groundwater Resource Management Pty Ltd (GRM) to complete the hydrological and surface water management component of the BFS.

GRM recently completed a Stage 1 - Baseline Hydrological Assessment for the project which presented the findings from a desktop study of regional hydro-meteorological data. It found that runoff will on occasion report to on-site watercourses and drainages and appropriate surface water management measures will be required to minimise operational interruptions and asset damage or loss.

This report presents the Stage 2 – Surface Water Management Study and builds on the hydro-meteorological, topographic and current mine planning data to provide feasibility engineering level designs of the works required to protect the proposed project facilities.

The following key findings were noted:

- Although there are no discernible river or creek channels within the project limits, there are several watercourses or drainages which may be inferred from inspection of the site topography and surface vegetation. These watercourses are ephemeral with flows occurring periodically during the summer months from January to March, when the potential exposure to high intensity rainfall is greatest. Consequently runoff will report to the watercourses in the vicinity of the Wonarah Project site and, on occasion, flows may be high and may cause flooding if appropriate measures are not in place.

- Based on a desktop review of the available data, it is assessed that the greatest flooding risk to the proposed project facilities relates to the approximately 868 km^2 catchment area upstream and to the southeast of the proposed Arruwurra Zone pits. Given its relatively large upstream catchment area, poorly defined alignment and indiscernible channel geometry it is possible that floodwater from this watercourse could report to the proposed Arruwurra pits or could cause flooding over much of the proposed Arruwurra mining area. The severity of the potential flooding at the Arruwurra site is exacerbated due to its relatively flat, low-lying topography, typically 30 m lower than ground level over the Main Zone mining area.

- Base Case flood protection measures will be required along the 2,900 m south-eastern perimeter of the proposed Arruwurra Year 1 and Year 2/3 pits. These measures may include dedicated flood berms, or strategically placed waste rock dumps, stockpiles and above-grade haul roads. Given the potential consequences of floodwaters reporting to the pits, it is recommended that these flood protection measures be designed for the 100 year average recurrence interval event.

- The preliminary alignment of the Arruwurra flood protection measures is presented in this report in addition to that for the upstream catchment diversion and arterial drainage ditches. Opportunities exist to reduce the required extent of these flood protection measures at the detailed design stage of the project through the judicious placement of waste rock dump/stockpile material and construction of haul roads.

The deliverables from the preliminary design of the Base Case flood protection and surface water management measures (calculations, description of proposed works, quantity estimate and feasibility level design drawings) are presented in this report. At this stage the design of the measures is at a feasibility level in order to develop construction quantities for MML's cost estimation purposes.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

DRAWINGS

1.0 INTRODUCTION

1.1 General

Groundwater Resource Management (GRM) has been assisting Minemakers Australia Pty Ltd (MML) with their permitting and feasibility studies for the Wonarah Phosphate Project, located about 240 km east of Tennant Creek in the Northern Territory. In addition to ongoing groundwater supply investigations, GRM recently completed a Stage 1 - Baseline Hydrological Assessment[1] for the project.

That report presented the findings from a desktop study of regional hydro-meteorological data for use in the analyses and design of the proposed water management measures at the Wonarah Project. In particular it found that although the project is situated in a semi-arid region with average annual rainfalls of between 300 and 400 mm, significant short duration rainfall events can and do occur, with daily rainfalls in excess of half the annual average having been recorded locally. Therefore runoff will on occasion report to on-site creeks and drainages and appropriate surface water management measures will be required to minimise operational interruptions and asset damage or loss.

This report presents surface water investigations completed as part of the Stage 2 – Surface Water Management Study required for the Environmental Impact Assessment and Bankable Feasibility Study currently being prepared by others. It builds on the hydro-meteorological, topographic and current mine planning data to provide feasibility engineering level designs of the works required to protect the proposed mine and associated facilities.

The Stage 2 scope of work comprised the following surface water analysis and design tasks:

- Floodwater management - hydrologic and hydraulic analyses;
- Surface water and sediment management - philosophy and design criteria;
- Feasibility level design of water management measures - described in the report and presented on preliminary plan/profile and sectional drawings; and,
- Risk assessment - completed in accordance with AMC methodology (July 2009).

It should be noted that the catchment delineation presented in this report has been developed using GIS spatial analysis tools based on the April 2009 Lidar[2] topographic data set. It was not possible to field verify the accuracy of either this data set or the catchment boundaries developed using the GIS tools. Detailed ground based survey data should be collected prior to completing the detailed design of all water management measures.

Further, the feasibility level design of the floodwater and drainage measures presented in this report relate solely to those required for start-up of mining operations and for the first two to three years thereafter and are considered to form the Base Case. It is currently not possible to prepare water management plans beyond this Base Case given the likelihood of changes to the mine plan.

The hydrologic and hydraulic calculations required as part of this study have been presented in the Appendices. The accompanying drawings have been completed to a level

[1] *Stage 1 - Baseline Hydrological Assessment*, GRM, July 2009
[2] Light Detection and Ranging - a technology that employs an airborne scanning laser rangefinder to produce topographic surveys.

suitable for inclusion in the project feasibility study and to form part of the future detailed civil engineering design of the project.

1.2 Surface Water Management Objectives

The following three goals define the objectives for surface water management for the Wonarah Project:

Goal No 1 - Reduce the Potential Risk of Loss of Life, Health Hazards and Property Damage:

- Provide protection for life, livelihood, and property;
- Control the incidence of nuisance or damage related to flooding, poor drainage and sedimentation to an acceptable level; and,
- Protect project infrastructure.

Goal No 2 - Preserve the Environment

- Minimise the potential project impacts such as changes in the streamflow regime, alteration of habitat, pollution or increased erosion and sedimentation;
- Where feasible, maintain the shape and composition (geomorphology) of the natural watercourse geometry, natural biological indicator conditions and flow conditions;
- Employ protection measures, to prevent adverse hydrological and water quality impacts, for all recognised watercourses within the site limits;
- Promote sound development that respects the natural environment; and,
- Rehabilitate any watercourses that are impacted as soon as practicable.

Goal No 3 - Conserve Social and Financial Resources

- Treat water as a resource, ensuring that water management facilities are functional and integrate multi-use objectives where possible;
- Provide a system of infrastructure that enhances site personnel convenience and safety, and allows development to proceed according to the mine plan;
- Sustain future mine development, support orderly and managed development of resources and integration of land uses within the site limits;
- Use best management water and sediment practices where feasible; and,
- Encourage economic design of drainage systems.

These objectives are intended to ensure a consistent approach to:

- Planning and analyses required for surface water management;
- Constructing new operational phase surface water management works; and,
- Installing future closure phase surface water management works.

The design philosophy for floodwater management is presented in Section 3.0 of this report, while that for surface water and sediment management is presented in Section 4.0.

2.0 FLOODWATER MANAGEMENT

2.1 Flood Protection Design Philosophy

The Stage 1 - Baseline Hydrological Assessment found that the Wonarah Project site sits within a region that is internally draining and which comprises gently undulating sand ridges and semi-desert of low relief. All watercourses and drainages in the vicinity of the site are ephemeral and tend to flow only for short periods following heavy rainfall. No discernible creeks or drainage channels have been found within the site limits and the only notable surface water feature is the presence of seasonally flooded swamps in the southwest of the project site, around Arruwurra.

However, rainfall runoff may report to the surface drainages and watercourses in the vicinity of the project periodically during the months of January to March, when the potential exposure to high intensity rainfall is greatest. Occasionally such flows may be high and may cause flooding if appropriate measures are not in place.

The findings from a site visit and inspection of the topographical maps and aerial photography for the project site indicate that there are a number of local watercourses that could adversely impact the proposed project facilities if not managed properly. They are shown on Figure 1 and include the following (note the following nomenclature has been developed for use in this report only):

- *Arruwurra Zone Watercourse* – draining an area of some 868 km^2 from the south-eastern limit of Barkly Surface Water Management Area (SWMA) in a generally northwesterly direction towards the Arruwurra mining area.

- *Main Zone Watercourse 1* – draining an approximately 6.6 km^2 area at the southwestern corner of the Main Zone mining area, in the vicinity of Pit C.

- *Main Zone Watercourse 2* – draining an approximately 15.7 km^2 area in the northwest of the Main Zone mining area, in the vicinity of Pit A.

- *Main Zone Watercourse 3* – draining an approximately 16.3 km^2 area in the northeast of the Main Zone mining area, in the vicinity of Pits A and B.

While all of the above watercourses will require some degree of management, it is assessed that the greatest flooding risk to the proposed project facilities relates to the Arruwurra Zone Watercourse (refer to Section 5.0 - Risk Assessment). Given its large upstream catchment area, poorly defined alignment and indiscernible channel geometry it is possible that floodwater from this watercourse could report to some of the proposed Arruwurra pits or could cause flooding over much of the proposed Arruwurra mining area. The severity of the potential flooding at the Arruwurra site is exacerbated due to its relatively flat, low-lying topography, typically 30 m lower than ground level over the Main Zone mining area.

Consequently the proposed Arruwurra mine facilities will require flood protection which may take the form of constructed berms and diversion ditching or strategically placed waste rock dumps, stockpiles and above-grade haul roads (as described later). Given the potential consequences of floodwaters reporting to the pit or the mine facilities, it is recommended that these flood protection measures be designed for the 100 year average recurrence interval (ARI) runoff event. The probability of occurrence for this event during the envisaged 10 year Stage 1 operational life of the project is approximately 10%.

A more likely, but perhaps with lower consequence, scenario requiring water management is the temporary collection of runoff in localised low lying areas close to the proposed mining areas and its infiltration into the open pits. Such areas occur naturally over the whole site but particularly around Arruwurra, where localised areas have storage capacities of up to approximately 2 GL. Runoff will collect seasonally in such areas following significant rainfall and the portion that infiltrates into the proposed pits will require in-pit sump pumping. Possible infiltration rates and the requirements of such pumping systems is presented in GRM's Groundwater Studies report.

2.2 Hydrologic and Hydraulic Analysis

Feasibility study level hydrologic analysis (100 year ARI peak flow estimation) and hydraulic analysis (preliminary flow depth estimation) are presented in the following sections, along with the methods and assumptions used.

2.2.1 Arruwurra Zone Watercourse Peak Discharge Estimation

Generally flow statistics at any location of interest can be generated using three different approaches (in order of preference):

- Site Measured Streamflow Analysis - From long-term streamflow records collected at the location of interest;

- Regional Hydrological Analysis - From streamflow records collected at the nearby watersheds with similar hydrological characteristics (e.g., similar drainage area, soils, vegetation, and slopes); and,

- Hydrological calculation/modeling.

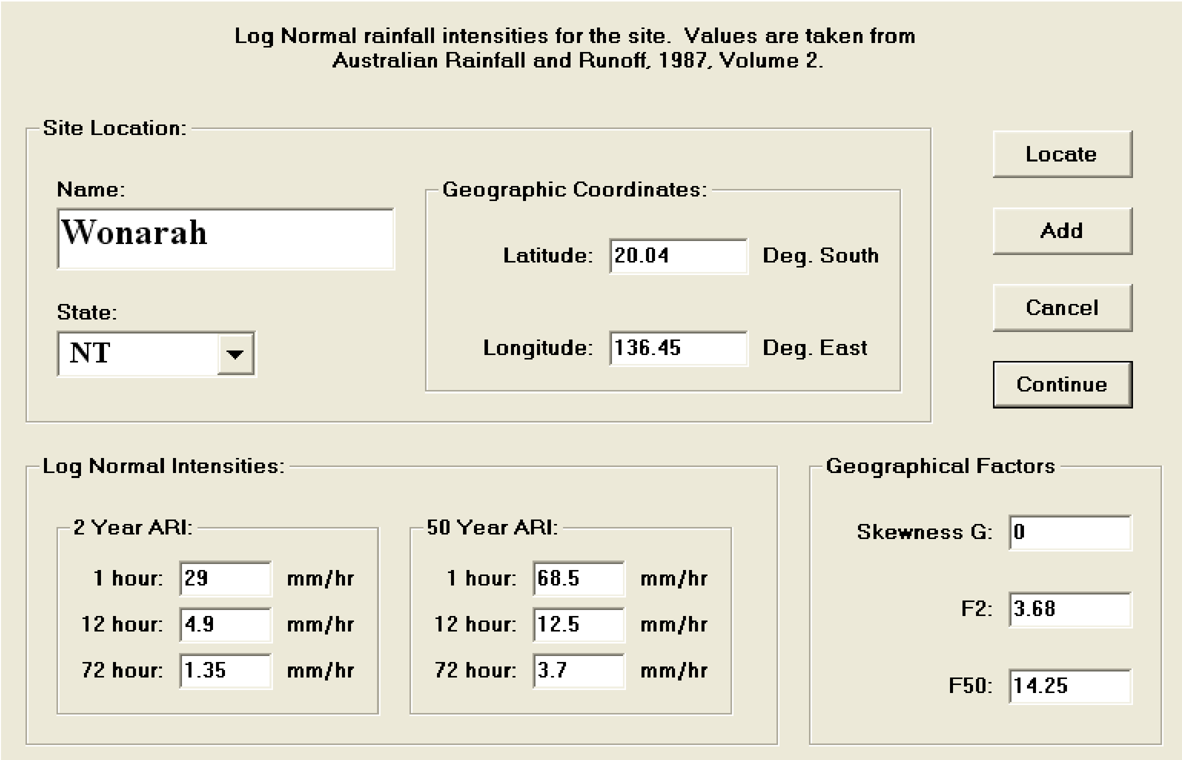
Given the non-availability of site streamflow data and the paucity of regional streamflow data (refer to Stage 1 – Baseline Hydrological Assessment), it was decided to use the hydrologic calculation methods presented in ARR97[3] to estimate peak flows in the Arruwurra Zone Watercourse under 100 year ARI conditions. The parameters adopted are presented in the following sections.

Intensity-Frequency-Duration Relationship

Intensity-Frequency-Duration (IFD) data were developed for Wonarah in accordance with Chapter 2 of ARR97 using the AUS-IFD computer software. The input parameters shown below were selected using Volume 2 of ARR97.

The resulting IFD relationship is presented in Appendix A of this report. In summary, the 100 year ARI intensities for 1, 3, 12, 24 and 72 hr duration events are 78.0, 37.2, 14.4, 9.3 and 7.3 mm/hr respectively i.e. giving equivalent storm depths of 78, 112, 173, 223[4] and 526 mm.

[3] *Australian Rainfall and Runoff*, *Volume One, Book Four, Estimation of Design Peak Discharges*, Institution of Engineers of Australia, 1997.
[4] The IFD value of 223 mm in 24 hours for the 100 year ARI event agrees well with the maximum recorded regional daily rainfall depth of 215 mm at Annitowa on 29 February 2000 during TC Steve (refer to Table 8 in Stage 1 – Baseline Hydrological Assessment report).



Catchment Characteristics

The combined Arruwurra Zone Watercourse catchment upstream of the Arruwurra mining area was found to have the following characteristics based on inspection of the topographical mapping and other data available for the region:

- Catchment Area, A = 867.72 km^2 comprising the following sub-catchments (refer to Figure 2):
    - Area 1 = 78.63 km^2
    - Area 2 = 49.45 km^2
    - Area 3 = 116.46 km^2
    - Area 4 = 46.96 km^2
    - Area 5 = 317.19 km^2
    - Area 6 = 82.47 km^2
    - Area 7 = 176.56 km^2
- Mainstream Length, L = 45.66 km;
- Equal Area Stream Slope, Se = 1.1 m/km; and,
- Average Annual Rainfall, P = 326 mm (median Ranken River value used).

ARR97 Estimation of 100 Year ARI Peak Discharge

The Arruwurra Zone Watercourse catchment characteristics fall within the relatively limited range of "South Australia Northern and Western Region" and "Western Australia Wheatbelt Loamy and Lateritic Catchments" identified in ARR97 for application of the Rational Method for peak discharge estimation.

Application of both versions of the Rational Method give 100 year ARI flood peaks in the Arruwurra Zone Watercourse in the vicinity of the of the proposed mining area in the order of 480 m^3/sec (see Appendix B for calculation). Assuming a simple triangular hydrograph with a total duration of 24 hours such an event could give rise to a total floodwater volume in excess of 20 GL.

Despite criticism of the Rational Method for its simplicity and tendency to overestimate peak flows, especially on larger, well vegetated catchments, its use was considered appropriate in this instance. The development of a detailed hydrological catchment model was not warranted at this stage, especially given the fact that there is no site data to calibrate such a model. The peak discharge rate and flood volume estimated above were therefore considered to represent upper bound values, but suitable for feasibility level design purposes.

2.2.2 Benchmarking with Gauged Stations

Given the synthetic nature of the two ARR97 Rational methods it was decided to compare the results with peak flows at the two closest comparable gauged catchments (Ranken River and Georgina River, presented previously in the Stage 1 – Baseline Hydrological Assessment[5]). This is a common hydrological method used in areas of sparse data and is typically carried out using a non-linear relationship of the following form:

$Flow_{site} = Flow_{station} \times (Area_{site}/Area_{station})^{0.7}$

For the purposes of this study it was assumed that the maximum flows recorded at the two gauged stations were, at least, indicative of significant rainfall/runoff events in the region and are suitable for benchmarking the 100 Year ARI flood peaks estimated using the ARR97 formulae.

Application of the non-linear relationship stated above gives flows at the Arruwurra Zone watercourse as follows:

$Flow_{site} = 2{,}000 \times (867.72 / 4{,}360)^{0.7} = 646\ m^3/sec$ (using Ranken River station[6])

$Flow_{site} = 3{,}832.8 \times (867.72 / 118{,}398)^{0.7} = 123\ m^3/sec$ (using Georgina River station)

These flows indicate that the average 100 year ARI estimate of 480 m^3/sec obtained from the ARR97 methods is of the correct magnitude. This estimated flow was therefore adopted for the feasibility level design.

[5] The record lengths at Ranken River and Georgina River are approximately 42 and 21 years respectively. There are three other regional flow monitoring stations on the Playford River, James River and Shakespeare Creek. However, rating curves have not been developed for these stations and only stage data are available.

[6] Estimate only as flow on 4 January 2009 exceeded the rating curve for the station.

2.2.3 Hydraulic Analysis (Preliminary Flow Depth Estimate)

Given the available topographic data it was not possible, nor appropriate, to carry out detailed hydraulic analysis for this feasibility level study, including peak floodwater elevation or backwater analyses. However, a preliminary assessment of the flow depth that might occur along Arruwurra Zone Watercourse under 100 year ARI flood conditions was made using Manning's Equation as follows:

$Q = (A\ R^{2/3}\ S^{1/2})/n$

where:

- Q = flow rate = 480 m^3/sec;
- A = cross-sectional area of hypothetical channel (m^2), assumed to be a trapezoidal cross-section with 0.5:1 (H:V) side slopes;
- R = hydraulic radius = cross-sectional area, A, divided by wetted perimeter, P (m);
- n = roughness coefficient, assumed to be 0.040 for a natural channel; and,
- S = river channel slope = 0.001 m/m as per watercourse existing slope.

By rearranging Manning's Equation, it was possible to obtain an estimate of the depth of flow required to pass the 100 year ARI flow for a range of hypothetical channel widths. The results of this analysis are shown in Table 1.

Table 1: Depths of Flow Required to Pass 100 Year ARI Peak Flow for Hypothetical Channel Widths

Hypothetical Channel Width (m)	Assumed Channel Roughness 'n'	Channel Slope (m/m)	100 Year ARI Peak flow (m^3/s)	Required Depth (m)	Calculated Flow Velocity (m/s)
100	0.040	0.001	480	2.98	1.59
200	0.040	0.001	480	1.95	1.22
300	0.040	0.001	480	1.53	1.04
400	0.040	0.001	480	1.29	0.93
500	0.040	0.001	480	1.12	0.85
600	0.040	0.001	480	1.01	0.79
700	0.040	0.001	480	0.92	0.75
800	0.040	0.001	480	0.85	0.71
900	0.040	0.001	480	0.79	0.68
1000	0.040	0.001	480	0.74	0.65

Note: All above results assume a hypothetical trapezoidal channel cross-section with 0.5:1 (H:V) side slopes

Despite the simplicity of this analysis it can be seen that significant flow depths, up to approximately 3 m for a hypothetical channel width of 100 m or almost 0.75 m for a channel width of 1 km are required to pass the 100 year ARI peak flow. Given that the Arruwurra Watercourse has no discernible channel it is possible that under such flood conditions the area affected could be well in excess of 1 km wide.

In the light of the above preliminary analysis it is recommended that the minimum height of all pit flood protection berms should be set at 2 m above existing ground level[7]. This should also be the minimum height of waste rock or stockpile material or haul road height where they are used in lieu of a flood berm. The proposed Arruwurra mine facilities area, including workshops, fuel storage and truck parking, should be situated at least 2 m above the watercourse average elevation of 255 mRL.

The feasibility level design of the flood protection measures are presented in Section 4.0.

As mentioned earlier, the possible infiltration rates from runoff stored in localised low-lying areas adjacent to open pits and the required pumping rates are presented in GRM's Groundwater Studies report.

[7] A 2 m minimum berm height is required if flood protection berms are to be used also for closure berms according to "*Safety Bund Walls Around Abandoned open Pit Mines – Guideline*", DoIR Western Australia, December 1997.

3.0 SURFACE WATER AND SEDIMENT MANAGEMENT

In addition to protecting the proposed project facilities against flooding from low frequency flood events such as the 100 year ARI event discussed above, it will also be necessary to manage runoff from more common tropical depression related rainfall events that occur typically between January and March. Although such events give rise to much lower runoff rates and volumes they will still need to be managed appropriately in order to protect project infrastructure, minimise erosion and reduce the potential loss of sediment laden or other contaminated runoff from the project site.

The drainage philosophy for the various project facilities are outlined in the following sections, while the feasibility level design of protection measures for the process plant site are presented in Section 4.0.

3.1 Drainage and Sediment Management Philosophy

The various project facilities should be segregated as follows for the management of stormwater:

- Processing facilities;
- Non processing facilities;
- Hazardous material storage areas;
- Disturbed areas; and,
- Undisturbed areas.

3.1.1 Processing Facilities

Rain falling within processing areas, e.g. screening and crushing areas, should be collected within bunded areas and returned to the process. Provision should be made for the return of such flows to the process by means of drains, launders, sumps, pumps etc.

3.1.2 Non Processing Facilities

Runoff from non process areas within the process plant area e.g. roads, roofs, yards, ROM area etc, should be captured in open drains. The drains should report to a sedimentation pond, before either being reused or, if suitable, released off-site.

To aid water quality management runoff from areas likely to be impacted by hydrocarbons, e.g. fuel storage and dispensing areas, truck wash and workshops, should also be captured in open drains that report to an oily water separator (OWS) provided upstream of the sedimentation pond.

Non process area drains reporting to a sedimentation pond should be sized for the peak of the 10 year ARI event as a minimum. Open drains should have a minimum freeboard of 500 mm and flow velocities along such drains should be limited to minimise erosion and the generation of sediment (refer to design criteria in Section 3.2).

3.1.3 Hazardous Materials Storage Areas

All chemical, oil and other hazardous material storage areas should be bunded in accordance with the relevant codes and standards. Water collected within the bunds should be assessed prior to release. If no leaks or spills are evident and the quality of the collected water is suitable, then the area can be drained to the closest non-process drain that reports to a sedimentation pond.

Water collected within the bunds that is assessed and is found to be impacted should either be returned to the process or disposed of appropriately.

3.1.4 Disturbed Areas

Outside the processing facilities the majority of project facilities will comprise pits, various topsoil stockpiles and waste rock dumps. Source controls and sedimentation ponds should be used to improve the quality of runoff from these areas prior to reuse or discharge off-site.

For runoff within the proposed pits source controls should comprise practices such as mining from upper levels or processing stockpiled material following significant rainfall events. In-pit staged sumps should be used to settle out sediment from collected runoff prior to pumping to surface for re-use or discharge off-site.

Source controls for dumps include minimising bench widths and inter-bench heights to limit sediment generation, back-grading benches to minimise potential overtopping and gully formation on slopes and longitudinal bench grading to engineered rock-lined chutes. These engineering design measures should be combined with Best Management Practices such as progressive rehabilitation and revegetation, placing brush barriers at dump toes, constructing check dams to minimise runoff flow velocity etc.

3.1.5 Undisturbed Areas

Run-off from undisturbed areas within the project boundaries should be diverted around proposed project facilities into existing natural watercourses or drainage lines by providing diversion drains typically sized for the 10 year ARI event with a minimum 500 mm freeboard. Flow velocities along all diversion drains should be limited to minimise erosion and the generation of sediment.

Where active mining areas or other sensitive facilities require protection from runoff from undisturbed areas the 100 year ARI event should typically be used for the design of flood protection berms.

3.2 Drainage and Sediment Management Design Criteria

As a minimum the following design criteria should be applied to drainage measures for the proposed project facilities:

3.2.1 Peak Flow Estimation

Peak discharges from catchment areas of less than 10 hectares should be estimated using the Rational Method (i.e. Q = CIA). The average run-off coefficient (C) should be based on the values presented in Table 2 below.

Table 2: Run-off Coefficients

Catchment Type	Run-off Coefficient
Undisturbed areas	0.20
Gravel roads and yard areas	0.50
Asphalt, concrete and roof areas	0.90

Rainfall intensity (I) for the critical event duration should be interpolated from the rainfall Intensity Duration Frequency (IDF) relationship developed for the Wonarah site provided in Appendix A. The time of concentration of each catchment area should be determined in accordance with the Kirpich Equation as follows:

$T_c = 0.00032 \times L^{0.77} \div S^{0.385}$

Where:

T_c = Time of concentration (hours).

L = Maximum length of water travel (m).

S = Average Slope (m/m).

The minimum time of concentration to be used for design purposes should be 5 minutes.

Catchment areas (A) should either be measured directly in the field or calculated using CAD tools and the latest field survey data.

Peak discharge estimates from areas larger than 10 hectares should be obtained by using hydrologic modelling methods such as those presented in Books 4 and 5 of ARR97.

3.2.2 Channel Design

Channel design parameters should be determined using Manning's Equation as follows:

$Q = (A\ R^{2/3}\ S^{1/2})/n$

where:

- Q = flow rate (m^3/sec).
- A = cross-sectional area of channel (m^2).
- n = roughness coefficient, as per values presented below (dimensionless).
- R = hydraulic radius = cross-sectional area, A, divided by wetted perimeter, P (m)
- S = channel slope (m/m).

Roughness coefficients should be based on the values presented in Table 3 below:

Table 3: Roughness Coefficients

Channel Type	Roughness Coefficient
Unlined Earth, Clean, recently completed	0.016-0.018
Unlined Earth, With short grass, few weeds	0.022-0.027
Unlined Rock, Smooth and uniform	0.035-0.040
Unlined Rock, Jagged and irregular	0.040-0.045
Lined, Formed concrete	0.017-0.020
Lined, Random stone mortar	0.020-0.023
Lined, Dry rubble (rip-rap)	0.023-0.033

3.2.3 Drainage Design

Open Drain Construction

Open drain construction should maintain:

- Minimum self cleansing velocity of 0.7 m/sec for 2 year ARI event;
- Maximum velocity of 1.0 m/sec for 10 year ARI event for unlined earth channels with no specific erosion protection;
- Maximum velocity of 1.5 m/sec for 10 year ARI for grassed channels with no specific erosion protection;
- Minimum 500 mm freeboard on open drains; and,
- Channel erosion control protection in the form of appropriate drop structures, rock check dams, rock-lined channels or concrete lined channels.

Culvert Installation

The minimum culvert diameter should be 450 mm. Culverts and underground stormwater pipes should be installed at slopes that should provide self-cleansing minimum velocities of 0.7 m/s for one-third depth of full-flow wherever possible.

Hardstand Area Drainage

Hardstand area drainage should be designed with a minimum surface grade of 0.5% in open yard areas and a minimum grade of 2% for a distance of 25 m away from structures.

3.2.4 Sedimentation Pond Design

For feasibility level design purposes sedimentation ponds should be designed to store runoff from the 10 year-24-hour rainfall event (i.e. 128 mm rainfall) without discharge. Sedimentation ponds should have a minimum live settling depth of 1 m and an aspect ratio (length:width) of not less than 3:1 and preferably 5:1. Sufficient provision for dead (sediment) storage and freeboard should also be made.

The future detailed design of sedimentation ponds should be based on removing the settleable fraction down to a selected minimum design particle size based on an analysis of the sediment particle size distribution reporting to the pond. The adopted design particle size should correspond to 25% of the sample passing by weight or an absolute minimum particle size of 20 micron (unless chemical coagulant dosing is used). The required pond surface area should be estimated using the peak inflow rate and design particle settling velocity according to Stokes Law and applying published sedimentation efficiency factors[8].

3.2.5 Oily Water Separator Design

Unless noted otherwise for specific facilities, all on-site OWS should be of the simple gravity type designed to remove free oil globules larger than 150 micron. The hydraulic design of all OWS should provide sufficient detention time for a maximum rise rate of 1×10^{-3} m/s, or an absolute minimum detention time of 45 minutes. Submerged inlet and outlet pipework should be used along with internal baffles to facilitate skimming. Provision should be made for removal of sludge that collects on the floor of the OWS.

[8] *The Constructed Wetlands Manual (Volumes 1 & 2)*, Department of Land and Water Conservation, New South Wales, 1998.

4.0 FEASIBILITY DESIGN OF MANAGEMENT MEASURES

The accompanying Figures 3 to 5 and Drawing Nos. J090004-D01 to -D04 show the preliminary layout of the proposed surface water facilities for the project site described in the following sections. This layout has been based on the aerial photography and Lidar topographical data set supplied by MML in April 2009 and the project infrastructure and pit crest plans supplied by GHD and AMC respectively in late July 2009.

The flood protection and drainage measures outlined in this report are considered to be appropriate for feasibility level planning of start-up to Year 2/3 mining operations in the Arruwurra Zone and Main Zone mining areas and, as such, form the Base Case for surface water management works. Additional flood protection and water management measures should be reviewed in advance of further project developments.

Further, it is understood that detailed mine planning and waste scheduling for the project is currently underway. The feasibility level design of the surface water management measures presented in this report should therefore be reviewed in the light of that work and modified as necessary. In particular the judicious placement of mine waste and construction of above-grade haul roads may allow the length of the flood protection berms to be reduced. The re-use of partially back-filled pit voids as water management ponds should also be considered where practical.

4.1 Flood Protection Berm

Given that flooding from the Arruwurra Zone Watercourse is possible under certain extreme conditions and is considered to pose the greatest flooding risk to the project, it is recommended that 100 year ARI flood protection be provided along the south eastern perimeter of the proposed Year 1 and Year 2/3 Arruwurra pits. This protection may take the form of a dedicated flood protection berm, strategically placed waste rock dump and stockpile materials, above-grade haul roads or a combination of these measures over a length of 2,900 m (refer to Dwg. No. J090004-D01).

The alignment of the flood protection berm has been set back a minimum of 150 m from the proposed pit crests if it is to also act as a pit closure berm. This setback is based on a 40 m maximum depth and a 25° design angle for weathered rock within the Arruwurra Zone pits. As discussed earlier, it is recommended that the minimum height of all such flood protection measures should be set at 2 m above existing ground level. The adequacy of these flood protection berms should be reviewed once the waste rock dump, stockpile and haul road design and construction schedule is completed.

The flood protection berm should not be constructed by end dumping of waste materials in piles, but instead the berm footprint should be cleared and it should be built from select waste material placed and compacted in controlled layers. The upstream (outside) face of the flood berm should be armoured with suitable graded waste rock or rip-rap.

The key specifications for the flood berms are as follows:

- Upstream maximum side slope = 2:1 (H:V);
- Downstream maximum side slope = 1.5:1 (H:V);
- Minimum height above existing ground = 2 m;

- Minimum base width = 10 m;
- Maximum compacted layer thickness = 300 mm;
- Minimum compaction standard = 95 % standard maximum dry density;
- Moisture conditioning = ± 2% optimum moisture content;
- Berm fill material to be select graded clayey gravel material from pit excavation with maximum particle size of 150 mm; and
- Riprap specification to be Dmax= 450 mm, D50= 300 mm and thickness = 700 mm.

A typical section through the Arruwurra flood protection berm is shown on Dwg. No. J090004–D04.

Dedicated flood protection berms are deemed unnecessary for the Main Zone Year 1 and Year 2/3 pits, provided that normal pit crest safety berms are provided. The initial Main Zone pits are located on a local high spot with minimal reporting upstream catchment area (refer to Dwg. Nos. J090004–D02 & D03). However if the mine plan changes the need for additional flood protection berms should be reviewed.

4.2 Diversion Ditches

In addition to the Arruwurra flood protection berm two upstream catchment diversion ditches will be required at the following locations (refer to Dwg. Nos. J060012-D01 to D03):

- Arruwurra Upstream Catchment Diversion Ditch – should be constructed immediately upstream of the proposed Arruwurra mine services area and non-DSO ore stockpile in order to divert runoff from a 3.94 km^2 undisturbed catchment. The diversion ditch will be some 3,420 m long and will collect runoff along its length, with a 10 year ARI peak flow at its outlet of approximately 10 m^3/s, which will be discharged to the north of the proposed flood protection berm alignment.

- Airstrip Upstream Catchment Diversion Ditch – two sections of diversion ditching should be constructed along the northeast side of the proposed airstrip facility to divert runoff from the a 3.33 km^2 undisturbed upstream catchment that may otherwise report to the runway. The high point of both drains should be on either side of the airstrip terminal facility. The northern drain will divert runoff over some 2,000 m towards the north-western corner of the airstrip, while the southern drain will extend some 1,000 m to the south-eastern corner of the airstrip. The 10 year ARI peak flows at the northern and southern outlets will be approximately 4.5 and 2.5 m^3/s respectively.

Table 4 summarises the preliminary design parameters for the diversion ditches discussed above.

Table 4: Diversion Ditch Preliminary Design Parameters for 10 Year ARI Event

Parameter	Unit	Arruwurra	Airstrip North	Airstrip South
Length	(m)	3,420	2,000	1,000
Side Slopes	(H:V)	2:1	2:1	2:1
Manning's Roughness	"n"	0.035	0.035	0.035
Flow Depth	(m)	1.4	0.9	0.7
Free-board	(m)	0.5	0.5	0.5
Total Ditch Depth	(m)	1.9	1.4	1.2
Average Channel Slope	(%)	0.25	0.25	0.20
10 Year ARI Peak Flow	(m^3/s)	10	4.5	2.5
Base Width	(m)	3.0	3.0	3.0
Maximum Earthworks Cut	(m^2/lin m)	12.40	7.95	6.00

A preliminary base width of 3 m was adopted for the design of the ditches given that the ditches will most likely be dozer cut. The minimum design flow depth required to safely pass the 10 year ARI peak flow was then determined before adding a freeboard allowance of 500 mm.

Where possible excavated spoil from construction of the diversion ditches should be placed opportunistically on the down-gradient, or facility site, side of the ditch to provide additional protection. The spoil should be setback approximately 3 to 5 m from the edge of the ditch to provide access for channel inspection and maintenance. The spoil should nominally be compacted with excavation equipment and re-vegetated to minimise erosion.

Minor natural channel realignment and riprap lined entrance treatments may be required where existing drainage lines join the diversion ditches. In addition, to reduce flow velocities and minimise erosion of the ditch sides and inverts, rock check dams should be installed along the steeper parts where the gradient exceeds 1%. Similarly, a stabilised basin with riprap lining should be provided at outfalls from the ditches. Typical details of the check dams and stabilised basins are shown on Drawing J090004–D04.

An approximately 1,200 m long section of diversion ditch may be required to divert runoff from the relatively limited catchment immediately to the south of the proposed Central mine services area. However, its preliminary design has not been included here given its minor nature and the possibility that this ditch may be incorporated into the roadside drainage channel of the proposed access road.

Upstream catchment diversion ditches are not required for the Year 1 and Year 2/3 Main Zone pits, again due to their relatively elevated location close to the catchment divide. However, if the mining plan should change this requirement should be reviewed.

4.3 Arterial Drainage Channels and Culverts

Arterial drainage channels will be required to collect runoff from the various mine facilities and convey it to sedimentation and, if suitable, off site. In addition culverts will also be used to safely convey the runoff below the Arruwurra and other site roads as required.

The detailed design of these drains and culverts is beyond the scope of the current study, but the following feasibility level design parameters are provided:

- The following drainage channels will be required at Arruwurra:
    - 1,000 m long channel to collect runoff from the mine services area and deliver it to and discharge it from the proposed Arruwurra Mine Services Area Sedimentation Pond;
    - 2,200 m long channel to collect runoff from the south-eastern side of the non-DSO stockpile and deliver it to the proposed Arruwurra Stockpile/Dump Sedimentation Pond;
    - 500 m long channel to collect runoff from the southern side of the waste rock dump and deliver it to the proposed Arruwurra Stockpile/Dump Sedimentation Pond; and,
    - 1,150 m long channel to discharge overflow from the proposed Arruwurra Stockpile/Dump Sedimentation Pond to the nearest drainage line to the east.
- The following drainage channels will be required at the Year 1 and Year 2/3 Main Zone pits:
    - 800 m long channel to collect runoff from the mine services area and deliver it to and discharge it from the proposed Central Mine Services Area Sedimentation Pond;
    - 780 m long channel to collect runoff from the northern side of the non-DSO stockpile and deliver it to the proposed Central Stockpile/Dump Sedimentation Pond; and,
    - 1,170 m long channel to collect runoff from the southern side of the waste rock dump and deliver it to the proposed Central Stockpile/Dump Sedimentation Pond.
- For all arterial drainage channels a minimum 10 Year ARI design flow and 0.5 m freeboard allowance should be used along with a Manning's roughness of 0.035, minimum base width of 1 m and side-slopes of 2H:1V.
- Approximately 12 to 15 culvert crossings will be required along the Arruwurra and other access roads. For feasibility level design purposes it may be assumed that each crossing will comprise two 600 mm diameter barrels, some 15 m long. All culverts should be helically wound, lock seamed, zinc galvanized, corrugated steel pipe with a minimum wall thickness of 1.6 mm.

4.4 Sedimentation Ponds

The use of two sedimentation ponds each at the Arruwurra and Central facilities i.e. four ponds in total, is recommended to allow separate treatment of potentially high suspended solids runoff from stockpile/waste rock dump areas and potential oily water from the mine services areas. The mine services area sedimentation ponds should have OWSs placed upstream of their inlets given that they will receive runoff from workshops, fuel storage and bowsers etc. All ponds should have emergency spillways/outlets in order to safely pass flow volumes greater than 10 year ARI magnitude around the ponds and off-site.

The detailed design of these ponds is beyond the scope of the current study but a feasibility level design has been carried out basing the pond volumes on storing runoff from the 10 year 24 hour rainfall event (i.e. 128 mm) from the catchment areas without discharge. The resulting required pond capacities and preliminary design parameters are presented in Appendix B and summarised in Table 5.

Table 5: Sedimentation Pond Preliminary Design Parameters

Parameter	Mine Facilities Pond	Dump/Stockpile Pond
Live Storage Capacity (m^3)	7,680	10,240
Dead Storage Capacity (m^3)	720	870
Combined Storage Capacity (m^3)	8,400	11,110
Excavated Pond Volume (m^3)	15,690	20,440
Pond Top Length (m)	200	225
Pond Top Width (m)	40	45
Fluid Depth (m)	1.5	1.5
Freeboard (m)	1.0	1.0
Pond Total Depth (m)	2.5	2.5

Note: Assumes side-slopes at 3H:1V.

The four sedimentation ponds have been placed as shown on Dwg. Nos. J090004–D01 to D03. Their exact configuration and location, including opportunities to integrate pond sides into haul road embankments and divert parts of the catchment that will likely be undisturbed, should be revisited as part of the project detailed design.

4.5 Oily Water Separators

OWSs should be provided at the following four facilities as a minimum:

- Arruwurra Fuel Storage & Workshops;
- Central Fuel Storage & Workshops;
- Airstrip Fuel Storage; and,
- LV Washdown and HME Tyre Wash.

The design of these facilities is currently too preliminary to permit the dimensions of the require OWS to be accurately determined. However none of these OWS is likely to exceed a maximum capacity of 100 m^3. For feasibility level design purposes all of them can be assumed to be constructed as in-ground reinforced concrete sumps with internal baffle walls and submerged inlets and outlets.

4.6 Preliminary Facility Elevations

Inspection of the current layout plan, topographical data set and inferred drainage paths suggests that the finished ground surface elevations shown in Table 6 should be adopted for the feasibility level design of the various mine facilities.

Table 6: Suggested Finished Elevations for Preliminary Design of Mine Facilities

Proposed Facility	Suggested Finished Elevations (mAHD)
Site Access T-Junction	280.0
Gatehouse, Security and Weighbridge	299.5
Administration Offices	299.5
LV Washdown and HME Tyrewash	299.5
Power Station	291.5
Sewage Treatment Plant & Putrescent Dump	293.0
Accommodation Village	299.5
Airstrip Terminal Facility	293.0
Central Mine Facilities	295.0
Explosives Storage	293.5
Central Fuel Storage & HME/LV Workshop	295.5
Arruwurra Mine Services Area	265.5

All of the above elevations comprise a degree of protection against potential flood events. However the adequacy of these elevations should be revisited as part of the detailed design of the project facilities.

4.7 Quantity Estimation

The water management measure construction quantities are presented in Appendix C and are summarised in Table 7. These may be used for feasibility level cost estimating purposes by MML.

Table 7: Water Management Measure Construction Quantity Summary

Description	Quantity	Unit
Flood Protection Berm Clearing and Foundation Preparation	40,600	m^2
Flood Protection Berm Earthworks (fill)	43,500	m^3
Flood Berm Rip-rap, 700 mm thick (D50 = 300 mm)	10,440	m^2
Diversion Ditch Clearing	86,932	m^2
Diversion Ditch Earthworks (cut)	64,308	m^3
Arterial Drainage Ditch Clearing	98,800	m^2
Arterial Drainage Ditch Earthworks (cut)	68,400	m^3
Culverts (12 crossings with 2 x 600 mm dia. barrels x 15 m long each.)	360	L m
Sedimentation Pond Clearing	48,950	m^2
Sedimentation Pond Earthworks (cut)	72,260	m^3

Note: Material cut from ditch excavation may be suitable for re-use to construct flood berms, subject to approval.

5.0 RISK ASSESSMENT

A primary risk analysis workshop was carried out on 20th August 2009 and was facilitated by Mr Mark Chesher of AMC. The risk analysis methodology and the workshop findings are presented in Section 19 of the Wonarah Project Bankable Feasibility Study report.

The following sections outline those risks relating solely to surface water management. Risks associated with the proposed project groundwater supply are dealt with in GRM's Groundwater Studies report.

5.1 Surface Water Management Risks

Four surface water risks to the project have been assessed as follows[9], based upon a ranking matrix provided by AMC Consultants Pty Ltd[10]:

- *Flood risk to Arruwurra Pits* – as discussed earlier in this report a potential flood risk exists for the proposed Arruwurra open pits due to the adjacent watercourse which drains a relatively large upstream catchment area. The alignment and channel geometry of this watercourse is poorly defined and, following a significant rainfall-runoff event, it is possible that floodwater could report to some of the proposed Arruwurra pits or could cause flooding over the proposed Arruwurra mining area.

  However, although possible, it is unlikely that such flooding will occur during the envisaged 10 year Stage 1 operational life of the project and the likelihood has been assessed as a level 2. The consequences of such an event are rated as being moderate due to potential loss of revenue of between $10 and $100 million and has been given a level of 3. Combining the likelihood and consequence values gives a moderate risk rank requiring floodwater management measures to be implemented during operations. The feasibility level design of the Base Case flood protection measures are presented in this report.

- *Flood risk to site infrastructure/facilities* – similarly potential risks exist for flooding of surface infrastructure and mining facilities due to runoff from on-site catchment areas following significant rainfall events.

  Again, although possible, it is unlikely that such flooding will occur more frequently than say once in five years and the likelihood has been assessed as a level 2. The consequences of such an event are rated as being moderate due to potential loss of revenue of between $10 and $100 million and has been given a level of 3. The combined values give a moderate risk rank requiring appropriate drainage measures to be implemented during operations. The feasibility level design of the Base Case drainage measures are presented in this report.

- *In-pit water management (rainfall and surface water runoff)* – direct precipitation will fall within the proposed pit crests during the months of January to March, when the potential exposure to high intensity rainfall is greatest. As a result runoff from the walls and floor of the pits will collect at low spots and may affect day-today mining operations.

---

[9] Flood risks to offsite infrastructure such as Barkly Highway and tenant Creek to Darwin railway that could affect ore transportation have been dealt with by others.
[10] AMC, 2009. "Wonarah feasibility study Minemakers Australia Pty Ltd Section 19 risk assessment", draft report dated June 2009.

Give that such occurrence is highly likely it has been given a likelihood level of 4, however, the consequences of such events are regarded as being relatively insignificant and a level of 1 has been applied. These values result in a medium risk ranking and will require that in-pit water management measures are implemented during operations. Such measures are likely limited to pit floor sumps with pumping to sedimentation ponds on surface prior to re-use or occasional discharge, subject to suitability. In-pit sumps and pumps will be required in any event to remove groundwater that may report to the proposed pits (refer to GRM's Groundwater Studies report).

- *Unacceptable surface water quality discharge off-site (elevated TSS and hydrocarbons)* – following significant rainfall it is possible that surface water of unacceptable quality may be discharged off-site due to large scale earthmoving activities and the presence of mechanical equipment. Surface water quality impacts may be related to elevated Total Suspended Solids (TSS) and/or hydrocarbons, particularly free oil and grease.

  While such an event is possible, it is unlikely to occur more frequently than say once in five years and the likelihood has been assessed as a level 2. The consequences of such an event are rated as being moderate due to short term environmental impacts and has been given a level of 3. The combined values give a moderate risk rank requiring appropriate water management measures, including the use of sedimentation ponds and OWSs, to be implemented during operations. The feasibility level design of the Base Case drainage measures are presented in this report.

The above risks and their likelihood of occurrence, resulting consequence and risk raking are summarised in Table 8.

Table 8: Surface Water Management Risks

Primary Risk Description	Likelihood Level	Consequence Level	Risk Rank
Flood risk to Arruwurra Pits	2	3	M
In-pit water management (from rainfall and surface water runoff)	4	1	M
Flood risk to site infrastructure/facilities	2	3	M
Unacceptable surface water quality discharge off-site (elevated TSS and hydrocarbons)	2	3	M

Note: Refer to BFS Section 19 for risk assessment conventions relating to likelihood, consequence and ranking.

6.0 RECOMMENDATIONS

The recommended floodwater protection and drainage and sediment management philosophies are presented in Sections 2 and 3 of this report. The resulting recommended Base Case surface water management works are summarised in Table 9.

Table 9: Summary of Surface Water Management Recommendations

Recommendation	Report Section
Arruwurra Flood Protection Berm	4.1
Arruwurra Upstream Catchment Diversion Ditch	4.2
Airstrip Upstream Catchment Diversion Ditch (North)	4.2
Airstrip Upstream Catchment Diversion Ditch (South)	4.2
Arruwurra Drainage Mine Services Area to Sedimentation Pond	4.2
Arruwurra Drainage Non DSO stockpile to Sedimentation Pond	4.3
Arruwurra Drainage Waste Dump to Sedimentation Pond	4.3
Arruwurra Drainage Sed Pond Outlet Drain	4.3
Central Drainage Mine Services Area to Sedimentation Pond	4.3
Central Drainage Non DSO stockpile to Sedimentation Pond	4.3
Central Drainage Waste Dump to Sedimentation Pond	4.3
Culverts (allowance)	4.3
Arruwurra Mine Services Area Sedimentation Pond	4.4
Arruwurra Dump/Stockpile Sedimentation Pond	4.4
Central Mine Services Area Sedimentation Pond	4.4
Central Dump/Stockpile Sedimentation Pond	4.4
Oily Water Separators	4.4

7.0 CLOSING REMARKS

This report builds on the findings of a hydro-meteorological study completed earlier and presents the feasibility level design of the Base Case water management measures required for the proposed project and, in particular, for the initial development of the Arruwurra Zone. The preliminary alignment of the Arruwurra flood protection measures is presented in this report in addition to that for the upstream catchment diversion and arterial drainage ditches.

Opportunities exist to reduce the required extent of these flood protection measures at the detailed design stage of the project through the judicious placement of waste rock dump/stockpile material and construction of haul roads

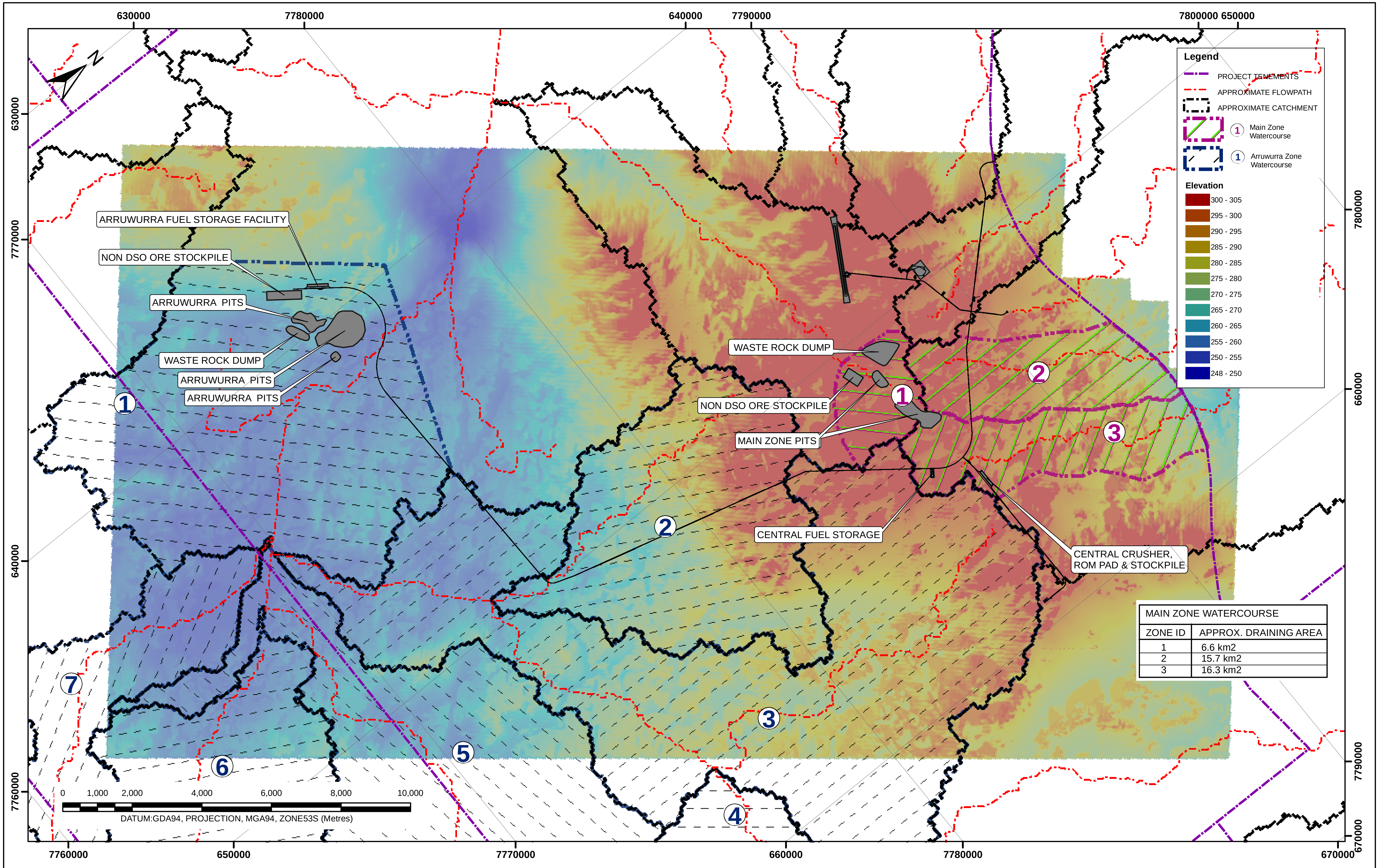
We trust that this report satisfies Minemakers current requirements and we look forward to discussing the ongoing development of the project with you.

Groundwater Resource Management Pty Ltd

Alistair Lowry	**Rob Garnham**
Senior Water Resources Engineer	**Principal Hydrogeologist**

Z:\JOBS2009\J090004_WONARAHSURFACEWATER\REPORT\FINAL\J090004R02\090004R02_FINAL_22OCT09.DOC

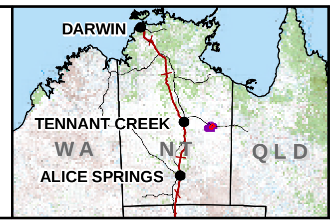
This report has been printed on paper that contains a proportion of recycled material as a gesture of Groundwater Resource Management's commitment to sustainable management of the environment.



MAIN ZONE WATERCOURSE	
ZONE ID	APPROX. DRAINING AREA
1	6.6 km2
2	15.7 km2
3	16.3 km2

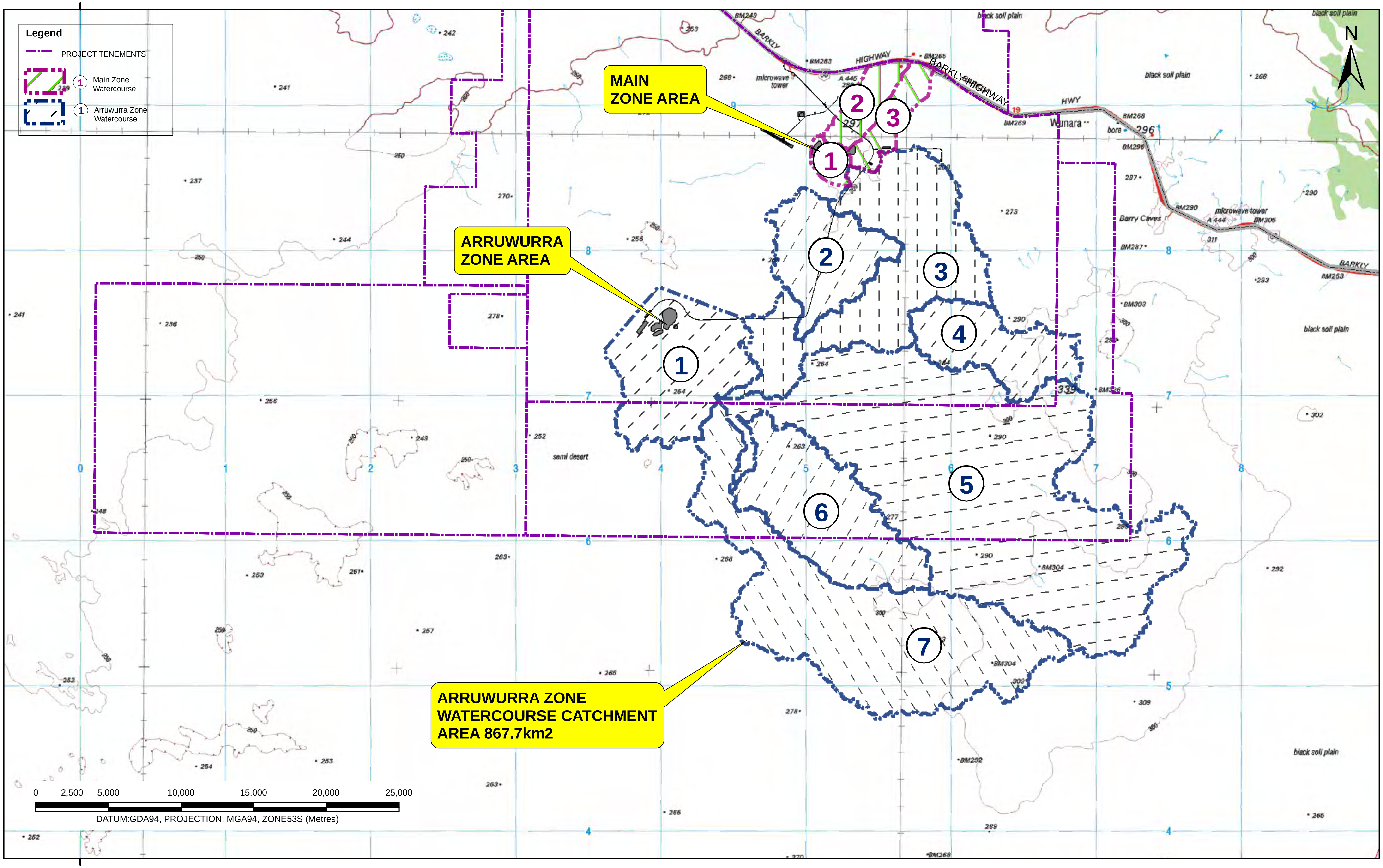
NOTES:

1. ELEVATION TIN, FLOWPATHS AND CATCHMENT AREAS DEVELOPED USING GIS TOOLS TO BE CONFIRMED IN FIELD.
2. BARKLY SRTM DATA USED IN CATCHMENT DELINEATION.
3. ONLY PIT CRESTS FOR YEAR 1 AND YEAR 2/3 PITS SHOWN.
4. REFER TO FIGURE 2 FOR EXTENTS OF ARRUWURRA ZONE WATERCOURSE CATCHMENT AREA



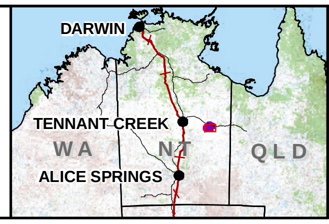
GROUNDWATER RESOURCE MANAGEMENT

CLIENT MINEMAKERS AUSTRALIA PTY LTD		PROJECT WONARAH PROJECT	
DRAWN DFH	DATE 24.08.2009	TITLE LOCAL CATCHMENT DELINEATION PLAN	
CHECKED ARL	DATE 24.08.2009		
SCALE 1:100,000 @ A3		PROJECT No J090004	FIGURE No 1



NOTES:

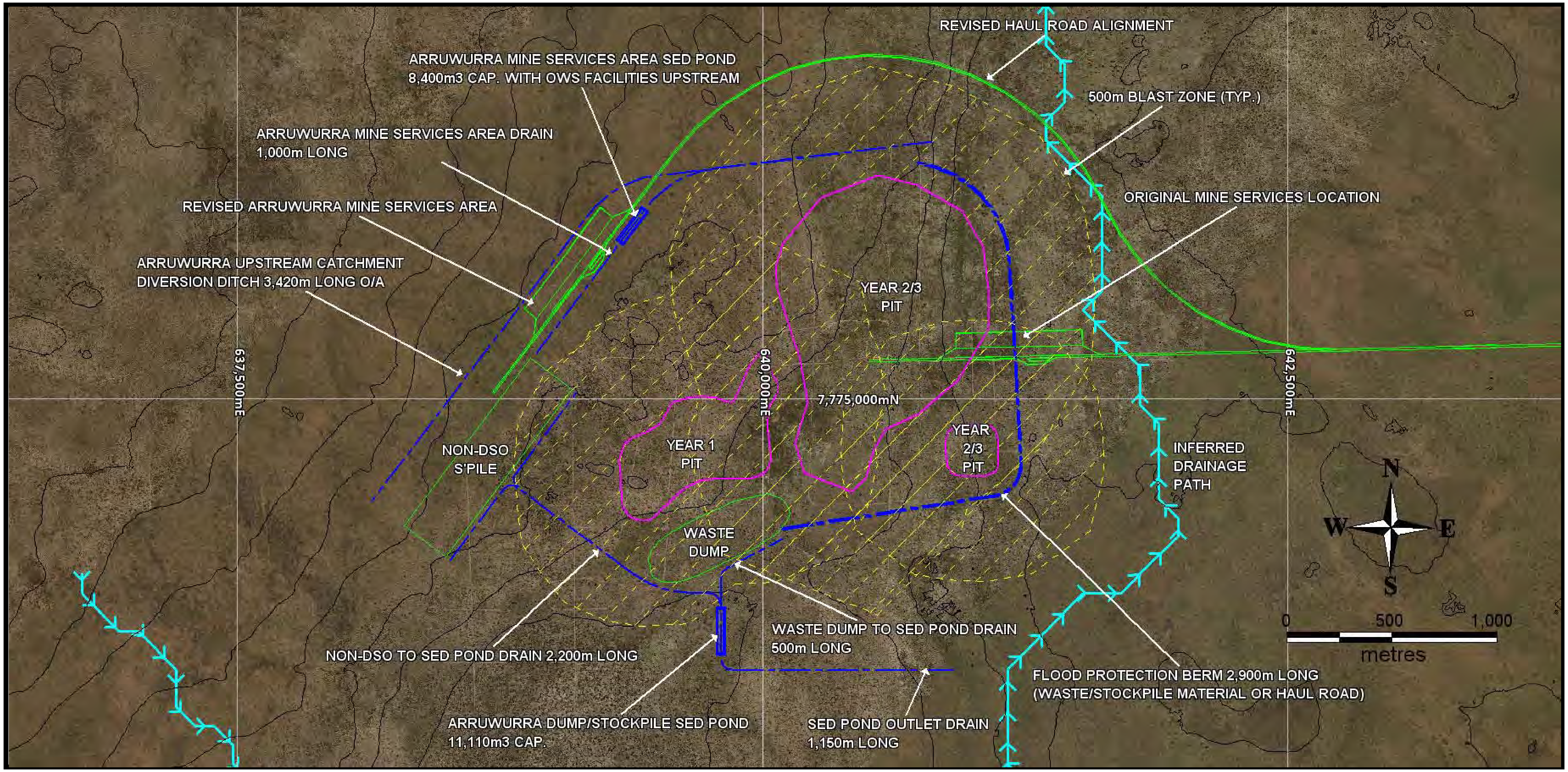
1. ELEVATION TIN, FLOWPATHS AND CATCHMENT AREAS DEVELOPED USING GIS TOOLS TO BE CONFIRMED IN FIELD.
2. REFER TO REPORT FOR SUB-CATCHMENT AREAS



GROUNDWATER RESOURCE MANAGEMENT

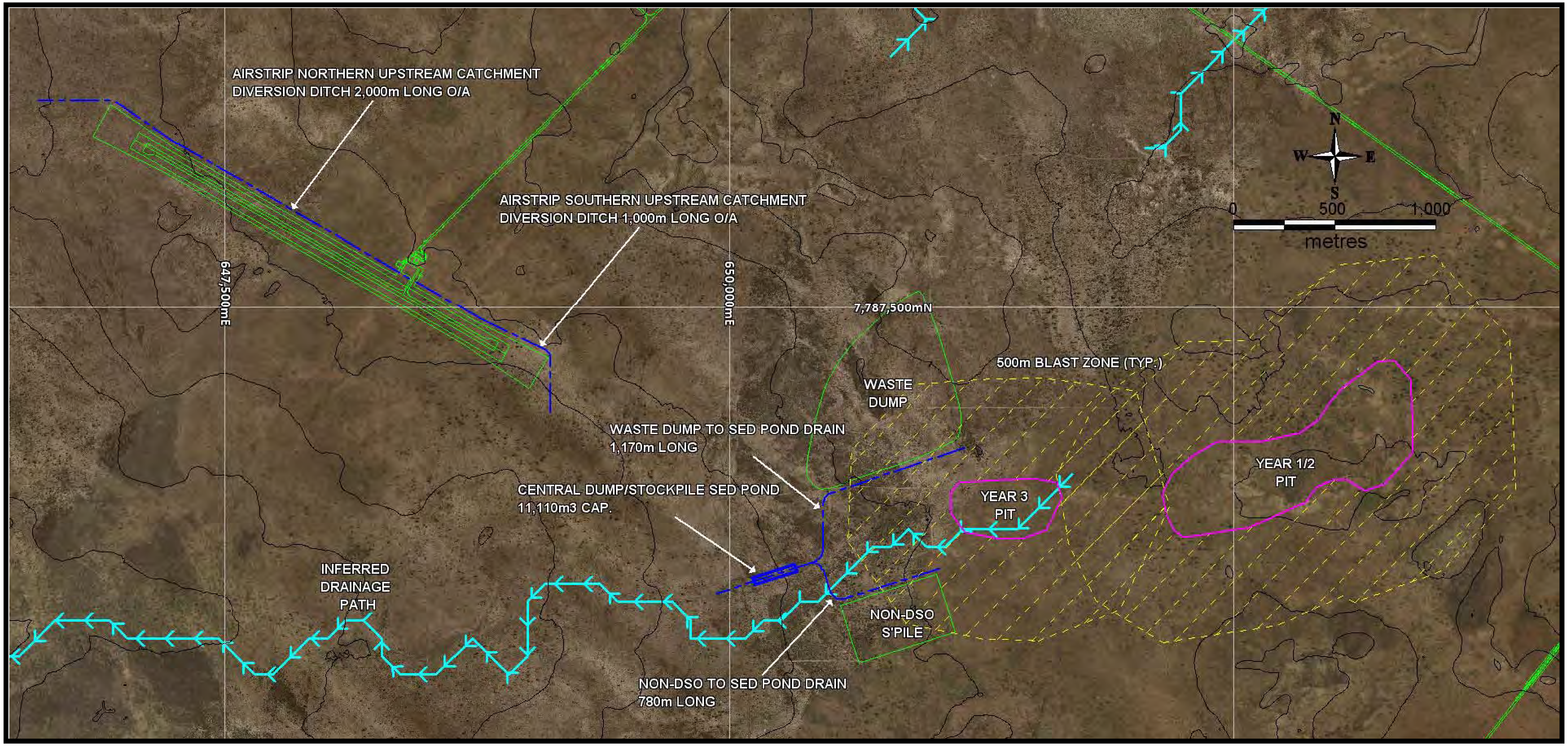
CLIENT MINEMAKERS AUSTRALIA PTY LTD		PROJECT WONARAH PROJECT	
DRAWN DFH	DATE 24.08.2009	TITLE ARRUWURRA ZONE WATERCOURSE CATCHMENT DELINEATION	
CHECKED ARL	DATE 24.08.2009		
SCALE 1:250,000 @ A3		PROJECT No J090004	FIGURE No 2

File Location : I:\CarrickConsulting\J090004_Wonarah_NT\03_ProjectData\01_Workspace



Notes:
1. Base Mapping provided by Minemakers Australia (GDA'94 Zone 53).
2. Drawing not to scale (2.5 km grid shown).
3. Contour interval is 2.5 m.

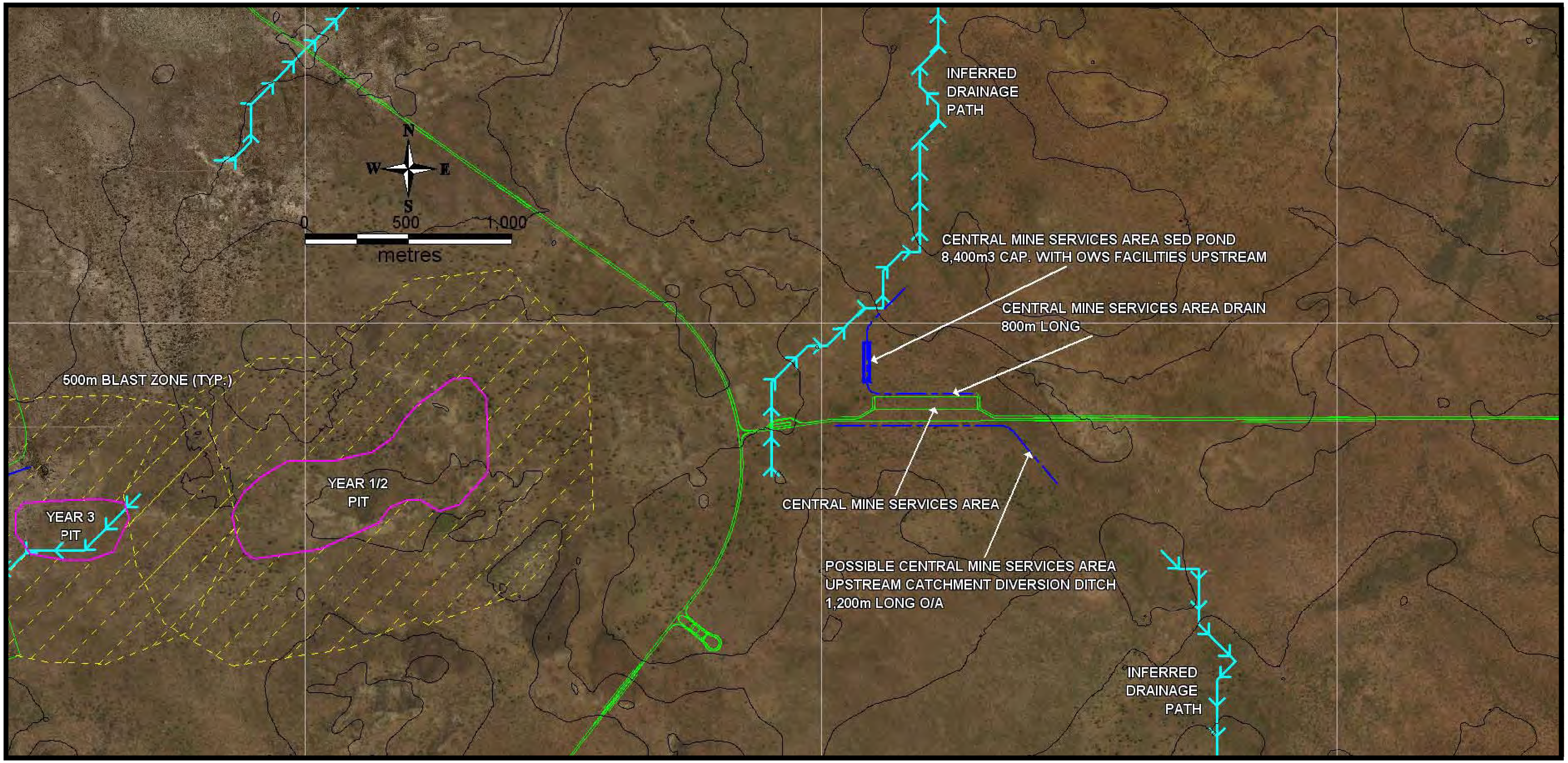
MINEMAKERS AUSTRALIA P/L			**PROPOSED SURFACE WATER MANAGEMENT MEASURES AT ARRUWURRA**	GROUNDWATER RESOURCE MANAGEMENT
WONARAH PROJECT				
ARL	Aug09	**FIGURE 3**		



Notes:
1. Base Mapping provided by Minemakers Australia (GDA'94 Zone 53).
2. Drawing not to scale (2.5 km grid shown).
3. Contour interval is 2.5 m.

MINEMAKERS AUSTRALIA P/L			PROPOSED SURFACE WATER MANAGEMENT MEASURES AT MAIN ZONE PITS & AIRFIELD
WONARAH PROJECT			
ARL	Aug09	FIGURE 4	

GROUNDWATER
RESOURCE MANAGEMENT



Notes:

1. Base Mapping provided by Minemakers Australia (GDA'94 Zone 53).
2. Drawing not to scale (2.5 km grid shown).
3. Contour interval is 2.5 m.

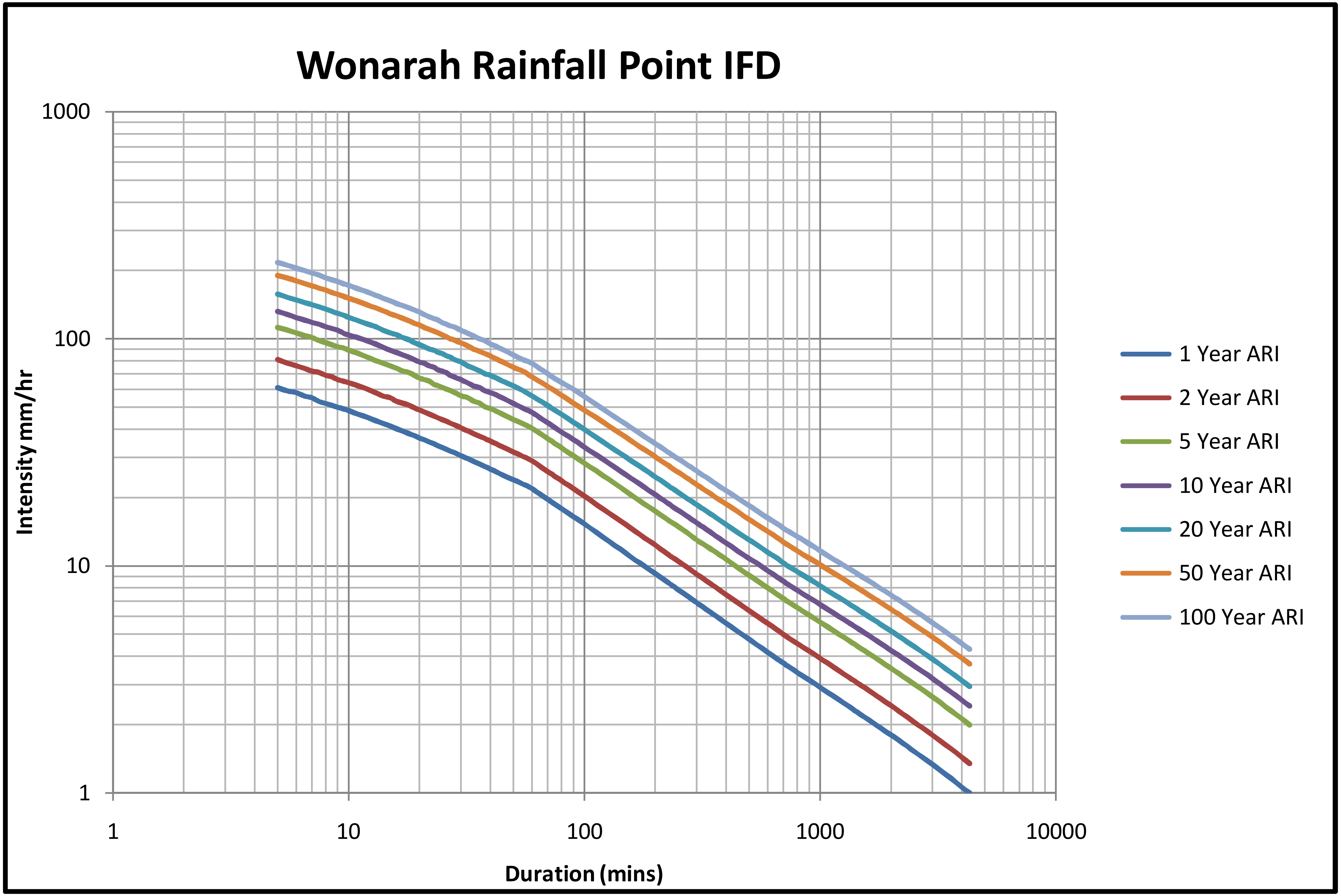
MINEMAKERS AUSTRALIA P/L			**PROPOSED SURFACE WATER MANAGEMENT MEASURES AT CENTRAL MINE SERVICES AREA**
WONARAH PROJECT			
ARL	Aug09	**FIGURE 5**	

GROUNDWATER RESOURCE MANAGEMENT

APPENDIX A

Point Intensity Frequency Duration Relationship for Wonarah

Rainfall Intensity Frequency Duration data for; Wonarah NT							
Geographic Location: , 20.04 , Deg. South, 136.45 , Deg. East							
AUSIFD, Version 2.0, 19 February,2009							
Duration (mins)	**1 Year ARI (mm/hour)**	**2 Year ARI (mm/hour)**	**5 Year ARI (mm/hour)**	**10 Year ARI (mm/hour)**	**20 Year ARI (mm/hour)**	**50 Year ARI (mm/hour)**	**100 Year ARI (mm/hour)**
5	61	81	112	132	157	190	217
5.5	59	78	109	128	152	185	211
6	58	76	106	124	148	180	205
6.5	56	74	103	121	144	175	200
7	55	72	101	118	141	171	195
7.5	53	71	98	116	138	167	191
8	52	69	96	113	135	164	186
8.5	51	68	94	111	132	160	182
9	50	66	92	109	129	157	179
9.5	49.2	65	91	106	127	154	175
10	48.3	64	89	104	124	151	172
11	46.6	62	86	101	120	146	166
12	45.1	60	83	98	116	141	161
13	43.7	58	80	95	113	137	156
14	42.5	56	78	92	109	133	151
15	41.3	55	76	89	106	129	147
16	40.2	53	74	87	104	126	143
17	39.2	52	72	85	101	123	140
18	38.3	51	71	83	99	120	137
19	37.5	49.6	69	81	96	117	134
20	36.6	48.5	67	79	94	115	131
21	35.9	47.5	66	78	92	112	128
22	35.2	46.6	65	76	90	110	125
23	34.5	45.7	63	75	89	108	123
24	33.8	44.8	62	73	87	106	121
25	33.2	44	61	72	86	104	118
26	32.6	43.3	60	71	84	102	116
27	32.1	42.5	59	69	83	100	114
28	31.6	41.8	58	68	81	99	113
29	31.1	41.2	57	67	80	97	111
30	30.6	40.5	56	66	79	96	109
32	29.7	39.3	55	64	76	93	106
34	28.9	38.2	53	62	74	90	103
36	28.1	37.2	52	61	72	88	100
38	27.4	36.3	50	59	70	86	98
40	26.7	35.4	49.2	58	69	84	95
45	25.2	33.4	46.5	55	65	79	90
50	24	31.8	44.1	52	62	75	85
55	22.9	30.3	42.1	49.5	59	72	81
60	21.9	29	40.3	47.4	56	68	78
75	18.7	24.8	34.6	40.7	48.5	59	67
90	16.5	21.9	30.5	36	42.9	52	60
105	14.8	19.6	27.4	32.3	38.6	47.1	54
120	13.4	17.8	25	29.5	35.2	43	49.1
135	12.3	16.4	23	27.2	32.4	39.6	45.3
150	11.4	15.2	21.3	25.2	30.2	36.9	42.2
165	10.6	14.2	19.9	23.6	28.2	34.5	39.5
180	9.99	13.3	18.7	22.2	26.6	32.5	37.2
195	9.43	12.6	17.7	21	25.1	30.8	35.2
210	8.94	11.9	16.8	19.9	23.9	29.2	33.5
225	8.5	11.3	16	19	22.7	27.9	31.9
240	8.11	10.8	15.3	18.1	21.7	26.6	30.5
270	7.44	9.93	14.1	16.7	20	24.6	28.2
300	6.89	9.2	13	15.5	18.6	22.8	26.2
360	6.04	8.07	11.5	13.6	16.4	20.1	23.1
420	5.4	7.22	10.3	12.2	14.7	18.1	20.8
480	4.9	6.56	9.35	11.1	13.4	16.5	19
540	4.5	6.02	8.61	10.3	12.4	15.2	17.5
600	4.17	5.59	7.99	9.54	11.5	14.2	16.3
660	3.89	5.22	7.47	8.92	10.8	13.3	15.3
720	3.66	4.9	7.03	8.4	10.1	12.5	14.4
840	3.29	4.42	6.35	7.59	9.17	11.3	13.1
960	3.01	4.04	5.81	6.96	8.41	10.4	12
1080	2.77	3.73	5.38	6.44	7.79	9.65	11.1
1200	2.58	3.47	5.01	6.01	7.28	9.02	10.4
1320	2.42	3.25	4.7	5.65	6.84	8.48	9.79
1440	2.27	3.06	4.43	5.33	6.46	8.01	9.25
1800	1.94	2.62	3.81	4.58	5.56	6.92	8
2160	1.71	2.3	3.35	4.04	4.91	6.12	7.08
2520	1.52	2.05	3.01	3.63	4.41	5.5	6.37
2880	1.38	1.86	2.73	3.3	4.01	5.01	5.8
3240	1.26	1.7	2.5	3.02	3.68	4.6	5.33
3600	1.16	1.57	2.3	2.79	3.4	4.25	4.94
3960	1.07	1.45	2.14	2.59	3.16	3.96	4.6
4320	1	1.35	1.99	2.42	2.95	3.7	4.3



Wonarah Rainfall Point IFD
Intensity mm/hr
1000
100
10
1
1
10
100
1000
10000
Duration (mins)
1 Year ARI
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI

APPENDIX B

Hydrologic & Hydraulic Calculations

Minemakers Ltd. Wonarah Project

Calculation of Peak Flow Estimate for Arruwurra Zone Watercourse

Job No.: 090004	Sheet No.	of
Calc. By: Alistair Lowry	Chk'd By:	
Calc Date: 4Aug09	Chk'd Date:	

Catchment Characteristics:

Catchment Area , A =	867.72	km2
Mainstream Length, L =	45.66	km
Equal Area Stream Slope, Se =	1.1	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	326	mm

Method 1 - South Australia - Northern & Western Region Rational Method:

	2	5	10	20	50	100
Runoff Coefficient C for "very flat streams <0.2%"=	0.2					

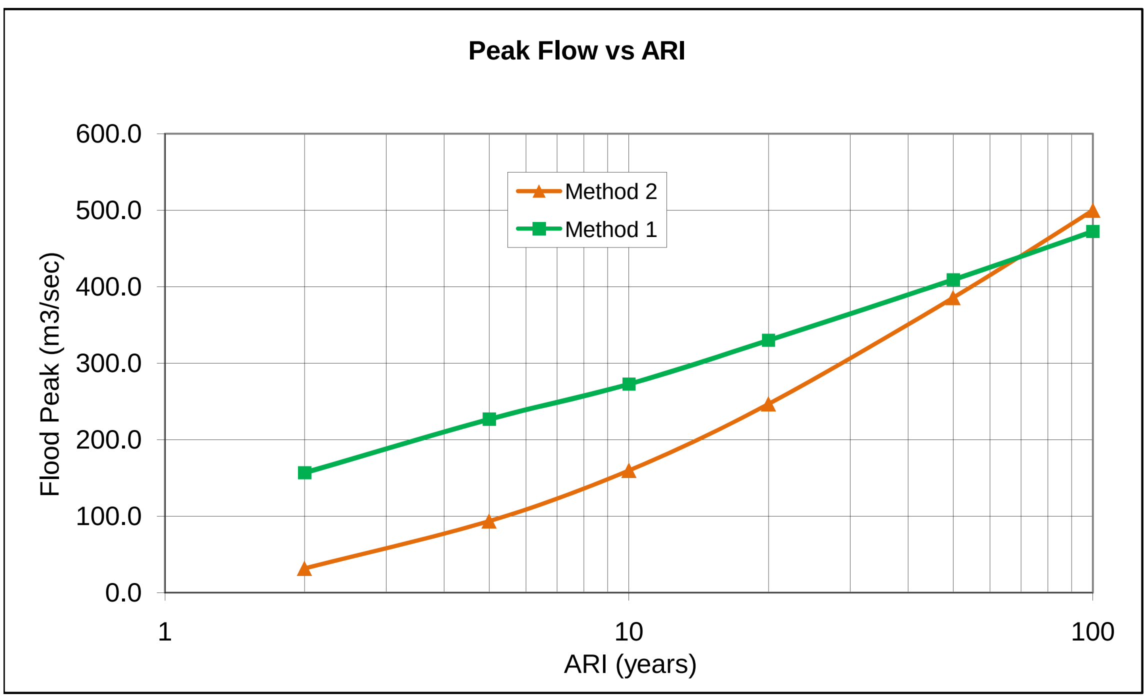
Using Bransby-Williams Eqn for Time of Concentration, tc (mins) = 58L/(A^0.1)*(Se^0.2)

tc =	1321	mins				
tc =	22	hours				
Use 22 hours for Time of Concentration => I_{tc} (mm/hr) =	3.25	4.7	5.65	6.84	8.48	9.79
Flood Peak Qy=0.278CIA (m3/sec) =	***157***	***227***	***273***	***330***	***409***	***472***

Method 2 - Western Australia - Wheatbelt Loamy Soil Catchment with Arid Interior Frequency Factors

Rational Method:	**2**	**5**	**10**	**20**	**50**	
tc=0.76A^0.38=	9.9	hours				
Use 10 hours for Time of Concentration => $I_{tc,Y}$ (mm/hr)=	5.59	7.99	9.54	11.5	14.2	N/A
C10=3.46*10^-1L^-0.42=	0.070	-				

	2	**5**	**10**	**20**	**50**	**100**
Frequency Factor (C_Y/C_{10}) =	0.34	0.7	1	1.28	1.62	N/A
Flood Peak Qy=0.278C_{10}(Cy/C10)IA (m3/sec) =	***31.9***	***93.8***	***160.0***	***246.8***	***385.7***	***500***



Pond Sizing Spreadsheet

MINEMAKERS LTD - Mine Facilities Sedimentation Pond

Calc. By:	A.Lowry	Sheet No.	
Date:	11-Aug-09	Chk'd By:	

Design based on 12ha disturbed area x C=0.5 x 128 mm = 7,680 m3 live cap.

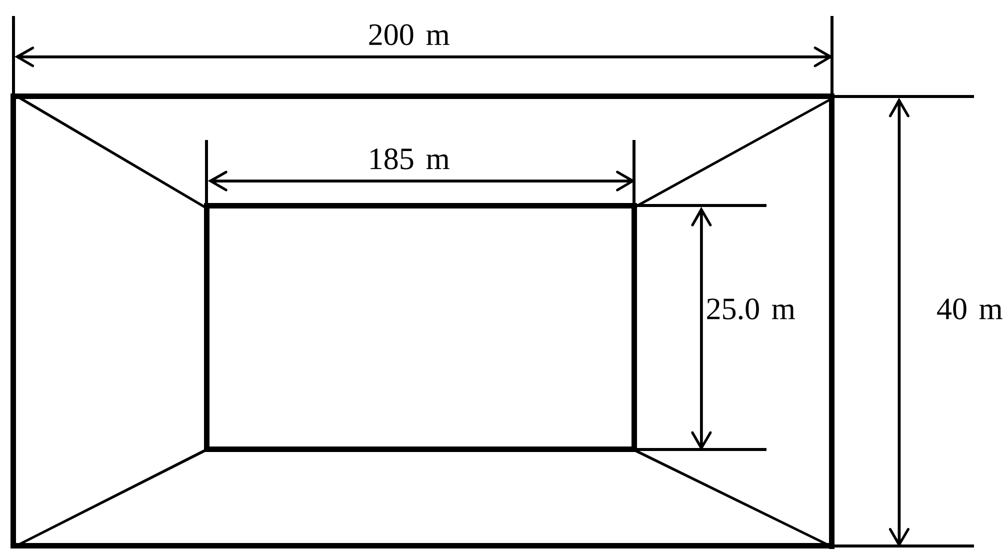
INPUT:

Top Length (m)	200.00
Top Width (m)	40.00
Side Slope (H: 1V)	3
Depth of Fluid (m)	1.50
Depth of Freeboard (m)	1.00
Total Pond Const. Depth (m)	2.50

OUTPUT:

Bottom Length (m)	185.00
Bottom Width (m)	25.00
Bottom Area (m2)	4,625
Fluid Length (m)	194.00
Fluid Width (m)	34.00
Fluid Area (m2)	6,596
Lined Surface Area (m2)	8,183
Volume of Fluid Stored (m3)	8,396
Volume of Excavation (m3)	15,688

SCHEMATIC:



Sideslopes 3 H: 1 V

Pond Sizing Spreadsheet

MINEMAKERS LTD - Waste Dump & Stockpile Sedimentation Pond

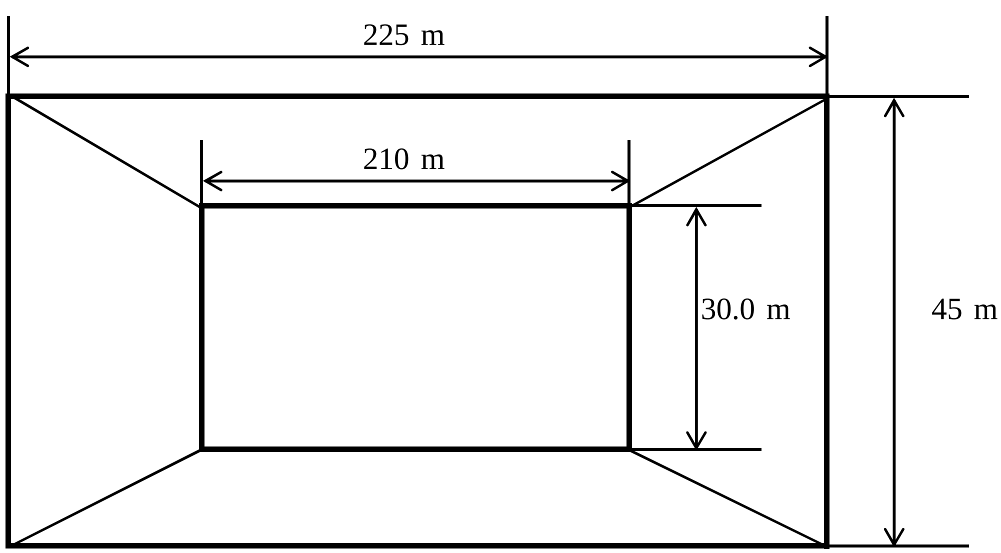
Calc. By:	A.Lowry	Sheet No.	
Date:	11-Aug-09	Chk'd By:	

Design based on 40ha disturbed area x C=0.2 x 128 mm = 10,240 m3 live cap.

INPUT:	Top Length (m)	225.00
	Top Width (m)	45.00
	Side Slope (H: 1V)	3
	Depth of Fluid (m)	1.50
	Depth of Freeboard (m)	1.00
	Total Pond Const. Depth (m)	2.50

OUTPUT:	Bottom Length (m)	210.00
	Bottom Width (m)	30.00
	Bottom Area (m2)	6,300
	Fluid Length (m)	219.00
	Fluid Width (m)	39.00
	Fluid Area (m2)	8,541
	Lined Surface Area (m2)	10,332
	Volume of Fluid Stored (m3)	11,111
	Volume of Excavation (m3)	20,438

SCHEMATIC:



Sideslopes 3 H: 1 V

APPENDIX C

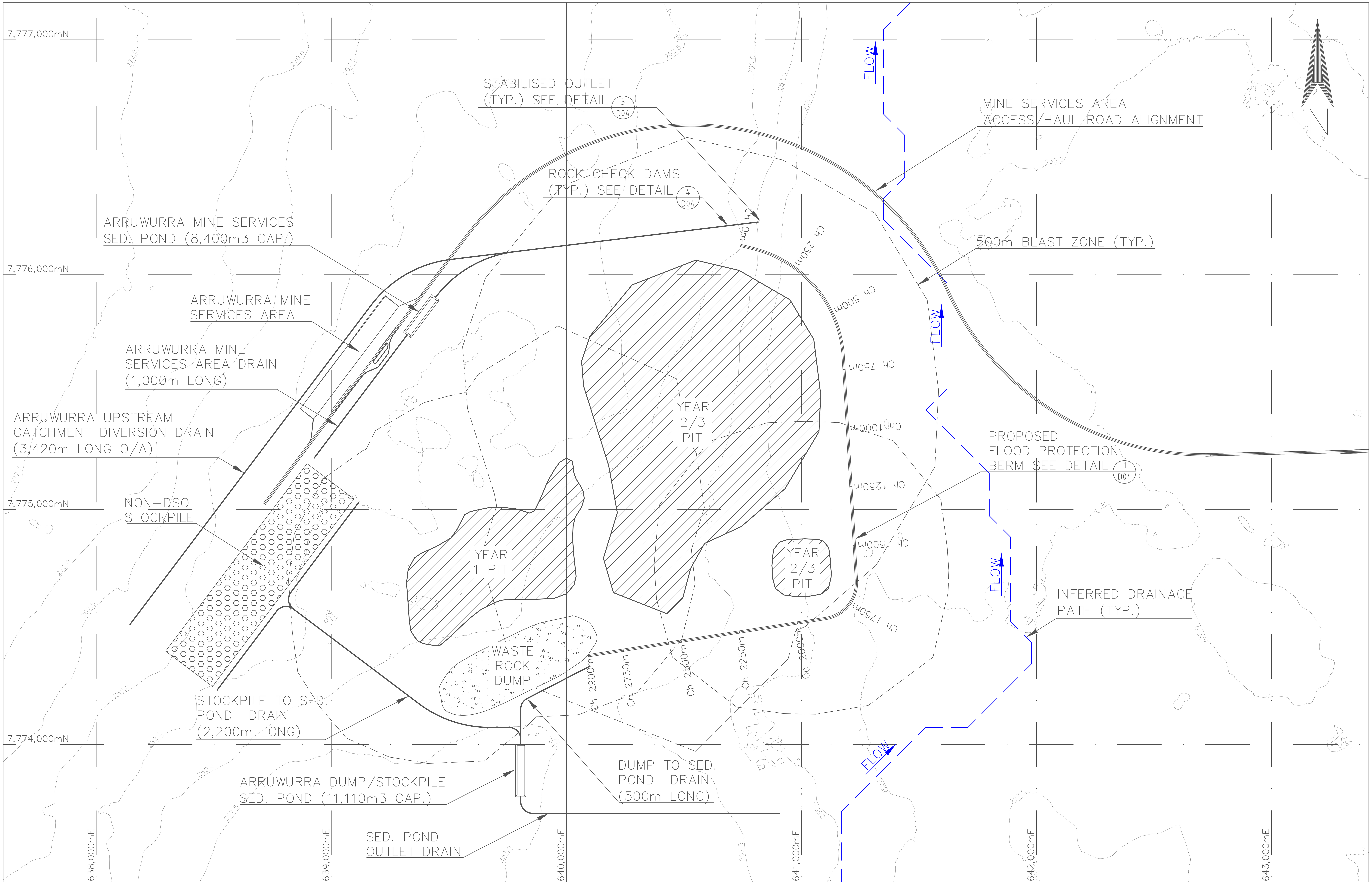
Water Management Measure
Construction Quantity Estimate

Wonarah Project Prelim Surface Water Measures - Quantities

A. Lowry

20-Aug-09

Description	Unit	Arruwurra Flood Protection Berm	Arruwurra UCD	Airstrip UCD (North)	Airstrip UCD (South)	Arruwurra Drainage Mine Services Area to Sed Pond	Arruwurra Drainage Non DSO stockpile to Sed Pond	Arruwurra Drainage Waste Dump to Sed Pond	Arruwurra Drainage Sed Pond Outlet Drain	Central Drainage Mine Services Area to Sed Pond	Central Drainage Non DSO stockpile to Sed Pond	Central Drainage Waste Dump to Sed Pond	Culverts (allowance)	Arruwurra Mine Services Area Sed Pond	Arruwurra Dump/S'pile Sed Pond	Central Mine Services Area Sed Pond	Central Dump/S'pile Sed Pond	TOTAL
Flood Protection Berm Clearing and Foundation Prep.	m^2	40,600																***40,600***
Flood Protection Berm Earthworks (fill)	m^3	43,500																***43,500***
Flood Berm Rip-rap, 700 mm thick (D_{50} = 300 mm)	m^2	10,440																***10,440***
UCD Diversion Ditch Clearing	m^2		49,932	25,200	11,800													***86,932***
UCD Diversion Ditch Earthworks (cut)	m^3		42,408	15,900	6,000													***64,308***
Arterial Drainage Ditch Clearing	m^2					13,000	28,600	6,500	14,950	10,400	10,140	15,210						***98,800***
Arterial Drainage Ditch Earthworks (cut)	m^3					9,000	19,800	4,500	10,350	7,200	7,020	10,530						***68,400***
Culverts (12 crossings with 2 x 600 mm dia. barrels x 15 m long each.)	lm												360					***360***
Sedimentation Pond Clearing	m^2													11,000	13,475	11,000	13,475	***48,950***
Sedimentation Pond Earthworks (cut)	m^3													15,690	20,440	15,690	20,440	***72,260***
Notes:																		
1. Cut & Fill quantities based on lengths and cut/fill allowances shown below:																		
Approx. Length	m	2,900	3,420	2,000	1,000	1,000	2,200	500	1,150	800	780	1170	N/A	N/A	N/A	N/A	N/A	
Cut/Fill allowance per lineal m.	m2/m	15	12.4	7.95	6	9	9	9	9	9	9	9	N/A	N/A	N/A	N/A	N/A	
2. Berm and ditch clearing areas include 2m additional width along both sides.																		
3. Pond clearing areas include 10m additional length at both ends and 5 m additional width along both sides																		



REVISION	DESCRIPTION	DRAWN	DATE	CHECKED	APPROVED
A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–

NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

CLIENT: MINEMAKERS AUSTRALIA PTY LTD

DRAWN: ARL — DATE: 18-08-2009 — DRAWING CHECK — DATE

DESIGNED: ARL — DATE: 18-08-2009 — DESIGN CHECK — DATE

AUTHORISED — DATE — SCALE: 1:7500 @A1

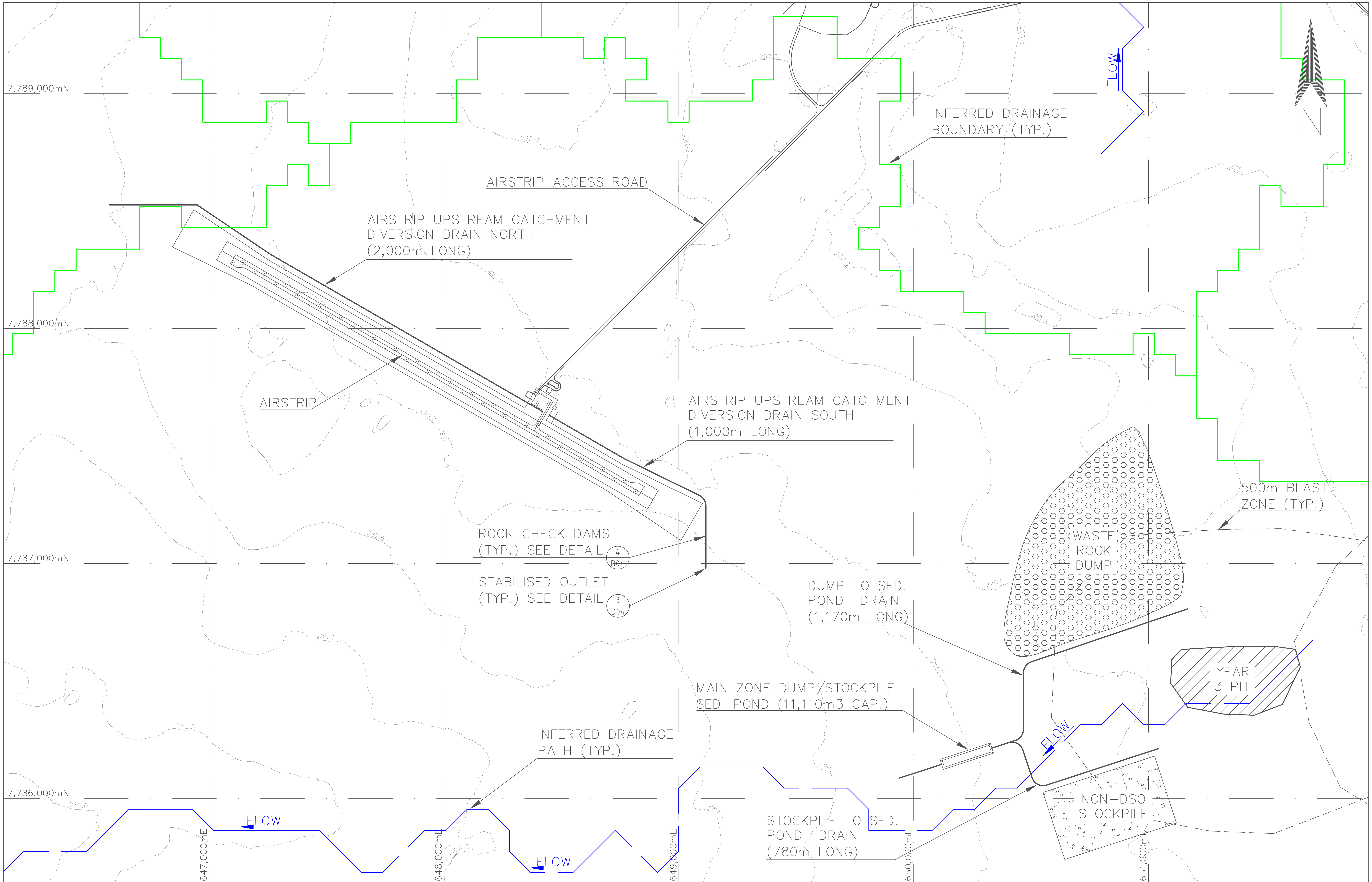
PROJECT: WONARAH PROJECT

DRAWING TITLE: PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES ARRUWURRA ZONE PLAN

PROJECT No: J090004 — DWG No D01 — A

PLTDATE CADFILE PLOTSCALE

A1



REVISION	DESCRIPTION	INITS	DATE	INITS	DATE
A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–
		CHECKED		APPROVED	

NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

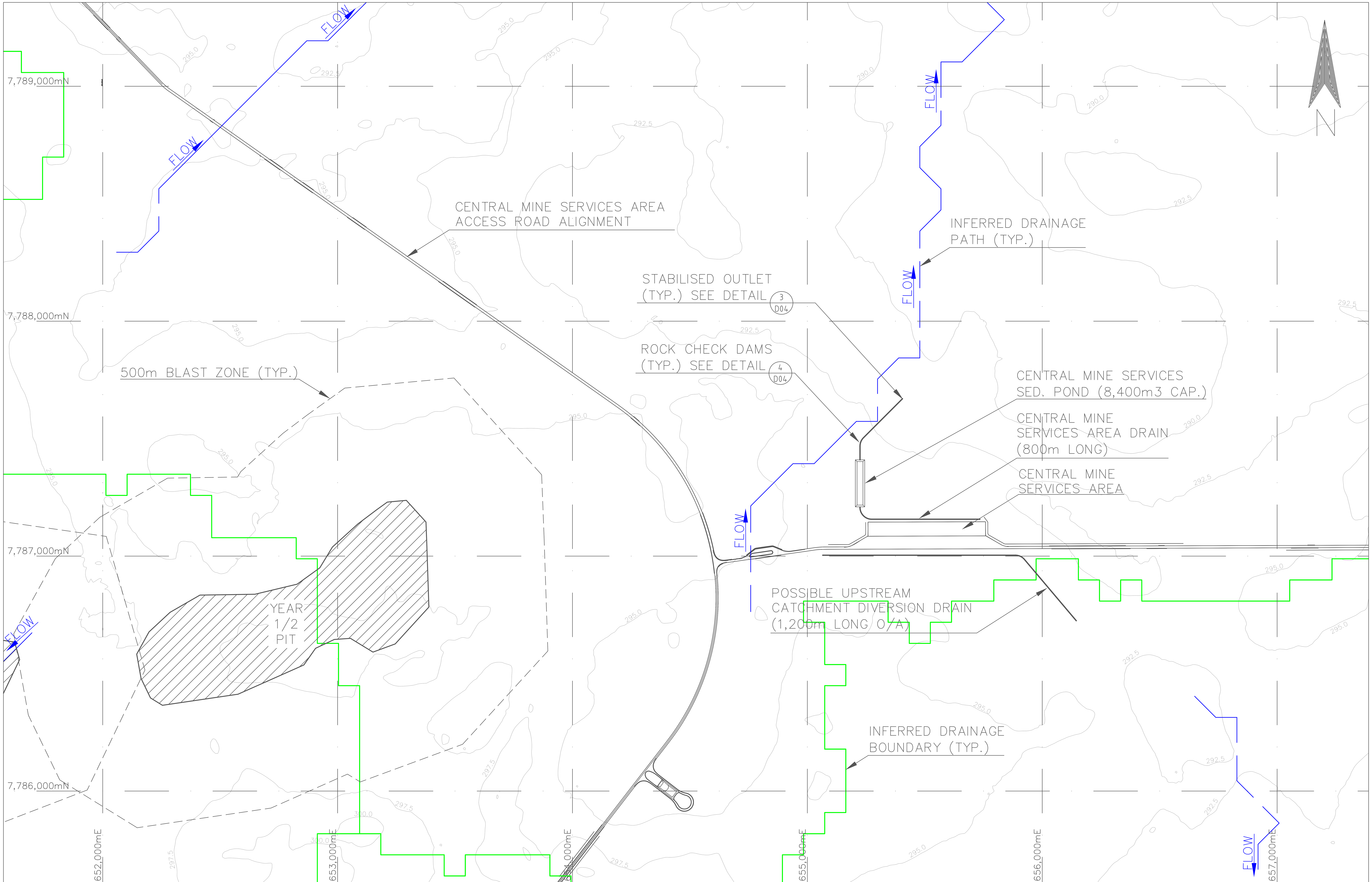
CLIENT: MINEMAKERS AUSTRALIA PTY LTD
DRAWN: ARL DATE: 18-08-2009 DRAWING CHECK DATE
DESIGNED: ARL DATE: 18-08-2009 DESIGN CHECK DATE
AUTHORISED DATE SCALE: 1:7500 @A1

PROJECT: WONARAH PROJECT
DRAWING TITLE: PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES MAIN ZONE & AIRSTRIP PLAN
PROJECT No: J090004 DWG No D02 A

1 2 3 4 5 6 7 8 9 10 11 12

H H

PLTDATE
CADFILE
PLOTSCALE
A1



REVISION	DESCRIPTION	CHECKED INITS	CHECKED DATE	APPROVED INITS	APPROVED DATE
A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–

NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

CLIENT: MINEMAKERS AUSTRALIA PTY LTD

DRAWN: ARL DATE: 18-08-2009 DRAWING CHECK DATE

DESIGNED: ARL DATE: 18-08-2009 DESIGN CHECK DATE

AUTHORISED DATE SCALE: 1:7500 @A1

PROJECT: WONARAH PROJECT

DRAWING TITLE: PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES CENTRAL MINE FACILITIES PLAN

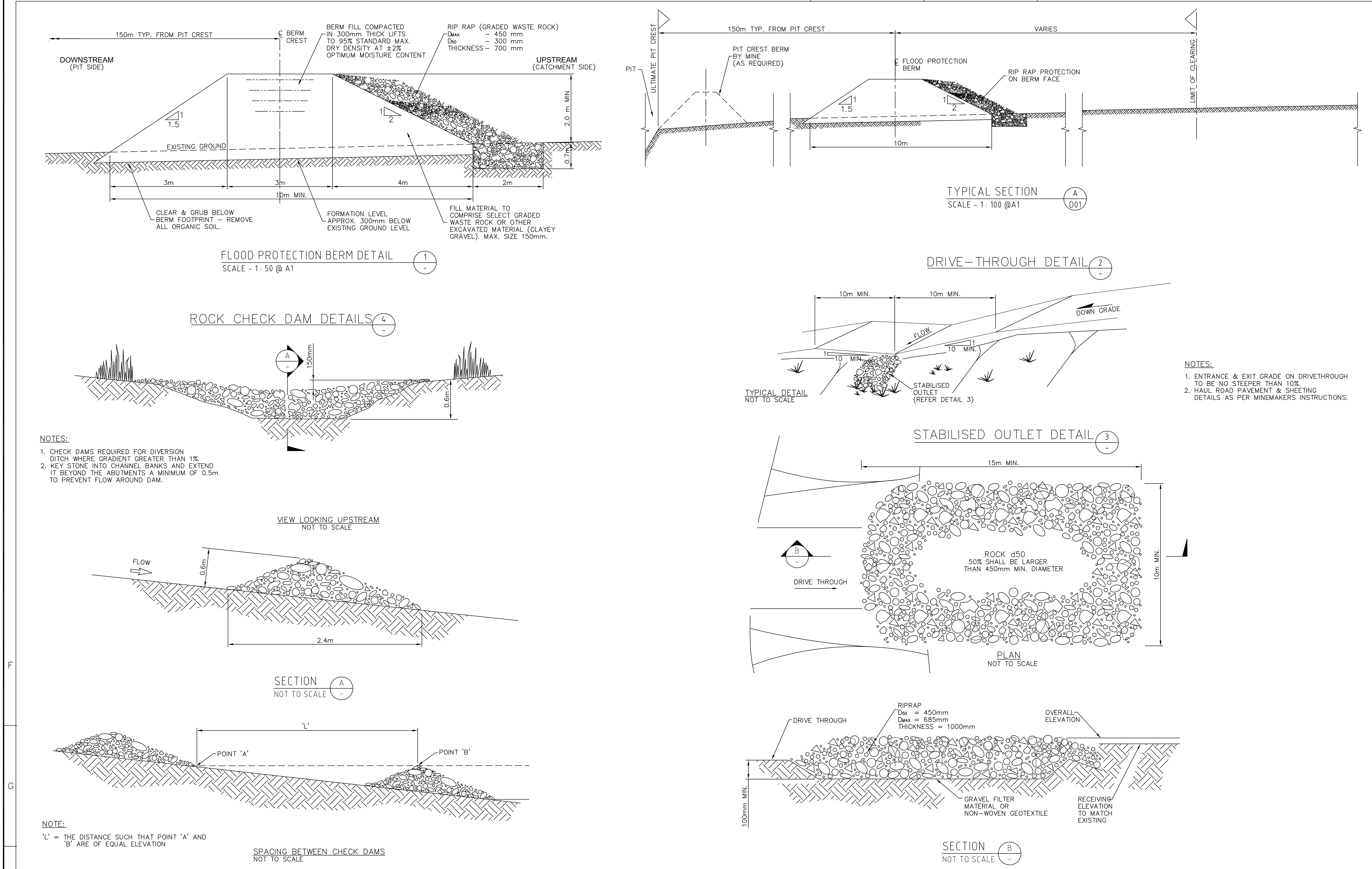
PROJECT No: J090004 DWG No D03 A

1 2 3 4 5 6 7 8 9 10 11 12

H H

PLTDATE
CADFILE
PLOTSCALE

A1



REVISION	DESCRIPTION	INITS	DATE	INITS	DATE
A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–
		CHECKED		APPROVED	

NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

CLIENT: MINEMAKERS AUSTRALIA PTY LTD

DRAWN: ARL DATE: 18-08-2009 DRAWING CHECK DATE

DESIGNED: ARL DATE: 18-08-2009 DESIGN CHECK DATE

AUTHORISED DATE SCALE: AS SHOWN

PROJECT: WONARAH PROJECT

DRAWING TITLE: PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES TYPICAL SECTIONS & DETAILS

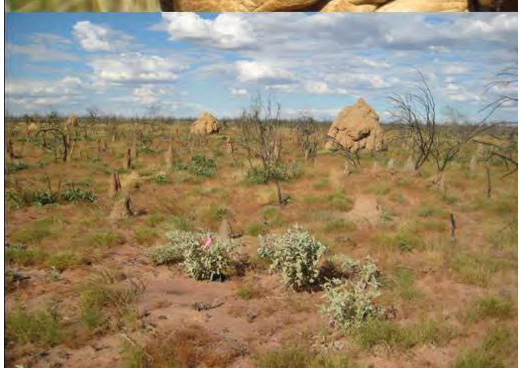
PROJECT No: J090004 DWG No D04 A

PLTDATE
CADFILE
PLOTSCALE
A1

Appendix 3

Baseline Flora and Fauna Report





Minemakers Wonarah Phosphate Project

Baseline Flora and Fauna Report

Prepared for
Coffey Natural Systems

By

Erin Moon, Tom Newsome and Dr Bill Low

Low Ecological Service P/L

P.O Box 3130

Alice Springs 0871

April 2009

Executive Summary

Overview

Minemakers Australia Pty Ltd is currently in the pre-feasibility stage of their Wonarah Phosphate Project. Low Ecological Services P/L (LES) was commissioned to broadly characterise the ecology of the area, to identify threatened species of flora and fauna present, or likely to be present in the project area, and determine if there is a potential for the project to have significant impacts on these species.

The biodiversity of the area has generally been documented at a regional scale with only occasional incursion to adjacent areas for on-the-ground flora and fauna survey (Wakaya Desert survey - Gibson and Wurst, 1994). Existing data sets were used for a rapid landscape analysis to determine, in a regional context, landforms, geology, drainage systems, vegetation communities or habitats, and compile flora and fauna species lists for the project area. Two landscape, flora and fauna surveys of the project area were conducted by Low Ecological Services between the 18th and 22nd June 2008 (Dry Season 2008) and 20th and 25th March 2009 (Wet Season 2009). A more detailed soil survey was included in the 2009 survey.

Regional Context

The project area lies within the Davenport and Murchison Ranges Bioregion. The project area overlies the phosphate rich Wonarah beds site, which is classified as significant on a bioregional scale as determined by the NT Parks and Conservation Masterplan (Baker *et al.*, 2005). This was likely due to the variety of habitats resulting from the relative mix of shallow sand covered rocky sub-crop and deeper aeolian sandy and alluvial silty drainage depressions. The project area is dominated by the Yelvertoft land system (Stewart *et al*. 1954) with minor occurrences of the Wonarah land system (Perry *et al.* 1962, Stewart *et al*. 1954).

The project area occurs within vegetation community 42 (Wilson et al., 1990) which is described as *Corymbia opaca* (Bloodwood) low open-woodland with *Triodia pungens* (Soft Spinifex) hummock grassland understorey. Vegetation community 42 occupies 28095.3 km^2 within the Northern Territory of which the Wonarah Phosphate Project area constitutes ~100 km^2 and the proposed disturbance (i.e. mine area) equates to 27 km^2 (0.1% of vegetation community).

Existing Data

A search of the NT Parks and Wildlife Flora Atlas (2007) for the project area and surrounding region did not identify any flora species of conservation significance under the EPBC Act. However, fourteen species were listed under the TPWC Act or by White *et al*. (2000) as significant at the NT or National level. Four of these species occur within the project area, two of which are listed as significant at a national level (*Sporobolus latzii* and *Bonamia alatisemina*) by White *et al.*, (2000). Many of these species are essentially data deficient due to lack of surveys in appropriate habitat in the region. No flora species of conservation significance were identified by a protected matters report generated by the Department of Environment Water Heritage and the Arts (DEWHA) web site for the project area and surrounding region.

A search of the NT Parks and Wildlife Fauna Atlas (2007) for the project area and surrounding region identified three species of conservation significance under the EPBC Act and TPWC Act, and eight species listed solely under the TPWC Act. Three of these species have been recorded within the project area (Australian bustard, *Ardeotis australis*, woma, *Aspidites ramsayi*, and long-haired rat, *Rattus villosissimus*). Two threatened (vulnerable) fauna species (mulgara, *Dasycercus cristicauda* or *D. blythi*, and Australian painted snipe, *Rostratula australis*); and eight migratory fauna species were identified by a protected matters report (DEWHA) as potentially present in the project area and surrounding region. No endangered or critically endangered species were listed.

Field Surveys

While the vegetation classification developed by Wilson *et al.* 1990 is broadly appropriate to the project area, LES desk top and field surveys defined five fine scale vegetation communities within the broader vegetation communities. The fine scale vegetation communities were found to be correlated with land units described by LES, which were verified in the field. Fine scale vegetation communities were mapped by LES for the project area to allow assessment of disturbance at a local scale.

The sand plain land units (Alluvial Sand Plains, Shallow Sand Plains and Deep Sand Plains) supported a continuous but variable vegetation community with differing proportions of flora species determined by landscape variables (vegetation community 1 = Eucalypt (coolabah, mallee & bloodwood) and Acacia (dogwood) low open-woodland with Senna sp. low shrublands over hummock grassland). The

Black Soil and Clay Plain land units were grouped, and supported vegetation community 2 = Coolabah low-open woodland with silky browntop (*Eulalia aurea*) and Mitchell grass grassland understorey. Calcareous Plains supported vegetation community 3 = Supplejack low open woodland with open-grassland understorey. Ephemeral Lakes supported vegetation community 4 = *E. victrix* (coolabah) low open-woodland with open-grassland understorey. There were limited floristic data for the Rocky rise land units (Limestone Outcrop and Mud Stone Outcrop) due to inaccessibility, but they were grouped with the surveyed rocky rise land units (Silcrete and Ironstone Rocky Rises) which were found to support the same vegetation community with varying proportions of species present. This was defined as vegetation community 5 = Acacia & mallee shrubland over hummock grassland.

Fine scale vegetation communities (as classified by LES) 1, 3 & 5 will be the only areas disturbed by the proposed works and the other two communities 2 and 4 are remote and not accessible to the mining operation. No habitats of ecological significance were detected within the project area; however the main ephemeral lake, which is located 5 km north of the Arruwurra Prospect and 13 km south-west of the Main Zone (Wonarah Prospect), is likely to provide important seasonal refuges for fauna and for both annual and perennial plant species adapted to seasonal inundations. This area is outside of the proposed disturbance area.

Up to 60% of the project area was burnt prior to the Dry Season 2008 survey, as reflected in the vegetation transects, which, on average, had 48 % bare ground and 23 % litter. Good vegetation growth was recorded during the Wet Season 2009 survey following favourable summer rains, with bare ground along vegetation transects reduced to an average of 19 %. Data from the Wet Season 2009 survey revealed an additional 102 flora species relative to the 42 species identified during the Dry Season 2008 survey, emphasising the importance of a follow-up survey to capture seasonal changes in species composition including those in response to fire. A total of 144 flora species was recorded in the Dry (2008) and Wet (2009) season surveys.

No plant species identified during LES field surveys are listed under the EPBC Act; however, two species are listed as Near Threatened (*Bergia barklyana* and *Hibiscus brachychlaenus*) and one as Data Deficient (*Heliotropium pulvinum*) under the TPWC Act. Two environmental weed species were recorded during the Wet Season 2009 survey along road verges and in drainage lines, buffel grass (*Cenchrus ciliaris*) and kapok bush (*Aerva javanica*). Neither species is declared under the *NT Weeds*

Management Act (2001), and Buffel Grass is a useful pasture species. Five declared weeds have been recorded in other studies within the surrounding region (50 km buffer); (Bellyache Bush (*Jatropha gossypifolia*), Mesquite (*Prosopis limensis*), Noogoora Burr (*Xanthium strumarium*), Paddy's Lucerne (*Sida rhombifolia*) and Parkinsonia (*Parkinsonia aculeata*)).

LES field surveys recorded a total of 15 mammal, 14 reptile and 33 bird species. One species listed as Vulnerable under the TPWC Act (2000), the Australian bustard, (*Ardeotis australis*), and the northern nailtail wallaby (*Onychogalea unguifera*), listed as Near Threatened under the TPWC Act, were recorded. A further nine species of conservation significance have been recorded within the project area and the surrounding region (50 km buffer) in other studies. LES conducted targeted surveys for species of conservation significance, especially bilby (*Macrotis lagotis*) and mulgara (*Dasycercus cristicauda* or *D. blythi*) where suitable habitat was identified during the Dry Season 2008 survey, but no evidence was found. Traditional owners assisted with tracking surveys and were consulted regarding their knowledge of significant fauna species occurring in the local region, but none were identified.

Within the surrounding region over 90 bird species have been recorded and many of these species are likely to occur within the project area. Sand plain habitats are likely to support the greatest bird diversity owing to the micro-topographic diversity and density of habitat, as well as the range of food resources due to the variable phenology of plant species that occur from ridge to flood out. Ephemeral wetland areas are also likely to be important habitats during wet seasons for many migratory species. None of the species listed are especially uncommon or rare in a regional sense. Most species present and potentially present, are wide-ranging.

Five species of introduced fauna were recorded. Three herbivore species, camel (*Camelus dromedarius*), cow (*Bos taurus*) and donkey (*Equus asinus*), were evidenced by old (> 1 month old) tracks at low densities around depressions, suggesting the animals were attracted to the water. Source populations for cattle include pastoral stations particularly to the north, but also possibly feral populations. Feral donkeys and especially camels are dispersed throughout the NT but congregate around water sources, which include natural waterholes and artificial sources such as dams, bores, and those at communities. Three carnivorous species were recorded: cat (*Felis catus*), fox (*Vulpes vulpes*) and dingo (*Canis lupis*). Fresh tracks (< 1 week old) were observed, mostly along exploration tracks, although some cat tracks were scattered within survey quadrats. Low incidence of tracks suggests low populations, with fresh tracks suggesting that the project area is currently utilised for intermittent hunting.

Bushfires within the project area are known to have a frequency of 1 – 2 events per 10 years. Beneficial fire conditions to assist persistence of significant species include low intensity, mosaic burns; however, there is limited information available for these species.

Plant and animal species of indigenous cultural value were identified and shown to be mainly of utilitarian value (i.e. food and medicine). All species are widespread and many are managed by indigenous peoples with fire. However, culturally significant trees are defined by the Central Land Council (CLC) as having trunk diameters equal to or greater than 12.5 cm and being at least 1.5 m tall and CLC approval is required prior to the removal and/or modification of such trees in these desert areas.

Low Ecological Services identified four soil types within the project area - Kandosols, Vertosols, Calcarosols and Rudosols (Australian Soil Classification: Isbell, 1996). Kandosols and Rudosols dominate the sand plains within the project area, Vertosols are restricted to areas subject to inundation (e.g. ephemeral lakes) and Calcarosols are restricted to two localities in the southern end of the Wonarah Phosphate Project area.

Minimising Impacts of the Operation

The proposed operations will not have a significant impact on flora and fauna at a national or bioregional scale as the habitat is common and widespread and most species recorded during on-site investigations are wide-ranging. Of the restricted or uncommon flora species recorded within the Wonarah Phosphate Project area, the Southern Sites of Botanical Significance (SSOBS) conservation codes, as defined by White *et al.* (2000), suggests that only *Sporobolus latzii* may be reliant on the project area for its continued persistence. The known record of this species is within a cultural exclusion zone associated with the ephemeral lake land unit which will not be disturbed by mining operations. Targeted fauna surveys, consultation with Traditional Owners and reference to the literature indicate that significant or major populations of fauna of conservation significance are unlikely to occur within the project area. It is therefore determined that the status of flora and fauna species of conservation significance that occur or could occur within the project area will not be affected by the proposed operations.

There will be loss of flora and fauna on a local scale and a variety of management strategies are described herein to minimise these impacts.

The most important of these are:

- On-going monitoring throughout the operation and rehabilitation phase of the project. In particular, track surveys for fauna species of conservation significance should be conducted immediately before mining operations commence, so identified threatened species can be translocated or harassed to move them out of the open cut pit or infrastructure sites;
- Important habitats, such as the ephemeral lakes land unit and areas subject to inundation, should be preserved where possible;
- Induction of all staff should include information on significant flora and fauna, how to identify them and how to minimise impact;
- Careful management of top soil, striped for mining activities, to aid rehabilitation success. Use of top soils (managed to maintain viable seed stocks) allows rehabilitated areas to regenerate utilising the existing seed bank.
    - Top soil stripping should be done after the soils have dried out to allow plants and seed to go into dormancy;
    - Top soil should be re-used as soon as possible after stripping, preferably within 3 to 6 months and before the wet season to enable maximum germination of seeds of appropriate maturity;
    - Early in the mine development, plant revegetation trials (based on stripped topsoil) should be established to determine if natural revegetation will be adequate for rehabilitation purposes. In the unlikely event that trials show inadequate revegetation, a seed collection program may be required based on local provenance material. A plant species list is provided herein showing suitable species for rehabilitation specific to land units within the project area;
    - Rehabilitation of soils and flora should be in accordance to the specific land unit which minimises impacts to biodiversity and species of conservation significance, and
- Best practice environmental principles should be adhered to at all times.

Table of Contents

Tables

Figures

1. Introduction

Minemakers Australia Pty Ltd (Minemakers) is currently in the pre-feasibility stage of their Wonarah Phosphate Project, located in the Barkly Tableland region of the Northern Territory (NT) (Appendix 1). Two main prospects have been identified within the project area, the Main Zone (Wonarah Prospect) and Arruwurra Prospect, (Appendix 2). Low Ecological Services P/L (LES) was commissioned to: broadly characterise the ecology of the area (habitats and faunal communities present); to characterise soils within the area and provide mitigating measures for potential soil degradation under mining; to identify threatened species of flora and fauna present or likely to be present in the project area; to highlight the potential for the project to have significant impacts on these species as well as assess potential impacts on these species of other disturbances such as bushfire and pest species which may be influenced by mining activities. LES conducted two field surveys, one in the dry and one in the wet seasons (June 2008 and March 2009). This report combines results from both surveys to address the requirements of Coffey Natural Systems in Briefs 1 and 2 (provided June 2008 and March 2009).

2. Scope of Works

The following scope of works was provided to LES and has been divided into Survey 1 and 2.

2.1. Study Objectives Survey 1 (Dry Season 2008)

- To broadly characterise the ecology of the area (habitats and faunal communities present);
- To determine whether threatened flora and fauna species listed under the *Environment Protection and Biodiversity Act* 1999 (EPBC Act) or *Territory Parks and Wildlife Conservation Act* 2000 (TPWC Act) are present, or likely to be present, in the two project areas;
- To determine the significance of the habitat in these areas for listed threatened flora and fauna species;
- To determine the potential for significant impacts on threatened flora and fauna species as a result of the project; and
- To recommend management and mitigation measures specific to any threatened species at risk from the project.

2.2. Study Objectives Survey 2 (Wet Season 2009)

- To characterise the vegetation and habitat types during the wet season, identifying any flora and fauna listed under the EPBC Act or TPWC Act present or likely to be present in the project area;
- To prepare maps identifying areas with conservation values and habitat known to support, or with potential to support, listed species including the mulgara, bilby, yellow chat and migratory birds.
- To prepare vegetation maps of the project area and the surrounding area at a sufficient scale to put vegetation disturbance as a result of the project into a regional context.
- To identify any introduced fauna and flora, assess their abundance in and around the project area and identify any potential source populations which may have an impact on the area;
- To assess the impact of attracting introduced grazing species (i.e. rabbits and camels) to the project area and outline mitigating measures;
- To identify flora and fauna in the project area of Indigenous value (e.g. mythical, cultural or utilitarian);
- To assess the potential for any significant impacts on threatened flora and fauna as a result of the project, and specifically the likelihood and consequence of these impacts. Potential impacts must be considered at the local, regional, territory and national scale;
- To recommend management and mitigation measures specific to any species at risk from the project as well as significant species (i.e. EPBC listed and TPWC listed species, species of indigenous values) at a local, regional, territory and national scale;
- To outline the impacts of bushfires on flora and fauna in the region, and identify threatened species potentially at risk from bushfire;
- To specify local plant species suitable for ongoing and final revegetation and rehabilitation works in the project area;
- To identify opportunities to rehabilitate and improve habitat availability and quality in the project area for EPBC and TPWC listed species;
- To characterise and describe the soils within the project area;
- To prepare maps detailing the soils of the study area, and
- To outline management and mitigation recommendations for soils likely to be disturbed during the construction and operation of the project.

2.3. Study Tasks Survey 1 (Dry Season 2008)

2.3.1. Desktop Survey

The initial desktop survey will include:

- A land system description; and,
- Identification of flora and fauna species expected to be present in the project areas based on data from LES and Northern Territory and Commonwealth government databases.

2.3.2. Field Surveys

Flora and fauna surveys within the project areas will:

- Identify fauna collected, directly observed or indirectly observed;
- Identify the major vegetation structural types, plant species and, particularly, vulnerable bushland resources for threatened fauna species, or local stakeholders, that will be affected by the project;
- Enable the preparation of a database for vegetation structure and/or floristic composition in the project areas; and,
- Record the locations of any observations of threatened flora or fauna species using a GPS.

2.4. Study Tasks Survey 2 (Wet Season 2009)

2.4.1. Desktop Survey

- Review existing data sources (e.g. aerial photography, satellite imagery and existing soils mapping) and describe the topography, geology and soils. Existing level of soil erosion and other disturbances within the study area will be identified.

2.4.2. Field Surveys

Flora and fauna surveys within the project areas will:

- Identify fauna collected, directly or indirectly observed;
- Identify and record the location of all survey quadrats, transects and traps with global positioning system (GPS) coordinates;
- Identify and record the distribution and abundance of introduced flora and fauna;
- Provide seasonal information regarding the distribution and abundance of flora and fauna;

- Provide information regarding the distribution of ephemeral water bodies in the project area and the fauna seasonally using this habitat;
- Enable preparation of habitat and vegetation maps for the project area with particular reference to potential habitat for significant species;
- Establish survey control sites (within the flora and fauna survey boundary but outside the project area and phosphorite deposits) and impact sites (within project area) for future monitoring programs. Sites should be representative of the various habitat types within and around the project area;
- Use appropriate methods to determine the extent and significance of the potential impacts of the project on flora and fauna. The Biodiversity Conservation Unit of the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) must be consulted on the survey methods prior to commencing field work. It is expected that staff from Coffey Natural Systems will participate in any meetings;
- A soil survey will be conducted, with areas to be disturbed by the project being mapped more intensively than non-disturbed areas. The survey should follow *Australian Soil and Land Survey Field Handbook* (McDonald *et al.*, 1990) guidelines; however if survey parameters deviate from acceptable survey standards, evidence must be provided to demonstrate why such a deviation is acceptable (for example soil profiles must be consistent across the survey area). Soil profiles should be mapped at a suitable scale and described according to the *Australian Soil and Land Survey Field Handbook* (McDonald *et al.*, 1990) and *Australian Soil Classification* (Isbell, 1996), and
- An appraisal of the depth and quality of topsoil will be undertaken. Any limiting properties of the soils will be discussed and any implications or special management requirements for the construction, operation and rehabilitation will be identified.

2.5. Reporting Survey 1 & 2 (Dry Season 2008 and Wet Season 2009)

A report collating all work to date (suitable as a stand alone document for inclusion as an appendix to a Public Environmental Report / Environmental Impact Statement) will be prepared. This report will include:

- A detailed description of the survey method and why this method provides confidence in results presented;

- A description of the ecology of the area (habitats and faunal communities present), including a list of species identified during the field visits;
- A list of all threatened species of flora and fauna present and likely to be present in the project area and the surrounds, including GPS coordinates of recorded locations for these species;
- Classification of these species in terms of their conservation significance at a local, regional, territory and national level;
- A habitat and vegetation map of the project area, including identification of any critical habitat types;
- Broad scale vegetation mapping for the project area, flora and fauna survey area and surrounding region;
- A summary of the potential for impacts on listed threatened species of flora and fauna, and habitats, as a result of the project;
- A summary of recommended management and mitigation measures to minimise the potential for impacts to species (including EPBC and TPWC listed species and species of Indigenous values) identified as present or potentially present;
- A list of local plant species suitable for use in regeneration and rehabilitation works;
- Opportunities and measures to rehabilitate and/or improve habitat for significant species (i.e. EPBC and TPWC listed species, species of indigenous significance);
- A detailed description of the soil survey method, detailing any deviations from Australian standards;
- A description of the geology and topography of the project area, and
- The soils and land units of the study area will be described and mapped, with particular reference to the physical and chemical properties of the soils that will influence erosion potential, acid generation and any other properties which require special management.

3. Methods

3.1. Summary of Terminology

For the purposes of this report we have focused on SEL 26452 (refered to as project area hereafter) south of the Barkly Highway, within the greater Wonarah Phosphate Project area (Appendix Two). The proposed disturbance area occupies a 27 km^2 area around the Main Zone (Wonarah) and Arruwurra Prospects and our surveys concentrated in these areas and within adjacent non impact areas. The two main prospects refer to the Main Zone and Arruwurra prospects and proposed mineral lease applications will cover these areas. The NT Flora and Fauna Atlases (2007) were searched for records occurring within a 50 km buffer from the centre of the project area. This search area is referred to as the surrounding region.

3.2. Existing data

Existing data formed the basis of a landscape analysis to determine, at a regional scale, landforms, geology, drainage systems, vegetation communities or habitats, and associated flora and fauna. Existing fauna and herbarium flora data were used to compile species lists for the project area and surrounding region. In order to account for changes in declared species of conservation significance listed under the EPBC Act and TPWC Act, a protected matters report was generated from the Department of Environment Water Heritage and the Arts (DEWHA) web site for the project area and surrounding region. Existing fire scar data was collected from the NT Bushfire Council website to determine fire frequency within the project area and surrounding region. Indigenous values of flora and fauna species were determined through consultations with Traditional Owners during field surveys and through utilising existing reference material. Detailed geological data for the project area, provided by Rio Tinto, was utilised in conjunction with on-site surveys to produce land unit, vegetation and soil maps of the project area.

3.3. Field Surveys

Two landscape, flora and fauna surveys of the project area were undertaken by LES between the 18^{th} and 22^{nd} June 2008 (Dry Season 2008) and 20^{th} and 25^{th} March 2009 (Wet Season 2009).

Fauna surveys were based on biodiversity sampling methods established by the Department of Natural Resources Environment and The Arts (NRETA) for Central Australia (Neave *et al.* 2006). Site descriptions and flora surveys were based on *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst *et al,* 2007; pp 85-87) and were adapted to suit the scope of works and landscape characteristics, and to take advantage of the expertise within LES. Two-hundred metre vegetation transects were introduced to the surveying methodology to provide a quantitative method to monitor temporal variability in floristics at sites.

The Dry Season 2008 survey consisted of:

- Establishing familiarity with the site and landscape to determine appropriate sites for flora and fauna surveys;
- Elliott and pitfall trapping for three nights at four selected sites;
- Intensive tracking surveys at eight selected sites;
- General flora surveys of the entire project area;
- Intensive flora surveys, including vegetation transects, at eight selected sites;
- Site descriptions (including landscape variables) at eight selected sites;
- Rapid landscape assessment and site description of the entire project area; and
- Searches for habitats of ecological significance.

The Wet Season 2009 survey consisted of:

- Establishment of eight survey quadrats within six land units representative of the project area, with six sites in proposed impact zones and two replicate sites in corresponding land units in non-impact zones, suitable for establishing an ongoing monitoring program. GPS coordinates were recorded for all survey quadrats, vegetation transects and traps.
- Elliott, pitfall, cage and funnel trapping for three nights at eight sample quadrats;
- ANABAT sonar microchiropteran bat detector at four sample quadrats for one night each.
- Bird survey at eight survey quadrats each day.
- Intensive tracking surveys at eight sample quadrats, including identification of introduced fauna. All incidental observations of fauna on the lease site were recorded with GPS and land unit data;
- Intensive flora surveys, including vegetation transects, at eight sample quadrats, including identification of introduced flora;
- Site descriptions (including landscape variables) at eight sample quadrats;

- Ground truthing of land unit map based on Rio Tinto geological map at an appropriate fine scale by traversing portions of the project area;
- Searches for habitats/flora/fauna of ecological significance, including brief survey of dried ephemeral lakes within mine lease; and
- Soil survey, including soil classification suitable for producing a soil map, of traversed areas including an appraisal of the depth and quality of topsoil and potential management issues.

3.3.1 Establishing Familiarity with the Site and Landscape (Dry Season 2008)

Following discussions about the site with supervisory geological exploration staff, a drive over the project area was undertaken to determine appropriate sites for flora and fauna surveys and to develop familiarity with the landscape. The aim of the process was to maximise exposure to different habitat zones and land units within the two main prospects and the project area. In 2008, five sites were selected in the two main prospects and three additional sites were selected throughout the project area. In 2009, six sites were selected within the two prospects and two sites were selected in non-impact areas. A description of survey methods used at each site is provided below.

3.3.2 Survey Methodologies

Site Selection

Eight survey quadrats were selected during the Dry Season 2008 survey to represent different land units within the project area, as well as replicate burnt and unburnt sites due to extensive fire within the region prior to the survey. Eight survey quadrats were selected during the Wet Season 2009 survey within six land units representative of the project area, with six sites in proposed impact zones and two replicate sites in corresponding land units in proposed non-impact zones. In the Wet Season 2009 survey, quadrats selected were suitable for recommended future monitoring to assess impacts of mining activities on local biodiversity and, specifically, on listed threatened species. Survey quadrats utilised in the Dry Season 2008 survey were re-used in the Wet Season 2009 survey when they met the above criteria.

Access to sites was by current roads, thus preventing access into some land units, which are therefore not represented in these surveys. As per the brief, the Dry Season 2008 survey focused quadrats within proposed impact areas within both prospects. The second brief (Wet Season 2009) required survey quadrats to be within replicate land units within proposed impact and non-impact areas, again spread between both prospects. However, our choice of land units in non impact areas was limited to those that occur on the single exploration track that links the two main zones. It may therefore be useful to install new access tracks for future monitoring if there is a desire to have exact land unit replicates within proposed impact and non-impact areas. Locations of survey quadrats are provided in Appendix Three and coordinates are provided in Table 1. An overview of the stratification of survey quadrats is provided in Appendix Four and Table 2.

Site Description

Site description summaries were completed for all quadrats surveyed in 2008 and 2009. Photographs were taken of each site, as well as more broadly, to provide examples of the habitat types in the area and features of note.

Fauna Trapping

During the Dry Season 2008 survey, vegetation description, fauna tracking and fauna trapping were undertaken at sites one to five (TS1-5 – Appendix Three), and vegetation description and fauna tracking were undertaken at an additional three sites (S6-S8 – Appendix Three) within the project area to maximise exposure to different habitat zones and land units (Appendix Four). Elliott trapping (one line with 25 traps placed 10 - 15 m apart) was conducted over three nights and represented a total of 225 trap nights (one Elliott trap open for one night = one trap night) for the survey. During the Wet Season 2009 survey, vegetation description, fauna tracking and fauna trapping were undertaken at eight sites (Appendix Three and Four). Elliott trapping was conducted over three nights and represented a total of 600 trap nights for the survey. Traps were baited with a mixture of oats and peanut butter. Two pit fall traps, consisting of a 25 L bucket with a 10 m drift fence, were placed 100 m apart along each of the Elliott trap lines. All traps were placed in potentially shady locations when available, or had shade shelters constructed using on-site vegetation; traps were checked each morning.

Vegetation Survey

The vegetation sampling consisted of recording all plant species within an approximate 200 m x 200 m area at each site. A 200 m transect was also established to provide abundance estimates, structural complexity and to provide a quantitative method to monitor temporal variability in floristics at each site. To enable future monitoring, permanent stakes were erected at each site, marking the start and finish of vegetation transects; GPS coordinates are provided in Table 1. All plant species were recorded at 1 m intervals along the 200 m transect. Plant structure was recorded by classifying all individuals occurring at a point into height classes of 1=1-10 cm, 2=10-25 cm, 3=25-50 cm, 4=50-100 cm, 5=100-200cm, and 6=200+ cm. Bare ground was categorised as bare soil/clay/sand and/or crusting. Litter was categorised as dead or loose plant material, and rocks were categorised as rock cover. Voucher specimens were collected when identification was uncertain, and were identified by Des Nelson (local botanist) with reference to the NT Herbarium. Vegetation characteristics were recorded to indicate species composition and cover, dominance and vegetation structure at each site. Percentage cover of dominant species was also estimated at each site. Dominant vegetation was categorised into four structural layers: (1) Emergent tree layer; (2) Upper shrub layer; (3) Lower shrub layer; and (4) Ground layer.

Vegetation communities were classified based on Wilson *et al.* (1990) but were modified, using more detail where required, to be more representative of the community, due to the broad classes provided by Wilson *et al.* (1990) who mapped at a 1:1 000 000 scale.

Fauna Tracking

Fauna tracking was undertaken at all survey quadrats, although high winds during the Dry Season 2008 survey period cleared tracks in sandy soils and the results are likely to be an underestimate of species occurrence and frequency. Weather conditions were ideal for tracking during the Wet Season 2009 survey. The fauna tracking consisted of a walk-over survey for 25 mins at each site within a 200 m x 200 m area. The 200 m vegetation transect was also utilised for fauna tracking and consisted of recording all tracks within each 1 m interval if present, allowing for occurance estimates to be derived. Again this methodology provides a quantitative survey method to detect change with future monitoring. Tracks and sign of fauna were also recorded opportunistically throughout the project area and have been added to the fauna species list for the Wonarah project area. Traditional Owners were involved in tracking and were consulted regarding unusual digs (e.g. Site 6 – Wet Season 2009 survey on a rocky rise where digs resembled bilby digs but were identified as echidna). Traditional owners were also consulted regarding any species of conservation significance known to occur in the region.

Bird Survey

Standardised bird surveys were undertaken at each site for 25 mins in the morning and/or afternoon, and all species seen or heard opportunistically throughout the project area were recorded.

Microchiropteran Bat Survey

Anabat II (Version 6) sonar detection devices were used to record the high frequency calls of microchiropteran bats. Recordings were made at four sites for a period of 12 consecutive hours (1800 to 0600). Call records are identified to species by Dennis Matthews (Consultant) using keys to calls developed by Parks and Wildlife and Matthews.

Despite conducting the microchiropteran bat survey during the Wet Season 2009 survey, no results were obtained, which was latter attributed to faulty equipment. It is recommended that microchiropteran bat surveys are incorporated into any future environmental surveys and the Anabat II detector may be sent to Minemakers staff on-site if data is required sooner.

Rapid Landscape Analysis

Rapid landscape analysis is a rapid assessment technique aimed at determining landforms, geology, drainage systems, vegetation communities or habitats, and associated fauna. Landscape patterns were determined from existing data and were refined using available aerial photographs, satellite imagery, and GIS layers (Digital Elevation Model, DEM, and Digital Terrain Model, DTM contours, and spot heights). These data were used to assess potential habitats of ecological significance, erosion potential and construction considerations for all sites.

Soil Survey

A soil survey was undertaken during the Wet Season 2009 survey and was based upon *Australian Soil and Land Survey Field Handbook* (McDonald *et al.*, 1990). Soils were classified according to *Australian Soil Classification* (Isbell, 1996). Soil surveying methodology deviated from McDonald *et al.*(1990) in the depth of soil profile surveyed (recommended 1.8 m), due to time constraints limiting use of an excavator and limited availability of pre-dug pits related to drilling operations. Forty centimetre pits were surveyed at survey quadrats and soil profiles of up to 1.2 m depth were opportunistically surveyed utilising pre-existing diamond drill sumps. The lack of horizons beyond 40 cm depth in the seven drill sumps analysed indicated that 40 cm pits were adequate for soil classification within the Wonarah Phosphate Project area. Horizon boundaries in soil trenches were measured and described using physical and chemical parameters according to criteria in Isbell (1996). Landform and soil data were documented at each site according to the criteria of McDonald *et al.* (1990). Soil classifications were corroborated by former NRETAS soil scientist, Rudy Lennartz utilising raw data including photographs of soil profiles, to ensure accurate classification of soils and confidence in data provided herein.

GPS Cataloguing and Mapping

Track and waypoint data were collected using a *Garmin GPS 76C Mapper* and were mapped in Arc Map (Version 9.2).

4. Regional Context – Background Data

4.1. Climate

The climate of the area is described by Slatyer and Christian (1954) as semi-arid and monsoonal with nearly all the rain being received between November and April. Climatic conditions are indicated by those described for Wonarah Weather Station which operated between 1946 and 1974 (Bureau of Meteorology (BOM), 2009). Mean annual rainfall is about 317 mm with a range of 300 mm to 460 mm. Temperatures are high throughout the year and average monthly maximum temperatures may reach 39^0C just before the onset of the wet season, minimum temperatures may reach 10^0C in the dry season. The strongly seasonal character of rainfall results in wet humid conditions for three to six months of the year and progressively drier conditions through to winter and spring when water stress can be quite severe. Potential evaporation rate is about 3000 mm/year.

Conditions in the region in June 2008 (Dry Season 2008 survey) were relatively warm, although at the time of this survey conditions an intense high pressure system created strong winds and cool temperatures. Furthermore, the Barkly region was experiencing a severe deficiency of rainfall verging on the lowest on record for the 12 months preceding the survey, and the majority of the project area had been burnt within the month prior to surveying (BOM, 2008).

Recent climatic conditions leading up to and during the Wet Season 2009 survey are described for the closest weather station recorded by BOM during the period, Brunette Downs 145.3 km NNW of Wonarah project area. Regional conditions in March 2009 (Wet Season 2009 survey) at Brunette Downs were warm, with average maximum temperatures of 36°C and average minimum temperatures of 20°C recorded at the closest weather station (Figure 1). Regional conditions at the time of the survey were relatively calm (wind speeds between (2 – 11 km/hr), warm (maximum temperatures between 36.4 – 38.2°C) and moderately humid (relative humidity between 18 – 29%) (BOM, 2009). A total of 600 mm rainfall fell during the summer months (Figure 1).

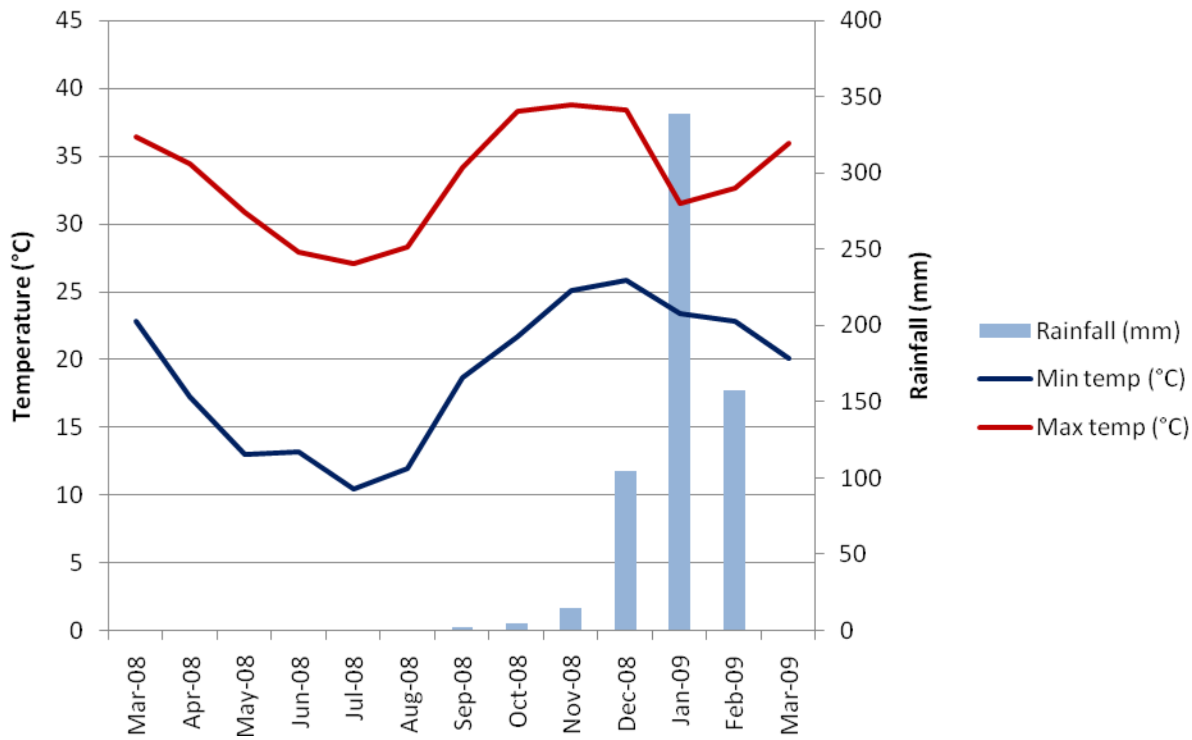


Figure 1: Maximum and minimum temperatures and rainfall between March 2008 and March 2009 at Brunette Downs (145.3 km NNW), the closest weather station to the Wonarah Phosphate Project area since Wonarah Weather Station ceased operations in 1974 (data adapted from BOM, 2009).

4.2. Bioregion

The project area lies within the Davenport and Murchison Ranges bioregion which is described by Purdie *et al.* (2008) as being "dominated by rugged rocky hills of folded volcanics, sandstone, siltstone and conglomerates. Soils are generally shallow lithosols, however deep fine-grained alluvial soils occur in the valleys and surrounding plains. Vegetation communities are dominated by spinifex (*Triodia* sp.), hummock grassland and low eucalypt and acacia open woodland". The project area overlies the Wonarah beds site, which is classified as significant on a bioregional scale as determined by the NRETA Parks and Conservation Masterplan (Appendix Five). White *et al.* (2000) describe the Wonarah beds as low rises of chert chalcedony, tertiary travertine, silicified coquinite and limestone, and outcrops of Cambrian dolomite framed in a sandplain. The beds occur over a very large area and values of this site may not be unique and may extend over a much larger region. The distinctive undulating feature is unique to the Wakaya desert and contains the only known collection site of *Sporobolus latzii* and is a type location for *Acacia drepanocarpa subsp. latifolia*. Another important feature of the bioregion is the relative diversity of aquatic and semi-aquatic plants associated with the large number of permanent or semi-permanent waterholes within the ranges. No ecosystems in this bioregion have been formally listed as threatened.

4.3. Landforms Physiography and Geology

The physiography of the project area has been described by Noakes and Traves (1954). The area is noted for general low relief of the landscape although small bevelled chert/silcrete rocky outcrops are locally common. Surface flow in the area is relatively disorganised, with no significant water courses present. More detailed geological information is available as a result of the considerable mineral exploration work in the region by Minemakers and its predecessors over the last 45 years.

4.4. Land Systems

Land systems of the surrounding region and project area have been mapped and described by Stewart *et al.* (1954) (Barkly Region) and Perry *et al.* (1962) (Southern NT). The project area falls on the edge of these two studies, and, for the purpose of this report, land systems boundaries have been modified slightly and combined where appropriate (Appendix Six). The Wonarah Phosphate Project area is dominated by Yelvertoft land system (Stewart *et al*. 1954) with minor Wonarah land system (Perry *et al.* 1962 and Stewart *et al*. 1954).

Stewart *et al.* (1954) describes the Yelvertoft land system as undulating, with mostly skeletal soils and truncated gravelley lateritic red earths; *Eucalyptus brevifolia* or *E. dichromophloia* woodlands. The Wonarah land system is described as gently undulating with lateritic red earths and *Eucalyptus brevifolia* woodland or *Eucalyptus. spp* (low mallees) – *Acacia* spp. shrubland. Perry *et al.* (1962) described the Wonarah land system as gently undulating plains with stonier higher parts and broad lowlands, relief mainly up to 30 ft; red clayey sands and red earths, partly lateritic; soft spinifex with sparse shrubs and low trees.

4.5. Soils

The soils in the Wonarah Phosphate Project area fall within soil classes By4 and My80 (Appendix Seven) (Bureau of Rural Sciences 1991). By4 dominates the project area, while My80 occurs in the north-east of the project area, outside of the proposed works. Soil classes are described as follows utilising Principal Profile Forms (PPF's) of Northcote (1979): By4 is composed of undulating ridge and slope terrain on lateritic sediments; some rock outcrops: chief soils seem to be shallow sands usually containing large amounts (> 60%) of mixed and variable gravels (K-Uc1.4) or ironstone gravels (KS-

Uc1.4), and also uniform coarse sands (Uc1.4) with some gravels on ridges and upper slopes generally. Associated are shallow to deep varieties of loose red siliceous sands (Uc1.23), and the previous incorporating large amounts (> 60%) of mixed and variable gravels (K-Uc1.23), neutral red earths (Gn2.12), and gravelly red neutral massive earths (K-Gn2.12) on mid and lower slopes. Small areas of other soils are likely. My80 contains gently undulating plains slightly elevated above the adjoining cracking clay plains; some narrow ridges and hills with rock outcrop and some shallow depressions. The dominant soils on the long gentle slopes and low rises are neutral red earths (Gn2.12) with a variable content and surface scatter of ironstone gravels. Associated are sands with coherent red and yellow earthy subsoils (Uc5.21 and Uc5.22) on slopes and in depressions; loamy massive earths (Gn2) incorporating neutral red earths (Gn2.12) and acid yellow earths (Gn2.21) marginal to the cracking clay plains; and some shallow gravelly and stony coarse sands (Uc) on ridges and hills. Small areas of soil units BA13, BY4, and My82 are included.

4.6. Flora

ARC/INFO coverage for the 1:1,000,000 NT vegetation map based on Wilson *et al.* (1990) indicates that the vegetation in the project area falls within Class 42 L1H3, which is described as encompassing *Corybia opaca*, (bloodwood), low open-woodland with *Triodia pungens* (soft spinifex) hummock grassland understorey. L1 is a structural formula referring to lifeform and height of trees <10m tall with a density (projective foliage coverage) of 1-9%. H3 is a structural formula referring to lifeform and height of hummock grassland with a density (projective foliage coverage) of 30-69% (Appendix Eight). Vegetation associations in the area are likely to be strongly related to soil types with distribution limited mainly by water availability which is affected by the summer wet and winter dry periods.

Within the Wonarah beds site, White *et al.* (2000) identify three taxa of Australian significance (*Bonamia alatisemina, Rothia indica subsp australis* and *Sporobolus latzii*) seven taxa of NT significance (*Distichostemon barklyanus*, *Heliotropium ballii, Heliotropium pulvinum*, *Najas marina*, *Triumfetta centralis*, *Triumfetta deserticola*) one taxa of southern NT significance (*Grevillea dryandri subs. dryandri*) and four taxa of bioregional significance (*Eragrostis olida*, *Exocarpos sparteus*, *Isoetes muelleri*, and *Tephrosia stuartii*).

A protected matters report generated from the DEWHA web site within the project area and surrounding region identified no flora species of conservation significance (Appendix Nine). A search of the NT Parks and Wildlife Flora Atlas (2007) identified 746 records with 346 species within the surrounding region (Appendices Ten & Eleven). None of these species were listed under the EPBC Act for conservation significance, although 14 species were listed under the TPWC Act as data deficient and/or by Baker *et al*. (2005) as significant at a NT or National level (Appendices Fourteen and Fifteen). Four of these species occur within the project area, two of which are listed as significant at a national level (White *et al.* 2000) (*Sporobolus latzii*, 1K, and *Bonamia alatisemina* 3K) (Appendices Twelve & Thirteen).

Five introduced flora species were identified by the NT Parks and Wildlife Flora Atlas (2007) within the surrounding region and some of these could potentially occur in the project area (Appendix Fourteen). Baker *et al*. (2005) identify 10 introduced species that are of concern in the bioregion (Appendix Fourteen). Many other introduced species could potentially occur, particularly as the project area is in close proximity to a major highway where vehicles are a major vector for weeds.

A biological survey of the Wakaya Desert was undertaken by DNRETAS in the early 1990's. Important species data from this survey have been entered in the NT Flora and Fauna Atlases (2007) which have been included in this report.

4.7. Fauna

The Davenport Murchison Range bioregion is not renowned for its high diversity of mammalian and reptile fauna, although there have been very few extensive surveys undertaken. As with other central Australian bioregions, the mammalian fauna has suffered substantial losses. Of 36 mammal species previously recorded, 9 have become extinct, 3 have declined and 24 remain stable. Connors. *et. al.*, (1996) listed 394 vertebrate species from the Davenport and Murchison Ranges Bioregion combined with the far larger Tanami bioregion. Avian fauna (particularly water birds) can be rich where large areas of semi-permanent water exist. An unconfirmed sighting of a night parrot (*Pezoporus occidentalis*) was recorded in 1970 along the Barkly Highway (Low 1985). Bilby (*Macrotis lagotis*) have been collected west of the present Barkly Roadhouse on Dalmore Downs station, and habitat in the surrounding region is suitable for the spectacled hare wallaby (*Lagorchestes conspicillatus*) and northern nailtail wallabies (*Onychogalea unguifera*). Burrowing bettongs (*Bettongia lesueur*) were once widespread throughout the area, but are now extinct in the wild on the mainland. One of the distinctive features of the Davenport and Murchison Ranges Bioregion is that it may contain core range area for the central pebble-mound mouse (*Pseudomys johnsoni*). The regionally extinct species include the central rock-rat

(*Zyzomys pedunculatus*), which has persisted in rocky ranges south of the Wonarah Phosphate Project area near Alice Springs.

A search of the NT Parks and Wildlife Fauna Atlas (2007) identified 693 records of 163 species within the surrounding region (Appendices Fifteen & Sixteen). Three of these species were listed for conservation significance under the EPBC Act and TPWC Act, and eight species were listed solely under the TPWC Act (Appendices Seventeen & Eighteen). Three of these species were located within the project area; Australian bustard (*Ardeotis australis*), woma (*Apsidites ramsayi*) and long-haired rat, (*Rattus villosissimus*). Species listed under the EPBC Act that occur within the surrounding region include mulgara (*Dasycercus cristicauda* or *D. blythi*), bilby (*Macrotis lagotis*) and yellow chat *(Epthianura crocea*). The yellow chat is listed as vulnerable under the EPBC Act, and as endangered/lower concern under the TPWC Act, although it is the northern sub species (Alligator River, *Epthianura crocea tunneyi*) that is listed as endangered. The yellow chat (southern form) has been recorded 20 km north east of the project area.

A protected matters report (generated from the DEWHA web site) for the Wonarah Phosphate Project area and surrounding region identified two threatened (vulnerable) species (mulgara, *Dasycercus cristicauda*, and Australian painted snipe, *Rostratula australi*) eight migratory bird species (Appendix Nine). No endangered or critically endangered species were listed.

Note that mulgara was reclassified by Woolley (2005) into two species, the Crest-tailed Mulgara (*Dasycercus cristicauda*) and the Brush-tailed Mulgara (*D. blythi*), and both these mulgara species are now recognised. *D. cristicauda* is classified as endangered under the EPBC Act and vulnerable under the TPWC Act. *D. blythi* is classified as vulnerable under both the EPBC and TPWC Acts. Due to this reclassification, it is unclear in historical data which species was recorded.

5 Site Description and Existing Environment – LES Field Survey Data

5.1 Survey Overview and Limitations

An initial flora, fauna and landscape survey of the project area was undertaken by LES between the 18th and 22nd June 2008 (Dry Season 2008 survey). Weather during the survey period was relatively cool, and a high-pressure system created strong winds each day. Cool temperatures decreased reptile and mammal activity and strong winds severely limited fauna tracking on the sandy soil. Further, 60% of the project area had burnt within the previous month, decreasing overall species records and the ability to locate flora species of conservation significance. To account for this, survey sites were distributed throughout burnt and unburnt sites (where possible) to maximise exposure to undisturbed areas and this, in combination with a drive-over inspection of the project area, allowed identification of habitats of ecological significance. It was recommended by LES that prior to the commencement of any works, additional fauna surveys should be conducted, especially towards the end of the year when conditions are warmer, to ensure baseline data is collected during different seasons.

A second flora, fauna and landscape survey of the project area was undertaken by LES between the 21st and 25th March 2009 (Wet Season 2009 survey). Good weather conditions during the survey provided good trackability of sites and warm evenings were conducive to high overnight fauna activity, evidenced by high track numbers each morning. Despite this, capture rates remained low. Favourable summer climatic conditions had facilitated good vegetation growth since the June 2008 fires with many plants in seed (especially Spinifex species). It is therefore likely that abundant food sources reduced the effectiveness of baiting traps and/or that additional time may be required for ground dwelling species to respond to the recent favourable conditions. It is also likely that the previous year's drought and fire had reduced fauna numbers. Nevertheless, tracking and opportunistic sightings bolstered species lists improving confidence in detecting fauna species present. Good vegetative growth and presence of flowers and fruit in the majority of plants allowed accurate identification of species.

The range of land units surveyed, and consequently, vegetation communities, was restricted to those accessible via existing exploration tracks. Large distances, vegetation growth, the potential for flat tyres (especially by stakes from burnt acacias), logistical and time constraints were all factors that limited surveying away from existing exploration tracks. However, all land units to be directly affected by mining were surveyed, with control sites in the same land units, but away from impact areas. Further, a high number of sites were surveyed in both survey periods, providing detailed baseline data and improving the capacity to detect change with future surveys.

5.2. Site Selection

Coordinates of survey quadrats for the Dry Season 2008 and Wet Season 2009 surveys within the Wonarah project area are provided in Table 1 and displayed in Appendix Three. Stratification of survey quadrats against land units and proposed disturbance zones are provided in Table 2 and displayed in Appendix Four.

Table 1: Coordinates of survey quadrats for Dry Season 2008 and Wet Season 2009 surveys within the Wonarah project area.

Year	Site	Latitude	Longitude
2008	TS1	-20.11548	136.33603
	TS2	-20.11533	136.35056
	TS3	-20.11531	136.35996
	TS4	-20.00894	136.45436
	TS5	-19.97024	136.50182
	S6	-20.11591	136.31153
	S7	-20.0094	136.47036
	S8	-20.00864	136.50196
2009	1	-20.13156	136.32523
	2	-20.11534	136.33611
	3	-20.09689	136.36247
	4	-20.04958	136.4555
	5	-20.00932	136.47204
	6	-19.97021	136.50192
	7	-20.01935	136.4549
	8	-20.09292	136.45692
	9	-20.07607	136.34425

Table 2: Survey quadrats for Dry Season 2008 and Wet Season 2009 surveys stratified by land units and proposed disturbance zones.

Land Unit	Disturbance	2008 Survey	2009 Survey	Replicate Sites
Alluvial Low Lying Sand Plain	Impact	TS1, TS4, S6, S7.	2, 5	7 (2008) = 5 (2009). 1 (2008) = 2 (2009).
Calcareous Plain	Impact	TS3	3	
Deep Sand Plain	Impact	TS2	7	7, 8 (2009).
	Non-impact		8	
Ephemeral Lakes	Non-impact		9	
Ironstone Rocky Rise	Impact	TS5, S8	6	5 (2008) = 6 (2009).
Shallow Sand Plain	Impact	TS3	1	
Silcrete Rocky Rise	Non-impact		4	6, 4 (2009)

5.3 Site Description Summaries - Flora

Site description summaries, including dominant plant species identified at each site, are provided in Appendices Nineteen to Thirty-five. A full list of flora (including conservation status) identified during LES field surveys (Dry Season 2008 & Wet Season 2009 surveys) is provided in Appendix Thirty-six. The project area is dominated by sand plains with *Acacia, Grevillea,* and *Hakea spp.* over *Aristida* and *Triodia*; open woodlands with *Acacia, Eucalyptus* and *Corymbia, Hakea* and *Melaleuca spp.* over *Acacia* shrubs and *Triodia* spp; and rocky rises with sparse *Acacia*, *Eucalyptus* and *Corymbia*, and *Triodia* spp.

A total of 144 plant species were recorded during the Dry Season (2008) and Wet Season (2009) surveys (Appendix Thirty-six).

Forty-two flora species were recorded during the Dry Season 2008 survey. Prior to the survey approximately 60% of the project area was burnt in the previous month; which was reflected in the vegetation transects which, on average, had 48% bare ground and 23% litter and the low number of species recorded. The vegetation was showing good signs of regeneration with many *Eucalyptus* and *Corymbia* and *Triodia* spp. re-sprouting from their bases.

Good vegetation growth was recorded during the Wet Season 2009 survey following favourable summer rains. During the Wet Season 2009 survey, a total of 132 flora species were recorded, providing an additional 102 flora species compared to the Dry Season 2008 survey. Although it was known that the Dry Season 2008 survey would have limited flora species due to the fire, this emphasises the importance of the follow-up survey to capture seasonal species, including species occurring in response to fire.

<u>**Habitats of Ecological Significance**</u>

No habitats of ecological significance were recorded during LES field surveys; however ephemeral areas are likely to provide important seasonal habitat or refuges for fauna and for both annual and perennial species which are adapted to seasonal inundations.

Significant Flora Species

LES surveys recorded no flora species listed under the EPBC Act; however, two species recorded are listed as Near Threatened (*Bergia barklyana* and *Hibiscus brachychlaenus*) and one as Data Deficient (*Heliotropium pulvinum*) under the TPWC Act, (Table 3 and Appendix Thirty-seven). A table compiling significant flora species recorded within the Wonarah project area in the NT Flora Atlas (2007) and LES surveys are presented in Appendix Thirty-seven and coordinates are provided Appendix Thirteen.

The Southern Sites of Botanical Significance (SSOBS) conservation codes, as defined by White *et al.* (2000) for each of these species are as follows: *Bergia barklyana* (SSOBS = 3R) – a rare species of national significance with a geographic range exceeding 100 km but not currently considered to be threatened; *Hibiscus brachychlaenus* (3r) – a rare species of significance in the Northern Territory with a geographic range exceeding 100 km but not currently considered to be threatened; and *Heliotropium pulvinum* (3k) a taxa with a geographic range exceeding 100 km with the potential to belong to a conservation category (Appendix Thirty-seven).

Table 3: Significant Flora Species identified during LES field surveys (Dry Season 2008 & Wet Season 2009 surveys).

Species Name	TPWC	EPBC	SSOBS level	SSOBS code	Site No.	
					2008	2009
Bergia barklyana	nt		National	3R		9
Heliotropium pulvinum	dd		Northern Territory	3K		6
Hibiscus brachychlaenus	nt		Northern Territory	3r		6

Sporobolus latzii

Sporobolus latzii is listed as data deficient under the TPWC Act and is recorded from only one site in the Northern Territory (and world), which is within the Wonarah Phosphate Project area at coordinates (136.33454, -20.06521536), making it potentially one of the most restricted and rarest plant taxa in the NT (Appendix Thirteen). More survey work is required to determine its conservation status under the TPWC and EPBC Acts; however it is noted here to be of significance because of the single record. The record occurs within a cultural exclusion zone associated with the ephemeral lake land unit (Appendices Four and Twelve).

The Wet Season 2009 survey conducted a land unit verification survey into the ephemeral lake cultural exclusion zone (with prior permission from the CLC and accompanied by traditional owners) which targeted identification of *S. latzii*, but it was not recorded.

As per existing CLC requirements, no further survey work is planned within the cultural exclusion zone.

<u>Weeds</u>

Two introduced plant species were recorded during the Wet Season 2009 survey, the pastoral grass, buffel grass (*Cenchrus ciliaris*) and road side rehabilitation species, kapok bush (*Aerva javanica*). Neither species are declared under the *NT Weeds Management Act* (2001). Both are invasive species and are identified as environmental weeds. Introduced plant species known to occur in the region are shown in Appendix Fourteen.

Buffel grass was recorded in four isolated patches along the exploration track between the Main and Arruwurra zones and near the proposed bore fields (Sites 1 & 3), occurring on low lying areas within sand plains. One patch was located within a clayey-loam depression at coordinates (S20.09432 E136.35818). Buffel grass occurs extensively outside the project area, especially along the Barkly Highway, where vehicles will be major vectors spreading seed into the project area. Buffel grass is regarded as a significant pastoral grass, a dominant land use in the Barkly Tableland, and continues to be sown for pastoral use today. Buffel grass has dramatically changed the vegetation structure and species composition of drainage systems in central Australia. As well as displacing native understorey species, buffel grass increases the intensity of wildfires due to the high fuel loads it produces (Paltridge and McAlpin, 2002). The spread of buffel grass has increased dramatically in some areas throughout central Australia, especially along major highways (Purdie *et al.* 2008).

An individual kapok bush was recorded along the exploration track leading into the Arruwurra Zone, in a shallow sand plain. Kapok bush grows in red sandy and gravelly soils along roadsides, particularly where the soil has been disturbed (Purdie *et al.* 2008). The proximity of the plant to the exploration track suggests that vehicle access and/or soil disturbance is responsible for its presence. In recent times it has been used a fodder plant and for stabilisation of earthworks (Purdie *et al.* 2008).

5.4 Site Description Summaries - Fauna

Site description summaries, including species identified at each site are provided in Appendices Nineteen to Thirty-five. A full list of fauna identified during LES field surveys (Dry Season 2008 & Wet Season 2009 surveys) are provided in Appendix Thirty-nine. In general, the area does not exhibit any special features for biodiversity although one species of conservation significance (Australian bustard, *Ardeotis australis*) was recorded at sites TS4, S7 & S8 during the Dry Season 2008 survey and Sites 2 & 3 during the Wet Season 2009 survey through tracks. One species listed as Near Threatened (northern nail-tailed wallaby, *Onychogalea unguifera*) (TPWC Act) was recorded at Site 1 during the Wet Season 2009 survey through scats. A table compiling significant fauna species recorded within the Wonarah project area in the NT Flora Atlas (2007) and LES surveys are presented in Appendix Thirty-eight and coordinates are provided in Appendix Eighteen.

Birds

A total of 33 bird species were recorded during LES field surveys (Appendix Thirty-nine) including one bird species of conservation significance, the Australian bustard (*Ardeotis australis*), listed as vulnerable under the TPWC Act 2000 (locations given above). No protected migratory species were recorded during LES field surveys. Within the surrounding region over 90 bird species have been recorded in habitats similar to those in the project area and many of these species are likely to occur within the project area. Sand plain habitats are likely to support the greatest bird diversity owing to the micro-topographic diversity and density of habitat, as well as the range of food resources due to the differing phenologies of plant species that occur from ridge to flood out. Ephemeral wetland areas are also likely to be important habitats during wet seasons for many migratory species, although no species specific to wetland areas were observed during LES field surveys. In general, species listed are not especially uncommon or rare in a regional sense. Most present and potential species are wide-ranging.

Mammals

A total of 15 mammals were recorded during LES field surveys (Appendix Thirty-nine). Trap captures during both surveys were relatively low over the three nights. Dring the Dry Season 2008 survey numbers ranged from 5 individuals (Trap Site 4 and 5) to 21 individuals (Trap Site 3). Highest trap captures were recorded in Trap Site 3, which had not been recently burnt. Unburnt areas are likely to act as refuges for some species, although there was an abundance of seeds available for small mammals to collect in some of the burnt sites. Weather during the survey was relatively cold and this may have reduced small mammal activity, although all sites had some trapping success. During the Wet Season 2009, only 3 individuals, all lesser-hairy footed dunnarts (*Sminthopsis youngsoni*), were captured. It is likely that good plant growth conditions following favourable summer rains and subsequently abundant seeds and fruit observed during the survey are responsible for the low effectiveness of trapping. However, nightly faunal activity was high, as evidenced by tracks each morning, and an additional nine species were recorded from tracks, scats and digs (Appendix Thirty-nine).

One species, the northern nailtail wallaby (*Onychogalea unguifera*), listed as near threatened under the TPWC Act (2000) was recorded at Site 1 during the Wet Season 2009 survey and has been recorded within a 50 km buffer of the project area in the NT Fauna Atlas (2007). No species listed under the EPBC Act (1999) were recorded during LES field surveys. However, habitats in the project area, particularly the acacia shrublands and hummock grasslands are suitable for bilby (*Macrotis lagotis*) and mulgara (*Dasycercus cristicauda* or *D. blythi*) and both of these species have been recorded within the surrounding region in the NT Fauna Atlas (2007) (Appendices Seventeen and Eighteen). Further, there is potential habitat in the open woodlands to the south-west of the project area for spectacled hare-wallaby *(Lagorchestes conspicillatus*).

Evidence of significant fauna species, in particular bilby and mulgara, were targeted in the Wet Season 2009 survey during which tracking conditions were excellent. Some survey quadrats during the Wet Season 2009 survey were established in habitats suitable for bilby and mulgara; Site 6 for bilby and hummock sand plains sites for both bilby and mulgara. An active search involving LES staff and Traditional Owners was conducted in the drainage channel containing large termite mounds built by *Nasutitermes triodiae,* proximal to Site 6, which are often shown to support bilby and mulgara in the Tanami desert (Moon and Low, 2006 & 2007); however no evidence was found. Furthermore, Traditional Owners were consulted regarding presence of these species but did not indicate knowledge of these species in the local region.

<u>Amphibian and Reptiles</u>

No amphibian species were recorded during LES field surveys (Appendix Thirty-nine).

A total of 14 reptile species were recorded during LES field surveys (Appendix Thirty-nine). Trapping yielded 12 species, while tracking added two species to this list during the Wet Season 2009 survey.

While tracking conditions were favourable during the survey, many tracks were unable to be identified to species level and have been categorised as legless lizard, snake, small lizard and goanna. Trapping success during the Wet Season survey ranged from 2 individuals at Site 3 (calcrete rise with surrounding sand plains) to 9 at Site 4 (silcrete rocky rise). Only one species (sand goanna, *Varanus gouldii*) was identified during the Dry Season 2008 survey and very few identifiable tracks were found due to strong winds and poor tracking conditions. Within the surrounding region, 50 reptile species have been recorded in the NT Fauna Atlas (2007), and LES field surveys observed suitable habitat within the project area for many of these species.

No species of conservation significance under the TPWC Act (2000) or EPBC Act (1999) were recorded during LES field surveys. One species (woma, *Apsidites ramsayi*) listed as near threatened under the TPWC Act was recorded within the project area in a previous survey (NT Fauna Atlas 2007). One species, *Varanus spenceri*, is listed as data deficient under the TPWC Act, and was recorded outside of the Wonarah project area within a 50 km buffer (NT Fauna Atlas 2007).

<u>Significant Fauna Species</u>

Locations of fauna species of conservation significance recorded during LES field surveys (Dry Season 2008 and Wet Season 2009 surveys) are listed in Table 4.

Table 4: Significant Fauna Species identified during LES field surveys (Dry Season 2008 & Wet Season 2009 surveys).

Species Name	TPWC	EPBC	Site No		Evidence
			2008	2009	
Ardeotis australis (Australian Bustard)	vu		TS4, S7 & S8	2 & 3	Tracks/Feather
Onychogalea unguifera (Northern nailtail Wallaby)	nt			2	Scats

A table compiling the current distribution, preferred habitat, preferred fire regimes and threatening process for significant fauna species is provided in Appendix Forty. These species include species recorded during on-site investigations (both LES field surveys and NT Fauna Atlas (2007) records) and species identified in the DEWHA *Matters of Environmental Significance* report (Appendix Nine) as potentially occurring within a 50 km buffer of the project area.

The preferred habitat for significant fauna species listed encompasses a wide range of landforms and plant communities. It does not suggest that the species exclusively occur in this habitat, however, where this habitat does occur in the project area then the likelihood of occurrence may be increased. Threatening processes are also highly variable; however, common themes include predation, alteration to habitat (by clearing, competition and degradation by introduced competitors) and alterations to fire regimes. Preferred fire regime data for significant fauna species is limited although it is evident that regimes developing a variety of habitat age and structure are important for the maintenance of shelter, reproductive and dietary requirements.

Feral Animals

Five introduced species were recorded within the project area during LES field surveys, (Appendix Thirty-nine). Three herbivore species were recorded: camel (*Camelus dromedarius*), cow (*Bos taurus*) and donkey (*Equus asinus*). All the evidence of these species was old (> 1 month old) tracks around depressions (suggesting water access). Tracks were few and, in the case of cow and donkey (only recorded during the Wet Season 2009 survey) were confined to one drill sump (S20.12903 E136.32635) and reflected single individuals. There was no evidence of camels within the project area during the Wet Season 2009 survey. A lack of fresh evidence of introduced herbivores during the Wet Season 2009 survey suggests that individuals are not reliant on the project area and that just a few individuals may access the site infrequently while searching for water. Source populations for cattle include those on surrounding cattle stations. Feral donkeys and especially camels disperse throughout the Northern Territory but congregate around water sources which include natural waterholes and artificial sources such as dams, bores and those on communities.

Two carnivore species; cat (*Felis catus*) and fox (*Vulpes vulpes*), were recorded during both LES field surveys. Fresh tracks (< 1 week) were observed during the Wet Season 2009 survey mostly along exploration tracks although some cat tracks were recorded scattered within survey quadrats. The low incidence of tracks suggests low populations, with fresh tracks suggesting that the project area is currently utilised for hunting.

5.5 Site Description Summaries – Land Unit Map

A land unit map was developed by LES for the project area, Appendix Four. Land Systems and Land Units have long been used as classification units (Perry *et al.* 1962) and have been suggested by many authors as surrogates for diversity (Ferrier and Watson 1997, Oliver 1998, Smart *et al.* 2000). Land units were therefore considered the appropriate level at which to commence stratification of the landscape. Existing land system mapping for the project area and surrounding region is described by Perry *et al.* (1962) and Stewart *et al*. (1954) although not at a sufficient scale to distinguish between land units within the project area. An alternative system was regolith (defined as the mantle of material that overlies bedrock) mapping which describes 12 units within the project area (derived from Rio Tinto). Low *et al*. (2001) showed that regolith units could be re-interpreted in a systematic way to provide meaningful inferred land units. Following the procedure employed by Holmes and Low (2000), Low *et al.* (2003a, 2003b) and Moon and Low (2006, 2007) regoliths with similar geology, soils and landform were grouped into inferred land units resulting in the formation of 11 land units over the study area. This was extended spatially using standard GIS procedures.

Fifty-four points were verified in the field during the Wet Season 2009 survey against the land unit map derived in 2008. Minor differences were found between the original land unit map and ground verifications, especially between the Shallow Sand Plain and Deep Sand Plain land units, and minor calcrete outcrops and drainages within Shallow Sand Plains. However, these differences within land units only occur at a fine scale (i.e. within 50 m). When points were assessed at a broader scale, they were shown to be consistent within the larger land unit. On-site verification therefore determined that the boundaries on the existing land unit map and the scale of the map (1:210,000) are adequate to use for stratification of the landscape and vegetation communities, as well as providing a "baseline" for detecting change with future monitoring.

5.6 *Site Description Summaries – Flora Map*

The project area occurs within vegetation community 42 which is described as *Corymbia opaca* (Bloodwood) low open-woodland with *Triodia pungens* (Soft Spinifex) hummock grassland understorey (Wilson *et al.* 1990). Vegetation community 42 occupies 28095.3 km^2 within the Northern Territory covering the broad desert country south of the cracking clay plains of the Barkly Tablelands. While this vegetation classification is broadly appropriate to the project area, LES field surveys identified five variable plant communities within the project area. These are related to Wilson *et al*. (1990) fine vegetation units as used by the NT Parks and Conservation Masterplan (Baker *et al.,* 2005) to show proportion of vegetation communities which are protected within reserves (Table 5). These were mapped by LES for the project area to allow assessment of disturbance at a local scale.

Classifications of vegetation communities are described and mapped in Appendix Forty-one. Vegetation communities were classified utilising floristic data (species composition and structure) collected during the Wet Season 2009 survey (refer to Appendices Twenty-seven to Thirty-five) and species presence data from the NT Flora Atlas (2007). Floristic data was insufficient from the Dry Season 2008 survey to classify vegetation communities due to recent fires. Vegetation communities were found to reflect land units through field verifications which were conducted simultaneously with land unit verifications during the Wet Season 2009 survey. However, the sand plain land units (Alluvial Low-lying Sand Plains, Shallow Sand Plains and Deep Sand Plains) were found to support the same vegetation community; with variations in landscape determined by differing proportions of flora species as opposed to determining different assemblages. Similarly, the three rocky rise land units (Silcrete Rocky Rise, Silcrete and Ironstone Rocky Rises) were found to support the same vegetation communities but with varying proportions of species. Site 3 (2009 survey) contained a small patch of mature Supplejack (*Ventilago viminalis*) over grasses and herbs on a calcrete rise. This species is consistent with the sand plain vegetation classification but is a unique patch (mostly due to the maturity of Supplejacks) and noteworthy in showing the variability within vegetation communities. Spinifex (*Triodia* spp.) throughout the project area is in early stages of regeneration following the July 2008 fires and is expected to be in higher densities and in more locations in future studies. This has been accounted for where possible in vegetation classifications.

A plant species list has been developed for each land unit using data from LES field surveys and the NT Flora Atlas (2007) (Appendix Forty-two). Plant species lists for some land units are still unrepresentative due to inabilities to access these areas during LES field surveys (Black Soil Plain, Clay Plains, Limestone Outcrop and Mud Stone Outcrop); all with limited distribution outside the proposed mine area. However, some information is available for these land units from the NT Flora Atlas (2007) and Land System descriptions (Appendix Forty-two). These land units occupy only a small area within the project area and are not within the proposed impact areas. Comprehensive species lists have been provided for land units within impact zones and will likely be expanded with future monitoring, as the vegetation will continue to regenerate following the 2008 fires. It is important to note that a verification column has been added to plant species list per land unit (Appendix Forty-two) that denotes plant species recorded in each land unit during LES surveys. Indication of presence of all other species was determined from the NT Flora Atlas (2007) by extracting data spatially using land unit boundaries in Arc Map. There are some discrepancies in the true location of these species and possibly the land units they occur in due to the accuracy of recording location in historic studies as well as the accuracy in transferring between mapping datum's used in the NT Flora Atlas (2007) spatial database.

Classification of vegetation communities in the unaccessed and very limited land units with limited floristic data, was simplified by combining the Black Soil Plain and Clay Plains land units, due to similar landscape characteristics, and classified according to Wilson *et al's.* (1990) coarsely mapped indicative vegetation classification using landscape data. Similarly, the two rocky rise land units (Limestone Outcrop and Mud Stone Outcrop) that were unable to be surveyed have been grouped with the surveyed rocky rise land units (Silcrete and Ironstone Rocky Rises), due to similar landscape characteristics. As noted above, the sand plain land units (Alluvial Sand Plains, Shallow Sand Plains and Deep Sand Plains) were found to support the same vegetation community and were grouped for the purposes of mapping. Excluding the Black Soil Plain and Clay Pan land units, all vegetation communities assigned to land units were not taken from Wilson *et al.* (1990) classification system as these were too course (scale of 1:1 000 000) to be appropriate to vegetation communities surveyed within LES field surveys. Instead, vegetation communities were classified based on the field data collected. Vegetation communities classified at each survey quadrat during the Wet Season 2009 survey are presented in Table 5 with vegetation descriptions defined during the Wet Season 2009 survey presented. Vegetation classifications are described in and mapped in Appendix Forty-one. Mapping of vegetation communities were extended over land units (Appendix Four) for the Wonarah Phosphate Project area and close surrounds (Appendix Forty-one).

Table 5: Classification of vegetation communities at each survey quadrat based upon floristic data collected during the Wet Season 2009 survey and their relationship to fine vegetation classes of Wilson *et al* 1990 that occur widely in the middle latitudes of NT.

LES Survey quadrat	**Land Unit**	**Vegetation Classification in this report**	**Fine Vegetation Classes of Wilson *et al* 1990 that contains this map unit**	**Vegetation description (as per the site description summaries, Appendices Twenty-seven to Thiry-five)**
1	Shallow Sand Plain	1	42, 43	Eucalypt open woodland dominated by scattered Coolabah upperstorey, Senna sp. lower shrub layer and dense *Indigofera colutea* and *Aristida holathera* ground cover
2	Alluvial Low-lying Sand Plain	1	27, 43, 76	Acacia open woodland dominated by scattered Dogwood (*Acacia sericophylla*), occasional Bloodwood and Coolabah emergent trees and dense *Aristida holathera, Yakirra australiensis* and *Whiteochloa airoides* ground cover.

LES Survey quadrat	Land Unit	Vegetation Classification in this report	Fine Vegetation Classes of Wilson *et al* 1990 that contains this map unit	Vegetation description (as per the site description summaries, Appendices Twenty-seven to Thiry-five)
3	Calcareous Plain	3	51, 27	Eucalypt open woodland dominated by scattered Coolabah and Bloodwood on floodplain and scattered Supplejack on calcrete rises, over *Aristida holathera, Tribulus eichlerianus* and *Cleome viscosa* grassland ground cover.
4	Silcrete Rocky Rise	5	36, 43, 76	Acacia and Mallee shrubland with hummock grassland dominated by E*ucalyptus odontocarpa, E. pachyphylla* and *Acacia hilliana* over soft Spinifex.
5	Alluvial Low-lying Sand Plain	1	42	Open Eucalypt woodland with hummock grassland dominated by Coolabah and Bloodwood upper-storey over Spinifex ground-cover.
6	Ironstone Rocky Rise	5	36, 43, 76	Acacia and Mallee shrubland dominated by *A. stipuligera, A. hilliana* and *Eucalyptus odontocarpa* over sedges and perennial grasses.
7	Deep Sand Plain	1	42, 43	Open Eucalyptus woodland over hummock grassland dominated by *Eucalyptus victrix, E. pachyphylla* and *Acacia sericophylla* over soft Spinifex.
8	Deep Sand Plain	1	26, 36, 42	Eucalypt and Acacia low open woodland over hummock grassland with *Melaleuca lasiandra* in drainages, dominated by *Acacia sericophylla, A. stipuligera* and *Triodia schinzii* and *Aristida holathera* groundcover.
9	Ephemeral Lake	1	*26, 27*	*E. microtheca* (Coolabah) low-open woodland with low grassland and clay depressions with sedges.

5.7 Site Description Summaries – Soil Map

Four soil types were classified using the Australian Soil Classification system (Isbell, 1996) based upon the Wet Season 2009 survey - Kandosols, Vertosols, Calcarosols and Rudosols and are described in Table 6. Soil classifications were found to correlate with land units, although many land units contained similar soil types and were thus grouped for mapping purposes, as described in Table 6 and mapped in Appendix Forty-three. Kandosols and Rudosols dominate the sand plains and rocky rises within the project area; Vertosols are restricted to areas subject to inundation (e.g. ephemeral lakes) and Calcarosols are restricted to two localities in the southern end of the lease area. Mapping of soil types was extended over land units (Appendix Four) for the Wonarah Phosphate Project area and close surrounds (Appendix Forty-three).

Table 6: Classification and description of soils within the Wonarah Phosphate Project area against land units based on the Wet Season 2009 survey.

Land Unit	Soil Classification	Soil description (Isbell, 1996)
Sand plains (Alluvial Low-lying, Shallow & Deep sand plains)	Kandosols	These soils lack strong textural contrast, B horizons are massive or weakly structured and the profile is not calcareous throughout. The maximum clay content in some part of the B2 horizon exceeds 15%. These soils are a widespread group in Central Australia.
Rocky Rises (Silcrete & Ironstone Rocky Rises & Limestone & Mud Stone Outcrops)	Rudosols	Soils in this order have little if any (rudimentary) pedological organisation. They are usually young soils that vary widely in terms of texture and depth. There is little or no texture or colour change with depth unless stratified or buried soils are present.
Black Soil & Clay Plains & Ephemeral lakes	Vertosols	Soils in this order have a field clay texture of 35% or more with clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick, and Have open cracks at some time in most years that are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, self-mulching horizon, or thin, surface crusty horizon, and At some depth in the solum (surface & sub-surface layers), have slickensides and/or lenticular peds.
Calcareous & Limestone Outcrops	Calcarosols	Soils that are normally calcareous throughout the profile or calcareous at least directly below the A1 or Ap horizon, or within a depth of 0.2 m (whichever is shallower). Carbonate accumulations must be pedogenic not fragments of calcareous rock such as limestone or shell fragments.

5.8 Site Description Summaries – Soil Erosion

Erodibility of soils was assessed through combining erosivity potentials of classified soils in accordance with descriptions of arid land soils and topography. Most soils were found to have low erodibility potentials, except deep soils (mostly Rudosols with loose rock aggregations) on sloping terrains overlain by deep clayey sands. These soils are most at risk from road construction, and road building techniques to mitigate erosion are provided in Appendix Forty-four.

An erosion gully was noted along the existing exploration track between the Main and Arruwurra zones; it occurred within the Shallow Sand Plain land unit along a slope at coordinates (S20.06971 E136.45474).

Winrows were recorded along the existing exploration track between the Main and Arruwurra prospects within the Shallow Sand Plain land unit at coordinates (S20.11501 E136.38703) (see Appendix Forty-five for photos). Winrows impact on natural water distribution and generally should not be formed.

5.9 Indigenous Values

Traditional Owners were consulted regarding flora and fauna of Indigenous value (e.g. mythical, cultural or utilitarian) within the Wonarah Phosphate Project area during the Wet Season 2009 survey (see Appendix Thirty-six for summary). Mature trees, especially Coolabah and Bloodwood, tend to be culturally significant.

Many ephemeral lakes within the project area are culturally significant sites and have been classed as exclusion zones by the CLC.

Traditional Owners identified fauna of cultural significance within the project area for utilitarian values, such as hunting. These include: red kangaroo, Australian bustard, sand goanna and large dragons. Large ephemeral lakes were identified as important hunting grounds which act as seasonal refuges for populations of larger fauna. No species of mythological significance were identified; however, the Traditional Owners consulted were not senior members of their community and may not have had authority to provide such information. The dingo has mythical significance for people in the nearby Tanami desert, and it is known that dingo dreamings extend into the Barkly region.

5.10 Bushfires

The Northern Territory Bushfires Council maps fires within the Northern Territory and for all Australia. Fire data in the Barkly region has been collected on an annual basis using raster data over a 10 year period and has been collated to provide a map of fire frequency (Appendix Forty-six). While this map provides broad information for a limited time frame, it is still useful in understanding recent regional fire characteristics. The Wonarah Phosphate Project area is shown to have a fire frequency of 1 to 2 events per 10 year period. However, this information does not include small scale fires due to the low resolution of the technique. Bushfires are caused by natural and anthropogenic sources, although it was noted by the Traditional Owners consulted that traditional burning occurs within the local region although it was not confirmed that this includes the Wonarah Phosphate Project area.

6 Impact Assessment

6.1 Legislative Component

The proposed operations will be subject to the following legislation and land clearing guidelines

Key Legislation:

- Environmental Assessment Act 1982;
- Territory Parks and Wildlife Conservation Act 2000;
- Weeds Management Act 2001;
- Environment Protection and Biodiversity Conservation Act 1999;
- Environmental Offences and Penalties Act 1996;
- Soil Conservation and Land Utilization Act 2001 of the Northern Territory;
- Heritage Conservation Act 2000;
- Meteorites Act 2000;
- Weed Management Act; 2001;
- Environmental Offences and Penalties Act; 1996;
- Environment Protection (National Pollutant Inventory) Objective;
- Litter Act;
- Water Act; and,
- National Environment Protection Council (Northern Territory) Act.

Land Clearing Guidelines:

- Northern Territory Planning Scheme – Land Clearing Guidelines 2006 (Technical Report No 27/2006)

Other:

- Minimum Construction Requirements for Water Bores in Australia

6.2 Potential Impacts of the Proposed Operation:

The extent to which the proposed operations will affect the environment will depend on the size of the operation. To determine whether the operation will affect the environment at a national level, criteria from the EPBC Act are reviewed; for effects on the environment at a bioregional level, criteria for identifying important habitats (Neave *et al.* 2006) are reviewed; to determine whether the operation will affect the environment at a local level, survey data provided herein is reviewed.

6.3 Potential Impacts of the Proposed Operation: National Level

The EPBC Act (revised 2005) came into force in July 2000. Since the inception of the Act, any proposed project that will have a significant impact on a matter of national environmental significance must be approved by the federal Minister for the Environment.

There are seven areas in which a project may have an impact of national environmental significance. These include:

- Impact on World Heritage properties;
- Impact on National Heritage properties;
- Impact on Ramsar wetlands of international importance;
- Impact on listed threatened species and communities;
- Impact on migratory species protected under international agreements;
- Nuclear actions, and;
- Impacts on the Commonwealth marine environment.

Of these seven areas only two areas, protected migratory species, and threatened species and communities, were potentially of interest for the current project.

No protected migratory species have been identified within the project area or surrounding region in on-site investigations including LES field surveys and the NT Fauna Atlas (2007), though eight migratory bird species are listed by DEWHA in the EPBC Act as potentially occurring in the area (Appendix Nine). As there are no large drainage channels or drainage basins within the project area or surrounding region, there is not a significant amount of potential habitat for these species in the area, although ephemeral areas may be important in good seasons. Hence, migratory avifaunas are only likely to appear during significant wet seasons when rainfall is large enough to cause local flood events.

No listed threatened ecological communities or flora species were recorded within the Wonarah Phosphate Project area, although eight flora species of significance (i.e. with near threatened or data deficient conservation codes) under the TPWC Act were recorded during LES field surveys and in the

NT Flora Atlas (2007) (Appendix Thirty-seven). Of these species, the SSOBS conservation codes, as defined by White *et al.* (2000), suggest that only *Sporobolus latzii* may be reliant on the project area for its continued persistence; however as discussed in Section 5.3, the known record is within a cultural exclusion zone associated with the ephemeral lake land unit which will not be disturbed by mining operations.

No fauna species listed under the EPBC Act were recorded within the Wonarah Phosphate Project area; however the *Ardeotis australis* (Australian bustard) listed as vulnerable under the TPWC Act was recorded in both LES field surveys and the NT Fauna Atlas (2007) (Appendices Fifteen and Thirty-nine). A further three species of significance (i.e. with near threatened or data deficient conservation codes) under the TPWC Act were recorded in on-site investigations (LES field surveys and NT Fauna Atlas (2007)) within the project area, while a further eight species listed under both the EPBC and/or the TPWC Acts were recorded within the surrounding region in the NT Fauna Atlas (2007) (Appendix Thirty-nine). Targeted surveys for significant species and in particular bilby and mulgara were conducted during the Wet Season 2009 survey, but no evidence was detected, as discussed in Section 5.4. Whilst we cannot rule out that these species could occur within the project area, LES field surveys, consultation with Traditional Owners and reference to the literature indicate that significant or major populations are unlikely to occur within the Wonarah Phosphate Project Area.

Based in the above research, the proposed mine operations will not impact flora or fauna at a national level.

6.4 Potential Impacts of the Proposed Operation: Bioregional Level

The following is an assessment of the importance of the Wonarah Phosphate Project area against criteria for important habitats developed by Neave *et al.* (2006) utilising data of the project area and surrounding region from LES field surveys and the NT Flora and Fauna Atlases (2007).

Criteria for identifying important habitats include:

1. Habitat with high species richness that supports a high abundance of native species and/or is structurally complex. These attributes may relate to: the number of vegetation types and the degree of contrast between them; availability of shelter sites (e.g. nesting sites, ground litter and logs, rock crevices) and water and food resources (e.g. presence of nectar producing shrubs); and/or topographic and geological complexity creating a range of micro-habitats.

Assessment:

The project area and surrounding region do not fully meet the characteristics of this criterion. The main vegetation community of the project area is described as *Eucalyptus (*now *Corymbia) opaca*, (bloodwood) low open-woodland with *Triodia pungens* (soft spinifex) hummock grassland understorey (Wilson *et al*. 1990). This particular vegetation community covers 28095.3 km^2 in the Northern Territory (Wilson *et al.* 1990), of which the proposed disturbance area constitutes 0.1 % of this area. On a regional scale the vegetation and landscape of the project area is not considered threatened or significant. This is highlighted by the relatively low number of flora and fauna species of conservation significance identified by existing data sets and LES field surveys, and the relatively low number of survey sites with multiple height classes.

2. Habitat supporting species of high conservation value (e.g. threatened species, endemic species, poorly reserved species and/or rare species).

Assessment:

The project area and surrounding region partially meets the characteristics of this criterion. Species of conservation significance were recorded within the Wonarah Phosphate Project area during on-site surveys (LES field surveys and NT Flora and Fauna Atlases (2007)) and are listed and discussed in Section 6.4. As discussed above, only one species *Sporobolus latzii,* is potentially reliant on the project area for its persistence, however, the location of the single record is located within a cultural exclusion zone (which prohibits access and disturbance) and the associated ephemeral lake land unit will not be disturbed by mining activities. LES field surveys did not identify any fauna species of conservation significance that would solely rely on habitats within the Wonarah Phosphate Project area.

3. Habitat that is of good quality (i.e. its compositional and structural integrity and ecological processes have not been undermined). The level of habitat integrity is influenced by:

- The presence/absence (or low cover abundance) of environmental weeds, especially buffel grass and couch grass, both of which are known to outcompete native plant taxa and alter habitat parameters for native fauna;
- The presence/absence (or low abundance) of introduced animal species;

- The presence/absence of an appropriate fire regime (inappropriate regimes are known to have an impact on species composition and canopy condition);
- Degree of isolation from infrastructure such as roads and water points (reduced risk of weed invasion and over-grazing); and,
- The state of the hydrological regime (altered regimes may lead to changes in site species composition).

Assessment:

The project area and surrounding region do not fully meet the characteristics of this criterion. Whilst only 2 weed species were recorded at low densities during LES field surveys, several species are known to occur in the surrounding region. Furthermore, high density Buffel Grass populations line the Barkly Highway road verge and occurs in low lying depressions on the lease. The project area is adjacent to infrastructure (major highway) increasing its susceptibility to invasion by introduced species. Five introduced species were recorded during LES field surveys within the project area, albeit at low numbers. Despite these indicators of diminished habitat integrity, it is important to note that the Wonarah Phosphate Project area supports suitable and varied habitats to support good native biodiversity and it is important that future land management sustains this.

4. Habitat that is poorly reserved elsewhere.

Assessment:

The project area and surrounding region do not fully meet the characteristics of this criterion. Although the closest reserve is the (proposed) Davenport Range National Park, habitat found within the project area is characteristic of typical habitat found widely in the surrounding bioregion. The area does contain several diverse plant communities with a high number of young seedlings due to drought and fire recovery, but flora and fauna in the area are generally common and widespread.

The project area occurs within vegetation community 42 which is described as *Corymbia (*formerly *Eucalyptus) opaca* (Bloodwood) low open-woodland with *Triodia pungens* (Soft Spinifex) hummock grassland understorey (Wilson *et al.* 1990). Vegetation community 42 occupies 28095.3 km^2 within the Northern Territory of which the Wonarah Phosphate Project area constitutes ~100 km^2 and the area of the proposed disturbance (i.e. mine area) is 27 km^2.

This impact assessment for determining important habitat at a bioregional scale against four criteria developed by Neave *et al.* (2006**)** found that three of the four criteria were not met. Criteria number 2 was partially met because of the presence of *Sporobolus latzii* within the project area, which is suggested to be dependent on the project area for its continued persistence. However, the proposed works will not disturb the known location of *S. latzii*, nor the associated ephemeral lake land unit, thereby not impacting upon Criterion 2. Therefore, based on this impact assessment, the proposed mine operations will not impact flora or fauna at a bioregional level.

6.5 Potential Impacts of the Proposed Operation: Local Level

Five vegetation communities exist within the project area, of which 3 (vegetation communities 1, 3 and 5 as described in Appendix Forty-one) will be affected by the proposed works. These vegetation communities are dominated by common species of *Aristida, Acacia*, Eucalypts, *Grevillea, Hakea, Melaleuca* and *Triodia* and the proposed operations will result in localised loss of habitat for these species and local alteration of landscape. LES field surveys did not identify any flora species of high conservation value under the TPWC Act/EPBC Act and most of the plants and associated vegetation communities are widespread throughout the region (Baker *et al*., 2005). However, LES field surveys and the NT Flora Atlas (2007) recorded flora species of conservation significance under the TPWC Act occurring within the project area and/or within a 50 km buffer, (Appendix Thirty-seven). These include 3 near threatened species, 12 data deficient species and 1 non-evaluated species. White *et al.* (2000) further classifies nine of these species to be of significance at the Northern Territory level and three at a national level. Five of the aforementioned species have been recorded on-site with coordinates provided in Appendix Thirteen. Furthermore, ephemeral areas, and also run-on and run-off areas, are likely to be important for both annual and perennial species. The proposed operations may result in disturbance to these areas, although a number of management strategies can be adopted to minimise disturbance. These are outlined in sections to follow.

Vegetation clearing for the proposed operation will result in localised habitat loss for the fauna living in the affected area, particularly those in the area of the pit, campsite and access roads. Mining will also indirectly impact on the local fauna through increased noise, vibration, dust, lights, roads, increased human activity, possible creation of artificial resources, and possible alteration of the natural drainage patterns. Although these disturbances may reduce populations in the affected parts of the project area, most species are common and widespread throughout their range and their status is unlikely to be altered.

Only one fauna species, (Australian bustard, *Ardeotis australis*) listed as threatened under the TPWC Act was identified during LES field surveys within the Wonarah Phosphate Project area, although there are a number species of conservation significance that have been previously identified within the project area and/or surrounding region (Appendix Thirty-eight). Those species that have a conservation status at or above vulnerable (TPWC Act/EPBC Act) are discussed below. The preferred habitat, distribution, preferred fire regimes and threatening processes to significant fauna species potentially occurring within the Wonarah project area are outlined in Appendix Forty.

The Australian bustard (*Ardeotis australis*) is listed as vulnerable under the TPWC Act and is known to occur widely in the project area. Distribution of the generally scarce bustard is widespread, though it is more common in the north of Australia and tend to occur in loose aggregations with the Barklys being one of the strongholds (Woinarski *et al.* 2007). Numbers are likely to fluctuate depending on seasons, and due to the highly mobile nature of the species, small, localised disturbance is not likely to affect its status. Threatening processes include predation, altered fire regimes, hunting, disturbance, habitat alteration (e.g. woody weed infestation), pesticides and grazing although the relative effects of each of these threats are still being researched (Ziembiki, 2006). Hunting by indigenous populations is identified as a potential threatening process due to breakdown of controls, compounded by access to modern weapons and vehicles, and a low reproductive rate (usually one young per year) increasing pressure on populations (Ziembiki, 2006). Impacts of potential mining operations on the Australian Bustard populations will be minor; however, protocols to minimise impacts are outlined below.

The Australian painted snipe, (*Rostratula australis*) is listed as vulnerable under the EPBC and TPWC Acts and has been recorded within the 50 km buffer of the project area. Threatening processes include wetland drainage and other forms of wetland and swampland degradation including that by cattle (Taylor *et al.,* 2006). Ephemeral lakes constitute the only possible habitat within the project area for the Australian painted snipe, although this is not ideal habitat. The main ephemeral lakes are within exclusion zones and will not be accessed by the proposed mining operations. Therefore, should the Australian painted snipe inhabit these areas; they will not be directly affected by mining operations.

The Alligator Rivers subspecies of the yellow chat, (*Epthianura crocea tunneyi*) is listed as Endangered under the TPWC Act and Vulnerable under the EPBC Act. This subspecies has not been recorded south of about Katherine and is restricted to a small geographic area encompassing floodplains from the Adelaide River to the East Alligator River (Woinarski *et al.* 2007). However, *Epthianura crocea* occurs across northern Australia, typically in chenopod shrublands and grasslands around water sources (Woinarski *et al.* 2007). The more common subspecies, *Epthianura crocea crocea* (inland subspecies) is listed as least concern under the TPWC Act and was recorded about 20 km north-east of the project area in cracking clay country with swamp depressions, a habitat not found within the project area. The status of yellow chats on a local, regional or national scale is therefore not likely to be affected by the proposed operations.

The bilby (*Macrotis lagotis*) is listed as vulnerable under the TPWC Act and EPBC Act. Bilbies have not been recorded in the project area and no signs of bilbies were identified during LES field surveys, despite targeted surveys. Local Traditional Owners did not know the species. However, bilbies have been recorded 40 km south-west of the project area (in 1994), and habitat is suitable within the project area for bilbies to occur. Potentially suitable habitat is identified in Appendix Forty-one. However, there are very few records post 1970 in the Barkly area. Woinarski *et al.* (2007) describes the suitable habitat as sandy soils dominated by hummock grasslands covered predominantly by spinifex and an overstorey of low shrub cover dominated by *Acacia* and *Melaleuca*. The sandy landscape also often comprises rocky outcrops, lateritic rises and low-lying drainage depressions. As there was no sign of bilbies in the project area, it is unlikely that the status of this species will be affected on a local scale. However, ongoing monitoring should occur to identify potential populations of this mobile species.

The mulgara (*Dasycercus cristicauda* and *D. blythi*) are listed as vulnerable under the TPWC Act and endangered and vulnerable respectively under the EPBC Act. Mulgaras have not been recorded in the project area and no sign of mulgaras were identified during LES field surveys, despite targeted surveys, good conditions for tracking during the Wet Season 2009 survey and consultation with Traditional Owners. However, mulgaras were recorded 40 km west-south-west of the project area in 1993, and habitat suitable for mulgaras occurs within the project area. Potentially suitable habitat is identified in Appendix Forty-one. Masters *et al*. (2003) describes the principle habitat for mulgara as hummock grasslands of spinifex, especially *Triodia basedowii* and *T. pungens*. As there was no sign of mulgara in the project area, it is unlikely that the status of this species will be affected by mining operations on a local scale. Ongoing monitoring should occur to identify potential populations of this mobile species that prefers disturbed and variable habitats.

Bushfire impacts

Fire frequency, intensity and timing are determining factors for ecological community composition and structure. Alterations to current fire regimes are recognised as a threatening process for many significant species recorded within the Wonarah project area and/or surrounding region (Ingleby 1991; Pavey 2006; Pavey *et al.* 2006; Ziembicki 2006). Unfortunately, research on beneficial fire regimes for the persistence of significant species is limited. However, generally fire is necessary for initiating the growth and reproductive cycles of fire promoted plants, of which many provide important habitat and dietary requirements for faunal species.

Beneficial habitat conditions resulting from fire were found for three threatened or near threatened species recorded in or within 50 km buffer of the Wonarah Phosphate Project area. The Australian bustard readily responds to fire as it promotes food and provides large areas of open space, which males seek for their courtship displays (Ziembicki 2006). Fire is necessary for the production of seeds of some species that are an important dietary component for bilbies (Pavey 2006) and the spectacled hare-wallaby frequently feeds in recently burnt country (Ingleby and Westoby 1992). Generally, low intensity mosaic patch burning, conducted in cooler months, ensures that spatial biodiversity is maintained and provides a higher likelihood of survival for many species of both flora and fauna (Preece *et al*. 1989).

Fire frequency models from the Northern Territory Bushfires Council broadly indicate a 1 to 2 in 10 year fire frequency within the region of the Wonarah project area. Alterations to this regime are likely to encourage alterations within the local ecological communities; however, it is not clear if this regime reflects traditional burning regimes and whether changes would therefore be detrimental to flora and fauna populations. No sites within the project area were identified as being important for the persistence of threatened species; therefore fire within the project area is unlikely to affect the persistence of these threatened species. Ephemeral lakes (especially the area within the CLC exclusion zone) are likely to be seasonally important to fauna as refuges and their disturbance may have substantial negative impacts on regional fauna populations in the event of wildfires. It is therefore appropriate to incorporate fire management for ecological protection/improvement into the mine management plan as discussed in Section 7.7.

7 Management Recommendations

One of the aims of environmental surveys is to identify features of the landscape and biota that should be considered during the project development and operation in order to avoid or minimise potential adverse impacts and optimise rehabilitation. Furthermore, survey data may be used as a baseline against which future monitoring may detect impacts of mining operations. The aim of rehabilitation is to return the landforms and wildlife to a stable condition, as near as possible to their original state. Rehabilitation needs to be an integral part of the mining plan and be applied progressively throughout mine development and operation. The following are guidelines for site planning and management.

7.1 Management of Significant Species

Species of conservation significance that have been recorded inside the Wonarah Phosphate Project area during on-site investigations (LES field surveys and NT Flora & Fauna Atlases (2007)) include flora species *Bonamia alatisemina, Distichostemon barklyanus, Heliotropium ballii, Heliotropium pulvinum, Sporobolus latzii, Triumfetta deserticola, Bergia barklyana* and *Hibiscus brachychlaenus* and fauna species, Australian bustard (*Ardeotis australis*), northern nailtail wallaby (*Onychogalea unguifera*), long-haired rat (*Rattus villosissimus*) and woma (*Aspidites ramsayi*). Additional fauna species of conservation significance recorded within the surrounding region (50 km buffer) in other studies, or are listed as potentially occurring in the project area under the DEWHA *Matters of Environmental Significance Report* are; Australian painted snipe (*Rostratula australis*), yellow chat, (*Epthianura crocea*), square-tailed kite (*Lophoictinia isura*), mulgara (*Dasycercus cristicauda* or *D. blythi*), bilby (*Macrotis lagotis*), flock bronzewing (*Phaps histrionica*), northern snapping frog (*Cyclorana australis*) and spectacled hare wallaby(*Lagorchestes conspicillatus*)

Flora:

White *et al.* (2000) note that the Wonarah Beds location is of bioregional significance and there is potential for a number of species of conservation significance to occur in this area. Land unit mapping derived herein suggested that *Sporobolus latzii* occurs within the ephemeral lakes land unit, the largest of which occurs 5 km to the north of the Arruwurra prospect and 13 km south-west of the Main Zone (Wonarah Prospect). This area is currently within a cultural exclusion zone which prevents mining activities within the area, limiting the likelihood of works impacting upon this known record. Furthermore, proposed works are located away from the ephemeral lake land unit thus minimising impacts on this species potentially occurring elsewhere in this land unit. However, there is also potential for *Sporobolus latzii* to occur in other drainage depressions and areas subject to prolonged water inundation including the ephemeral lake land unit. The lower areas of the alluvial (low lying) sand plain and shallow sand plain land units would be potential areas where *S. latzii* could occur. Low lying areas within impact areas that are inundated during wet periods should be noted by Minemakers and where possible, works should be restricted or impacts minimised in these areas to reduce impacts on potential individuals. Rio Tinto prepared a procedure for protecting *Sporobolus latzii* on the Wonarah tenements, and this should be adopted (see Appendix Forty-seven).

Disturbance within the project area should minimise impacts to land units identified as potentially supporting flora species of conservation significance listed in Appendix Thirty-seven. Fauna species of conservation significance recorded within the project area are dispersive (i.e. Australian bustard, northern nailtail wallaby and long haired rat) and not specifically correlated to land units within the project area. Land units identified to be potentially impacted by the proposed works are; Alluvial Low Lying Sand Plains, Calcareous Plains, Deep Sand Plains, Ironstone Rocky Rises and Shallow Sand Plains. Land units identified to potentially support flora of conservation significance are; Alluvial Low Lying Sand Plains, Deep Sand Plains, Ironstone Rocky Rises, Silcrete Rocky Rises and Ephemeral Lakes (Appendix Thirty-seven). Coordinates of flora species of conservation significance are provided in Appendix Thirteen.

A general induction manual for all flora species of conservation significance listed in Appendix Thirty-seven should be prepared so that all workers are aware of the key plant species of conservation significance and their potential distributions.

Fauna:

To mitigate impacts on all native fauna, including significant species, the following techniques should be implemented:

- If areas must be disturbed, a walk-over survey of all areas should be conducted prior to the commencement of any work to locate possible individuals or presence (i.e. tracks, scats, digs, dens etc). This must be conducted by experienced personnel.

- Establish monitoring programs utilising sites established during the Wet Season 2009 survey to assess potential impacts of mining operations and include further monitoring during different seasons to identify seasonal species variations through time. Recommendations for future monitoring programs are outlined in Section 7.9.
- Manage artificial resource points (i.e. dams, bores, rubbish points and food storages) to avoid attracting and increasing populations of predators (native and feral) and introduced herbivores (discussed in Sections 7.2 and 7.3). A detailed management plan to avoid attracting dingos (a potential culturally significant species) to artificial resource points is provided in Appendix Forty-eight. The guiding principals of this plan are suitable for deterring non-target predators and introduced herbivores; however further actions may be required to suit the characteristics of specific feral animals.
- Provide a manual and implement an induction program so all employees and contractors are able to identify significant species and are aware all sightings must be reported to the Environmental Manager and/or consultant or the Parks and Wildlife Service of the Northern Territory. Furthermore, observations of plant or animal species of unknown identity should also be reported; where possible, reports should be accompanied with a detailed description, including location and, if possible, a photo.
- Review management protocols if additional significant species or known locations are recorded so that impact on these species can be considered and minimised if necessary.
- Train key staff in identification of threatened species and provide for rescue and relocation of species of conservation significance. All rescue and relocation protocols should be developed in consultation with Parks and Wildlife Service of the NT.
- To minimise fauna death on roads, restrict speeds on haulage routes and mine roads, particularly during periods when it is known wildlife may be using the roads or nearby areas.
- If it is deemed appropriate, Minemakers may develop and implement a fire management program in collaboration with Traditional Owners and Bush Fires Council to produce mosaic patterns enhancing spatial diversity of habitat and improving habitat quality for some significant species (as identified in Appendix Forty-one). Such fire management programs are implemented by some mining companies in the Northern Territory and utilise knowledge and expertise of the Traditional Owners. However, it is the responsibility of the mining company to

ensure protection of their assets and of human lives, and therefore fire management plans must consider these aspects carefully.

7.2 Management of Native Predator Species

Dingoes were recorded throughout the project area, and, although they are likely to be present at low numbers, several management strategies can be introduced to minimise access to food and water resources which will, in turn, reduce the chance of animal and human welfare incidents. In particular these include:

- Undertaking inductions for all workers on site about not feeding or interacting with dingoes;
- Separating food from normal waste and burning in a separate location;
- Installing predator-proof fencing around all food waste areas;
- Installing dingo proof bins;
- Maintaining clean work and camp sites;
- Minimising access to artificial water sources; and
- Monitoring dingo movements and behaviour.

A detailed management plan to avoid attracting dingos to artificial resource points is provided in Appendix Forty-eight, and should be incorporated into the planning phase of the Wonarah Phosphate Project.

7.3 Management of Introduced Species

Introduced species of flora and fauna already existing within the project area and surrounding region are listed in Appendices Thirty-six & Thirty-seven. Management practices should minimise the potential for spreading or increasing introduced species. Control of weeds and feral species will minimise disturbance to the local environment and greatly assist rehabilitation programs.

Weeds: Mining development will lead to increased disturbance and potential for the introduction and spread of weed species. A program for weed identification and control should be implemented. Control of existing weed species prior to mine activity, particularly in areas used by mine vehicles, will reduce weed spread. Potential invading weed species are listed in Appendix Fourteen. The presence and spread of these species should be reported to the district Weeds Officer (Dept of Natural Resources, Environment, The Arts and Sport, DNRETAS). The area should be examined by a weeds officer annually. Identification pictures and description of expected weed species should be provided to staff as a part of the mine site induction so they can easily distinguish between natives and weedy plants and avoid spreading seeds from weeds.

Machinery brought into the lease areas should be "washed down" before use on-site. Topsoil from weed-infested areas should not be used in revegetation work. Any weeds establishing in rehabilitation areas should be immediately eradicated before they set seed. Monitoring of weed spread by periodic mapping at the beginning of the wet season is advisable. Preventative and control measures for weed spread should be developed in consultation with DNRETAS or a qualified weeds officer. Any landscaping within the project area should only use local native species.

Feral animals: Mining operations have the potential to significantly increase the feral animal populations in the area. Feral cats and rodents may be attracted to exposed rubbish dumps and artificial water resources. Rubbish tips should be covered and fenced to avoid attracting these animals. Control of feral animals (e.g. by fencing out stock) may be necessary to prevent damage to sites undergoing rehabilitation.

Access to artificial resources that may attract other feral animals, such as camels and donkeys, should be minimised so that the mine does not aid in population increases. Efforts to control these species should be considered when developing a feral animal control program as part of the mine management plan. Many of the techniques outlined in the dingo management strategy in Appendix Forty-eight are useful for controlling feral animals in general; however, further actions, may be required to suit the characteristics of specific feral animals. For example, camels and donkeys are large and strong and therefore capable of knocking down inappropriate fencing to access resources (e.g. water). Camels accustomed to humans have become aggressive towards humans in some central Australian indigenous communities and have also chewed off water taps to access water. Such examples illustrate why incorporating feral animal management strategies into the planning process is critical to avoid feral animals developing associations between human settlements and resources. Feral animal control programs would require appropriate authorisation from CLC and NT government.

7.4 Vegetation Removal

To minimise clearing of vegetation, mineral exploration operations should attempt to use existing disturbed areas and roads where possible. Clearing of vegetation should be minimal and should be avoided in the ephemeral land systems and areas subject to inundation. Areas to be cleared should be clearly marked with flagging tape prior to any works. The Central Land Council must be consulted for clearance and/or modification to all trees that meet the criteria for cultural significance. Culturally significant trees are defined by the Central Land Council (CLC) as having trunk diameters equal to or greater than 12.5 cm and being at least 1.5 m tall. Removal and/or modification of such trees may require Traditional Owner approval. Vegetation clearing for the mining operation should be progressive, and conducted in stages as cleared areas are required, rather than initially clearing the complete footprint. This will avoid superfluous clearing, reduce dust and erosion potential, retain seed sources for rehabilitation and allow local fauna to adapt to loss of habitat. Vegetation removed can be used for minor constructions such as ponding and sediment banks. Trees and shrubs could be stockpiled within waste dumps or placed on top to assist rehabilitation and create habitat for microfauna. This option is preferred to burning and results in less nutrient loss from the environment as well as reducing green house gas production.

7.5 Rehabilitation

Rehabilitation of the project is best achieved through careful management of top soils, facilitating revegetation from the seed bank. In areas targeted for earthworks the topsoil (top 100 mm), including groundcover plants, and subsoil (to about 300 mm) should be stripped and stockpiled separately for use in rehabilitation programs. Stripping and other earthworks should be performed during the dry season when chances of runoff erosion and destruction of soil structure is minimal. It is best to double-strip the topsoils by removing and separately storing the top 100 mm of the soil, which contains the significant proportion of the seed bank, nutrients and microfauna. Immediate use of topsoil on areas awaiting rehabilitation is the most productive option, because soil components such as micro-organisms, seeds and organic matter will deteriorate during storage. If stockpiling of the soils is necessary, stockpiles should be stored away from drainage areas to reduce erosion and loss of useful soil material. Topsoil should be stored in low mounds, preferably less than 1 to 2 m high, to allow the seed bank to germinate. Stockpiles should be allowed to revegetate to protect against erosion and sustain microbe populations, which are essential to maintaining nutrient composition.

It is recommended that the revegetation of waste rock landforms involve the laying of 5 to 10 cm of stripped topsoil (preferably less than 4 months old) over the waste rock, followed by contour furrowing or ripping. This will allow infiltration of rainfall, mixing of waste rock and topsoil and loosen the soil surface for sowing or planting of tube stock if required. Ripping should be carried out prior to the wet season (i.e. in October - November). Minemakers propose to progressively backfill pits during mining operations, thus limiting the creation of wasterock landforms.

Early in the mine development plant revegetation trials (based on stripped topsoil) should be established to determine if natural revegetation will be adequate for rehabilitation purposes. Should trials show inadequate revegetation, a seed collection program will be required based on local provinance material and care needs to be taken to exclude weed species. Plant species to be used for revegetation must be appropriate to the land unit. A plant species list is provided indicating potentially suitable species for rehabilitation specific to land units within the project area, Appendix Forty-two. It is recommended that Traditional Owners are consulted and employed to collect local seeds.

Rehabilitation should be progressive so disturbed areas are stabilised before erosion develops. This will minimise the impact on the local environment and maximise the extent of rehabilitation completed during the mine operation period. The rehabilitation program needs to combine the application of standard methods of monitoring and research in order to customise techniques. Progressive revegetation should begin as early as possible in the mining operation, so the area will end up as a mosaic of various regrowth stages of local vegetation types.

Opportunities to improve habitat availability and quality for EPBC and TPWC listed species essentially do not apply to the project areas since only one species of conservation significance (*Sporobolus latzii*) was identified to be potentially reliant on the project area for its persistence and this occurs in the ephemeral lakes areas which are in restricted locations or in areas where there is limited or no ore body. However, habitat enhancement for most local species can be achieved by ensuring that rehabilitation is undertaken as early as possible in order that top soils and contained seed remain fresh and are used in locations specific to the land unit in which rehabilitation is undertaken.

Opportunities to improve habitat for local species is a vexed question in that it implies that habitat will be improved for particular obvious species. Little is known of the general ecology of the region and it would require more intensive studies to determine the impact on non-target species. One major requirement for management of the operation will be to avoid attracting predators such as dingoes, foxes, cats as well as raptors which could prey on local species such as Nail-tail Wallabies in the southern portion of the lease. This requires management of artificial resource sources to avoid attracting and increasing wild animal populations as discussed in Section 7.3.

7.6 Fire Management

Fire is an inevitable and common environmental feature of the desert country south of the Barkly. The approach of "letting nature take its course" is an unreasonable option (Preece *et al*. 1989). This ignores the fact that humans have been influencing fire regimes for al least 40,000 years (Preece *et al*. 1989). Australian ecosystems and species are adapted to a dynamic fire regime but rehabilitating areas need to be protected from fire to assist revegetation.

Fire intensity, frequency and timing are important factors influencing ecological communities. Excessive burning (i.e. greater than once every 2 to 5 years) in open woodlands may result in reduced complexity of flora and predominance of grasses in the understorey. Mott and Andrew (1985) determined that a number of perennial grasses such as *Sorghum plumosum*, *Heteropogon contortus* and *Themeda australis* prefer biennial burns. However, a fire management plan should be developed in consultation with and approved by NT Bush Fires Council and traditional owners who may determine that a lower fire frequency is required for the project area. Active management can regulate and moderate wildfires so they have an acceptable impact on the environment (Preece *et al.* 1989). The establishment of a local fire management control program will assist containment of wildfires.

Fire will not normally be a part of the project management plan; however, hazard reduction may be necessary when fuel load increases within the operational areas. Patch burning is the preferred method of reducing fire hazard. This method of fire management results in small fires which flora and fauna have a better chance of surviving. In addition to reducing the risk of intense or large-scale fire, a mosaic pattern of burning will produce a diverse range of habitats and hence maintain local biotic diversity (Preece *et al.* 1989).

Fire management plans should be developed in consultation with the NT Bushfires Council and may utilise the knowledge and expertise of Traditional Owners. Hazard reduction burning should be conducted at the beginning of the dry season (March to May), when the vegetation is less flammable and the soils are moist; this will favour the survival of stressed trees. Areas of severe erosion should be protected from burning, as removal of vegetation and intense heat will reduce soil stability and accelerate erosion. Appropriate permits are required from the NT Bushfires Council.

7.7 Recommended Future Environmental Monitoring

During the Wet Season 2009 survey, 46 more fauna species and 102 more flora species were recorded than in the Dry Season 2008 survey. Although it was known that the Dry 2008 Season survey would have limited plant species due to the fire, the increased values emphasise the importance of follow-up surveys to capture changes in seasonal species composition, including species occurring in response to fire. Furthermore, the spatial, temporal and seasonal variability of arid rangelands necessitates future environmental monitoring to detect the presence of significant species not previously recorded within the project area, to detect delayed impacts of mining operations and to assess the effectiveness of rehabilitation works.

Recommended future monitoring should replicate the methods described herein for the flora and fauna component of the Wet Season 2009 survey. Additionally, it is recommended that as additional access tracks are installed, more survey sites (or quadrats) are added so sites can be stratified equally across land units and impact and non-impact areas. The current survey quadrats represent 6 land units, with 6 survey quadrats in proposed impact sites, and 2 in non-impact sites. This has initiated the collection of baseline data, although the establishment and stratification of additional sites will provide a more extensive and robust data set. As a general rule of thumb in broad scale surveys, at least 20 monitoring sites are required to establish biological and landscape information against which the impacts of mining activity can be effectively and statistically assessed (Pers. comm., February, 2009, R. B. Cunningham, Adjunct Professor (Statistics), Fenner School of Environment and Society, ANU, Canberra)

Long term environmental monitoring should pursue three main objectives:

1) Describe the pre-development environment to provide a basis for identifying potential impacts and associated remedial action.

2) Monitor the project's environmental impacts and identify unforeseen impacts.

3) Assess environmental management strategies and compliance with regulatory permits and licenses.

Further, it is important to update maps with weed sightings and details of weed eradication efforts within the project area to avoid using weed-infested soils in revegetation programs, and to monitor the effect of development on weed abundance.

Ongoing monitoring programs will be required to assess impact and identify management issues concerning:

- Surface and ground waters
- Disturbed catchment areas
- Relative abundance of introduced species (flora and fauna)
- Wildfire control
- Dust deposition
- Weathering products of mine waste (i.e. acid drainage)
- Revegetation and rehabilitation techniques

It is recommended that adaptive management plans are developed to incorporate findings from the future monitoring programs. This may include scheduled reviews of management plans that facilitate their assessment in light of results from continued monitoring. In turn, management plans should contain tools to review and adapt monitoring programs to incorporate new data as appropriate.

8 References

Baker, B., Price, O., Woinarski, J., Gold, S., Connors, G., Fisher, A. and Hempel, C. (2005), Northern Territory Parks and Conservation Masterplan: Northern Territory Bioregions – Assessment of key biodiversity values and threats, Darwin, Northern Territory.

http://nt.gov.au/nretas/parks/management/masterplan/pdf/bioregions_assessment.pdf

Brocklehurst, P., Lewis, D., Napier, D., and Lynch, D. (2007) *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping.* Technical Report No. 02/2007D. Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

Bureau of Meteorology (2008 & 2009): website: http://www.bom.gov.au.

Bureau of Rural Sciences (1991) Digital Atlas of Australian Soils (ARC/INFO® vector format). [Online] Available HTML: http://www.brs.gov.au/data/datasets.

Connors, G., Oliver, B., and Woinarski, J. (1996) Bioregions in the Northern Territory: Conservation Values, Reservations Status and Information Gaps. Final report to ANCA National Reserves System Cooperative Program (Project N607), Parks and Wildlife Commission of the Northern Territory, Palmerston, Northern Territory.

Dickman, C. R. (1993). The biology and management of native rodents of the arid zone in New South Wales. Species Management Report Number 12. New South Wales National Parks and Wildlife Service, Hurstville.

Ferrier, S., and Watson, G. (1997) An Evaluation of the Effectiveness of Environmental Surrogates and Modelling Techniques in Predicting the Distribution of Biological Diversity. Environment Australia, Canberra.

Gibson, D.F. and Wurst P.D. (1994) *Reptile survey of the Wakaya Desert, Northern Territory*. A consultancy report to Australian Heritage Commission and Conservation Commission of the Northern Territory, Alice Springs.

Holmes, J. and Low, W. (2000) Environmental Impact Assessment of the Proposed Haul Road from the Groundrush Prospect Evaluation Area to Tanami Mine. Report to Normandy North Flinders Mining Ltd., Wayville, S.A.

Ingleby, S. (1991). Distribution and status of the Spectacled Hare-wallaby, *Lagorchestes conspicillatus. Wildlife Research* **18**, 501-519.

Ingleby, S. and Westoby, M. (1992). Habitat requirements of the Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) in the Northern Territory and Western Australia. *Wildlife Research* **19**, 721-741.

Isbell, R.F. (1996). *The Australian Soil Classification*, CSIRO, Melbourne.

Low, W.A. (1985) Alroy Downs and Dalmore Downs Stations Pastoral Leases 883 and 885 Resource Appraisal. Report prepared for Conservation Commission of the Northern Territory.

Low, W.A., Cassanet, M. and Hill, A. (2003a) Environmental Profile Magellan 2. Report to Newmont NFM Tanami Operations, Alice Springs, N.T.

Low, W.A., Cassanet, M., and Hill, A. (2003b) Environmental Profile Windy Hill. Report to Newmont NFM Tanami Operations, Alice Springs, N.T.

Low, W.A., Holmes, J., Vea, J., and Davies., B.K. (2001) Schist Hills Borefield Vegetation Survey: Water Extraction Impact Assessment and Vegetation Monitoring Programme, November 2000. Report to Normandy Mining Limited, Normandy Tanami Operations, Alice Springs, N.T.

Masters, P., Dickman, C., and Crowther, M. (2003) Effects of cover reduction on Mulgara *Dasycercus cristicauda* (Marsupiala; Dasyuridae), rodent and invertebrate populations in central Australia: implications for land management. *Austral Ecology* 28, 658-665.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J., and Hopkins, M.S. (1990) *Australian Soil and Land Survey - Field Handbook.* 2nd ed., Inkata Press, Melbourne, Australia.

Moon, E., and Low, W.A. (2006 and 2007) Regional Biodiversity Monitoring in the Tanami Desert: Summary of the 4th and 5th Surveys. Report to Newmont Tanami Pty Lty, Alice Springs, N.T.

Mott, J.J., and Andrew, M.H. (1985). The effect of fire on population dynamics of native grasses of northwest Australia. Proc. Ecol. Soc. Aust. 13: 231-239

Neave, H., Sparrow, B., and Clifford, B. (2006). Preliminary Report: Towards a Resource Assessment of the Burt Plain Bioregion for Conservation Planning. Biodiversity Conservation, Department of Natural Resources, Environment and the Arts, Palmerston, Northern territory.

Noakes, L.C., and Traves, D.M. (1954) Part III. Outline of the geology of the Barkly Region. In Christian et al. 1954. Survey of the Barkly Region, 1947-48. Land Research Series No. 3, CSIRO Melbourne.

Northern Territory Parks and Wildlife Flora Atlas (2007). Developed by the Department of Natural Resources, Environment, Arts and Sport; Parks and Conservation Division, updated in 2008.

Northern Territory Parks and Wildlife Fauna Atlas (2007). Developed by the Department of Natural Resources, Environment, Arts and Sport; Parks and Conservation Division, updated in 2008.

Northcote, K.H. (1979) *'A Factual Key for the Recognition of Australian Soils'.* 4th edn. Rellim Tech. Pubs, Adelaide, SA, Australia.

Oliver, I. (1998) Land Systems as Surrogates for Biodiversity – Initial Report to the Resource and Conservation Assessment Council. NSW National Parks and Wildlife Service.

Paltridge, R and McAlpin, S (2002) A guide to rare and threatened animals in Central Australia. World Wildlife Fund Australia.

Pavey, C. (2007). Greater Bilby, *Macrotis lagotis*. In *Lost from our landscape: threatened species of the Northern Territory.* (2007). (eds J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward) pp. 230-231. Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

Pavey, C. (2006). National Recovery Plan for the Greater Bilby *Macrotis lagotis*. Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

Pavey, C., Cole, J., and Woinarski, J. (2006). Crest-tailed mulgara, Ampurta, *Dasycercus cristicauda*. In *Lost from our landscape: threatened species of the Northern Territory.* (2007). (eds J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward) p. 214. Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

Perry, R.A., Mabbutt, J.A., Litchfield, W.H., and Quinlan, T. (1962) Land Systems of the Alice Springs Area, Northern Territory, Australia. Part II In R.A. Perry, J.A., Mabbut, W.H., Litchfield, T., Quinlan, T. (1962) Lands of the Alice Springs Area, Northern Territory, Australia. CSIRO, Canberra.

Preece, N., Latz, P., O'Bryrne, D., Portlock, H., and Waithman, J. (1989). Fire Management Manual: For Central Australian Parks and Reserves. Conservation Commission of the Northern Territory, Alice Springs.

Purdie, J., Materne, C., and Bubb, A. (2008) A field guide to Plants of the Barkely Region, Northern Territory.

Slatyer, R.O., and Christian, C.S. (1954) Part II. Climate of the Barkly Region. In Christian, C.S., et al. 1954 (q.v.).

Smart, J.M., Knight, A.T. and Robinson, M. (2000) A Conservation Assessment for the Cobar Peneplain Biogeographic Region - Methods and Opportunities. NSW National Parks and Wildlife Service, Sydney, Australia.

Stewart, G.A., Christian, C.S. and Perry, R.A. (1954). Part VIII. Land Systems of the Barkly Region, Northern Territory, Australia. In Christian, C.S., Noakes, L.C., Perry, R. A., Slatyer, R. O., Stewart, G. A. and Traves, D. M. Survey of the Barkly Region, 1947-48. Land Research Series No. 3. CSIRO, Melbourne.

Taylor, R., Chatto, R. and Woinarski, J. (2006). Australian painted snipe, *Rostratula australis*. In *Lost from our landscape: threatened species of the Northern Territory.* (2007). (eds J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward) p. 187. Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

White, M., Albrecht, D., Duguid, A., Latz, P. and Hamilton, M. (2000) Plant species and sites of botanical significance in the southern bioregions of the Northern Territory. Volume 1: significant vascular plants. Report to the Australian Heritage Commission. (Arid Lands Environment Centre: Alice Springs)

Wilson, S. and Swan, G. (2003) *A Complete Guide to Reptiles of Australia.* New Holland (Australia), Sydney.

Wilson, B.A., Brocklehurst, P.S., Clark, M.J. and Dickinson, K.J.M. (1990) Vegetation survey of the Northern Territory Australia. Technical report – No 49. Conservation Commission of the Northern Territory.

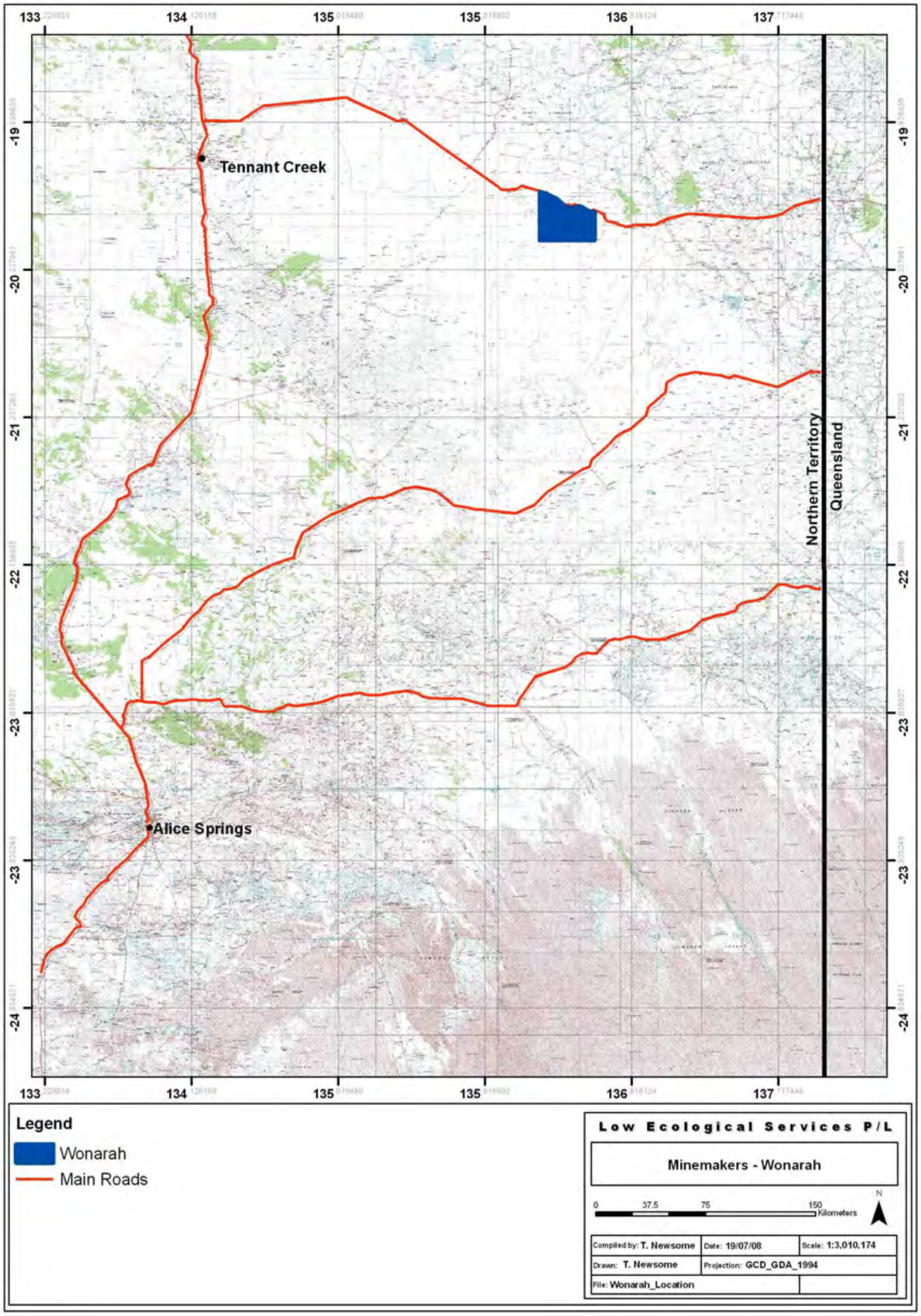
Woinarski, J.C.Z., Pavey, C., Kerrigan, R., Cowie, I. and Ward, S. (2007) *Lost from our landscape; threatened species of the Northern Territory*. NT Dept NRETA. NT Govt Printer, Darwin.

Woolley, P.A. (2005). The species of *Dasycercus* Peters, 1875 *(Marsupialia), Memoirs of Museum Victoria,* **62**(2): 213-221.

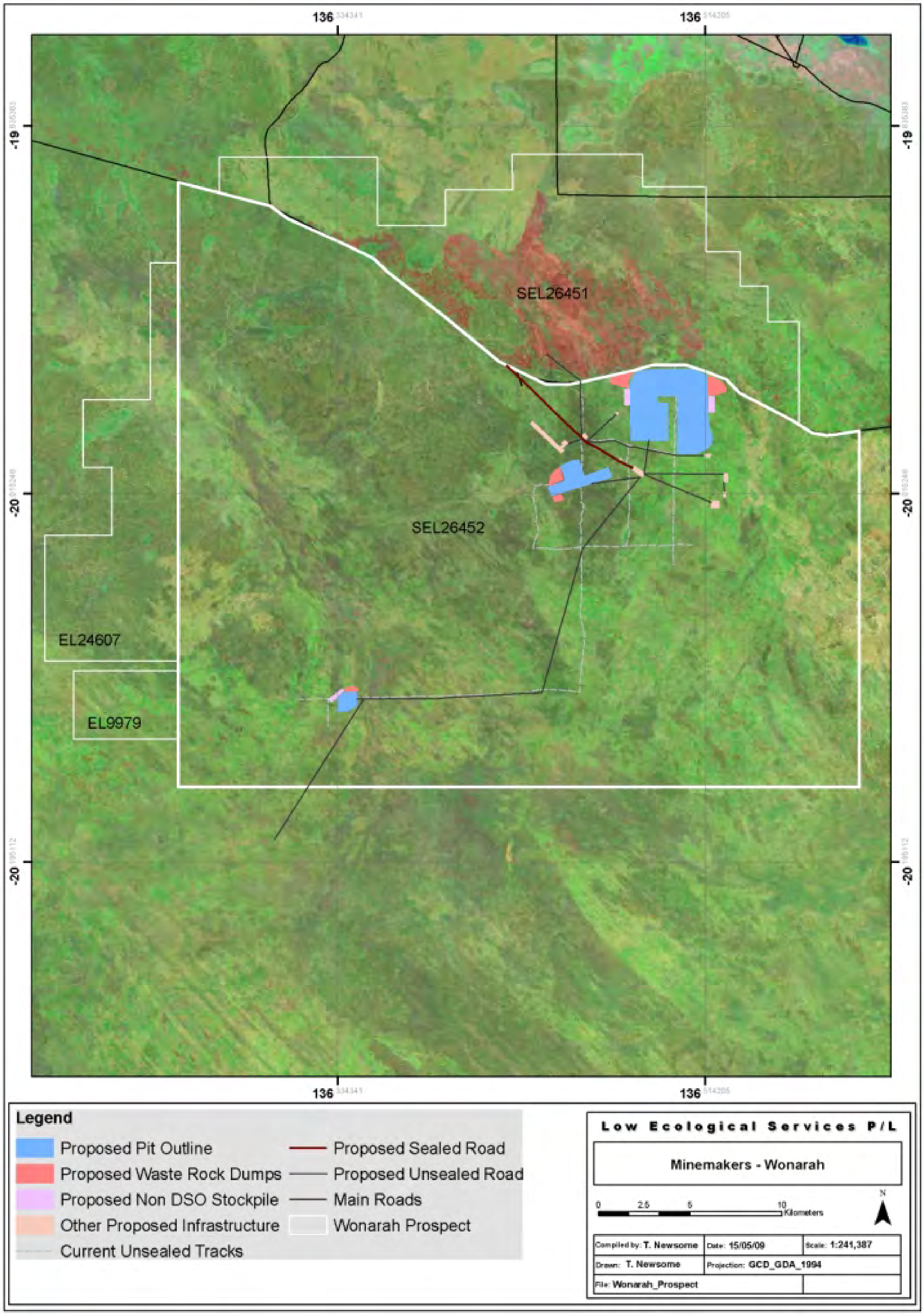
Ziembicki, M. (2006). Australian bustard, *Ardeotis australis*. In *Lost from our landscape: threatened species of the Northern Territory.* (2007). (eds J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward) pp. 184-185. Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

9 Appendices

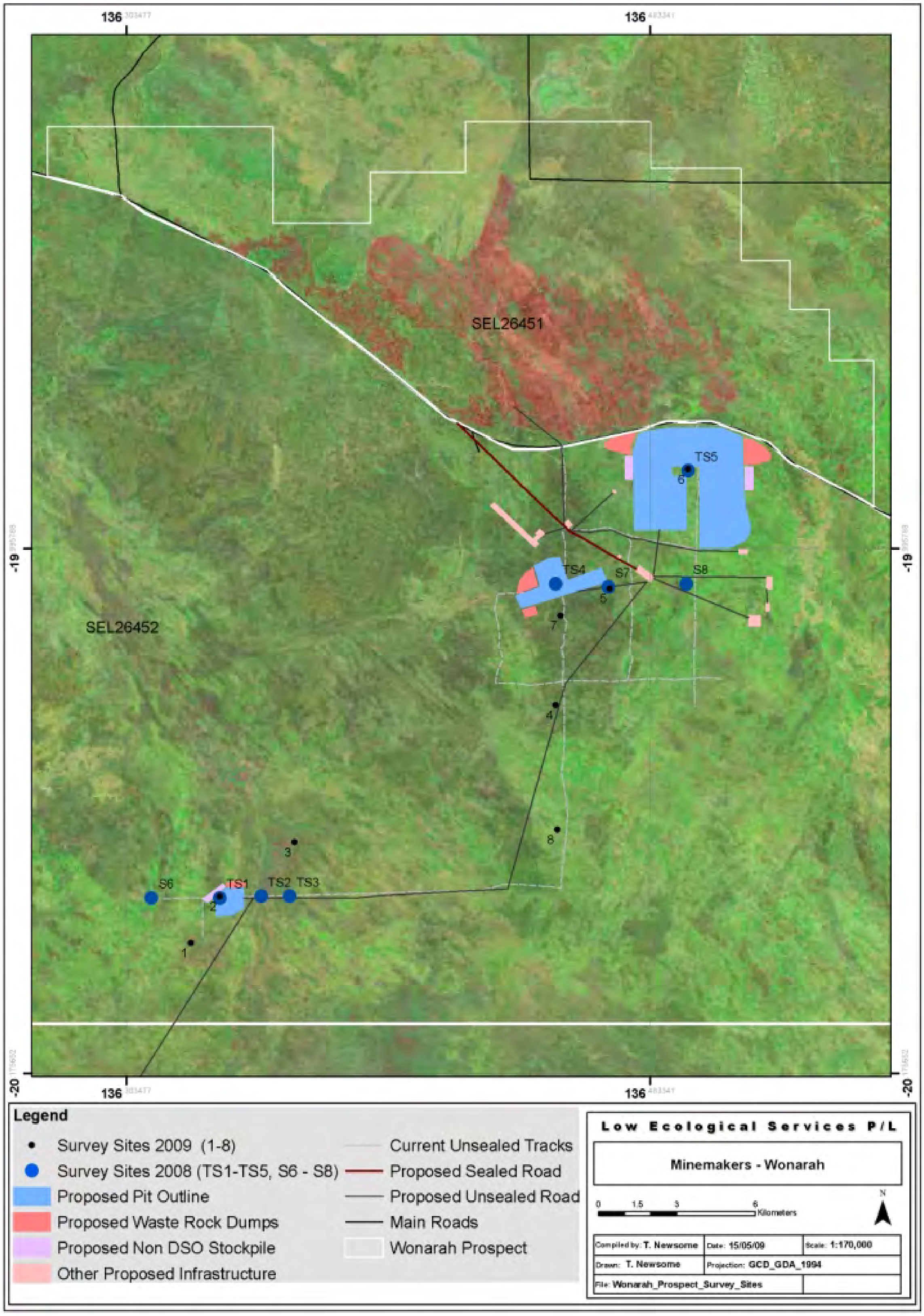
9.1 **Appendix One:** Location of Minemakers Wonarah Phosphate Project in relation to Alice Springs and Tennant Creek, Northern Territory.



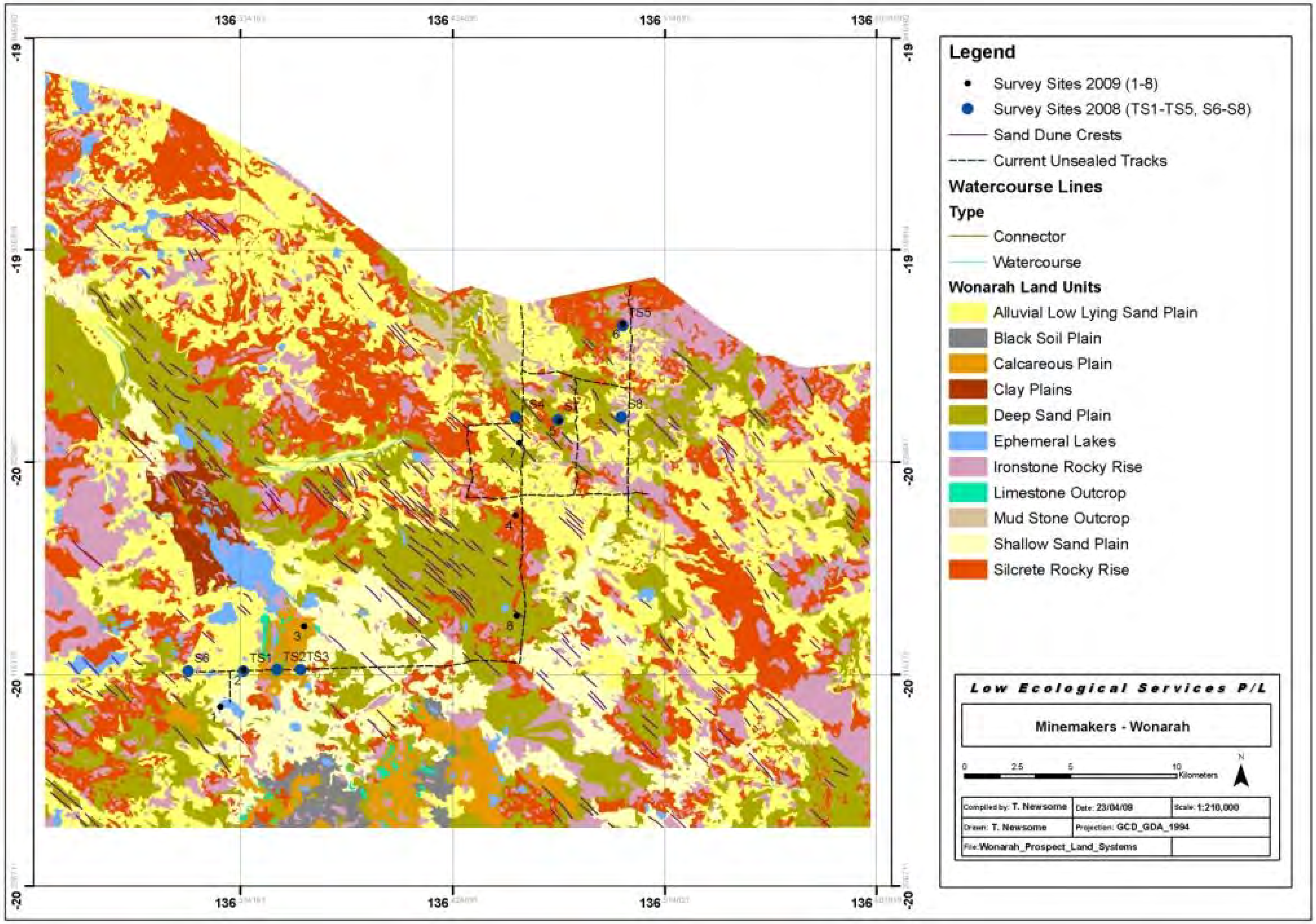
9.2 Appendix Two: Minemakers Wonarah prospect zones over Landsat 5 image. The Wonarah Phosphate Project area occurs within of exploration licence SEL 26452.



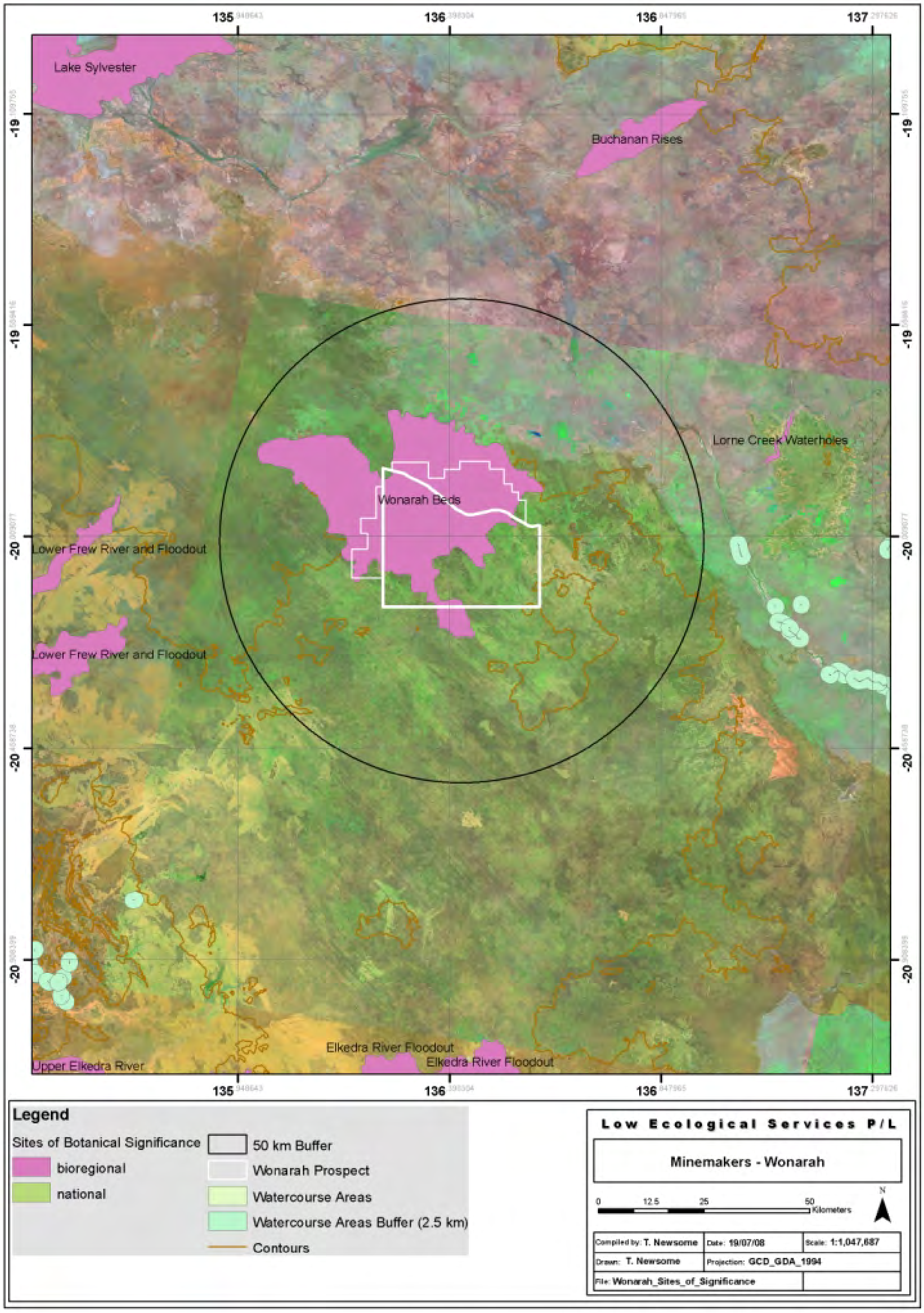
9.3 **Appendix Three:** Location of survey quadrats studied during LES field surveys (Dry Season 2008 & Wet Season 2009 surveys) and proposed disturbance areas over Landsat 5 image.



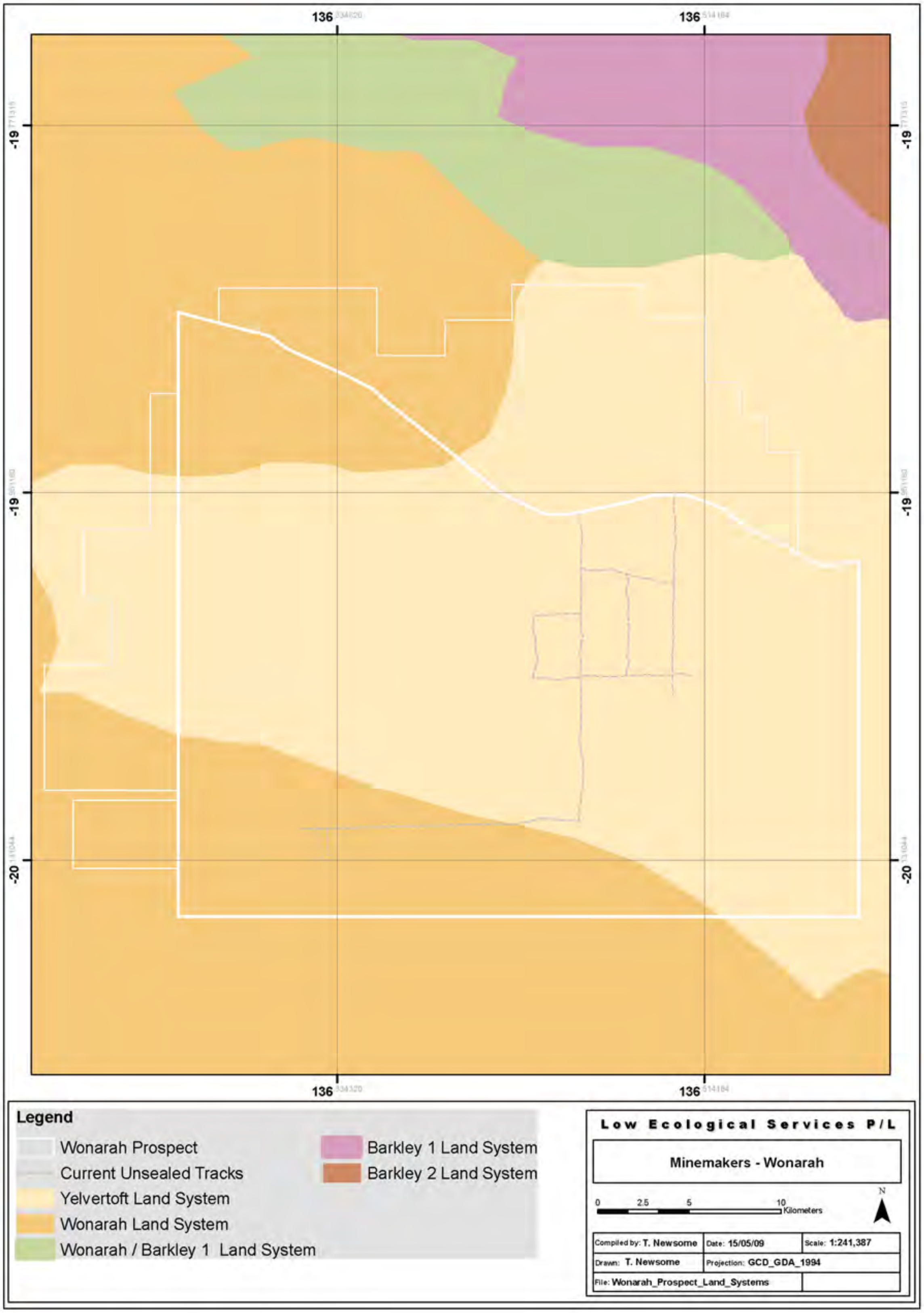
9.4 Appendix Four: Land units and survey quadrat locations utilised in LES field surveys (Dry Season 2008 and Wet Season 2009 surveys) within the Wonarah project area. Land units were developed by LES utilising regolith units surveyed by Rio Tinto and were verified on-site during the Wet Season 2009 survey, as discussed in Section 5.5.



9.5 Appendix Five: Location of Wonarah Phosphate Project area in relation to sites of significance as determined by the Northern Territory Parks and Conservation Masterplan and watercourse areas over Landsat 5 image.

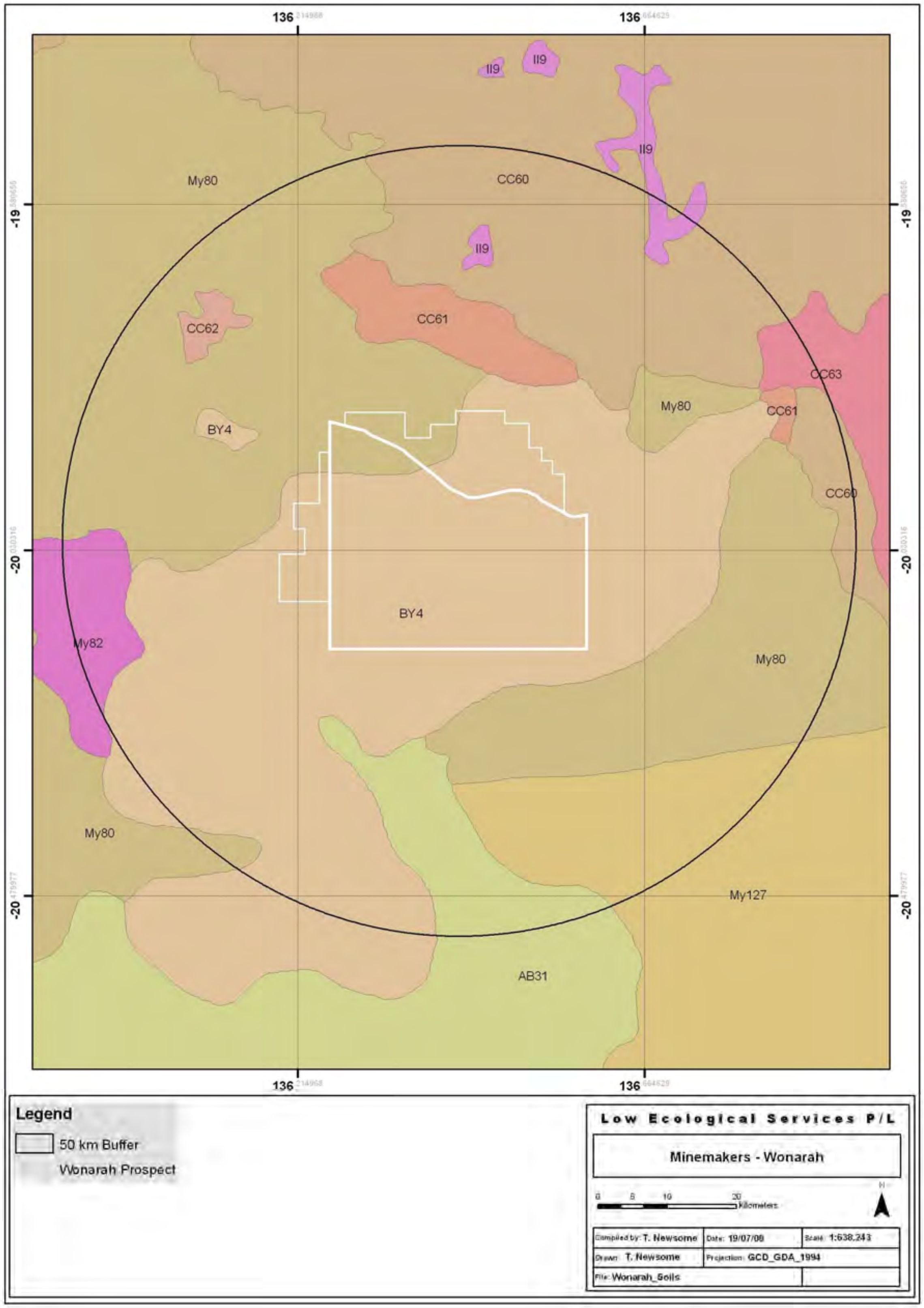


9.6 Appendix Six: Land Systems of the Wonarah Phosphate Project area. Modified after Perry et al. (1962) and Stewart et al. (1954).



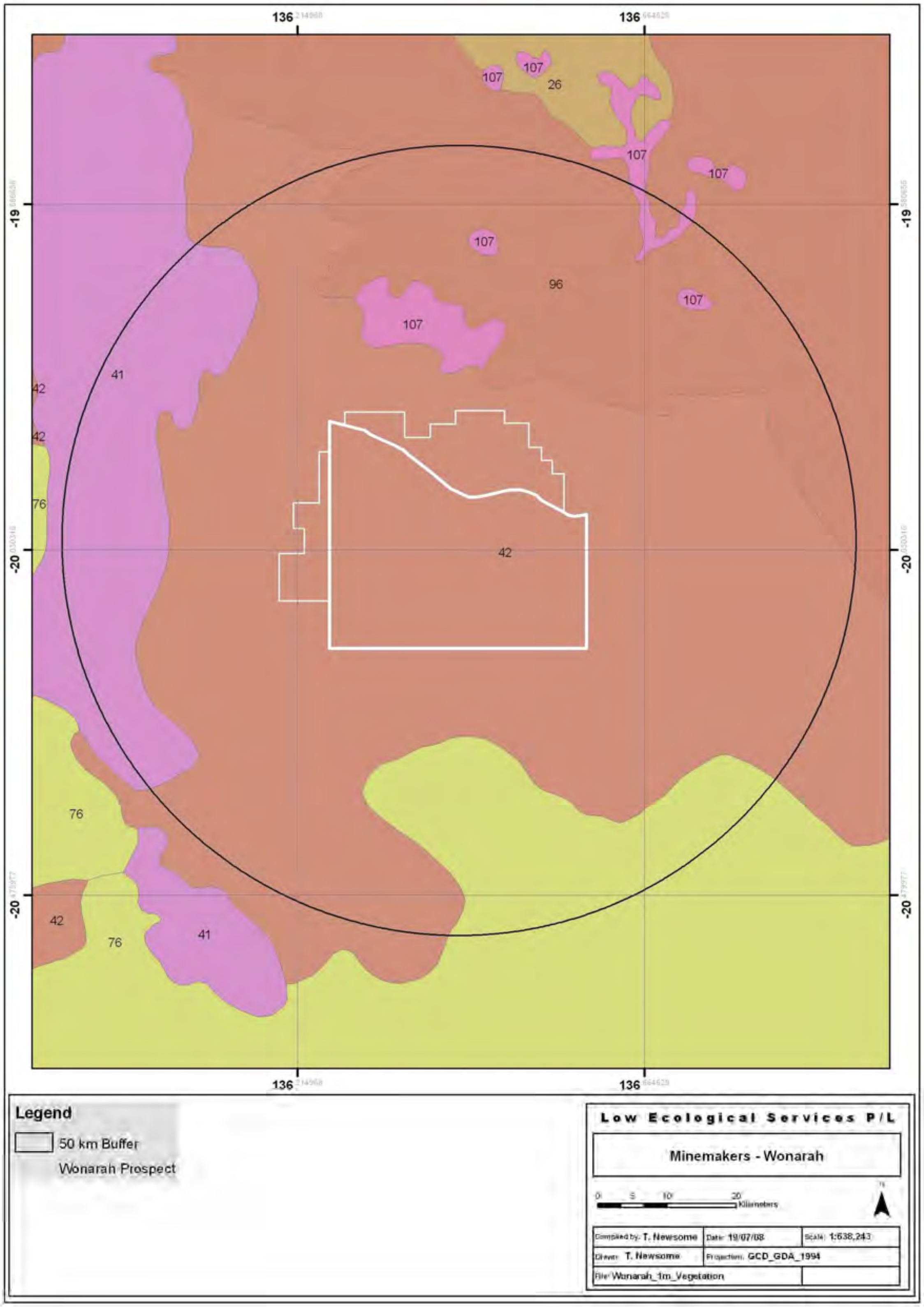
9.7 **Appendix Seven:** Classification of soils in the Wonarah Prospect and surrounding region (50 km buffer) (Bureau of Rural Sciences 1991).

Refer to section 4.5 for descriptions of codes.



9.8 **Appendix Eight:** ARC/INFO coverage's for the 1:1,000,000 NT vegetation map (Conservation Commission of the NT, 1991) in the Wonarah Prospect and surrounding region (50 km buffer).

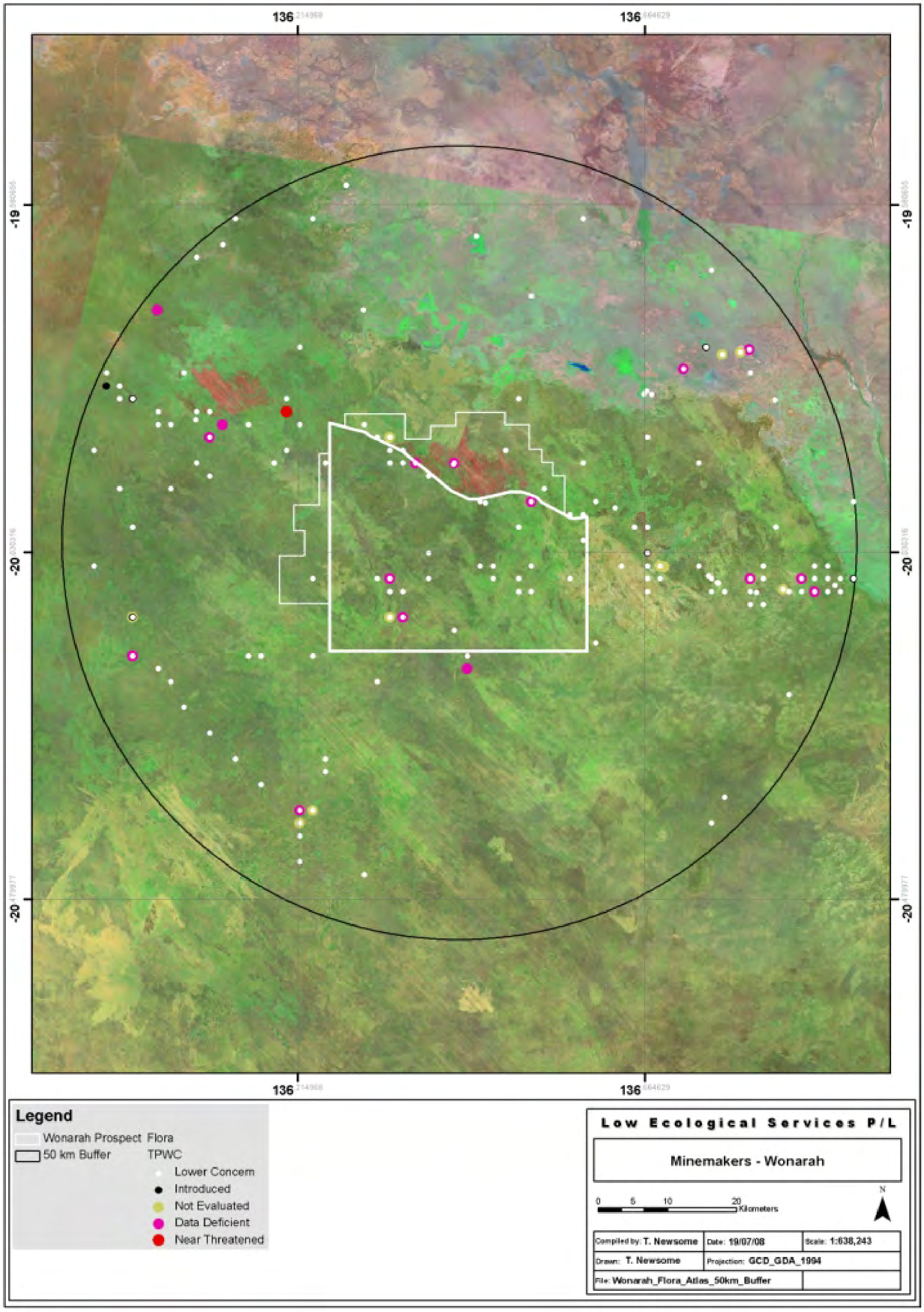
See text section 4.6 for description of codes.



9.9 **Appendix Nine:** Matters of Environmental Significance (Department of Environment Water Heritage and the Arts): Species of Conservation Significance listed under the Environmental Protection and Biodiversity Conservation Act (1999), (EPBC) and Territory Parks and Wildlife Conservation Act (2000) (TPWC), that occur or could possibly occur within a 50 km buffer of the Wonarah Prospect. Note the category "migratory" includes terrestrial, migratory marine and migratory wetland species.

Species Name and Status	Common Name	Level of Status	Present during the survey / known to occur within 50 km buffer	Preferred habitat
VULNERABLE				
Mammals				
Dasycercus cristicauda	mulgara	EPBC TPWC	Not Recorded / known to occur in the region	Arid and semi arid sandy regions particularly mature hummock grasslands
Birds				
Rostratula australis	Australian painted snipe	EPBC	Not Recorded / known to occur in the region	Well vegetated ephemeral areas
MIGRATORY – Species or species habitat may occur within the area				
Birds				
Apus pacificus	fork-tailed swift	EPBC	Not Recorded / not known to occur	Boreal and temperate forests
Ardea alba	great egret, white egret	EPBC	Not Recorded / not known to occur	Wet areas and damp grasslands
Ardea ibis	cattle egret	EPBC	Not Recorded / not known to occur	Grasslands, woodlands and wetlands
Charadrius veredus	oriental plover	EPBC	Not Recorded / not known to occur	Timbered Habitats
Glareola maldivarum	oriental pratincole	EPBC	Not Recorded / not known to occur	Creeklines
Merops ornatus	rainbow bee-eater	EPBC	Not Recorded / not known to occur	Open forests, woodlands and shrublands, and cleared areas, usually near water. Migratory in summer.
Numenius minutus	little curlew, little whimbrel	EPBC	Not Recorded / not known to occur	Dry grasslands and ephemeral areas
Rostratula australis	Australian painted snipe	EPBC	Not Recorded / not known to occur	Well vegetated ephemeral areas

9.10 Appendix Ten: Flora species of conservation significance within the Wonarah prospect and surrounding region (50km), recorded in the Northern Territory Parks and Wildlife Flora Atlas (2007), over Landsat 5 image. Note that some sites have multiple species records so this figure should be used as a guide only. A key to conservation codes is provided in Appendix Eleven.



9.11 **Appendix Eleven:** Flora species list for the Wonarah prospect and surrounding region based on the Northern Territory Parks and Wildlife Flora Atlas (2007) records (existing data) and status under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004), Territory Parks and Wildlife Conservation Act (2000) (TPWC) and conservation codes (SSOBS) defined by White et al. (2000).

Where:
LC = least concern (TPWC);
INTRO = introduced species;
DD = data deficient (TPWC);
NT = near threatened (TPWC);
NE = not evaluated (TPWC).
Codes and classifications (SSOBS) are defined in White *et al*. (2000), where:
1 = Poorly known taxonomic records or taxa known only from the type collection;
3 = Taxa with a geographic range within Australia exceeding 100 km;
C = Indicates that the species occurs with a conservation reserve;
k = These taxa have the potential to belong in a conservation category but there is presently insufficient information;
R = Nationally, these species are rare but not currently considered to be threatened;
r = Within the NT, these species are rare but not currently considered to be threatened; and
- = Indicates that the taxon has been recorded from a reserve but that the population size within the reserve in unknown.

Codes for bioregions are as follows:

BRT	Burt Plain
CR	Central Ranges
DMR	Davenport Murchison Ranges (NB you used DAV – I corrected)
GSD	Great Sandy Desert
MAC	MacDonnell Ranges
SSD	Simpson Strzelecki Dunefields
TAN	Tanami

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Abelmoschus ficulneus	native rosella	LC			
Abutilon fraseri subsp. fraseri	dwarf lantern-bush	LC			
Abutilon hannii		LC			
Abutilon otocarpum	keeled lantern-bush, desert Chinese lantern, desert lantern	LC			
Acacia acradenia		LC			
Acacia adoxa var. adoxa		LC		bioregional	TAN (eastern range limit)
Acacia adsurgens	whipstick wattle, sugar brother	LC			
Acacia ancistrocarpa	Fitzroy wattle, pirraru	LC			
Acacia aneura	mulga	LC			
Acacia cambagei	gidgee, stinking wattle	LC			
Acacia chippendalei	Chippendales wattle	LC		bioregional	CR (southern range limits)
Acacia cowleana	Halls Creek wattle	LC			
Acacia drepanocarpa subsp. latifolia		LC			
Acacia elachantha		LC			
Acacia hilliana	flying-saucer bush	LC		bioregional	CR (southern range limit)
Acacia lysiphloia	turpentine, turpentine bush, turpentine wattle	LC		bioregional	GSD (disjunct and southern range limit)
Acacia melleodora	waxy wattle	LC			
Acacia monticola	hill turpentine	LC		bioregional	CR (southern range limit)
Acacia sericophylla	dogwood, wirewood	LC			
Acacia stipuligera	scrub wattle, kurapuka	LC			
Acacia tenuissima	broom wattle, minyana	LC		bioregional	CR (disjunct)
Acacia victoriae	acacia bush, bramble wattle, Victoria wattle	LC			
Acacia victoriae subsp. victoriae	acacia bush, bramble wattle, Victoria wattle	LC			
Acrachne racemosa		DD		Northern	3k

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
				Territory	
Aerva javanica	kapok bush, snow bush	INTRO			
Aeschynomene indica	budda pea, kath sola	LC			
Alternanthera angustifolia	narrow-leaf joyweed	NE			
Alternanthera nodiflora	common joyweed	LC			
Alysicarpus muelleri	rough chain-pea	LC			
Amaranthus cochleitepalus		LC			
Amaranthus mitchellii	boggabri	LC			
Ammannia multiflora	jerry jerry	LC			
Amphipogon caricinus var. caricinus	grey-beard grass, long grey-beard grass	LC			
Amyema sanguinea var. sanguinea	blood mistletoe	LC			
Aristida contorta	bunched kerosene grass, mulga grass	LC			
Aristida holathera var. holathera	erect kerosene grass, white grass, arrow grass	LC			
Aristida latifolia	feathertop wiregrass	LC			
Aristida pruinosa	blue wiregrass, Gulf feathertop wiregrass	LC			
Astrebla elymoides	hoop Mitchell grass, weeping Mitchell grass, slender Mitchell grass	LC			
Astrebla pectinata	barley mitchell grass	LC			
Bergia ammannioides	water-fire	LC		bioregional	BRT (apparently rare), SSD (disjunct)
Bergia henshallii		LC		bioregional	CHC (eastern range limit)
Bergia trimera	small water-fire	LC			
Blumea tenella		LC			
Boerhavia burbidgeana		LC		bioregional	DMR (apparently rare)
Boerhavia coccinea		LC			
Boerhavia paludosa	black-soil tar vine	LC		bioregional	BRT (disjunct), MAC (disjunct
Boerhavia repleta		LC			
Bonamia alatisemina		DD		national	3K
Bonamia deserticola	creep weed	LC			
Bonamia media var. media		LC			
Bonamia pannosa		LC			
Brachyachne convergens	spider grass, false couch, annual couch	LC		bioregional	BRT (disjunct), GSD (disjunct)
Cajanus marmoratus		LC			
Calandrinia pumila	tiny purslane, tiny parakeelya	LC			
Calotis porphyroglossa	channel burr-daisy	LC			
Calytrix carinata		LC			
Capparis lasiantha	split-arse-jack, wait-a-while, nepine, maypan	LC			
Capparis umbonata	northern wild orange, wild orange, bush orange, native pomegranate	LC		bioregional	MGD (southern range limit)
Carissa lanceolata	conkerberry, conkle berry, kungsberry bush	LC			
Cassytha capillaris	hairless dodder-laurel, snotty gobble	LC			
Centipeda racemosa	erect sneezeweed	LC			
Chamaecrista symonii	dwarf cassia	LC			
Chenopodium auricomum	northern bluebush, swamp bluebush	LC			
Chloris pectinata	comb chloris	LC			
Chrysocephalum apiculatum	small yellow button, common everlasting, yellow buttons	LC			
Cleome viscosa	tickweed, mustard bush	LC			
Clerodendrum floribundum	smooth clerodendrum, smooth spiderbush, lollybrush, lolly bush	NE			
Corchorus aestuans		LC			

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Corchorus sidoides subsp. vermicularis	flannel weed	LC			
Corchorus tridens		LC		bioregional	SSD (southern range limit)
Corymbia aparrerinja	ghost gum, white gum, desert white gum	LC			
Corymbia deserticola subsp. mesogeotica	desert bloodwood	LC		bioregional	MGD (eastern range limit), TAN (northern range limit), GSD (western and southern range limits)
Corymbia flavescens		LC			
Corymbia opaca	bloodwood	LC			
Crotalaria crispata		LC			
Crotalaria dissitiflora	grey rattlepod	DD			
Crotalaria dissitiflora subsp. rugosa	grey rattlepod	LC			
Crotalaria medicaginea		LC			
Crotalaria medicaginea var. neglecta		LC			
Crotalaria montana		LC			
Crotalaria novae-hollandiae subsp. lasiophylla	New Holland rattlepod	LC			
Croton aridus		LC			
Cucumis melo	bush cucumber, wild cucumber, native cucumber, ulcardo melon	LC			
Cullen cinereum	annual verbine	LC			
Cuscuta victoriana		LC			
Cyperus bifax	Downs nutgrass	LC		bioregional	MAC (disjunct)
Cyperus bulbosus	yalka, nutgrass	LC			
Cyperus concinnus	trim sedge	LC			
Cyperus cuspidatus		LC		southern NT	(disjunct & apparently rare)
Cyperus difformis	variable-leaf sedge, variable flat-sedge, dirty dora	LC			
Cyperus gilesii		LC			
Cyperus iria		LC			
Cyperus victoriensis		LC			
Dactyloctenium radulans	button grass, finger grass, toothbrush grass	LC			
Desmodium campylocaulon	creeping tick-trefoil	LC		bioregional	BRT (disjunct), MAC (disjunct), TAN (disjunct)
Desmodium muelleri		LC		bioregional	CHC (disjunct), TAN (disjunct and apparently rare)
Dichanthium sericeum	silky bluegrass, Queensland bluegrass	LC			
Dichanthium sericeum subsp. sericeum	silky bluegrass, Queensland bluegrass	LC			
Digitaria brownii	cotton panic grass	LC			
Digitaria coenicola	umbrella grass, finger panic grass	LC			
Digitaria ctenantha	comb finger grass	LC			
Diplatia grandibractea	royal mistletoe	LC		bioregional	SSD (disjunct and apparently rare)
Diplopeltis stuartii var. glandulosa		DD		Northern Territory	3k
Distichostemon barklyanus		DD		Northern Territory	3k
Dodonaea coriacea	hopbush	LC			
Dolichandrone heterophylla s.lat.	dohwa, lemonwood	LC			
Ehretia saligna s.lat.	coonta, false cedar, peachwood, peachbush	NE			
Einadia nutans subsp. eremaea	climbing saltbush	LC			
Eleocharis atropurpurea		LC		bioregional	GSD (disjunct and apparently rare)

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Eleocharis pallens	pale spike-rush	LC			
Elytrophorus spicatus	spikegrass	LC			
Enchylaena tomentosa	ruby saltbush, Sturts saltbush, plum puddings, berry cottonbush	LC			
Enneapogon cylindricus	jointed nine-awn, limestone oat-grass, jointed bottlewasher	LC			
Enneapogon pallidus	conetop nine-awn, pale bottlewasher	LC			
Enneapogon polyphyllus	woolly oat-grass, oat-grass, leafy nine-awn	LC			
Enneapogon purpurascens	purple nine-awn, purple bottlewasher	LC		bioregional	TAN (southern range limit)
Enteropogon acicularis s.lat.	curly windmill grass, umbrella grass, spider grass	LC			
Eragrostis cumingii	fairy grass, Cumings lovegrass	LC			
Eragrostis eriopoda subsp. Red earth (D.J.Nelson 1651)		LC			
Eragrostis eriopoda subsp. Sandy fire-weed (P.K.Latz 12908)		LC			
Eragrostis falcata	sickle lovegrass	LC			
Eragrostis kennedyae	small-flowered lovegrass	LC			
Eragrostis olida		LC		bioregional	DMR (eastern range limit)
Eragrostis setifolia	neverfail, narrow-leaf neverfail	LC			
Eragrostis tenellula	delicate lovegrass	LC			
Eremophila latrobei var. glabra	native fuchsia	LC			
Eremophila longifolia	emu bush, weeping emu bush, long-leaved desert fuchsia	LC			
Eriachne aristidea	three-awn wanderrie	LC			
Eriachne armitii	longawn wanderrie	LC			
Eriachne ciliata	slender wanderrie, wiregrass	LC			
Eriachne melicacea	fire grass	LC		bioregional	DMR (southern range limit)
Eriachne mucronata	mountain wanderrie	LC			
Eriachne obtusa	northern wanderrie, wiregrass	LC			
Eriachne pulchella subsp. pulchella	pretty wanderrie	LC			
Erythrina vespertilio	bean tree, batswing coral tree	LC			
Eucalyptus chlorophylla	green-leaf box	LC			
Eucalyptus coolabah		LC			
Eucalyptus coolabah	coolabah	LC			
Eucalyptus coolabah subsp. arida	coolabah	LC		bioregional	TAN (tentative western range limit)
Eucalyptus odontocarpa	Sturt Creek mallee	LC		bioregional	GSD (southern range limit)
Eucalyptus pachyphylla	red-bud mallee	LC		bioregional	DMR (northern range limit)
Eucalyptus pruinosa subsp. pruinosa	silver box, silver-leaf box, apple box, smoke tree	LC			
Eucalyptus victrix	smooth-barked coolibah, ghost gum coolibah, gum-barked coolibah	LC		bioregional	MGD (eastern range limit)
Eulalia aurea	silky browntop, sugar grass	LC			
Euphorbia alsiniflora		LC			
Euphorbia drummondii	caustic weed, caustic creeper, mat spurge	LC			
Evolvulus alsinoides	blue periwinkle, tropical speedwell	LC			
Evolvulus alsinoides var. decumbens	blue periwinkle, tropical speedwell	LC			
Evolvulus alsinoides var. villosicalyx	blue periwinkle, tropical speedwell	LC			
Exocarpos sparteus	slender cherry, broombush	LC		bioregional	DMR (northern range limit)
Fimbristylis ammobia		LC		bioregional	MGD (eastern range limit)
Fimbristylis dichotoma	eight day grass, common fringe-rush	LC			
Fimbristylis eremophila	desert fringe-rush	LC		bioregional	TAN (eastern range limit)
Fimbristylis microcarya		LC			
Fimbristylis oxystachya	iukarrara	LC			

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Flaveria australasica	yellow twin stem, speedy weed	LC			
Gomphrena breviflora		LC			
Gomphrena conica (southern NT populations)		DD			
Gomphrena lanata		LC			
Goodenia armitiana	narrow-leaved goodenia	LC			
Goodenia fascicularis	silky goodenia	LC			
Goodenia heterochila	serrated goodenia	LC			
Goodenia lamprosperma		LC			
Goodenia modesta		LC		bioregional	TAN (northern range limit)
Goodenia ramelii		LC			
Goodenia strangfordii		LC		bioregional	MGD (southern range limit)
Goodenia triodiophila	spinifex goodenia	LC			
Gossypium australe	native cotton, tall desert rose	LC			
Grevillea dryandri subsp. dryandri	Dryanders grevillea	LC			
Grevillea juncifolia subsp. juncifolia	desert grevillea, honey grevillea, honeysuckle grevillea	LC			
Grevillea refracta	silver-leaf grevillea	LC			
Grevillea refracta subsp. refracta	silver-leaf grevillea	LC			
Grevillea striata	beefwood	LC			
Grevillea wickhamii subsp. aprica	holly-leaf grevillea	LC		bioregional	CR (southern range limit)
Hakea chordophylla	northern corkwood, bootlace tree, bull hakea, whistling tree	LC			
Hakea macrocarpa	flat-leaved hakea	LC		bioregional	SSD (southern range limit)
Haloragis aspera	rough raspwort	LC			
Haloragis glauca forma glauca	grey raspwort	LC			
Haloragis uncatipila		LC			
Heliotropium ballii		DD		Northern Territory	3k
Heliotropium conocarpum	white heliotrope	DD			
Heliotropium haesum		LC			
Heliotropium ovalifolium		LC			
Heliotropium pulvinum		DD		Northern Territory	3K
Heteropogon contortus	bunch speargrass, black speargrass	LC			
Hibiscus leptocladus	variable-leaf hibiscus	LC			
Hibiscus sturtii var. campylochlamys	Sturts hibiscus	LC			
Hibiscus sturtii var. grandiflorus	Sturts hibiscus	LC			
Hibiscus sturtii var. platychlamys	Sturts hibiscus	LC			
Hibiscus trionum var. vesicarius	bladder ketmia	LC		bioregional	SSD (disjunct and southern range limit), BRT (disjunct)
Hybanthus aurantiacus	orange spade flower	LC			
Indigastrum parviflorum	small-flower indigo	LC			
Indigofera colutea	sticky indigo	LC			
Indigofera ewartiana		LC			
Indigofera linifolia	native indigo	LC			
Indigofera linnaei	Birdsville indigo, nine-leaved indigo	LC			
Indigofera trita		LC		bioregional	BRT (disjunct)
Ipomoea coptica		LC			
Ipomoea costata	bush potato, potato vine, desert yam	LC			
Ipomoea lonchophylla	common cowvine	LC		bioregional	BRT (disjunct), SSD (disjunct)
Ipomoea plebeia	bellvine	LC		southern NT	(apparently rare)
Ipomoea polymorpha	silky cowvine	LC			
Iseilema membranaceum	small Flinders grass	LC			
Iseilema vaginiflorum	red Flinders grass	LC			
Iseilema windersii	scented Flinders grass	LC			
Isoetes muelleri	quillwort	LC		bioregional	DMR (disjunct and apparently

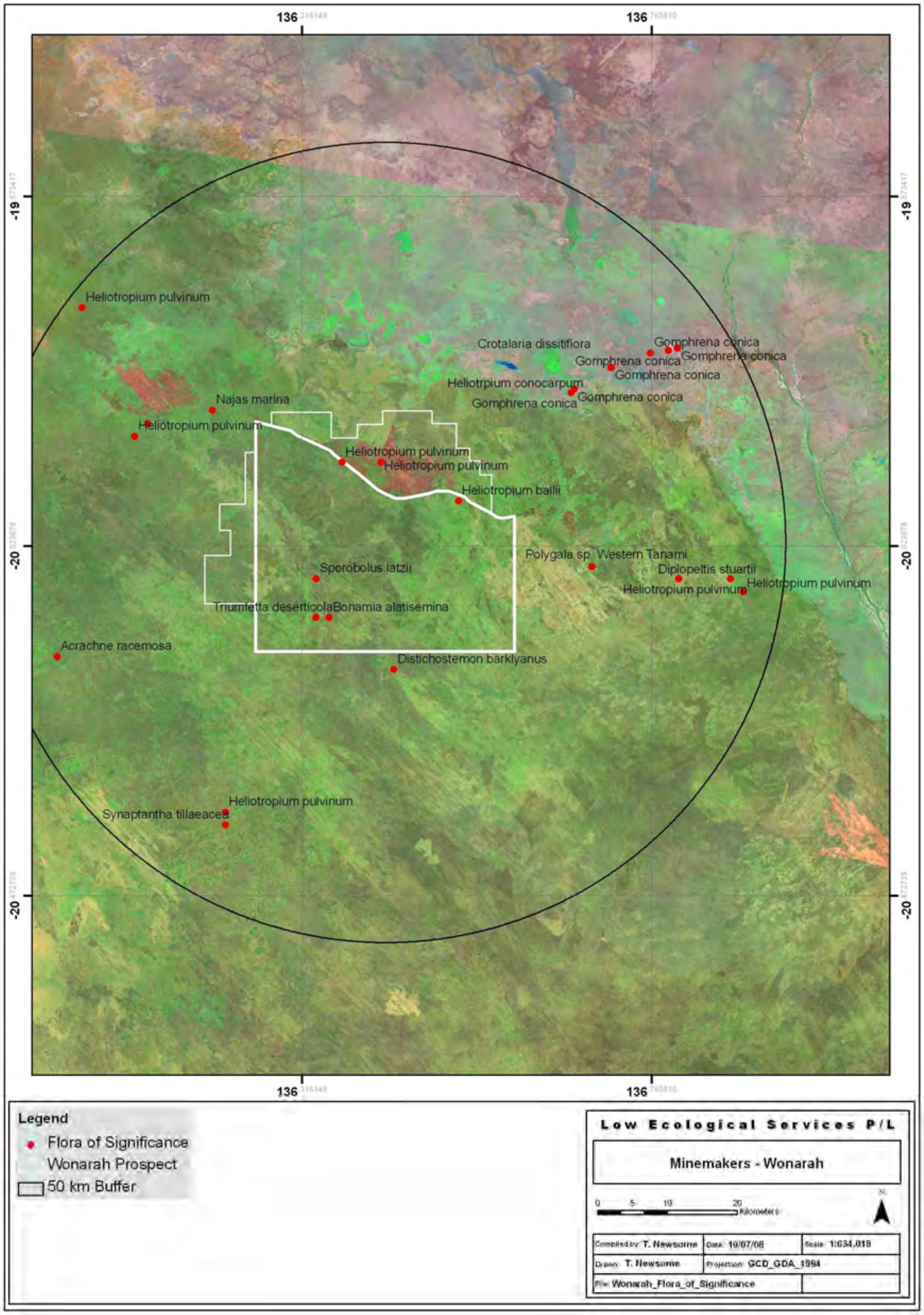
Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
					rare)
Isotropis atropurpurea	poison sage	LC		bioregional	TAN (eastern range limit)
Isotropis winneckei		LC		bioregional	GSD (western range limit)
Jatropha gossypifolia	cotton-leaf physic nut, bellyache bush	INTRO			
Keraudrenia nephrosperma		LC			
Leptochloa fusca subsp. fusca	small-flowered beetle grass	LC			
Leptosema anomalum		LC		bioregional	TAN (eastern range limit)
Leptosema chambersii	upside-down plant, Chambers leptosema	LC		bioregional	DMR (northern and eastern range limits)
Lipocarpha microcephala	button rush	LC			
Lysiana spathulata	flat-leaved mistletoe	LC			
Maireana villosa	silky bluebush	LC			
Malvastrum americanum	malvastrum, spiked malvastrum	INTRO			
Marsilea costulifera	narrow-leaf nardoo	LC		Northern Territory	3k
Marsilea crenata		LC		southern NT	(disjunct)
Marsilea exarata	swayback nardoo, little nardoo	LC			
Melaleuca lasiandra	sandhill tea-tree	LC			
Melaleuca viridiflora	green paperbark, broad-leaved paperbark, large-leaved paperbark	LC			
Melhania oblongifolia	velvet hibiscus	LC			
Merremia davenportii	white morning glory	LC		bioregional	BRT (southern range limit)
Mirbelia viminalis	yellow broom	LC			
Mukia maderaspatana	head-ache vine	LC			
Najas marina	prickly waternymph, prickly naiad	NT		Northern Territory	3rC-
Najas tenuifolia	waternymph, thin-leaved naiad	LC		southern NT	(disjunct)
Neptunia dimorphantha	sensitive plant, nervous plant	LC			
Oldenlandia argillacea		LC		bioregional	MGD (apparently rare), TAN (apparently rare), BRT (disjunct)
Oldenlandia mitrasacmoides		LC			
Oldenlandia mitrasacmoides subsp. mitrasacmoides		LC		bioregional	BRT (southern range limit)
Operculina aequisepala		LC		bioregional	CHC (southern range limit), TAN (disjunct and apparently rare)
Opuntia elatior		LC			
Panicum decompositum	native millet, native panic, Australian millet	LC			
Panicum decompositum var. decompositum	native millet, native panic, Australian millet	LC			
Panicum laevinode	pepper grass	LC			
Paraneurachne muelleri	spinifex couch, northern mulga grass	LC			
Paspalidium jubiflorum	Warrego summer grass	LC			
Paspalidium rarum	bunch paspalidium	LC			
Paspalidium retiglume		LC		bioregional	MGD (southern range limit)
Peplidium muelleri		LC		bioregional	BRT (apparently rare), MGD (apparently rare), SSD (apparently rare), STP (apparently rare)
Perotis rara	comet grass	LC			
Petalostylis cassioides	butterfly bush, petalostylis	LC			
Phyllanthus exilis		LC			
Phyllanthus maderaspatensis var. angustifolius		LC			
Polycarpaea corymbosa		LC			
Polygala sp. Davenport Range		LC		bioregional	BRT (apparently rare), TAN

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
(C.R.Dunlop 6042)					(western range limit)
Polygala sp. Western Tanami (D.E.Albrecht 10660)		NE		Northern Territory	3k
Polygala tepperi		LC		bioregional	DMR (southern range limit)
Portulaca filifolia s.lat.	slender pigweed	LC			
Portulaca oleracea	pigweed, common purslane, munyeroo	LC			
Portulaca sp. Clay soil (S.T.Blake 17854)		LC			
Pseudoraphis spinescens	swamp grass, spiny mudgrass, water couch	LC			
Psydrax ammophila		LC			
Psydrax attenuata var. myrmecophila forma myrmecophila		LC			
Psydrax attenuata var. myrmecophila forma myrmecophila		LC			
Pterocaulon serrulatum var. serrulatum	fruit-salad bush, apple bush	LC			
Ptilotus calostachyus	weeping mulla mulla	LC			
Ptilotus calostachyus var. calostachyus	weeping mulla mulla	LC			
Ptilotus clementii	limestone pussycats tails, tassel top	LC			
Ptilotus fusiformis	skeleton plant	LC			
Ptilotus obovatus	smoke bush, silver bush, silver tails	NE			
Ptilotus obovatus var. obovatus	smoke bush, silver bush, silver tails	LC			
Ptilotus polystachyus	long pussy-tails	NE			
Ptilotus polystachyus var. polystachyus	long pussy-tails	LC			
Ptilotus schwartzii var. schwartzii forma schwartzii		LC			
Ptilotus spicatus		NE			
Rhagodia eremaea	tall saltbush	LC			
Rhynchosia minima	native pea, rhynchosia	LC			
Rothia indica subsp. australis		LC		southern NT	(disjunct and apparently rare)
Rutidosis helichrysoides subsp. helichrysoides		LC			
Salsola tragus	buckbush, rolypoly, tumbleweed	LC			
Salsola tragus subsp. tragus	buckbush, rolypoly, tumbleweed	LC			
Santalum lanceolatum	plumbush, wild plum	LC			
Sauropus trachyspermus	slender spurge	LC			
Scaevola glabrata		LC			
Scaevola ovalifolia	bushy fanflower	LC		bioregional	GSD (western range limit)
Scaevola parvifolia subsp. parvifolia	fanflower	LC			
Schoenoplectus dissachanthus		LC			
Schoenoplectus laevis		LC		bioregional	FIN (disjunct and apparently rare)
Sclerolaena bicornis var. bicornis	goathead burr, bassia burr	LC			
Sclerolaena lanicuspis	woolly copper burr	LC			
Sebastiania chamaelea		LC			
Senna artemisioides subsp. oligophylla	oval-leaf cassia	LC			
Senna costata		LC			
Senna glutinosa subsp. pruinosa		LC			
Senna notabilis	cockroach bush	LC			
Sesbania chippendalei		LC			
Setaria dielsii	Diels pigeon grass	LC			
Setaria verticillata	whorled pigeon grass	INTRO			
Sida cunninghamii		LC			

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Sida fibulifera	silver sida, pin sida	LC			
Sida goniocarpa		LC			
Sida platycalyx	lifesaver burr, teddy bears arsehole	LC			
Sida rohlenae subsp. rohlenae	shrub sida	LC			
Sida sp. Wakaya Desert (P.K.Latz 11894)		LC		bioregional	TAN (northern range limit)
Sida spinosa	spiny sida	LC			
Sida trichopoda	high sida, narrow-leaf sida	LC			
Solanum centrale	desert raisin, kampurarrpa	LC			
Solanum chippendalei	bush tomato, ngaru	LC			
Solanum cleistogamum	shy nightshade	LC			
Solanum ellipticum var. Foothills (G.J.Leach 1145)	native tomato, potato bush, potato weed	LC			
Solanum quadriloculatum	wild tomato, tomato bush	LC			
Solanum tumulicola	black-soil wild tomato	LC			
Spathia neurosa	spathe grass	LC			
Spermacoce hillii		LC			
Sporobolus australasicus	Australian dropseed	LC			
Sporobolus latzii		DD		national	1K
Sporobolus mitchellii	rat-tail couch, swamp rat-tail grass, short rat-tail grass	LC			
Stackhousia intermedia	wiry stackhousia	LC			
Streptoglossa adscendens		LC			
Streptoglossa macrocephala	large-flowered aromatic daisy	LC			
Streptoglossa odora	aromatic daisy	LC			
Stylosanthes hamata	verano stylo, verano, carribbean stylo, stylo	INTRO			
Swainsona burkei		LC		bioregional	TAN (western range limit)
Synaptantha tillaeacea	synaptantha	DD			
Tephrosia lasiochlaena		LC		bioregional	MAC (southern range limit)
Tephrosia leptoclada		LC			
Tephrosia sp. Barrow Creek (G.M.Chippendale 921)		LC		bioregional	GSD (southern range limit)
Tephrosia sp. Willowra (G.M.Chippendale 4809)		LC			
Tephrosia stuartii		LC		bioregional	DMR (eastern range limit)
Teucrium integrifolium	green germander	LC		bioregional	TAN (disjunct and western range limit)
Themeda triandra	kangaroo grass	LC			
Tragus australianus	small burr-grass, sock grass, tickgrass	LC			
Trianthema pilosa		LC			
Trianthema triquetra	red spinach	LC			
Tribulopis angustifolia		LC			
Tribulus eichlerianus s.lat.	bindieye	LC			
Trichodesma zeylanicum	cattle bush, camel bush	LC			
Triodia pungens	soft spinifex, gummy spinifex	LC			
Triodia schinzii	feathertop spinifex	LC			
Triumfetta centralis		LC		bioregional	SSD (eastern range limit)
Triumfetta deserticola		DD		Northern Territory	3k
Urochloa piligera	hairy armgrass, hairy summer grass, green summer grass	LC			
Urochloa praetervisa	large armgrass, large summer grass	LC			
Ventilago viminalis	supplejack, vine tree	LC			
Vigna lanceolata	pencil yam, maloga bean, parsnip bean	LC			
Waltheria indica		LC			

Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Wedelia asperrima	sunflower daisy	LC			
Whiteochloa cymbiformis		LC			
Yakirra australiensis var. australiensis	desert Flinders grass	LC			
Zaleya galericulata subsp. galericulata	hogweed	LC			
Zornia albiflora		LC		bioregional	GSD (southern range limit)

9.12 Appendix Twelve: Northern Territory Parks and Wildlife Flora Atlas (2007) locations of conservation significance as defined by White et al. (2000) or Territory Parks and Wildlife Conservation Act (2000) within the Wonarah prospect and surrounding region (50km) over Landsat 5 image. A key to conservation codes and species status is provided in Appendix Eleven.



9.13 Appendix Thirteen: Coordinates for flora species of conservation significance (as defined by the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004) and Territory Parks and Wildlife Conservation Act (2000) (TPWC)) recorded in LES field surveys and the Northern Territory Parks and Wildlife Fauna Atlas (2007) within the Wonarah Phosphate Project area and surrounding 50 km buffer area. A key to conservation codes is provided in Appendix Thirteen.

Long	Lat	Species Name	Common name	TPWC	EPBC	SSOBS level	SSOBS code
136.00121	-20.16521752	*Acrachne racemosa*		DD		Northern Territory	3k
136.34425	-20.07607	*Bergia barklyana*		NT		National	3R
136.35121	-20.11521518	*Bonamia alatisemina*		DD		National	3K
136.71469	-19.79324	*Crotalaria dissitiflora*	Grey Rattlepod	DD			
136.78819	-19.77134	*Crotalaria dissitiflora*	Grey Rattlepod	DD			
136.79999	-19.76834	*Crotalaria dissitiflora*	Grey Rattlepod	DD			
136.8012	-20.06521217	*Diplopeltis stuartii var. glandulosa*		DD		Northern Territory	3k
136.43454	-20.18187452	*Distichostemon barklyanus*		DD		Northern Territory	3k
136.66319	-19.82574	*Gomphrena conica*		DD			
136.66689	-19.82154	*Gomphrena conica*		DD			
136.71469	-19.79324	*Gomphrena conica*		DD			
136.78819	-19.77134	*Gomphrena conica*		DD			
136.79999	-19.76834	*Gomphrena conica*		DD			
136.76519	-19.77474	*Gomphrena conica*		DD			
136.51788	-19.96521424	*Heliotropium ballii*		DD		Northern Territory	3k
136.71469	-19.79324	*Heliotropium conocarpum*	White Heliotrope	DD			
136.0333	-19.7167	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.11788	-19.8652171	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.10121	-19.88187719	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.41788	-19.91521499	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.36788	-19.91521533	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.86787	-20.06521171	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.8845	-20.08184158	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.21788	-20.36521579	*Heliotropium pulvinum*		DD		Northern Territory	3K
136.50192	-19.97021	*Heliotropium pulvinum*	dd	dd		Northern Territory	3K
136.50192	-19.97021	*Hibiscus brachychlaenus*	nt	nt		Northern Territory	3r
136.20121	-19.84854656	*Najas marina*	Prickly Waternymph, Prickly Naiad	NT		Northern Territory	3rC-
136.6894	-20.0497	*Polygala sp. Western Tanami (D.E.Albrecht 10660)*		NE		Northern Territory	3k
136.33454	-20.06521536	*Sporobolus latzii*		DD		National	1K
136.21788	-20.38187577	*Synaptantha tillaeacea*	Synaptantha	DD			
136.33454	-20.11521529	*Triumfetta deserticola*		DD		Northern Territory	3k

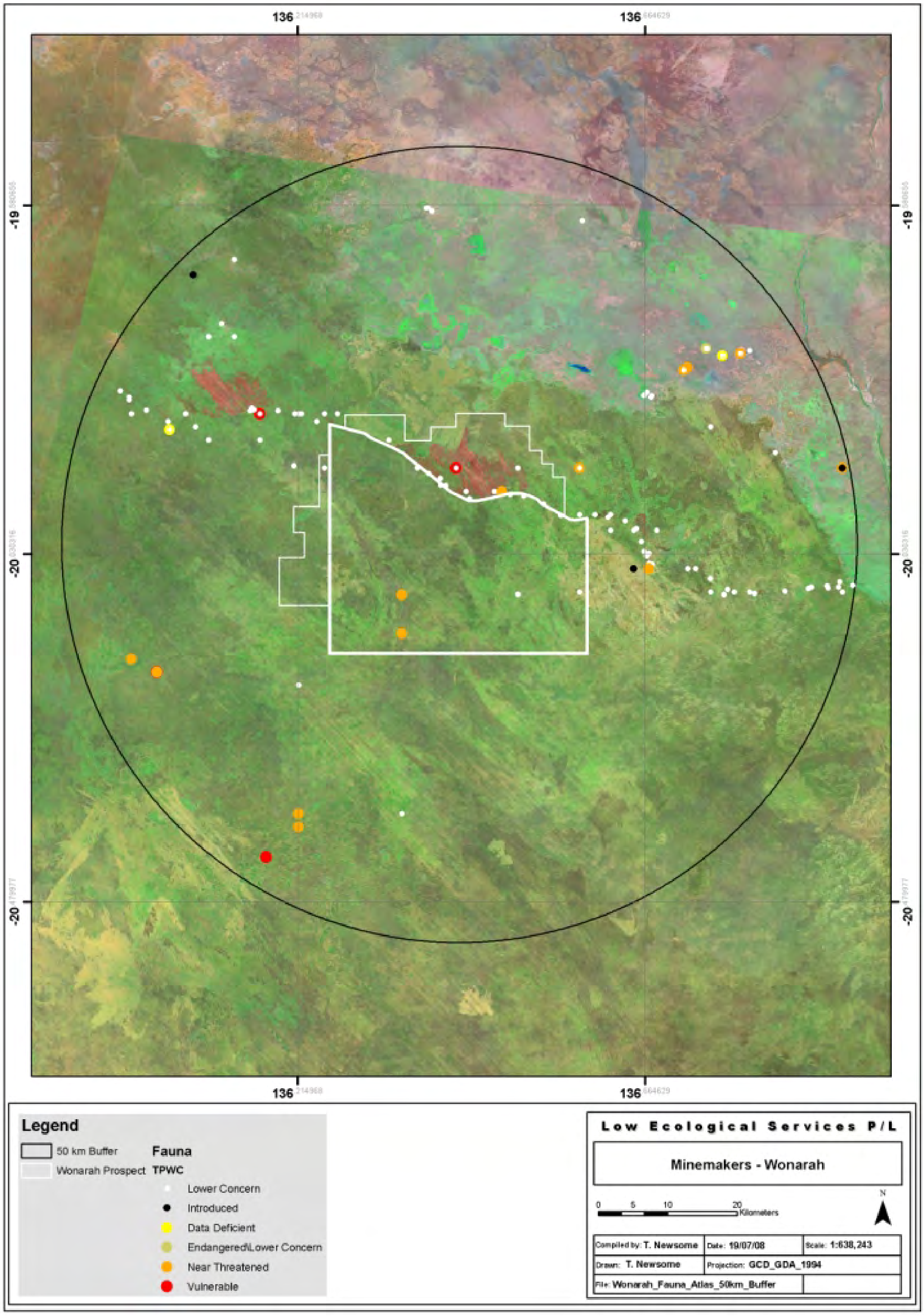
9.14 **Appendix Fourteen:** Weed species that may occur within the Wonarah project area.

Data source: 1) Northern Territory Bioregions – Assessment of key biodiversity values and threats (Baker *et al*. 2005; p66-67), and 2) NT Parks and Wildlife Flora Atlas (2007) (<50 km buffer).

Name	NT Weed Class	WONS	Habitat	Data Source
Bellyache Bush (*Jatropha gossypifolia*)	B			2
Buffel Grass (*Cenchrus ciliaris*)	not declared		Disturbed areas, towns, roads, swamp margins	1
Caribbean Stylo (*Stylosanthes hamata*)	not declared			2
Coffee Bush (*Leucaena leucocephala*)	not declared		Disturbed areas, towns	1
Kapok Bush (Aerva javanica)	not declared		Disturbed areas, roads	2
Marvel Grass (*Dichanthium annulatum*)	not declared			1
Mesquite (*Prosopis limensis*)	B	WONS	Pastoral, water ways and floodplains	1
Neem (*Azadirachta indica*)	not declared		Towns, riparian,	1
Noogoora Burr (*Xanthium strumarium*)	B		Pastoral, roads and tracks	1
Olive Hymenachne (*Hymenachne amplexicaulis*)	not declared	WONS	Water ways and floodplains	1
Paddy's Lucerne (*Sida rhombifolia*)	B		Blocks & gardens, pastoral, roads and tracks	1
Parkinsonia (*Parkinsonia aculeata*)	B	WONS	Pastoral, water ways and floodplains, blocks & gardens	1
Ruby Dock (*Acetosa vesicaria*)	not declared		Waterways and floodplains	1
Setaria verticillate	not declared			2
Spiked Malvastrum (*Malvastrum americanum*)	not declared		Water ways, pastoral and roads.	2

Note: NT Weed classes: A (to be eradicated), B (growth and spread to be controlled), Weeds of National Significance (WONS), and exotic plants of conservation importance.

9.15 Appendix Fifteen: Fauna species of conservation significance within the Wonarah prospect and surrounding region (50km), recorded in the Northern Territory Parks and Wildlife Fauna Atlas (2007), over Landsat 5 image. Note that some sites have multiple species records so this figure should be used as a guide only. A key to conservation codes is provided in Appendix Eleven.



9.16 Appendix Sixteen: Fauna species list for the Wonarah prospect and surrounding region based on the Northern Territory Parks and Wildlife Fauna Atlas (2007) records (existing data) and status under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004) and Territory Parks and Wildlife Conservation Act (2000) (TPWC).

Where:
LC = lower concern
DD = data deficient
VU = vulnerable
EN = endangered
NT = near threatened
INT = introduced
NL = near listed

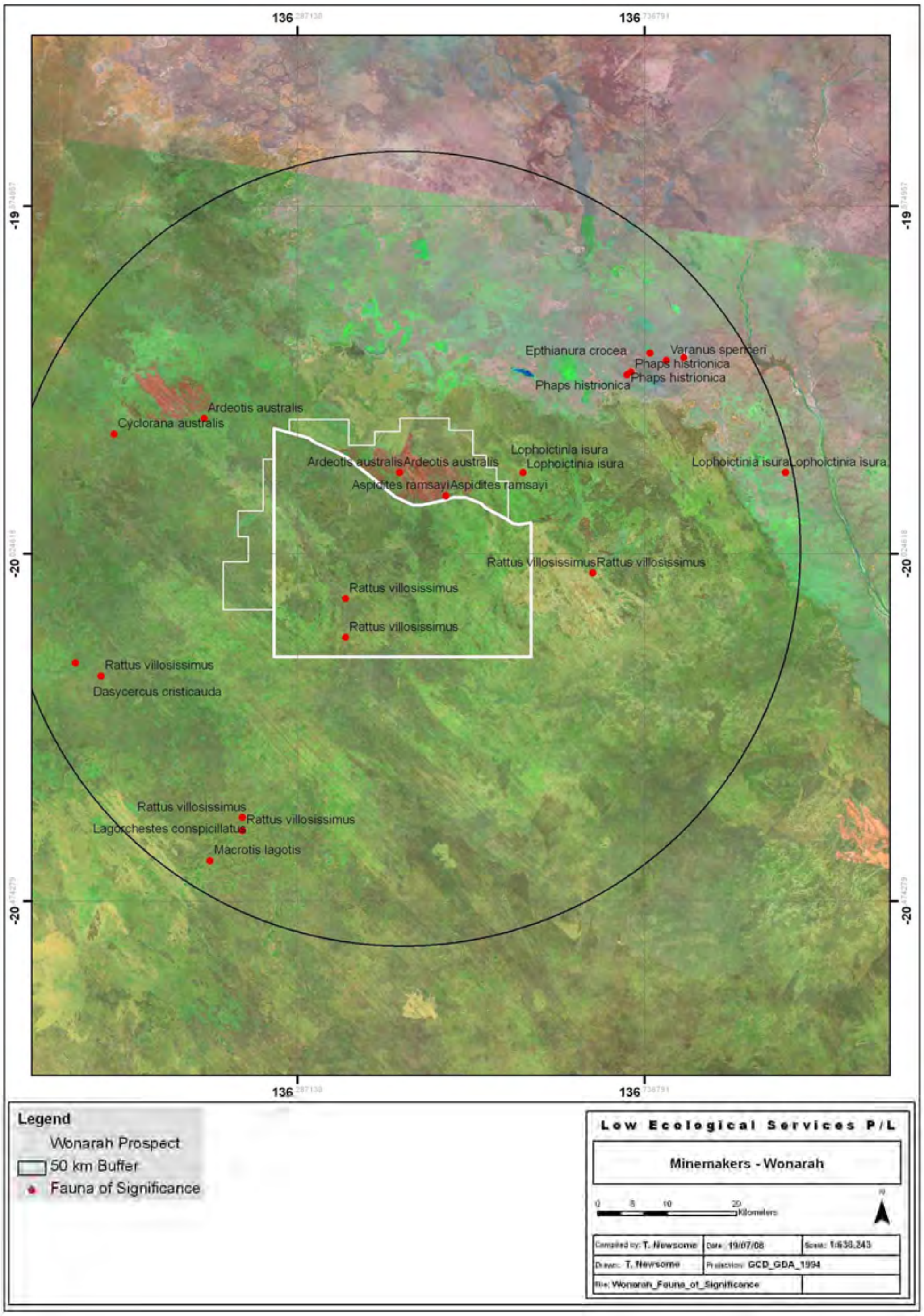
Group	Species Name	TPWC	EPBC	Significant	Exotic	Threatened
Bird	*Acanthiza apicalis*	LC		0	0	0
Bird	*Accipiter cirrhocephalus*	LC		0	0	0
Bird	*Accipiter fasciatus*	LC		0	0	0
Bird	*Aegotheles cristatus*	LC		0	0	0
Bird	*Anas gracilis*	LC		0	0	0
Bird	*Anhinga melanogaster*	LC		0	0	0
Bird	*Anthus novaeseelandiae*	LC		0	0	0
Bird	*Aquila audax*	LC		0	0	0
Bird	*Ardea alba*	LC		1	0	0
Bird	*Ardea pacifica*	LC		0	0	0
Bird	*Ardeotis australis*	VU		1	0	1
Bird	*Artamus cinereus*	LC		0	0	0
Bird	*Artamus personatus*	LC		0	0	0
Bird	*Artamus superciliosus*	LC		0	0	0
Bird	*Aythya australis*	LC		0	0	0
Bird	*Cacatua roseicapilla*	LC		0	0	0
Bird	*Cacatua sanguinea*	LC		0	0	0
Bird	*Certhionyx niger*	LC		0	0	0
Bird	*Certhionyx variegatus*	LC		0	0	0
Bird	*Chalcites basalis*	LC		0	0	0
Bird	*Chlidonias hybridus*	LC		0	0	0
Bird	*Cincloramphus cruralis*	LC		0	0	0
Bird	*Cincloramphus mathewsi*	LC		0	0	0
Bird	*Circus approximans*	LC		0	0	0
Bird	*Circus assimilis*	LC		0	0	0
Bird	*Colluricincla harmonica*	LC		0	0	0
Bird	*Coracina novaehollandiae*	LC		0	0	0
Bird	*Corvus bennetti*	LC		0	0	0
Bird	*Corvus coronoides*	LC		0	0	0
Bird	*Corvus orru*	LC		0	0	0
Bird	*Cracticus nigrogularis*	LC		0	0	0
Bird	*Daphoenositta chrysoptera*	LC		0	0	0
Bird	*Dendrocygna eytoni*	LC		0	0	0
Bird	*Dicaeum hirundinaceum*	LC		0	0	0
Bird	*Elanus axillaris*	LC		0	0	0
Bird	*Elseyornis melanops*	LC		0	0	0
Bird	*Emblema pictum*	LC		0	0	0

Group	Species Name	TPWC	EPBC	Significant	Exotic	Threatened
Bird	*Epthianura crocea*	EN\LC	VU\NL	1	0	1
Bird	*Epthianura tricolor*	LC		0	0	0
Bird	*Erythrogonys cinctus*	LC		0	0	0
Bird	*Falco berigora*	LC		0	0	0
Bird	*Falco cenchroides*	LC		0	0	0
Bird	*Falco longipennis*	LC		0	0	0
Bird	*Falco peregrinus*	LC		0	0	0
Bird	*Falco subniger*	LC		0	0	0
Bird	*Geopelia cuneata*	LC		0	0	0
Bird	*Geopelia placida*	LC		0	0	0
Bird	*Grallina cyanoleuca*	LC		0	0	0
Bird	*Grus rubicunda*	LC		0	0	0
Bird	*Gymnorhina tibicen*	LC		0	0	0
Bird	*Haliastur sphenurus*	LC		0	0	0
Bird	*Hamirostra melanosternon*	LC		0	0	0
Bird	*Hieraaetus morphnoides*	LC		0	0	0
Bird	*Himantopus himantopus*	LC		0	0	0
Bird	*Hirundo ariel*	LC		0	0	0
Bird	*Hirundo nigricans*	LC		0	0	0
Bird	*Lalage sueurii*	LC		0	0	0
Bird	*Lichenostomus keartlandi*	LC		0	0	0
Bird	*Lichenostomus penicillatus*	LC		0	0	0
Bird	*Lichenostomus plumulus*	LC		0	0	0
Bird	*Lichenostomus virescens*	LC		0	0	0
Bird	*Lichmera indistincta*	LC		0	0	0
Bird	*Lophoictinia isura*	NT		1	0	0
Bird	*Malurus lamberti*	LC		0	0	0
Bird	*Malurus leucopterus*	LC		0	0	0
Bird	*Malurus melanocephalus*	LC		0	0	0
Bird	*Manorina flavigula*	LC		0	0	0
Bird	*Melanodryas cucullata picata/westralensis*	LC		0	0	0
Bird	*Melithreptus gularis*	LC		0	0	0
Bird	*Melopsittacus undulatus*	LC		0	0	0
Bird	*Merops ornatus*	LC		1	0	0
Bird	*Milvus migrans*	LC		0	0	0
Bird	*Mirafra javanica*	LC		0	0	0
Bird	*Neopsephotus bourkii*	LC		0	0	0
Bird	*Nymphicus hollandicus*	LC		0	0	0
Bird	*Ocyphaps lophotes*	LC		0	0	0
Bird	*Pachycephala rufiventris*	LC		0	0	0
Bird	*Pardalotus rubricatus*	LC		0	0	0
Bird	*Passer domesticus*	INT		0	1	0
Bird	*Pelecanus conspicillatus*	LC		0	0	0
Bird	*Phalacrocorax melanoleucos*	LC		0	0	0
Bird	*Phalacrocorax sulcirostris*	LC		0	0	0
Bird	*Phalacrocorax varius*	LC		0	0	0
Bird	*Phaps histrionica*	NT		1	0	0
Bird	*Plegadis falcinellus*	LC		1	0	0
Bird	*Rhipidura leucophrys*	LC		0	0	0
Bird	*Smicrornis brevirostris*	LC		0	0	0

Group	Species Name	TPWC	EPBC	Significant	Exotic	Threatened
Bird	*Stiltia isabella*	LC		0	0	0
Bird	*Taeniopygia guttata*	LC		0	0	0
Bird	*Todiramphus pyrrhopygia*	LC		0	0	0
Bird	*Tringa nebularia*	LC		1	0	0
Bird	*Turnix pyrrhothorax*	LC		0	0	0
Bird	*Turnix velox*	LC		0	0	0
Bird	*Vanellus tricolor*	LC		0	0	0
Frog	*Cyclorana australis*	DD		1	0	0
Frog	*Notaden nichollsi*	LC		0	0	0
Frog	*Uperoleia trachyderma*	LC		0	0	0
Mammal	*Bos taurus*	INT		0	1	0
Mammal	*Canis lupus*	LC		0	1	0
Mammal	*Dasycercus cristicauda*	VU	VU	1	0	1
Mammal	*Lagorchestes conspicillatus*	NT		1	0	0
Mammal	*Leggadina forresti*	LC		0	0	0
Mammal	*Macropus rufus*	LC		0	0	0
Mammal	*Macrotis lagotis*	VU	VU	1	0	1
Mammal	*Notomys alexis*	LC		0	0	0
Mammal	*Oryctolagus cuniculus*	INT		0	0	0
Mammal	*Planigale ingrami*	LC		0	0	0
Mammal	*Pseudomys desertor*	LC		0	0	0
Mammal	*Pseudomys hermannsburgensis*	LC		0	0	0
Mammal	*Rattus villosissimus*	NT		1	0	0
Mammal	*Saccolaimus flaviventris*	LC		0	0	0
Mammal	*Sminthopsis macroura*	LC		0	0	0
Mammal	*Sminthopsis youngsoni*	LC		0	0	0
Reptile	*Antaresia stimsoni*	LC		0	0	0
Reptile	*Aspidites ramsayi*	NT		1	0	0
Reptile	*Carlia munda*	LC		0	0	0
Reptile	*Carlia triacantha*	LC		0	0	0
Reptile	*Cryptoblepharus plagiocephalus*	LC		0	0	0
Reptile	*Ctenophorus isolepis*	LC		0	0	0
Reptile	*Ctenophorus nuchalis*	LC		0	0	0
Reptile	*Ctenotus grandis*	LC		0	0	0
Reptile	*Ctenotus greeri*	LC		0	0	0
Reptile	*Ctenotus helenae*	LC		0	0	0
Reptile	*Ctenotus joanae*	LC		0	0	0
Reptile	*Ctenotus leonhardii*	LC		0	0	0
Reptile	*Ctenotus pantherinus*	LC		0	0	0
Reptile	*Ctenotus robustus*	LC		0	0	0
Reptile	*Delma tincta*	LC		0	0	0
Reptile	*Diplodactylus conspicillatus*	LC		0	0	0
Reptile	*Diplodactylus stenodactylus*	LC		0	0	0
Reptile	*Diplodactylus tessellatus*	LC		0	0	0
Reptile	*Diporiphora lalliae*	LC		0	0	0
Reptile	*Diporiphora winneckei*	LC		0	0	0
Reptile	*Egernia stokesii*	LC		0	0	0
Reptile	*Eremiascincus richardsonii*	LC		0	0	0
Reptile	*Gehyra minuta*	LC		0	0	0
Reptile	*Gehyra montium*	LC		0	0	0
Reptile	*Gehyra variegata*	LC		0	0	0

Group	Species Name	TPWC	EPBC	Significant	Exotic	Threatened
Reptile	*Heteronotia binoei*	LC		0	0	0
Reptile	*Lerista bipes*	LC		0	0	0
Reptile	*Lerista xanthura*	LC		0	0	0
Reptile	*Lophognathus longirostris*	LC		0	0	0
Reptile	*Menetia greyii*	LC		0	0	0
Reptile	*Menetia maini*	LC		0	0	0
Reptile	*Moloch horridus*	LC		0	0	0
Reptile	*Morethia ruficauda*	LC		0	0	0
Reptile	*Oedura marmorata*	LC		0	0	0
Reptile	*Pogona vitticeps*	LC		0	0	0
Reptile	*Proablepharus kinghorni*	LC		0	0	0
Reptile	*Pseudechis australis*	LC		0	0	0
Reptile	*Pseudonaja ingrami*	LC		0	0	0
Reptile	*Pseudonaja modesta*	LC		0	0	0
Reptile	*Pseudonaja nuchalis*	LC		0	0	0
Reptile	*Ramphotyphlops diversus*	LC		0	0	0
Reptile	*Rhynchoedura ornata*	LC		0	0	0
Reptile	*Strophurus ciliaris*	LC		0	0	0
Reptile	*Tiliqua multifasciata*	LC		0	0	0
Reptile	*Tympanocryptis lineata*	LC		0	0	0
Reptile	*Varanus acanthurus*	LC		0	0	0
Reptile	*Varanus gilleni*	LC		0	0	0
Reptile	*Varanus gouldii*	LC		0	0	0
Reptile	*Varanus spenceri*	DD		1	0	0
Reptile	*Varanus tristis*	LC		0	0	0

9.17 Appendix Seventeen: Northern Territory Parks and Wildlife Fauna Atlas (2007) records of conservation significance (Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004) and/or Territory Parks and Wildlife Conservation Act (2000) (TPWC)) within the Wonarah prospect and surrounding region (50km) over Landsat 5 image. The keys to conservation codes and species status are provided in Appendix Eleven and Sixteen respectively.



9.18 Appendix Eighteen: Coordinates for fauna species of conservation significance (as defined by the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004) and Territory Parks and Wildlife Conservation Act (2000) (TPWC) recorded in LES field surveys and Northern Territory Parks and Wildlife Fauna Atlas (2007) records within the Wonarah Phosphate Project area and surrounding 50 km buffer area. A key to conservation codes is provided in Appendix Sixteen.

Group	Long	Lat	Species Name	TPWC	EPBC	Significant	Threatened
Bird	136.42	-19.92	*Ardeotis australis*	VU		1	1
Bird	136.1667	-19.85	*Ardeotis australis*	VU		1	1
Bird	136.45436	-20.00894	*Ardeotis australis*	VU		1	1
Bird	136.47036	-20.0094	*Ardeotis australis*	VU		1	1
Bird	136.50196	-20.00864	*Ardeotis australis*	VU		1	1
Bird	136.33611	-20.11534	*Ardeotis australis*	VU		1	1
Bird	136.36247	-20.09689	*Ardeotis australis*	VU		1	1
Bird	136.7442	-19.765	*Epthianura crocea*	EN\LC	VU\NL	1	1
Bird	136.92	-19.92	*Lophoictinia isura*	NT		1	0
Bird	136.58	-19.92	*Lophoictinia isura*	NT		1	0
Bird	136.7147	-19.7932	*Phaps histrionica*	NT		1	0
Bird	136.7882	-19.7713	*Phaps histrionica*	NT		1	0
Bird	136.7442	-19.765	*Phaps histrionica*	NT		1	0
Bird	136.7199	-19.7896	*Phaps histrionica*	NT		1	0
Frog	136.05	-19.87	*Cyclorana australis*	DD		1	0
Mammal	136.0333	-20.1833	*Dasycercus cristicauda*	VU	VU	1	1
Mammal	136.2167	-20.3667	*Lagorchestes conspicillatus*	NT		1	0
Mammal	136.2167	-20.3667	*Lagorchestes conspicillatus*	NT		1	0
Mammal	136.1746	-20.4223	*Macrotis lagotis*	VU	VU	1	1
Mammal	136.32523	-20.13156	*Macrotis lagotis*	VU	VU	1	1
Mammal	136.67	-20.05	*Rattus villosissimus*	NT		1	0
Mammal	136	-20.1667	*Rattus villosissimus*	NT		1	0
Mammal	136.0333	-20.1833	*Rattus villosissimus*	NT		1	0
Mammal	136	-20.1667	*Rattus villosissimus*	NT		1	0
Mammal	136.0333	-20.1833	*Rattus villosissimus*	NT		1	0
Mammal	136.2167	-20.3667	*Rattus villosissimus*	NT		1	0
Mammal	136.2167	-20.3833	*Rattus villosissimus*	NT		1	0
Mammal	136.35	-20.0833	*Rattus villosissimus*	NT		1	0
Mammal	136.35	-20.1333	*Rattus villosissimus*	NT		1	0
Reptile	136.48	-19.95	*Aspidites ramsayi*	NT		1	0
Reptile	136.7652	-19.7747	*Varanus spenceri*	DD		1	0

Appendix Ninteen: Site Description Summaries: **Survey 1 2008:** Trap Site 1.

Site No.: Trap Site 1	**Survey:** Wonarah Trap Site 1	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 1 (see Appendix Three).

Alluvial Low Lying Sand Plain / open woodland dominated by *Hakea divaricata* with scattered *Acacia* shrubs

Photo References:

Land unit: Alluvial Sand Plain	**Run:** Off	**Topographic position:** Flat
Closest Ecotone- 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 5	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 1 **Species -** Camel
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground** / **Veg Cover**
0 %	0 %	100 % =100%	70 % 30 %

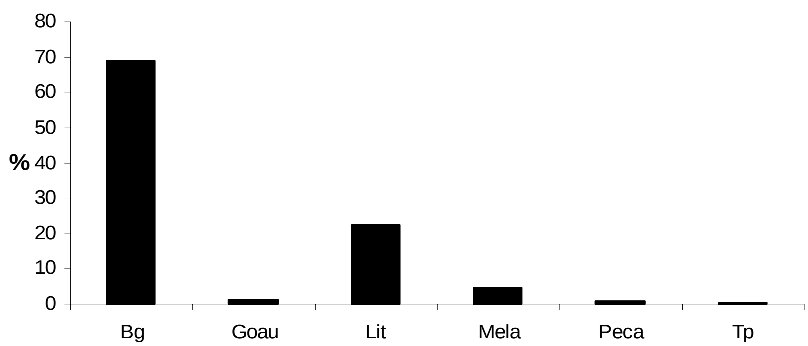
Pebbles (<0.6cm):	0	**Rock Types and Description**
Small stones (0.6-2cm):	0	
Stones (2-6cm):	0	
Small rocks (6-20cm):	0	
Rocks (20-60cm):	0	
Big rocks (60cm-2m):	0	
Boulders (>2m):	0	
Outcrop / slab:	0	

Soil texture: red sand
Soil depth (cm): 10-40
Soil crust, termites, log habitat and vegetation strata structure

Termite mounds (no.): 10	Max. ht. (m): 1	Profile: dome
Number of fallen logs >15cm diameter in the quadrat: 20		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Acacia ancistrocarpa*	5-8	<10
	Carissa lanceolata	5-8	<10
	Corymbia opaca	5-8	<10
	Eucalyptus leucophloia	5-8	<10
	Hakea macrocarpa	5-8	<10
	Melaleuca lasiandra	4	<10
Upper shrub layer:	*Acacia stipuligera*	0.2	10-30
	Eucalyptus leucophloia	1	<10
	Melaleuca lasiandra	2	<10
	Petalostylis cassioides	0.5	10-30
Lower shrub layer:	*Carissa lanceolata*	0.3	<10
	Gossypium australe	0.3	<10
	Melaleuca lasiandra (re-sprouting)	0.4	<10
	Petalostylis cassioides	0.3	<10
Ground layer:	*Triodia pungens*	0.2	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Bg = Bare Ground, Goau = *Gossypium australe,* Lit = Litter, Mela = *Melaleuca lasiandra,* Peca = *Petalostylis cassioides*, and Tp = *Triodia pungens.*



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 11 (5.5 %)

Fauna List	Evidence
Mammals	
Camelus dromedarius (camel)	Tracks
Notomys alexis (spinifex hopping mouse)	Tracks, Trapped (6)
Birds	
Rhipidura leucophrys (willie wagtail)	Observed

Appendix Twenty: Site Description Summaries**: Survey 1 2008:** Trap Site 2

Site No.: Trap Site 2	**Survey:** Wonarah Trap Site 2	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 2 (see Appendix Three).

Deep Sand Plain / open woodland dominated by *Eucalyptus, Atalaya, and Acacia* spp.

Photo References:

Land unit: Deep Sand Plain	**Run:** On	**Topographic position:** Flat
Closest Ecotone- 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 5	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 1 **Species -** Camel
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground**	**Veg Cover**
0 %	0 %	100 % =100%	65 %	35 %

Pebbles (<0.6cm):	0
Small stones (0.6-2cm):	0
Stones (2-6cm):	0
Small rocks (6-20cm):	0
Rocks (20-60cm):	0
Big rocks (60cm-2m):	0
Boulders (>2m):	0
Outcrop / slab:	0

Rock Types and Description

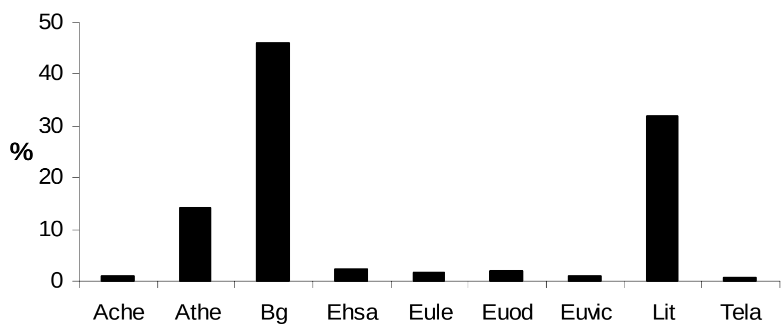
Soil texture: red sand

Soil depth (cm): 10-40

Soil crust, termites, log habitat and vegetation strata structure		
Termite mounds (no.): 3	**Max. ht. (m):** 0.2	**Profile:** dome
Number of fallen logs >15cm diameter in the quadrat: 1		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Atalaya hemiglauca*	6	<10
	Acacia hemignosta	6	<10
	Acacia sericophylla	5-8	<10
	Eucalyptus odontocarpa	5-8	<10
	Eucalyptus victrix	5-8	<10
	Ventilago viminalis	5-8	<10
Upper shrub layer:	*Atalaya hemiglauca* (re- sprouting)	1	<10
	Ehretia saligna	1	<10
Lower shrub layer:	*Eucalyptus leucophloia*	0.5	<10
	Tephrosia lasiochlaena	0.5	<10
Ground layer:	*Aristida contorta*	0.1	<10
	Abutilon otocarpum	0.1	<10
	Astrebla pectinata	0.1	<10
	Gossypium sturtianum	0.1	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Ache = *Acacia hemignosta,* Athe = *Atalaya hemiglauca*, Bg = bare ground, Ehsa = *Ehretia saligna*, Eule = *Eucalyptus leucophloia,* Euod = *Eucalyptus odontocarpa*, Euvic = *Eucalyptus victrix,* Lit = Litter and Tela = *Tephrosia lasiochlaena.*



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 22 (11 %)

Fauna List	Evidence
Mammals	
Camelus dromedarius (camel)	Tracks
Macropus robustus (euro)	Tracks
Notomys alexis (spinifex hopping mouse)	Tracks, Trapped (6)
Pseudomys hermannsburgensis (sandy inland mouse)	Trapped (3)

Site No.: Trap Site 3	**Survey:** Wonarah Trap Site 3	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 3 (see Appendix Three)

Shallow Sand Plain / Calcareous Plain / open scattered woodland dominated by *Atalaya hemiglauca* over *Aristida inaequiglumis* and *Triodia pungens.*

Photo References:

Land unit: Shallow Sand Plain / Calcareous Plain	**Run:** On	**Topographic position:** Flat
Closest Ecotone- 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 1	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 1 **Species -** Camel
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**		**Bare Ground**	**Veg Cover**
5 %	15 %	80 %	=100%	20 %	80 %

Pebbles (<0.6cm):	0	**Rock Types and Description**
Small stones (0.6-2cm):	0	**Siltstone**
Stones (2-6cm):	>90 %	
Small rocks (6-20cm):	0	
Rocks (20-60cm):	0	
Big rocks (60cm-2m):	0	
Boulders (>2m):	0	
Outcrop / slab:	0	

Soil texture: red sand

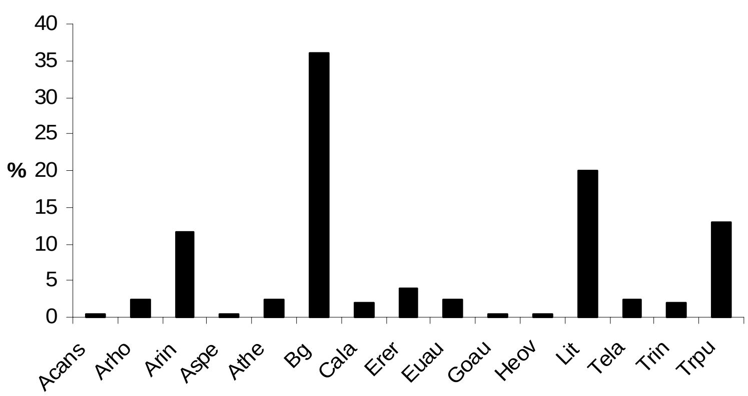
Soil depth (cm): 10-40

Soil crust, termites, log habitat and vegetation strata structure

Termite mounds (no.): 0	**Max. ht. (m):** N/A	**Profile:**
Number of fallen logs >15cm diameter in the quadrat: 4		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Atalaya hemiglauca*	6	<10
Upper shrub layer:	*Atalaya hemiglauca*	1	<10
Lower shrub layer:	*Atalaya hemiglauca*	1	<10
Ground layer:	*Aristida holathera*	0.1	<10
	Aristida inaequiglumis	0.1	<10
	Astrebla pectinata	0.1	10-30
	Triodia pungens	0.1	<10
	Triodia intermedia	0.1	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Acans = *Acacia ancistrocarpa,* Arho = *Aristida holathera,* Arin = *Aristida inaequiglumis,* Aspe = *Astrebla pectinata,* Athe = *Atalaya hemiglauca,* Bg = bare ground, Cala = *Carissa lanceolata,* Erer = *Eragrostis eriopoda,* Euau = *Eulalia aurea,* Goau = *Gossypium australe,* Heov = *Heliotropium ovalifolium,* Lit = Litter, Tela = *Tephrosia lasiochlaena,* Trin = *Triodia intermedia,* Trpu = *Triodia pungens.*



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 16 (11 %)

Fauna List	Evidence
Mammals	
Camelus dromedarius (camel)	Tracks
Canis lupis (dingo)	Tracks
Macropus robustus (euro)	Tracks, Scats
Macropus rufus (red kangaroo)	Tracks
Notomys alexis (spinifex hopping mouse)	Tracks, Trapped (15)
Pseudomys hermannsburgensis (sandy inland mouse)	Trapped (3)
Pseudomys desertor (desert mouse)	Trapped (2)
Sminthopsis crassicaudata (fat tailed dunnart)	Trapped (1)
Reptiles	
Goanna (unknown)	Diggings

Appendix Twenty-two: Site Description Summaries**: Survey 1 2008:** Trap Site 4

Site No.: Trap Site 4	**Survey:** Wonarah Trap Site 4	**Quadrat size:** 200 x 200

Site description & location details: Main Zone – Trap Site 4 (see Appendix Three)

Alluvial Low Lying Sand Plain with minor Deep Sand Plain and Silcrete Rocky Rises dominated by *Acacia stipuligera* and *Grevillea wichkamii* with scattered *Eucalyptus victrix* over *Triodia pungens.*

Photo References:

Land unit: Alluvial Low Lying Sand Plain / Deep Sand Plain / Silcrete Rocky Rise	**Run:** Off	**Topographic position:** Flat
Closest Ecotone- 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 4	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 0 **Species:**
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop: 20 %	**Loose Rock/stones:** 20 %	**Bare soil/sand:** 60 % =100%	**Bare Ground** 40 % **Veg Cover** 60 %

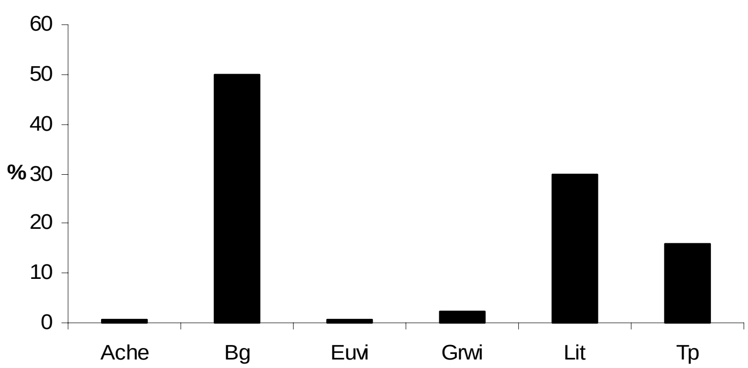
Pebbles (<0.6cm):	50-70 %	**Rock Types and Description**
Small stones (0.6-2cm):	50-70 %	**Siltstone**
Stones (2-6cm):	70-90 %	
Small rocks (6-20cm):	10-20 %	
Rocks (20-60cm):	10-20 %	
Big rocks (60cm-2m):	10-20 %	
Boulders (>2m):	<2 %	
Outcrop / slab:	0 %	

Soil texture: red sand

Soil depth (cm): 10-40		
Soil crust, termites, log habitat and vegetation strata structure		
Termite mounds (no.): 30	**Max. ht. (m):** 1	**Profile:** Dome
Number of fallen logs >15cm diameter in the quadrat: 4		

Strata	**Dominant species**	**Average ht. (m) of strata**	**Cover (%) of strata (% cover classes) <10 10-30 30-70 >70**
Emergent tree layer:	*Atalaya hemiglauca*	6	<10
	Eucalyptus victrix	6	<10
Upper shrub layer:	*Acacia stipuligera*	2	10-30
	Grevillia wichkamii	2	10-30
Lower shrub layer:	*Acacia hemignosta*	0.3	<10
Ground layer:	*Triodia pungens*	0.2	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Ache = *Atalaya hemiglauca,* Bg = bare ground, Euvi = *Eucalyptus victrix,* Grwi = *Grevillea wichkamii,* Lit = Litter, Tp = *Triodia pungens.*



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 33 (16.5 %)

Fauna List	**Evidence**
Mammals	
Canis lupis (dingo)	Tracks
Felis catus (feral cat)	Tracks
Macropus rufus (red kangaroo)	Tracks, Scats
Notomys alexis (spinifex hopping mouse)	Trapped (5)
Vulpes vulpes (fox)	Tracks
Birds	
Ardeotis australis (Australian bustard)	

Site No.: Trap Site 5	**Survey:** Wonarah Trap Site 5	**Quadrat size:** 200 x 200

Site description & location details: Main Zone – Trap Site 5 (see Appendix Three)

Ironstone / Silcrete Rocky Rise with Alluvial Low Lying Sand Plain

Photo References:

Land unit: Alluvial Low Lying Sand Plain / Silcrete Rocky Rise	**Run:** On / Off	**Topographic position:** Flat
Closest Ecotone- 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 5	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 0 **Species:**
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground**	**Veg Cover**
50 %	10 %	40 % =100%	90 %	10 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description**
Small stones (0.6-2cm):	2-10 %	Silcrete Outcrop
Stones (2-6cm):	10-20 %	
Small rocks (6-20cm):	10-20 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

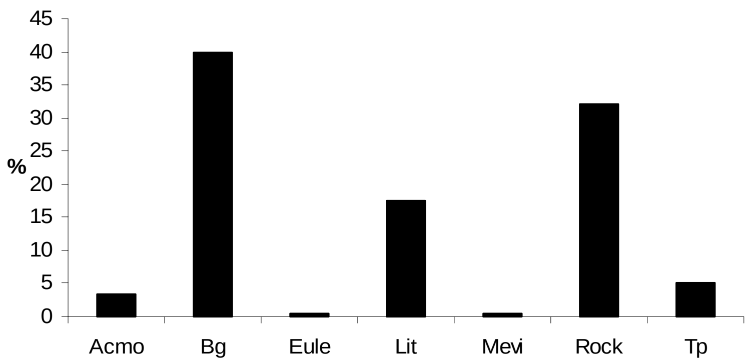
Soil texture: red sand, deep in sand plain

Soil depth (cm): 10-40

Soil crust, termites, log habitat and vegetation strata structure		
Termite mounds (no.): 50	**Max. ht. (m):** 2.5	**Profile:** Dome
Number of fallen logs >15cm diameter in the quadrat: 20		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Acacia monticola* *Hakea macrocarpa*	2 2	<10 <10
Upper shrub layer:	*Acacia monticola*	2	<10
Lower shrub layer:	*Eucalyptus leucophloia* (re-sprouting)	0.3	<10
Ground layer:	*Triodia pungens*	0.1	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Acmo = *Acacia monticola,* Bg = bare ground, Eule = *Eucalyptus leucophloia,* Lit = Litter, Mevi = *Melaleuca viridiflora*, Rock = Rock, Tp = *Triodia pungens.*



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 10 (5 %)

Fauna List	Evidence
Mammals	
Canis lupis (dingo)	Tracks
Notomys alexis (spinifex hopping mouse)	Tracks, Trapped (5)

Site No.: Site 6	**Survey:** Wonarah Site 6	**Quadrat size:** 200 x 200

Site description & location details: End Aruwurra Road – Site 6 (see Appendix Three)

Alluvial Low Lying Sand Plain adjacent to lateritic rise with *Eucalyptus odontocarpa* and *Hakea macrocarpa* over *Grevillea spp*. and *Triodia pungens*

Photo References:

Land unit: Alluvial Low Lying Sand Plain	**Run:** On / Off	**Topographic position:** Flat
Closest Ecotone - 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 3	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 1 **Species:** Camel
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop: 5 %	**Loose Rock/stones:** 0 %	**Bare soil/sand:** 95 % =100%	**Bare Ground** 70 % **Veg Cover** 30 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description**
Small stones (0.6-2cm):	<2 %	Silcrete Outcrop
Stones (2-6cm):	<2 %	
Small rocks (6-20cm):	<2 %	
Rocks (20-60cm):	<2 %	
Big rocks (60cm-2m):	2 - 10 %	
Boulders (>2m):	2 - 10 %	
Outcrop / slab:	2 - 10 %	

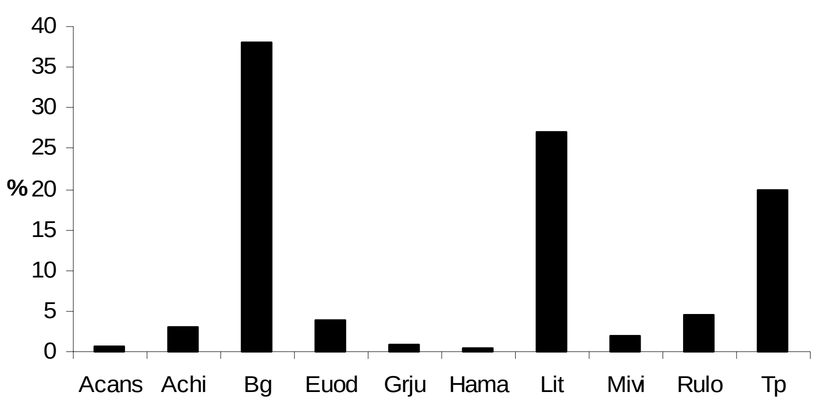
Soil texture: red sand

Soil depth (cm): 10-40

Soil crust, termites, log habitat and vegetation strata structure		
Termite mounds (no.): 0	**Max. ht. (m):** 0	**Profile:**
Number of fallen logs >15cm diameter in the quadrat: 0		

Strata	**Dominant species**	**Average ht. (m) of strata**	**Cover (%) of strata (% cover classes) <10 10-30 30-70 >70**
Emergent tree layer:	*Acacia ancistrocarpa*	2	<10
	Acacia sericophylla	2	<10
	Eucalyptus odontocarpa	2	<10
	Hakea macrocarpa	2	<10
Upper shrub layer:	*Grevillea juncifolia*	2	<10
	Grevillea refracta	2	<10
Lower shrub layer:	*Acacia hilliana*	0.3	<10
	Dodonaea coriacea	0.3	<10
	Scaevola parvifolia	0.3	<10
	Scaevola amblyanthera	0.3	<10
Ground layer:	*Aristida holothera*	0.2	<10
	Triodia pungens	0.1	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Acans = *Acacia ancistrocarpa,* Achi = *Acacia hilliana*, Bg = bare ground, Euod = *Eucalyptus odontocarpa*, Grju = *Grevillea juncifolia*, Hama = *Hakea macrocarpa*, Lit = Litter, Mivi = *Mirbelia viminalis*, Rulo = *Rulingia loxophylla*, Tp = *Triodia pungens*.



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 25 (12.5 %)

Fauna List	**Evidence**
Mammals	
Canis lupis (dingo)	Tracks
Goanna (unknown)	Tracks

Appendix Twenty-five: Site Description Summaries**:** **Survey 1 2008:** Site 7

Site No.: Site 7	**Survey:** Wonarah Site 7	**Quadrat size:** 200 x 200

Site description & location details: Main Prospect – Site 7 (see Appendix Three)

Alluvial Low Lying Sand Plain with minor Deep Sand Plain / Open *Eucalyptus* woodland over *Triodia pungens*

Photo References:

Land unit: Alluvial Low Lying Sand Plain / Deep Sand Plain	**Run:** On	**Topographic position:** Flat
Closest Ecotone- 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 3	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 1 **Species:** Camel
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground**	**Veg Cover**
0 %	0 %	100 % =100%	40 %	60 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description**
Small stones (0.6-2cm):	0 %	
Stones (2-6cm):	0 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

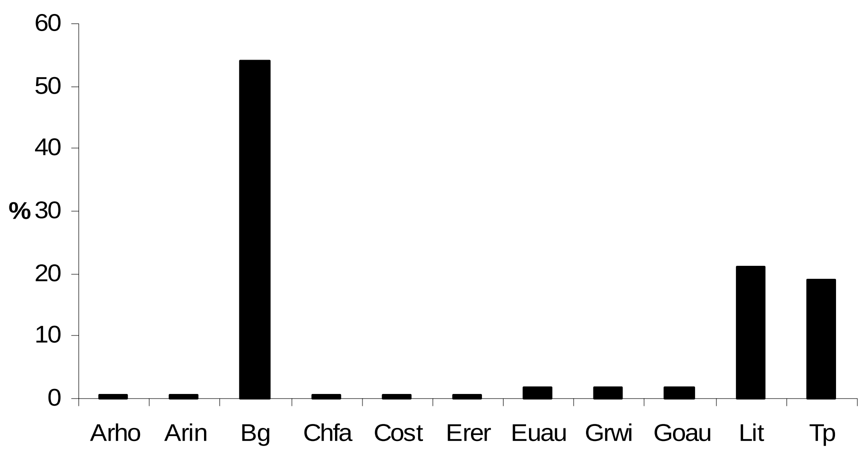
Soil texture: red sand

Soil depth (cm): 10-40

Soil crust, termites, log habitat and vegetation strata structure		
Termite mounds (no.): 50	**Max. ht. (m):** 1	**Profile:** Tower
Number of fallen logs >15cm diameter in the quadrat: 0		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Eucalyptus victrix*	> 5	<10
Upper shrub layer:	*Grevillea wichkamii*	2	<10
Lower shrub layer:	*Eucalyptus victrix* (re-sprouting)	0.2	0.2
Ground layer:	*Eulalia aurea*	0.1	<10
	Triodia pungens	0.1	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Arho = *Aristida holathera*, Arin = *Aristida inaequiglumis*, Bg = bare ground, Chfa = *Chrysopogon fallax*, Cost = *Sclerolaena costata*, Erer = *Eragrostis eriopoda*, Euau = *Eulalia aurea*, Grwi = *Grevillea wichkamii*, Goau = *Gossypium australe*, Lit = Litter, Tp = *Triodia pungens*.



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 25 (12.5 %)

Fauna List	Evidence
Mammals	
Canis lupis (dingo)	Tracks
Goanna sp (unknown)	Tracks
Birds	
Ardeotis australis (Australian bustard)	Tracks

Appendix Twenty-six: Site Description Summaries: Survey 1 2008: Site 8

Site No.: Site 8	**Survey:** Wonarah Site 8	**Quadrat size:** 200 x 200

Site description & location details: Main Prospect – Site 8 (see Appendix Three)

Ironstone Rocky Rise / Deep Sand Plain.

Photo References:

Land unit: Ironstone Rocky Rise / Deep Sand Plain	**Run:** On	**Topographic position:** Flat
Closest Ecotone- 200 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: 0		**Current water:** 0
Climate (1-4): 2 = Dry, no plant stress		

Disturbance type-	
Fire impact (0-5): 4	**Last fire:** This year
Rabbit damage (0-5): 0	**Introduced herbivores (0-5):** 0 **Species:**
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground**	**Veg Cover**
20 %	5 %	75 % =100%	90 %	10 %

Pebbles (<0.6cm):	<2 %	**Rock Types and Description**
Small stones (0.6-2cm):	2-10 %	
Stones (2-6cm):	2-10 %	
Small rocks (6-20cm):	2- %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

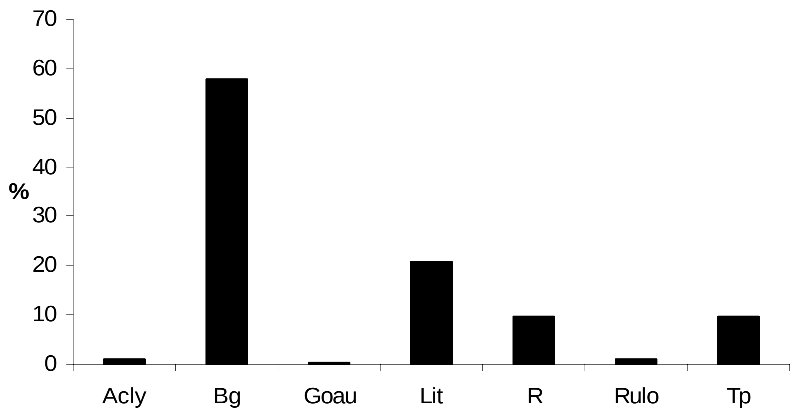
Soil texture: red sand

Soil depth (cm): 10-40

Soil crust, termites, log habitat and vegetation strata structure		
Termite mounds (no.): 50	**Max. ht. (m):** 1	**Profile:** Tower
Number of fallen logs >15cm diameter in the quadrat: 0		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:			
Upper shrub layer:	*Acacia lysiphloia*	2	<10
Lower shrub layer:			
Ground layer:	*Triodia pungens*	0.1	<10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Acly = *Acacia lysiphloia,* Bg = Bare ground, Goau = *Gossypium australe*, Lit = Litter, R = Rock, Rulo = *Rulingia loxophylla*, Tp = *Triodia pungens*.



Number of intervals with more than 1 height class (i.e. multiple vegetation layers) = 10 (5 %)

Fauna List	Evidence
Mammals	
Canis lupis (dingo)	Tracks
Birds	
Ardeotis australis (Australian bustard)	Tracks

Appendix Twenty-seven: Site Description Summaries**: Survey 2 2009:** Trap Site 1

Site No.: Trap Site 1	**Survey:** Wonarah Survey 2 2009: Trap Site 1	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 1.

Shallow Sand Plain with low lying (seasonally wet) areas / Eucalypt open woodland dominated by scattered Coolibah upperstorey, Senna sp. lower shrub layer and dense *Inidgofera colutea* and *Aristida holathera* ground cover.

Photo References:

Land unit: Shallow Sand Plain	**Run:** On	**Topographic position:** Lower Slope
Closest Ecotone: 100 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: >5 km		**Current water:** 0.5 – 5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 1	**Last fire:** Last year
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 1	**Weed Species:** Buffel Grass (*Cenchrus ciliaris*)

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground** / **Veg Cover**
0 %	0 %	100 % =100%	40 % 60 %

Pebbles (<0.6cm): **Small stones (0.6-2cm):** **Stones (2-6cm):** **Small rocks (6-20cm):** **Rocks (20-60cm):** **Big rocks (60cm-2m):** **Boulders (>2m):** **Outcrop / slab:**	0 % 0 % 0 % 0 % 0 % 0 % 0 % 0 %	**Rock Types and Description:**

Soil Classification: Kandosol – KA, AA, AB, E, M, V. Site also borders Vertosols.

Surface: Fine Sand

Depth (m)	Horizon	Texture	pH	Colour
0 – 0.01	A1	Sandy Loam (SL) (A) (F) (K)	5.5	10R3/4
0.01 – 0.05	B2	Sandy Clay Loam (SCL) (M) (E)	5.5	10R3/4
0.05 – 0.40	B21	Sandy Clay Loam (SCL) (M) (E)	5.5	10R4/6

Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure

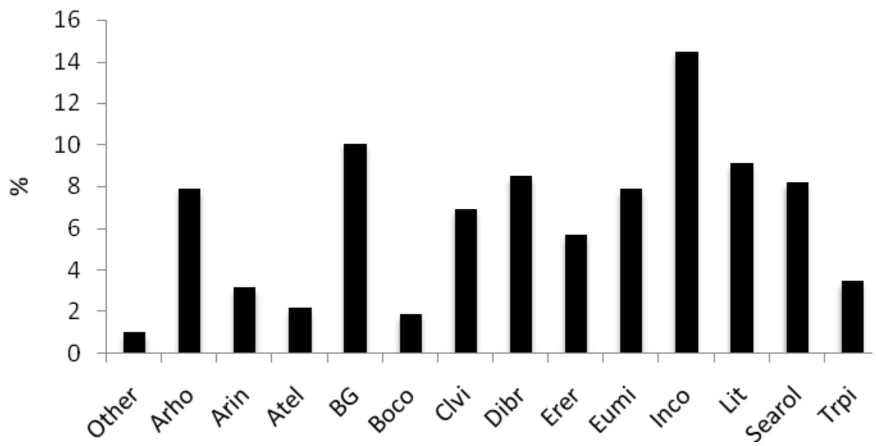
Crust Present: Yes (minor)	**Crust soil cover:** 2%	**Crust Composition:** Biological
Termite mounds (no.): none	**Max. ht. (m):** n/a	**Profile:** n/a

Number of fallen logs >15cm diameter in the quadrat: 3

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Eucalyptus microtheca*	3	< 10
Upper shrub layer:	*Atalaya hemiglauca* *Acacia ancistrocarpa*	1.5 1.5	< 10 < 10
Lower shrub layer:	*Senna artemisioides ssp. oligophylla*	1	< 10

Ground layer:	*Inidgofera colutea*	0.3	10 – 30
	Aristida holathera	0.3	10 – 30
	Digitaria brownii	0.2	< 10
	Cleome viscosa	0.7	< 10
	Eragrostis eriopoda	0.4	< 10
	Aristida inaequiglumis	0.7	< 10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Arho=*Aristida holathera,* Arin=*Aristida inaequiglumis,* Atel=*Atriplex elachophylla,* BG=Bare ground, Boco=*Boerhavia coccinea,* Clvi=*Cleome viscosa,* Dibr=*Digitaria brownii,* Erer=*Eragrostis eriopoda,* Eumi=*Eucalyptus microtheca,* Inco=*Inidgofera colutea,* Lit=Litter, Searol=*Senna artemisioides ssp. oligophylla* and Trpi=*Trianthema pilosa.* **Other** = species < 2 % cover (*Capparis umbonata, Eremophila latrobei, Ptilotus polystachyus, Tephrosia brachyodon, Acacia ancistrocarpa, Carrisa lanceolata, Chrysopogon fallax, Scaevola ovalifolia, Tephrosia benthamii, Dactyloctenium radulans, Eremophila longifolia, Portulaca oleracea, Psydrax latifolia, Enneapogon polyphyllus* and *Indigofera linifolia).*



No. of intervals with > 1 height class (i.e. multiple veg layers) = 98 (49 %); **> 2 height classes =** 20 (10 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 30.

Incidentals (within survey quadrat but not on transect): *Abutilon otocarpum, Atalaya hemiglauca, Cenchrus ciliaris* and *Crotolaria medicaginea.*

Fauna List	**Evidence**
Mammal	
Macropus rufus (Red Kangaroo)	Scats
Onychogalea unguifera (Northern Nailtail Wallaby)	Scats
Sminthopsis youngsoni (Lesser Hairy-footed Dunnart)	Trapped (1)
Reptile	
*Ctenotus leonhardii (*Ctenotus Skink)	Trapped (1)
Eremiascincus richardsonii (Broad-banded Sand-swimmer)	Trapped (1)
Lerista bipes (Two-toed Lerista)	Trapped (2)
Varanus eremius (Pygmy Desert Monitor)	Trapped (1)
*Varanus gilleni (*Pygmy Mulga Monitor)	Trapped (1)
Varanus gouldii (Sand Goanna)	Digs
Birds	
Budgerigar (*Melopsittacus undulatus*)	Sighting
Dove, Diamond (*Geopelia cuneata*)	Sighting
Finch, Zebra(*Taeniopygia guttata*)	Sighting
Pardalote, Red-browed(*Pardalotus rubricatus*)	Call
Triller, White-winged(*Lalage sueurii*)	Sighting
Woodswallow, Blackfaced(*Artamus cinereus*)	Sighting
Woodswallow, Masked(*Artamus personatus*)	Sighting

Appendix Twenty-eight: Site Description Summaries: **Survey 2 2009:** Trap Site 2.

Site No.: Trap Site 2	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 2.

Alluvial Low-lying Sand Plain / Acacia open woodland dominated by scattered Dogwood (*Acacia sericophylla*), occasional Bloodwood and Coolibah emergent trees and dense *Aristida holathera, Yakirra australiensis* and *Whiteochloa airoides* ground cover.

Photo References:

Land unit: Alluvial Low-lying Sand Plain	**Run:** Plain	**Topographic position:** Flat sand plain
Closest Ecotone: 1 km		**Road Type in Vicinity:** Exploration track
Perm. Water: >5 km		**Current water:** >5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 0	**Last fire:** Last year.
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop: 0 %	**Loose Rock/stones:** 0 %	**Bare soil/sand:** 100 % =100%	**Bare Ground** 50 % **Veg Cover** 50 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description:**
Small stones (0.6-2cm):	0 %	
Stones (2-6cm):	0 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	
	0 %	

Soil Classification: Kandosol - KA, AA, AB, A, E, M, X.

Surface: Fine Sand

Depth (m)	Horizon	Texture	pH	Colour
0 – 0.02	A1	Sandy Loam (SL) (A) (F) (K)	6	10R3/4-2/2
0.02 – 0.10	B2	Sandy Clay Loam (SCL) (M)	6	10R4/6
0.10 – 0.40	B21	Sandy Clay Loam (SCL) / Clay Loam (CL) (M) (X)	6	10R4/6


Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure

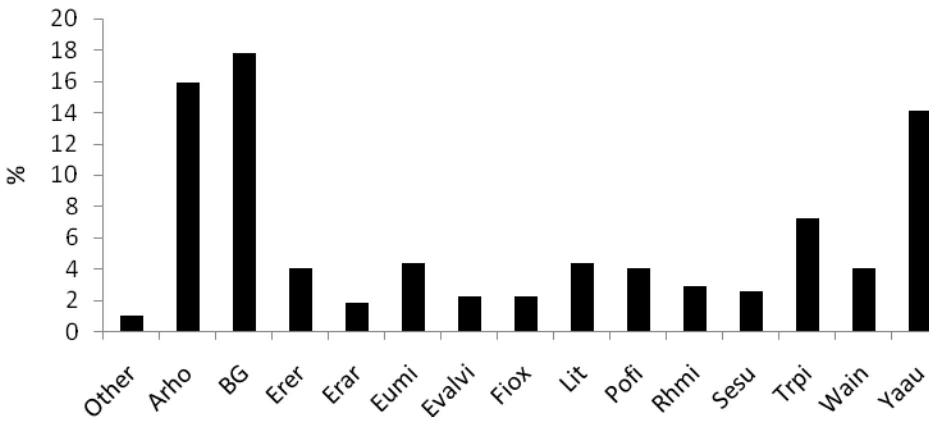
Crust Present: No	**Crust soil cover:** N/A	**Crust Composition:** N/A
Termite mounds (no.): 1	**Max. ht. (m):** 0.2	**Profile:** Dome

Number of fallen logs >15cm diameter in the quadrat: 1

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Eucalyptus microtheca* *Corymbia opaca*	5 4	< 10 < 10
Upper shrub layer:	*Acacia sericophylla* *Capparis umbonata*	3 2	< 10 < 10

Lower shrub layer:	*Acacia sericophylla*	0.7	< 10
	Eucalyptus microtheca	0.7	< 10
	Ehrtia saligna	1	< 10
	Gossypium australe	0.6	< 10
Ground layer:	*Aristida holathera*	0.3	10 – 30
	Yakirra australiensis	0.2	10 – 30
	Whiteochloa airoides	1.2	10 – 30
	Trianthema pilosa	0.3	10 – 30
	Eragrostis eriopoda	0.3	< 10
	Eriachne aristida	0.2	< 10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Arho=*Aristida holathera,* BG=Bare Ground, Erer=*Eragrostis eriopoda,* Erar=*Eriachne aristida,* Eumi=*Eucalyptus microtheca,* Evalvi=*Evolvulus alsinoides var. villosicalyx,* Fiox=*Fimbristylus oxystachya,* Lit=Litter, Pofi=*Portulaca filifolia,* Rhmi=*Rhynchosia minima,* Sesu=*Setaria surgens,* Trpi=*Trianthema pilosa,* Wain=*Waltheria indica* and Yaau=*Yakirra australiensis.* **Other** = species < 2 % cover (*Boerhavia coccinea, Corymbia opaca, Ehretia saligna, Euphorbia comans, Gomphrena lanata, Scaevola parvifolia, Schizachyrium fragile, Trianthema triquetra, Whiteochloa airoides, Acacia sericophylla, Triodia schinzii, Ptilotus polystachyus, Tephrosia benthamii, Melaleuca lasiandra, Spermacoce dolichosperma, Tribulopis angustifolia and Zornia albiflora*).



No. of intervals with > 1 height class (i.e. multiple veg layers) = 64 (32 %); **> 2 height classes =** 10 (5 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 40.

Incidentals (within survey quadrat but not on transect): *Acacia ancistrocarpa, Acacia stipuligera, Capparis umbonata, Carrisa lanceolata, Crotalaria novae-hollandiae, Eragrostis cumingii, Eremophila latrobei, Eriachne mucronata, Fimbristylis ammobia, Gossypium australe* and *Keraudrenia integrifolia.*

Fauna List	Evidence
Mammal	
Felis catus (Feral Cat)	Tracks
Macropus rufus (Red Kangaroo)	Tracks
Mouse (unknown)	Tracks
Reptile	
Goanna (unknown)	Tracks
Varanus gouldii (Sand Goanna)	Trapped (1)
Lerista bipes (Two-toed Lerista)	Trapped (3)
Legless lizard (unknown)	Tracks
Small lizard (unknown)	Tracks
Birds	
Babbler, Grey-crowned (*Pomatostomus temporalis*	Sighting/Call
Budgerigar (*Melopsittacus undulatus*)	Sighting
Bustard, Australian (*Ardeotis australis*)	Tracks
Button-Quail, Little (*Turnix pyrrhothorax*)	Tracks
Chat, Crimson (*Epthianura tricolor*)	Sighting
Finch, Zebra (*Taeniopygia guttata*)	Sighting
Owl, Barn (*Tyto alba*)	Feather
Woodswallow, Blackfaced (*Artamus cinereus*)	Sighting
Woodswallow, Masked (*Artamus personatus*)	Sighting

9.19

Appendix Twenty-nine: Site Description Summaries: Survey 2 2009: Trap Site 3.

Site No.: Trap Site 3	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 3.

Calcrete rise surrounded by Floodplain / Eucalypt open woodland dominated by scattered Coolibah and Bloodwood on floodplain and scattered Supplejack on calcrete rises, over *Aristida holathera, Tribulus eichlerianus* and*Cleome viscosa* grassland ground cover.

Photo References:

Land unit: Calcareous Plain	**Run:** Off	**Topographic position:** Hill / Plain
Closest Ecotone: 100 m		**Road Type in Vicinity:** Exploration Track.
Perm. Water: >5 km		**Current water:** >5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 0	**Last fire:** Last year.
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 1	**Weed Species:** Buffel Grass (*Cenchrus ciliaris*)

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground**	**Veg Cover**
5 %	5 %	90 % =100%	10 %	90 %

Pebbles (<0.6cm): **Small stones (0.6-2cm):** **Stones (2-6cm):** **Small rocks (6-20cm):** **Rocks (20-60cm):** **Big rocks (60cm-2m):** **Boulders (>2m):** **Outcrop / slab:**	2-10 % 2-10 % 2-10 % 2-10 % 0 % 0 % 0 % 0 %	**Rock Types and Description:** Calcrete pedogenic nodules in rises – deep sandy loams.

Soil Classification: Calcarosol - CA, AB, BC, U.

Surface / Comment: Calcrete pedogenic nodules in rises with sandy loams.

Depth (m)	Horizon	Texture	pH	Colour
0 – 0.02	A1	Sandy Clay Loam (SCL) (M)	6.5	10R3/4-46
0.02 – 0.1	B2	Sandy Clay Loam (SCL) (M) (U)	8.5	10R3/4
0.1 – 0.6 +	B21	Sandy Clay Loam (SCL) (M) (U)	9.5	10R3/4

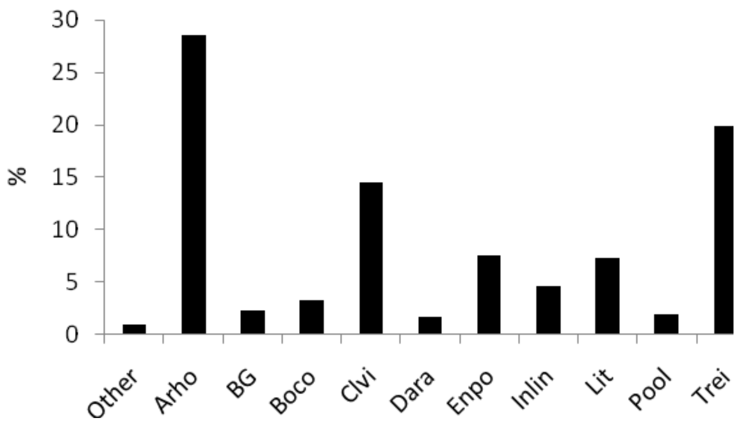
Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure		
Crust Present: Minor	**Crust soil cover:** <1 %	**Crust Composition:** Biological
Termite mounds (no.): 0	**Max. ht. (m):** N/A	**Profile:** N/A
Number of fallen logs >15cm diameter in the quadrat: 2		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Corymbia opaca* *Eucalyptus microtheca* *Ventilago viminalis*	8 8 6	< 10 < 10 < 10
Upper shrub layer:	*Capparis umbonata* *Ventilago viminalis*	2 3	< 10 < 10
Lower shrub layer:	*Gossypium australe* *Corymbia opaca* *Eucalyptus microtheca*	0.8 0.8 0.8	< 10 < 10 < 10

Ground layer:	*Aristida holathera*	0.5	30 – 70
	Tribulus eichlerianus	0.3	30 – 70
	Cleome viscosa	0.7	30 – 70
	Indigofera linifolia	0.2	10 – 30
	Enneapogon polyphyllus	0.4	< 10
	Dactyloctenium radulans	0.2	< 10
	Crotolaria medicaginea	0.3	< 10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Arho=*Aristida holathera,* BG=Bare Ground, Boco=*Boerhavia coccinea,* Clvi=*Cleome viscosa,* Dara=*Dactyloctenium radulans,* Enpo=*Enneapogon polyphyllus,* Inlin=*Indigofera linifolia,* Lit=Litter, Pool=*Portulaca oleracea* and Trei=*Tribulus eichlerianus.* **Other** = species < 2 % cover (*Acacia hemignosta, Eragrostis eriopoda, Portulaca filifolia, Salsola tragus, Corymbia opaca, Crotolaria medicaginea, Eulalia aurea, Gossypium australe* and *Ventilago viminalis.*



No. of intervals with > 1 height class (i.e. multiple veg layers) = 95 (48 %); **> 2 height classes =** 13 (7 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 25

Incidentals (within survey quadrat but not on transect): *Aristida contorta, Atalaya hemiglauca, Capparis umbonata, Cenchrus ciliaris, Eucalyptus microtheca, Cucumis maderaspatanus, Swainsonia sp.* and*Triraphis mollis.*

Fauna List	**Evidence**
Mammal	
Macropus rufus (Red Kangaroo)	Tracks/Scats/Lay-down areas
Reptile	
Goanna (unknown)	Digs
*Ctenotus leonhardii (*Ctenotus Skink)	Trapped (1)
Ctenotus schomburgkii (Ctenotus skink)	Trapped (1)
Birds	
Budgerigar (*Melopsittacus undulatus*)	Sighting
Bustard, Australian (*Ardeotis australis*)	Feather
Button-Quail, Little (*Turnix pyrrhothorax*)	Sighting
Dove, Diamond (*Geopelia cuneata*)	Sighting
Finch, Zebra (*Taeniopygia guttata*)	Sighting
Kite, Black (*Milvus migrans*)	Sighting
Songlark, Brown (*Cincloramphus cruralis*)	Sighting
Triller, White-winged(*Lalage sueurii*)	Sighting
Woodswallow, Blackfaced (*Artamus cinereus*)	Sighting
Woodswallow, Masked (*Artamus personatus*)	Sighting

Appendix Thirty: Site Description Summaries: Survey 2 2009: Trap Site 4.

Site No.: Trap Site 4	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 4.

Shallow Sand Plain below Silcrete Rocky Rise / Acacia and Mallee shrubland with hummock grassland dominated by E*ucalyptus odontocarpa, E. pachyphylla* and *Acacia hilliana* over soft Spinifex.

Photo References:

Land unit: Silcrete Rocky Rise	**Run:** Off	**Topographic position:** Mid Slope.
Closest Ecotone: 0.5 km		**Road Type in Vicinity:** Exploration Track
Perm. Water: >5 km		**Current water:** >5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 4	**Last fire:** Last year.
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground**	**Veg Cover**
0 %	5 %	95 % =100%	70 %	30 %

		Rock Types and Description:
Pebbles (<0.6cm):	0 %	Silcrete alluvial / colluvial wash from ridge to north.
Small stones (0.6-2cm):	2-10 %	
Stones (2-6cm):	< 2 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

Soil Classification: Rudosol – RU, AA, AB, A, E, K, X

Surface / Comment: Fine sand grains minor silcrete rock outcrops

Depth (m)	Horizon	Texture	pH	Colour
0 – 0.002	A1	Sand (S) (A) (E) (K)	6	10R 3/4
0.002 – 0.14	B	Sand (S) (K)	5.8	10R 3/6
0.14 – 0.6 +	B	Loamy Sand (LS) (M) (X)	5.8	10R 3/2

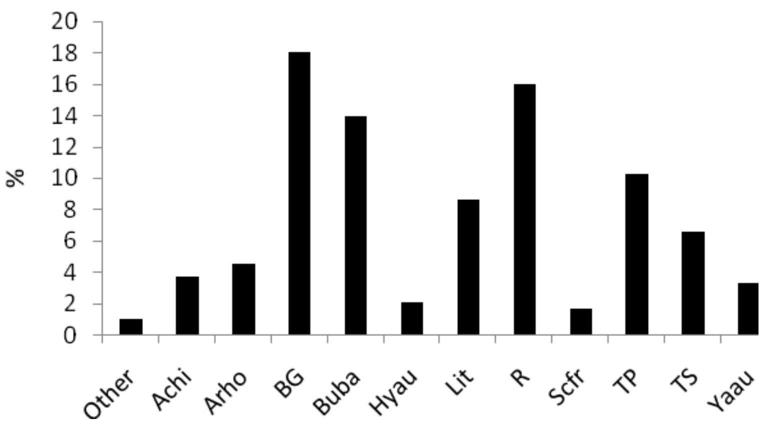
Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure		
Crust Present: Yes	**Crust soil cover:** 10 %	**Crust Composition:** Biological
Termite mounds (no.): > 50	**Max. ht. (m):** 0.8	**Profile:** Tower.
Number of fallen logs >15cm diameter in the quadrat: 0		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Corymbia opaca*	4	< 10
	Hakea lorea	3	< 10
	Eucalyptus setosa	4	< 10
Upper shrub layer:	*Hakea lorea*	2	< 10
	Grevillea refracta	1.5	< 10

Lower shrub layer:	*Acacia hilliana*	0.6	< 10
	Eucalyptus odontocarpa	0.6	< 10
	Eucalyptus pachyphylla	0.6	< 10
	Gossypium australe	0.5	< 10
	Acacia adoxa	0.5	< 10
Ground layer:	*Triodia pungens*	0.3	10 – 30
	Triodia schinzii	0.3	10 – 30
	Aristida holathera	0.3	10 – 30
	Yakirra australiensis	0.2	10 – 30
	Bulbostylis barbata	0.1	10 – 30
	Hybanthus aurantiacus	0.3	< 10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Achi=*Acacia hilliana,* Arho=*Aristida holathera,* BG=Bare Ground, Buba=*Bulbostylis barbata,* Hyau=*Hybanthus aurantiacus,* Lit=Litter, R=Rock, Scfr=*Schizachyrium fragile,* TP=*Triodia pungens,* TS=*Triodia schinzii* and Yaau=*Yakirra australiensis.* **Other** = species < 2 % (*Amphipogon caricinus, Eucalyptus odontocarpa, Eucalyptus pachyphylla, Corymbia setosa, Fimbristylis simulans, Goodenia armitiana, Grevillea refracta, Petalostylis cassioides, Polycarpaea spirostylis, Ptilotus calostachyus, Ptilotus polystachyus, Spermacoce dolichosperma, Goodenia ramelii, Gossypium australe, Paraneurachne muelleri, Ptilotus fusiformis, Urochloa sp., Acacia adoxa* and *Setaria surgens*).



No. of intervals with > 1 height class (i.e. multiple veg layers) = 42 (21 %); **> 2 height classes =** 1 (0.5 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 34.

Incidentals (within survey quadrat but not on transect): *Brunonia australis, Cassytha capillaries, Corchorus sidoides, Corymbia opaca, Eragrostis cumingii, Eucalyptus setosa, Hakea lorea* and *Sida filiformis.*

Fauna List	Evidence
Mammal	
Mouse (unknown)	Tracks
Reptile	
Ctenophorus isolepis (Military Dragon)	Trapped (2)
Diplodactylus conspicillatus (Fat-tailed Gecko)	Trapped (1)
Gecko (unknown)	Tracks
Legless lizard (unknown)	Tracks
Lerista bipes (Two-toed Lerista)	Trapped (5)
Small lizard (unknown)	Trapped (1)
Strophurus ciliaris (Spiny-tailed Gecko)	Tracks
Varanus gouldii (Sand Goanna)	Diggings / Holes
Birds	
Budgerigar (*Melopsittacus undulatus*)	Sightings
Button-Quail, Little (*Turnix pyrrhothorax*)	Tracks
Chat, Crimson (*Epthianura tricolor*)	Sightings
Dove, Diamond (*Geopelia cuneata*)	Sightings
Finch, Zebra(*Taeniopygia guttata*)	Sightings
Woodswallow, Masked *(Artamus personatus*)	Sightings

Appendix Thirty-one: Site Description Summaries: Survey 2 2009: Trap Site 5.

Site No.: Trap Site 5	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 5 .

Alluvial Low-lying Sand Plain / open Eucalypt woodland with hummock grassland dominated by Coolibah and Bloodwood upper-storey over Spinifex ground-cover.

Photo References:

Land unit: Alluvial Low-lying Sand Plain	**Run:** Plain	**Topographic position:** Lower Slope Floodpalin
Closest Ecotone: 0.5 km		**Road Type in Vicinity:** Exploration track
Perm. Water: >5 km		**Current water:** >5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 4	**Last fire:** Last year.
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground** / **Veg Cover**
0 %	0 %	100 % =100%	70 % / 30 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description:** Aeolian sand grains to 2 mm. Mostly fine sands with iron staining.
Small stones (0.6-2cm):	0 %	
Stones (2-6cm):	0 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

Soil Classification: Rudosol – RU, AA, AB, A, E, K, W

Surface / Comment: Fine sand grains minor outcrops

Depth (m)	Horizon	Texture	pH	Colour
0 – 0.002	A	Sand (S) (A) (E)	5.7	10R 5/4
0.002 – 0.05	B	Sand (S) (K)	5.75	10R 3/4
0.05 – 0.22	B	Sand (S) (K)	5.75	10R 3/4
0.22 – 0.6	B	Sand (S) (K)	5.75	10R 4/6- 3/4


Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure

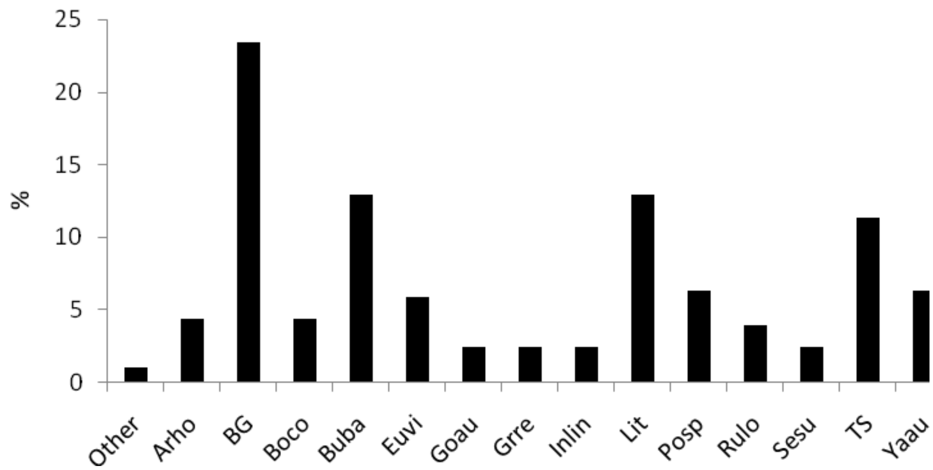
Crust Present: Yes	**Crust soil cover:** 5 %	**Crust Composition:** Biological
Termite mounds (no.): 30	**Max. ht. (m):** 1	**Profile:** Tower & Dome.

Number of fallen logs >15cm diameter in the quadrat: 0

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Eucalyptus victrix*	15	< 10
	Hakea macrocarpa	5	< 10
Upper shrub layer:	*Eucalyptus odontocarpa*	1.5	< 10
	Grevillea refracta	1.5	< 10
Lower shrub layer:	*Gossypium australe*	1	< 10

Ground layer:	*Triodia schinzii*	0.3	10 – 30
	Bulbostylis barbata	0.1	10 – 30
	Aristida holathera	0.3	10 – 30
	Rulingia loxophylla	0.3	10 – 30
	Boerhavia coccinea	0.2	10 – 30
	Yakirra australiensis	0.2	10 – 30
	Indigofera linifolia	0.3	10 - 30

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Arho=*Aristida holathera,* BG=Bare Ground, Boco=*Boerhavia coccinea,* Buba=*Bulbostylis barbata,* Euvi=*Eucalyptus victrix,* Goau=*Gossypium australe,* Grre=*Grevillea refracta,* Inlin=*Indigofera linifolia,* Lit=Litter, Posp=*Polycarpaea spirostylis,* Rulo=*Rulingia loxophylla,* Sesu=*Setaria surgens,* TS=*Triodia schinzii* and Yaau=*Yakirra australiensis.* **Other** = species < 2 % (*Aristida inaequiglumis, Cleome viscosa, Eulalia aurea, Ptilotus fusiformis, Sebastiana chamaelea* and *Eragrostis eriopoda*).



No. of intervals with > 1 height class (i.e. multiple veg layers) = 58 (29 %); **> 2 height classes =** 8 (4 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 29.

Incidentals (within survey quadrat but not on transect): *Clerodendrum floribundum, Crotalaria novae-hollandiae, Eucalyptus odontocarpa, Euphorbia tannensis, Fimbristylis oxystachya, Grevillea wickhamii, Hakea macrocarpa, Heliotropium glanduliferum, Paraneurachne muelleri* and *Spermacoce dolichosperma.*

Fauna List	**Evidence**
Mammal	
Mouse (unknown)	Tracks
Notomys alexis (Spinifex Hopping Mouse)	Tracks
Sminthopsis youngsoni (Lesser Hairy-footed Dunnart)	Trapped (1)
Reptile	
Ctenophorus isolepis (Military Dragon)	Trapped (1)
*Ctenotus leonhardii (*Ctenotus Skink)	Sighted (1)
Diplodactylus conspicillatus (Fat-tailed Gecko)	Trapped (1)
Gehyra variegata (Variegated Gecko)	Trapped (1)
Small lizard (unknown)	Tracks
Snake (unknown)	Tracks
Varanus gouldii (Sand Goanna)	Tracks
Birds	
Budgerigar (*Melopsittacus undulatus*)	Sightings
Cockatiel (*Nymphicus hollandicus*)	Sightings
Galah (*Cacatua roseicapilla*)	Sightings
Hobby, Australian (*Falco longipennis*)	Sightings
Kite, Black (*Milvus migrans*)	Sightings
Kite, Whistling (*Haliastur sphenurus*)	Sightings
Magpie, Black-backed (*Gymnorhina tibicen*)	Sightings
Miner, Yellow-throated (*Manorina flavigula*)	Sightings
Wagtail, Willie (*Rhipidura leucophrys*)	Sightings

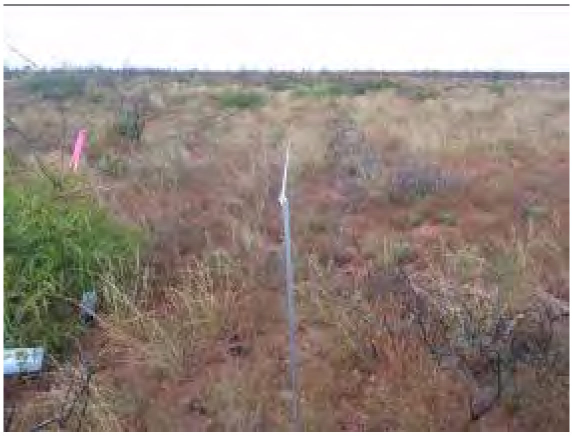
Appendix Thirty-two: Site Description Summaries: Survey 2 2009: Trap Site 6.

Site No.: Trap Site 6	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 6 (same as Site TS5 2008 survey)

Ironstone Rocky Rise surrounded by drainage depression / Acacia and Mallee shrubland dominated by *A. stipuligera, A. hilliana* and *Eucalyptus odontocarpa* over sedges and perennial grasses.

Photo References:



Land unit: Ironstone Rocky Rise	**Run:** Off	**Topographic position:** Slope (Upper & Lower)
Closest Ecotone: 100m		**Road Type in Vicinity:** Exploration Track
Perm. Water: >5 km		**Current water:** >5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 2	**Last fire:** Last year
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground** / **Veg Cover**
10 %	10 %	80 % =100%	30 % 60 %
			Rock Types and Description: Silcrete

Pebbles (<0.6cm):	0 %	**Rock Types and Description:**
Small stones (0.6-2cm):	0 %	Silcrete
Stones (2-6cm):	0 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	
	0 %	

Soil Classification: Rudosol – RU, AA, AB, A, E, K, U

Surface / Comment: Fine sand grains minor silcrete outcrops

Depth (m)	Horizon	Texture	pH	Colour
0 – 0.005	A	Sand (S) (A) (E)	5.75	10R 3/4
0.005 – 0.1	B	Sand (S) (K)	5.75	10Y 4/6
0.1 – 0.16	B	Sand (S) (K)	5.75	10R 3/4 - 4/6
0.16 – 0.6	B	Sand (S) (K)	5.75	10R 3/4 - 4/6

Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure

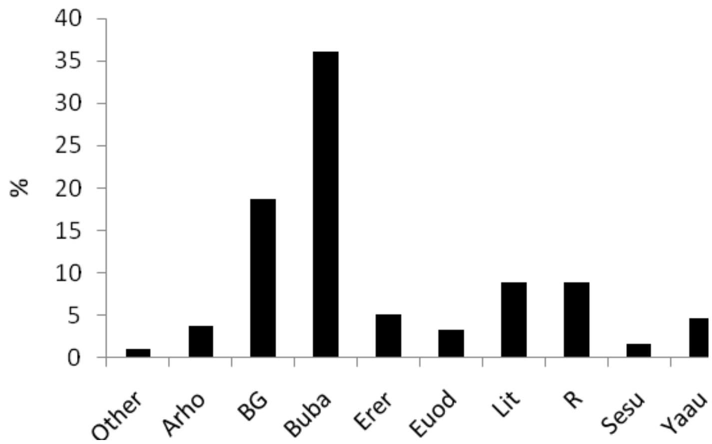
Crust Present: No	**Crust soil cover:** N/A	**Crust Composition:** N/A
Termite mounds (no.): In sand plain outside of quadrat	**Max. ht. (m):** 2	**Profile:** Tower

Number of fallen logs >15cm diameter in the quadrat: 0

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	None	-	-
Upper shrub layer:	Litter (Dead *Acacia stipuligera*)	2	< 10
Lower shrub layer:	*Eucalyptus odontocarpa* Litter (Dead *Acacia hilliana*)	1 0.7	< 10 < 10

Ground layer:	*Bulbostylis barbata*	0.2	30 – 70
	Eragrostis eriopoda	0.3	10 – 30
	Yakirra australiensis	0.1	10 – 30
	Aristida holathera	0.3	10 – 30
	Grevillea wickhamii	0.1	< 10
	Grevillea refracta	0.1	< 10
	Schizachyrium fragile	0.1	< 10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Arho=*Aristida holathera,* BG=Bare Ground, Buba=*Bulbostylis barbata,* Erer=*Eragrostis eriopoda,* Euod=*Eucalyptus odontocarpa,* Lit=Litter, R=Rock, Sesu=*Setaria surgens* and Yaau=*Yakirra australiensis.* **Other** = species < 2 % cover (*Acacia adoxa, Acacia stipuligera, Cucumis maderaspatanus, Goodenia ramelii, Gossypium australe, Hybanthus aurantiacus, Indigofera linifolia, Rulingia loxophylla, Schizachyrium fragile, Sida arenicola, Urochloa sp., Eragrostis cumingii, Euphorbia comans, Grevillea refracta, Grevillea wickhamii* and *Heliotropium glanduliferum*).



No. of intervals with > 1 height class (i.e. multiple veg layers) = 52 (26 %); **> 2 height classes =** 4 (2 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 37.

Incidentals (within survey quadrat but not on transect): *Cleome viscosa, Corchorus sidoides, Dicrastylis gilesii, Heliotropium pulvinum, Ipomoea costata, Keraudrenia integrifolia, Cucumis maderaspatana, Portulaca filifolia, Portulaca oleracea, Ptilotus fusiformis, Senna notables, Sida fibulifera, Sida filiformis* and *Spermacoce dolichosperma.*

Fauna List	Evidence
Mammal	
Felis catus (Feral Cat)	Tracks
Mouse (unknown)	Tracks
Notomys alexis (Spinifex Hopping Mouse)	Tracks
Tachyglossus aculeatus (Short-beaked Echidna)	Digs
Reptile	
Ctenophorus isolepis (Military Dragon)	Trapped (1)
*Diporiphora lalliae (*Dragon)	Trapped (1)
Legless lizard (unknown)	Tracks
Small lizard (unknown)	Tracks
Snake (unknown)	Tracks
Varanus gouldii (Sand Goanna)	Trapped (3), Tracks
Birds	
Bellbird, Crested (*Oreoica gutturalis*)	Sightings
Budgerigar (*Melopsittacus undulatus*)	Sightings
Button-Quail, Little (*Turnix pyrrhothorax*)	Sightings
Chat, Crimson (*Epthianura tricolor*)	Sightings
Dove, Diamond (*Geopelia cuneata*)	Sightings
Fairy-wren, Variegated (*Malurus lamberti*)	Sightings
Finch, Zebra(*Taeniopygia guttata*)	Sightings
Honeyeater, Grey headed (*Lichenostomus keartlandii*)	Sightings
Honeyeater, Spiny-cheeked (*Acanthagenys rufogularis*)	Sightings
Kite, Black (*Milvus migrans*)	Sightings
Woodswallow, Blackfaced *(Artamus cinereus*)	Sightings
Woodswallow, Masked *(Artamus personatus*)	Sightings

Appendix Thirty-three: Site Description Summaries: Survey 2 2009: Trap Site 7.

Site No.: Trap Site 7	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** 200 x 200

Site description & location details: Arruwurra Prospect – Trap Site 7

Deep Sand Plain / open Eucalyptus woodland over hummock grassland dominated by *Eucalyptus victrix, E. pachyphylla* and *Acacia sericophylla* over soft Spinifex.

Photo References:

Land unit: Deep Sand Plain	**Run:** Plain	**Topographic position:** Bottom
Closest Ecotone: > 5 km		**Road Type in Vicinity:** Exploration Track
Perm. Water: >5 km		**Current water:** >5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 4	**Last fire:** Last year
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground**	**Veg Cover**
0 %	0 %	100 % =100%	80 %	20 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description:**
Small stones (0.6-2cm):	0 %	
Stones (2-6cm):	0 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

Soil Classification: Kandosol - KA, AA, AB, A, E, K, X.

Surface / Comment: Fine aeolian sand

Depth (m)	Horizon	Texture	pH	Colour
0 - 0.002	A1	Sand (S) (A) (E) (K)	6	10R 3/2
0.002 – 0.05	B2	Sand (S) (K)	5.8	10R 3/2
0.05 – 0.12	B21	Sand (S) (K)	6	10R 3/3
0.12 – 0.6	B21	Sand (S) (K) (X)	6	10R 3/6.

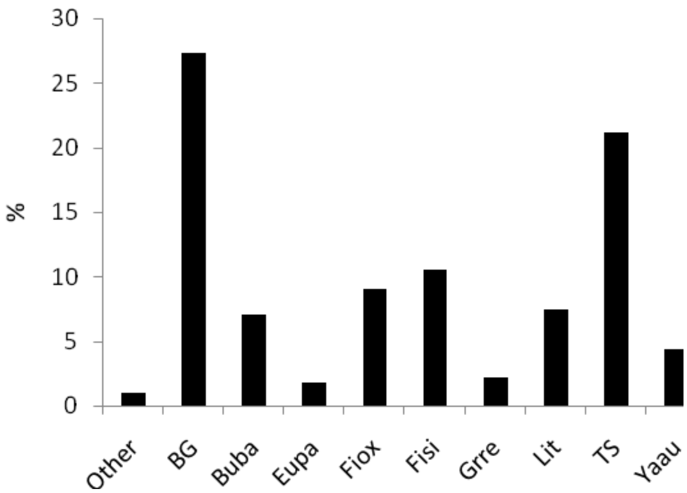

Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure		
Crust Present: Yes	**Crust soil cover:** 10 %	**Crust Composition:** Biological
Termite mounds (no.): 5	**Max. ht. (m):** 0.5	**Profile:** Dome
Number of fallen logs >15cm diameter in the quadrat: 5		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Acacia sericophylla* *Eucalyptus victrix*	4 5	< 10 < 10
Upper shrub layer:	*Grevillea refracta*	2	< 10
Lower shrub layer:	*Eucalyptus pachyphylla*	1	< 10

Ground layer:	*Triodia schinzii*	0.2	10 – 30
	Fimbristylis simulans	0.2	10 – 30
	Fimbristylis oxystachya	0.2	10 – 30
	Bulbostylis barbata	0.1	< 10
	Senna notablis	0.3	< 10
	Yakirra australiensis	0.2	< 10
	Paraneurachne muelleri	0.3	< 10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: BG=Bare Ground, Buba=*Bulbostylis barbata,* Eupa=*Eucalyptus pachyphylla,* Fiox = *Fimbristylis oxystachya,* Fisi=*Fimbristylis simulans,* Grre=*Grevillea refracta,* Lit=Litter, TS=*Triodia schinzii* and Yaau=*Yakirra australiensis.* **Other** = species < 2 % cover (*Amphipogon caricinus, Eragrostis eriopoda, Paraneurachne muelleri, Scaevola parvifolia, Schizachyrium fragile, Spermacoce dolichosperma, Urochloa sp., Acacia sericophylla, Aristida holathera, Setaria surgens, Stackhousia 'Mt Leibig', Polycarpaea spirostylis* and *Tribulopis angustifolia*).



No. of intervals with > 1 height class (i.e. multiple veg layers) = 28 (14 %); **> 2 height classes =** 1 (0.5 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 27.

Incidentals (within survey quadrat but not on transect): *Gossypium australe, Heliotropium glanduliferum, Ptilotus fusiformis, Ptilotus polystachyus, Senna notables* and *Ventilago viminalis.*

Fauna List	Evidence
Mammal	
Felis catus (Feral Cat)	Tracks
Macropus rufus (Red Kangaroo)	Tracks
Mouse (unknown)	Tracks
Notomys alexis (Spinifex Hopping Mouse)	Tracks
Sminthopsis youngsoni (Lesser Hairy-footed Dunnart)	Trapped (1)
Reptile	
Ctenophorus isolepis (Military Dragon)	Trapped (2)
*Ctenotus leonhardii (*Ctenotus Skink)	Trapped (1)
Diplodactylus conspicillatus (Fat-tailed Gecko)	Trapped (1)
*Varanus gilleni (*Pygmy Mulga Monitor)	Trapped (1)
Varanus gouldii (Sand Goanna)	Tracks
Legless lizard (unknown)	Tracks
Small lizard (unknown)	Tracks
Snake (unknown)	Tracks
Birds	
Bellbird, Crested (*Oreoica gutturalis*)	Sightings
Budgerigar (*Melopsittacus undulatus*)	Sightings
Button-Quail, Little (*Turnix pyrrhothorax*)	Sightings
Chat, Crimson (*Epthianura tricolor*)	Sightings
Dove, Diamond (*Geopelia cuneata*)	Sightings
Finch, Zebra (*Taeniopygia guttata*)	Sightings
Honeyeater, Grey headed (*Lichenostomus keartlandii*)	Sightings
Honeyeater, Singing (*Lichenostomus virescens*)	Sightings
Jacky Winter (*Microeca fascinans*)	Sightings
Kingfisher, Sacred (*Todiramphus sanctus*)	Sightings
Kite, Black (*Milvus migrans*)	Sightings
Pardalote, Red-browed (*Pardalotus rubricatus*)	Sightings
Triller, White-winged *(Lalage sueurii*)	Sightings
Woodswallow, Masked *(Artamus personatus*)	Sightings

Appendix Thirty-four: Site Description Summaries: Survey 2 2009: Trap Site 8.

Site No.: Trap Site 8	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** 200 x 200

Site description & location details: Aruwurra Prospect – Trap Site 8.

Deep Sand Plain / Eucalypt and Acacia low open woodland over hummock grassland with *Melaleuca lasiandra* in drainages, dominated by *Acacia sericophylla, A. stipuligera* and *Triodia schinzii* and *Aristida holathera* groundcover.

Photo References:

Land unit: Deep Sand Plain	**Run:** Plain	**Topographic position:** Flat Plain
Closest Ecotone: 100 m		**Road Type in Vicinity:** Exploration Track
Perm. Water: >5 km		**Current water:** >5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:

0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 3	**Last fire:** Last year.
Rabbit damage: 0	**Introduced herbivores :** 0 **Species:** N/A
Weeds (0-5): 0	**Weed Species:** N/A

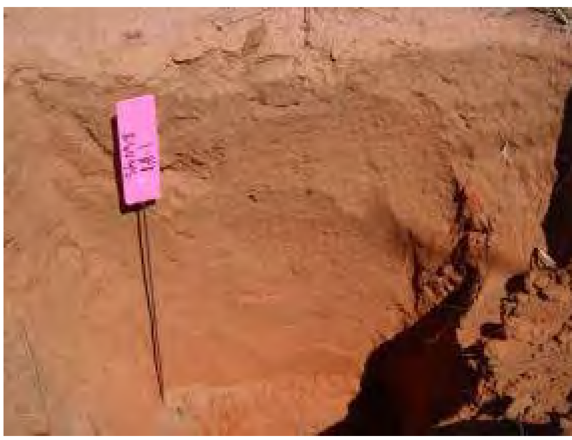
Outcrop:	**Loose Rock/stones:**	**Bare soil/sand:**	**Bare Ground** / **Veg Cover**
0 %	0 %	100 % =100%	80 % / 20 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description:**
Small stones (0.6-2cm):	0 %	Deep sands.
Stones (2-6cm):	0 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

Soil Classification: Kandosol - KA, AA, AB, A, E, K, X.

Surface / Comment: Fine aeolian sand

Depth (m)	Horizon	Texture	pH	Colour
0 – 0.002	A1	Clayey Sand (CS)	5.5	10R 2/4
0.002 – 0.12	B2	Sand (S)	5.8	10R 3/4
0.12 – 0.6+	B21	Sand (S)	5.5	10R 4/6



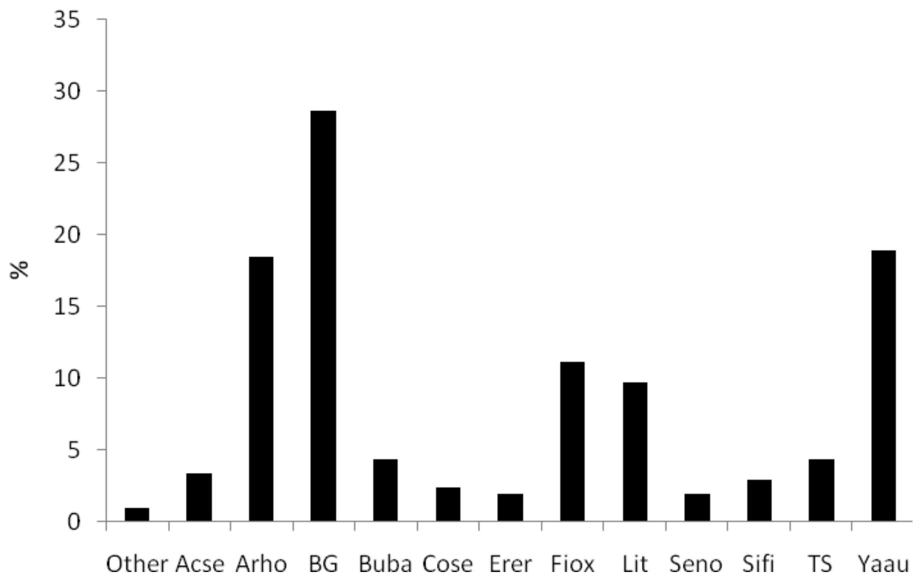
Soil depth (cm): > 40

Soil crust, termites, log habitat and vegetation strata structure		
Crust Present: Yes	**Crust soil cover:** 10 %	**Crust Composition:** Biological / Pedological **Comment:** Clay cryptogam.
Termite mounds (no.): 0	**Max. ht. (m):** N/A	**Profile:** N/A
Number of fallen logs >15cm diameter in the quadrat: 5		

Strata	Dominant species	Average ht. (m) of strata	Cover (%) of strata (% cover classes) <10 10-30 30-70 >70
Emergent tree layer:	*Acacia sericophylla* *Eucalyptus setosa*	4 3	< 10 < 10
Upper shrub layer:	*Acacia stipuligera* *Melaleuca lasiandra*	2 2	< 10 < 10
Lower shrub layer:	*Gossypium australe*	1	< 10

Ground layer:	*Triodia schinzii*	0.3	10 – 30
	Yakirra australiensis	0.2	10 – 30
	Aristida holathera	0.3	10 – 30
	Sida filiformis	0.2	< 10
	Bulbostylis barbata	0.1	< 10
	Eragrostis eriopoda	0.3	< 10

Percentage Ground Cover (counts at 1 m intervals over 200 m transect). Where: Acse =*Acacia sericophylla,* Arho=*Aristida holathera,* BG=Bare Ground, Buba=*Bulbostylis barbata,* Erer=*Eragrostis eriopoda,* Cose=*Corymbia setosa,* Fiox=*Fimbristylis oxystachya,* Lit=Litter, Seno=*Senna notabilis,* Sifi=*Sida filiformis,* TS=*Triodia schinzii* and Yaau=*Yakirra australiensis.* **Other** = species < 2 % cover (*Schizachyrium fragile, Tephrosia* sp Barrow Creek , *Trichodesma zeylanicum, Amphipogon caricinus, Eriachne aristidea, Evolvulus alsinoides var. decumbens, Melaleuca lasiandra, Urochloa sp., Eucalyptus odontocarpa, Setaria surgens* and *Triumfetta centralis.*



No. of intervals with > 1 height class (i.e. multiple veg layers) = 47 (24 %); **> 2 height classes =** 1 (0.5 %); **> 3 height classes =** 0.

Species Richness (total species) including incidental species = 27.

Incidentals (within survey quadrat but not on transect): *Acacia stipuligera, Corchorus sidoides, Gossypium australe, Heliotropium glanduliferum, Ptilotus fusiformis* and *Spermacoce dolichosperma.*

Fauna List	Evidence
Mammal	
Dunnart (unknown)	Tracks
Macropus rufus (Red Kangaroo)	Tracks / Scats
Notomys alexis (Spinifex Hopping Mouse)	Tracks
Reptile	
*Ctenotus leonhardii (*Ctenotus Skink)	Trapped (2)
Legless lizard (unknown)	Tracks
Lerista bipes (Two-toed Lerista)	Trapped (1)
Small lizard (unknown)	Tracks
Snake (unknown)	Tracks
Varanus gouldii (Sand Goanna)	Tracks / Hole
Birds	
Bellbird, Crested (*Oreoica gutturalis*)	Sightings
Budgerigar (*Melopsittacus undulatus*)	Sightings
Button-Quail, Little (*Turnix pyrrhothorax*)	Sightings / Tracks
Chat, Crimson (*Epthianura tricolor*)	Sightings
Dove, Diamond (*Geopelia cuneata*)	Sightings
Finch, Zebra (*Taeniopygia guttata*)	Sightings
Honeyeater, Grey headed (*Lichenostomus keartlandii*)	Sightings
Honeyeater, Singing (*Lichenostomus virescens*)	Sightings
Wedgebill, Chiming (*Psophodes occidentalis*)	Sightings
Woodswallow, Masked *(Artamus personatus*)	Sightings

Appendix Thirty-five: Site Description Summaries: Survey 2 2009: Ephemeral Lake.

Site No.: 9 - Ephemeral Lake	**Survey:** Wonarah Survey 2 2009	**Quadrat size:** Drive over

Site description & location details: Ephemeral lake within CLC exclusion zone. *E. microtheca* (Coolibah) low-open woodland with low grassland and clay depressions with sedges.
(Visit supervised by Traditional Owners with prior agreement from CLC).

Photo References:

Land unit: Ephemeral Lake	**Run:** On	**Topographic position:** Bottom slope
Closest Ecotone: 300m		**Road Type in Vicinity:** None
Perm. Water: >5km		**Current water:** 0.5 – 5 km
Climate (1-4): 4 = Recent rain, noticeable vegetation response.		

Disturbance:
0 = no visible impact
1 = disturbance present but negligible impact
2 = low level of disturbance throughout quadrat, *or* moderate level in patches in the quadrat
3 = moderate level of disturbance throughout quadrat, *or* high level in patches in the quadrat
4 = high level of disturbance throughout quadrat, *or* major level in patches in the quadrat
5 = major impact affecting all of quadrat

Disturbance type-

Fire impact: 0	**Last fire:** Long unburnt

Rabbit damage: None	**Introduced herbivores :** none **Species:** N/A
Weeds (0-5): 0	**Weed Species:** N/A

Outcrop: 0 %	**Loose Rock/stones:** 20 %	**Bare soil/sand:** 80- % =100%	**Bare Ground** 60 % **Veg Cover** 40 %

Pebbles (<0.6cm):	0 %	**Rock Types and Description:** Colluvial & alluvial silcrete stone outwash from adjacent hills.
Small stones (0.6-2cm):	50 - 70 %	
Stones (2-6cm):	2-10 %	
Small rocks (6-20cm):	0 %	
Rocks (20-60cm):	0 %	
Big rocks (60cm-2m):	0 %	
Boulders (>2m):	0 %	
Outcrop / slab:	0 %	

Soil texture:		
Soil depth (cm): 10-40		
Soil crust, termites, log habitat and vegetation strata structure		
Termite mounds (no.): 0	**Max. ht. (m):** N/A	**Profile: N/A**
Number of fallen logs >15cm diameter in the quadrat: 3		

Strata	Flora species list		
Emergent tree layer:	*Eucalyptus victrix*		
Upper shrub layer:	*Capparis umbonata* *Psydrax latifolia*		
Lower shrub layer:	*Eremophila latrobei* *Eremophila longifolia*		
Ground layer:	*Aeschynomene indica* *Ammannia multiflora* *Aristida contorta* *Aristida holathera* *Aristida inaequiglumis* *Bergia barklyana* *Cleome viscosa* *Dactyloctenium radulans*	*Enneapogon polyphyllus* *Eragrostis falcata* *Eucalyptus victrix* *Fimbristylus dichotoma* *Gossypium australe* *Indigofera linnaei* *Leptoclada fusca* *Neptunia gracilis*	*Paspalidium rarum* *Portulaca filifolia* *Portulaca oleracea* *Solanum coactiliferum* *Teucrium integrifolium* *Trianthema pilosa* *Trianthema triquetra* *Whiteochloa airoides*

A vegetation transect was not conducted.

No trapping or tracking data collected, although bird observations were made during drive through.

Birds	
Budgerigar (*Melopsittacus undulatus*)	Sightings
Cockatiel (*Nymphicus hollandicus*)	Sightings

Appendix Thirty-six: Flora recorded during on site investigations by LES within the Wonarah prospect.

Status is given under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004), Territory Parks and Wildlife Conservation Act (2000) (TPWC) and conservation codes defined by White et al. (2000). See Appendix Sixteen for conservation code descriptions. Indigenous use of species was determined from discussions with traditional owners during field surveys and supplemented with searches through the literature.

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Abutilon otocarpum	Keeled Lantern-bush, Desert Chinese Lantern, Desert Lantern					TS2	1	Seeds edible	Utilitarian
Acacia adoxa							4,6		
Acacia ancistrocarpa	Fitzroy Wattle, Pirraru					TS1, TS3, S6	1,2		
Acacia hemignosta	Club-leaf Wattle			bioregional	BRT (southern range limit)	TS2, TS4	3	Seeds edible	Utilitarian
Acacia hilliana	Flying-saucer Bush			bioregional	CR (southern range limit)	S6	4, Inc. (Ironstone/chert rise S19.97287 E136.45370).		
Acacia lysiphloia	Turpentine, Turpentine Bush, Turpentine Wattle			bioregional	GSD (disjunct and southern range limit)	S8		Medicinal - pain relief, cold relief. Mothers and babies 'smoked' after birth.	Cultural, Utilitarian
Acacia monticola	Hill Turpentine			bioregional	CR (southern range limit)	TS5			
Acacia sericophylla	Dogwood, Wirewood					TS2, S6	2,7,8	Seeds edible	Utilitarian
Acacia stipuligera	Scrub Wattle, Kurapuka					TS1, TS4	2,6,8	Seeds edible	Utilitarian
Aerva javanica	Kapok Bush, Snow Bush	Int.					Inc. (along road near Arruwurra prospect)		
Aeschynomene indica	Budda Pea, Kath Sola						9		
Ammannia multiflora	Jerry Jerry						9		
Amphipogon caricinus	Grey-beard Grass, Long Grey-beard Grass						4,7,8		
Aristida contorta	Bunched Kerosene Grass, Mulga Grass					TS2	3,9		

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Aristida holathera	Erect Kerosene Grass, White Grass, Arrow Grass					TS3, S6, S7	1,2,3,4,5,6,7,8,9		
Aristida inaequiglumis	Curly Wiregrass, Fire Grass, Unequal Three-awn					TS3, S7	1,5,9	Medicinal - tea for immune boost	Utilitarian
Astrebla pectinata	Barley Mitchell Grass					TS2, TS3			
Atalaya hemiglauca	Whitewood					TS2, TS3, TS4	1,3	Flowering an indicator for crocodile egg laying	Cultural
Atriplex elachophylla	Annual Saltbush, Saltbush						1		
Bergia barklyana		nt		national	3R		9		
Boerhavia coccinea	Tar Vine						1,2,3,5		
Brunonia australis	Pincushion, Blue Pincushion						4		
Bulbostylis barbata	Short-leaved Rush						4,5,6,7,8		
Capparis umbonata	Northern Wild Orange, Wild Orange, Bush Orange, Native Pomegranate			bioregional	MGD (southern range limit)		1,2,3,9	Fruit edible	Utilitarian
Carissa lanceolata	Conkerberry, Conkle Berry, Kungsberry Bush					TS1, TS3	1,2	Medicinal - pain relief, antiseptic. Sick children 'smoked'	Cultural, Utilitarian
Cassytha capillaris	Hairless Dodder-laurel, Snotty Gobble						4		
Cenchrus ciliaris	Buffel Grass	Int.					1,3		
Chrysopogon fallax	Golden Beard Grass, Ribbon Grass, Weeping Grass, Spear Grass					S7	1		
Cleome viscosa	Tickweed, Mustard Bush						1,3,5,6,9	Medicinal - treat sores, ulcers and wounds, headache, rheumatism and diarrhoea	Utilitarian
Clerodendrum floribundum	Smooth Clerodendrum, Smooth Spiderbush, Lollybrush, Lolly Bush						5	Medicinal.	Utilitarian

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Corchorus sidoides	Flannel Weed						4,6,8		
Corymbia opaca	Bloodwood					TS1	2,3,4		
Corymbia setosa	Rough-leaved Bloodwood						4,8		
Crotalaria medicaginea	Clover-leaf Rattlepod, Trefoil Rattlepod						1,3		
Crotalaria novae-hollandiae	New Holland Rattlepod						2,5		
Cucumis maderaspatanus	Head-ache Vine						3,6		
Dactyloctenium radulans	Button Grass, Finger Grass, Toothbrush Grass						1,3,9		
Dicrastylis gilesii							6		
Digitaria brownii	Cotton Panic Grass						1		
Dodonaea coriacea	Hopbush					S6			
Ehretia saligna	Coonta, False Cedar, Peachwood, Peachbush					TS2	2		
Enneapogon polyphyllus	Woolly Oat-grass, Oat-grass, Leafy Nine-awn						1,3,9		
Eragrostis cumingii	Fairy Grass, Cumings Lovegrass						2,4,6		
Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail					TS3, S7	1,2,3,5,6,7,8		
Eragrostis falcata	Sickle Lovegrass						9		
Eremophila latrobei	Native Fuchsia, Latrobes Desert Fuchsia, Georgina Poison Bush						1,2,9	Medicinal. Ceremonially increase mothers milk supply	Cultural, Utilitarian
Eremophila longifolia	Emu Bush, Weeping Emu Bush, Long-leaved Desert Fuchsia						1,9	Medicinal. 'Smoking' of candidates in rites of passage	Cultural, Utilitarian
Eriachne aristidea	Three-awn Wanderrie						2,8		
Eriachne mucronata	Mountain Wanderrie						2		

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Eucalyptus gamophylla	Blue Mallee, Twin-leaved Mallee, Blue-leaved Mallee			bioregional	TAN (northern range limit)		Inc. (Emphemeral lakes) Inc. (Shallow sand plain S19.97053 E136.45397).		
Eucalyptus leucophloia	Snappy Gum, Migum					TS1, TS2, TS5			
Eucalyptus microtheca	Coolibah						1,2,3	Coolamon carved out of bark.	Utilitarian
Eucalyptus odontocarpa	Sturt Creek Mallee			bioregional	GSD (southern range limit)	TS2, S6	4,5,6,8		
Eucalyptus pachyphylla	Red-bud Mallee			bioregional	DMR (northern range limit)		4,7		
Eucalyptus pruinosa	Silver Box, Silver-leaf Box, Apple Box, Smoke Tree						Inc. (Silcrete rocky rise associated with Site 5)		
Eucalyptus victrix	Smooth-barked Coolibah, Ghost Gum Coolibah, Gum-barked Coolibah			bioregional	MGD (eastern range limit)	TS2, TS4, S7	5,7,9		
Eulalia aurea	Silky Browntop, Sugar Grass					TS3, S7	3,5		
Euphorbia comans							2,6		
Euphorbia tannensis	Caustic Bush, Desert Spurge						5		
Evolvulus alsinoides var. decumbens	Blue Periwinkle, Tropical Speedwell						8		
Evolvulus alsinoides var. villosicalyx	Blue Periwinkle, Tropical Speedwell						2		
Fimbristylis ammobia				bioregional	MGD (eastern range limit)		2		
Fimbristylis dichotoma	Eight Day Grass, Common Fringe-rush						9		
Fimbristylis oxystachya	Lukarrara						2,5,7,8		

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Fimbristylis simulans				bioregional	DMR (eastern range limits)		4,7		
Gomphrena lanata							2		
Goodenia armitiana	Narrow-leaved Goodenia						4		
Goodenia ramelii							4,6		
Gossypium australe	Native Cotton, Tall Desert Rose					TS1, TS3, S7, S8	2,3,4,5,6,7,8,9		
Gossypium sturtianum	Sturts Desert Rose					TS2			
Grevillea juncifolia	Desert Grevillea, Honey Grevillea, Honeysuckle Grevillea					S6		Flowers edible and steeped	Utilitarian
Grevillea refracta	Silver-leaf Grevillea					S6	4,5,6,7		
Grevillea wickhamii	Holly-leaf Grevillea					TS4, S7	5,6		
Hakea lorea	Long-leaf Corkwood, Corkbark Tree						4		
Hakea macrocarpa	Flat-leaved Hakea			bioregional	SSD (southern range limit)	TS1, TS5, S6	5	Flowers steeped	Utilitarian
Heliotropium glanduliferum							5,6,7,8		
Heliotropium ovalifolium						TS3			
Heliotropium pulvinum		dd		Northern Territory	3K		6		
Hibiscus brachychlaenus		nt		Northern Territory	3r		6		
Hybanthus aurantiacus	Orange Spade Flower						4,6		
Indigofera colutea	Sticky Indigo						1		
Indigofera linifolia	Native Indigo						1,3,5,6		
Indigofera linnaei	Birdsville Indigo, Nine-leaved Indigo						9		
Ipomoea costata	Bush Potato, Potato Vine, Desert Yam						6, Inc. (deep sand plain)	Tubers edible	Utilitarian
Jacquemontia browniana	Snake Stem						2		
Keraudrenia integrifolia							2,6		

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Leptochloa fusca	Beetle Grass						9		
Marsdenia australis	Bush Banana, Lungkwa, Doubah						2		
Melaleuca lasiandra	Sandhill Tea-tree					TS1	2,8		
Melaleuca viridiflora	Green Paperbark, Broad-leaved Paperbark, Large-leaved Paperbark					TS5			
Mirbelia viminalis	Yellow Broom					S6			
Neptunia gracilis	Native sensitive grass						9		
Pandorea doratoxylon	Spearwood, Wonga Vine, Spearbush						Inc. (Deep sand plain associated with TS2)	Spear-making	Utilitarian
Paraneurachne muelleri	Spinifex Couch, Northern Mulga Grass						4,5,7		
Paspalidium rarum	Bunch Paspalidium						9		
Petalostylis cassioides	Butterfly Bush, Petalostylis					TS1	4	Medicinal - skin treatment	Utilitarian
Polycarpaea spirostylis	Copper Plant						4,5,7		
Portulaca filifolia	Slender Pigweed						2,3,6,9		
Portulaca oleracea	Pigweed, Common Purslane, Munyeroo						1,3,6,9	Whole plant edible	Utilitarian
Psydrax latifolia	Native Currant, Orange Bush						1,9		
Ptilotus calostachyus	Weeping Mulla Mulla						4		
Ptilotus fusiformis	Skeleton plant						4,5,6,7,8		
Ptilotus polystachyus	Long Pussy-tails						1,2,4,7		
Rhynchosia minima	Native Pea, Rhynchosia						2		
Rulingia loxophylla	Desert Fire Weed					S6, S8	5,6		
Salsola tragus	Buckbush, Rolypoly, Tumbleweed						3		

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Santalum lanceolatum	Plumbush, Wild Plum						Inc. (Deep sand plain associated with TS2)	Fruits and seeds edible. Medicinal - skin treatment, cold and cough relief. Babies 'smoked' to ensure good health	Cultural, Utilitarian
Scaevola amblyanthera						S6			
Scaevola ovalifolia	Bushy Fanflower			bioregional	GSD (western range limit)		1		
Scaevola parvifolia	Fanflower					S6	2,7		
Sclerolaena costata				bioregional	CHC (eastern range limit)	S7			
Schizachyrium fragile	Firegrass, Red Spathe Grass, Small Red-leaf						2,4,6,7,8		
Sebastiania chamaelea							5		
Senna artemisioides subsp. oligophylla	Oval-leaf Cassia						1	Medicinal - bathe patient for skin treatment, cold & cough relief.	Utilitarian
Senna notablis	Cockroach Bush						6,7,8		
Senna venusa	Graceful Cassia						Inc. (Silcrete rocky rise associate with Site 5)		
Setaria surgens	Brown Pigeon Grass			bioregional	GSD (southern range limit)		2,4,5,6,7,8		
Sida arenicola							6		
Sida fibulifera	Silver Sida, Pin Sida						6		
Sida filiformis	Fire Sida, Fine Sida						4,6,8		
Solanum coactiliferum	Western Nightshade						9		
Spermacoce dolichosperma							2,4,5,6,7,8		
Stackhousia 'Mt Leibig'							7		

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	Survey Sites		Indigenous Use	Category
						2008	2009		
Swainsonia sp.							3		
Tephrosia benthamii							1,2,8		
Tephrosia brachyodon	Red Pea-bush						1		
Tephrosia lasiochlaena				bioregional	MAC (southern range limit)	TS2, TS2			
Teucrium integrifolium	Green Germander			bioregional	TAN (disjunct and western range limit)		9		
Trianthema pilosa							1,2,9		
Trianthema triquetra	Red Spinach						2,9		
Tribulopis angustifolia							2,7		
Tribulus eichlerianus	Bindieye						3		
Trichodesma zeylanicum	Cattle Bush, Camel Bush						8		
Triodia intermedia	Winged Spinifex			bioregional	DMR (disjunct and eastern range limit), BRT (disjunct and southern range limit)	TS3			
Triodia pungens	Soft Spinifex, Gummy Spinifex					TS1, TS3, TS4, TS5, S6, S7, S8	4		
Triodia schinzii	Feathertop Spinifex						2,4,5,7,8		
Triraphis mollis	Purple Plumegrass, Purple Heads, Needle Grass						3		
Triumfetta centralis				bioregional	SSD (eastern range limit)		8		
Urochloa sp.							4,6,7,8		
Ventilago viminalis	Supplejack, Vine Tree					TS2	3,7		
Waltheria indica							2		
Whiteochloa airoides							2,9		
Yakirra australiensis	Desert Flinders Grass						2,4,5,6,7,8		
Zornia albiflora				bioregional	GSD (southern range limit)		2		

Appendix Thirty-seven: Significant flora recorded within the Wonarah project area during on-site investigations including LES field surveys and NT Flora Atlas (2007) records.

__Note:__ "LES Survey" indicates species recorded during LES surveys (Dry Season 2008 & Wet Season 2009 surveys). All other species were recorded in the NT Flora Atlas (2007).

See Appendix Sixteen for conservation code descriptions.

__**Land unit codes:**__

ASP: Alluvial low-lying sand plain
DSP: Deep sand plain
IRR: Ironstone rocky rise
SRR: Silcrete rocky rise
EL: Ephemeral lake
CP: Calcareous plain

Species Name	TPWC	EPBC	SSOBS level	SSOBS Code	LES Survey	Land unit
Bonamia alatisemina	DD		National	3K		**DSP**
Distichostemon barklyanus	DD		Northern Territory	3k		**DSP**
Heliotropium ballii	DD		Northern Territory	3k		**IRR**
Heliotropium pulvinum	DD		Northern Territory	3K	*	**IRR, SRR**
Sporobolus latzii	DD		National	1K		**EL**
Triumfetta deserticola	DD		Northern Territory	3k		**ASP**
Bergia barklyana	nt		National	3R	*	**EL**
Hibiscus brachychlaenus	nt		Northern Territory	3r	*	**IRR**

Appendix Thirty-eight: Significant fauna species recorded within the Wonarah Phosphate Project area during on-site investigations including LES field surveys and NT Flora Atlas (2007) records.

Note: "Inside" column refers to species recorded inside the Wonarah Phosphate Project area. All other species were recorded outside the Wonarah Phosphate Project area but within a 50 km buffer.

"LES Survey" indicates species recorded during LES surveys (Dry Season 2008 & Wet Season 2009 surveys). All other species were recorded in the NT Flora Atlas (2007).

See Appendix Sixteen for conservation code descriptions.

Species Name	Common Name	TPWC	EPBC	Inside	LES Survey
Ardeotis australis	Australian Bustard	VU		*	*
Epthianura crocea	Yellow Chat	EN\LC	VU\NL		
Lophoictinia isura	Square-tailed kite	NT			
Phaps histrionica	Flock Bronzwing	NT			
Cyclorana australis	Northern Snapping Frog or Giant Frog	DD			
Dasycercus cristicauda or *D. blythi*	Crest-tail or Brush-tail Mulgara	VU	VU		
Lagorchestes conspicillatus	Spectacled Hare Wallaby	NT			
Macrotis lagotis	Bilby	VU	VU		
Onychogalea unguifera	Northern Nailtail Wallaby	NT		*	*
Rattus villosissimus	Long-haired rat	NT		*	
Aspidites ramsayi	Woma	NT		*	
Varanus spenceri	Spencers Goanna	DD			

Appendix Thirty-nine: Fauna recorded during LES field surveys (Dry Season 2008 & Wet Season 2009 surveys) within the Wonarah Phosphate Project area.

Status is given under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004), and the Territory Parks and Wildlife Conservation Act (2000) (TPWC). See Appendix Sixteen for conservation code descriptions.

Note: Location details of incidental records are provided in the "Inc. Locations" column.

Common Name	Scientific	Evidence	Conservation Status		Survey Sites		
Mammals			**EPBC**	**TPWC**	**2008**	**2009**	**Inc. Locations**
Camel	*Camelus dromedarius*			Int.	TS1, TS2, TS3		
Cat, Feral	*Felis catus*	Tracks	-	Int.	TS4	2,6,7, Inc.	Drill Sump S20.12903 E136.32635
Cow	*Bos taurus*	Tracks	-	Int.		Inc.	Drill Sump S20.12903 E136.32635
Dingo	*Canis lupis*	Tracks	-	LC	TS3, TS4, TS5, S6, S7, S8		
Donkey, Feral	*Equus asinus*	Tracks	-	Int.		Inc.	Drill Sump S20.12903 E136.32635
Dunnart, Fat-tailed	*Sminthopsis crassicaudata*			LC	TS3		
Dunnart, Lesser hairy-footed	*Sminthopsis youngsoni*	Trapped	-	LC		1,5,7	
Dunnart (unidentified)		Tracks	-	-		8	
Echidna, Short-beaked	*Tachyglossus aculeatus*	Tracks/Digs	-	LC		6, Inc.	Within Arruwurra prospect along road
Euro	*Macropus robustus*			LC	TS2, TS3		
Fox, Red	*Vulpes vulpes*	Tracks	-	Int.	TS4		
Kangaroo, Red	*Macropus rufus*	Tracks/Scats	-	LC	TS3, TS4	1,2,3,7,8	
Mouse, Sandy inland	*Pseudomys hermannsburgensis*			LC	TS2		
Mouse, Desert	*Pseudomys desertor*			LC	TS3		
Mouse, Spinifex Hopping	*Notomys alexis*			LC	TS1, TS2, TS3, TS4, TS5	5,6,7,8	
Mouse (unidentified)						2,4,5,6,7	
Wallaby, Northern Nailtail	*Onychogalea unguifera*	Scats	-	NT		1	
Reptiles			**EPBC**	**TPWC**	**2008**	**2009**	**Inc. Locations**
Blue-tongue, Centralian	*Tiliqua multifasciata*	Track	-	LC		Inc.	Alluvial Low-lying Sand Plain associated with Site 2.
Dragon	*Diporiphora lalliae*	Trapped	-	LC		6	
Dragon, Military	*Ctenophorus isolepis*	Trapped	-	LC		4,5,6,7	
Gecko, Fat-tailed	*Diplodactylus conspicillatus*	Trapped	-	LC		4,5,7	

Common Name	Scientific	Evidence	Conservation Status		Survey Sites		
Gecko, Spiny-tailed	*Strophurus ciliaris*	Trapped	-	LC		4	
Gecko, Varigated	*Gehyra variegata*					5	
Gecko (unidentified)		Track	-	-		4	
Goanna, Sand	*Varanus gouldii*	Trapped/Sighting/Digs	-	LC		1,2,4,5,6,7,8, Inc.	Silcrete Rise
Goanna (unidentified)		Track/Digs	-	-	TS3, S6, S7	2,3	
Legless lizard (unidentified)		Track	-	-		2,4,6,7,8	
Lerista, Two-toed	*Lerista bipes*	Trapped	-	LC		1,2,4,8	
Monitor, Pygmy Desert	*Varanus eremius*	Trapped	-	LC		1	
Monitor, Pygmy Mulga	*Varanus gilleni*	Trapped	-	LC		1,7	
Thorny Devil	*Moloch horridus*	Track	-	LC		Inc.	Calcareous plain associated with Site 3
Sand-swimmer, Broad-banded	*Eremiascincus richardsonii*	Trapped	-	LC		1	
Skink, Ctenotus	*Ctenotus leonhardii*	Trapped	-	LC		1,3,5,7,8	
Skink, Ctenotus	*Ctenotus schomburgkii*	Trapped	-	LC		3	
Small lizard (unidentified)						2,4,5,6,7,8	
Snake (unidentified)		Track	-	-		5,6,7,8	
Birds			**EPBC**	**TPWC**	**2008**	**2009**	**Inc. Locations**
Babbler, Grey-crowned	*Pomatostomus temporalis*	Call	-	LC		2	
Bellbird, Crested	*Oreoica gutturalis*	Call	-	LC		6,7,8	
Budgerigar	*Melopsittacus undulatus*	Sighting	-	LC		1,2,3,4,5,6,7,8,9	
Bustard, Australian	*Ardeotis australis*	Tracks/Feather	-	VU	TS4, S7, S8	2,3	
Button-Quail, Little	*Turnix pyrrhothorax*	Sighting/Tracks	-	LC		2,3,4,6,7,8	
Chat, Crimson	*Epthianura tricolor*	Sighting	-	LC		2,4,6,7,8	
Cockatiel	*Nymphicus hollandicus*	Sighting	-	LC		5,9	
Dove, Diamond	*Geopelia cuneata*	Sighting	-	LC		1,3,4,6,7,8	
Fairy-wren, Variegated	*Malurus lamberti*	Sighting	-	LC		6	
Falcon, Brown	*Falco berigora*	Sighting	-	LC		Inc.	Deep sand plain at Nth cross track & Ironstone Rocky Rise associated with Site 6
Finch, Zebra	*Taeniopygia guttata*	Sighting	-	LC		1,2,3,4,6,7,8	
Galah	*Cacatua roseicapilla*	Sighting	-	LC		5	
Hobby, Australian	*Falco longipennis*	Sighting	-	LC		5	
Honeyeater, Grey headed	*Lichenostomus keartlandi*	Sighting	-	LC		6,7,8	
Honeyeater, Singing	*Lichenostomus virescens*	Sighting	-	LC		7,8	
Honeyeater, Spiny-	*Acanthagenys*	Sighting	-	LC		6	

Common Name	Scientific	Evidence	Conservation Status		Survey Sites		
cheeked	*rufogularis*						
Jacky Winter	*Microeca fascinans*	Sighting	-	LC		7	
Kingfisher, Sacred	*Todiramphus sanctus*	Sighting	-	LC		7, Inc.	Alluvial low-lying sand plain associated with S6 (2008 site)
Kite, Black	*Milvus migrans*	Sighting	-	LC		3,5,6,7	
Kite, Whistling	*Haliastur sphenurus*	Sighting	-	LC		5	
Magpie, Black-backed	*Gymnorhina tibicen*	Sighting	-	LC		5	
Miner, Yellow-throated	*Manorina flavigula*	Sighting	-	LC		5	
Owl, Barn	*Tyto alba*	Feather	-	LC		2	
Pardalote, Red-browed	*Pardalotus rubricatus*	Sighting	-	LC		1,7	
Parrot, Australian Ringneck	*Barnardius zonarius*	Sighting	-	LC		Inc.	Deep sand plain associated with Site 7
Pratincole, Australian	*Stiltia isabella*	Sighting	-	LC		Inc.	Camp
Quail-thrush Cinnamon	*Cinclosoma cinnamomeum*	Sighting	-	LC		Inc.	Deep sand plain associated with Site 8
Songlark, Brown	*Cincloramphus cruralis*	Sighting	-	LC		3	
Triller, White-winged	*Lalage sueurii*	Sighting	-	LC		1,3,7	
Wagtail, Willie	*Rhipidura leucophrys*	Sighting	-	LC	TS1	5	
Wedgebill, Chiming	*Psophodes occidentalis*	Call	-	LC		8	
Woodswallow, Blackfaced	*Artamus cinereus*	Sighting	-	LC		1,2,3,6	
Woodswallow, Masked	*Artamus personatus*	Sighting	-	LC		1,2,3,4,6,7,8	

Appendix Forty: The preferred habitat, distribution, threatening process and beneficial fire characteristics for significant species that may potentially occur within the Wonarah Project Area.

See Appendix Sixteen for conservation code descriptions.

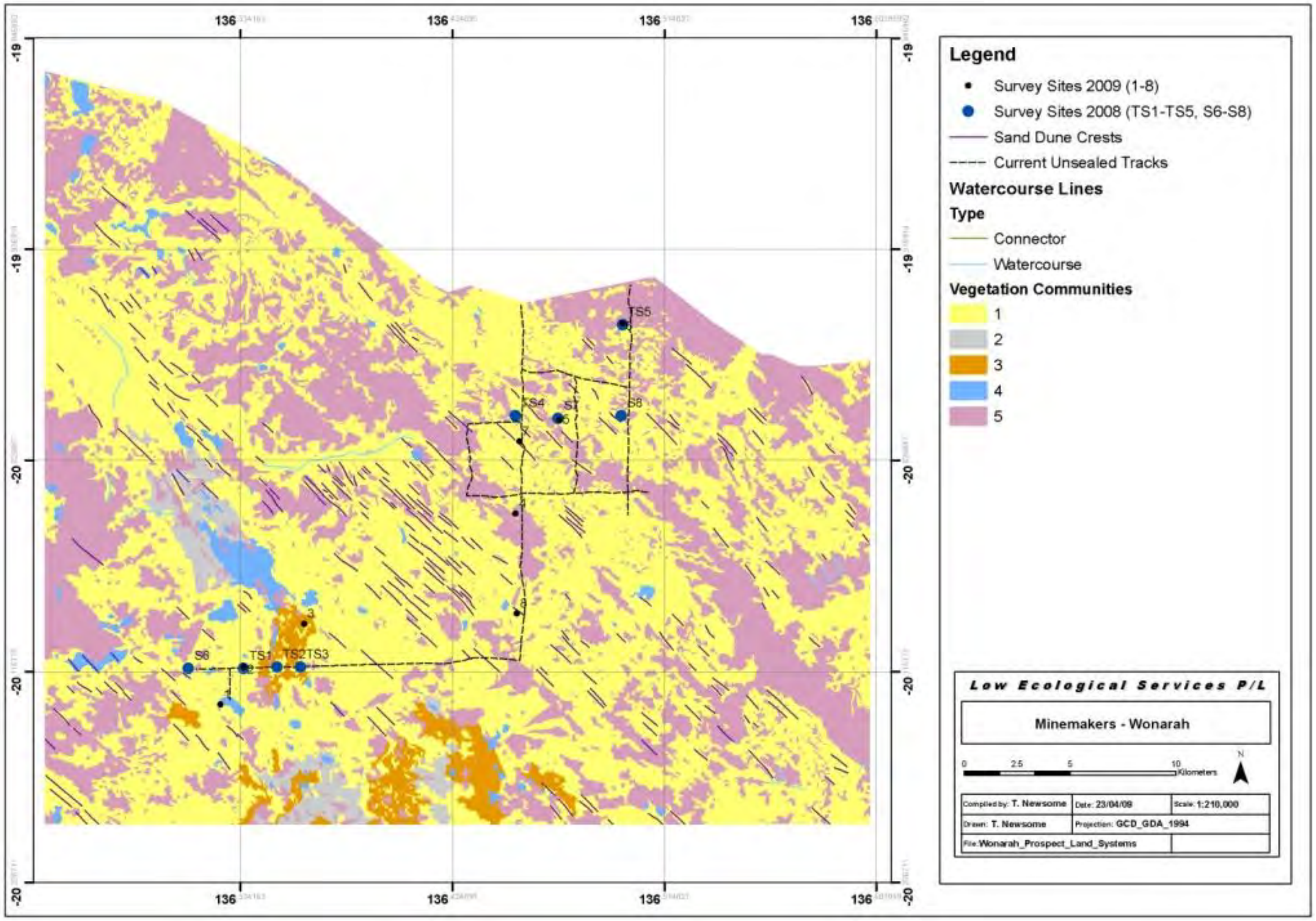
Species	EPBC	TPWC	Preferred Habitat	Threatening processes	Distribution	Fire requirements
Bird						
Ardeotis australis (Australian bustard)		VU	Open grasslands, low shrublands, grassy woodlands and other similar artificial habitats such as crop lands and airfields (Ziembicki 2006)	Predation, altered fire regimes, hunting, disturbance, habitat alteration, pesticides and grazing (Ziembicki 2006)	Away from settlements in part of east inland, inland, northern Aust and W.A. Nomadic, dispersive in response to rainfall; regular movements south in summer & to northern Aust in winter (Pizzey & Knight, 2001).	Often found in recently burnt country. Respond readily to fire which is conducive to their opportunistic diet and reproductive behaviours (Ziembicki 2006)
Epthianura crocea (Yellow chat)	VU\NL	EN\LC	Chenopod shrublands and grasslands around water sources in semi-arid areas		From Roebuck Plains, near Broome (W.A), to Barkly Tablelands (N.T)-Gulf lowlands (Qld), east to approx. Hughenden. Rare. Sedentary; nomadic (Pizzey & Knight, 2001).	
Rostratula australis (Australian painted snipe)	VU	VU	Shallow, vegetated, freshwater swamps, claypans, inundated grassland and temporary wetlands (Taylor *et al*, 2006)	Predominately wetland drainage although habitat degradation by cattle is also possible (Taylor *et al*, 2006)	Mostly south-east Aust, south of Brisbane-Adelaide; scarce & erratic over much of inland, northern Qld, N.T. & coastal W.A.; vagrant Tas.	
Lophoictinia isura (Square-tailed kite)		NT	Heathlands, woodlands, forests; tropical & sub-tropical rainforest; timbered watercourses; hills & gorges (Pizzey & Knight, 2001).		Mostly a non-breeding visitor to coastal & sub-coastal northern Aust but in eastern Qld widely scattered breeding occurs. Sedentary; part-migratory. Rare. (Pizzey & Knight, 2001).	

Species	EPBC	TPWC	Preferred Habitat	Threatening processes	Distribution	Fire requirements
Mammal						
Macrotis lagotis (Bilby)	VU	VU	Sandy soils dominated by hummock grasslands covered predominately by spinifex and an overstorey of low shrub cover dominated by *Acacia* and *Melaleuca*. Often comprises rocky outcrops, lateritic rises and low-lying drainage depressions (Pavey, 2007)	Predation by carnivores (especially European fox), competition with rabbits and grazing by cattle (Pavey 2007). Unsuitable fire regimes may restrict breeding and impede dispersal and colonisation of unoccupied areas. High intensity, uncontrolled wildfires are of particular concern (Pavey 2006)	2 separate geographic areas; 1st extending from the western deserts region of N.T. & W.A. into the Pilbara & Kimberley regions, 2nd into the Channel country of SW Qld. (Pavey, 2007)	Seed promoted by fire is an important dietary requirement. A mosaic of fire ages will increase the chance that a crop of fire promoted plants will occur each year. Bilbies occupy the full spectrum of seral states from recently burnt to long unburnt. (Pavey 2006)
Lagorchestes conspicillatus (Spectacled hare wallaby)		NT	Open forests, open woodland, tall shrublands, tussock grasslands and hummock grasslands. Particularly favours *Acacia shirleyi* /*Macropteranthes kekwickii* thickets with an open understorey (Ingleby and Westoby 1992)	Introduced predators and competitors, pastoralism and alteration to fire regimes (Ingleby 1991)	Extremely patchy. Qld - widespread from Weipa to Dajarra and south to Rolleston, WA - extremely rare, few isolated populations in the Pilbara and Kimberley, NT - Widespread, as far north as 12°S, common in suitable habitat between 16-18°S, rarely occurring south of 21°S (Ingleby 1991)	Frequently feeds in areas regenerating after fire (Ingleby and Westoby 1992)
Onychogalea unguifera (Northern nailtail wallaby)		NT	Open long-grass woodlands, grasslands & shrubby savannah, usually near water.		Northern Australia coast and the 500mm rainfall isohyet. Extends several hundred kilometres inland into North-western Australia although tends to avoid higher rainfall in Arnhemland and the Kimberleys.	
Rattus villosissimus (Long-haired rat)		NT	Mesic, densely vegetated sites (Dickman 1993)	Overgrazing, degradation of vegetation and soil by rabbits and livestock and predation (Dickman 1993)		
Dasycercus cristicauda or *D. blythi* (Crest-tailed mulgara or Brush-tailed mulgara)	EN/VU	VU/VU	Arid and semi arid sandy regions particularly mature hummock grasslands of spinifex, especially *Triodia basedowii* and *T. pungens* (Masters *et al*. 2003).	Cause of decline unknown. Changes to fire regimes, grazing by introduced herbivores and predation by introduced predators are all likely threatening processes (Pavey *et al*. 2006)	*D. cristicauda* occurs predominately in the Simpson desert & nthn S.A. *D. blythi* occurs from Western & Simpson deserts, with confirmed records in N.T. from Haast Bluff, Uluru, Papunya, Tanami Desert, Illamurta, Charlotte Waters and Crown Point (Woolley, 2005).	

Species	EPBC	TPWC	Preferred Habitat	Threatening processes	Distribution	Fire requirements
Reptile						
Apsidites ramsayi (Woma)		NT	Subhumid to arid interior. Woodlands, heaths and shrublands, often with spinifex, sheltering in abandoned monitor and mammal burrows and soil cracks (Wilson & Swan 2003).	Land-clearing & possible predation by feral animals (Wilson & Swan, 2003).	Northwest coast W.A to Moonie & Tara districts, nthn S.A. & sthn Qld.	
Varanus spenceri (Spencer's monitor)		DD	Treeless, deeply cracking clay plains vegetated with Mitchell grass, sheltering in soil cracks (Wilson & Swan, 2003).	None. Limited data prevents classification of species.	Limited distribution, Barkly Tablelands N.T. into inland S.E. Qld.	

Appendix Forty-one: Vegetation Communities within the Wonarah Project Area

See table below for descriptions



Appendix Forty-one (cont): Vegetation community classifications against land unit boundaries utilising floristic data collected during the Wet Season 2009 LES field survey and species presence data in the NT Flora Atlas (2007).

Veg No.	Land Unit	Veg. Community Name	Dominant flora species
1	Sand Plain (Alluvial Low-lying, Shallow & Deep Sand Plains)	Eucalypt (Coolabah, Mallee & Bloodwood) and Acacia (Dogwood) low open-woodland with Senna sp. low shrublands over hummock grassland.	**Emergent Trees:** *Eucalyptus microtheca, E. victrix, E. setosa, Corymbia opaca* and *Acacia sericophylla.* **Lower Shrub Layer:** *Senna artesmisioides subsp. oligophylla, Gossypium australe* and *A. stipuligera.* **Ground cover:** *Triodia pungens, T. schinzii, Aristida holathera and Yakirra australiensis.*
2	Black soil & Clay plains	Coolabah low-open woodland with Silky browntop (*Eulalia aurea*) and *Aristida* sp. grasslands.	Further surveys conducted due to inaccessibility; however these sites are outside the proposed impact areas.
3	Calcareous Plain	Supplejack low open woodland with open-grassland understorey.	**Emergent Trees:** *Ventilago viminalis* and *Eucalyptus microtheca.* **Ground cover:** *Digitaria brownii* and *Cleome viscosa.*
4	Ephemeral Lake	*E. victrix* (Coolabah) low open-woodland with open-grassland understorey.	**Emergent Trees:** *Eucalyptus victrix.* **Ground cover:** *Whiteochloa airoides*
5	Rocky Rises (Silcrete & Ironstone Rocky Rises & Limestone & Mud Stone Outcrops)	Acacia & mallee shrubland over hummock grassland.	**Emergent Trees:** *Eucalyptus microtheca, E. victrix, Corymbia opaca* and *Acacia sericophylla.* **Upper Shrub Layer:** *E. odontocarpa, E. pachyphylla* **Lower Shrub Layer:** *Acacia hilliana, Grevillea refracta, G. wickhamii* **Ground cover:** *Triodia pungens, T. schinzii, Aristida holathera* and *Yakirra australiensis*

Appendix Forty-two: Flora species list within Land Units and suitable species for rehabilitation

(See also Appendix Four). Based on the NT Flora Atlas (2007) and LES surveys herein. Status is given under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004), Territory Parks and Wildlife Conservation Act (2000) (TPWC) and conservation codes defined by White et al. (2000). See Appendix Eleven for conservation code descriptions.

Note: Flora species recorded in each land unit by LES are denoted with an asterisk in the "LES Survey" column. All other species were recorded in the NT Flora Atlas (2007) and were not verified by LES as occurring in the given land unit. There is some discrepancies in the true location of these species and possibly the land units they occur in due to the accuracy of recording location in historic studies as well as the accuracy in transferring between mapping datum's used in the NT Flora Atlas (2007) spatial database.

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
Alluvial Low Lying Sand Plain	*Acacia adoxa var. adoxa*		LC		bioregional	TAN (eastern range limit)		good	
	Acacia ancistrocarpa	Fitzroy Wattle, Pirraru	LC				*	good	
Regolith Unit	*Acacia hemignosta*	Club-leaf Wattle	LC		bioregional	BRT (southern range limit)	*		
Active Colluvium / Colluvium over Mudstone	*Acacia hilliana*	Flying-saucer Bush	LC		bioregional	CR (southern range limit)	*	good	
	Acacia melleodora	Waxy Wattle	LC						
	Acacia monticola	Hill Turpentine	LC		bioregional	CR (southern range limit)			
	Acacia sericophylla	Dogwood, Wirewood	LC				*	good	
	Acacia stipuligera	Scrub Wattle, Kurapuka	LC				*	good	
	Amphipogon caricinus var. caricinus	Grey-beard Grass, Long Grey-beard Grass	LC					mod	
	Aristida holathera		LC				*	good	
	Aristida inaequiglumis	Curly Wiregrass, Fire Grass, Unequal Three-awn	LC				*		
	Atalaya hemiglauca	Whitewood	LC				*	good	
	Boerhavia coccinea	Tar Vine	LC				*	good	
	Bonamia media var. media		LC					good	
	Bulbostylis barbata	Short-leaved Rush	LC				*	good	
	Capparis umbonata	Northern Wild Orange, Wild Orange, Bush Orange, Native Pomegranate	LC		bioregional	MGD (southern range limit)	*	good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
Alluvial Low Lying Sand Plain	*Carissa lanceolata*	Conkerberry, Conkle Berry, Kungsberry Bush	LC				*	good	
	Chrysopogon fallax	Golden Beard Grass, Ribbon Grass, Weeping Grass, Spear Grass	LC				*	good	periodically wet areas
	Cleome viscosa	Tickweed, Mustard Bush	LC				*		
	Clerodendrum floribundum	Smooth Clerodendrum, Smooth Spiderbush, Lollybrush, Lolly Bush	NE				*		
	Corymbia deserticola subsp. mesogeotica	Desert Bloodwood	LC		bioregional	MGD (eastern range limit), TAN (northern range limit), GSD (western and southern range limits)			
	Corymbia opaca	Bloodwood	LC				*		
	Crotalaria medicaginea var. neglecta	Clover-leaf Rattlepod, Trefoil Rattlepod	LC					good	
	Crotalaria novae-hollandiae		LC				*		
	Crotalaria novae-hollandiae subsp. lasiophylla	New Holland Rattlepod	LC						
	Cyperus bulbosus	Yalka, Nutgrass	LC					good	periodically wet areas
	Digitaria brownii	Cotton Panic Grass	LC					good	
	Dodonaea coriacea	Hopbush	LC				*	good	
	Ehretia saligna		LC				*	good	
	Eragrostis cumingii	Fairy Grass, Cumings Lovegrass	LC				*		
	Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail	LC				*	good	
	Eremophila latrobei	Native Fuchsia, Latrobes Desert Fuchsia, Georgina Poison Bush	LC				*	good	
	Eriachne aristidea		LC				*	good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
Alluvial Low Lying Sand Plain	*Eriachne mucronata*	Mountain Wanderrie	LC				*	good	
	Eucalyptus chlorophylla	Green-leaf Box	LC					good	
	Eucalyptus leucophloia	Snappy Gum, Migum	LC				*	good	
	Eucalyptus microtheca	Coolibah	LC				*	good	
	Eucalyptus odontocarpa	Sturt Creek Mallee	LC		bioregio nal	GSD (souther n range limit)	*	good	
	Eucalyptus victrix	Smooth-barked Coolibah, Ghost Gum Coolibah, Gum-barked Coolibah	LC		bioregio nal	MGD (eastern range limit)	*	good	
	Eulalia aurea	Silky Browntop, Sugar Grass	LC				*	good	
	Euphorbia comans		LC				*		
	Euphorbia tannensis	Caustic Bush, Desert Spurge	LC				*		
	Evolvulus alsinoides var. villosicalyx		LC				*		
	Exocarpos sparteus	Slender Cherry, Broombush	LC		bioregio nal	DMR (norther n range limit)			
	Fimbristylis ammobia		LC		bioregio nal	MGD (eastern range limit)	*	good	periodical ly wet areas
	Fimbristylis oxystachya	Lukarrara	LC				*	good	periodical ly wet areas
	Gomphrena lanata		LC				*	good	
	Goodenia armitiana	Narrow-leaved Goodenia	LC					good	
	Goodenia heterochila	Serrated Goodenia	LC					good	
	Gossypium australe	Native Cotton, Tall Desert Rose	LC				*	good	
	Grevillea juncifolia	Desert Grevillea, Honey Grevillea, Honeysuckle Grevillea	LC				*		
	Grevillea refracta	Silver-leaf Grevillea	LC				*	good	
	Grevillea refracta subsp. refracta	Silver-leaf Grevillea	LC					good	
	Grevillea wickhamii	Holly-leaf Grevillea	LC				*	good	
	Grevillea wickhamii subsp. aprica	Holly-leaf Grevillea	LC		bioregio nal	CR (souther n range limit)			
	Hakea macrocarpa	Flat-leaved Hakea	LC		bioregio nal	SSD (souther	*	good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
						n range limit)			
Alluvial Low Lying Sand Plain	*Heliotropium glanduliferum*		LC				*		
	Hibiscus leptocladus	Variable-leaf Hibiscus	LC					good	
	Indigofera linifolia	Native Indigo	LC				*		
	Indigofera trita		LC		bioregional	BRT (disjunct)			
	Jacquemontia browniana		LC				*		
	Keraudrenia integrifolia		LC				*	good	
	Keraudrenia nephrosperma		LC					good	
	Lipocarpha microcephala	Button Rush	LC						
	Marsdenia australis		LC				*		
	Melaleuca lasiandra	Sandhill Tea-tree	LC				*	good	periodically wet areas
	Melaleuca viridiflora	Green Paperbark, Broad-leaved Paperbark, Large-leaved Paperbark	LC					good	periodically wet areas
	Melhania oblongifolia	Velvet Hibiscus	LC					good	
	Mirabilia viminalis		LC				*	good	
	Paraneurachne muelleri	Spinifex Couch, Northern Mulga Grass	LC				*	good	
	Petalostylis cassioides	Butterfly Bush, Petalostylis	LC				*	good	
	Polycarpaea spirostylis	Copper Plant	LC				*		
	Portulaca filifolia	Slender Pigweed	LC				*	good	
	Psydrax attenuata var. myrmecophila forma myrmecophila		LC					good	
	Ptilotus fusiformis	Skeleton plant	LC				*	good	
	Ptilotus polystachyus	Long Pussy-tails	LC				*	good	
	Rhynchosia minima	Native Pea, Rhynchosia	LC				*	good	
	Rulingia loxophylla	Desert Fire Weed	LC				*	good	
	Scaevola amblyanthera		LC				*		
	Scaevola ovalifolia	Bushy Fanflower	LC		bioregional	GSD (western range limit)			
	Scaevola parvifolia	Fanflower	LC				*	good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
Alluvial Low Lying Sand Plain	*Schizachyrium fragile*	Firegrass, Red Spathe Grass, Small Red-leaf	LC				*	good	
	Sclerolaena costata		LC		bioregio nal	CHC (eastern range limit)	*	good	
	Sebastiania chamaelea		LC				*		
	Senna notabilis		LC					good	
	Setaria surgens	Brown Pigeon Grass	LC		bioregio nal	GSD (souther n range limit)	*	good	
	Spermacoce dolichosperma		LC				*	good	
	Tephrosia sp Barrow Creek		LC				*		
	Tephrosia stuartii		LC		bioregio nal	DMR (eastern range limit)		good	
	Trianthema pilosa		LC				*	good	
	Trianthema triquetra	Red Spinach	LC				*	good	
	Tribulopis angustifolia		LC				*	good	
	Tribulus eichlerianus	Bindieye	LC					good	
	Triodia pungens	Soft Spinifex, Gummy Spinifex	LC				*	good	
	Triodia schinzii	Feathertop Spinifex	LC				*	good	
	Triumfetta deserticola		DD		Norther n Territor y	3k			
	Ventilago viminalis	Supplejack, Vine Tree	LC					good	
	Waltheria indica		LC				*	good	
	Whiteochloa airoides		LC				*	good	
	Yakirra australiensis	Desert Flinders Grass	LC				*	good	
	Zornia albiflora		LC		bioregio nal	GSD (souther n range limit)	*	good	
Land Unit: Black Soil Plain **Regolith Unit** Black Soil	*Digitaria brownii*	Cotton Panic Grass	LC						Land unit occurs distal to proposed works
	Goodenia heterochila	Serrated Goodenia	LC						
	Ventilago viminalis	Supplejack, Vine Tree	LC						
	Zornia albiflora		LC		bioregio nal	GSD (souther n range limit)			

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
Land Unit:	*Acacia ancistrocarpa*		LC				*		
Calcareous Plain	*Acacia hemignosta*	Club-leaf Wattle	LC		bioregio nal	BRT (souther n range limit)	*		
Regolith Unit	*Aristida contorta*	Bunched Kerosene Grass, Mulga Grass	LC				*		
Colluvium over Dolomite	*Aristida holathera*	Erect Kerosene Grass, White Grass, Arrow Grass	LC				*		
	Aristida inaequiglumis	Curly Wiregrass, Fire Grass, Unequal Three-awn	LC				*		
	Astrebla pectinata	Barley Mitchell Grass	LC				*		
	Atalaya hemiglauca	Whitewood	LC				*		
	Boerhavia coccinea	Tar Vine	LC				*		
	Capparis umbonata	Northern Wild Orange, Wild Orange, Bush Orange, Native Pomegranate	LC		bioregio nal	MGD (souther n range limit)	*		
	Carissa lanceolata	Conkerberry, Conkle Berry, Kungsberry Bush	LC				*		
	Cenchrus ciliaris	Buffel Grass	INT				*		
	Cleome viscosa	Tickweed, Mustard Bush	LC				*		
	Corymbia opaca	Bloodwood	LC				*		
	Crotolaria medicaginea		LC				*		
	Cucumis maderaspatanus	Head-ache Vine	LC				*		
	Dactyloctenium radulans	Button Grass, Finger Grass, Toothbrush Grass	LC				*		
	Enneapogon polyphyllus	Woolly Oat-grass, Oat-grass, Leafy Nine-awn	LC				*		
	Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail	LC				*		
	Eucalyptus microtheca	Coolibah	LC				*		
	Eulalia aurea	Silky Browntop, Sugar Grass	LC				*		
	Gossypium australe	Native Cotton, Tall Desert Rose	LC				*		
	Heliotropium ovalifolium		LC				*		
	Indigofera linifolia	Native Indigo	LC				*		
	Perotis rara	Comet Grass	LC						

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
	Portulaca filifolia	Slender Pigweed	LC				*		
Calcareous Plain	*Portulaca oleracea*	Pigweed, Common Purslane, Munyeroo	LC				*		
	Salsola tragus	Buckbush, Rolypoly, Tumbleweed	LC				*		
	Setaria surgens	Brown Pigeon Grass	LC		bioregional	GSD (southern range limit)	*		
	Swainsonia sp.		LC				*		
	Tribulopis angustifolia		LC						
	Tribulus eichlerianus	Bindieye	LC				*		
	Triodia intermedia	Winged Spinifex	LC		bioregional	DMR (disjunct and eastern range limit), BRT (disjunct and southern range limit)	*		
	Triodia pungens	Soft Spinifex, Gummy Spinifex	LC				*		
	Triraphis mollis	Purple Plumegrass, Purple Heads, Needle Grass	LC				*		
	Urochloa piligera	Hairy Armgrass, Hairy Summer Grass, Green Summer Grass	LC						
	Ventilago viminalis	Supplejack, Vine Tree	LC				*		
	Whiteochloa cymbiformis		LC						
Land Unit:	*Abutilon otocarpum*	Keeled Lantern-bush, Desert Chinese Lantern, Desert Lantern	LC				*	good	
Deep Sand Plain	*Acacia coriacea*		LC						
Regolith Unit:	*Acacia hemignosta*	Club-leaf Wattle	LC		bioregional	BRT (southern range limit)	*		
Deep Aeolian Sand Deposits	*Acacia lysiphloia*	Turpentine, Turpentine Bush, Turpentine Wattle	LC		bioregional	GSD (disjunct and southern range limit)		good	
	Acacia	Dogwood,	LC				*	good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
	sericophylla	Wirewood							
Deep Sand Plain	*Acacia stipuligera*	Scrub Wattle, Kurapuka	LC				*	good	
	Amphipogon caricinus	Grey-beard Grass, Long Grey-beard Grass	LC				*	good	
	Aristida contorta	Bunched Kerosene Grass, Mulga Grass	LC				*	good	
	Aristida holathera	Erect Kerosene Grass, White Grass, Arrow Grass	LC				*	good	
	Astrebla pectinata	Barley Mitchell Grass	LC				*		
	Atalaya hemiglauca	Whitewood	LC				*	good	
	Bonamia alatisemina		DD		national	3K			
	Bulbostylis barbata	Short-leaved Rush	LC				*	good	periodical ly wet areas
	Corchorus sidoides	Flannel Weed	LC				*	good	
	Corymbia setosa		LC				*		
	Distichostemon barklyanus		DD		Norther n Territor y	3k			
	Ehretia saligna s.lat.	Coonta, False Cedar, Peachwood, Peachbush	NE				*		
	Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail	LC				*	good	
	Eriachne aristidea	Three-awn Wanderrie	LC				*	good	
	Eucalyptus leucophloia	Snappy Gum, Migum	LC				*	good	
	Eucalyptus odontocarpa	Sturt Creek Mallee	LC		bioregio nal	GSD (souther n range limit)	*	good	
	Eucalyptus pachyphylla	Red-bud Mallee	LC		bioregio nal	DMR (norther n range limit)	*	good	
	Eucalyptus victrix	Smooth-barked Coolibah, Ghost Gum Coolibah, Gum-barked Coolibah	LC		bioregio nal	MGD (eastern range limit)	*	good	
	Evolvulus alsinoides var. decumbens	Blue Periwinkle, Tropical Speedwell	LC				*		
	Fimbristylis ammobia		LC		bioregio nal	MGD (eastern range		good	periodical ly wet areas

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
						limit)			
Deep Sand Plain	*Fimbristylis oxystachya*	Lukarrara	LC				*	good	periodically wet areas
	Fimbristylis simulans		LC		bioregional	DMR (eastern range limits)	*	good	periodically wet areas
	Gossypium australe	Native Cotton, Tall Desert Rose	LC				*	good	
	Gossypium sturtianum	Sturts Desert Rose	LC				*	good	
	Grevillea refracta	Silver-leaf Grevillea	LC				*	good	
	Grevillia wickhamii	Northern Corkwood, Bootlace Tree, Bull Hakea, Whistling Tree	LC					good	
	Heliotropium glanduliferum		LC				*		
	Ipomoea costata	Bush Potato, Potato Vine, Desert Yam	LC				*	good	
	Melaleuca lasiandra	Sandhill Tea-tree	LC				*	good	
	Melaleuca viridiflora	Green Paperbark, Broad-leaved Paperbark, Large-leaved Paperbark	LC					good	
	Pandorea doratoxylon	Spearwood, Wonga Vine, Spearbush	LC				*	good	
	Paraneurachne muelleri	Spinifex Couch, Northern Mulga Grass	LC				*	good	
	Polycarpaea spirostylis	Copper Plant	LC				*		
	Ptilotus fusiformis	Skeleton plant	LC				*	good	
	Ptilotus polystachyus	Long Pussy-tails	LC				*	good	
	Santalum lanceolatum	Plumbush, Wild Plum					*	good	
	Scaevola parvifolia	Fanflower	LC				*	good	
	Schizachyrium fragile	Firegrass, Red Spathe Grass, Small Red-leaf	LC				*	good	
	Senna notablis	Cockroach Bush	LC				*	good	
	Setaria surgens	Brown Pigeon Grass	LC		bioregional	GSD (southern range limit)	*	good	
	Sida filiformis	Fire Sida, Fine Sida	LC				*	good	
	Spermacoce dolichosperma		LC				*		
	Stackhousia 'Mt Leibig'		LC				*		
	Swainsona burkei		LC		bioregio	TAN			

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
					nal	(western range limit)			
Deep Sand Plain	*Tephrosia lasiochlaena*		LC				*		
	Tephrosia sp. Barrow Creek (G.M.Chippendale 921)		LC		bioregional	GSD (southern range limit)	*		
	Tribulopis angustifolia		LC				*		
	Trichodesma zeylanicum	Cattle Bush, Camel Bush	LC				*		
	Triodia pungens	Soft Spinifex, Gummy Spinifex	LC					good	
	Triodia schinzii	Feathertop Spinifex	LC				*	good	
	Triumfetta centralis		LC		bioregional	SSD (eastern range limit)	*		
	Urochloa sp.		LC				*		
	Ventilago viminalis	Supplejack, Vine Tree	LC				*	good	
	Yakirra australiensis	Desert Flinders Grass	LC				*	good	
Land Unit: Ephemeral Lakes **Regolith Unit:** Alluvium	*Acacia lysiphloia*	Turpentine, Turpentine Bush, Turpentine Wattle	LC		bioregional	GSD (disjunct and southern range limit)			no mining in these areas
	Aeschynomene indica	Budda Pea, Kath Sola					*		
	Ammannia multiflora	Jerry Jerry	LC				*		
	Aristida contorta	Bunched Kerosene Grass, Mulga Grass	LC				*		
	Aristida holathera	Erect Kerosene Grass, White Grass, Arrow Grass	LC				*		
	Aristida inaequiglumis	Curly Wiregrass, Fire Grass, Unequal Three-awn	LC				*		
	Bergia ammannioides	Water-fire	LC		bioregional	BRT (apparently rare), SSD (disjunct)			
	Bergia barklyana		nt		national	3R	*		
	Bergia trimera	Small Water-fire	LC						
	Blumea tenella		LC						
	Boerhavia coccinea	Tar Vine	LC						
	Cajanus		LC						

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
	marmoratus								
Ephemeral Lakes	*Calandrinia pumila*	Tiny Purslane, Tiny Parakeelya	LC						
	Calotis porphyroglossa	Channel Burr-daisy	LC						
	Capparis umbonata	Northern Wild Orange, Wild Orange, Bush Orange, Native Pomegranate	LC		bioregio nal	MGD (souther n range limit)	*		
	Cleome viscosa	Tickweed, Mustard Bush					*		
	Crotalaria medicaginea var. neglecta	Clover-leaf Rattlepod, Trefoil Rattlepod	LC						
	Cullen cinereum	Annual Verbine	LC						
	Cuscuta victoriana		LC						
	Cyperus bifax	Downs Nutgrass	LC		bioregio nal	MAC (disjunct)			
	Cyperus iria		LC						
	Dactyloctenium radulans	Button Grass, Finger Grass, Toothbrush Grass	LC				*		
	Enchylaena tomentosa	Ruby Saltbush, Sturts Saltbush, Plum Puddings, Berry Cottonbush	LC						
	Enneapogon pallidus	Conetop Nine-awn, Pale Bottlewasher	LC						
	Enneapogon polyphyllus	Woolly Oat-grass, Oat-grass, Leafy Nine-awn	LC				*		
	Eragrostis falcata	Sickle Lovegrass	LC				*		
	Eremophila latrobei	Native Fuchsia, Latrobes Desert Fuchsia, Georgina Poison Bush	LC				*		
	Eremophila longifolia	Emu Bush, Weeping Emu Bush, Long-leaved Desert Fuchsia	LC				*		
	Eucalyptus coolabah subsp. arida	Coolabah	LC		bioregio nal	TAN (tentativ e western range limit)			
	Eucalyptus microtheca	Coolibah	LC				*		
	Fimbristylis dichotoma	Eight Day Grass, Common Fringe-rush	LC				*		
	Fimbristylis microcarya		LC						
	Gossypium australe	Native Cotton, Tall Desert Rose	LC				*		

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
Ephemeral Lakes	*Heliotropium ovalifolium*		LC						
	Indigofera linnaei	Birdsville Indigo, Nine-leaved Indigo	LC				*		
	Ipomoea coptica		LC						
	Isoetes muelleri	Quillwort	LC		bioregional	DMR (disjunct and apparently rare)			
	Leptochloa fusca	Beetle Grass	LC				*		
	Leptochloa fusca subsp. fusca	Small-flowered Beetle Grass	LC						
	Lysiana spathulata	Flat-leaved Mistletoe	LC						
	Neptunia dimorphantha	Sensitive Plant, Nervous Plant	LC						
	Neptunia gracilis	Native sensitive grass	LC				*		
	Paspalidium rarum	Bunch Paspalidium	LC				*		
	Portulaca filifolia	Slender Pigweed	LC				*		
	Portulaca oleracea	Pigweed, Common Purslane, Munyeroo	LC				*		
	Psydrax latifolia	Native Currant, Orange Bush	LC				*		
	Rothia indica subsp. australis		LC		southern NT	(disjunct and apparently rare)			
	Sida cunninghamii		LC						
	Solanum coactiliferum	Western Nightshade	LC				*		
	Solanum tumulicola	Black-soil Wild Tomato	LC						
	Sporobolus latzii		DD		national	1K			
	Streptoglossa adscendens		LC						
	Teucrium integrifolium	Green Germander	LC		bioregional	TAN (disjunct and western range limit)	*		
	Trianthema pilosa		LC						
	Trianthema triquetra	Red Spinach	LC				*		
	Whiteochloa airoides		LC				*		
Land Unit:	*Acacia adoxa*		LC				*	good	
Ironstone Rocky Rise	*Acacia drepanocarpa subsp. latifolia*		LC						
	Acacia hilliana		LC				*	good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
Ironstone Rocky Rise	*Acacia lysiphloia*	Turpentine, Turpentine Bush, Turpentine Wattle	LC		bioregional	GSD (disjunct and southern range limit)	*	good	
Regolith Unit: Ferrugnous Duricrust	*Acacia monticola*	Hill Turpentine	LC		bioregional	CR (southern range limit)	*		
	Acacia stipuligera	Scrub Wattle, Kurapuka	LC				*	good	
	Amyema sanguinea var. sanguinea	Blood Mistletoe	LC						
	Aristida holathera	Erect Kerosene Grass, White Grass, Arrow Grass	LC				*	good	
	Bulbostylis barbata	Short-leaved Rush	LC				*	good	
	Cleome viscosa	Tickweed, Mustard Bush	LC				*		
	Corchorus sidoides	Flannel Weed	LC				*	good	
	Cucumis maderaspatanus	Head-ache Vine	LC				*		
	Dicrastylis gilesii		LC				*	good	
	Eragrostis cumingii	Fairy Grass, Cumings Lovegrass	LC				*	good	
	Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail	LC				*	good	
	Eucalyptus leucophloia	Snappy Gum, Migum	LC				*	good	
	Eucalyptus odontocarpa	Sturt Creek Mallee	LC		bioregional	GSD (southern range limit)	*	good	
	Euphorbia comans		LC				*		
	Evolvulus alsinoides var. villosicalyx	Blue Periwinkle, Tropical Speedwell	LC						
	Goodenia ramelii		LC				*	good	
	Gossypium australe	Native Cotton, Tall Desert Rose	LC				*	good	
	Grevillea refracta	Silver-leaf Grevillea	LC				*	good	
	Grevillea refracta subsp. refracta	Silver-leaf Grevillea	LC					good	
	Grevillea wickhamii	Holly-leaf Grevillea	LC				*	good	
	Hakea macrocarpa	Flat-leaved Hakea	LC		bioregional	SSD (southern range limit)	*	good	
	Haloragis		LC					good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
	uncatipila								
Ironstone Rocky Rise	*Heliotropium ballii*		DD		Northern Territory	3k			
	Heliotropium glanduliferum		LC				*		
	Heliotropium pulvinum		DD		Northern Territory	3K	*		
	Hibiscus brachychlaenus		NT		Northern Territory	3R	*		
	Hybanthus aurantiacus		LC				*		
	Indigofera linifolia	Native Indigo	LC				*		
	Ipomoea costata	Bush Potato, Potato Vine, Desert Yam	LC				*	good	
	Keraudrenia integrifolia		LC				*	good	
	Melaleuca viridiflora	Green Paperbark, Broad-leaved Paperbark, Large-leaved Paperbark	LC					good	
	Mirbelia viminalis	Yellow Broom	LC					good	
	Portulaca filifolia	Slender Pigweed	LC				*	good	
	Portulaca oleracea	Pigweed, Common Purslane, Munyeroo	LC				*	good	
	Ptilotus calostachyus var. calostachyus	Weeping Mulla Mulla	LC					good	
	Ptilotus fusiformis	Skeleton Plant	LC				*	good	
	Rulingia loxophylla	Desert Fire Weed	LC				*	good	
	Schizachyrium fragile	Firegrass, Red Spathe Grass, Small Red-leaf	LC				*	good	
	Senna notablis	Cockroach Bush	LC				*	good	
	Setaria surgens	Brown Pigeon Grass	LC		bioregional	GSD (southern range limit)	*	good	
	Sida arenicola		LC				*	good	
	Sida fibulifera	Silver Sida, Pin Sida	LC				*	good	
	Sida filiformis	Fire Sida, Fine Sida	LC				*	good	
	Spermacoce dolichosperma		LC				*		
	Spermacoce hillii		LC						
	Themeda triandra	Kangaroo Grass	LC					good	
	Triodia pungens	Soft Spinifex,	LC				*	good	

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
		Gummy Spinifex							
Ironstone Rocky Rise	*Triumfetta centralis*		LC		bioregional	SSD (eastern range limit)			
	Urochloa sp.		LC				*		
	Yakirra australiensis	Desert Flinders Grass	LC				*	good	
Land Unit: Limestone Outcrop **Regolith Unit:** Oucropping Dolomitic Facies	No Survey Sites Present								
Land Unit: Mudstone Outcrop **Regolith Unit:** Outcropping Hangingwall Mudstone	No Survey Sites Present								
Land Unit: Shallow Sand Plain	*Abutilon otocarpum*		LC				*		
	Acacia ancistrocarpa	Fitzroy Wattle, Pirraru	LC				*	good	
	Aerva javanica	Kapok Bush, Snow Bush	Int.				*		
Regolith Unit:	*Aristida holathera*	Erect Kerosene Grass, White Grass, Arrow Grass	LC				*	good	
Stabilised Aeolian Sand	*Aristida inaequiglumis*	Curly Wiregrass, Fire Grass, Unequal Three-awn	LC				*		
	Astrebla pectinata	Barley Mitchell Grass	LC						
	Atalaya hemiglauca	Whitewood	LC				*	good	
	Atriplex elachophylla		LC				*	good	
	Boerhavia coccinea	Tar Vine	LC				*	good	
	Capparis umbonata	Northern Wild Orange, Wild Orange, Bush Orange, Native Pomegranate	LC		bioregional	MGD (southern range limit)	*	good	
	Carissa lanceolata	Conkerberry, Conkle Berry, Kungsberry Bush	LC				*	good	
	Cenchrus ciliaris	Buffel Grass	INT				*	introduced species and not recommended	
	Chrysopogon	Golden Beard	LC				*	good	

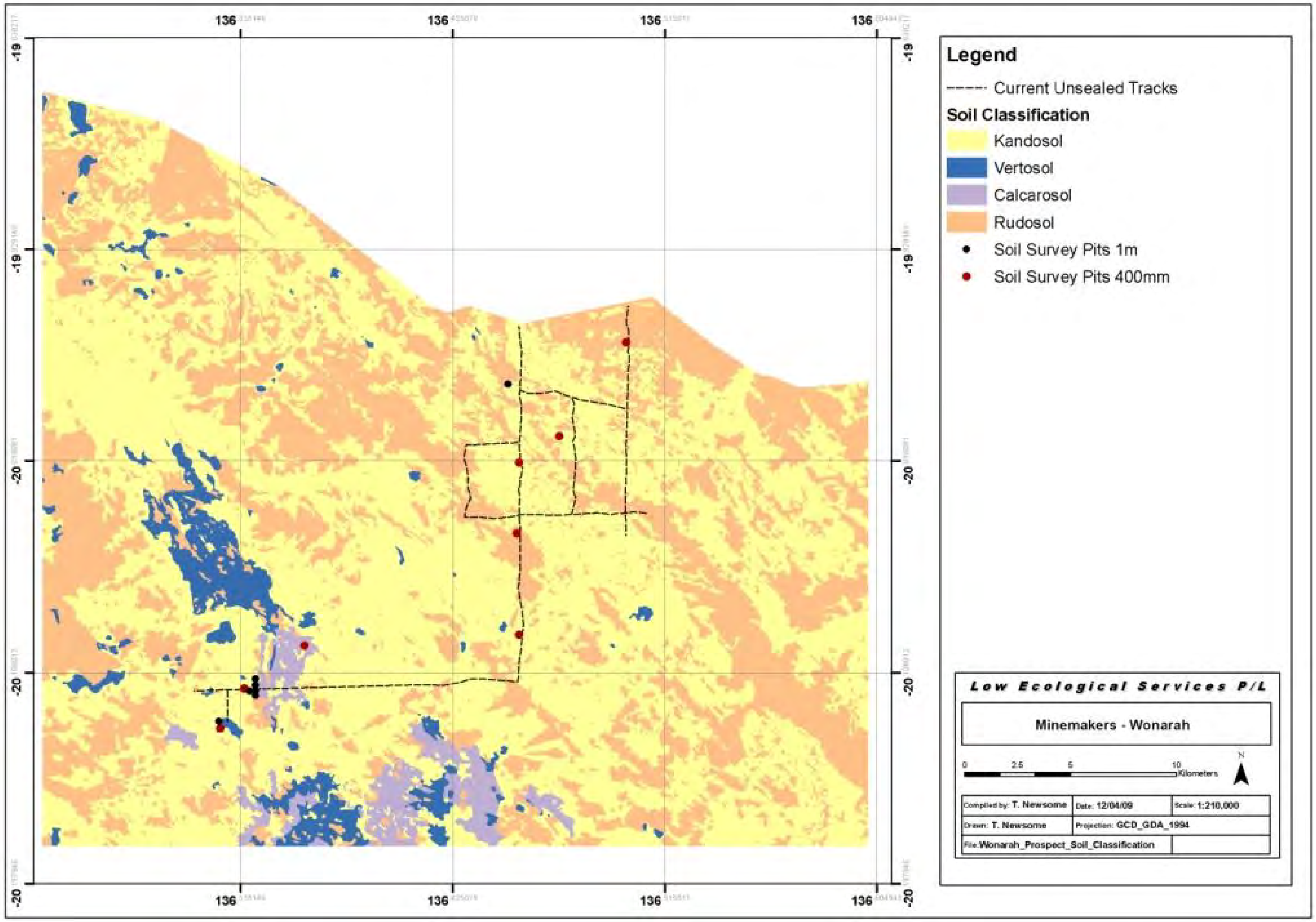
Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
	fallax	Grass, Ribbon Grass, Weeping Grass, Spear Grass							
Shallow Sand Plain	*Cleome viscosa*	Tickweed, Mustard Bush	LC				*		
	Crotalaria medicaginea		LC					good	
	Dactyloctenium radulans	Button Grass, Finger Grass, Toothbrush Grass	LC				*	good	
	Digitaria brownii		LC				*	good	
	Enneapogon polyphyllus	Woolly Oat-grass, Oat-grass, Leafy Nine-awn	LC				*	good	
	Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail	LC				*	good	
	Eremophila latrobei	Native Fuchsia, Latrobes Desert Fuchsia, Georgina Poison Bush	LC				*	good	
	Eremophila longifolia	Emu Bush, Weeping Emu Bush, Long-leaved Desert Fuchsia	LC				*	good	
	Eucalyptus gamophylla	Blue Mallee, Twin-leaved Mallee, Blue-leaved Mallee	LC		bioregional	TAN (northern range limit)	*	good	
	Eucalyptus microtheca	Coolibah	LC				*	good	
	Eulalia aurea	Silky Browntop, Sugar Grass	LC				*	good	
	Gossypium australe	Native Cotton, Tall Desert Rose	LC					good	
	Heliotropium ovalifolium		LC					good	
	Indigofera linifolia	Native Indigo	LC				*		
	Indigofera colutea		LC				*		
	Portulaca oleracea	Pigweed, Common Purslane, Munyeroo	LC				*	good	
	Psydrax latifolia	Native Currant, Orange Bush	LC				*	good	
	Ptilotus polystachyus	Long Pussy-tails	LC				*	good	
	Scaevola amblyanthera		LC				*	good	
	Scaevola ovalifolia	Bushy Fanflower	LC		bioregional	GSD (western range limit)		good	
	Senna artesmisioides ssp. oligophylla		LC				*	good	
	Tephrosia sp Barrow Creek		LC				*		

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Requirements
Shallow Sand Plain	*Tephrosia brachyodon*	Red Pea-bush	LC				*		
	Tephrosia lasiochlaena		LC		bioregional	MAC (southern range limit)			
	Trianthema pilosa		LC				*	good	
	Triodia intermedia	Winged Spinifex	LC		bioregional	DMR (disjunct and eastern range limit), BRT (disjunct and southern range limit)		good	well drained sites
Land Unit: Silcrete Rocky Rise	*Acacia adoxa*		LC				*	good	
	Acacia hilliana		LC				*	good	
Regolith Unit:	*Acacia lysiphloia*	Turpentine, Turpentine Bush, Turpentine Wattle	LC		bioregional	GSD (disjunct and southern range limit)		good	
Silcrete Breccia Duricrust	*Acacia monticola*	Hill Turpentine	LC		bioregional	CR (southern range limit)			
	Amphipogon caricinus	Grey-beard Grass, Long Grey-beard Grass	LC				*	good	
	Aristida holathera	Erect Kerosene Grass, White Grass, Arrow Grass	LC				*	good	
	Brunonia australis	Pincushion, Blue Pincushion	LC				*		
	Bulbostylis barbata	Short-leaved Rush	LC				*	good	
	Cassytha capillaris	Hairless Dodder-laurel, Snotty Gobble	LC				*		
	Corchorus sidoides	Flannel Weed	LC				*	good	
	Corymbia opaca	Bloodwood	LC				*	good	
	Corymbia setosa		LC				*		
	Eragrostis cumingii	Fairy Grass, Cumings Lovegrass	LC				*	good	
	Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail	LC				*	good	
	Eragrostis eriopoda subsp.		LC						

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
	Sandy fireweed (P.K.Latz 12908)								
Silcrete Rocky Rise	*Eucalyptus odontocarpa*	Sturt Creek Mallee	LC		bioregio nal	GSD (souther n range limit)	*	good	
	Eucalyptus pachyphylla	Red-bud Mallee	LC		bioregio nal	DMR (norther n range limit)	*	good	
	Eucalyptus pruinosa	Silver Box, Silver-leaf Box, Apple Box, Smoke Tree	LC				*		
	Fimbristylis simulans		LC		bioregio nal	DMR (eastern range limits)	*	good	wet areas
	Goodenia armitiana	Narrow-leaved Goodenia	LC				*	good	
	Goodenia ramelii		LC				*	good	
	Goodenia strangfordii		LC		bioregio nal	MGD (souther n range limit)		good	
	Gossypium australe	Native Cotton, Tall Desert Rose	LC				*	good	
	Grevillea dryandri subsp. dryandri	Dryanders Grevillea	LC					good	
	Grevillea refracta	Silver-leaf Grevillea	LC				*	good	
	Hakea lorea	Long-leaf Corkwood, Corkbark Tree	LC				*	good	
	Hakea macrocarpa	Flat-leaved Hakea	LC		bioregio nal	SSD (souther n range limit)		good	
	Heliotropium pulvinum		DD		Norther n Territor y	3K			
	Hybanthus aurantiacus		LC				*		
	Melaleuca viridiflora	Green Paperbark, Broad-leaved Paperbark, Large-leaved Paperbark	LC					good	
	Paraneurachne muelleri	Spinifex Couch, Northern Mulga Grass	LC				*	good	
	Petalostylis cassioides	Butterfly Bush, Petalostylis	LC				*	good	
	Polycarpaea spirostylis	Copper Plant	LC				*		
	Ptilotus calostachyus	Weeping Mulla Mulla	LC				*		
	Ptilotus calostachyus var. calostachyus	Weeping Mulla Mulla	LC						
	Ptilotus fusiformis	Skeleton plant	LC				*		

Land Unit	Species Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code	LES Survey	Rehab potential	Special Require ments
Silcrete Rocky Rise	*Ptilotus polystachyus*	Long Pussy-tails	LC				*	good	
	Schizachyrium fragile	Firegrass, Red Spathe Grass, Small Red-leaf	LC				*	good	
	Senna notabilis	Cockroach Bush	LC					good	
	Senna venusa	Graceful Cassia	LC				*	good	
	Setaria surgens	Brown Pigeon Grass	LC		bioregio nal	GSD (souther n range limit)	*	good	
	Sida filiformis	Fire Sida, Fine Sida	LC				*	good	
	Solanum chippendalei	Bush Tomato, Ngaru	LC					good	
	Spermacoce dolichosperma		LC				*		
	Triodia pungens	Soft Spinifex, Gummy Spinifex	LC				*	good	
	Triodia schinzii	Feathertop Spinifex	LC				*	good	
	Urochloa sp.		LC				*		
	Yakirra australiensis	Desert Flinders Grass	LC				*	good	

Appendix Forty-three: Soil map for the Wonarah prospect area.



Appendix Forty-four: Road building techniques for arid Australia to mitigate soil degradation.

Soil Erosion Recommendations

The susceptibility of soils and topography to potential erosion is outlined in Section 5.7. To protect the project area techniques must be utilised to minimise the risk of erosion and subsequent sedimentation; topography, drainage, soil erosion risk and vegetation all need to be considered. With any change in land use it is important to understand the impact altered drainage may have on the surrounding environment. When planning the development it is essential to have an understanding of the existing natural drainage not only on the site, but also in the surrounding catchment. Operations such as road building and clearing for construction can cause localized erosion such as sheet wash or gullying even on very gentle slopes. Major constructed drainage or formalized drainage, such as table and mitre drains, should not be required if careful consideration is given to the following issues:

- Identify any natural waterways (eg. drainage lines, creeks and rivers).
- Ensure receiving waterways and habitats are protected from the impacts of runoff (e.g. using buffer zones, filter strips).
- Ensure crossfall drainage is incorporated into roads. It is important that water can move across the roads unimpeded. Allowing natural cross flow will reduce the likelihood of erosion, sedimentation, ponding and water starvation of downslope vegetation.
- Ensure that the surfaces of roads are never below natural ground level. Roads constructed below ground level intercept natural sheet flows and watercourses, concentrating them and directing flows away from their natural paths.
- Ensure windrows are not created. Windrows concentrate and divert natural overland water flows causing erosion and sedimentation.

Soil erosion risk

While some types of soils are more susceptible to erosion than others, all areas cleared of vegetation are at risk of either water or wind erosion. Wind erosion of disturbed areas is of particular concern in the arid areas of the NT. Wind erosion may lead to permanent degradation and initiate a cycle of increased erosion and instability.

It is therefore desirable that the amount of soil exposed should be minimised at any one time. If extensive clearing is unavoidable, all land which is not to be used before the onset of the wet season in the tropical regions, or summer in the arid and semiarid regions should be stabilised. This should be done in advance of the onset of rainfall.

No works should be undertaken during or shortly after a rainfall event. The use of machinery on wet soils causes compaction and rutting, ultimately leading to an increased possibility of initiating erosion. All works should be suspended until the work area has dried out.

Site management

Timing and duration of construction

When planning construction it is recommended that a timeline be developed which takes into consideration all of the activities that will be undertaken. This is to ensure that the proposed commencement and completion dates are achievable and that disturbed areas which are temporary or not for immediate use are rehabilitated, or at least stabilised in the interim, prior to October in the tropics, and as soon as possible in the arid and semi-arid regions where rain is more unpredictable. If the development is of a scale where works will not be completed prior to this time, consideration should be given to staging the proposed works. Staging can reduce the cleared, disturbed or modified area to a more manageable size. It is important to remember that the larger the disturbed area, the more management and maintenance will be required to ensure erosion and subsequent sedimentation is minimised.

Erosion and sediment controls

The main issue, for erosion and sediment control, is to minimise disturbance of soil, vegetation and drainage during construction, and to promote site restoration following disturbance. Some factors which need to be taken into account when designing drainage or erosion control works are:

- The slopes, soil types, rainfall regime and vegetation present.
- River and creek crossings.
- Presence of existing erosion.
- The estimated maximum flows from expected rainfall events.
- Inspection and maintenance of control structures until the area becomes stable.
- Identification and flagging riparian vegetation to be avoided.
- Maintenance of cross flow (to prevent down slope water starvation). Drainage and erosion control can be achieved using a number of different techniques. Selection of a technique and the design of control structures need to be carefully considered to ensure the site are protected from erosion.
- Diversion banks should be constructed based on the degree of slope and erosion risk.

- Runoff is to be dispersed onto stabilised areas.
- Areas of construction identified as high erosion risk may require additional measures.
  - Cleared vegetation is not to be pushed into drainage lines.

Supplies and stockpiles

There are a few basic methods which can significantly reduce erosion of stockpiles and supplies and stop sediment entering waterways.

• Try to locate all stockpiles in a central area, on an open flat area and away from drainage lines and creeks.

• It is good practice for all stockpiles, no matter where they are located, to have controls such as sediment fencing installed a few metres from the base. This will minimise the risk of sediment leaving the stockpile area during rain events.

- All site debris and unused materials should be removed from the site.

Techniques for Erosion Control

Below are a number of structures and techniques which are commonly used to control erosion and sediment movement. Depending on the individual situation and the nature of the issue which requires control, only some of the measures may be suitable to a specific situation. Commonly used structures and techniques for erosion and sediment control are detailed below.

Temporary measures

Please note that some of the following temporary measures are only implemented in the tropical regions of the NT. In the arid and semi-arid regions only permanent measures are used.

- Diversion banks
- Sediment fence
- Coir logs

Permanent measures

- Diversion banks

Maintenance

Monitoring should be carried out on a regular basis. It is good practice to monitor the effectiveness of erosion and sediment controls regularly throughout the duration of the development, even in periods of dry weather. A standard monitoring schedule should include checks as follows:

- At weekly intervals.
- Following each rain event after the ground has dried out (in the arid and semi-arid regions).
- Following each storm event (in the tropical region).

Maintenance schedule

There are a number of actions that should be incorporated into a maintenance schedule during construction and throughout the life of the project. These include:

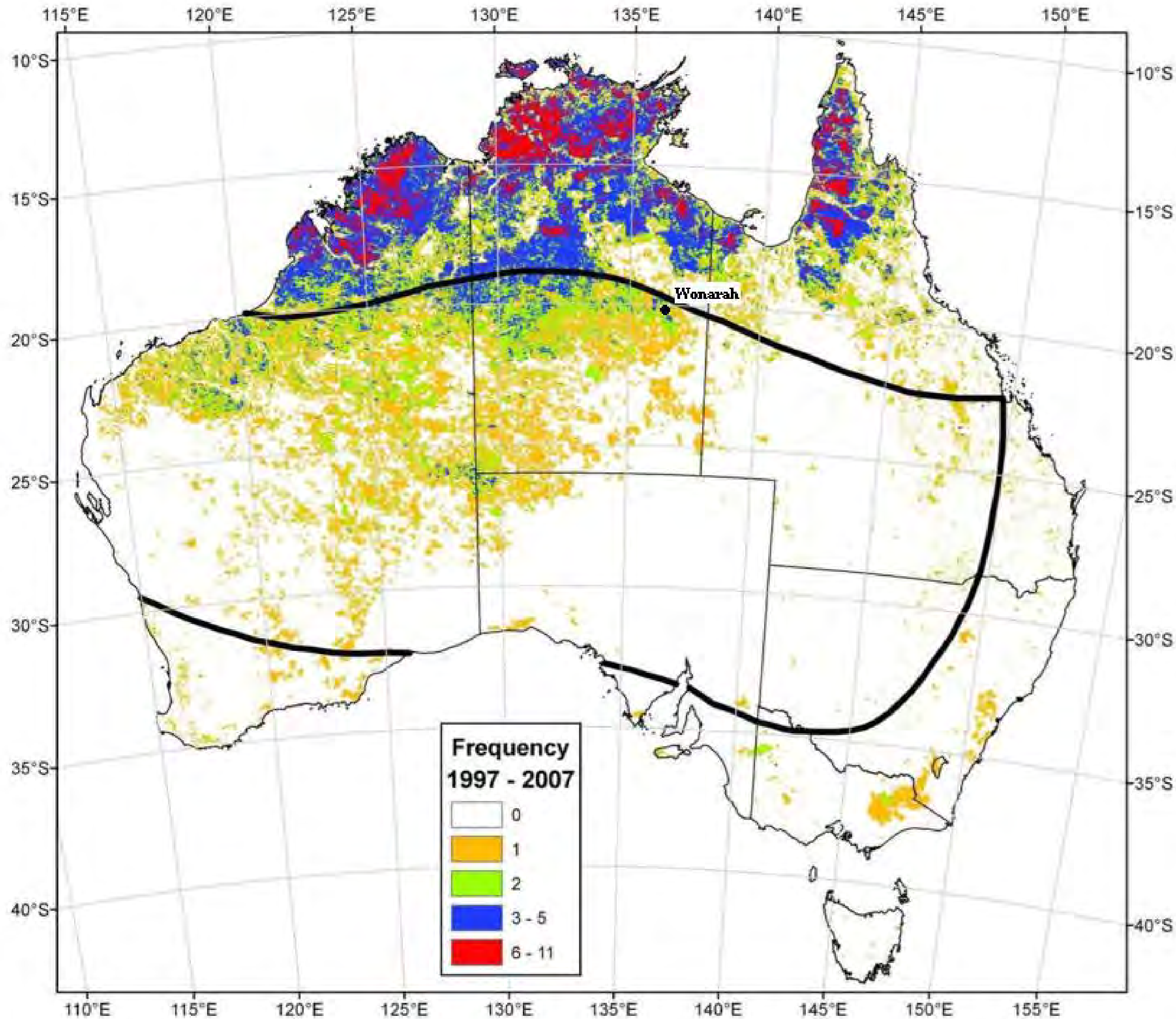
- Repair erosion control structures if and when necessary.
- Ensure that natural drainage is maintained down slope of disturbed areas by using whoa boy dispersion banks and off let drains to facilitate cross road drainage.

It is important to note that workers do NOT attempt to tidy up areas that are currently well vegetated or stable. This will unnecessarily leave new areas exposed.

Appendix Forty-five: Winrows located within the Wonarah Phosphate Project area.

Winrows were recorded during the Wet Season 2009 survey. These were located along the existing exploration track between the Main and Arruwurra prospects, within the Shallow Sand Plain land unit at coordinates (S20.11501 E136.38703). Winrows trap water and prevent natural drainage and their formation should be avoided. Whoah boy diversion banks and off let drains should be installed to facilitate cross road drainage.

Appendix Forty-six: Fire frequency within Australia between 1997 and 2007. Source: NT Bushfires Council.



Appendix Forty-seven: Rio Tinto's procedure for protecting Sporobolus latzii on the Wonarah tenements.

Background
Sporobolus latzii is potentially located on RTE-AR Wonarah tenements. The characteristics of this species are:

Significance
National 1K

Life Form
Erect perennial grass

Habitat
Known to occur in seasonal swamps with clay soils.

Distribution
May be endemic to the study region. Known only from a single location in the Wakaya Desert, in the east of the Tanami Bioregion.

Notes
Little known about this recently described species. Need to search areas of similar habitat to determine the conservation status of the species.

Issues
Due to the poor taxonomic recording of *Sporobolus latzii* the species is classed as having conservation significance. The only collected specimen was on a seasonal swamp clay area in the Wakaya Desert region, on the eastern portion of the Tanami Bioregion. The RTE-AR Wonarah tenement area is located in this region. Therefore, it is important that all RTE-AR activities conducted in this region do not disturb the habitat and communities of *Sporobolus latzii*.

Field Procedure
Habitat Identification
A ground survey will be conducted with maps to identify the potential habitats where the species are found. This will involve ground truthing the areas, identified on maps, located on the RTE-AR tenements as clay pan seasonal swamps habitat types. These areas will be clearly demarcated and recorded. Monitoring stations will be set up at these sites according to ENVT104 Site Monitoring.

Field Personnel Induction
It is fundamental that all personnel in the field are made aware of the situation. All personnel will be:
• Briefed on the conservation significance of *Sporobolus latzii*.
• Provided with a description of the plant
• Made familiar with the designated 'no-go areas' on the tenement

Appendix Forty-eight: Managing Dingoes within the proposed Wonarah Phosphate Project (WPP).

Minemakers Australia Pty Ltd (Minemakers) proposes to establish the Wonarah Phosphate Project (the project) to mine phosphate rock, in the Barkly region, Northern Territory. This will require establishment of a mine camp. Without appropriate strategic management, it is likely that the WPP will attract dingoes, affect these animals' natural behaviour and lead to negative human-dingo interactions. This is because dingoes are naturally inquisitive and opportunistic animals, and because many local dingoes conceivably already associate human activity with the provision of key resources.

The guiding principle for effective dingo management within the WPP should be:
No food, water or shelter for dingoes

Adherence to this principle by staff, contractors and visitors will significantly reduce the likelihood of negative interactions between humans and dingoes. To avoid likely problems developing in the future, this principle must be incorporated into the planning, construction and operational phases of the WPP. Proactive management of food, water and shelter availability will reduce future problems.

<u>Food Management</u>

No human-provided food should be available to dingoes.

Recommended Actions – WPP Planning Phase:

- Ensure supply of sufficient wildlife-proof bins to manage waste securely during the construction and operational phases.
- Ensure adequate waste removal and processing during the construction and operational phases.
- Provide staff time and resources to ensure that food management actions can be implemented during the construction and operational phases.
- Ensure agreements with staff and contractors include full compliance with food management actions during the construction and operational phases.

Recommended Actions – WPP Construction Phase:

- Make appropriate waste management a condition of working on and/or visiting the WPP site.

- Specifically, ensure that staff, contractors and visitors do not provide food directly, or indirectly, to dingoes or other wildlife.
- Install wildlife-proof bins on-site prior to the commencement of construction activity.
- Position bins appropriately relative to construction activity to increase likelihood of use.
- Ensure that all food/drink rubbish is immediately placed in the wildlife-proof bin.
- Remove food-drink rubbish to existing burn-tips on a schedule that prevents bins overflowing.
- Ensure staff and contractors perform a daily clean-up of their work areas to prevent dingoes from accessing food/drink rubbish.
- Minemakers should perform weekly inspections of construction areas to ensure staff, contractors and visitors comply with the waste management strategy.

Recommended Actions – WPP Operational Phase:

- Ensure staff, contractors and visitors do not provide food directly, or indirectly, to dingoes or other wildlife.
- Install wildlife-proof bins on-site prior to human habitation/operation. Provide areas where food and/or drink is likely to be consumed with additional wildlife-proof bins, e.g. outside dry mess, wet mess, BBQ areas etc.
- Actively encourage all staff, contractors and visitors to place food/drink rubbish in these bins.
- Remove all rubbish to landfills/processing areas daily, or more regularly if necessary, to prevent bins from overflowing.
- Schedule regular camp-wide clean-ups within the staff roster.
- Minemakers should regularly inspect the camp to ensure that personal items, such as boots, gloves, clothes etc. are not left outside rooms.
- Minemakers should constantly review compliance with the waste management strategy across the entire WPP site.

Water Management

Water management should focus on preventing water becoming available rather than preventing animals from accessing available water.

Recommended Actions – WPP Planning Phase:

- Provide staff and resources to ensure that water management actions can be implemented during the construction and operational phases.
- Ensure agreements with staff and contractors include full compliance with water management actions during the construction and operational phases.
- Ensure staff and contractors are aware of the requirement to seek approval from the Senior Environmental Officer to accumulate water in dams, ponds, open tanks etc.
- Ensure provision is made for dispersal of water resulting from leaking taps, cracked pipes, etc.

Recommended Actions – WPP Construction and Operational Phases:

- Ensure appropriate water management is made a condition of working on and/or visiting the WPP.
- Specifically, staff, contractors and visitors must not provide water directly, or indirectly, to dingoes or other wildlife.
- Ensure water is not accumulated (for example in dams, ponds, open tanks, troughs, or similar holdings) without prior approval from the Senior Environmental Officer. Such approval should be dependent upon both: i) necessity, and ii) a viable strategy for not attracting dingoes or other wildlife.
- Ensure leaks, e.g. dripping taps/pipes are fixed as a high priority.
- Ensure water that accumulates as a result of leaks (e.g. from dripping taps, cracked pipes etc.) is dispersed to facilitate rapid evaporation/infiltration.
- Ensure Minemakers regularly inspect the site to ensure staff, contractors and visitors comply with water management actions.

Shelter Management

Available shelter provides an incentive for dingoes to use an area, especially females seeking den sites. Minemakers should ensure that artificial shelter is not readily available to dingoes on the WPP site. Effective barriers will be important for preventing adult and juvenile dingoes from entering spaces underneath buildings. In designing and installing barriers, animal welfare must be a high priority, e.g. ensure there are no sharp edges or opportunities to become entangled or trapped.

Recommended Actions – WPP Planning Phase:

- Design the WPP to minimise opportunities for providing shelter to dingoes.

- In particular, provide staff time and resources to ensure that shelter management actions can be implemented during the construction and operational phases.
- Ensure agreements with staff and contractors include full compliance with shelter management actions during the construction and operational phases.

Recommended Actions – WPP Construction and Operational Phases:

- Ensure that (when it is practical to do so) building materials are stacked/stored so that shelter is not created for dingoes.
- Ensure building waste that could provide shelter to dingoes is removed regularly. In the interim any such waste should be stacked/arranged to limit its attractiveness to dingoes.
- Ensure that barriers preventing dingoes entering spaces underneath buildings are installed and regularly maintained.
- Hazing of dingoes (i.e. scaring dingoes to deter them from the area) should only undertaken by Minemakers with the approval of the Senior Environmental Officer.
- Minemakers regularly audit the site to ensure staff, contractors and visitors comply with the shelter management strategy.

Appendix 4

Desktop Flora and Fauna Assessment: Proposed Borefield and Water Pipeline

Minemakers Wonarah Phosphate Project

Desktop Flora and Fauna Assessment:

Proposed Borefield and Water Pipeline

Prepared for

Coffey Natural Systems

By

Tom Newsome and Dr Bill Low

Low Ecological Service P/L

P.O Box 3130

Alice Springs 0871

November 13th 2009

Summary

Minemakers Australia Pty Ltd (Minemakers) is currently in the development stage of their Wonarah Phosphate Project, located in the Barkly Tableland region of the Northern Territory (NT). Following on from flora, fauna and landscape surveys completed in June 2008 and March 2009, Low Ecological Services P/L (LES) was commissioned to undertake a desktop flora and fauna assessment of a proposed borefield and water supply pipeline, which will service the operations. The proposed borefield is located to the north of the Wonarah Phosphate Mineral Lease and consists of two existing production bores and three new production bores.

The borefield is located within the Mitchell Grass Downs Bioregion and the pipeline is located mainly within the Davenport and Murchison Ranges bioregion, it also occurs within part of the Wonarah Beds site of botanical significance.

Applicable NT (Parks and Wildlife Flora and Fauna Atlas) and Federal databases (Protected Matters Search from the Department of Environment Heritage and the Arts) were interrogated for presence of species listed under the TPWC Act or EPBC Act for conservation significance within a 50 km radius of the proposed borefield. Data collected by Low Ecological Services in 2008 and 2009 were also incorporated into the search.

The review of environmental factors identified the following key issues within the search area that may require management during the construction and operation of the borefield and pipeline.

- The proposed pipeline is located within the Wonarah Beds site of botanical significance where White *et al.* (2000) identify a number of rare (but not formally listed) flora species;
- Nine flora species were listed as data deficient under the TPWC Act;
- Five flora species were listed as near threatened under the TPWC Act;
- Eleven introduced (and possibly more) flora species could occur;
- Two fauna species were listed as vulnerable under the EPBC and/or TPWC
- Five fauna species were listed as near threatened and two as data deficient under the TPWC Act;
- Eight migratory bird species listed under the EPBC Act; and,
- Five (and possibly more) introduced fauna species could occur.

Whilst the review of environmental factors did not identify any species or habitats of high ecological or conservation significance within the area surrounding the proposed borefield and pipeline, the following should be taken into consideration:

- There were very few flora or fauna records within the Black Soil Plains habitat around the borefield and this habitat type**.** LES did not survey this habitat type in detail in SEL26452.

Where possible the pipeline Right of Way should divert around the following areas:

- Wetland and swamps;
- Grey clays and black soils plains (due to cracking clay construction stability issues); and,

- Any low lying areas subject to frequent inundation with water.

During the construction and operational phase of the project, the following should be considered when developing the construction and environmental management plan:

- The borefield and pipeline should be built so that there is no free standing water, regardless of whether or not it is fenced off;
- The amount of trench open at any one time should be minimised;
- Lateral ramps should be installed in the trench to allow for fauna to escape;
- Trenches must be examined daily to remove any fauna trapped in the trenches;
- If any animal is caught in the trench it should be removed asap and a system of photographing and recording should be developed (note that the 1983 NT Gas Pipeline project provided some of the best fossorial fauna data in the NT);
- When closing the trench no soil mounds or trenches should be left to minimise impact on surface water flow;
- Erosion control features should be installed as necessary along with flat bottom (not V) offlet drains or diversion bunds at intervals relative to the slope;
- No winrows should be left along the pipeline or adjacent service track;
- An audit should be conducted by an experienced consultant at the start, middle and end of the project;
- A flora, fauna and landscape management induction should be given to all contractors.

Contents

Figures

Tables

1. Introduction

Minemakers Australia Pty Ltd (Minemakers) is currently in the development stage of their Wonarah Phosphate Project, located in the Barkly Tableland region of the Northern Territory (NT). Following on from flora, fauna and landscape surveys completed in June 2008 and March 2009, Low Ecological Services P/L (LES) was commissioned to undertake a desktop flora and fauna assessment of a proposed borefield and water supply pipeline which will service the operations.

The proposed borefield is located to the north of the Wonarah Phosphate Mineral Lease and consists of two existing production bores and three new production bores (Figure 1). The estimated area of disturbance around each bore site is 30 m x 30 m and each bore will be fenced. The final route or Right of Way (ROW) for the water supply pipeline will run in the most direct line from the borefield to the Mineral Lease (ML). The ROW construction area for the pipeline will be 25 m wide with an operational area of 4.5 m (or the width of a light vehicle track) which will provide access to service the pipeline after construction.

The purpose of this desktop assessment is to review existing data to determine flora and fauna that are likely to be disturbed by the construction and operation of the borefield and associated water supply infrastructure and to identify areas to avoid.

2. Bioregional Context

The proposed borefield lies in the Mitchell Grass Downs Bioregion which is described by Baker *et al.* (2005) as "Georgina and Dunmurra Basins containing sedimentary rocks of Cretaceous, Tertiary and Cambrian ages and soils are predominantly cracking clays. The vegetation is predominantly *Eucalyptus microtheca* low open-woodland with bluebush (*Chenopodium auricomum*) sparse shrubland understorey, and mitchell grass (*Astrebla*) grassland on the Barkly Tableland. The southern section contains gidgee (*Acacia georginae*) low open woodland with Astrebla open grassland understorey. Drainage in the tableland is complex, with a number of short creeks and rivers flowing toward several large seasonal lakes, while the Rankin and Georgina Rivers flow southeast of the bioregion".

The proposed pipeline lies within the Davenport and Murchison Ranges bioregion, which Purdie *et al.* (2008) describes as being "dominated by rugged rocky hills of folded volcanics, sandstone, siltstone and conglomerates. Soils are generally shallow lithosols, however deep fine-grained alluvial soils occur in the valleys and surrounding plains. Vegetation communities are dominated by spinifex (Triodia sp.), hummock grassland and low eucalypt and acacia open woodland".

The water supply pipeline overlies the Wonarah beds site, which is classified as significant on a bioregional scale by the NRETAS Parks and Conservation Masterplan (Figure 2). White *et al.* (2000) describe the Wonarah beds as low rises of chert chalcedony, tertiary travertine, silicified coquinite and limestone, and outcrops of Cambrian dolomite framed in a sandplain. The beds occur over a very large area and values of this site may not be unique and extend over a much larger region. The distinctive undulating feature is unique to the Wakaya desert to the west of the area and contains the only known collection site of *Sporobolus latzii* and is a type location for *Acacia drepanocarpa subsp. latifolia*. No ecosystems in the greater bioregion have been formally listed as threatened.

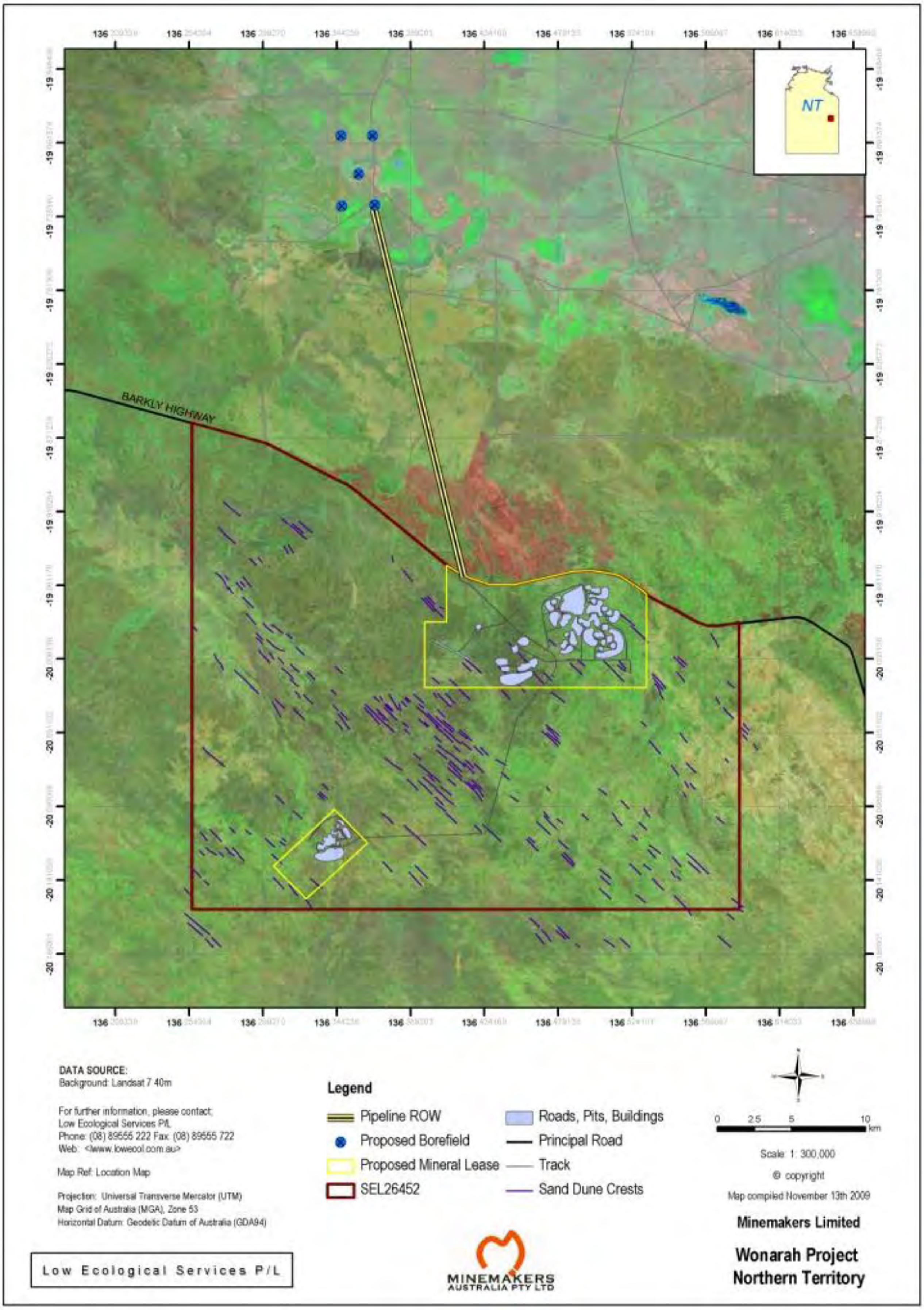


Figure 1: Proposed borefield and water pipeline in relation to the Wonarah Mineral Lease

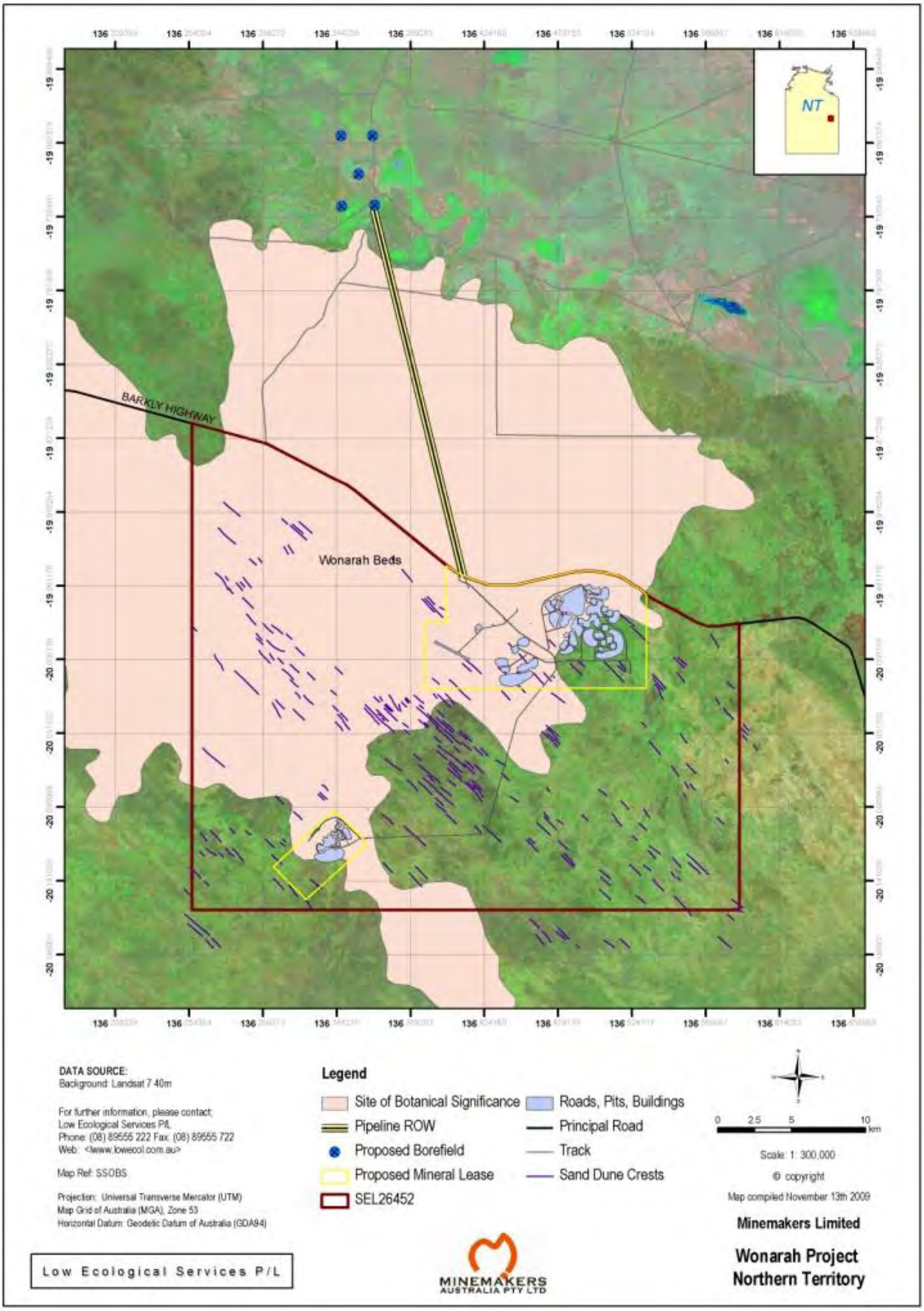


Figure 2: Wonarah Beds Site of Botanical Significance in relation to the proposed borefield and water pipeline

2.1. Landforms Physiography and Geology

The physiography of the project area has been described by Noakes and Traves (1954). The area is noted for general low relief of the landscape although small bevelled chert/silcrete rocky outcrops are locally common. Surface flow in the area is relatively disorganised, with no significant water courses present. More detailed geological information is available as a result of the considerable mineral exploration work in the region by Minemakers and its predecessors over the last 45 years.

2.2. Landsystems

Stewart *et al.* (1954) (Barkly Region) and Perry *et al.* (1962) (Southern NT) broadly mapped the Landsystems (LS) of the region (Figure 3). Low Ecological Services (see Moon *et al.* 2009) provided detailed LS mapping (based on regolith units) south of the proposed borefield and pipeline in SEL26452 (see Figures herein for location of SEL26452) and extension of this mapping to the north is possible. However, in this report (due to time restraints) we only provide reference to the broader land units.

The borefield is located within the Barkly LS and Wonarah/Barkly LS and the proposed pipeline traverses the Wonarah/Barkly LS and Yelvertoft LS (Figure 3).

Stewart *et al.* (1954) describe the Barkly LS as gently undulating to nearly flat with *Astrebla pectinata* (mitchell grass) plains covering much of the area and the Yelvertoft LS as undulating, with mostly skeletal soils and truncated gravelley lateritic red earths; *Eucalyptus brevifolia* or *E. dichromophloia* woodlands.

Stewart *et al.* (1954) describe the Wonarah LS as gently undulating with lateritic red earths and *Eucalyptus brevifoli*a woodland or *Eucalyptus*. spp (low mallees) – Acacia spp. shrubland. Perry *et al.* (1962) describe the Wonarah LS as gently undulating plains with stonier higher parts and broad lowlands, relief mainly up to 30 ft; red clayey sands and red earths, partly lateritic; soft spinifex with sparse shrubs and low trees.

2.3. Soils

The Bureau of Rural Sciences (1991) broadly mapped the soils in the region (Figure 4). Low Ecological Services (see Moon *et al.* 2009) provided more detailed soil mapping (following Isbell 1996) south of the proposed borefield and pipeline in SEL26452 and extension of this mapping to the north is possible. However, in this report (due to time restraints) we only provide reference to the to the broader soil mapping.

Soils in the proposed pipeline and borefield area fall within soil classes CC61, By4 and My80 (Figure 4). CC61 is described as flat to gently undulating plains of grey clays interspersed with low undulating rises of red earths. Using the Australian Soil Classification (Isbell 1996) the units are likely to be made of Epicalcareous Endohypersodic grey Sodosols, Vertosols (grey clays) and red Dermosols (red earths).

By4 is described as undulating ridge and slope terrain on lateritic sediments; some rock outcrops: chief soils are shallow sands usually containing large amounts (>60%) of mixed and variable gravels or ironstone gravels and also uniform coarse sands with some gravels on ridges and upper slopes generally. Associated are shallow to deep varieties of loose red siliceous sands and the previous incorporating large amounts (> 60%) of mixed and variable gravels, neutral red earths and gravelly red neutral massive earths on mid and lower slopes. Small areas of other soils are likely. By4 occurs across much of the SEL26452 where Moon et al. (2009) divided the soils into Kandosols, Vertosols, Calcarosols and Rudosols.

My80 contains gently undulating plains slightly elevated above the adjoining cracking clay plains; some narrow ridges and hills with rock outcrop and some shallow depressions. The dominant soils on the long gentle slopes and low rises are neutral red earths with a variable content and surface scatter of ironstone gravels. Associated are sands with coherent red and yellow earthy subsoils (on slopes and in depressions; loamy massive earths incorporating neutral red earths and acid yellow earths marginal to the cracking clay plains; and some shallow gravelly and stony coarse sands on ridges and hills. My80 occurs only in the north-western edge of SEL26452 where the unit was divided into Kandosols, Vertosols and Rudosols by Moon *et al.* (2009)

2.4. Flora

ARC/INFO coverage for the 1:1,000,000 NT vegetation map based on Wilson *et al.* (1990) indicates that the vegetation in the borefield and pipeline area falls within Class 42 L1H3, Class 107 Z2G3 and Class 96 G3 (Figure 5).

Class 42 L1H3 is described as encompassing *Corymbia opaca*, (bloodwood), low open-woodland with *Triodia pungens* (soft spinifex) hummock grassland understorey. L1 is a structural formula referring to lifeform and height of trees <10m tall with a density (projective foliage coverage) of 1-9%. H3 is a structural formula referring to lifeform and height of hummock grassland with a density (projective foliage coverage) of 30-69%.

Class 107 Z2G3 is described as chenopod low sparse shrub/forbes land with Chenopodium auricomum (bluebush) low open-shrubland with ephemeral grassland understorey. Z2 is a structural formula referring to lifeform and height of shrubs < 2m tall with a density (projective foliage coverage) of 10-29 %. H3 is a structural formula referring to lifeform and height of hummock grassland with a density (projective foliage coverage) of 30-69%.

Class 96 G3 is described as *Astrebla pectinata* (mitchell grass) grassland. G3 is a structural formula referring to lifeform and height of tussock grass with a density (projective foliage coverage) of 10-29 %.

Within the Wonarah beds site, White *et al.* (2000) identify three taxa of Australian significance (*Bonamia alatisemina, Rothia indica subsp australis* and *Sporobolus latzii*) six taxa of NT significance (*Distichostemon barklyanus*, *Heliotropium ballii*, *Heliotropium pulvinum*, *Najas marina*, *Triumfetta centralis*, *Triumfetta deserticola*), one taxa of southern NT significance (*Grevillea dryandri subs. dryandri*) and four taxa of bioregional significance (*Eragrostis olida*, *Exocarpos sparteus*, *Isoetes muelleri*, and *Tephrosia stuartii*).

A biological survey of the Wakaya Desert was undertaken by the Department of Natural Resources Environment Arts and Sports (NRETAS) in the early 1990's. Important species data from this survey have been entered in the NT Flora and Fauna Atlas (2008) which have been included in this report below.

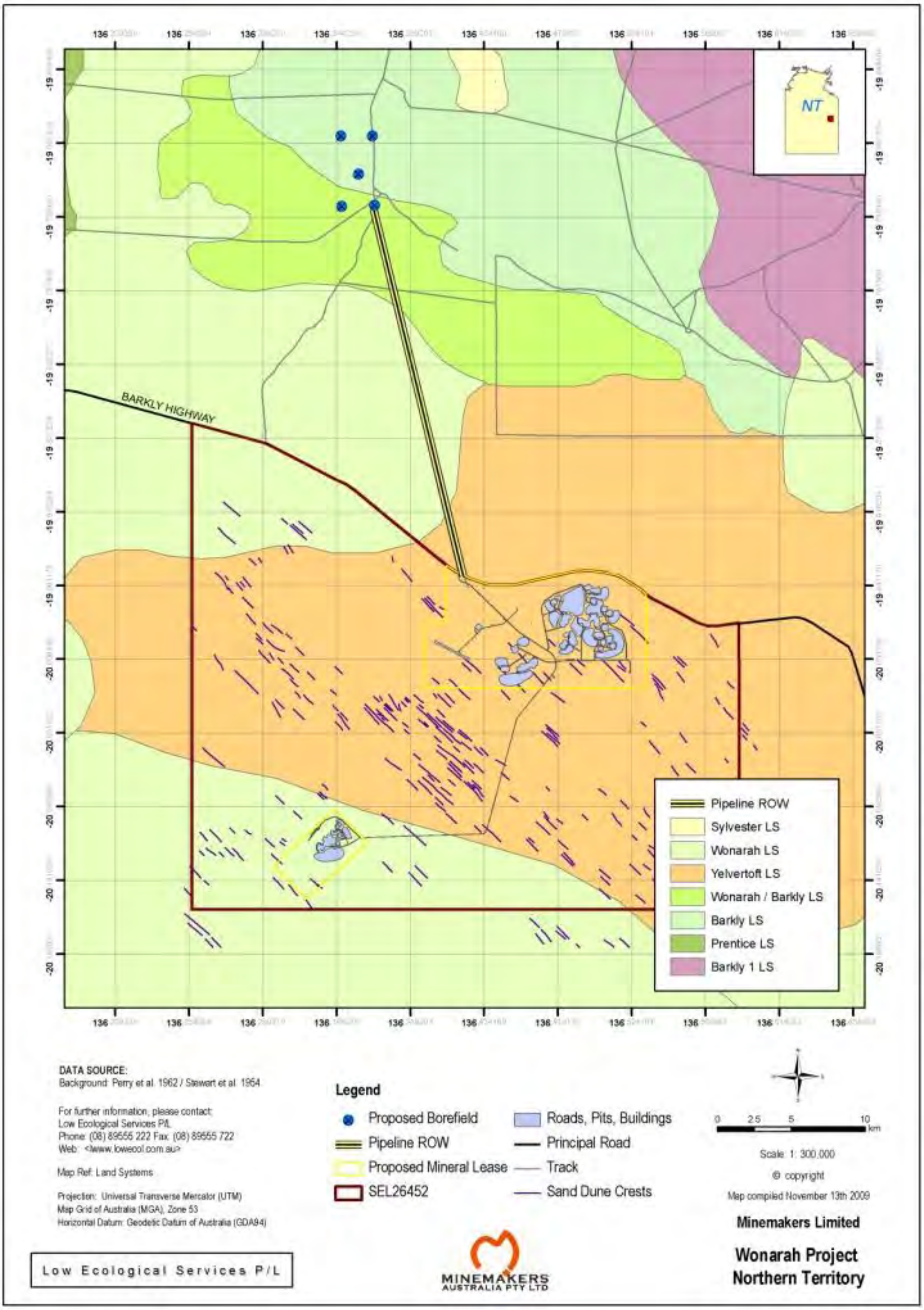


Figure 3: Landsystems (LS) of the area surrounding the proposed borefield and water pipeline. Modified after Stewart *et al.* (1954) and Perry *et al.* (1962)

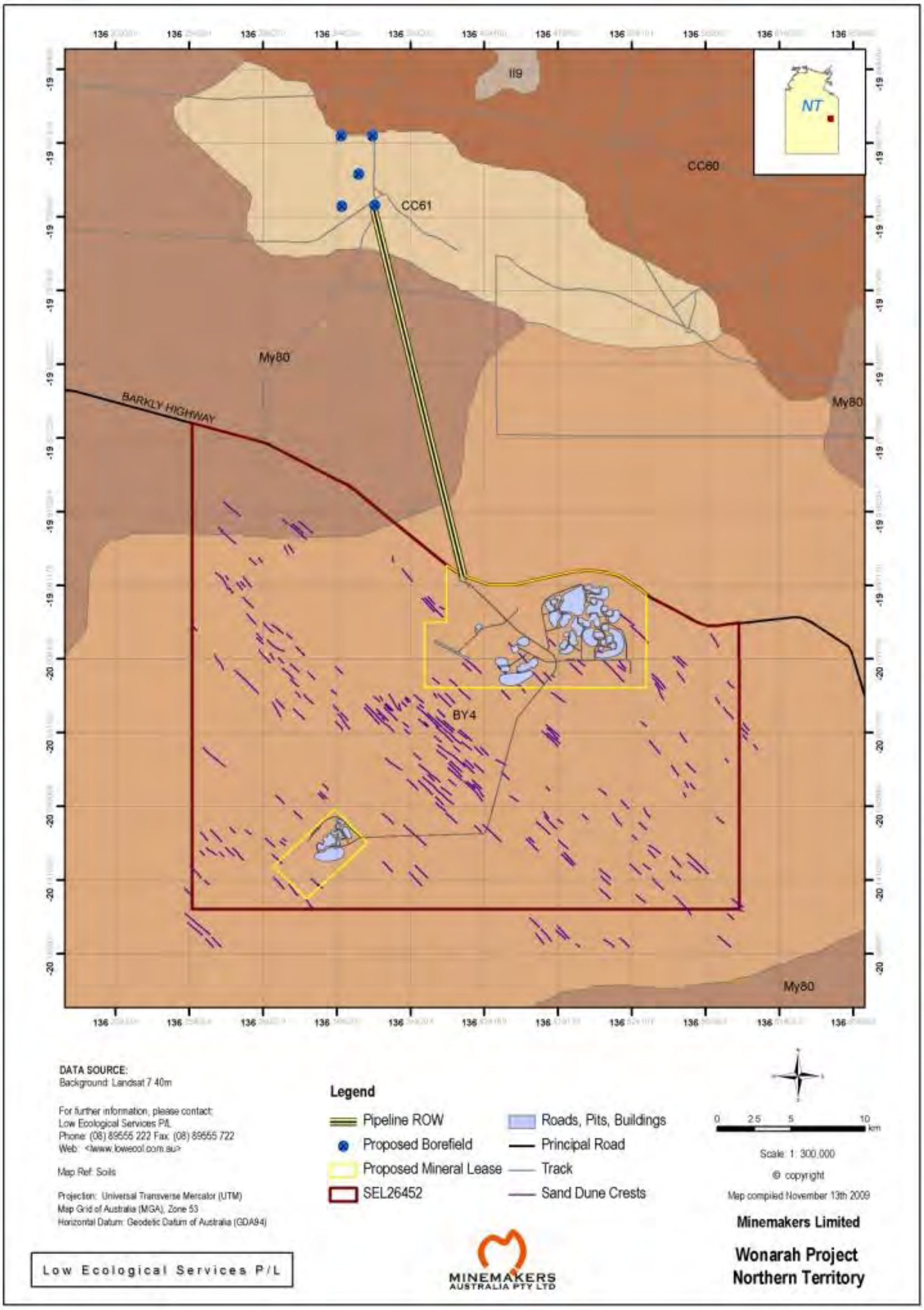


Figure 4: Soils of the area surrounding the proposed borefield and water pipeline. Modified after Bureau of Rural Sciences (1991)

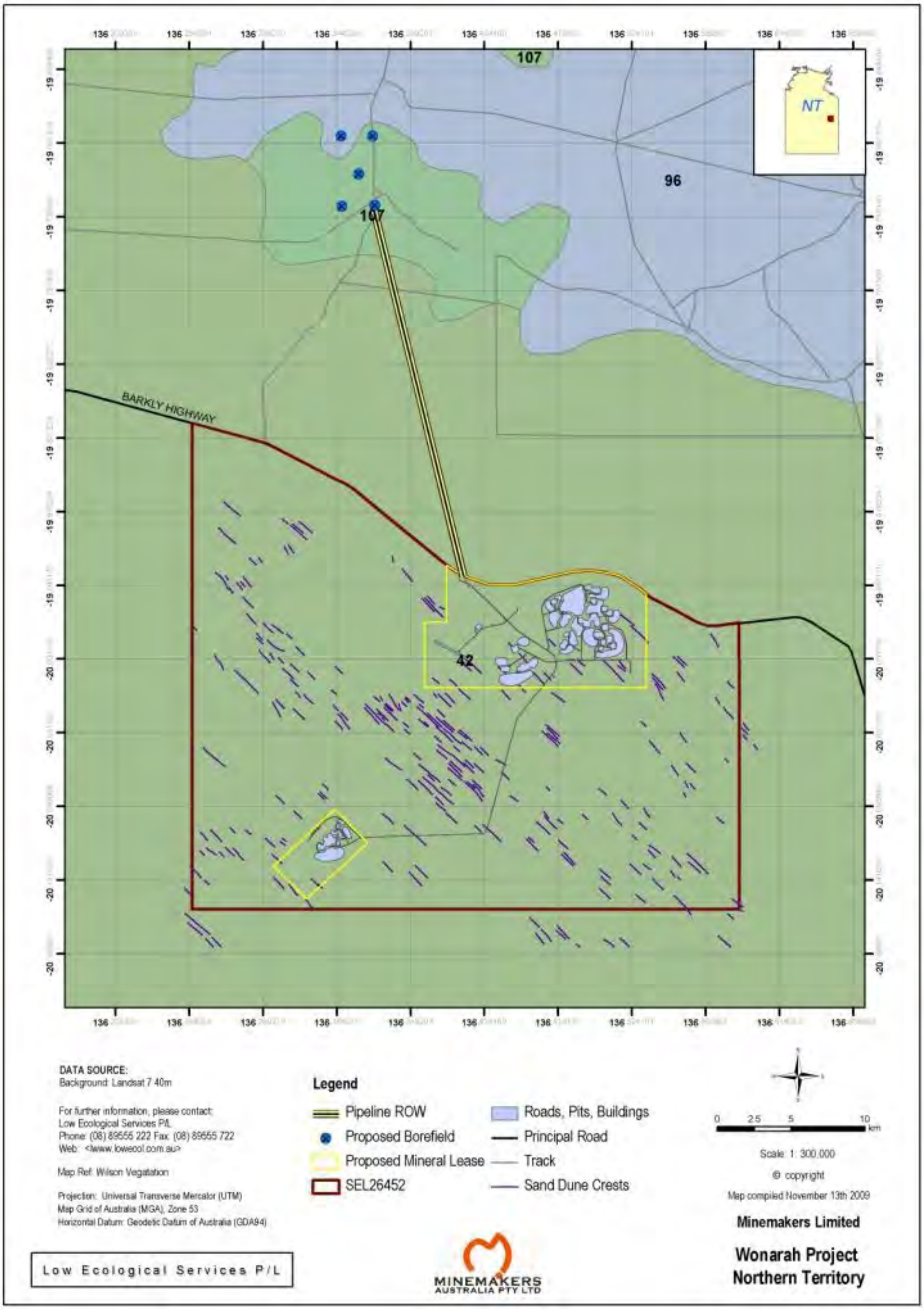


Figure 5: Arc/Info coverage for vegetation classes of the area surrounding the proposed borefield and water pipeline. Modified after Conservation Commission of the NT (1991). See text for descriptions coded by numbers 42, 96 and 107.

3. Database Searches and Survey Data

3.1. Flora

3.1.1 Protected Matters Search

A protected matters report generated from the Department of the Environment Water Heritage and the Arts (DEWHA) web site (21st October 2009) within a 50 km radius of the proposed borefield was undertaken (Appendix 1). The borefield was chosen as the centre for this search to take in the black soil plain country, which was not represented well in the areas to the south where LES completed detailed flora surveys.

No flora species listed under the Environment Protection and Biodiversity Act 1999 (EPBC Act) or Territory Parks and Wildlife Conservation Act 2000 (TPWC Act) were identified within the search area.

3.1.2 NT Atlas

A search of the NT Parks and Wildlife Flora Atlas (2008) for the same area as the protected matters report identified 611 records of 296 species (Appendix 2 and Figure 6). Note that there are very few flora records near the proposed borefield and northern end of the pipeline (Figure 6).

No flora species listed under the EPBC Act or TPWC Act were identified at or above Vulnerable Status although nine species were listed under the TPWC Act as data deficient and/or by Baker et al. (2005) as significant at a NT or National level. A further three species were listed as near threatened under the TPWC Act and by Baker et al. (2005) as significant at National level (Table 1).

Table 1: Flora identified by the NT Parks and Wildlife Flora database within a 50 km radius of the proposed borefield (see Appendix 2 for key to conservation codes)

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Bonamia alatisemina		dd		National	3K
Distichostemon barklyanus		dd		Northern Territory	3k
Heliotropium ballii		dd		Northern Territory	3k
Heliotropium pulvinum		dd		Northern Territory	3K
Pennisetum basedowii	Asbestos Grass	dd		Northern Territory	3k
Senecio depressicola		dd		Northern Territory	3k
Sesbania simpliciuscula		dd		Northern Territory	3k
Sporobolus latzii		dd		National	1K
Triumfetta deserticola		dd		Northern Territory	3k
Dentella minutissima		nt		Northern Territory	3rC-
Najas marina	Prickly Waternymph, Prickly Naiad	nt		Northern Territory	3rC-
Potamogeton pectinatus	Fennel Pondweed, Sago Pondweed	nt		Northern Territory	3r

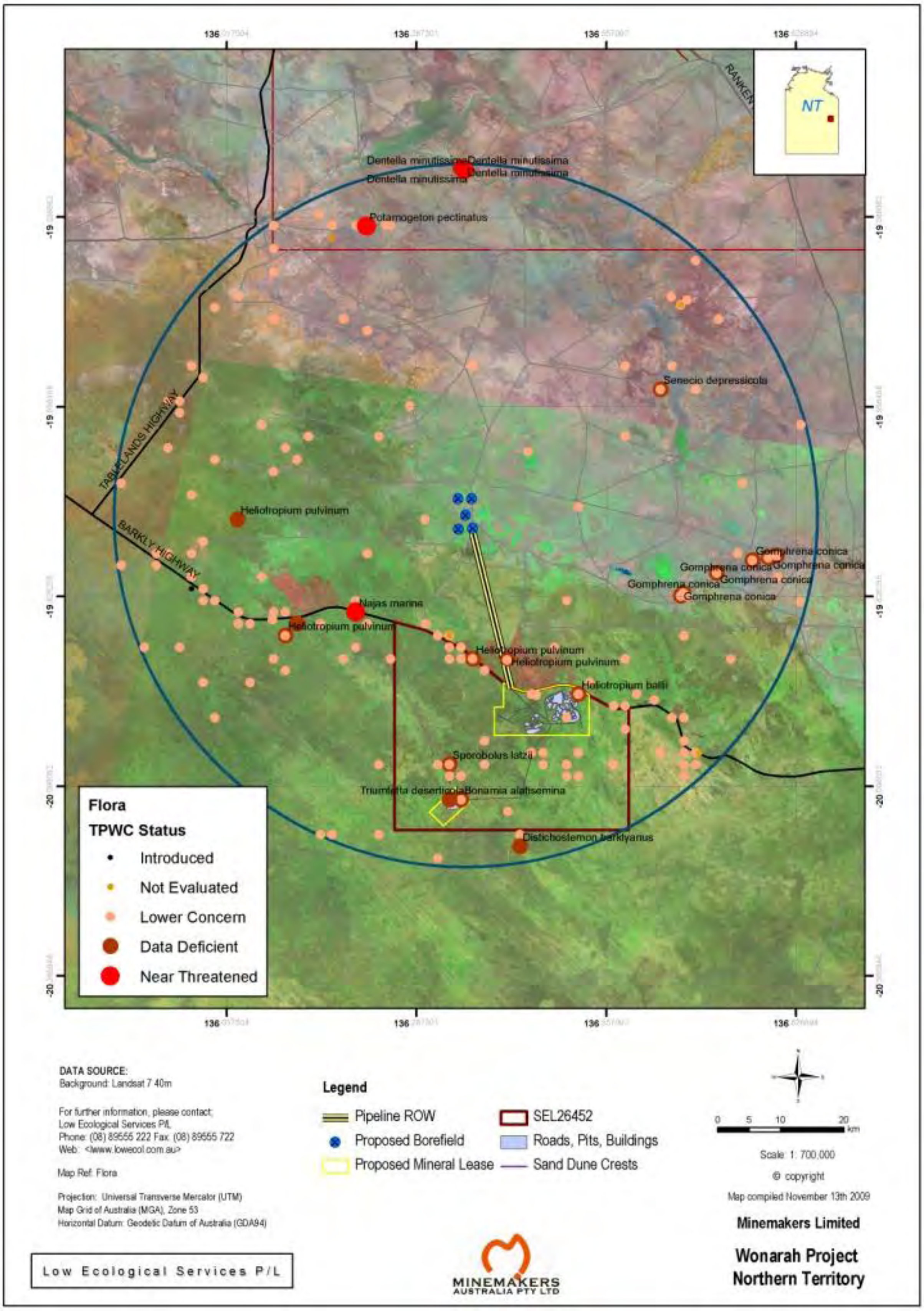


Figure 6: Locations of NT Parks and Wildlife Flora Atlas records within a 50 km radius of the proposed borefield. Species names are for records which have a status of data deficient or near threatened.

Note: Some sites have multiple species records so this figure is a guide only. Appendix Two provides a key to conservation along with a complete list of species recorded.

3.1.3 Low Ecological Services – Flora Surveys

Low Ecological Services completed two flora surveys (in the Dry Season 2008 and Wet season 2009) within SEL26452 (see Moon *et al.* 2009 for methods). This data is useful to indicate the likely occurrence of flora species within the southern end of the pipeline where similar habitat occurs (see Figures 3, 4 and 5 for boundaries of soils, LS and vegetation classes). The borefield and northern end of the pipeline is located in black soil plain country which was not surveyed or represented well within SEL26452.

A total of 162 flora species were recorded during the two surveys (Appendix 3). In general the area was dominated by sand plains with *Acacia, Grevillea,* and *Hakea spp.* over *Aristida* and *Triodia*; open woodlands with *Acacia, Eucalyptus (and Corymbia), Hakea and Melauleuca spp.* over *Acacia* shrubs and *Triodia* spp; and rocky rises with sparse *Acacia*, *Eucalyptus*, and *Triodia* spp.

No flora species identified during these investigations were listed under the EPBC Act or TPWC Act at or above Vulnerable level; however, two species were listed as Near Threatened (Bergia barklyana and Hibiscus brachychlaenus) and one as Data Deficient (Heliotropium pulvinum) under the TPWC Act (Table 2).

Table 2: Flora species of conservation significance identified by Low Ecological Services within SEL26452 (see Moon *et al*. 2009 for details)

Full Name	TPWC	EPBC	SSOBS level	SSOBS code
Bergia barklyana	nt		National	3R
Hibiscus brachychlaenus	nt		Northern Territory	3r
Heliotropium pulvinum	DD		Northern Territory	3K

The SSOBS conservation code, as defined by White *et al.* (2000) for each of these species are:
Bergia barklyana (3R) – a rare species of national significance with a geographic range exceeding 100 km but not currently considered to be threatened.
Hibiscus brachychlaenus (3r) – a rare species of significance in the NT with a geographic range exceeding 100 km but not currently considered to be threatened.
Heliotropium pulvinum (3k) as taxa with a geographic ranges exceeding 100 km with the potential to belong to a conservation category.

3.1.4 Introduced Species

Two introduced flora species (*Aerva javanica*, kapok bush and *Cenchrus ciliaris*, buffel grass) were identified by the NT Parks and Wildlife Flora Atlas (2008) within the 50 km of the borefield (and also by LES in 2009).

Neither of these species are listed under the NT Weeds Management Act (2001) but both have the potential to occur in the borefield and/or pipeline area.

Baker *et al.* (2005) identify 11 introduced species that are of concern in the Davenport and Murchinson and/or Mitchell Grass Downs bioregion (Table 3). Many other introduced flora species could potentially occur, particularly as the project area is in close proximity to a major highway where vehicles are a vector for weeds.

Table 3: Weed species that could occur within the Borefield and Pipeline project area.

Name	Class	WONS	Habitat	Source
Bellyache bush (*Jatropha gossypifolia*)	B			2
Buffel Grass (*Cenchrus ciliaris*)	not classed		Disturbed areas, Towns, Roads, swamp margins	1
Carribbean Stylo (*Stylosanthes hamata*)	not classed			2
Coffee Bush (*Leucaena leucocephala*)	not classed		Disturbed areas, Towns	1
Kapok Bush (*Aerva javanica*)	not classed		Disturbed areas, Roads	2
Marvel Grass (*Dichanthium annulatum*)	not classed			1
Mesquite (*Prosopis limensis*)	B	WONS	Pastoral, Water ways and floodplains	1
Neem (*Azadirachta indica*)	not classed		Towns, Riparian,	1
Noogoora Burr (*Xanthium strumarium*)	B		Pastoral, Roads and tracks	1
Olive hymenachne (*Hymenachne amplexicaulis*)	not classed	WONS	Water ways and floodplains	1
Para Grass (*Urochloa mutica*)	not classes		Floodplains, drainage lines	1
Paddy's Lucerne (*Sida rhombifolia*)	B		Blocks & gardens, Pastoral, Roads and Tracks	1
Parkinsonia (*Parkinsonia aculeata*)	B	WONS	Pastoral, Water ways and floodplains, Blocks & gardens	1
Ruby Dock (*Acetosa vesicaria*)	not classed		Waterways and floodplains	1
Setaria verticillate	not classed			2
Spiked Malvastrum (*Malvastrum americanum*)	not classed		Water ways, Pastoral and Roads.	2

Data source: 1) Northern Territory Bioregions – assessment of key biodiversity values and threats (Baker *et al.* 2005; p66-67, p108), and 2) NT Parks and Wildlife Flora Atlas (2008) (<50 km radius). **Note:** NT Weed classes A (to be eradicated), B (growth and spread to be controlled), Weeds of National Significance (WONS), and exotic plants of conservation importance.

3.2. Fauna

3.2.1 Protected Matters Search

A protected matters report generated from the DEWHA web site (21st October 2009) within a 50 km radius of the proposed borefield was undertaken (Appendix 1). Again, the borefield was chosen as the centre for this search to take in more of the black soil plain country, which was not represented well in the areas to the south where LES completed detailed fauna surveys.

No endangered or critically endangered species were listed, although one threatened (Vulnerable - EPBC Act) species (Australian painted snipe, Rostratula australi) and eight migratory bird species were listed (Appendix 1). Australian painted snipe could occur in well vegetated ephemeral areas, all migratory species are not known to occur but could in appropriate seasons. Note that Mulgara (Dasycercus cristicauda/D. Blythi) was not included in this protected matters report, although it was included when the centre of the search was 25 km to the south-east.

3.2.2 NT Atlas

A search of the NT Parks and Wildlife Fauna Atlas (2008) for the same area as the Protected Matters Search identified 896 records of 187 species (Appendix 4 and Figure 7). Note that there were no fauna records near the proposed borefield and northern end of the pipeline (Figure 7).

One fauna species was listed under the TPWC Act at Vulnerable Status along with four species at near threatened and two species data deficient level. One species was listed under the EPBC Act although the listing refers to the northern sub species of yellow chat (Epthianura crocea) (Table 4)

Table 4: Fauna recorded under the NT Parks and Wildlife Fauna database within a 50 km radius of the proposed borefield (see Appendix 4 for key to conservation codes)

Group	Species Name	TPWC	EPBC
Reptile	*Aspidites ramsayi*	NT	
Bird	*Lophoictinia isura*	NT	
Bird	*Phaps histrionica*	NT	
Mammal	*Rattus villosissimus*	NT	
Bird	*Ardeotis australis*	VU	
Frog	*Cyclorana australis*	DD	
Reptile	*Varanus spenceri*	DD	
Bird	*Epthianura crocea*	EN\LC	VU\NL

3.3. Low Ecological Services – Fauna Surveys

Low Ecological Services completed two fauna surveys (in the Dry Season 2008 and Wet season 2009) within SEL26452 (see Moon *et al.* 2009 for methods). This data is useful to indicate the likely occurrence of fauna species within the southern end of the pipeline where similar habitat occurs (see Figures 3, 4 and 5 for boundaries of soils, LSs and vegetation classes). The borefield and northern end of the pipeline is located in black soil plain country is was not surveyed or represented well within SEL26452.

Overall, a total of 33 birds, 15 Mammals, and 14 Reptiles were recorded during the two surveys and a full list of species identified is provided in Appendix 5.

In general, the area surveyed did not exhibit any special features for biodiversity although one species of conservation significance (Australian bustard, Ardeotis australis) Vulnerable under the TPWC ACT was recorded along with one species listed as Near Threatened (northern nail-tailed wallaby, Onychogalea unguifera) (TPWC Act). Both of these species could occur in the pipeline area depending on seasonal conditions. Habitats in the project area, particularly the acacia shrublands and hummock grasslands are also suitable for bilby (Macrotis lagotis) and mulgara (Dasycercus cristicauda or D. blythi) although no sign was detected during LES surveys.

3.3.1 Introduced Species

Five introduced species were recorded within the project area during LES field surveys: three herbivores (camel, *Camelus dromedarius*, cow, *Bos taurus* and donkey, *Equus asinus*) and two omnivors (cat, *Felis catus* and fox *Vulpes vulpes*). All of these species could occur in the borefield and/or pipeline area depending on seasonal conditions.

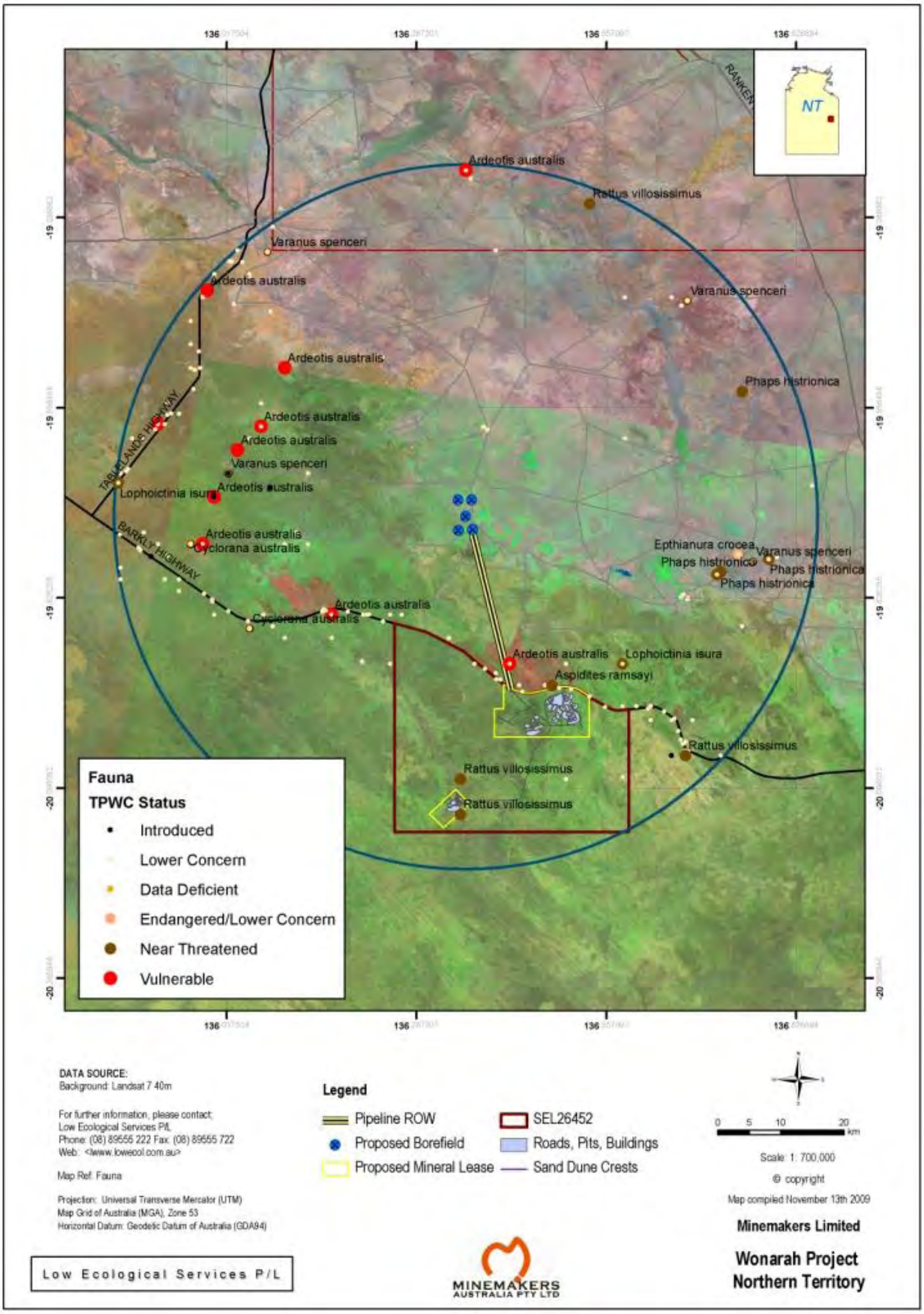


Figure 7: Locations of Northern Territory Parks and Wildlife Fauna Atlas records within a 50 km radius of the proposed borefield. Species names are for records that have a status of data deficient, endangered/lower concern, near threatened or vulnerable only.

Note: Some sites have multiple species records so this figure is a guide only. Appendix Four provides a key to conservation along with a complete list of species recorded.

4. Summary of Desktop Review

The following key issues were identified within the search area that may require management during the proposed borefield and pipeline project:

- The proposed pipeline is located within the Wonarah Beds site of botanical significance where White *et al.* (2000) identify a number of rare (but not formally listed) flora species;
- Nine flora species were listed as data deficient under the TPWC Act;
- Five flora species were listed as near threatened under the TPWC Act;
- Eleven introduced (and possibly more) flora species could occur;
- Two fauna species were listed as Vulnerable under the EPBC and/or TPWC
- Five fauna species were listed as near threatened and two as data deficient under the TPWC Act;
- Eight migratory bird species listed under the EPBC Act; and,
- Five (and possibly more) introduced fauna species could occur.

5. Recommendations

Whilst the review of environmental factors did not identify any species or habitats of high ecological or conservation significance within the area surrounding the proposed borefield and pipeline, the following should be taken into consideration:

- There were very few flora or fauna records within the Black Soil Plains habitat around the borefield and this habitat type LES did not survey this habitat type in detail in SEL26452.

Where possible the pipeline ROW should divert around the following areas:

- Wetland and swamps;
- Grey clays and black soils plains (due to cracking clay construction stability issues); and,
- Any low-lying areas subject to frequent inundation with water.

During the construction and operational phase of the project the following aspects should be considered when developing the construction and environmental management plan:

- The borefield and pipeline should be built so that there is no free standing water, regardless of whether or not it is fenced off;
- The amount of trench open at any one time should be minimised;
- Lateral ramps should be installed in the trench to allow for fauna to escape;
- Trenches must be examined daily to remove any fauna trapped in the trenches;
- If any animal is caught in the trench it should be removed as soon as possible and a system of photographing and recording should be developed (note that the 1983 NT Gas Pipeline project provided some of the best fossorial fauna data in the NT);
- When closing the trench no soil mounds or trenches should be left to minimise impact on surface water flow;

- Erosion control features should be installed as necessary along with flat bottom (not V) offlet drains or diversion bunds at intervals relative to the slope;
- No winrows should be left along the pipeline or adjacent service track;
- An audit should be conducted by an experienced consultant at the start, middle and end of the project;
- A flora, fauna and landscape management induction should be given to all contractors.

6. References

Baker, B., Price, O., Woinarski, J., Gold, S., Connors, G., Fisher, A. and Hempel, C. (2005), Northern Territory Parks and Conservation Masterplan: Northern Territory Bioregions – Assessment of key biodiversity values and threats, Darwin, Northern Territory.

http://nt.gov.au/nretas/parks/management/masterplan/pdf/bioregions_assessment.pdf

Bureau of Rural Sciences (1991) Digital Atlas of Australian Soils (ARC/INFO® vector format). [Online] Available HTML: http://www.brs.gov.au/data/datasets.

Gibson, D.F. and Wurst P.D. (1994) Reptile survey of the Wakaya Desert, Northern Territory. A consultancy report to Australian Heritage Commission and Conservation Commission of the Northern Territory, Alice Springs.

Isbell, R.F. (1996). The Australian Soil Classification, CSIRO, Melbourne

Moon, E., Newsome, T., and Low, W. (2009) Baseline flora and fauna report – Minemakers Wonarah Phosphate project. Unpublished report prepared for Coffey Natural Systems.

Noakes, L.C., and Traves, D.M. (1954) Part III. Outline of the geology of the Barkly Region. In Christian et al. 1954. Survey of the Barkly Region, 1947-48. Land Research Series No. 3, CSIRO Melbourne.

Northern Territory Parks and Wildlife Flora Atlas (2007). Developed by the Department of Natural Resources, Environment, Arts and Sport; Parks and Conservation Division, updated in 2008.

Northern Territory Parks and Wildlife Fauna Atlas (2007). Developed by the Department of Natural Resources, Environment, Arts and Sport; Parks and Conservation Division, updated in 2008.

Perry, R.A., Mabbutt, J.A., Litchfield, W.H., and Quinlan, T. (1962) Land Systems of the Alice Springs Area, Northern Territory, Australia. Part II In R.A. Perry, J.A., Mabbut, W.H., Litchfield, T., Quinlan, T. (1962) Lands of the Alice Springs Area, Northern Territory, Australia. CSIRO, Canberra.

Purdie, J., Materne, C., and Bubb, A. (2008) A field guide to Plants of the Barkely Region, Northern Territory.

Stewart, G.A., Christian, C.S. and Perry, R.A. (1954). Part VIII. Land Systems of the Barkly Region, Northern Territory, Australia. In Christian, C.S., Noakes, L.C., Perry, R. A., Slatyer, R. O., Stewart, G. A. and Traves, D. M. Survey of the Barkly Region, 1947-48. Land Research Series No. 3. CSIRO, Melbourne.

White, M., Albrecht, D., Duguid, A., Latz, P. and Hamilton, M. (2000) Plant species and sites of botanical significance in the southern bioregions of the Northern Territory. Volume 1: significant vascular plants. Report to the Australian Heritage Commission. (Arid Lands Environment Centre: Alice Springs)

Wilson, B.A., Brocklehurst, P.S., Clark, M.J. and Dickinson, K.J.M. (1990) Vegetation survey of the Northern Territory Australia. Technical report – No 49. Conservation Commission of the Northern Territory.

7. Appendices

7.1 Appendix One: Matters of Environmental Significance (Department of Environment Water Heritage and the Arts): Species of Conservation Significance listed under the Environmental Protection and Biodiversity Conservation Act (1999), (EPBC) and Territory Parks and Wildlife Conservation Act (2000) (TPWC), that occur or could possibly occur within a 50 km buffer of the proposed Borefield. Note the category "migratory" includes terrestrial, migratory marine and migratory wetland species.

Species Name and Status	Common Name	Level of Status	Present / known to occur	Preferred habitat
VULNERABLE				
Birds				
Rostratula australis	Australian painted snipe	EPBC	Not Recorded / known to occur in the region	Well vegetated ephemeral areas
MIGRATORY – Species or species habitat may occur within the area				
Birds				
Apus pacificus	fork-tailed swift	EPBC	Not Recorded / not known to occur	Boreal and temperate forests
Ardea alba	great egret, white egret	EPBC	Not Recorded / not known to occur	Wet areas and damp grasslands
Ardea ibis	cattle egret	EPBC	Not Recorded / not known to occur	Grasslands, woodlands and wetlands
Charadrius veredus	oriental plover	EPBC	Not Recorded / not known to occur	Timbered Habitats
Glareola maldivarum	oriental pratincole	EPBC	Not Recorded / not known to occur	Creeklines
Merops ornatus	rainbow bee-eater	EPBC	Not Recorded / not known to occur	Open forests, woodlands and shrublands, and cleared areas, usually near water. Migratory in summer.
Numenius minutus	little curlew, little whimbrel	EPBC	Not Recorded / not known to occur	Dry grasslands and ephemeral areas
Rostratula australis	Australian painted snipe	EPBC	Not Recorded / not known to occur	Well vegetated ephemeral areas

7.2 **Appendix Two:** Flora species list for the area contained within a 50 km radius of the proposed borefield based on the Northern Territory Parks and Wildlife Flora Atlas (2008) records (existing data) and status under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004), Territory Parks and Wildlife Conservation Act (2000) (TPWC) and conservation codes (SSOBS) defined by White *et al.* (2000).

Status is given under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004), Territory Parks and Wildlife Conservation Act (2000) (TPWC) and conservation codes defined by White *et al.* (2000).

Where:
LC = least concern (TPWC);
INTRO = introduced species;
DD = data deficient (TPWC);
NT = near threatened (TPWC);
NE = not evaluated (TPWC).

Codes and classifications (SSOBS) are defined in White *et al*. (2000), where:
1 = Poorly known taxonomic records or taxa known only from the type collection;
3 = Taxa with a geographic range within Australia exceeding 100 km;
C = Indicates that the species occurs with a conservation reserve;
k = These taxa have the potential to belong in a conservation category but there is presently insufficient information;
R = Nationally, these species are rare but not currently considered to be threatened;
r = Within the NT, these species are rare but not currently considered to be threatened; and
- = Indicates that the taxon has been recorded from a reserve but that the population size within the reserve in unknown.

Codes for bioregions are as follows:
BRT Burt Plain
CR Central Ranges
DMR Davenport Murchison Ranges
GSD Great Sandy Desert
MAC MacDonnell Ranges
SSD Simpson Strzelecki Dunefields
TAN Tanami

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Abelmoschus ficulneus	Native Rosella				
Abutilon fraseri subsp. fraseri	Dwarf Lantern-bush				
Abutilon hannii					
Abutilon hannii subsp. Erect (J.Russell-Smith 7032)					
Acacia acradenia					
Acacia adoxa var. adoxa				bioregional	TAN (eastern range limit)
Acacia ancistrocarpa	Fitzroy Wattle, Pirraru				
Acacia aneura	Mulga				
Acacia bivenosa	Hill Umbrella Bush				
Acacia cambagei	Gidgee, Stinking Wattle				
Acacia cowleana	Halls Creek Wattle				
Acacia drepanocarpa subsp. latifolia					
Acacia hemignosta	Club-leaf Wattle			bioregional	BRT (southern range limit)
Acacia hilliana	Flying-saucer Bush			bioregional	CR (southern range limit)
Acacia lysiphloia	Turpentine, Turpentine Bush, Turpentine Wattle			bioregional	GSD (disjunct and southern range limit)
Acacia melleodora	Waxy Wattle				

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
Acacia monticola	Hill Turpentine			bioregional	CR (southern range limit)
Acacia sericophylla	Dogwood, Wirewood				
Acacia stipuligera	Scrub Wattle, Kurapuka				
Acacia tenuissima	Broom Wattle, Minyana			bioregional	CR (disjunct)
Acacia victoriae	Acacia Bush, Bramble Wattle, Victoria Wattle				
Aerva javanica	Kapok Bush, Snow Bush				
Aeschynomene indica	Budda Pea, Kath Sola				
Alternanthera nodiflora	Common Joyweed				
Alysicarpus muelleri	Rough Chain-pea				
Amaranthus cochleitepalus				bioregional	STP (southern range limit)
Amaranthus mitchellii	Boggabri				
Ammannia multiflora	Jerry Jerry				
Amphipogon caricinus var. caricinus	Grey-beard Grass, Long Grey-beard Grass				
Aristida contorta	Bunched Kerosene Grass, Mulga Grass				
Aristida holathera var. holathera	Erect Kerosene Grass, White Grass, Arrow Grass				
Aristida latifolia	Feathertop Wiregrass				
Aristida pruinosa	Blue Wiregrass, Gulf Feathertop Wiregrass				
Astrebla elymoides	Hoop Mitchell Grass, Weeping Mitchell Grass, Slender Mitchell Grass				
Astrebla pectinata	Barley Mitchell Grass				
Bergia ammannioides	Water-fire			bioregional	BRT (apparently rare), SSD (disjunct)
Bergia trimera	Small Water-fire				
Blumea tenella					
Boerhavia burbidgeana				bioregional	DAV (apparently rare)
Boerhavia coccinea	Tar Vine				
Boerhavia dominii					
Boerhavia paludosa	Black-soil Tar Vine			bioregional	BRT (disjunct), MAC (disjunct
Bonamia alatisemina		dd		national	3K
Bonamia media var. media					
Bonamia pannosa					
Brachyachne convergens	Spider Grass, False Couch, Annual Couch			bioregional	BRT (disjunct), GSD (disjunct)
Cajanus marmoratus					
Calandrinia pumila	Tiny Purslane, Tiny Parakeelya				
Calotis porphyroglossa	Channel Burr-daisy				
Capparis lasiantha	Split-arse-jack, Wait-a-whlie, Nepine, Maypan				
Capparis umbonata	Northern Wild Orange, Wild Orange, Bush Orange, Native Pomegranate			bioregional	MGD (southern range limit)
Cassytha capillaris	Hairless Dodder-laurel, Snotty Gobble				
Chamaecrista symonii	Dwarf Cassia				
Chenopodium auricomum	Northern Bluebush, Swamp Bluebush				

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
Chloris pectinata	Comb Chloris				
Chrysocephalum apiculatum	Small Yellow Button, Common Everlasting, Yellow Buttons				
Cleome viscosa	Tickweed, Mustard Bush				
Clerodendrum floribundum	Smooth Clerodendrum, Smooth Spiderbush, Lollybrush, Lolly Bush				
Corchorus aestuans					
Corchorus sidoides subsp. vermicularis	Flannel Weed				
Corchorus tridens				bioregional	SSD (southern range limit)
Corymbia aparrerinja	Ghost Gum, White Gum, Desert White Gum				
Corymbia deserticola subsp. mesogeotica	Desert Bloodwood			bioregional	MGD (eastern range limit), TAN (northern range limit), GSD (western and southern range limits)
Corymbia flavescens					
Crotalaria crispata					
Crotalaria dissitiflora	Grey Rattlepod				
Crotalaria medicaginea	Clover-leaf Rattlepod, Trefoil Rattlepod				
Crotalaria medicaginea var. neglecta					
Crotalaria montana					
Crotalaria novae-hollandiae subsp. lasiophylla	New Holland Rattlepod				
Croton aridus				bioregional	TAN (southern range limit)
Cucumis melo	Bush Cucumber, Wild Cucumber, Native Cucumber, Ulcardo Melon				
Cucumis melo subsp. agrestis	Bush Cucumber, Wild Cucumber, Native Cucumber, Ulcardo Melon			bioregional	TAN (disjunct)
Cullen cinereum	Annual Verbine				
Cuscuta victoriana					
Cyperus bifax	Downs Nutgrass			bioregional	MAC (disjunct)
Cyperus bulbosus	Yalka, Nutgrass				
Cyperus cuspidatus				southern NT	(disjunct & apparently rare)
Cyperus difformis	Variable-leaf Sedge, Variable Flat-sedge, Dirty Dora				
Cyperus gilesii					
Cyperus iria					
Cyperus victoriensis					
Dactyloctenium radulans	Button Grass, Finger Grass, Toothbrush Grass				
Dentella minutissima		nt		Northern Territory	3rC-
Desmodium campylocaulon	Creeping Tick-trefoil			bioregional	BRT (disjunct), MAC (disjunct), TAN (disjunct)
Desmodium muelleri				bioregional	CHC (disjunct), TAN (disjunct and apparently rare)

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
Dichanthium sericeum	Silky Bluegrass, Queensland Bluegrass				
Dichanthium sericeum subsp. sericeum	Silky Bluegrass, Queensland Bluegrass				
Digitaria brownii	Cotton Panic Grass				
Digitaria ctenantha	Comb Finger Grass				
Distichostemon barklyanus		dd		Northern Territory	3k
Dodonaea coriacea	Hopbush				
Dolichandrone heterophylla	Dohwa, Lemonwood				
Eleocharis atropurpurea				bioregional	GSD (disjunct and apparently rare)
Elytrophorus spicatus	Spikegrass				
Enchylaena tomentosa	Ruby Saltbush, Sturts Saltbush, Plum Puddings, Berry Cottonbush				
Enneapogon pallidus	Conetop Nine-awn, Pale Bottlewasher				
Enneapogon polyphyllus	Woolly Oat-grass, Oat-grass, Leafy Nine-awn				
Enneapogon purpurascens	Purple Nine-awn, Purple Bottlewasher			bioregional	TAN (southern range limit)
Eragrostis desertorum	Desert Lovegrass, Spreading Lovegrass				
Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail				
Eragrostis eriopoda subsp. Sandy fireweed (P.K.Latz 12908)					
Eragrostis kennedyae	Small-flowered Lovegrass				
Eragrostis olida				bioregional	DAV (eastern range limit)
Eragrostis setifolia	Neverfail, Narrow-leaf Neverfail				
Eragrostis tenellula	Delicate Lovegrass				
Eriachne aristidea	Three-awn Wanderrie				
Eriachne armitii	Longawn Wanderrie				
Eriachne ciliata	Slender Wanderrie, Wiregrass				
Eriachne melicacea	Fire Grass			bioregional	DAV (southern range limit)
Eriachne nervosa	Plains Wanderrie				
Eriachne obtusa	Northern Wanderrie, Wiregrass				
Erythrina vespertilio	Bean Tree, Batswing Coral Tree				
Eucalyptus barklyensis				bioregional	MGD (southern range limit), DAV (apparently rare)
Eucalyptus chlorophylla	Green-leaf Box				
Eucalyptus chlorophylla subsp. chlorophylla					
Eucalyptus coolabah	Coolabah				
Eucalyptus coolabah subsp. arida	Coolabah			bioregional	TAN (tentative western range limit)
Eucalyptus leucophloia subsp. euroa	Snappy Gum, Migum				
Eucalyptus odontocarpa	Sturt Creek Mallee			bioregional	GSD (southern range limit)

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
Eucalyptus pruinosa subsp. pruinosa	Silver Box, Silver-leaf Box, Apple Box, Smoke Tree				
Eucalyptus victrix	Smooth-barked Coolibah, Ghost Gum Coolibah, Gum-barked Coolibah			bioregional	MGD (eastern range limit)
Eulalia aurea	Silky Browntop, Sugar Grass				
Euphorbia alsiniflora					
Euphorbia drummondii	Caustic Weed, Caustic Creeper, Mat Spurge				
Euphorbia stevenii	Bottletree Caustic				
Evolvulus alsinoides	Blue Periwinkle, Tropical Speedwell				
Evolvulus alsinoides var. decumbens	Blue Periwinkle, Tropical Speedwell				
Evolvulus alsinoides var. villosicalyx	Blue Periwinkle, Tropical Speedwell				
Exocarpos sparteus	Slender Cherry, Broombush			bioregional	DAV (northern range limit)
Fimbristylis ammobia				bioregional	MGD (eastern range limit)
Fimbristylis microcarya					
Fimbristylis oxystachya	Iukarrara				
Flaveria australasica	Yellow Twin Stem, Speedy Weed				
Flueggea virosa subsp. melanthesoides	White Grape, White Berry Bush, White Raisin, White Currant			bioregional	GSD (disjunct)
Gomphrena breviflora					
Gomphrena conica					
Gomphrena lanata					
Goodenia armitiana	Narrow-leaved Goodenia				
Goodenia fascicularis	Silky Goodenia				
Goodenia heterochila	Serrated Goodenia				
Goodenia ramelii					
Goodenia strangfordii				bioregional	MGD (southern range limit)
Gossypium australe	Native Cotton, Tall Desert Rose				
Grevillea dryandri subsp. dryandri	Dryanders Grevillea				
Grevillea refracta	Silver-leaf Grevillea				
Grevillea refracta subsp. refracta	Silver-leaf Grevillea				
Grevillea wickhamii subsp. aprica	Holly-leaf Grevillea			bioregional	CR (southern range limit)
Hakea macrocarpa	Flat-leaved Hakea			bioregional	SSD (southern range limit)
Haloragis glauca forma glauca	Grey Raspwort				
Haloragis uncatipila					
Heliotropium ballii		dd		Northern Territory	3k
Heliotropium brachythrix					
Heliotropium conocarpum	White Heliotrope				
Heliotropium haesum					
Heliotropium ovalifolium					
Heliotropium pulvinum		dd		Northern Territory	3K
Heliotropium tanythrix					

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
Heteropogon contortus	Bunch Speargrass, Black Speargrass				
Hibiscus leptocladus	Variable-leaf Hibiscus				
Hibiscus sturtii var. campylochlamys	Sturts Hibiscus				
Hibiscus sturtii var. platychlamys	Sturts Hibiscus				
Hibiscus trionum var. vesicarius	Bladder Ketmia			bioregional	SSD (disjunct and southern range limit), BRT (disjunct)
Indigastrum parviflorum	Small-flower Indigo				
Indigofera colutea	Sticky Indigo				
Indigofera linifolia	Native Indigo				
Indigofera linnaei	Birdsville Indigo, Nine-leaved Indigo				
Indigofera trita				bioregional	BRT (disjunct)
Ipomoea coptica					
Ipomoea costata	Bush Potato, Potato Vine, Desert Yam				
Ipomoea lonchophylla	Common Cowvine			bioregional	BRT (disjunct), SSD (disjunct)
Ipomoea plebeia	Bellvine			southern NT	(apparently rare)
Ipomoea polymorpha	Silky Cowvine				
Iseilema membranaceum	Small Flinders Grass				
Iseilema vaginiflorum	Red Flinders Grass				
Iseilema windersii	Scented Flinders Grass				
Isoetes muelleri	Quillwort			bioregional	DAV (disjunct and apparently rare)
Jatropha gossypifolia	Cotton-leaf Physic Nut, Bellyache Bush				
Keraudrenia nephrosperma					
Leptochloa fusca subsp. fusca	Small-flowered Beetle Grass				
Lipocarpha microcephala	Button Rush				
Lysiana spathulata	Flat-leaved Mistletoe				
Maireana villosa	Silky Bluebush				
Malvastrum americanum	Malvastrum, Spiked Malvastrum				
Marsilea angustifolia					
Marsilea crenata				southern NT	(disjunct)
Melaleuca viridiflora	Green Paperbark, Broad-leaved Paperbark, Large-leaved Paperbark				
Melhania oblongifolia	Velvet Hibiscus				
Melochia pyramidata					
Merremia davenportii	White Morning Glory			bioregional	BRT (southern range limit)
Minuria integerrima	Smooth Minuria				
Mirbelia viminalis	Yellow Broom				
Muehlenbeckia florulenta	Lignum, Tangled Lignum			bioregional	TAN (apparently rare)
Mukia maderaspatana	Head-ache Vine				
Najas marina	Prickly Waternymph, Prickly Naiad	nt		Northern Territory	3rC-
Najas tenuifolia	Waternymph, Thin-leaved Naiad			southern NT	(disjunct)

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
Neptunia dimorphantha	Sensitive Plant, Nervous Plant				
Oldenlandia argillacea				bioregional	MGD (apparently rare), TAN (apparently rare), BRT (disjunct)
Oldenlandia mitrasacmoides					
Operculina aequisepala				bioregional	CHC (southern range limit), TAN (disjunct and apparently rare)
Ophiuros exaltatus					
Panicum decompositum	Native Millet, Native Panic, Australian Millet				
Panicum laevinode	Pepper Grass				
Paraneurachne muelleri	Spinifex Couch, Northern Mulga Grass				
Paspalidium retiglume				bioregional	MGD (southern range limit)
Pennisetum basedowii	Asbestos Grass	dd		Northern Territory	3k
Perotis rara	Comet Grass				
Petalostylis cassioides	Butterfly Bush, Petalostylis				
Phyllanthus maderaspatensis var. angustifolius					
Polycarpaea corymbosa					
Polygala sp. Davenport Range (C.R.Dunlop 6042)				bioregional	BRT (apparently rare), TAN (western range limit)
Polygala sp. Tennant Creek (J.L.Egan 2299)					
Portulaca filifolia	Slender Pigweed				
Portulaca oleracea	Pigweed, Common Purslane, Munyeroo				
Potamogeton pectinatus	Fennel Pondweed, Sago Pondweed	nt		Northern Territory	3r
Prosopis pallida	Mesquite, Algaroba				
Psydrax attenuata var. myrmecophila					
Psydrax attenuata var. myrmecophila forma myrmecophila					
Pterocaulon serrulatum var. serrulatum	Fruit-salad Bush, Apple Bush				
Ptilotus calostachyus var. calostachyus	Weeping Mulla Mulla				
Ptilotus clementii	Limestone Pussycats Tails, Tassel Top				
Ptilotus fusiformis	Skeleton plant				
Ptilotus obovatus var. obovatus	Smoke Bush, Silver Bush, Silver Tails				
Ptilotus polystachyus	Long Pussy-tails				
Ptilotus polystachyus var. polystachyus	Long Pussy-tails				
Ptilotus spicatus					
Rhynchosia minima	Native Pea, Rhynchosia				
Rothia indica subsp. australis				southern NT	(disjunct and apparently rare)
Salsola tragus	Buckbush, Rolypoly, Tumbleweed				
Salsola tragus subsp. tragus	Buckbush, Rolypoly,				

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
	Tumbleweed				
Santalum lanceolatum	Plumbush, Wild Plum				
Sauropus trachyspermus	Slender Spurge				
Scaevola glabrata					
Scaevola ovalifolia	Bushy Fanflower			bioregional	GSD (western range limit)
Schoenoplectus dissachanthus					
Schoenoplectus laevis				bioregional	FIN (disjunct and apparently rare)
Sclerolaena bicornis var. bicornis	Goathead Burr, Bassia Burr				
Sclerolaena lanicuspis	Woolly Copper Burr				
Sebastiania chamaelea					
Senecio depressicola		dd		Northern Territory	3k
Senna artemisioides subsp. alicia					
Senna artemisioides subsp. filifolia	Desert Cassia, Broom Bush, Punty Bush				
Senna artemisioides subsp. oligophylla	Oval-leaf Cassia				
Senna costata					
Senna glutinosa subsp. pruinosa					
Senna notabilis	Cockroach Bush				
Sesbania brachycarpa					
Sesbania chippendalei					
Sesbania simpliciuscula		dd		Northern Territory	3k
Sida cunninghamii					
Sida fibulifera	Silver Sida, Pin Sida				
Sida filiformis s.lat.	Fire Sida, Fine Sida				
Sida platycalyx	Lifesaver Burr, Teddy Bears Arsehole				
Sida spenceriana				bioregional	FIN (apparently rare and eastern range limit)
Sida spinosa	Spiny Sida				
Sida trichopoda	High Sida, Narrow-leaf Sida				
Solanum chippendalei	Bush Tomato, Ngaru				
Solanum quadriloculatum	Wild Tomato, Tomato Bush				
Solanum tumulicola	Black-soil Wild Tomato				
Spathia neurosa	Spathe Grass				
Spermacoce hillii					
Sphaeranthus indicus					
Sporobolus australasicus	Australian Dropseed				
Sporobolus latzii		dd		national	1K
Sporobolus mitchellii	Rat-tail Couch, Swamp Rat-tail Grass, Short Rat-tail Grass				
Streptoglossa adscendens					
Streptoglossa macrocephala	Large-flowered Aromatic Daisy				
Swainsona burkei				bioregional	TAN (western range limit)
Tephrosia lasiochlaena				bioregional	MAC (southern range limit)
Tephrosia sp. Barrow Creek (G.M.Chippendale 921)				bioregional	GSD (southern range limit)

Full Name	Common Name	TPWC	EPBC	SSOBS	SSOBS code
Tephrosia sp. Willowra (G.M.Chippendale 4809)					
Tephrosia stuartii				bioregional	DAV (eastern range limit)
Teucrium integrifolium	Green Germander			bioregional	TAN (disjunct and western range limit)
Themeda triandra	Kangaroo Grass				
Tragus australianus	Small Burr-grass, Sock Grass, Tickgrass				
Trianthema pilosa					
Trianthema triquetra	Red Spinach				
Tribulopis angustifolia					
Tribulus eichlerianus	Bindieye				
Tribulus terrestris s.lat.	Cat-head, Caltrop, Bindieye				
Trichodesma zeylanicum	Cattle Bush, Camel Bush				
Triodia pungens	Soft Spinifex, Gummy Spinifex				
Triodia schinzii	Feathertop Spinifex				
Triraphis mollis	Purple Plumegrass, Purple Heads, Needle Grass				
Triumfetta centralis				bioregional	SSD (eastern range limit)
Triumfetta deserticola		dd		Northern Territory	3k
Urochloa piligera	Hairy Armgrass, Hairy Summer Grass, Green Summer Grass				
Urochloa praetervisa	Large Armgrass, Large Summer Grass				
Vachellia sutherlandii	Barklys Wattle				
Ventilago viminalis	Supplejack, Vine Tree				
Vigna lanceolata	Pencil Yam, Maloga Bean, Parsnip Bean				
Wedelia asperrima	Sunflower Daisy				
Whiteochloa cymbiformis					
Yakirra australiensis var. australiensis	Desert Flinders Grass				
Zaleya galericulata subsp. galericulata	Hogweed				
Zornia albiflora				bioregional	GSD (southern range limit)

7.3 **Appendix Three:** Flora recorded during on site investigations by Low Ecological Services in 2008 and 2009 within the Wonarah prospect (SEL26452)

See Appendix Two for Conservation Codes

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Abutilon otocarpum	Keeled Lantern-bush, Desert Chinese Lantern, Desert Lantern				
Acacia adoxa					
Acacia ancistrocarpa	Fitzroy Wattle, Pirraru				
Acacia hemignosta	Club-leaf Wattle			bioregional	BRT (southern range limit)
Acacia hilliana	Flying-saucer Bush			bioregional	CR (southern range limit)
Acacia lysiphloia	Turpentine, Turpentine Bush, Turpentine Wattle			bioregional	GSD (disjunct and southern range limit)
Acacia monticola	Hill Turpentine			bioregional	CR (southern range limit)
Acacia sericophylla	Dogwood, Wirewood				
Acacia stipuligera	Scrub Wattle, Kurapuka				
Aerva javanica	Kapok Bush, Snow Bush	INTRO			
Aeschynomene indica	Budda Pea, Kath Sola				
Ammannia multiflora	Jerry Jerry				
Amphipogon caricinus	Grey-beard Grass, Long Grey-beard Grass				
Aristida contorta	Bunched Kerosene Grass, Mulga Grass				
Aristida holathera	Erect Kerosene Grass, White Grass, Arrow Grass				
Aristida inaequiglumis	Curly Wiregrass, Fire Grass, Unequal Three-awn				
Astrebla pectinata	Barley Mitchell Grass				
Atalaya hemiglauca	Whitewood				
Atriplex elachophylla	Annual Saltbush, Saltbush				
Bergia barklyana		nt		national	3R
Boerhavia coccinea	Tar Vine				
Brunonia australis	Pincushion, Blue Pincushion				
Bulbostylis barbata	Short-leaved Rush				
Capparis umbonata	Northern Wild Orange, Wild Orange, Bush Orange, Native Pomegranate			bioregional	MGD (southern range limit)
Carissa lanceolata	Conkerberry, Conkle Berry, Kungsberry Bush				
Cassytha capillaris	Hairless Dodder-laurel, Snotty Gobble				
Cenchrus ciliaris	Buffel Grass	INTRO			

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Chrysopogon fallax	Golden Beard Grass, Ribbon Grass, Weeping Grass, Spear Grass				
Cleome viscosa	Tickweed, Mustard Bush				
Clerodendrum floribundum	Smooth Clerodendrum, Smooth Spiderbush, Lollybrush, Lolly Bush				
Corchorus sidoides	Flannel Weed				
Corymbia opaca	Bloodwood				
Corymbia setosa	Rough-leaved Bloodwood				
Crotalaria medicaginea	Clover-leaf Rattlepod, Trefoil Rattlepod				
Crotalaria novae-hollandiae	New Holland Rattlepod				
Cucumis maderaspatanus	Head-ache Vine				
Dactyloctenium radulans	Button Grass, Finger Grass, Toothbrush Grass				
Dicrastylis gilesii					
Digitaria brownii	Cotton Panic Grass				
Dodonaea coriacea	Hopbush				
Ehretia saligna	Coonta, False Cedar, Peachwood, Peachbush				
Enneapogon polyphyllus	Woolly Oat-grass, Oat-grass, Leafy Nine-awn				
Eragrostis cumingii	Fairy Grass, Cumings Lovegrass				
Eragrostis eriopoda	Woollybutt Grass, Naked Woollybutt, Wire Wanderrie Grass, Never Fail				
Eragrostis falcata	Sickle Lovegrass				
Eremophila latrobei	Native Fuchsia, Latrobes Desert Fuchsia, Georgina Poison Bush				
Eremophila longifolia	Emu Bush, Weeping Emu Bush, Long-leaved Desert Fuchsia				
Eriachne aristidea	Three-awn Wanderrie				
Eriachne mucronata	Mountain Wanderrie				
Eucalyptus gamophylla	Blue Mallee, Twin-leaved Mallee, Blue-leaved Mallee			bioregional	TAN (northern range limit)
Eucalyptus leucophloia	Snappy Gum, Migum				
Eucalyptus microtheca	Coolibah				
Eucalyptus odontocarpa	Sturt Creek Mallee			bioregional	GSD (southern range limit)
Eucalyptus pachyphylla	Red-bud Mallee			bioregional	DMR (northern range limit)
Eucalyptus pruinosa	Silver Box, Silver-leaf Box,				

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
	Apple Box, Smoke Tree				
Eucalyptus victrix	Smooth-barked Coolibah, Ghost Gum Coolibah, Gum-barked Coolibah			bioregional	MGD (eastern range limit)
Eulalia aurea	Silky Browntop, Sugar Grass				
Euphorbia comans					
Euphorbia tannensis	Caustic Bush, Desert Spurge				
Evolvulus alsinoides var. decumbens	Blue Periwinkle, Tropical Speedwell				
Evolvulus alsinoides var. villosicalyx	Blue Periwinkle, Tropical Speedwell				
Fimbristylis ammobia				bioregional	MGD (eastern range limit)
Fimbristylis dichotoma	Eight Day Grass, Common Fringe-rush				
Fimbristylis oxystachya	Lukarrara				
Fimbristylis simulans				bioregional	DMR (eastern range limits)
Gomphrena lanata					
Goodenia armitiana	Narrow-leaved Goodenia				
Goodenia ramelii					
Gossypium australe	Native Cotton, Tall Desert Rose				
Gossypium sturtianum	Sturts Desert Rose				
Grevillea juncifolia	Desert Grevillea, Honey Grevillea, Honeysuckle Grevillea				
Grevillea refracta	Silver-leaf Grevillea				
Grevillea wickhamii	Holly-leaf Grevillea				
Hakea lorea	Long-leaf Corkwood, Corkbark Tree				
Hakea macrocarpa	Flat-leaved Hakea			bioregional	SSD (southern range limit)
Heliotropium glanduliferum					
Heliotropium ovalifolium					
Heliotropium pulvinum		dd		Northern Territory	3K
Hibiscus brachychlaenus		nt		Northern Territory	3r
Hybanthus aurantiacus	Orange Spade Flower				
Indigofera colutea	Sticky Indigo				
Indigofera linifolia	Native Indigo				
Indigofera linnaei	Birdsville Indigo, Nine-leaved Indigo				
Ipomoea costata	Bush Potato, Potato Vine, Desert Yam				
Jacquemontia browniana	Snake Stem				

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Keraudrenia integrifolia					
Leptochloa fusca	Beetle Grass				
Marsdenia australis	Bush Banana, Lungkwa, Doubah				
Melaleuca lasiandra	Sandhill Tea-tree				
Melaleuca viridiflora	Green Paperbark, Broad-leaved Paperbark, Large-leaved Paperbark				
Mirbelia viminalis	Yellow Broom				
Neptunia gracilis	Native sensitive grass				
Pandorea doratoxylon	Spearwood, Wonga Vine, Spearbush				
Paraneurachne muelleri	Spinifex Couch, Northern Mulga Grass				
Paspalidium rarum	Bunch Paspalidium				
Petalostylis cassioides	Butterfly Bush, Petalostylis				
Polycarpaea spirostylis	Copper Plant				
Portulaca filifolia	Slender Pigweed				
Portulaca oleracea	Pigweed, Common Purslane, Munyeroo				
Psydrax latifolia	Native Currant, Orange Bush				
Ptilotus calostachyus	Weeping Mulla Mulla				
Ptilotus fusiformis	Skeleton plant				
Ptilotus polystachyus	Long Pussy-tails				
Rhynchosia minima	Native Pea, Rhynchosia				
Rulingia loxophylla	Desert Fire Weed				
Salsola tragus	Buckbush, Rolypoly, Tumbleweed				
Santalum lanceolatum	Plumbush, Wild Plum				
Scaevola amblyanthera					
Scaevola ovalifolia	Bushy Fanflower			bioregional	GSD (western range limit)
Scaevola parvifolia	Fanflower				
Sclerolaena costata				bioregional	CHC (eastern range limit)
Schizachyrium fragile	Firegrass, Red Spathe Grass, Small Red-leaf				
Sebastiania chamaelea					
Senna artemisioides subsp. oligophylla	Oval-leaf Cassia				
Senna notablis	Cockroach Bush				

Full Name	Common Name	TPWC	EPBC	SSOBS level	SSOBS code
Senna venusa	Graceful Cassia				
Setaria surgens	Brown Pigeon Grass			bioregional	GSD (southern range limit)
Sida arenicola					
Sida fibulifera	Silver Sida, Pin Sida				
Sida filiformis	Fire Sida, Fine Sida				
Solanum coactiliferum	Western Nightshade				
Spermacoce dolichosperma					
Stackhousia 'Mt Leibig'					
Swainsonia sp.					
Tephrosia benthamii					
Tephrosia brachyodon	Red Pea-bush				
Tephrosia lasiochlaena				bioregional	MAC (southern range limit)
Teucrium integrifolium	Green Germander			bioregional	TAN (disjunct and western range limit)
Trianthema pilosa					
Trianthema triquetra	Red Spinach				
Tribulopis angustifolia					
Tribulus eichlerianus	Bindieye				
Trichodesma zeylanicum	Cattle Bush, Camel Bush				
Triodia intermedia	Winged Spinifex			bioregional	DMR (disjunct and eastern range limit), BRT (disjunct and southern range limit)
Triodia pungens	Soft Spinifex, Gummy Spinifex				
Triodia schinzii	Feathertop Spinifex				
Triraphis mollis	Purple Plumegrass, Purple Heads, Needle Grass				
Triumfetta centralis				bioregional	SSD (eastern range limit)
Urochloa sp.					
Ventilago viminalis	Supplejack, Vine Tree				
Waltheria indica					
Whiteochloa airoides					
Yakirra australiensis	Desert Flinders Grass				
Zornia albiflora				bioregional	GSD (southern range limit)

7.4 Appendix Four: Fauna species list for the area contained within a 50 km radius of the proposed borefield based on the Northern Territory Parks and Wildlife Fauna Atlas (2007) records (existing data) and status under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004) and Territory Parks and Wildlife Conservation Act (2000) (TPWC).

Where:
LC = lower concern
DD = data deficient
VU = vulnerable
EN = endangered
NT = near threatened
INT = introduced
NL = near listed

Group	*Species Name*	TPWC	EPBC
Bird	*Acanthagenys rufogularis*	LC	
Bird	*Acanthiza apicalis*	LC	
Bird	*Accipiter cirrhocephalus*	LC	
Bird	*Accipiter fasciatus*	LC	
Bird	*Actitis hypoleucos*	LC	
Bird	*Aegotheles cristatus*	LC	
Bird	*Anas gracilis*	LC	
Bird	*Anas superciliosa*	LC	
Bird	*Anthus novaeseelandiae*	LC	
Bird	*Aquila audax*	LC	
Bird	*Ardea alba*	LC	
Bird	*Ardea pacifica*	LC	
Bird	*Ardeotis australis*	VU	
Bird	*Artamus cinereus*	LC	
Bird	*Artamus personatus*	LC	
Bird	*Artamus superciliosus*	LC	
Bird	*Cacatua roseicapilla*	LC	
Bird	*Cacatua sanguinea*	LC	
Bird	*Certhionyx niger*	LC	
Bird	*Certhionyx variegatus*	LC	
Bird	*Chalcites basalis*	LC	
Bird	*Chlidonias hybridus*	LC	
Bird	*Cincloramphus cruralis*	LC	
Bird	*Cincloramphus mathewsi*	LC	
Bird	*Circus approximans*	LC	
Bird	*Circus assimilis*	LC	
Bird	*Colluricincla harmonica*	LC	
Bird	*Coracina maxima*	LC	
Bird	*Coracina novaehollandiae*	LC	

Group	*Species Name*	TPWC	EPBC
Bird	*Corvus bennetti*	LC	
Bird	*Corvus coronoides*	LC	
Bird	*Corvus orru*	LC	
Bird	*Cracticus nigrogularis*	LC	
Bird	*Daphoenositta chrysoptera*	LC	
Bird	*Dendrocygna eytoni*	LC	
Bird	*Dicaeum hirundinaceum*	LC	
Bird	*Egretta garzetta*	LC	
Bird	*Egretta novaehollandiae*	LC	
Bird	*Elanus axillaris*	LC	
Bird	*Elanus scriptus*	LC	
Bird	*Elseyornis melanops*	LC	
Bird	*Emblema pictum*	LC	
Bird	*Epthianura crocea*	EN\LC	VU\NL
Bird	*Epthianura crocea crocea*	LC	
Bird	*Epthianura tricolor*	LC	
Bird	*Erythrogonys cinctus*	LC	
Bird	*Eurostopodus argus*	LC	
Bird	*Falco berigora*	LC	
Bird	*Falco cenchroides*	LC	
Bird	*Falco longipennis*	LC	
Bird	*Falco peregrinus*	LC	
Bird	*Falco subniger*	LC	
Bird	*Fulica atra*	LC	
Bird	*Geopelia cuneata*	LC	
Bird	*Geopelia placida*	LC	
Bird	*Grallina cyanoleuca*	LC	
Bird	*Grus rubicunda*	LC	
Bird	*Gymnorhina tibicen*	LC	
Bird	*Haliastur sphenurus*	LC	
Bird	*Hamirostra melanosternon*	LC	
Bird	*Hieraaetus morphnoides*	LC	
Bird	*Himantopus himantopus*	LC	
Bird	*Hirundo ariel*	LC	
Bird	*Hirundo nigricans*	LC	
Bird	*Lalage sueurii*	LC	
Bird	*Lichenostomus flavescens*	LC	
Bird	*Lichenostomus keartlandi*	LC	
Bird	*Lichenostomus penicillatus*	LC	
Bird	*Lichenostomus plumulus*	LC	
Bird	*Lichenostomus virescens*	LC	
Bird	*Lichmera indistincta*	LC	
Bird	*Lophoictinia isura*	NT	
Bird	*Malacorhynchus membranaceus*	LC	

Group	*Species Name*	TPWC	EPBC
Bird	*Malurus lamberti*	LC	
Bird	*Malurus leucopterus*	LC	
Bird	*Malurus melanocephalus*	LC	
Bird	*Manorina flavigula*	LC	
Bird	*Melanodryas cucullata picata/westralensis*	LC	
Bird	*Melithreptus gularis*	LC	
Bird	*Melopsittacus undulatus*	LC	
Bird	*Merops ornatus*	LC	
Bird	*Milvus migrans*	LC	
Bird	*Mirafra javanica*	LC	
Bird	*Neopsephotus bourkii*	LC	
Bird	*Nymphicus hollandicus*	LC	
Bird	*Ocyphaps lophotes*	LC	
Bird	*Oreoica gutturalis*	LC	
Bird	*Pachycephala rufiventris*	LC	
Bird	*Pardalotus rubricatus*	LC	
Bird	*Pardalotus striatus*	LC	
Bird	*Passer domesticus*	(Int)	
Bird	*Pelecanus conspicillatus*	LC	
Bird	*Petroica goodenovii*	LC	
Bird	*Phalacrocorax melanoleucos*	LC	
Bird	*Phaps chalcoptera*	LC	
Bird	*Phaps histrionica*	NT	
Bird	*Platalea flavipes*	LC	
Bird	*Platalea regia*	LC	
Bird	*Plegadis falcinellus*	LC	
Bird	*Podargus strigoides*	LC	
Bird	*Pomatostomus temporalis*	LC	
Bird	*Porphyrio porphyrio*	LC	
Bird	*Rhipidura leucophrys*	LC	
Bird	*Smicrornis brevirostris*	LC	
Bird	*Sterna nilotica*	LC	
Bird	*Stiltia isabella*	LC	
Bird	*Tachybaptus novaehollandiae*	LC	
Bird	*Taeniopygia bichenovii*	LC	
Bird	*Taeniopygia guttata*	LC	
Bird	*Threskiornis spinicollis*	LC	
Bird	*Todiramphus pyrrhopygia*	LC	
Bird	*Tringa nebularia*	LC	
Bird	*Tringa stagnatilis*	LC	
Bird	*Turnix pyrrhothorax*	LC	
Bird	*Turnix velox*	LC	
Bird	*Tyto alba*	LC	
Bird	*Vanellus miles*	LC	

Group	*Species Name*	TPWC	EPBC
Bird	*Vanellus tricolor*	LC	
Frog	*Cyclorana australis*	DD	
Frog	*Cyclorana maculosa*	LC	
Frog	*Notaden nichollsi*	LC	
Frog	*Uperoleia trachyderma*	LC	
Mammal	*Bos taurus*	(Int)	
Mammal	*Canis lupus*	LC	
Mammal	*Felis catus*	(Int)	
Mammal	*Leggadina forresti*	LC	
Mammal	*Macropus rufus*	LC	
Mammal	*Notomys alexis*	LC	
Mammal	*Oryctolagus cuniculus*	(Int)	
Mammal	*Planigale ingrami*	LC	
Mammal	*Pseudomys desertor*	LC	
Mammal	*Pseudomys hermannsburgensis*	LC	
Mammal	*Rattus villosissimus*	NT	
Mammal	*Sminthopsis macroura*	LC	
Mammal	*Sminthopsis youngsoni*	LC	
Mammal	*Vulpes vulpes*	(Int)	
Reptile	*Antaresia stimsoni*	LC	
Reptile	*Aspidites melanocephalus*	LC	
Reptile	*Aspidites ramsayi*	NT	
Reptile	*Carlia munda*	LC	
Reptile	*Carlia triacantha*	LC	
Reptile	*Cryptoblepharus plagiocephalus*	LC	
Reptile	*Ctenophorus isolepis*	LC	
Reptile	*Ctenophorus nuchalis*	LC	
Reptile	*Ctenotus grandis*	LC	
Reptile	*Ctenotus greeri*	LC	
Reptile	*Ctenotus helenae*	LC	
Reptile	*Ctenotus joanae*	LC	
Reptile	*Ctenotus leonhardii*	LC	
Reptile	*Ctenotus pantherinus*	LC	
Reptile	*Delma tincta*	LC	
Reptile	*Diplodactylus conspicillatus*	LC	
Reptile	*Diplodactylus immaculatus*	LC	
Reptile	*Diplodactylus stenodactylus*	LC	
Reptile	*Diplodactylus tessellatus*	LC	
Reptile	*Diporiphora lalliae*	LC	
Reptile	*Egernia stokesii*	LC	
Reptile	*Gehyra minuta*	LC	
Reptile	*Gehyra variegata*	LC	
Reptile	*Heteronotia binoei*	LC	
Reptile	*Lerista bipes*	LC	

Group	*Species Name*	TPWC	EPBC
Reptile	*Lerista xanthura*	LC	
Reptile	*Lialis burtonis*	LC	
Reptile	*Menetia greyii*	LC	
Reptile	*Menetia maini*	LC	
Reptile	*Moloch horridus*	LC	
Reptile	*Morethia ruficauda*	LC	
Reptile	*Oedura marmorata*	LC	
Reptile	*Pogona vitticeps*	LC	
Reptile	*Proablepharus kinghorni*	LC	
Reptile	*Pseudonaja ingrami*	LC	
Reptile	*Pseudonaja modesta*	LC	
Reptile	*Pseudonaja nuchalis*	LC	
Reptile	*Pygopus nigriceps*	LC	
Reptile	*Pygopus uncertain*		
Reptile	*Ramphotyphlops diversus*	LC	
Reptile	*Rhynchoedura ornata*	LC	
Reptile	*Strophurus ciliaris*	LC	
Reptile	*Suta punctata*	LC	
Reptile	*Suta suta*	LC	
Reptile	*Tiliqua multifasciata*	LC	
Reptile	*Tympanocryptis lineata*	LC	
Reptile	*Tympanocryptis tetraporophora*	LC	
Reptile	*Varanus acanthurus*	LC	
Reptile	*Varanus gouldii*	LC	
Reptile	*Varanus spenceri*	DD	
Reptile	*Varanus tristis*	LC	

7.5 **Appendix Five:** Fauna recorded during on site investigations by Low Ecological Services in 2008 and 2009 within the Wonarah prospect (SEL26452)

Status is given under the Commonwealth Environment Protection and Biodiversity Act (1999) (EPBC) (amended 2004), and the Territory Parks and Wildlife Conservation Act (2000) (TPWC). See Appendix 4 for key to conservation code descriptions.

Common Name	**Scientific**	**Conservation Status**	
Mammals		**EPBC**	**TPWC**
Camel	*Camelus dromedarius*		Int.
Cat, Feral	*Felis catus*	-	Int.
Cow	*Bos taurus*	-	Int.
Dingo	*Canis lupis*	-	LC
Donkey, Feral	*Equus asinus*	-	Int.
Dunnart, Fat-tailed	*Sminthopsis crassicaudata*		LC
Dunnart, Lesser hairy-footed	*Sminthopsis youngsoni*	-	LC
Dunnart (unidentified)		-	-
Echidna, Short-beaked	*Tachyglossus aculeatus*	-	LC
Euro	*Macropus robustus*		LC
Fox, Red	*Vulpes vulpes*	-	Int.
Kangaroo, Red	*Macropus rufus*	-	LC
Mouse, Sandy inland	*Pseudomys hermannsburgensis*		LC
Mouse, Desert	*Pseudomys desertor*		LC
Mouse, Spinifex Hopping	*Notomys alexis*		LC
Mouse (unidentified)			
Wallaby, Northern Nailtail	*Onychogalea unguifera*	-	NT
Reptiles		**EPBC**	**TPWC**
Blue-tongue, Centralian	*Tiliqua multifasciata*	-	LC
Dragon	*Diporiphora lalliae*	-	LC
Dragon, Military	*Ctenophorus isolepis*	-	LC
Gecko, Fat-tailed	*Diplodactylus conspicillatus*	-	LC
Gecko, Spiny-tailed	*Strophurus ciliaris*	-	LC
Gecko, Varigated	*Gehyra variegata*		
Gecko (unidentified)		-	-
Goanna, Sand	*Varanus gouldii*	-	LC
Goanna (unidentified)		-	-
Legless lizard (unidentified)		-	-
Lerista, Two-toed	*Lerista bipes*	-	LC
Monitor, Pygmy Desert	*Varanus eremius*	-	LC
Monitor, Pygmy Mulga	*Varanus gilleni*	-	LC
Thorny Devil	*Moloch horridus*	-	LC
Sand-swimmer, Broad-banded	*Eremiascincus richardsonii*	-	LC
Skink, Ctenotus	*Ctenotus leonhardii*	-	LC

Common Name	Scientific	Conservation Status	
Skink, Ctenotus	*Ctenotus schomburgkii*	-	LC
Small lizard (unidentified)			
Snake (unidentified)		-	-
Birds		**EPBC**	**TPWC**
Babbler, Grey-crowned	*Pomatostomus temporalis*	-	LC
Bellbird, Crested	*Oreoica gutturalis*	-	LC
Budgerigar	*Melopsittacus undulatus*	-	LC
Bustard, Australian	*Ardeotis australis*	-	VU
Button-Quail, Little	*Turnix pyrrhothorax*	-	LC
Chat, Crimson	*Epthianura tricolor*	-	LC
Cockatiel	*Nymphicus hollandicus*	-	LC
Dove, Diamond	*Geopelia cuneata*	-	LC
Fairy-wren, Variegated	*Malurus lamberti*	-	LC
Falcon, Brown	*Falco berigora*	-	LC
Finch, Zebra	*Taeniopygia guttata*	-	LC
Galah	*Cacatua roseicapilla*	-	LC
Hobby, Australian	*Falco longipennis*	-	LC
Honeyeater, Grey headed	*Lichenostomus keartlandi*	-	LC
Honeyeater, Singing	*Lichenostomus virescens*	-	LC
Honeyeater, Spiny-cheeked	*Acanthagenys rufogularis*	-	LC
Jacky Winter	*Microeca fascinans*	-	LC
Kingfisher, Sacred	*Todiramphus sanctus*	-	LC
Kite, Black	*Milvus migrans*	-	LC
Kite, Whistling	*Haliastur sphenurus*	-	LC
Magpie, Black-backed	*Gymnorhina tibicen*	-	LC
Miner, Yellow-throated	*Manorina flavigula*	-	LC
Owl, Barn	*Tyto alba*	-	LC
Pardalote, Red-browed	*Pardalotus rubricatus*	-	LC
Parrot, Australian Ringneck	*Barnardius zonarius*	-	LC
Pratincole, Australian	*Stiltia isabella*	-	LC
Quail-thrush Cinnamon	*Cinclosoma cinnamomeum*	-	LC
Songlark, Brown	*Cincloramphus cruralis*	-	LC
Triller, White-winged	*Lalage sueurii*	-	LC
Wagtail, Willie	*Rhipidura leucophrys*	-	LC
Wedgebill, Chiming	*Psophodes occidentalis*	-	LC
Woodswallow, Blackfaced	*Artamus cinereus*	-	LC
Woodswallow, Masked	*Artamus personatus*	-	LC

Appendix 5

Hydrogeological and Water Supply Investigations

GROUNDWATER RESOURCE MANAGEMENT

REPORT ON

HYDROGEOLOGICAL AND WATER SUPPLY INVESTIGATIONS

WONARAH PHOSPHATE PROJECT

Prepared for

Minemakers Australia Pty Ltd

Level 2, 34 Colin Street

WEST PERTH WA 6005

Report Distribution

No. Copies	
2	Minemakers Australia Pty Ltd (digital copies included with each report)
1	Groundwater Resource Management Pty Ltd

J080028R01 October 2009

EXECUTIVE SUMMARY

Minemakers Australia Pty Ltd (Minemakers) is planning to develop the Wonarah Phosphate Project. Stage 1 involves the mining of direct ship ore (DSO) and is subject to a Bankable Feasibility Study (BFS). Groundwater issues for the BFS relate to estimation of the water demand, identification of a suitable water supply, assessment of the security of the supply and impacts from pumping, assessment of other mining activities' impacts upon the groundwater environment, characterization of the groundwater environment and groundwater quality, and development of an operating strategy.

A water balance for the Project, including supplies for construction, development and mining estimated a maximum combined demand during the initial construction phase of 15 L/s, rising to 67 L/s at the end of development. The demand during mining is predicted to be between 32 and 60 L/s.

A field programme was completed during which four production bores were installed one near Minemakers' camp, one at Arruwurra and two north of Minemakers' tenements. The results of the programme included the following:

- Minor groundwater supplies were found within Minemakers' tenements mostly in the vicinity of the Arruwurra deposit.
- Good groundwater supplies were identified north of Minemakers' tenements with maximum bore yields of about 20 L/s.
- Groundwater quality is fresh to brackish with elevated concentrations of iron and silica in the northern bores and at Arruwurra; boron was also high in the camp bore.
- Groundwater levels measured within the Main Zone and Arruwurra areas were generally below the base of the ore zones, apart from a few minor occurrences that are judged to be isolated.

It is planned to develop an initial supply for construction and development from five modest yielding production bores within Minemakers tenements at Arruwurra. The longer term supply will then be developed off Minemakers' tenements to the north, comprising five high yielding production bores. Both short and long-term supplies will make use of the recently completed test production bores.

The combined yield from the five short-term Arruwurra production bores is estimated at about 12.5 L/s, using standard methods.

A numerical model was developed to assess the longer term yield and impacts from the production bores located off tenement. The model results indicate a combined pumping rate of up to 75 L/s can be sustained over the 10 year mine life. Impacts from long-term pumping are expected to be limited to possibly six existing third party users, located within a 10 km radius of the planned production bores. Minemakers has committed to providing an alternative water supply should unacceptable impacts occur at these locations.

A groundwater level survey carried out at the Main Zone and Arruwurra show levels mostly lie below the base of the ore. Dewatering requirements are therefore likely to be negligible, possibly limited to localized sump pumping to manage short-term seepage inflows.

A risk assessment for the Project has identified a number of groundwater related risks. However, all risks were ranked as Low, apart from the risk of groundwater supply failure and unacceptable impacts upon the environment, which were rated as Moderate. The adequate mitigation of these risks can be achieved through effective control measures, including adequate monitoring, provision of sufficient redundancy in the groundwater supply and installation of additional suitably located bores if required.

The requirement for a suitable operating strategy has been identified which will be presented under a separate cover in a standalone document. A monitoring schedule has been provided that will form part of the strategy.

GLOSSARY OF HYDROGEOLOGICAL TERMS

Aquifer	A saturated geological unit that is permeable enough to yield economic quantities of water.
Aquitard	A geological unit that is permeable enough to transmit water but not sufficient to yield economic quantities.
Aquiclude	A geological unit that is impermeable, *i.e.* cannot transmit water.
Confined Aquifer	An aquifer bounded above and below by an aquiclude, where the water level in the aquifer extends above the aquifer top and is represented by a pressure head, *i.e.* the aquifer is completely saturated.
Leaky Aquifer or Semi-Confined Aquifer	An aquifer with upper and/or lower boundaries as an aquitard, where the water level in the aquifer extends above the aquifer top and is represented by a pressure head. Pumping from the aquifer induces leakage from the neighbouring aquitard units.
Unconfined or Watertable Aquifer	An aquifer that is bounded below by an aquiclude, but is not restricted on its upper boundary, which is represented by the water table.
Hydraulic Conductivity (K) [Permeability]	The volume of water that will flow in a unit time under a unit hydraulic gradient through a unit area. Analogous to the permeability with respect to fresh water (units commonly m/d or m/s).
Transmissivity (T)	The product of the hydraulic conductivity and the saturated aquifer thickness (units commonly m^3/d/m or m^2/d).
Specific Storage (S_s)	The volume of water released from a unit volume of aquifer under a unit decline in hydraulic head, assuming confined aquifer conditions. Water is released because of compaction of the aquifer under effective stress and expansion of the water due to decreasing pressure (units commonly m^{-1}).
Storativity (S)	The volume of water released from a unit area of aquifer, i.e the aquifer column, per unit decline in hydraulic head (dimensionless parameter).
Specific Yield (S_y)	The volume of water released from an unconfined aquifer per unit decline in the water table. The release of water is mostly from aquifer draining. Contributions from aquifer compaction are generally small. Analogous with effective porosity (dimensionless parameter).

Terms referenced from Kruseman GP and deRidder NA (1994) 2nd edition, Analysis and Evaluation of Pumping Test Data. ILRI Publication 47 The Netherlands.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Minemakers Australia Pty Ltd (Minemakers) is planning to develop the Wonarah Phosphate Project located south of the Barkly Highway, about 240 km east of Tennant Creek and 960 km southeast of Darwin in the Northern Territory (Figure 1).

The Project involves the mining of two phosphate deposits, known as Arruwurra and Main Zone. The Project has an inferred JORC compliant resource estimated at 461 Mt at 18.8% phosphate (P_2O_5) that will be developed over two discrete Stages. Stage 1 involves the mining of direct ship ore (DSO). During Stage 1 the Project will comprise a number of open pits, a treatment plant for ore crushing and screening, waste dumps, mine infrastructure and mine camp.

Stage 2 of the Project, which will comprise the mining and beneficiation of lower grade ore, is still being defined and lies outside the scope of the current studies for the Project.

Stage 1 will required a water supply for dust suppression, mining purposes and potable/domestic use. Groundwater levels in the vicinity of the two deposits generally lie below the expected base of the orebodies, therefore the requirement to manage groundwater inflows during mining is expected to be minimal.

This report presents the results of hydrogeological and water supply investigations carried out on behalf of Minemakers by Groundwater Resource Management Pty Ltd (GRM). The investigations comprised:

- The development of a site water balance to estimate the water demand for the Project during Stage 1.
- The identification and assessment of a groundwater supply to meet the anticipated water demand, both in terms of quantity and quality.
- The assessment of the likely impacts upon the groundwater environment from operation of the proposed groundwater supply, including effects upon environmentally sensitive areas and existing groundwater users.
- The assessment of impacts from other mining activities, e.g. storage of mine waste and disposal of waste water.
- The characterisation of the groundwater environment in the mining areas and in the vicinity of the proposed groundwater supply to:
    - i. confirm the expected low dewatering requirements in the planned pits;
    - ii. identify the main aquifers;
    - iii. identify the main recharge and discharge zones.
- The assessment of groundwater quality in the mining areas and in the vicinity of the proposed groundwater supply.
- The development of a groundwater operating strategy, which:
    - i. presents a schedule of production and monitoring bores, including the maximum duty rate for each production bore;

ii. identifies environmentally sensitive areas and existing third party groundwater users in the vicinity of the proposed groundwater supply;

iii. presents a suitable groundwater monitoring programme for the Project, both during mining and after closure;

iv. identifies review requirements, assessment criteria and reporting frequencies for the groundwater monitoring data.

2.0 BACKGROUND

2.1 Climate

The climate of much of the Barkly region is semi-arid, merging into an arid zone at the southern limit and into a narrow sub-humid northern strip adjoining the Gulf of Carpentaria[1]. The climate is monsoonal with well-defined wet and dry seasons, with nearly all rain falling between November and March and the greatest incidence during January and February. Light rains are sometimes received during the dry season, but the period between April and September is frequently dry.

Although tropical cyclones may bring heavy rains to the Barkly region, they are erratic in nature and occur relatively infrequently. Typically they track either from east to west or from northwest to southeast. Disturbances following the former track usually develop in the Coral Sea and enter the region after passing across the Cape York Peninsula; those following the latter track usually arise in the Arafura Sea and enter the region after crossing Arnhem Land or the Gulf of Carpentaria.

Day temperatures are high throughout the year, particularly in October, November and December prior to the onset of the wet season. With the occurrence of wetter conditions and slightly lower temperatures, humidity reaches its highest levels during January and February.

Table 1: Rainfall and Evaporation Data

Month	Mean Rainfall (mm)*	Median Rainfall (mm)*	Maximum Rainfall (mm)*	Minimum Rainfall (mm)*	Calculated Evaporation (mm)
January	85.6	61.5	273.6	5.0	313
February	82.9	65.3	270.6	0	254
March	46.1	32.5	312.0	0	258
April	13.4	0.0	156.2	0	240
May	9.5	0.0	127.8	0	206
June	9.0	0.0	102.6	0	164
July	3.9	0.0	46.5	0	180
August	2.2	0.0	83.9	0	221
September	4.2	0.0	66.9	0	276
October	14.2	8.1	101.3	0	340
November	26.7	15.7	118.0	0	324
December	61.9	39.3	430.6	0	338
Total	359.6	222.4	2090	5	3114

Note: * data for the Ranken River meteorological station

[1] Survey of the Barkly Region, Northern Territory and Queensland, 1947-48, C. S. Christian, L. C. Noakes, R. A. Perry, R. O. Slatyer, G. A. Stewart, and D. M. Traves, Land Research Series No.3. CSIRO, Melbourne 1954.

Rainfall averages, maxima and minima for the Ranken River meteorological station (Number 15026), located about 70 km to the east of the Project and considered the most representative due to its proximity and record duration (GRM 2009), are presented in Table 1. Also presented in the table are the calculated mean monthly evaporation rates based on measured values at Brunette Downs meteorological station (Number 15085) and Camooweal meteorological station (Number 37010), located about 170 km northwest and east of the Project respectively.

2.2 Mining Schedule and Project Timing

The timing for the Wonarah Project is based upon an initial production rate of 1 mtpa increasing to 3 mtpa after approximately 1 year. The schedule is summarised below.

i) Construction for 1 mtpa production rate commencing in mid July 2010 and finishing at the end of December 2010.

ii) Pre-stripping at Arruwurra commencing early August 2010 and finishing at the end of October 2010.

iii) Pre-stripping at the Main Zone commencing early August 2010 and finishing at the end of December 2011.

iv) Construction for the 3 mtpa production rate commencing in March 2011 and finishing at the end of December 2011.

2.3 Geology

2.3.1 Regional geology

The Wonarah Project is situated in the central western Georgina Basin, a large late Proterozoic to early Palaeozoic basin that extends from northwestern Queensland through much of the eastern Northern Territory.

Basement rocks in this part of the Georgina Basin comprise Mesoproterozoic sediments and volcanics overlain by the Early Cambrian Peaker Piker Volcanics. A northeast-southwest trending basement high comprising a mag-haematite rich basalt runs through the Wonarah Project area.

The overlying Middle Cambrian sediments, which contain the phosphate mineralisation, are divided into two basin-wide sequences.

- Sequence One comprises clastics, carbonates, organic shales and minor phosphorites. In the vicinity of the Project, basement highs are flanked by onlapping dolomitic rocks equivalent to the Thorntonia Limestone. An unconformity separates this unit from the overlying Sequence Two rocks with remnants of the paleo-erosion surface developing Karstic features in the carbonate sequences.

- Sequence Two is made up of shallow clastics, carbonates, grainstones, peritidal phosphorites and phosphatic limestones. At Wonarah dolostone, mudstone and phosphorite of the lower Middle Cambrian, Upper Gum Ridge Formation overlie Sequence One rocks and basement highs. This formation contains major phosphorite mineralisation and is host to the Arruwurra and Main Zone deposits. This sequence is likely to be stratigraphically equivalent to the Beetle Creek

Formation on the eastern Margin of the basin, which hosts Phosphate Hill and Lady Annie-D-Tree phosphate deposits. The overlying Wonarah Beds comprise Middle Cambrian mudstone, siltstone and dolostones.

Silcrete, ferricrete and calcrete regolith are extensively developed at the Project and large areas are covered by aeolian sand.

2.3.2 Main Zone Geology

The basement lithology in the Main Zone area is dominantly basalt of the Peaker Piker Volcanics. The top of the basalt is extremely weathered; and a ferruginous and manganiferous duricrust is developed locally. Some dolomitic rocks of the Thorntonia Limestone equivalent are present above the basalt at the southeastern extremity of the Main Zone. Further to the east and the south the carbonate rocks are extensively exposed.

The overlying phosphate-bearing Upper Gum Ridge Formation is divided into four main units: basal undifferentiated transitional sediments, chert breccia phosphorite, mudstone phosphorite and convolute mudstone.

The Transition Unit is laterally continuous, 4 to 8 m thick and comprises clay-rich mudstone and siltstone with minor phosphorite, dolomite, sandstone and basal epiclastics. The basal Transitional Phosphorite is a laterally discontinuous high grade porcellinous phosphorite up to 3 m thick developed throughout the eastern and southern part of the Main Zone.

The Chert Breccia Phosphorite forms a distinctive, laterally continuous horizon, 1 to 10 m thick, and comprises yellow, grey or pink friable to indurated low to high grade phosphorite with abundant dark grey chert. The chert content of the horizon averages 50% to 60%.

The Mudstone Phosphorite is the main phosphate-bearing unit at the Project and is comprised of 1 to 10 m of yellow and pink mudstone phosphorite with trace to minor dark grey chert. The mineralogy is dominated by (carbonate) fluorapatite.

The Convolute Mudstone is a 1 to 10 m thick unit of white, light grey and yellow clay rich variably convolute mudstone with minor siltstone and fine sandstone interbeds. It generally contains minor phosphate.

The Wonarah Beds form the hanging wall to the deposit, overlying the Convolute Mudstone, and comprise mudstone and siltstone with minor chert. The Wonarah Beds thicken towards the east and south away from the basement high that defines the western fringe of the Main Zone. East and south of the Main Zone the hanging wall comprises dolomite and dolostone.

The regolith is extensively developed throughout the Main Zone with silcrete and ferricrete present in most drill-holes. Low silcrete ridges are prominent features. Colluvial and alluvial deposits are common with extensive aeolian sands covering much of the regolith.

The phosphatic units thin and peter out towards the basement high which trends in a northeast-southwest direction towards Arruwurra.

2.3.3 Arruwurra Geology

At Arruwurra the phosphate mineralisation occupies a broad northeast-southwest trending shelf sloping gently to the southwest. The shelf drops away sharply at the western end and along the southeastern edge. Mineralisation outcrops in the northeast before petering out against the basement high to the north.

The basement at Arruwurra comprises basalt of the Peaker Piker Volcanics. Thorntonia Limestone equivalent dolomites and dolostones overlay the basalt along the southeastern and southern margin of the deposit. An abrupt change in lithology and depth to basalt basement indicates a probable fault which has thrown the deposit side upwards. A karst surface is present on the dolomite.

The Upper Gum Ridge Formation at Arruwurra is different to the Main Zone. The Transition Unit is thinner and less well developed. Generally the unit comprises 1 to 5 m of mudstone, siltstone and phosphorite.

The laterally continuous chert breccia horizon is absent at Arruwurra. There appears to be some chert-rich domains within the deposit, but chert is generally sparsely and patchily distributed through the Arruwurra Phosphorite. The Phosphorite is white to yellow-brown in colour and ranges from friable to indurated or porcellinous. Chert averages 10% to15% of the Phosphorite unit.

The Arruwurra Phosphorite is overlain by and, near surface, interdigitates with a limestone carbonate unit in the northeastern part of the deposit. Outcropping high grade phosphorites occur in this area. To the southwest the Aruwurra Phosphorite is overlain by the Hangingwall Mudstone unit of the Wonarah Beds, which comprise siltstones and mudstones with variable but minor chert. Towards the southwest this unit thickens and becomes patchy but increasingly ferruginous.

Aeolian sand covers much of the area and is underlain by ferricrete, silcrete, and, above the carbonate unit in the northeast, calcrete and black soil.

2.4 Hydrogeology

The main aquifers on the Barkly tableland comprise cavernous zones that are commonly weathered and fractured, within calcareous units of the Wonarah Formation and Camooweal Dolomite. These aquifers have been used to provide domestic and stock water across the tableland for nearly a century. The majority of the existing bores have not been test pumped preventing reliable estimates of aquifer yields. However, airlift rates of over 5 L/s are common and sometimes over 100 L/s (Read RE, 2007) have been reported.

The volcanic rocks, which form the basement at the Project, have generally low permeability. Groundwater occurrence within the basement rocks is restricted to discrete fractures and zones of higher weathering. Maximum flow rates from the fractures is likely to be less than 5 L/s.

Groundwater recharge is predominantly from rainfall infiltration. Recharge from surface water will occur locally in the vicinity of the major rivers and, after rainfall events, from minor water courses and marshy areas. Rainfall recharge rates have been estimated from water balance calculations at 4 mm/year and from chloride balance methods of between 1.5 and 5 mm/year.

Groundwater levels within Minemakers' tenements are extremely variable, ranging from about 25 to over 100 m bgl. The regional groundwater flow regime is poorly understood. Estimates by NRETAS (Tickel, 2003) suggest there may be a north south groundwater divide along latitude 20S, with groundwater south of this parallel flowing to the southeast and from the northern catchment to the north east towards and discharging to the Gregory River.

Groundwater quality over the tableland is generally fresh to brackish, ranging from 500 to 4,000 mg/L Total Dissolved Solids (TDS).

2.5 Other Groundwater Users and Groundwater Sensitive Areas

The locations of other groundwater users within and north of Minemakers' tenements were sourced from the NRDB1 database managed by NRETAS. The locations of the third party bores are shown on Figure 2, along with the four production bores completed for Minemakers as part of this investigation (Section 3.1.2).

Figure 2 shows the following:

- Ten pre-existing bores lie within the tenement areas, all located either along or north of the Barkly Highway. All seven bores were installed by the Northern Territory Government for construction and/or maintenance of the highway.
- Six pre-existing holes lie within a 10 km radius of the two Minemakers' northern production bores (WNWB003 and 004). All the bores were installed by Dalmore Downs Station for stock watering purposes.

Details of the 16 third party bores located within Minemakers' tenements and within 10 km of the two northern Project production bores are presented in Table 2.

Two environmentally sensitive areas that could be affected by groundwater extraction were identified by Coffey Environmental, sourced from Geoscience Australia. The sensitive areas comprise two marshes, Kerringnew Swamp located about 10 km north east of WNWB003 and Oolgoolgam Swamp located about 37 km east of bores WNWB003 and 004.

Kerringnew Swamp was visited and an environment monitoring bore (WNEM001) installed during the field programme (Section 3.1.2). At the time of the site visit there was no evidence of surface water, although the vegetation suggested inundation may occur after rainfall events. The monitoring bore (completed to 18 m depth) was dry during subsequent visits. These conditions suggest the marsh is an ephemeral surface water feature and not related to groundwater. It would therefore not be expected to be influenced by changes in the underlying groundwater level.

Oolgoolgam Swamp was not visited because of it's distance from the northern bores.

Table 2: Third Party Bores

RN Number	Bore Name	Depth (m)	Compl. Date	Depth (m)	Location MGA Zn 53		Status	Use	SWL (mbgl)	Yield (L/s)
					(mE)	(mN)				
RN000031	4A-132 Barkly Hwy	92.9	ND	92.9	636,226	7,801,919	ND	Not Known	69.1	0.39
RN000301	3A-128 Mile Barkly Hwy	60.9	ND	60.9	641,726	7,798,919	Not in use	None	ND	ND
RN000302	2A-128 Mile Barkly Hwy	ND0	ND	ND	641,726	7,798,919	Not in use	None	ND	ND
RN000370	1A-124 Mile Barkly Hwy	0ND	ND	ND	646,126	7,794,869	Not in use	Not Known	ND	ND
RN001237	No 2 Eagles Nest, Dalmore Downs Stn	81.7	1950	81.7	643,850	7,818,572	ND	Production	51.5	2.6
RN001238	No 3 Blue Bush, Dalmore Downs Stn	88	1951	88	634,207	7,815,614	ND	Production	46.3	2.6
RN001778	Wonarah repeater station, Barkly Hwy	111.5	1958	111.5	640,212	7,799,448	ND	Production	53.9	0.68
RN004087	No 11 Alroy Downs	71	1963	71	634,526	7,825,369	ND	Production	56	2.86
RN006751	No 11 Dalmore Downs Stn	94.5	1970	94.5	634,571	7,825,132	ND	Production	52	3
RN020997	81/1 Barry Caves West, Dalmore Downs Stn	ND	1981	200	648,937	7,792,271	ND	Not Known	ND	0.4
RN020998	81/2 Barry Caves West, Dalmore Downs Stn	125	1981	125	646,026	7,794,669	ND	Not Known	ND	0.25
RN021238	81/3 Barkly Hwy Barry Caves West	145	1981	145	653,526	7,792,769	ND	Not Known	63	0.38
RN021239	81/4 Barkly Hwy Barry Caves West	76	1981	76	652,227	7,795,886	Not in use	Not Known	ND	ND
RN021245	81/5 Barkly Hwy Barry Caves West	134	1981	134	640,230	7,799,600	ND	Not Known	109.8	1.9
RN025678	No 10A 88/37 Dalmore	140	1988	140	645,306	7,825,367	ND	Production	100	5
RN025874	No 10 Dalmore Downs Stn	135.6	1971	135.6	645,320	7,825,391	ND	Production	68.6	1.4

Note: RN number relates to the identifier used in the NRDB1 database, SWL = static water level, mbgl = metres below ground level, ND = no data available.

2.6 Previous Investigations

Previous groundwater investigations carried out in the vicinity of the Wonarah Project were conducted by the Northern Territory Government and Coffey Mining Pty Ltd and included:

- early field investigations carried out by Randall in 1967;
- a regional field programme carried out north and east of the Project for the Department of Lands, Planning and Environment (Territory Groundwater Services, 1998), which comprised the drilling and geophysical logging of 13 bores and the test pumping of nine pre-existing stock and domestic bores;
- a desktop study into the hydrogeology of the Avon Downs and Ranken 1:250,000 Geological Sheets carried out by the Department of Infrastructure, Planning and Environment (2003);
- an assessment of the water resources of the Arruwurru, Wakaya and Warramunga aboriginal land trusts carried out by the Department of Natural Resources, Environment and the Arts (2007), which included the drilling of five holes near the eastern boundary of Minemakers' tenements;
- a desktop investigation carried out by Coffey Mining for Minemakers.

The desktop study carried out by Coffey Mining identified eight Groundwater Exploration Areas (GEAs), comprising GEA1 to GEA7 and Arruwurra, based on historic drilling results, geological interpretation, inferred recharge areas and proximity to the mining area and Barkly Highway. Recommendations from the study included the air-flown geophysical survey of the eight GEAs. The survey was subsequently carried out by Fugro Airborne Surveys and comprised magnetic and electromagnetic surveys. The datasets were processed to provide the following results: total magnetic field, calculated magnetic gradient and apparent conductivity at five frequencies (400, 1800, 8200, 40,000 and 140,000 Hz).

2.7 Regulatory Issues

Groundwater exploration drilling within tenements held by Minemakers is permitted under a Memorandum of Understanding between the Water and Mining Acts. The memorandum states that a mining company is free to drill for groundwater within their mining tenements where the water is to be used for mining related purposes, e.g. dust suppression, processing and dewatering. However, the construction of a production bore for supply of water to mine personnel must still be undertaken by a water bore driller holding a Northern Territory water bore drillers licence.

The water exploration drilling and bore construction carried out north of Minemakers' tenements was carried out under Ministerial Approval provided under Section 182(2) of the Mining Act. A copy of the approval letter is presented in Appendix A.

The drilling of the four Minemakers' production bores completed as part of these investigations (Section 3.1.2) was supervised by suitably licensed water bore drillers. Details of the drilling supervisors are summarised below.

- Production bores WNWB001 and 002 were supervised by Mr Gregory Scott, licence number 23.

- Production bores WNWB003 and 004 were supervised by Mr Dean Johnston, licence number 80.

3.0 FIELD INVESTIGATIONS

Field investigations overseen by GRM at the Project comprised three phases of drilling and a programme of test pumping. The first two drilling phases were restricted to tenements held by Minemakers. The third programme targeted an area north of Minemakers' tenements, which had been identified from the historical drilling record as being prospective in terms of groundwater supply.

The first two drilling phases were carried out by Tom Browne Drilling Services using various reverse circulation drilling rigs. The last phase was completed by Gorey and Cole and direct circulation air-hammer methods. All drilling was overseen by a GRM hydrogeologist, who was responsible for site selection, arranging access and recording of drilling, geological and hydrogeological data. During the programme care was taken to note air-loss to the formation, especially when associated with intersection of cavities.

3.1 Drilling and Bore Construction

Information on the three drilling phases is summarised below.

- Drilling Phase 1 was undertaken between 23 February and 12 April 2009 and comprised the drilling of 28 exploration holes.

- Drilling Phase 2 was undertaken between 19 April and 7 June 2009 and comprised the drilling of 40 exploration holes and the reaming and construction of two production bores.

- Drilling Phase 3 was undertaken between 20 August and 2 September 2009 and comprised the drilling of eight exploration holes, two of which were reamed and constructed as production bores and the remaining six constructed as monitoring/observation bores.

During the drilling programme 76 exploration holes were drilled. Four of the exploration holes were reamed out and completed as production bores and six completed as monitoring/ observation bores.

The first two phases of drilling, confined to tenements held by Minemakers, targeted lineaments identified from the air-flown magnetic survey data and, to a lesser extent, the air-flown EM survey data. Lineaments identified from the air-flown magnetic data relate to magnetic contrasts in the basement rocks, commonly geological structures and lithological contacts, while lineaments interpreted from the EM data reflect changes in the subsurface electrical properties.

As a general rule the air-flown magnetic survey data provided a greater contrast in ground properties, enabling better interpretation of lineaments in the eight surveyed areas. The EM survey data was used to identify a lineament in GEA5, but in the remaining survey areas the air-flown magnetic data was considered more appropriate.

Regional air-flown magnetic survey data was also sourced from the Geoscience Australia online database. However the low resolution of the survey limited the use of the data during the groundwater search, although a reasonable correlation was noted between the high resolution Fugro and the low resolution regional surveys.

3.1.1 Exploration drilling results

Of the 76 holes 68 were drilled on tenements held by Minemakers, 39 at Arruwurra, three in GEA2, eight in GEA3, four in both GEA4 and GEA5, five in GEA6 and five in the camp area. The remaining eight holes were drilled north of Minemakers' tenements.

A summary of the exploration drilling results is presented in Table 3 and the hole locations shown in Figure 3. Graphical bore logs presenting the geological, hydrogeological and bore construction data are presented in Appendix B.

<u>Tenement area drilling results</u>

The results from the holes drilled on tenements held by Minemakers showed that the basin sediments are generally limited in thickness in the Project area, with most completed drill-holes penetrating through to the underlying basaltic basement. A maximum basement depth of 164 m was recorded, although the majority of drill-holes intersected basalt well above 150 m.

Within the tenements groundwater was generally intersected in fractured basement rocks, with only low airlift yields. Cavities within dolomite were identified in about 20 drill-holes, but these were commonly dry or had minimal inflow rates. The poor results were due to the location of the cavities near surface (i.e. above or near the water table) and/or because of infilling with regolith (clay and silt etc).

The most promising results within the tenements were identified at Arruwurra, which comprised the following intersects:

- Drill-holes WNWE005, 012, 018, 019, 052 (converted to production bore WNWB002) and 061; which targeted a major air-magnetic lineament trending approximately north-south (Figure 4). Airlift rates associated with this lineament were generally around 1 to 2 L/s, with a peak flow of 4.5 L/s at hole WNWE005.

- Drill-hole WNWE057 which airlifted 1.5 L/s from fractured basement.

- Drill-hole WE061 and 062 which airlifted around 1.5 L/s from cavities in weathered dolomite.

Significant airlift rates (greater than 1 L/s) were also observed in GEA2 at drill-holes WNWE013 and 015, located near the southern boundary of Minemakers' tenements, and adjacent to the Minemakers' camp (WNWE001 and WNWE051). Groundwater at GEA2 was intersected in fractured quartz and chert at depth, which is consistent with the deepening of the Georgina Basin to the south of the Project area. Although the airlift rates from holes in GEA2 were promising it was noted that the water was highly turbid and construction of a usable production bore at the tested locations would be problematic.

The groundwater intersects near the camp were related to discrete fractures in the basalt basement rocks. Exploration hole WNWE051 was subsequently converted into a production bore (WNWB001) and used to supply water to Minemakers' camp.

A potential groundwater source was also identified in GEA5 where cavities were intersected at depth in drill-holes WNWE049 and 050. Although airlift yields were low, the loss of circulation indicates higher permeabilities at these locations.

The locations of the 68 holes drilled on Minemakers' tenements are presented in Figure 4 (Arruwurra, GEA2 and GEA5) and Figure 5 (GEA3, GEA4, GEA6 and the camp area).

Table 3: Summary of Exploration Drilling Results

Hole ID	Collar Location MGA Zn 53 (mE)	(mN)	Dip	Azimuth	Depth (m)	Max Yield (L/s)	Final EC (mS/cm)	Inflow Depths (m)	Inflow Feature	Date Completed	GEA
WNWE001	652,971	7,789,602	60	90	162	1.2	1.3	78-96, 132-138	Fractured basalt	28/02/09	Camp Area
WNWE002	653,043	7,789,596	60	90	150	Trace	1.3	90-102	Fractured basalt	27/02/09	Camp Area
WNWE003	652,893	7,789,600	60	90	150	Trace	1.3	96-102	Fractured basalt	1/03/09	Camp Area
WNWE004	653,114	7,789,600	60	270	132	1	1.1	84-90, 96-102, 108-114, 129-132	Fractured basalt	4/03/09	Camp Area
WNWE005	642,549	7,777,102	60	313	132	4.5	2	108-114	Fractured basalt	6/03/09	Arruwurra
WNWE006	639,122	7,773,122	60	316	156	Trace	NA	NA	NA	7/03/09	Arruwurra
WNWE007	639,170	7,773,071	60	316	150	Trace	NA	NA	NA	8/03/09	Arruwurra
WNWE008	639,068	7,773,176	60	316	150	0.2	1.2	108, 126-132, 138-144	Fractured basalt	10/03/09	Arruwurra
WNWE009	639,015	7,773,230	60	316	144	Trace	NA	NA	NA	10/03/09	Arruwurra
WNWE010	642,605	7,777,048	60	313	156	Trace	NA	NA	NA	12/03/09	Arruwurra
WNWE011	642,440	7,777,200	60	313	144	2	2	129-130, 135-141	Fractured basalt	13/03/09	Arruwurra
WNWE012	642,495	7,777,149	60	313	120	1.3	1.9	91-96	Fractured basalt	14/03/09	Arruwurra
WNWE013	636,070	7,767,130	60	305	150	2	1.4	90-96, 108-114	Fractured quartzite & chert	16/03/09	GEA2
WNWE014	636,133	7,767,089	60	305	150	1	1.4	96-108	Fractured quartzite & chert	17/03/09	GEA2
WNWE015	636,196	7,767,048	60	305	156	2	1.4	84-102	Fractured siltstone, quartzite & chert	20/03/09	GEA2
WNWE016	641,250	7,775,183	60	270	150	0.5	4.1	100-102, 111	Fractured basalt	23/03/09	Arruwurra
WNWE017	641,335	7,775,188	60	270	156	Trace	4.3	NA	NA	24/03/09	Arruwurra
WNWE018	641,175	7,775,189	60	270	150	1.8	3	94-108, 120-126	Fractured basalt	25/03/09	Arruwurra

Hole ID	Collar Location MGA Zn 53		Dip	Azimuth	Depth (m)	Max Yield (L/s)	Final EC (mS/cm)	Inflow Depths (m)	Inflow Feature	Date Completed	GEA
	(mE)	(mN)									
WNWE019	641,095	7,775,171	60	270	156	1.9	3	96-114, 120-126, 132-138, 144-150	Fractured and weathered basalt	27/03/09	Arruwurra
WNWE020	660,111	7,788,268	60	216	150	Trace	NA	NA	NA	30/03/09	GEA4
WNWE021	660,151	7,788,322	60	216	150	Dry	NA	NA	NA	31/03/09	GEA4
WNWE022	660,196	7,788,379	60	216	156	Trace	NA	NA	NA	1/04/09	GEA4
WNWE023	660,237	7,788,444	60	216	144	Trace	NA	NA	NA	2/04/09	GEA4
WNWE024	664,344	7,779,305	60	329	174	Trace	NA	NA	NA	4/04/09	GEA6
WNWE025	664,371	7,779,250	90	NA	157	Trace	NA	NA	NA	8/04/09	GEA6
WNWE026	664,264	7,779,421	90	NA	151	Trace	NA	NA	NA	9/04/09	GEA6
WNWE027	664,431	7,779,154	90	NA	175	Trace	NA	NA	NA	10/04/09	GEA6
WNWE028	664,482	7,779,072	90	NA	104	Dry	NA	NA	NA	10/04/09	GEA6
WNWE029	641,396	7,773,090	60	300	156	1	3.4	117, 132-138	Fractured basalt	20/04/09	Arruwurra
WNWE030	641,335	7,773,132	60	300	156	1	3.2	138-156	Fractured basalt	21/04/09	Arruwurra
WNWE031	641,463	7,773,057	60	300	150	0.6	2	102-108, 114-120	Fractured basalt	22/04/09	Arruwurra
WNWE032	641,269	7,773,169	60	300	150	0.2	NA	114	Fractured basalt	23/04/09	Arruwurra
WNWE033	641,407	7,773,784	60	270	150	0.2	NA	132	Fractured basalt	24/04/09	Arruwurra
WNWE034	641,264	7,773,786	60	270	150	1.5	3.3	102-108	Fractured basalt	24/04/09	Arruwurra
WNWE035	641,190	7,773,786	60	270	150	0.2	3.2	108	Fractured basalt	25/04/09	Arruwurra
WNWE036	641,333	7,773,783	60	270	150	0.3	3.2	120	Fractured basalt	26/04/09	Arruwurra
WNWE037	641,111	7,773,784	60	270	150	Trace	NA	NA	NA	27/04/09	Arruwurra
WNWE038	641,486	7,773,788	60	270	150	1	1.6	126-132	Fractured basalt	28/04/09	Arruwurra
WNWE039	649,800	7,794,500	60	270	150	Dry	NA	NA	NA	1/05/09	GEA3
WNWE040	649,875	7,794,500	60	270	150	Dry	NA	NA	NA	2/05/09	GEA3
WNWE041	649,725	7,794,500	60	270	150	Trace	NA	NA	NA	2/05/09	GEA3

Hole ID	Collar Location MGA Zn 53		Dip	Azimuth	Depth (m)	Max Yield (L/s)	Final EC (mS/cm)	Inflow Depths (m)	Inflow Feature	Date Completed	GEA
	(mE)	(mN)									
WNWE042	649,588	7,793,757	60	315	150	Dry	NA	NA	NA	3/05/09	GEA3
WNWE043	649,642	7,793,705	60	315	156	1.3	2.4	137, 138-144	Fractured and weathered basalt	3/05/09	GEA3
WNWE044	649,695	7,793,652	60	315	150	Trace	NA	NA	NA	4/05/09	GEA3
WNWE045	649,802	7,793,547	60	315	150	0.3	1.8	130-132	Fractured basalt	5/05/09	GEA3
WNWE046	649,855	7,793,494	60	315	150	Trace	NA	NA	NA	5/05/09	GEA3
WNWE047	647,285	7,771,890	90	0	133	Trace	1.9	NA	NA	7/05/09	GEA5
WNWE048	647,327	7,771,952	90	0	139	Trace	NA	NA	NA	8/05/09	GEA5
WNWE049	647,368	7,772,015	90	0	151	1	1.5	75-82, 87-89, 129	Cavity in dolomite and fractured siltstone & basalt	9/05/09	GEA5
WNWE050	647,410	7,772,077	90	0	133	Trace	1.5	77-79	Cavity in dolomite	9/05/09	GEA5
WNWB001 (WNWE051)	653,043	7,789,600	90	0	150	1		92-93	Fractured basalt	9/05/09	Camp Area
WNWB002 (WNWE052)	642,520	7,777,128	90	0	150	2.5	2.1	109.5-110, 111, 125	Fractured basalt	9/05/09	Arruwurra
WNWE053	642,188	7,775,163	90	0	133	Trace	1.8	NA	NA	25/05/09	Arruwurra
WNWE054	642,257	7,775,171	90	0	150	Trace	NA	NA	NA	26/05/09	Arruwurra
WNWE055	642,340	7,775,165	90	0	150	Trace	NA	NA	NA	27/05/09	Arruwurra
WNWE056	642,407	7,775,161	90	0	150	0.2	2	77	Cavity in dolomite	28/05/09	Arruwurra
WNWE057	642,094	7,775,159	90	0	150	1.5	1.7	117, 132-138, 144-150	Fractured granodiorite	29/05/09	Arruwurra
WNWE058	643,389	7,775,162	90	0	60	Dry	NA	NA	NA	30/05/09	Arruwurra
WNWE059	643,393	7,775,165	90	0	150	0.2	2.1	84-90	Weathered dolomite	31/05/09	Arruwurra

Hole ID	Collar Location MGA Zn 53 (mE)	(mN)	Dip	Azimuth	Depth (m)	Max Yield (L/s)	Final EC (mS/cm)	Inflow Depths (m)	Inflow Feature	Date Completed	GEA
WNWE060	643,506	7,775,154	90	0	150	1.3	1.8	60-75	Cavity & weathered dolomite	1/06/09	Arruwurra
WNWE061	643,579	7,775,151	90	0	150	1.4	1.8	69-74	Cavity & weathered dolomite	2/06/09	Arruwurra
WNWE062	643,661	7,775,158	90	0	120	Trace	NA	NA	NA	3/06/09	Arruwurra
WNWE063	643,661	7,775,156	90	0	150	Trace	NA	NA	NA	4/06/09	Arruwurra
WNWE064	643,868	7,775,152	90	0	150	Trace	1.7	NA	NA	4/06/09	Arruwurra
WNWE065	643,959	7,775,156	90	0	150	Trace	1.7	NA	NA	5/05/09	Arruwurra
WNWE066	644,056	7,775,158	90	0	150	Trace	1.7	NA	NA	6/05/09	Arruwurra
WNWE067	641,404	7,775,194	60	270	150	Trace	NA	NA	NA	6/06/09	Arruwurra
WNWE068	641,473	7,775,198	60	270	150	2	4.5	126-144	Fractured quartz porphyry	7/06/09	Arruwurra
WNMB001 (WNWE069)	643,262	7,822,237	90	0	126	>6	2.9	62, 114-126	Fractured/ weathered dolomite	22/08/09	Northern off tenement area
WNWB003 (WNWE070)	643,257	7,822,227	90	0	126	>8	2.5	78, 106-126	Cavity & fractured/ weathered dolomite	24/08/09	Northern off tenement area
WNMB002 (WNWE071)	643,269	7,822,277	90	0	120	6	2.6	60, 108-120	Fractured/ weathered dolomite	26/08/09	Northern off tenement area
WNMB003 (WNWE072)	640,896	7,817,696	90	0	126	5	2.5	90, 108-120	Cavity & fractured/ weathered dolomite	27/08/09	Northern off tenement area
WNWB004 (WNWE073)	640,889	7,817,697	90	0	126	>10	2.2	80, 96-126	Cavity & fractured/ weathered dolomite	28/08/09	Northern off tenement area

Hole ID	Collar Location MGA Zn 53		Dip	Azimuth	Depth (m)	Max Yield (L/s)	Final EC (mS/cm)	Inflow Depths (m)	Inflow Feature	Date Completed	GEA
	(mE)	(mN)									
WNMB004 (WNWE074)	640,937	7,817,691	90	0	126	6	2.2	90-96, 108-126	Fractured/ weathered dolomite	30/08/09	Northern off tenement area
WNMB005 (WNWE075)	651,036	7,824,275	90	0	150	5	2.7	137-150	Fractured/ weathered dolomite	31/08/09	Northern off tenement area
WNEM001 (WNWE076)	651,088	7,826,194	90	0	18	Dry	NA	NA	NA	31/08/09	Northern off tenement area

Note: the maximum airlift yield relates to rates measured during drilling, NA = not applicable.

Northern off-tenement drilling results

Eight holes were drilled north of Minemakers' tenements permitted under Ministerial Approval (Section 2.6). The drill-hole sites were selected in an area known to be prospective in terms of groundwater supply, based upon drilling records held by the Northern Territory Government and available from the online NRETAS database. The historical record shows groundwater is commonly intersected at depths greater than 100 m in weathered and cavernous dolomite. In selecting the sites care was taken to avoid environmentally sensitive areas and, so far as practicable, other groundwater users (Section 2.5).

Initially five possible bore sites were selected with the aim of installing two production bores that could be used to assess aquifer parameters and for subsequent groundwater flow modelling. However high airlift yields were intersected at the first two sites and it was decided to install the two production bores at these locations. Two monitoring/observation bores were also installed at each site, located at radial distances of approximately 10 and 50 m from the production bore.

Drilling at the two production bore sites identified an aquifer within cavernous, fractured and weathered dolomite. The top of the aquifer was intersected at about 100 m depth at both locations. All the drill-holes were terminated early without fully penetrating the aquifer, because of poor ground conditions and loss of circulation. It is therefore likely the aquifer extends beyond the 25 to 30 m intersected during drilling.

A third site (WNWE075, completed as monitoring bore WNMB005) was also drilled to confirm the lateral extent of the dolomite aquifer. Similar groundwater conditions were observed during drilling, although the top of the aquifer was intersected at 137 m depth.

Airlift rates varied from about 5 to greater than 10 L/s. Loss of circulation was generally observed in the lowest yielding holes and it is likely the recorded airlift rates underestimated the maximum potential groundwater supply.

An environmental monitoring bore (WNWE076), completed as monitoring bore WNEM001, was drilled at the Kerringnew Swamp about 9 km east north-east of production bore WNWB003, to investigate groundwater level depths. The bore was drilled dry to 18 m depth. Later attempts to measure groundwater levels in the bore show the bore to be dry.

The locations of the holes drilled north of Minemakers' tenements are shown in Figure 6.

3.1.2 Production and monitoring bore construction

Schedules for the four production bores and six monitoring bores are presented in Tables 4 and 5 respectively.

Table 4: Production Bore Schedule

Bore ID	Collar Location MGA Zn 53		Depth Drilled (m)	Cased Depth (m)	Casing Type	Slotted Interval (mbgl)	Stick-up (magl)	SWL (mbtc)	SWL Date	Max Yield (L/s)	Final EC (mS/cm)
	(mE)	(mN)									
WNWB001	653,043	7,789,600	150	124.7	155mm ND uPVC Class 9	64.7-124.7	0.1	55.62	23/05/2009	1.5	1.6
WNWB002	642,520	7,777,128	150	125.4	155mm ND uPVC Class 9	65.4-125.4	0.1	24.58	19/05/2009	3	2.1
WNWB003	643,257	7,822,227	126	122	155.6mm ID/168.3mm OD Steel	98-122	0.4	50.86	24/08/2009	>8	2.5
WNWB004	640,889	7,817,697	126	102	155.6mm ID/168.3mm OD Steel	102-126	0.5	48.64	28/08/2009	5	2.2

Note: the maximum airlift yield relates to rates measured during development, mbgl= metres below ground level, magl = metres above ground level, SWL = static water level, mbtc = metres below top of casing.

Table 5: Monitoring Bore Schedule

Bore ID	Collar Location MGA Zn 53		Depth Drilled (m)	Cased Depth (m)	Casing Type	Slotted Interval (mbgl)	Stick-up (magl)	SWL (mbtc)	SWL Date	Max Yield (L/s)	Final EC (mS/cm)
	(mE)	(mN)									
WNMB001	643,262	7,822,237	126	118	50mm ND uPVC Class 9	64-118	0.6	50.85	23/08/2009	>6	2.9
WNMB002	643,269	7,822,277	120	101	50mm ND uPVC Class 9	47-101	0.6	50.91	28/08/2009	6	2.6
WNMB003	640,896	7,817,696	126	101	50mm ND uPVC Class 9	47-101	0.6	48.73	29/08/2009	5	2.5
WNMB004	640,937	7,817,691	126	126	50mm ND uPVC Class 9	66-126	0.8	48.7	30/08/2009	6	2.2
WNMB005	651,036	7,824,275	150	150	50mm ND uPVC Class 9	108-150	0.5	64.55	31/08/2009	5	2.7
WNEM001	651,088	7,826,194	18	18	50mm ND uPVC Class 9	2-18	0.5	Dry	31/08/2009	Dry	NA

Note: the maximum airlift yield relates to rates measured during development, mbgl= metres below ground level, magl = metres above ground level, SWL = static water level, mbtc = metres below top of casing.

The two production bores completed by Tom Browne Drilling Services within Minemakers' tenements (WNWB001 and 002) were constructed using 155 mm nominal diameter (ND) uPVC casing with an annular formation stabiliser.

The two production bores constructed by Gorey and Cole north of Minemakers tenements (WNWB003 and 004) were completed using schedule 20, 150 mm steel casing. Formation stabiliser was not used to construct the two northern bores, which reduced reaming diameters from 250 mm to 200 mm and also reduced well loss during pumping.

All monitoring bores were constructed using 50 mm ND uPVC casing. Bore locations are shown on Figure 4 (Arruwurra, GEA2 and GEA5), Figure 5 (GEA3, GEA4, GEA6 and the camp area) and Figure 6 (northern off tenement area).

3.2 Test Pumping

Test pumping was carried out on three of the four production bores by McMinns Bore Services between 3 and 13 September 2009. The two higher yielding bores (WNWB003 and 004) were tested using a Southern Cross SC50-10 15kW 6 inch electrical submersible pump with a capacity of about 13 L/s at 80 m head. The lower flow bore (WNWB002) was tested using a Southern Cross SC8-15 2.2kW 4 inch submersible pump with a capacity of about 2.2 L/s at 60 m head.

Bore WNWB001 was not tested, because of its low yield and current use as the water supply bore for the Minemakers' camp. It should be noted that the bore has been operated continuously since May 2009.

Testing comprised both step and 48-hour constant rate tests. The step test was used to identify a suitable rate for the constant rate test and is not reported here. The pumping and drawdown data for the constant rate test were used to estimate aquifer properties of storativity and transmissivity, using standard analytical methods. The drawdown curves were also assessed to identify aquifer boundary conditions and aquifer type (unconfined, confined and leaky).

The results of the constant rate test are presented in Table 6 and the analysis shown in Appendix C. The results show the following:

- A modest aquifer transmissivity at WNWB002 of about 15 m^2/d, with an unconfined response. The results are consistent with a moderately low yielding production bore.
- Very high transmissivities at WNWB003 during early time, but an increase in the drawdown rate after about 2,000 minutes (1.4 days) indicating a lower transmissivity boundary condition. Late time data still indicate good transmissivities in the order of 350 to 500 m^2/d consistent with a short-term duty rate of between 15 and 20 L/s.
- High transmissivities at WNWB004 of between 700 and 900 m^2/d consistent with a short-term duty rate of between 15 and 20 L/s.

GROUNDWATER RESOURCE MANAGEMENT

Table 6: Summary of Test Pumping Results

Production Bore	Monitor Bore	Cooper-Jacob				Theis Recovery T (m^2/d)	Radial Distance (m)	Constant Test Rate (L/s)	Final Drawdown (m)	Description
		Early Time	Late Time	Early Time	Late Time					
		T (m^2/d)		S						
WNWB002	WNWB002	15		NA		13	NA	2.5	12.91	Unconfined response, curve matched to late time data
WNWB003	WNWB003	1,100	340	NA		1500	NA	12	2.04	Confined late and early time responses, barrier boundary after 2,000 minutes
WNWB003	WNMB001	960	370	4.00E-05	4.00E-02	NA	11.2	12	1.27	Confined late and early time responses, barrier boundary after 2,000 minutes
WNWB003	WNMB002	1700	500	8.00E-05	6.00E-03	NA	51.4	12	0.8	Confined late and early time responses, barrier boundary after 200 minutes
WNWB004	WNWB004	690		NA		370	NA	12	5.11	Leaky response, curve mated to late time data
WNWB004	WNMB003	800		3.00E-18			7.1	12	4.5	Leaky response, curve mated to late time data
WNWB004	WNMB004	900		4.00E-06			48.4	12	1.17	Leaky response, curve mated to late time data

Note: T = transmissivity, S = storativity, NA = not applicable.

3.3 Groundwater Level Surveys

3.3.1 Groundwater levels in mining areas

A groundwater level survey was carried out at Arruwurra and the Main Zone using the resource drill-holes. The survey data were used to identify if the water table extends into the ore zones and hence the likely dewatering requirements during mining.

A total of 51 holes were visited at the Main Zone and 29 holes at Arruwurra (Table 7 and Figure 10). At both deposits the drill-holes were mostly dry. However, 14 of the holes at the Main Zone and seven of the holes at Arruwurra did register a water level.

Measured groundwater levels at the Main Zone varied from 3.11 to 63.39 m bgl, but only two of the holes had levels above 50 m depth. Both the holes with recorded shallow groundwater levels were plumbed and found to be blocked just below the measured water level. It is therefore almost certain the elevated levels in these holes are atypical and probably reflect a shallow, isolated and perched groundwater body.

The remaining 12 wet holes at the Main Zone were further investigated to assess the groundwater elevation with respect to the depth of mineralization and hence likely pit floor level. The results of the assessment showed the ore zone in the 12 holes lie at least 3 m below the measured groundwater level.

Similarly at Arruwurra 4 of the 7 wet holes were blocked just below the recorded groundwater level, and the depth of the ore zone in one of the remaining 3 wet holes was found to lie well below the measured water level. The two other wet holes did contain appreciable groundwater depths, 6.2 m in WNRC202 and 8.12 m in WNRC209. The reason for the anomalous levels is not known, but is expected to be localized.

The results show the water table at Arruwurra and the Main Zone lies below the base of the ore bodies.

Table 7: Mineral Exploration Hole Water Level Measurements

Hole ID	Collar Location MGA Zn 53		SWL (mbgl)	Plumbed Depth (m)	Sat. Thickness (m)	Measurem't Date	Base of Mineralisat'n (mbgl)	Deposit
	(mE)	(mN)						
WNRC470	658,249	7,790,496	3.11	4.86	1.75	7/04/09	NA	Main Zone
WNRC871	655,507	7,791,628	25.17	26.6	1.43	14/09/09	NA	Main Zone
WNRC678	654,253	7,791,486	50.82	52.4	1.58	14/09/09	49	Main Zone
WNRC795	654,252	7,788,000	51.17	51.17	0	14/09/09	43	Main Zone
WNRC604	651,757	7,790,755	52	53.5	1.5	14/09/09	45	Main Zone
WNRC663	653,750	7,791,252	52.45	54.5	2.05	14/09/09	NM	Main Zone
WNRC796	654,500	7,787,379	52.98	57	4.02	14/09/09	45	Main Zone
WNRC672	654,241	7,789,999	53.88	55.5	1.62	14/09/09	45	Main Zone
WNRC656	653,492	7,790,493	54.08	55.4	1.32	14/09/09	NM	Main Zone
WNRC684	653,500	7,786,629	55.15	55.15	0	14/09/09	42	Main Zone
WNRC869	655,501	7,791,128	56.65	59	2.35	14/09/09	48	Main Zone
WNRC901	655,999	7,792,871	58.83	62	3.17	14/09/09	NM	Main Zone
WNRC926	656,749	7,792,123	60.67	62.5	1.83	14/09/09	50	Main Zone

Hole ID	Collar Location MGA Zn 53		SWL (mbgl)	Plumbed Depth (m)	Sat. Thickness (m)	Measurem't Date	Base of Mineralisat'n (mbgl)	Deposit
	(mE)	(mN)						
WNRC564	657,248	7,788,750	63.39	68.42	5.03	14/09/09	61	Main Zone
WNRC132	656,623	7,789,205	D	63	NA	7/04/09	NA	Main Zone
WNRC143	656,629	7,790,674	D	69	NA	7/04/09	NA	Main Zone
WNRC277	652,250	7,786,376	D	47.52	NA	14/09/09	NA	Main Zone
WNRC313	655,003	7,789,501	D	55.4	NA	14/09/09	NA	Main Zone
WNRC324	655,499	7,789,755	D	57.4	NA	14/09/09	NA	Main Zone
WNRC354	651,000	7,786,752	D	42.1	NA	14/09/09	NA	Main Zone
WNRC360	650,506	7,785,996	D	41.9	NA	14/09/09	NA	Main Zone
WNRC385	650,998	7,787,750	D	45.5	NA	14/09/09	NA	Main Zone
WNRC404	656,500	7,790,498	D	24	NA	14/09/09	NA	Main Zone
WNRC459	658,254	7,790,250	D	70	NA	7/04/09	NA	Main Zone
WNRC469	657,997	7,790,497	D	64	NA	7/04/09	NA	Main Zone
WNRC471	658,248	7,790,747	D	58	NA	7/04/09	NA	Main Zone
WNRC472	658,005	7,790,746	D	5	NA	7/04/09	NA	Main Zone
WNRC483	655,499	7,788,003	D	54.6	NA	14/09/09	NA	Main Zone
WNRC485	657,996	7,791,001	D	1	NA	7/04/09	NA	Main Zone
WNRC488	657,252	7,791,000	D	1	NA	7/04/09	NA	Main Zone
WNRC567	658,000	7,788,751	D	68.3	NA	14/09/09	NA	Main Zone
WNRC567	658,000	7,788,751	D	68.3	NA	14/09/09	NA	Main Zone
WNRC576	657,248	7,788,000	D	20	NA	14/09/09	NA	Main Zone
WNRC579	658,000	7,788,001	D	64.5	NA	14/09/09	NA	Main Zone
WNRC579	658,000	7,788,001	D	64.5	NA	14/09/09	NA	Main Zone
WNRC591	653,000	7,787,244	D	46.5	NA	14/09/09	NA	Main Zone
WNRC600	652,748	7,791,754	D	45.3	NA	14/09/09	NA	Main Zone
WNRC602	650,752	7,791,752	D	42	NA	14/09/09	NA	Main Zone
WNRC607	650,750	7,789,752	D	42	NA	14/09/09	NA	Main Zone
WNRC637	653,004	7,788,750	D	49.4	NA	14/09/09	NA	Main Zone
WNRC646	651,998	7,788,000	D	50.5	NA	14/09/09	NA	Main Zone
WNRC655	656,748	7,789,754	D	43.5	NA	14/09/09	NA	Main Zone
WNRC675	654,256	7,790,755	D	55	NA	14/09/09	NA	Main Zone
WNRC830	655,004	7,790,376	D	45.5	NA	14/09/09	NA	Main Zone
WNRC833	655,000	7,791,129	D	52	NA	14/09/09	NA	Main Zone
WNRC856	655,249	7,792,376	D	ND	NA	14/09/09	NA	Main Zone
WNRC873	655,501	7,792,125	D	60	NA	14/09/09	NA	Main Zone
WNRC875	655,503	7,792,630	D	56	NA	14/09/09	NA	Main Zone
WNRC897	656,002	7,791,877	D	55	NA	14/09/09	NA	Main Zone
WNRC899	656,008	7,792,371	D	58	NA	14/09/09	NA	Main Zone
WNRC925	656,754	7,791,872	D	61.5	NA	14/09/09	NA	Main Zone
WNDD10	640,745	7,775,129	D	18	NA	24/05/09	NA	Arruwurra
WNDD28	640,745	7,775,129	21.68	22.5	0.82	24/05/09	14.9	Arruwurra
WNRC108	641,200	7,775,692	D	21	NA	25/05/09	NA	Arruwurra

Hole ID	Collar Location MGA Zn 53		SWL (mbgl)	Plumbed Depth (m)	Sat. Thickness (m)	Measurem't Date	Base of Mineralisat'n (mbgl)	Deposit
	(mE)	(mN)						
WNRC197	639,747	7,774,750	3.97	4	0.03	24/05/09	NA	Arruwurra
WNRC202	640,000	7,775,245	12.8	19	***6.2***	24/05/09	NA	Arruwurra
WNRC204	640,038	7,774,747	D	25	NA	24/05/09	NA	Arruwurra
WNRC205	640,029	7,774,504	2.12	2.5	0.38	24/05/09	NA	Arruwurra
WNRC209	640,252	7,775,503	4.88	13	***8.12***	24/05/09	NA	Arruwurra
WNRC211	640,241	7,774,997	D	24	NA	24/05/09	NA	Arruwurra
WNRC218	640,498	7,775,247	D	24	NA	24/05/09	NA	Arruwurra
WNRC227	640,740	7,774,996	D	24	NA	25/05/09	NA	Arruwurra
WNRC230	640,995	7,775,996	D	18	NA	25/05/09	NA	Arruwurra
WNRC231	640,996	7,775,751	D	18	NA	25/05/09	NA	Arruwurra
WNRC233	640,999	7,775,247	D	23	NA	25/05/09	NA	Arruwurra
WNRC235	640,738	7,774,753	D	28	NA	25/05/09	NA	Arruwurra
WNRC236	640,749	7,774,498	D	27	NA	24/05/09	NA	Arruwurra
WNRC241	640,246	7,774,490	D	25	NA	24/05/09	NA	Arruwurra
WNRC243	640,250	7,774,248	D	25	NA	24/05/09	NA	Arruwurra
WNRC246	639,498	7,774,001	D	31	NA	24/05/09	NA	Arruwurra
WNRC251	639,249	7,773,746	D	34	NA	24/05/09	NA	Arruwurra
WNRC252	638,999	7,774,001	D	33	NA	24/05/09	NA	Arruwurra
WNRC256	639,246	7,774,497	D	31	NA	24/05/09	NA	Arruwurra
WNRC261	638,745	7,773,500	D	39	NA	24/05/09	NA	Arruwurra
WNRC264	638,485	7,774,000	3.61	4	0.39	24/05/09	NA	Arruwurra
WNRC267	638,750	7,774,498	3.5	5	1.5	24/05/09	NA	Arruwurra
WNRC269	641,252	7,774,746	D	35	NA	24/05/09	NA	Arruwurra
WNRC271	641,251	7,774,494	D	32	NA	25/05/09	NA	Arruwurra
WNRC272	639,998	7,774,253	D	34	NA	25/05/09	NA	Arruwurra
WNRC274	641,249	7,775,249	D	23	NA	25/05/09	NA	Arruwurra

Note: SWL = static water level, NA = not applicable, NM = not mineralized, values in bold/italics are anomalous, mbgl = metres below ground level.

3.3.2 Regional groundwater levels

Regional groundwater levels were measured in production and monitoring bores (Tables 4 and 5 respectively) and within Minemakers' tenement at some groundwater exploration drill-holes (Table 8).

The groundwater level data show levels in the area north of Minemakers' tenements measured during the last phase of drilling are reasonably consistent, lying between 48.64 and 50.86 m bgl in the vicinity of production bores WNWB003 and 004, and falling to 64.55 m bgl at WNMB005 located about 8 km east northeast of WNWB003. This reasonably flat lying groundwater level is in keeping with the presence of a well connected aquifer system within the cavernous and weathered dolomite.

The groundwater levels measured within Minemakers' tenements show a higher degree of variability, ranging from 24.58 m bgl in WNWB002 to 103.29 m bgl in WNWE027. This variance suggests a heterogeneous groundwater system, with poor hydraulic connections between aquifers.

Table 8: Groundwater Exploration Hole Water Level Measurements

Hole ID	Collar Location MGA Zn 53		Hole Dip	Hole Depth (m)	SWL (mbtc)	SWL Date
	(mE)	(mN)				
WNWE025	664,371	7,779,250	90	157	102.88	1/05/09
WNWE027	664,431	7,779,154	90	175	103.29	1/05/09
WNWE047	647,285	7,771,890	90	133	66.59	7/05/09
WNWE054	642,257	7,775,171	90	150	63.15	27/05/09
WNWE055	642,340	7,775,165	90	150	63.55	28/05/09
WNWE056	642,407	7,775,161	90	150	63.78	29/05/09
WNWE057	642,094	7,775,159	90	150	63.15	30/05/09
WNWE060	643,506	7,775,154	90	150	65.75	5/06/09
WNWE061	643,579	7,775,151	90	150	65.73	5/06/09
WNWE063	643,661	7,775,156	90	150	65.89	5/06/09
WNWE064	643,868	7,775,152	90	150	>100	6/06/09
WNWE065	643,959	7,775,156	90	150	66.36	6/06/09
WNWE066	644,056	7,775,158	90	150	66.7	6/06/09

Note: SWL = static water level, mbtc = metres below top of casing.

4.0 GROUNDWATER QUALITY

Groundwater samples were collected from the test production bores at the end of the 48-hour constant rate tests; and from WNWB001 when the bore was first used to supply camp water. All samples were submitted to a suitably accredited laboratory for analysis. Field testing, comprising measurements of electrical conductivity (EC) and pH, was also routinely carried out during the constant rate tests to identify any effects on general water quality from groundwater extraction.

Table 9: Water Quality Analysis Results

Analyte	Units	WNWB001	WNWB002	WNWB003	WNWB004
Conductivity	µS/cm	ND	2100	2700	2400
TDS (evap 180C)	mg/L	780	1300	1800	1500
pH		8	7.4	7.1	7
TSS	mg/L	ND	<5	10	8
Turbidity	NTU	ND	<1	2	7
Turbidity filtered 0.45µm	NTU	ND	<1	<1	<1
Colour	PCU	ND	<5	<5	<5
Total Hardness	mg/L $CaCO_3$	170	ND	ND	ND
Calcium	mg/L	59	25	140	140
Magnesium	mg/L	6.5	34	97	88
Sodium	mg/L	ND	450	330	290
Potassium	mg/L	ND	29	53	46
Strontium	mg/L	ND	0.35	1.7	1.5
Barium	mg/L	0.065	<0.01	0.02	<0.01
Total Iron	mg/L	ND	<0.02	0.11	0.31
Manganese	mg/L	0.055	<0.005	0.51	0.059
Carbonate	mg/L $CaCO_3$	ND	<1	<1	<1
Bicarbonate	mg/L $CaCO_3$	ND	640	420	460
Sulphate	mg/L	ND	120	330	230
Chloride	mg/L	ND	310	550	450
Nitrate	mg/L	0.01	14	5.8	0.4
Fluoride	mg/L	1.2	1.4	1.2	1.1
Silica	mg/L	ND	46	17	19
Arsenic	mg/L	0.0026	ND	ND	ND
Cadmium	mg/L	<0.0001	ND	ND	ND
Lead	mg/L	<0.001	ND	ND	ND
Selenium	mg/L	0.0049	ND	ND	ND
Antimony	mg/L	<0.05	ND	ND	ND

Analyte	Units	WNWB001	WNWB002	WNWB003	WNWB004
Boron	mg/L	1.4	ND	ND	ND
Chromium	mg/L	<0.002	ND	ND	ND
Copper	mg/L	<0.002	ND	ND	ND
Molybdenum	mg/L	<0.01	ND	ND	ND
Nickel	mg/L	<0.005	ND	ND	ND
Total Mercury	mg/L	<0.001	ND	ND	ND
Total Cyanide	mg/L	<0.005	ND	ND	ND

Note: ND = not determined.

The results of the laboratory analysis are summarised in Table 9, which show the following:

- The groundwater at WNWB001 (camp bore) is fresh and slightly brackish at the other three bores.
- pH ranges from neutral to slightly alkaline.
- Total suspended solids (TSS) and turbidity at the two northern bores, which were constructed without filter pack, are slightly elevated; but below detection in WNWB002 which was constructed with a filter pack.
- The dominant ions in water from WNWB002 are sodium and bicarbonate/chloride, and in the northern bores sodium and chloride.
- Iron concentrations were elevated in the two northern bores.
- High silica values were measured in WNWB002 and high to moderate values in the northern bores.
- High boron values were detected in WNWB001.

It should be noted that drinking water will be treated by reverse osmosis, therefore elevated concentrations of metals should not enter the potable supply.

The water quality field measurements are presented as time series graphs in Figures 7 to 9. The graphs show both EC and pH are steady in the three production bores tested. The EC values in the northern production bores range from about 2.4 to 2.8 mS/cm, roughly equivalent to a salinity of 1.4 to 1.7 mg/L TDS. The EC of the groundwater at WNWB002 is slightly lower at about 2.2 mS/cm (1.3 mg/L TDS). The pH of the water in the three bores ranged from 7 to 7.5 (neutral to slightly alkaline).

5.0 GROUNDWATER CONTAMINATION RISKS

Groundwater contamination risks from mining operations are normally associated with seepage from tailings storage facilities. However, the current investigation is associated with the first stage of the project development, which relates to the mining of direct ship ore (DSO) requiring no processing beyond ore crushing and screening. The DSO option removes the requirement for a processing plant and hence a tailings storage facility.

The risks of groundwater contamination are therefore associated with management of hazardous materials storage areas, e.g. chemicals and hydrocarbons, in particular rainfall runoff from these areas. The design of runoff control measures have been identified by GRM in the surface water management report for the Wonarah Project (GRM, 2009).

6.0 WATER BALANCE MODELLING

A dynamic water balance was developed for the Project to estimate the water demand during construction and over the ten year mine life. The water balance was developed using the generic systems modelling package GoldSim, which is well suited to simulating dynamic systems such as water balances.

The various components making up the Project water demand are summarised below.

- Construction phase:
  - i. water for material conditioning during road construction;
  - ii. dust suppression water for the roads;
  - iii. construction water for the plant and village;
  - iv. potable water demand.
- Demand during mining:
  - i. dust suppression water for the roads;
  - ii. dust suppression water for the mining areas;
  - iii. water for plant operations;
  - iv. potable water demand.

For the purposes of the water balance it was assumed the construction phase will commence on 15 July 2010 and run for approximately five months. Pre-stripping is expected to commence at the start of August 2010 and mining to start at the beginning of October 2010. The current life of mine is expected to be 10 years, i.e. finishing in late 2020.

6.1 Construction Water Demand

The total volumetric water requirement for road construction was calculated from first principles, based upon the following relationship for each of the road construction components (sub-grade, base coarse and sub-base). Information used in the estimation of the construction water requirements was sourced from GHD Pty Ltd and 4D Geotechnics Pty Ltd.

$Q = L \times W \times T \times P_s \times (M_2 - M_1) / P_w$

Where:

Q = the total volumetric water requirement.

L = the linear lengths of the roads (32.3 and 4.3 km for major and minor roads respectively).

W = the road widths (7 m).

T = the thickness of the road construction materials (300, 200 and 200 mm for the sub-grade, base coarse and sub-base respectively).

P_s = the density of the road construction materials (1.8 tonne/m^3).

M_2 = the desired moisture content for the road construction materials (10%, allowing for a 2% loss from seepage and evaporation during construction).

M_1 = the ambient moisture content for the road construction materials (4% for all materials).

P_w = the density of water.

The water demand rate for road construction was calculated by pro-ratering the volumetric demand over the five month construction period.

The road dust suppression water demand during construction was calculated by pro-ratering the total road dust suppression demand (i.e. the total demand during mining – Section 6.2) over the five month construction period. For example at the start of construction the dust suppression demand will be 0 L/s and at the end of construction the demand will be equivalent to the full dust suppression requirement.

The water demand for construction of the plant and village (2 L/s) was provided by GHD.

The potable water demand was calculated from the expected number of personnel on site required during construction (100 personnel) and a daily per capita demand of 350 L/day per person.

6.2 Mining Water Demand

The dust suppression water requirement for the roads during mining was calculated using the surface area of the roads, the calculated monthly evaporation rate (Section 2.1) and a road usage factor. The road usage factor was varied to represent the road utilization and therefore the frequency of road watering. The following utilization factors were adopted:

- for minor roads a factor of 0.25 of the pan evaporation rate;
- for major roads a factor of 1 of the pan evaporation rate.

The dust suppression demand for the mining areas was calculated in a similar manner, using a combined mining area provided by AMC Consultants. These areas comprise the active pit floors, roads within the pit footprint and the ROM pad. A utilization factor of 0.25 was adopted for the mining area dust suppression.

The water demand at the crushing and screening plant is expected to be minimal and a nominal flow of 5 L/s was used, based on discussions with Minemakers.

The potable water demand during mining was calculated from the expected number of personnel on site required during pre-stripping and for mining (100 and 150 personnel respectively) and a daily per capita demand of 350 L/day per person.

6.3 Water Balance Results

The various water demands and the combined water demand for the Project are shown as a time-series graph in Figure 11.

The figure shows the following:

- The total water demand during construction rises from zero in mid July 2010 to about 15 L/s in mid August 2010.
- The peak water demand of around 67 L/s is at the end of construction when mining has already commenced.
- After the completion of the construction phase the water demand varies from about 32 L/s during the winter months to 60 L/s in summer when evaporation rates are highest.

7.0 PROJECT WATER SUPPLY

The Project water demand was calculated using the site water balance (Section 6.0). To meet the predicted demand a two stage supply is planned. The first stage will provide approximately 10 to 15 L/s for the start of construction, using lower yielding bores at Arruwurra, and the camp bore for potable water.

During this initial period the longer term supply (stage 2) will be developed, which will consist of a northern borefield located off Minemakers' tenements in the area of existing production bores WNWB003 and 004. The development will comprise drilling and construction of the additional northern production bores and installation of pumping infrastructure (pipelines, pumping stations etc.) to enable the transfer of water from the borefield to the mine and village. The expected time to install the borefield pipeline is around 3 months.

7.1 Initial Construction Water Supply

Initially construction water will be drawn from nominally five lower yielding bores in the Arruwurra area. These bores will comprise existing production bore WNWB002 and four new bores located near wet groundwater exploration holes WNWE056, WNWE057, WNWE061 and WNWE068 (Section 3.1.1).

Based upon the drilling results the new production bores are expected to have similar hydraulic properties to those at existing bore WNWB002 (Section 3.2). The test pumping results for WNWB002 have therefore been adopted as being representative of the new Arruwurra bores.

It is anticipated the Arruwurra production bores will be needed for up to three months before the northern borefield is available. The sustainability of the five production bores over this period has been assessed using standard analytical curve-matching methods by extending the elapsed time on the test pumping results for WNWB002 (Figure 12). The resultant curve shows the expected drawdown after 3 months will be about 18 m (43 m bgl), well above the main aquifer zone which lies below 109 m bgl .

7.2 Long-term Water Supply

The longer term project water supply will be sourced from a northern borefield located in the vicinity of existing production bores WNWB003 and 004. Groundwater at these locations is drawn from a cavernous, weathered dolomite aquifer that is judged to extend regionally to the north, east and west.

Based upon the water balance results the long-term demand is likely to be between 35 and 60 L/s, varying seasonally with evaporation rates. For the purposes of the BFS a constant rate of 75 L/s has been adopted to provide some redundancy to the supply. The sustainability and impact of the borefield operation has been assessed using a numerical groundwater flow model. The configuration of the numerical model and the modelling results are discussed in the following sections.

7.2.1 Conceptual groundwater model

The conceptual model for the northern borefield area, used in development of the numerical model, recognises four hydrogeological units; HU1 to 4, which are described below.

- HU1 comprises the dolomite aquifer intersected in the northern bores WNWB003 and 004. The unit is overlain by low permeability sedimentary rocks (HU2) and underlain by low permeability basement or sedimentary rocks (HU3). Based on the results from the last phase of drilling the top of the unit has been set at 100 m below surface.

- HU2 comprises the near surface sedimentary deposits overlying the HU1 dolomite aquifer. The deposits are characterised by low permeabilities and, most likely, moderate aquifer storage. The upper and lower extents of the unit comprise the ground surface and the top of the dolomite aquifer respectively.

- HU3 comprises the low permeability unit underlying the HU1 dolomite aquifer. The lithology of the unit is unknown as the dolomite aquifer was not fully penetrated during the last phase of drilling because of poor ground conditions.

- HU4 comprises the low permeability sedimentary and basement rocks that occur in the Wonarah Project area. The unit extends to the north and forms the southern boundary of the HU1 to 3 sequence north of the Barkly Highway.

The actual thickness and depth of the dolomite aquifer is no known, but the drilling results indicate a minimum thickness of about 25 m.

Similarly the lateral extent of the aquifer is also not well understood, although the historical drilling data, sourced from the NRETAS database, suggests the aquifer stretches tens of kilometres to the north, east and west (Section 2.4). Results from the first two phases of drilling show the aquifer does not continue as far south as the Project area which is characterised as a basement high within the Georgina Basin (Section 2.3.1), but the location of its southern boundary is unknown. Conservatively it has been assumed to coincide with the southern boundaries of the Dalmore Downs and Alroy Stations.

Groundwater levels in the dolomite aquifer lie around 50 m bgl. Water levels in the overlying low permeability sediments are likely to be marginally higher, resulting in downward vertical groundwater flows and aquifer recharge.

Rainfall recharge rates are expected to be low, consistent with the semi-arid climate and exacerbated by the low permeability of the HU2 sediments. Recharge from surface water will occur locally in the vicinity of the major rivers and, after rainfall events, from minor water courses and marshy areas. Although recharge rates are likely to be low, long-term groundwater production should be supported by the high transmissivity of the dolomite aquifer.

A schematic of the conceptual model is presented in Figure 13.

7.2.2 Numerical Flow Model

Groundwater flow modelling for the area north of Minemakers' tenements was developed to assess the requirements, impacts and sustainability of a borefield supply from the dolomite aquifer. The model was developed using the MODFLOW finite difference code and the pre- and post-processor Groundwater Vistas.

The model was based upon a conceptual model of the groundwater system (Section 7.2.1), which was developed using the data collected during the last phase of the drilling programme and the test pumping results, along with information sourced from the NRETAS bore database.

Numerical model set-up

The model comprises two layers (representing the near surface sediments and dolomite aquifer) and 196 rows by 248 columns. The model cell sizes range from 5 m by 5 m in the area of the production bores to 500 m by 500 m along the model's lateral boundaries. The model domain covers an area of about 7,260 km^2.

The upper and lower surfaces of the two model layers are flat and horizontal. The upper surface of the top layer (Layer 1) was set at 50 m bgl, equivalent to the expected groundwater level in the near surface sediments (HU2). The base of Layer 1 was set at 100 m depth, coincidental with the top of the dolomite aquifer (HU1) in the conceptual model. The base of Layer 2 was set at 125 m depth, giving an aquifer thickness of 25 m.

The HU4 aquitard was not included in the model. The southern model boundary Is defined as the adopted southern limit of the dolomite aquifer, thereby removing the requirement to directly model the unit.

The model grid is presented in Figure 14 and the model set-up summarised in Table 10.

Table 10: Summary of Numerical Model Set-up

Layer	Hydrogeological Unit	Layer Top (m depth)	Layer Base (m depth)
1	HU2 - Near surface sediments (aquitard)	50	100
2	HU1 - Dolomite aquifer	100	125

Note: model set-up assumes the ground surface is flat and horizontal.

Hydraulic parameters

The hydraulic parameters used to simulate the dolomite aquifer for the base case were founded on the transmissivities and storativities estimated from the test pumping results (Section 3.2), assuming isotropic conditions. The adopted values were consistent with the lower estimates for aquifer parameters to maintain a conservative modelling approach.

The parameters for the overlying sediments were consistent with low permeability sedimentary rocks.

In addition to the base case a number of sensitivity analysis runs were completed (Section 7.2.3) to investigate the influence of variation in the following poorly understood parameters:

- vertical and horizontal hydraulic conductivity in Layer 1;
- specific yield in Layer 1;
- vertical hydraulic conductivity in Layer 2.

The parameter values used in the numerical model are summarised in Table 11 for the base case and the three sensitivity runs (SR1 to SR3).

Table 11: Numerical Model Hydraulic Parameters

Model Run	Layer	Kh (m/d)	T (m^2/d)	Kv (m/d)	Sc (m-1)	Sy	Comments
Base case	1	0.001	NA	0.001	1.00E-05	0.01	Expected condition
	2	10	250	10	1.00E-06	0.1	
SR1	1	0.0001	NA	0.0001	1.00E-05	0.01	Reduced hydraulic conductivity in Layer 1
	2	10	250	10	1.00E-06	0.1	
SR2	1	0.001	NA	0.001	1.00E-05	0.005	Reduced specific yield in Layer 1
	2	10	250	10	1.00E-06	0.1	
SR3	1		NA	0.001	1.00E-05	0.01	Reduced vertical hydraulic conductivity in Layer 2
	2	10	250	1	1.00E-06	0.1	

Note: Kh = horizontal hydraulic conductivity, T = transmissivity (assuming fully saturated conditions), Sc = confined storage and Sy = specific yield.

Groundwater abstraction

Five production bores were used to model groundwater production from the borefield, comprising the two existing bores and three future bores. The locations of the bores are shown in Figure 6 and their coordinates presented in Table 12.

Table 12: Modelled Production Bore Locations

Bore ID	Collar Location MGA Zn 53		Comments
	(mE)	(mN)	
WNWB003	643,257	7,822,227	Existing production bore
WNWB004	640,889	7,817,697	Existing production bore
WNWB005	641,955	7,819,849	Future production bore
WNWB006	640,871	7,822,232	Future production bore
WNWB007	643,021	7,817,782	Future production bore

Pumping from the bores was simulated using MODFLOW's Well Package. A constant pumping rate of 15 L/s per production bore was adopted over the 10 year model run time, drawing water exclusively from Layer 2. This gives a combined extraction of 75 L/s.

Model boundary conditions

The boundary conditions adopted in the model comprised the following:

- The lateral model boundaries to the north, east and west were set as constant heads, with groundwater levels at 50 m below surface, consistent with the groundwater level used in the conceptual model and the initial water levels in the active model area.

- The southern lateral model boundary, coincidental with the adopted southern limit of the dolomite aquifer, was defined as a no flow boundary. This provides a conservative approach as some groundwater flows across this contact would be expected should drawdowns extend that far.

The base of Layer 2, which is coincidental with the base of the dolomite aquifer, was set as a no flow boundary. Again this is a conservative approach, removing any potential inflows from HU3 that could assist in sustaining groundwater extraction from the production bores.

It was assumed that there will be no rainfall recharge over the 10 year model run time.

Layer 1 was defined as an unconfined MODFLOW layer type, using calculated transmissivities and storativities. Layer 2 was defined as a confined/ unconfined layer type, again with calculated transmissivities and storativities.

Vertical flows between layers were calculated using adopted vertical permeabilities in the two layers.

7.2.3 Numerical model predictions

The numerical model was run for 10 years, based upon the current life of mine. The predicted groundwater level drawdowns in the two model layers for the base case after 10 years are presented as contour plots in Figures 15 and 16 for Layers 1 and 2 respectively. The predicted drawdowns for the three sensitivity runs are also presented as contour plots in the following figures:

- Figures 17 and 18 (Layers 1 and 2 respectively for Sensitivity Run 1);
- Figures 19 and 20 (Layers 1 and 2 respectively for Sensitivity Run 2);
- Figures 21 and 22 (Layers 1 and 2 respectively for Sensitivity Run 3).

The base case drawdown contours have also been included in the sensitivity run plots to facilitate comparison of results.

In addition to the drawdown contours, time series graphs of the predicted drawdowns in Layer 2 at the locations of the five production bores have also been prepared (Figures 23 to 25). The time graphs show the results for the base case and three sensitivity runs.

The modelling results are summarised below.

- The modelling indicates a combined production rate of 75 L/s over the 10 year mine life is readily achievable. Maximum drawdowns at the bores in Layer 2 range from 14.3 m (for the base case and sensitivity run 3) to 16.9 m for sensitivity run 2.
- The predicted drawdown in Layer 1 at the two environmentally sensitive areas identified within the model domain are as follows:
  - less than 0.2 m at Oolgoolgam Swamp for all model runs;
  - between 1.5 and 3 m at Kerringnew Swamp.
- Only six stock bores (RN025678, 025874, 004087, 006751, 001237 and 001238) lie within the 5 m drawdown contour for Layer 2 after 10 years, based upon the results from the base case and all sensitivity runs.

- Only one stock bore (RN001237) lies within the 10 m drawdown contour for Layer 2 after 10 years, based upon the results from the base case and all sensitivity runs.

It should be noted that groundwater level monitoring at bore WNEM001, located at Kerringnew Swamp has identified the swamp as a perched surface water feature (Section 3.3). Therefore groundwater level drawdowns in the near surface sediments are not expected to impact upon the swamp water budget.

Comparison of the base case and sensitivity analysis show:

i. The highest rate of drawdown at the start of groundwater production occurs in sensitivity run 2 (reduced vertical hydraulic conductivity in Layer 1).

ii. In the longer term the model is most sensitive to the specific yield in Layer 1 (sensitivity run 1), both in terms of drawdowns at the bores and the lateral drawdown extent.

iii. The model is insensitive to changes in the vertical hydraulic conductivity in Layer 2.

In viewing the numerical modelling results it should also be noted that the model set-up reflects a conservative condition with the exclusion of rainfall recharge and adoption of the lower range in hydraulic conductivity for the dolomite aquifer.

8.0 DEWATERING

The dewatering requirements for the Wonarah Project relate to management of groundwater inflows and of seepage from surface water that could be stored within natural topographic depressions in the vicinity of the Arruwurra Pits following high rainfall events. The Main Zone Pits lie within a topographic high preventing flood water accumulation.

8.1 Groundwater Inflow Management

A comprehensive groundwater level survey at Arruwurra and the Main Zone was carried out by GRM during the recent field programme (Section 3.3.1). The survey identified that groundwater levels almost always lie below the ore zones at the two mining areas. A small number of drill-holes did contain elevated groundwater levels extending into the ore. However, these water levels are believed to reflect small, isolated, and most likely perched, groundwater bodies.

Based upon this assessment any groundwater inflows into the pits are expected to be minor (1 to 2 L/s) and short-lived with a duration of a few weeks or days. It is possible the discharge will evaporate on the pit floor or infiltrate to the underlying water table. If flows persist they should be readily manageable with a locally excavated sump and small sump pump.

8.2 Surface Water Seepage Management

Seepage inflows from stored surface water may occur at Arruwurra, based on surface water studies (GRM, 2009). The likely limit of the stored water is presented in Figure 26. The figure shows the water covers an area of about 180 ha, extending along a 500 m width adjacent to the Arruwurra Pits. The stored surface water is conservatively estimated to lie about 100 m from the pit crests. The maximum elevation of the stored water is 257 m AHD, some 20 m above the base of the adjacent Arruwurra Pits.

The potential seepage rates from the stored surface water have been calculated using Darcy's groundwater flow equation, presented below.

$Q = A \times K \times (dh/dx)$

Where:

Q = seepage rate into the Arruwurra Pit.

A = cross sectional area perpendicular to the flow direction, calculated as the extent of the water body adjacent to the pit crests (500 m) multiplied by the depth of the Arruwurra Pits (20 m).

K = hydraulic conductivity.

dx = difference in head, calculated as the difference between the surface water level and the base of the Arruwurra Pit (20 m).

dx = flow path length, assumed to be the distance from the stored surface water body to the Arruwurra Pit crests (100 m).

A schematic diagram of this conceptual model is presented in Figure 27.

Seepage rates were calculated for two conditions, expected and worst case, based upon variation in the hydraulic conductivity of the near surface sedimentary rocks. For the expected case an hydraulic conductivity of 0.001 m/d was adopted (consistent with the value used in the numerical model) and for the worst case a value of 0.01 m/d was used.

The calculated seepage rates ranged from about 0.02 L/s to 0.2 L/s. The seepage rates are low in comparison to the likely incidental rainfall into the pits that would be associated with a significant rainfall event. The impacts of seepage upon the overall dewatering requirement following a major storm event are therefore likely to be negligible.

9.0 BOREFIELD EQUIPPING AND OPERATING STRATEGY

9.1 Borefield Equipping and Operation

Recommended pumping rates for the three production bores tested are presented in Table 13, along with the recommended pump inlet setting and available drawdown.

Table13: Bore Equipping Recommendations

Bore ID	Maximum Pumping Rate		Pump Inlet Setting (mbgl)	SWL (mbtc)	Available Drawdown (m)	Total Bore Depth (mbgl)	Recommended Pumping Rate	
	(m^3/hr)	(L/s)					(m^3/hr)	(L/s)
WNWB002	9	2.5	100	24.58	75	125.4	9	2.5
WNWB004	72	20	95	50.86	44	122	54	15
WNWB005	72	20	95	48.64	46	126	54	15

Note: mbgl = metres below ground level, SWL = static water level, mbtc = metres below top of casing

The recommended pumping rates comprise:

- the maximum duty rate, based upon the test pumping results (Section 3.2);
- the recommended long-term pumping rates based upon the sustainable yield of the aquifer resource, which have been estimated using the numerical groundwater flow model (Section 7.2.2).

For the purposes of this study it is assumed the three planned new northern borefield bores will have the same characteristics as existing bores WNWB003 and 004. Similarly the four planned new Arruwurra production bores will be similar to existing bore WNWB002. This provides a combined recommended pumping rate of 75 L/s from the northern borefield and 12.5 L/s from the Arruwurra production bores.

9.2 Operating Strategy

9.2.1 Strategy overview

Operation of the Arruwurra production bores and northern borefield will require a suitable operating strategy to help:

- maintain adequate water supply to the Project;
- identify unacceptable impacts upon other groundwater users;
- identify unacceptable impacts upon the groundwater environment.

The strategy should:

i) Describe the borefield and monitoring system, including a schedule of production and monitoring bores.

ii) Identify other users in the vicinity of the borefield and environmentally sensitive areas.

iii) Present a copy of the approvals under which groundwater extraction is permitted, including any conditions related to the approvals.

iv) Identify the persons responsible for operation of the borefield, and present their contact details.

v) Detail the monitoring requirements for the borefield.

vi) Detail the routine data assessment programme, including frequency, reporting commitments and trigger values used to identify possible unacceptable impacts upon the groundwater environment.

vii) Detail action and contingency plans that may be required should unacceptable impacts upon the groundwater environment be identified.

It is intended that the strategy will be prepared under a separate cover as a stand-alone document and therefore is not included in this report. However, the proposed monitoring schedule for the Wonarah Project has been developed and is presented in the following section.

9.2.2 Monitoring schedule

The recommended monitoring schedule for the Arruwurra production bores and northern borefield is presented in Table 14.

Table 14: Recommended Monitoring Schedule

Monitoring Site	Parameter	Frequency	Comments
Arruwurra and Camp Area			
Production Bores	Groundwater level depth	Monthly	
	Cumulative pumping volume	Monthly	
	EC, temperature and pH	Monthly	Measured in the field using a calibrated hand-held meter
Northern Borefield			
Production Bores	Groundwater level depth	Monthly	
	Cumulative pumping volume	Monthly	
	EC, temperature and pH	Monthly	Measured in the field using a calibrated hand-held meter
	Water quality laboratory analysis	Annual	Analytes: pH, TDS, EC, major ions, NO3 and Fe
Monitoring Bores	Groundwater level depth	Monthly	
Regional Sites			
Environmental monitoring bore (WNEM001)	Groundwater level depth	Monthly	
Nearby stock bores	Groundwater level depth	Monthly	

The locations of the existing Arruwurra and Camp Bore (WNWB001 and 002) are shown on Figures 4 and 5. The northern borefield bores are shown on Figure 6 along with the corresponding monitoring bores and regional stock bores.

Regional monitoring of third party users is recommended in six stock bores (RN025678, 025874, 004087, 006751, 001237 and 001238), identified from the numerical modelling as being within the 5 m drawdown contour after ten years of operation for the base case condition (Section 7.2.3). The locations of the stock bores are presented in Figure 16 and the bore details in Table 2.

10.0 RISK ASSESSMENT

A primary risk analysis workshop was carried out on 20 August 2009, facilitated by AMC. The risk analysis methodology and the workshop findings are presented in Section 19 of the Wonarah Project Bankable Feasibility Study report (AMC, 2009).

The following sections outline the risks relating to groundwater and a copy of the current risk register (Rev 1.0) presenting a summary of the groundwater related risks is provided in Appendix D.

10.1 Risk of Groundwater Supply Failure

The risk of groundwater supply failure relates to the failure of the Arruwurra production bores at the start of construction; and/or failure of the northern borefield at the end of construction or during development and mining. The probability of water supply failure is considered unlikely (Level 2), given the successful groundwater intersections north of Minemakers' tenements and the five potential production bore locations already identified at Arruwurra (Section 3.1). The consequence is considered moderate (Level 3), because of possible delays to construction (particularly of the roads); and mining and haulage should there be insufficient water for dust suppression, which is the main water use once operations commence. The adopted likelihood/consequence matrix gives a risk rating of Low.

Controlling strategies to assist in mitigation of the risk comprise adequate monitoring of groundwater levels and pumping rates; and assessment of the monitoring data to provide early warning of possible supply failure. In addition, provision of sufficient redundancy in the borefield to allow enough time for additional production bores to be installed should they be needed.

10.2 Unacceptable Reduction in Groundwater Supply Quality

The risk of an unacceptable reduction in groundwater supply quality relates to changes in the groundwater quality with time (i.e. seasonally or due to pumping). The probability of unacceptable quality water is unlikely (Level 2) and the consequence minor (Level 2), giving a risk rating of Low. Regional groundwater quality data show groundwater salinities range from 500 to 4,000 mg/L TDS. It is therefore unlikely pumping will draw in lower quality saline groundwater into production bores. This is supported by the extensive use of groundwater across the Barkly Tableland for stock watering purposes. It should also be noted that the majority of the water will be used for dust suppression, which is relatively insensitive to changes in water quality. It is also planned to treat potable water by reverse osmosis, minimizing the risk to health from elevated concentrations of metals and other toxic ions.

Controlling strategies to assist in mitigation of the risk comprise adequate monitoring of groundwater quality and assessment of the monitoring data. This should provide early warning of possible reductions in groundwater quality and enable installation of additional production bores away from the area affected or discussions with regulators to relax water quality use conditions.

10.3 Pit Dewatering from Groundwater

The risk of pit inundation from groundwater inflow is low. This is based on a probability of rare (Level 1) and a consequence Level of 1 (rare). As discussed in Section 8.1, a survey of groundwater levels in the vicinity of Arruwurra and the Main Zone have identified water table levels below the base of the ore, apart from a few isolated locations that show evidence of minor perched water bodies.

Controlling strategies comprise ongoing assessment of potential elevated groundwater conditions during resource drilling and installation of a suitable dewatering system should higher than expected groundwater levels be encountered. In addition, the maintenance of adequate ore stockpiles to provide sufficient time to dewater the pit(s) should this be necessary.

10.4 Pit Dewatering from Infiltrating Rainfall

The risk of pit flooding from infiltrating rainfall, relates to seepage inflows from stored surface water at Arruwurra (Section 8.2). The likelihood of occurrence is rated as possible (Level 3) and the consequence as insignificant (Level 1). Because the Arruwurra Pit lies in a topographic low some storage of runoff water within topographic depressions is possible (depending upon the severity of the storm event), which may result in seepage into the pit. However, the seepage rates will be low (0.02 to 0.2 L/s) in comparison to the potential flooding in the pit from incidental rainfall, and should therefore be readily managed by the flood management infrastructure (internal drainage system, sumps and sump pumps).

Controlling strategies comprise installation of suitable flood management infrastructure and the maintenance of adequate ore stockpiles to provide sufficient time to dewater the pit(s) should this be necessary.

10.5 Unacceptable Environmental Impacts from Groundwater Production

The risk of unacceptable impacts upon the environment relate to drying up of the two marshes identified 10 and 37 km north east and east of the proposed northern borefield (Section 2.5). The likelihood of occurrence is rated as rare (Level 1) and the consequence as moderate (Level 3). This results in a Moderate risk level. Groundwater modelling results indicate drawdowns of less than 3 m at the nearest marsh after 10 years of pumping, which is considered to be negligible considering the ambient groundwater depth of around 50 m. In addition, monitoring results indicate the marshes are surface water features and will therefore be unaffected by changes in the underlying groundwater level.

Controlling strategies to assist in mitigation of the risk comprise adequate monitoring of groundwater levels and pumping rates; and assessment of the monitoring data to provide early warning of unacceptable impacts upon the marshes. If unacceptable impacts are identified, additional production bores located away from the proposed northern borefield and from the sensitive areas will be installed, thereby reducing interference effects from groundwater production.

10.6 Unacceptable Impacts on Other Users from Groundwater Production

The risk of unacceptable impacts on other users relates to lowering of regional groundwater levels in the vicinity of the northern borefield. No third party users have been identified at

Arruwurra. The probability of occurrence is rated at unlikely (Level 2) and the consequence as minor (Level 2), resulting in a low risk result based upon AMC's matrix.

Groundwater modelling results show six bores lie within the 5 m drawdown contour and only one bore lies within the 10 m drawdown contour after 10 years groundwater production. This provides significant redundancy, given the available drawdown in the aquifer system (approximately 50 m).

Controlling strategies to assist in mitigation of the risk comprise adequate monitoring of drawdown extents in the regional bores and monitoring bore WNMB005. In addition, Minemakers has committed to maintaining existing water supplies, where monitoring indicates pumping from the proposed northern borefield has had an unacceptable impact.

11.0 COST ESTIMATE

Cost estimates have been prepared covering:

- drilling and construction of four new production bores at Arruwurra;
- drilling and construction of three new production bores at the northern borefield;
- drilling and construction of three monitoring/observation bores adjacent to the new northern borefield production bores;
- completion of step and 48-hour constant rate tests on the seven new production bores;
- supply of suitable submersible pumps and associated infrastructure (rising main, electrical cable, control box with cabinet, head works, flow meter, gate valve, sample tap and pressure gauge) for five production bores at Arruwurra and four production bores at the northern borefield.

The estimated drilling and bore construction costs are presented in Table 15. The costs are based upon rates provided by Gorey and Cole, who undertook the last drilling phase, and the following assumptions.

- Production and monitoring bore depths of 144 m.
- Construction of the production bores using 155.6mm ID/168.3mm OD mild steel blank and slotted casing.
- Construction of the monitoring bores using 50 mm nominal diameter class 9 uPVC blank and slotted casing.
- Formation stabiliser or filter pack is not required for either production or monitoring bores.
- All drill-holes can be completed using direct circulation air hammer.

Table 15: Estimated Drilling and Bore Construction Costs

Item	Unit	Rate ($)	Qty	Amount ($)
Mobilisation / Demobilisation	Item	4,000	1	4,000
Drilling				
Drill to accept 200mm surface casing	m	145	42	6,090
Drill 203 mm hole	m	105	1,008	105,840
Drill to accept 150mm surface casing	m	105	18	1,890
Drill 152 mm hole	m	65	432	28,080
Casing				
Supply of 200 mm NB steel casing (8")	m	85	60	5,100
Supply of 150 mm NB blank steel casing (6")	m	65	672	43,680
Supply of 150 mm NB slotted steel casing (6")	m	120	336	40,320
Supply of 50 mm NB PVC blank casing (2")	m	7	288	2,016
Supply of 50 mm NB PVC slotted casing (2")	m	12	144	1,728
Miscellaneous				
Work time (Run casing, Bore development etc)	Hour	700	119	83,300
Standby Time -	Hour	550	10	5,500
Consumables				
Cement	bag	20	40	800
Quickfoam	Ltr	4.50	200	900
Diesel Fuel	Ltr	1.25	17,000	21,250
TOTAL				**350,494**

Note: all costs provided are exclusive of Goods and Services Tax (GST).

Costs for test pumping of the new bores and supply of submersible pumps and associated infrastructure were provided by McMinns Bore Services, who completed the test pumping programme for the current study. The estimated costs are summarised in Table 16 (test pumping costs) and Table 17 (supply of pumps and infrastructure).

Table 16: Estimated Bore Testing Costs

Item	Unit	Rate ($)	Qty	Amount ($)
Mobilisation / Demobilisation	Item	4,600	1	4,600
Install and remove pump	hr	800	7	5,600
Carry out step rate test	hr	160	28	4,480
Carry out constant rate test	hr	80	336	26,880
Carry out recovery test	hr	80	28	2,240
TOTAL				**43,800**

Note: all costs provided are exclusive of GST.

In estimating the cost of submersible pumps and associated infrastructure it has been assumed that the pump purchased by Minemakers for the test pumping of WNWB003 and 004 will be available for use when the borefield is commissioned.

Table 17: Estimated Bore Pump Supply Costs

Item	Unit	Rate ($)	Qty	Amount ($)
4 inch pump Southern Cross SC8 18 3kW motor, complete with rising main, electrical cable, control box with cabinet, head works, flow meter, gate valve, sample tap and pressure gauge	Item	9,610	5	48,050
6 inch pump, Southern Crosssc 65-10 18.5kW, complete with rising main, electrical cable, control box with cabinet, head works, flow meter, gate valve, sample tap and pressure gauge	Item	24,230	4	96,920
TOTAL				**144,970**

Note: all costs provided are exclusive of GST, costs do not include freight or installation costs.

Performance data for the pumps specified in Table 17 are presented in Appendix E.

12.0 SUMMARY AND CONCLUSIONS

Minemakers Australia Pty Ltd (Minemakers) is planning to develop the Wonarah Phosphate Project. Stage 1 involves the mining of direct ship ore (DSO) and is subject to a Bankable Feasibility Study (BFS). Groundwater issues for the BFS relate to estimation of the water demand, identification of a suitable water supply, assessment of the security of the supply and impacts from pumping, assessment of other mining activities' impacts upon the groundwater environment, characterization of the groundwater environment and groundwater quality, and development of an operating strategy.

A water balance for the Project, including supplies for construction, development and mining estimated a maximum combined demand during the initial construction phase of 15 L/s, rising to 67 L/s at the end of development. The demand during mining is predicted to be between 32 and 60 L/s, varying seasonally with evaporation rates. The largest water users are road construction (construction phase) and dust suppression during development and mining.

An extensive field programme was carried out, including drilling, bore construction, test pumping and groundwater level surveys. Four production bores were installed one near Minemakers' camp, one at Arruwurra and two north of Minemakers' tenements.

The results of the programme included the following:

- Minor groundwater supplies were found within Minemakers' tenements mostly in the vicinity of the Arruwurra deposit.
- Good groundwater supplies were identified north of Minemakers' tenements with maximum bore yields of about 20 L/s.
- Groundwater quality is fresh to brackish with elevated concentrations of iron in the northern bores and silica at Arruwurra and in the northern bores; boron was also high in the camp bore.
- Groundwater levels measured within the Main Zone and Arruwurra areas were generally below the base of the ore zones, apart from a few minor occurrences that are judged to be isolated.

A two stage approach was developed to meet the predicted Project water requirement. The first stage involves the development of five modest yielding bores at Arruwurra to meet the initial demands during construction (nominally for three months). During this initial period a further three high yielding production bores will be installed in the area north of Minemakers' tenements. These along with the two existing northern bores will form the northern borefield and provide the long-term supply (second stage) to the Project.

The security of the supply from the two stages was assessed using analytical methods (first stage) and numerical modelling (second stage). The outcomes from the two assessments show:

– Maximum drawdowns of about 18 m in the Arruwurra bores after 3 months pumping at a combined rate of 12.5 L/s.

– Maximum drawdowns of about 14 m at the northern borefield after 10 year groundwater production (equivalent to the current life of mine), using expected hydraulic parameter values and a combined pumping rate of 75 L/s.

- Maximum drawdowns of about 17 m at the northern borefield after 10 years using likely worst case values for hydraulic parameters and a combined pumping rate of 75 L/s.

These outcomes indicate a suitable water supply can be provided during construction, development and mining.

The numerical modelling was also used to estimate long-term impacts from pumping upon groundwater levels near environmentally sensitive areas and upon third party groundwater users.

Two sensitive sites were identified in the vicinity of the northern borefield, which comprised marshes located at distances of about 10 and 37 km. Maximum predicted drawdowns in the water table at the closest marsh range from 1.5 m for the expected aquifer conditions to 3 m for the worst case conditions. It is important to note that field investigations at the closest marsh found no connection between it and the underlying groundwater system. It is therefore considered unlikely that any changes in the water table will impact upon the marsh.

The numerical modelling indicated six existing production bores lie within the 5 m drawdown contour and therefore maybe adversely affected by the northern borefield. This risk has been mitigated by a commitment by Minemakers to provide a suitable alternative supply should it be necessary.

The dewatering requirements in the Main Zone and Arruwurra Pits is expected to be negligible, based upon the measured water table depths at the two deposits. Any inflows are likely to be associated with isolated groundwater bodies that can be readily managed with local sumping. There is also the possibility of seepage inflows from stored surface water runoff at Arruwurra following a major storm event. However, seepage estimates using Darcy's equation indicate small inflow rates of 0.2 L/s or less. Again these rates should be readily manageable via inpit sumping.

A risk assessment for the Project has identified a number of groundwater related risks. However, all risks were ranked as Low, apart from the risk of groundwater supply failure and unacceptable impacts upon the environment, which were rated as Moderate. The adequate mitigation of these risks can be achieved through effective control measures, including adequate monitoring, provision of sufficient redundancy in the groundwater supply and installation of additional suitably located bores if required.

The requirement for a suitable operating strategy has been identified which will be presented under a separate cover in a standalone document. A monitoring schedule has been provided that will form part of the strategy.

Estimated costs associated with the groundwater aspects of the Project have been prepared, which comprise:

- installation of additional production and monitoring bores (approximately $350,000);
- test pumping of additional production bores (approximately $44,000); and
- supply of bore pumps and associated infrastructure (approximately $145,000).

Groundwater Resource Management Pty Ltd.

R. Garnham

Robert Garnham **Peter Mayers**

PRINCIPAL HYDROGEOLOGIST **SENIOR HYDROGEOLOGIST**

\\TOASTER\GRM\JOBS2008\J080028_WONARAH\REPORT\DRAFT\J080028R01DRAFT.DOC

This report has been printed on paper that contains a proportion of recycled material as a gesture of Groundwater Resource Management's commitment to sustainable management of the environment.

REFERENCES

AMC 2009. "Wonarah feasibility study, section 19 risk assessment", report reference AMC209021 Section 19_090630 DRAFT, June 2009. Unpublished draft report prepared for Minemakers Australia Pty Ltd.

Fugro 2008. "Resolve survey for Minemakers Limited GEA1-7and Arruwurra Blocks Northern Territory, Australia", report number 08064, 18 December 2008. Unpublished report prepared by Fugro Airborne Surveys Corporation for Minemakers Ltd.

Department of Infrastructure, Planning and Environment, 2003. "Avon downs and ranken sheets groundwater occurrence", report number 40/2003A, December 2003.

Read RE, 2007. "Groundwater potential of the Arruwurru, Wakaya and Warramunga ALT", report number 33/2007A, November 2007.

GRM 2009. "Hydrological baseline assessment, Wonarah Phosphate Project", report number J090004R01, July 2009. Unpublished report prepared by Groundwater Resource Management Pty Ltd for Minemakers Ltd.

Randall, 1967. "Groundwater in the Barkly tableland", Bull 91 of the BMR.

Territory Groundwater Services, 1998. "Drilling, geophysical logging and test pumping report map study regions 1 and 2", report number 37/97A, April 1998. Published report prepared for the Department of Lands, Planning and Environment.

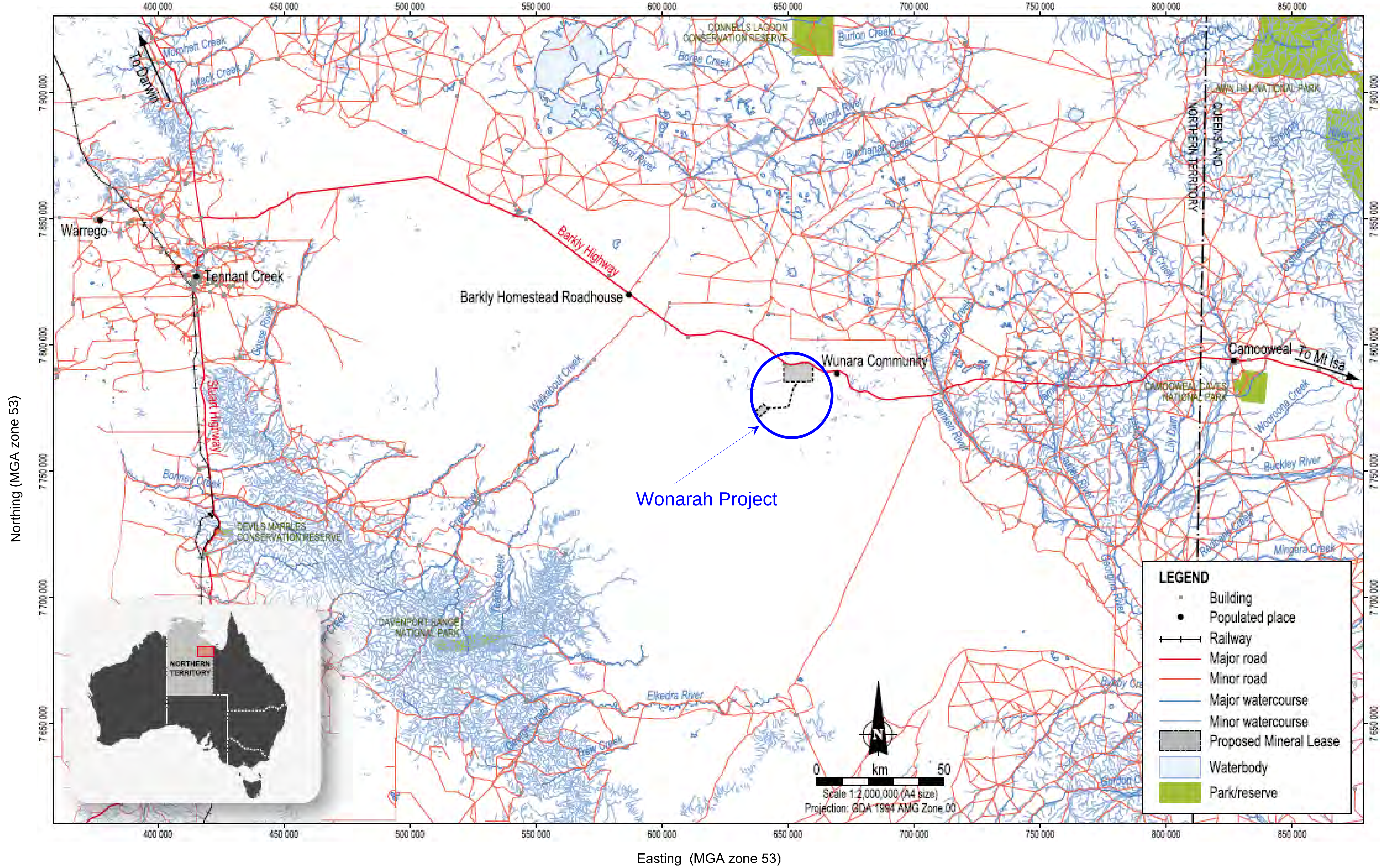
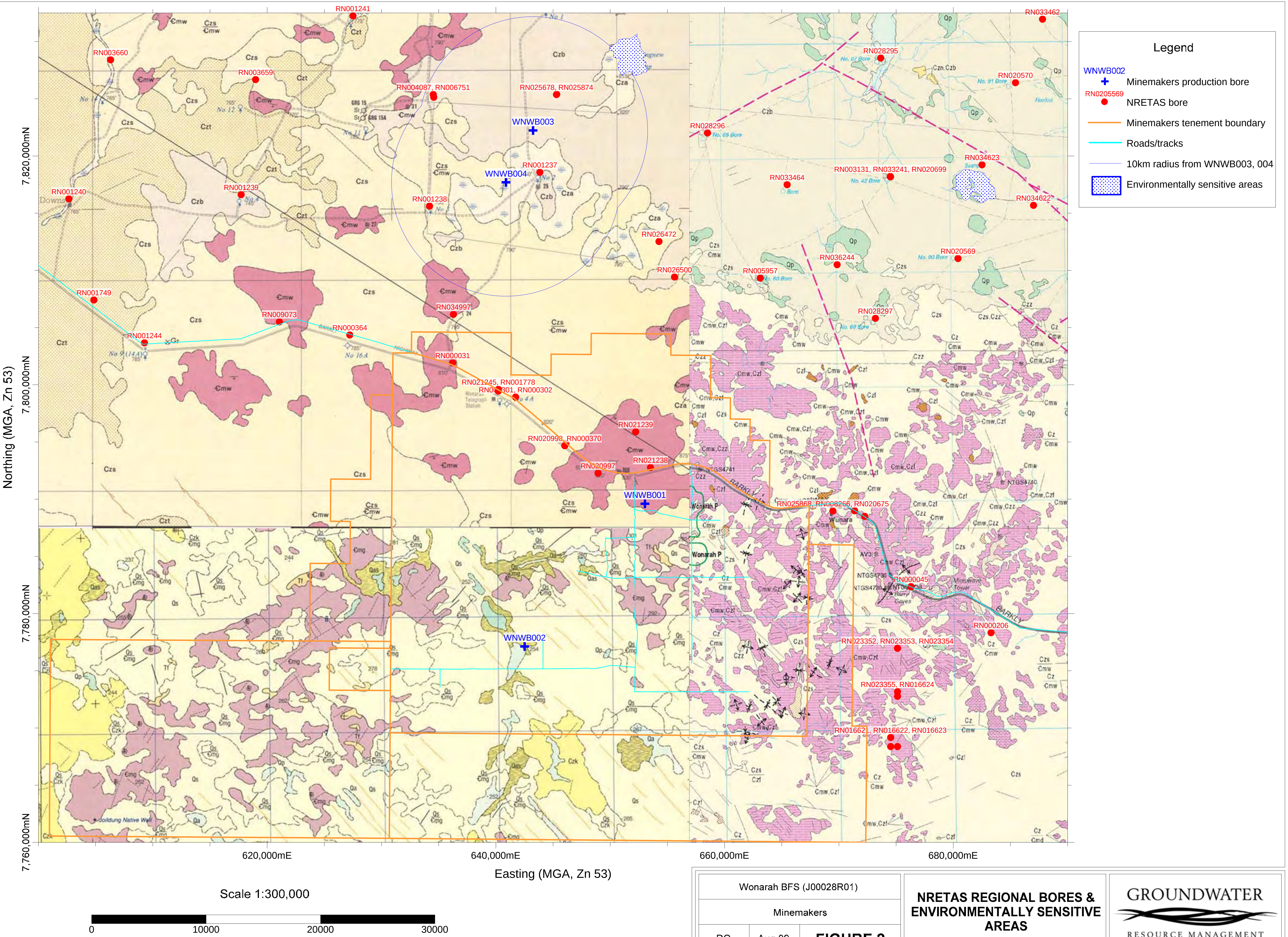


Figure Copied from Notice of Intent For Public Display, March 2009.Report prepared for Minemakers Ltd by Coffey Natural Systems Pty Ltd

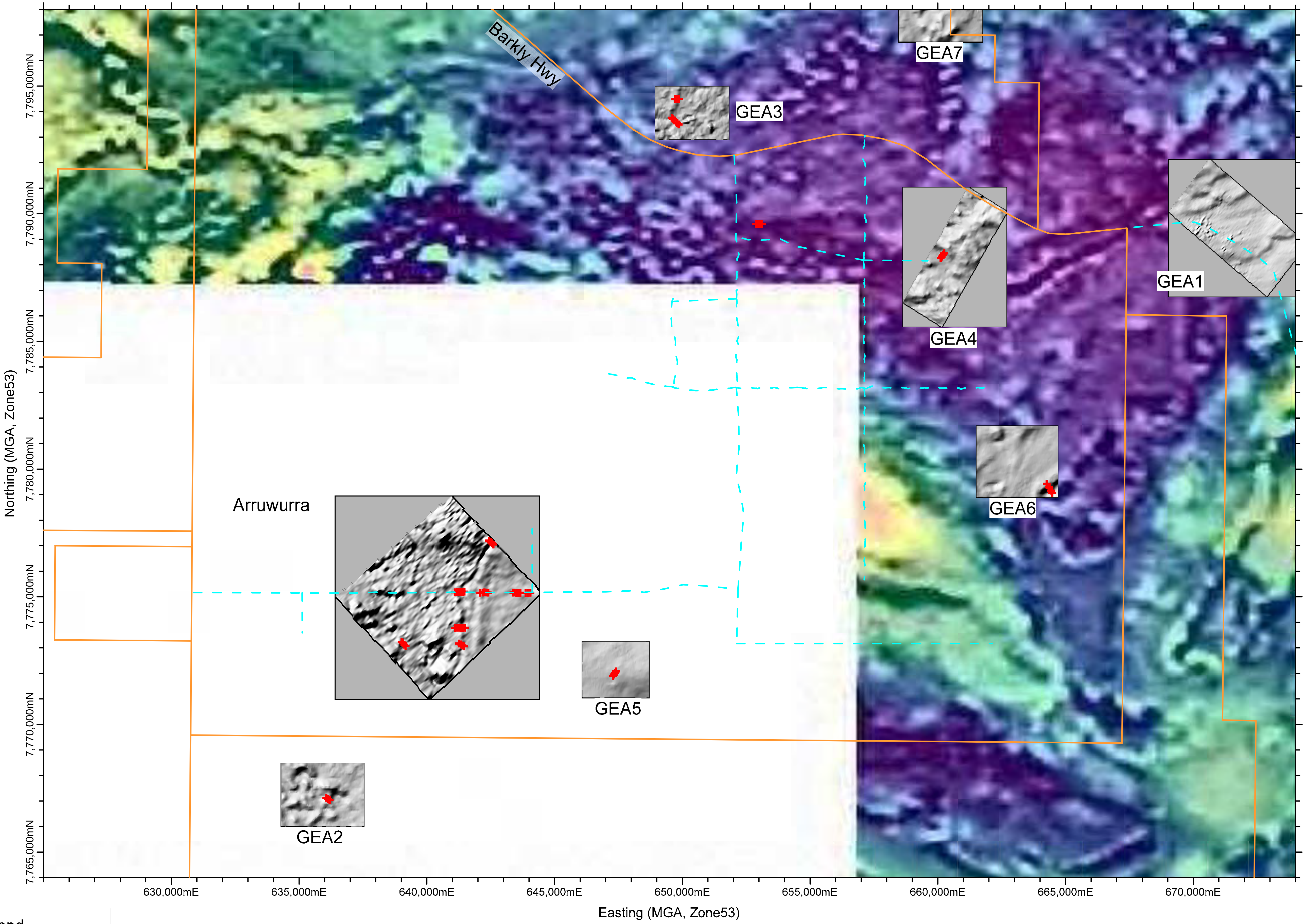
Wonarah BFS (J090028)			PROJECT LOCATION PLAN	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
PM	Oct 09	**FIGURE 1**		

FILE:/Jobs 2008/J080028_Wonarah/Figures/Surfer/Figure 1



Wonarah BFS (J00028R01)			**NRETAS REGIONAL BORES & ENVIRONMENTALLY SENSITIVE AREAS**	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Aug 09	**FIGURE 2**		

FILE://J080028/figures/surfer/J080028R01Surfer/NRETASBoreLocPlan.srf



Legend

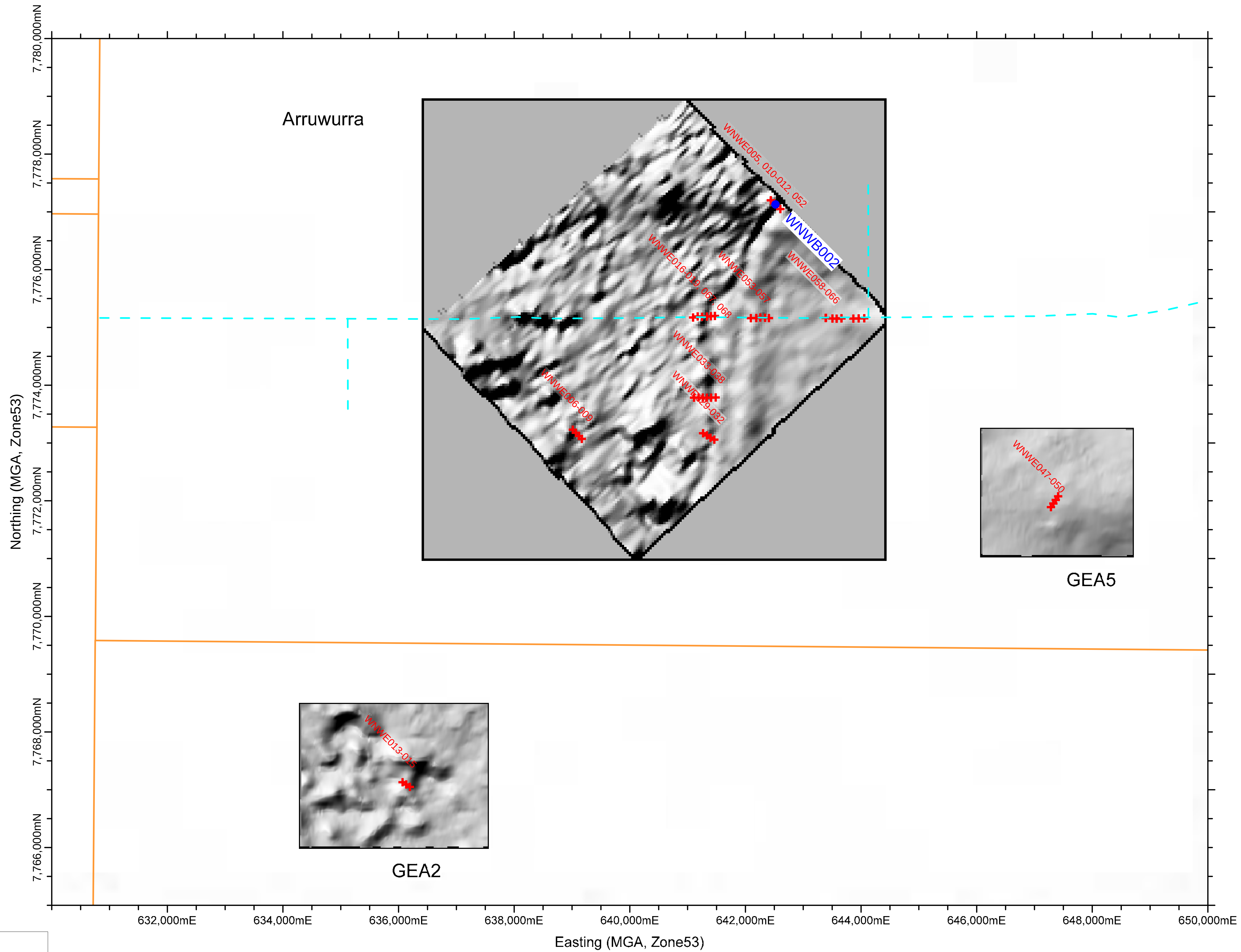
- Groundwater exploration hole
- Tracks/roads
- Tenement boundary

Scale 1:150,000

0m 5,000m 10,000m

Wonarah BFS (J080028R01)			DRILL HOLE LOCATIONS ON MINEMAKERS TENEMENTS	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 3**		

J080028/figures/surfer/J080028R01Surfer/HoleLocPlan.srf



Legend

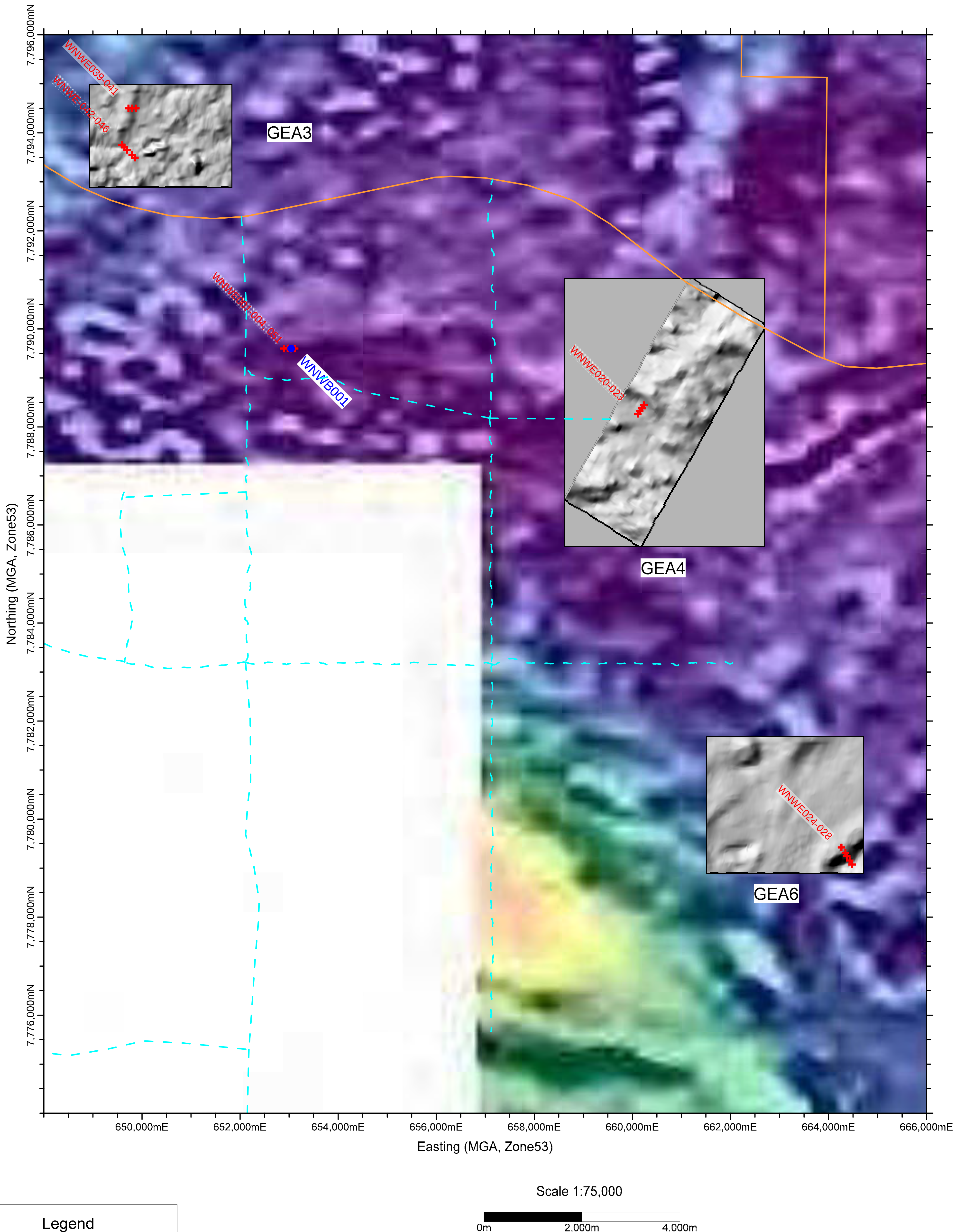
- Production bores
- Groundwater exploration hole
- Tracks/roads
- Tenement boundary

Scale 1:70,000

0m 2,000m 4,000m

Wonarah BFS (J080028R01)			DRILL HOLE LOCATIONS ARRUWURRA, GEA2 & GEA5	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 4**		

J080028/figures/surfer/J080028R01Surfer/HoleLocPlan.srf

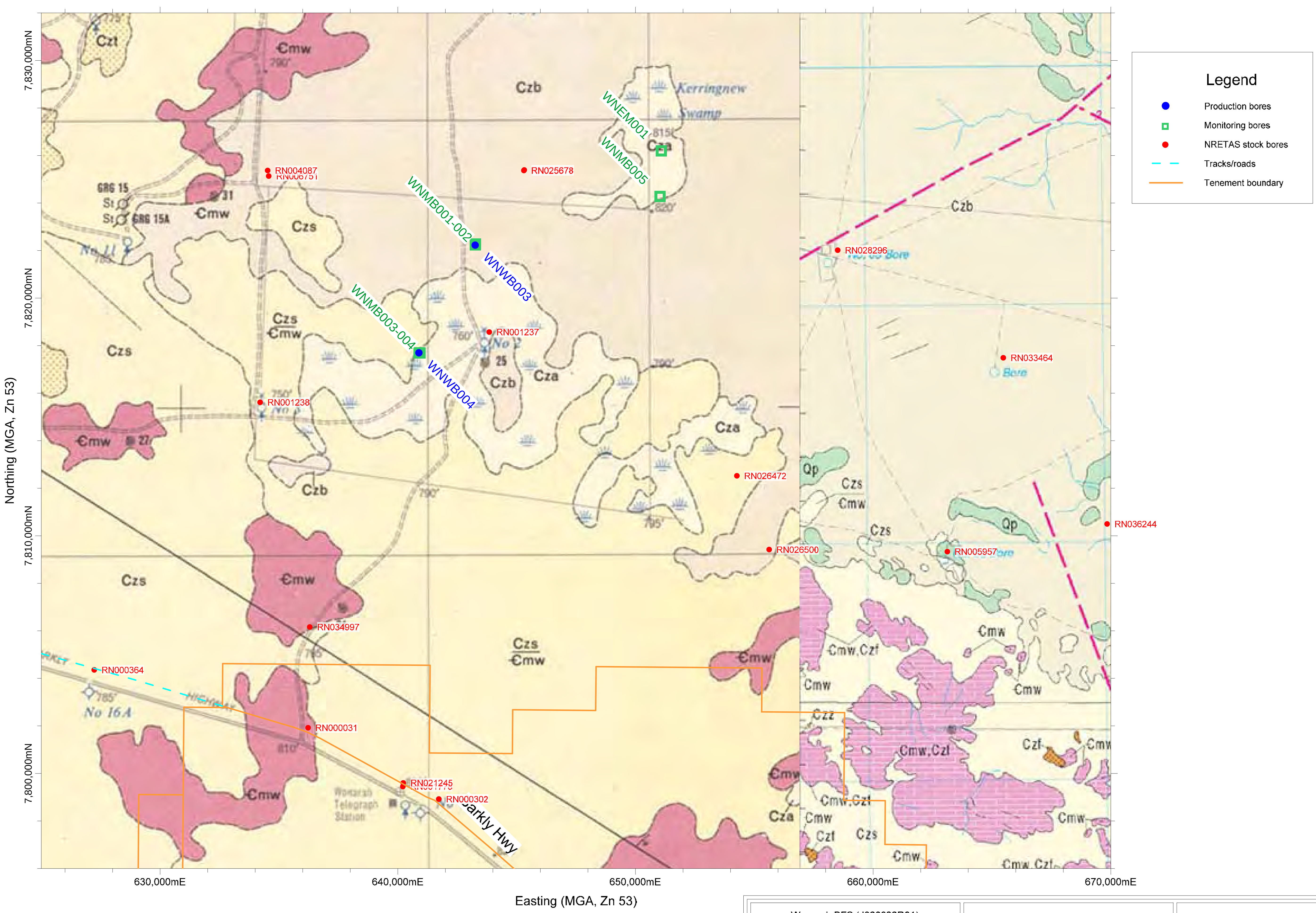


Legend

- Production bores
- Groundwater exploration hole
- Tracks/roads
- Tenement boundary

Wonarah BFS (J080028R01)			DRILL HOLE LOCATIONS GEA3, 4, 6 AND IN THE CAMP AREA	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 5**		

J080028/figures/surfer/J080028R01Surfer/HoleLocPlanGEA3_4_6.srf



Wonarah BFS (J080028R01)			TEST PRODUCTION BORE LOCATIONS	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	FIGURE 6		

FILE://J080028/figures/surfer/J080028R01Surfer/HoleLocPlanOffTenement.srf

\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\WNWB02_TP_DATA.grf

SMW

Sep 09

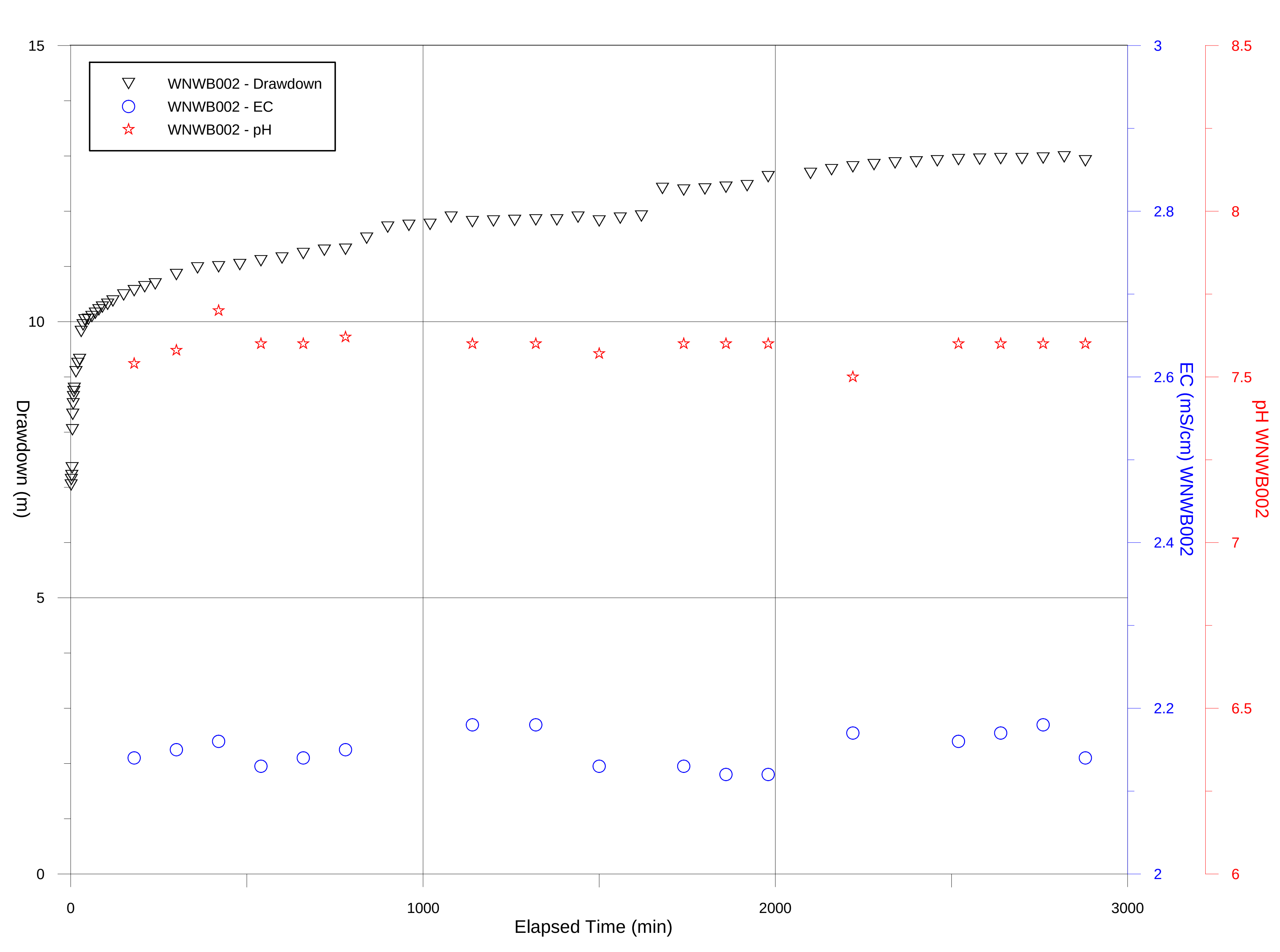
FIGURE 7

Wonarah BFS (J080028R01)

Minemakers

TEST PUMPING DATA
WNWB002 (2.5L/s)

GROUNDWATER
RESOURCE MANAGEMENT



Wonarah BFS (J080028R01)

Minemakers

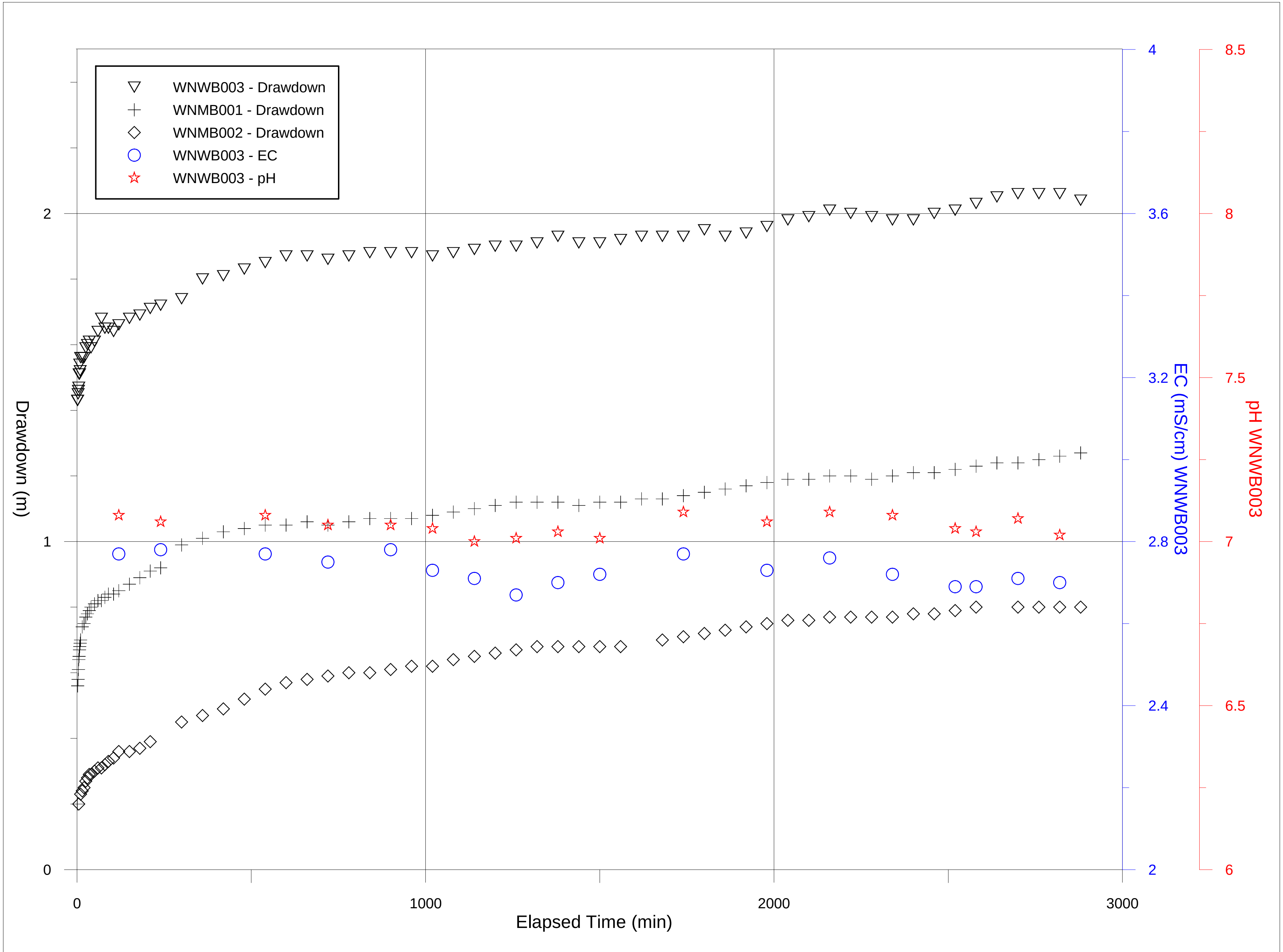
SMW

Sep 09

FIGURE 8

TEST PUMPING DATA WNWB003 (12L/s)

GROUNDWATER RESOURCE MANAGEMENT



\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\WNWB003_TP_DATA.grf

\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\WNWB04_TP_DATA.grf

SMW

Sep 09

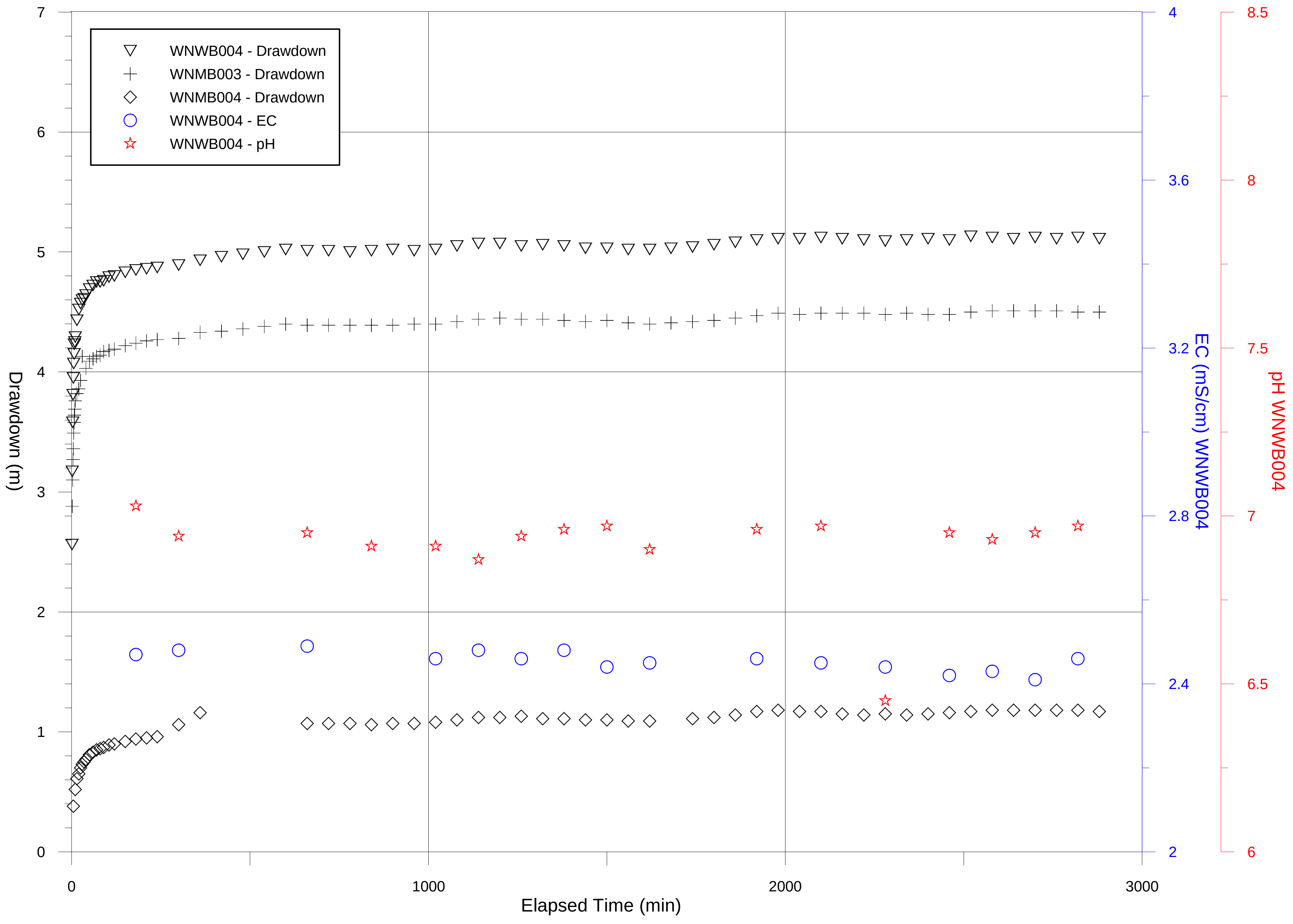
FIGURE 9

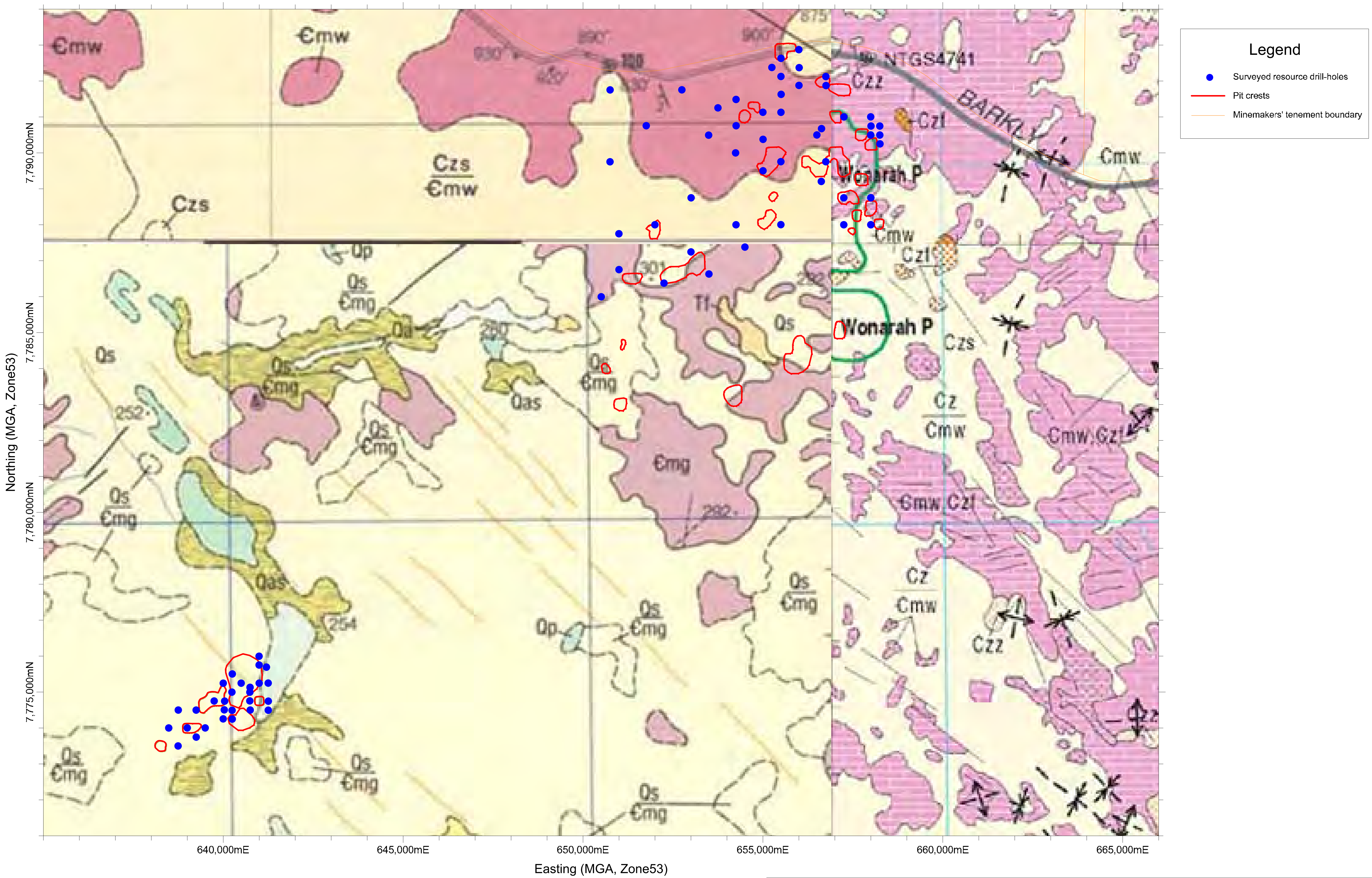
Minemakers

Wonarah BFS (J080028R01)

TEST PUMPING DATA
WNWB004 (12L/s)

GROUNDWATER
RESOURCE MANAGEMENT





Wonarah BFS (J080028R01)			GROUNDWATER LEVEL SURVEY DRILL-HOLES	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 10**		

J080028/figures/surfer/J080028R01Surfer/SWLSurveyHoles.srf

RG

Sep 09

FIGURE 11

Minemakers

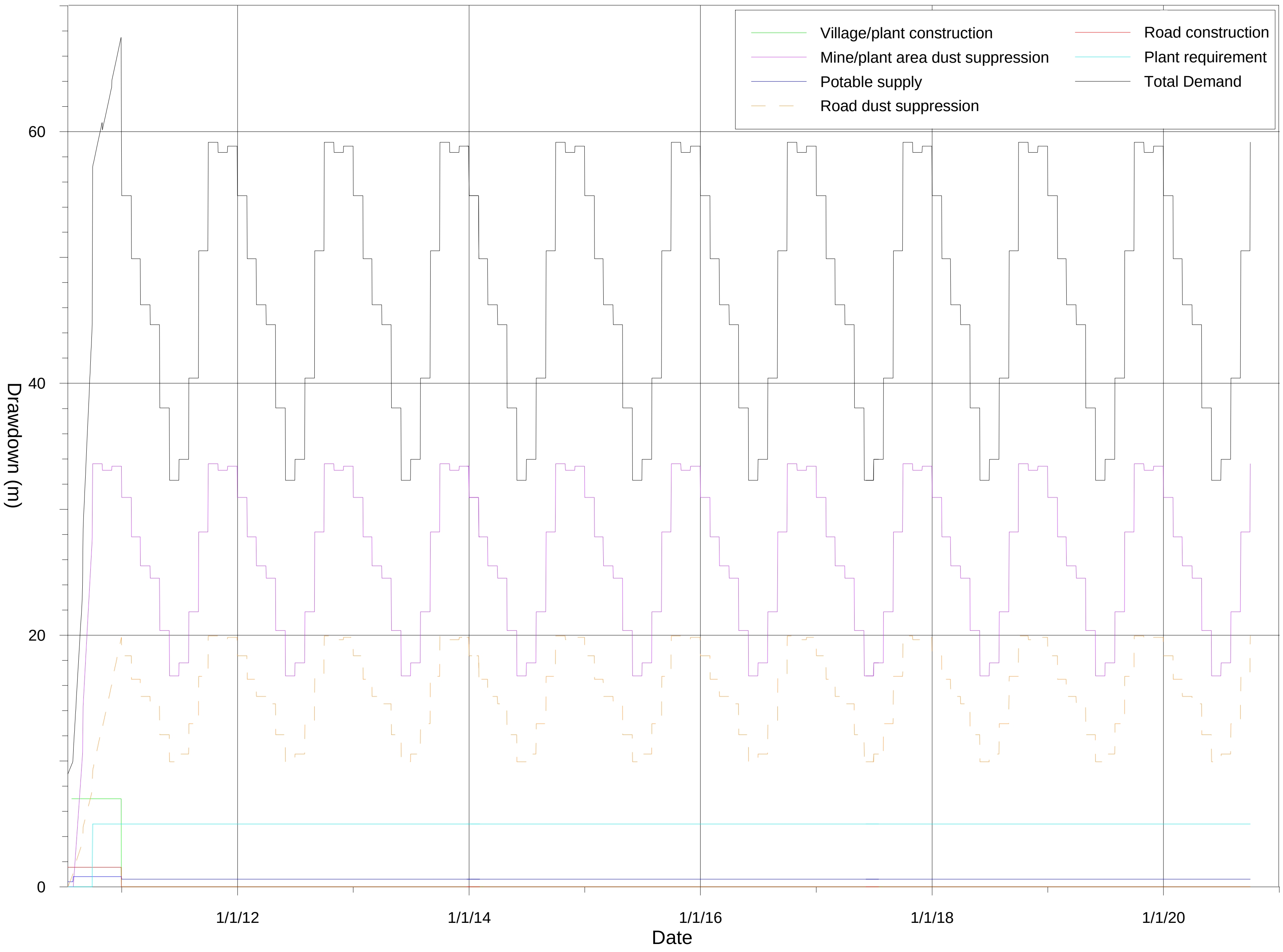
Wonarah BFS (J080028R01)

WATER BALANCE RESULTS

GROUNDWATER

RESOURCE MANAGEMENT

\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\WaterBalanceResults_220909.grf



Wonarah BFS (J080028R01)

Minemakers

SMW

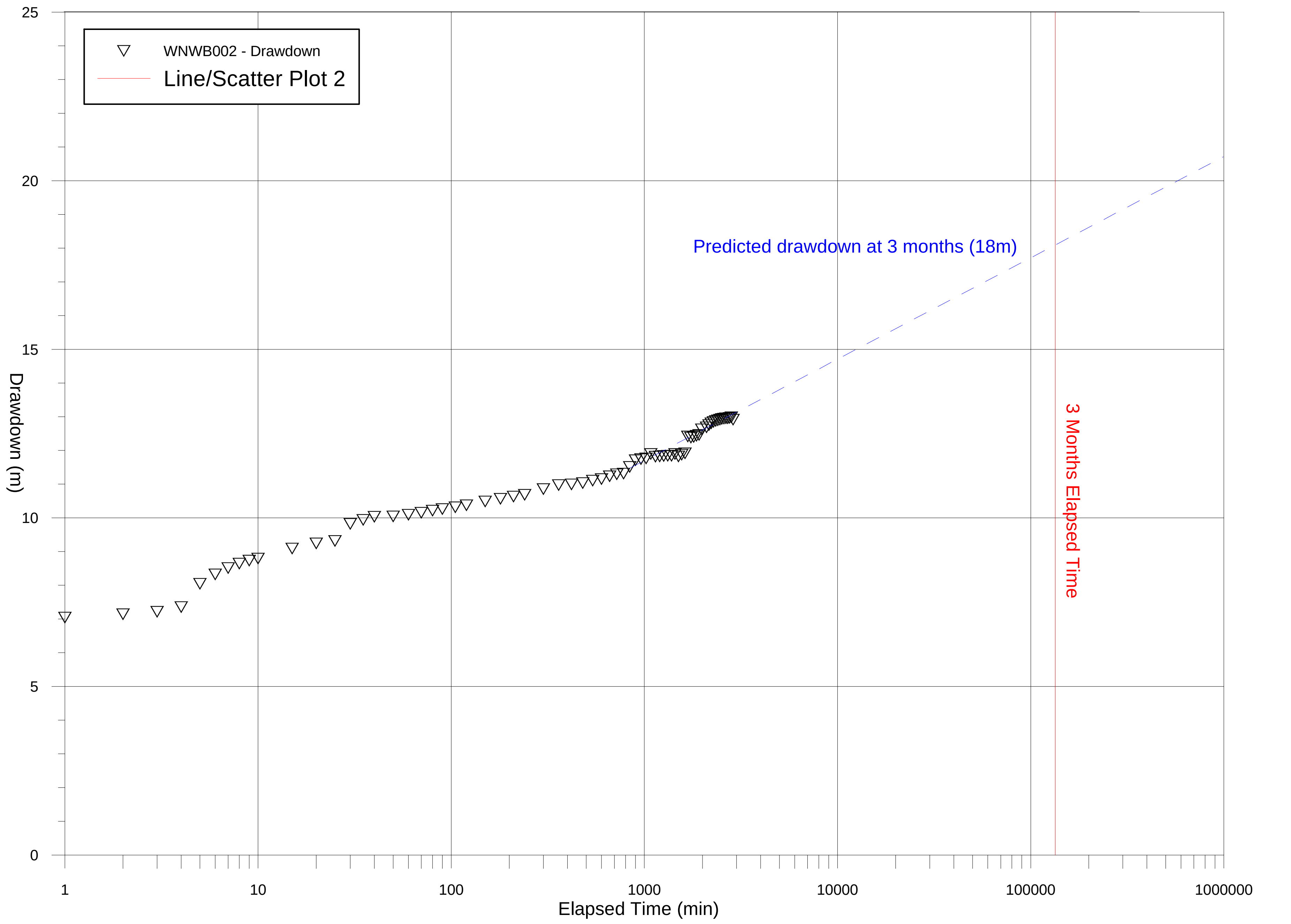
Sep 09

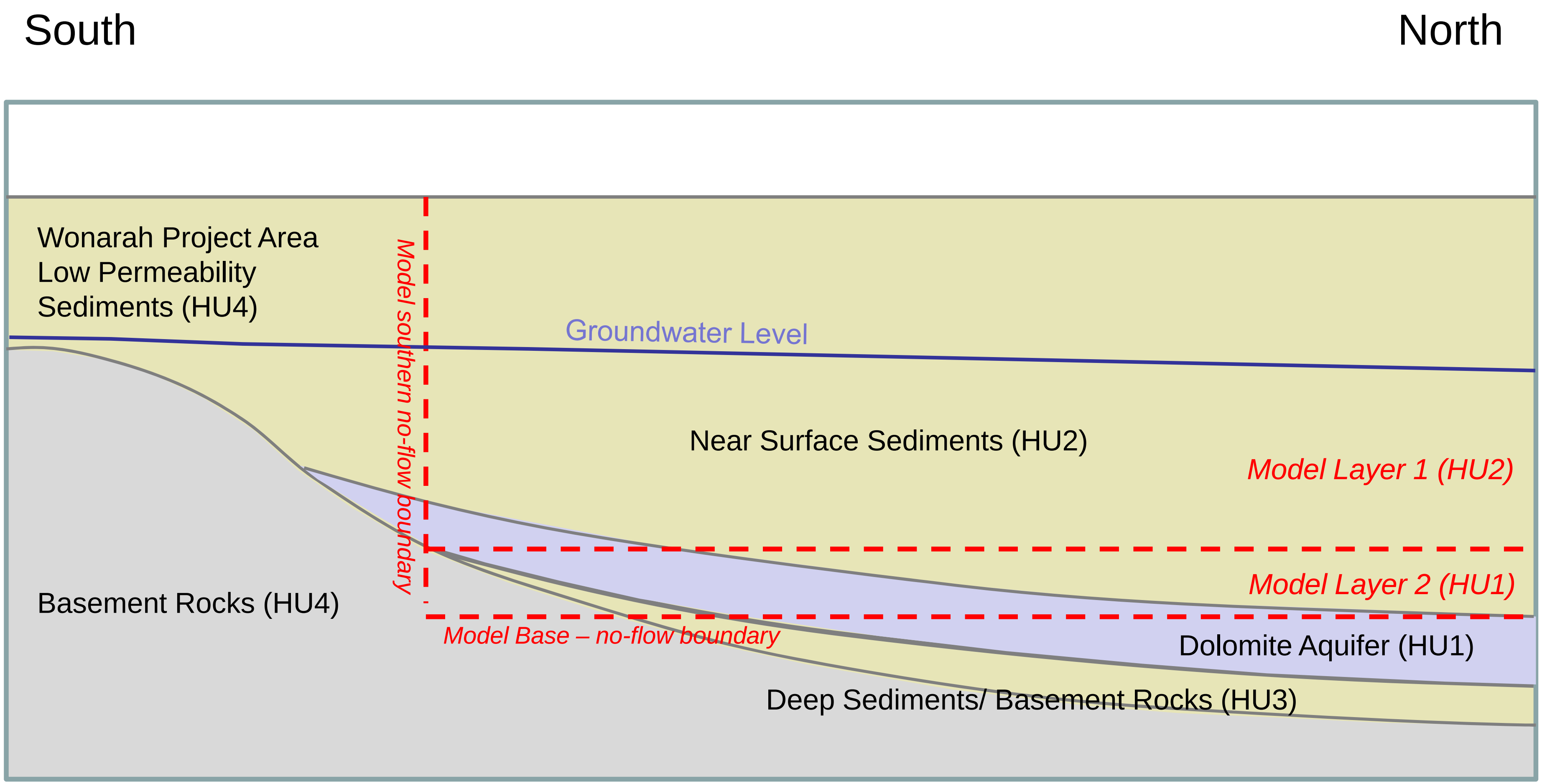
FIGURE 12

PREDICTED DRAWDOWN AFTER 3 MONTHS WNWB002

GROUNDWATER
RESOURCE MANAGEMENT

\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\WNWB02_ExtendedOperation.grf

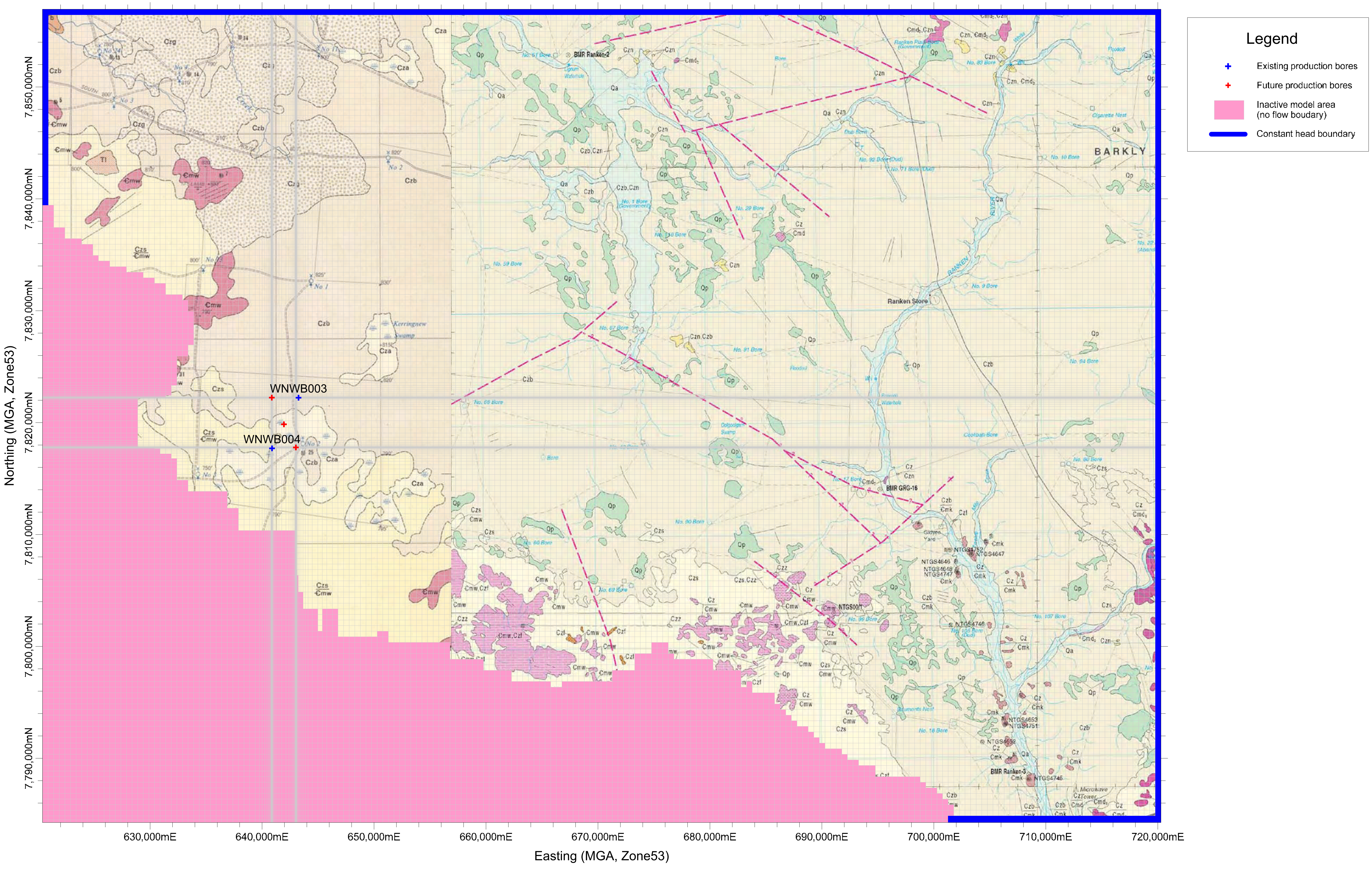




Wonarah BFS (J080028R01)		
Minemakers		
RG	Sep 09	**FIGURE 13**

CONCEPTUAL HYDROGEOLOGICAL MODEL

GROUNDWATER RESOURCE MANAGEMENT

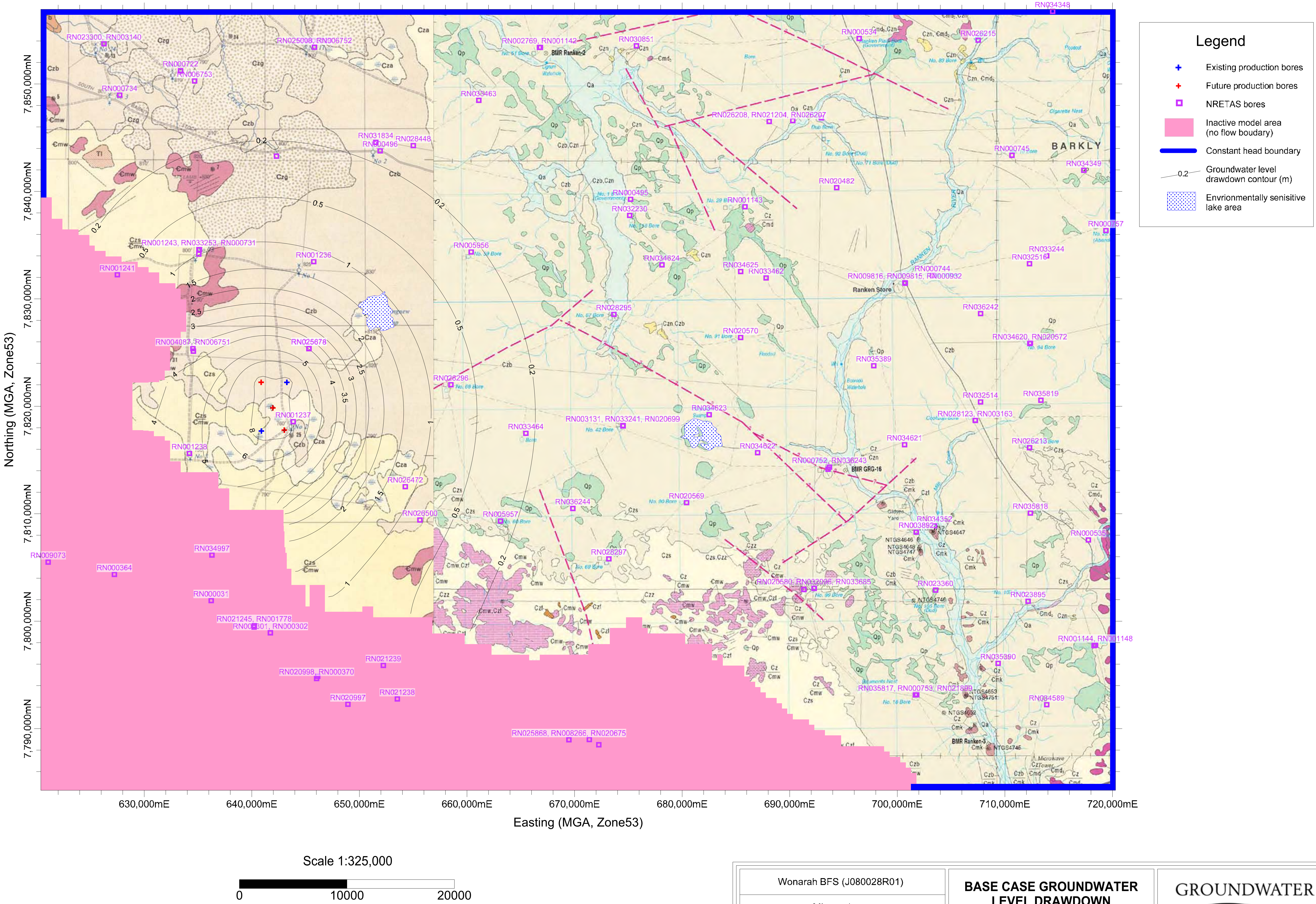


Wonarah BFS (J080028R01)		
Minemakers		
RG	Sep 09	FIGURE 14

NUMERICAL MODEL SET-UP

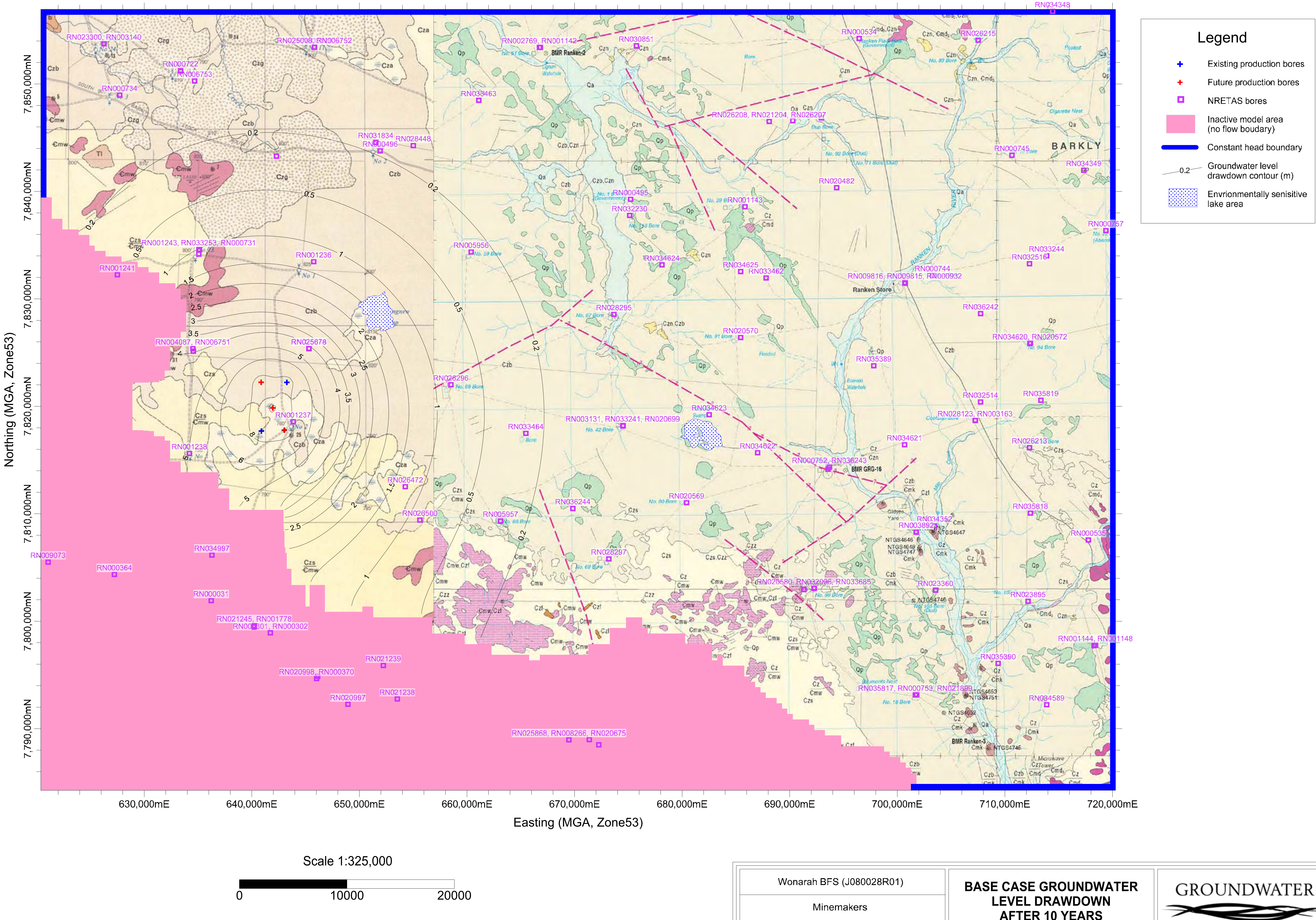
GROUNDWATER RESOURCE MANAGEMENT

J080028/figures/surfer/J080028R01Surfer/ModelGridSetUp.srf



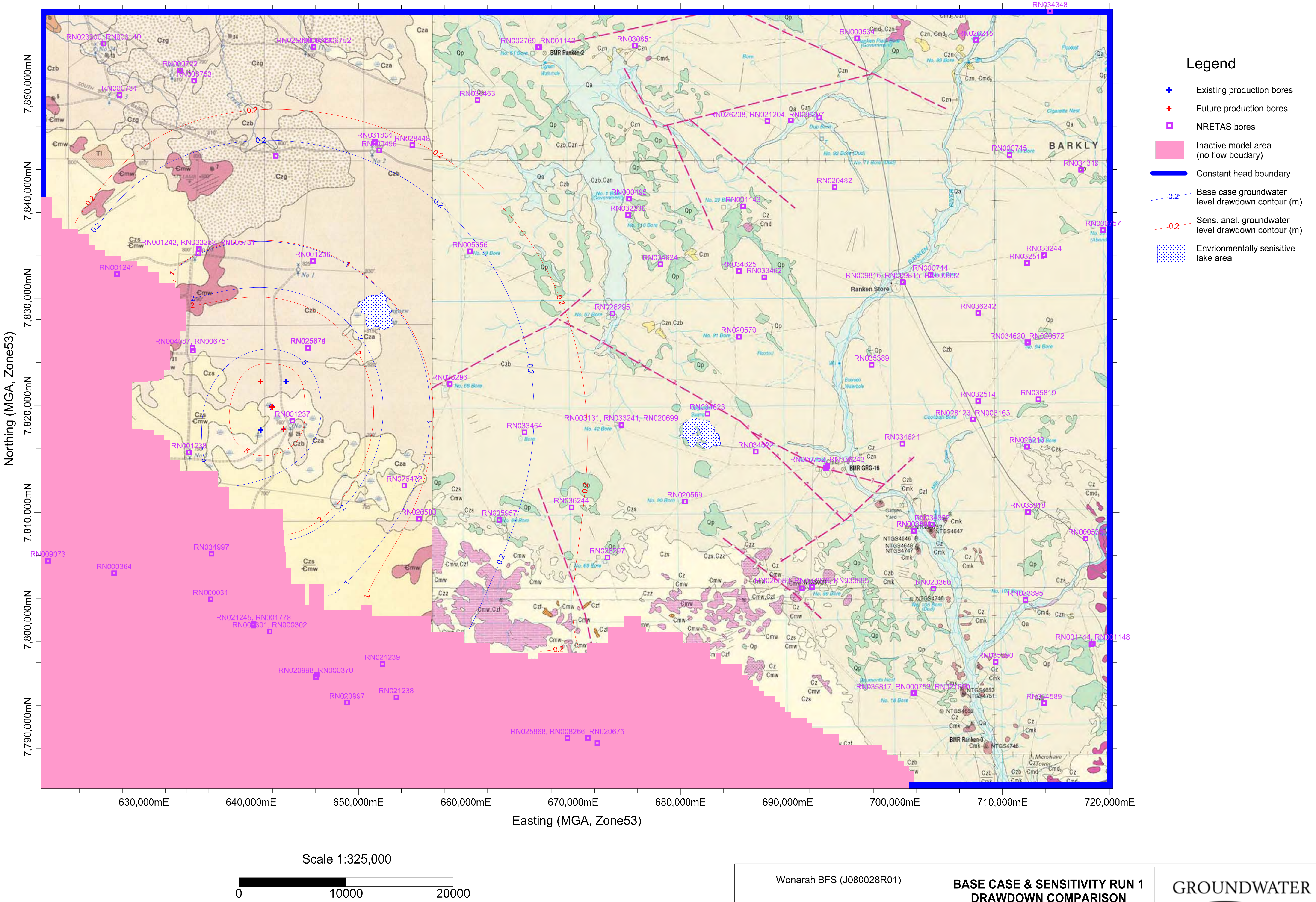
Wonarah BFS (J080028R01)			BASE CASE GROUNDWATER LEVEL DRAWDOWN AFTER 10 YEARS LAYER 1	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 15**		

J080028/figures/surfer/J080028R01Surfer/BaseCaseDrawdownL1.srf



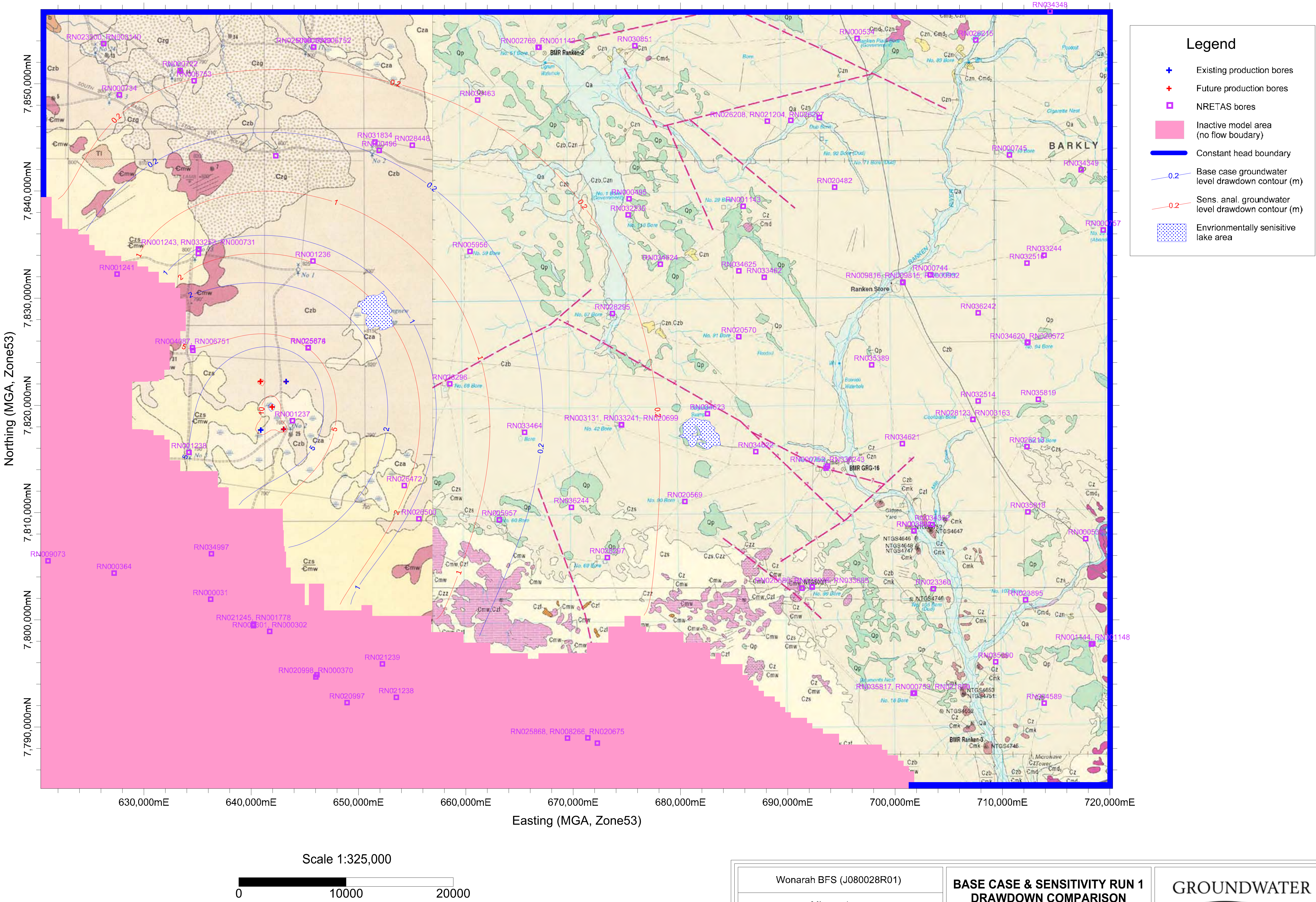
Wonarah BFS (J080028R01)			BASE CASE GROUNDWATER LEVEL DRAWDOWN AFTER 10 YEARS LAYER 2	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	FIGURE 16		

J080028/figures/surfer/J080028R01Surfer/BaseCaseDrawdownL2.srf



Wonarah BFS (J080028R01)			BASE CASE & SENSITIVITY RUN 1 DRAWDOWN COMPARISON AFTER 10 YEARS LAYER 1	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 17**		

J080028/figures/surfer/J080028R01Surfer/SR1DrawdownL1Comparison.srf

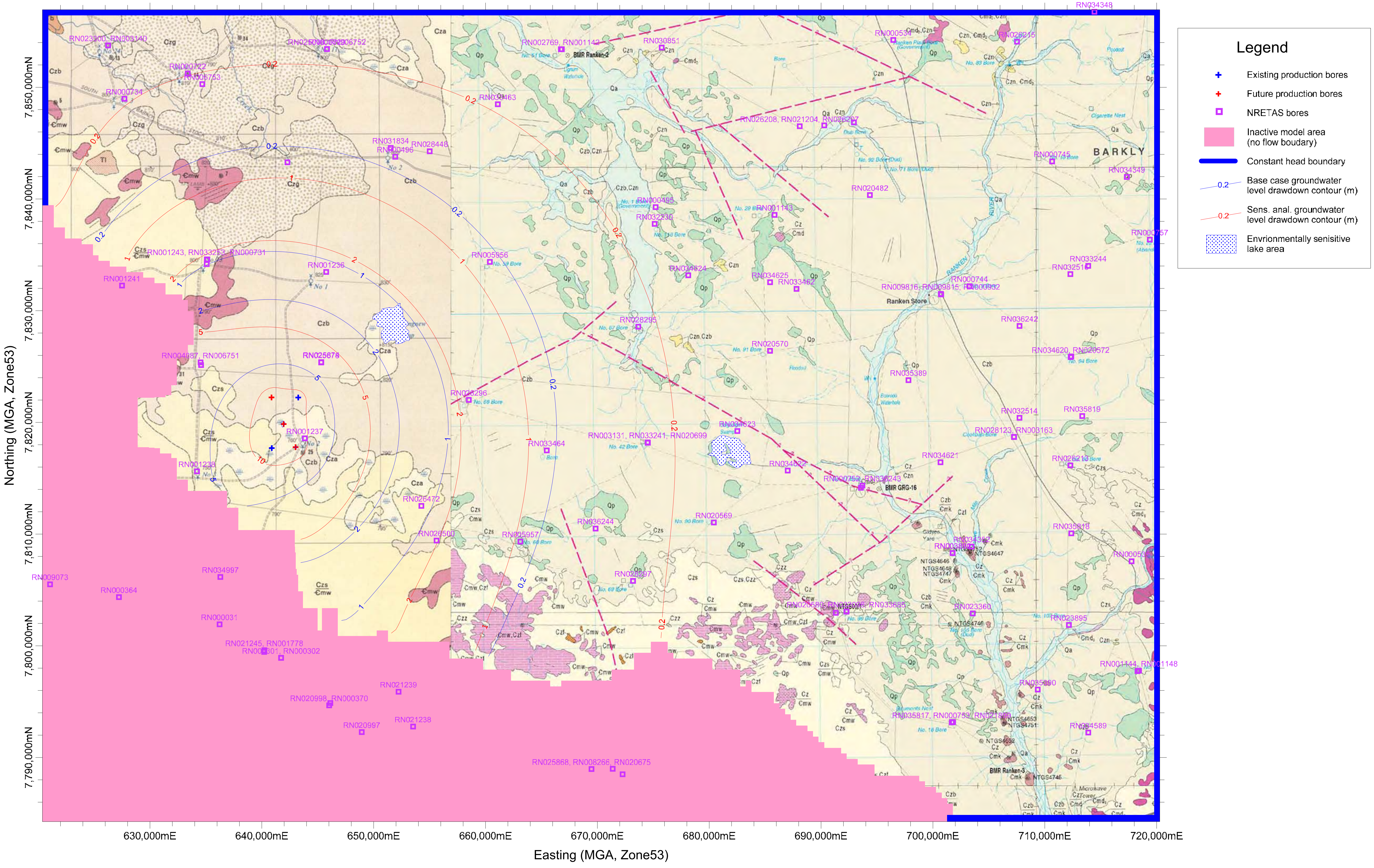


Wonarah BFS (J080028R01)		
Minemakers		
RG	Sep 09	FIGURE 18

BASE CASE & SENSITIVITY RUN 1 DRAWDOWN COMPARISON AFTER 10 YEARS LAYER 2

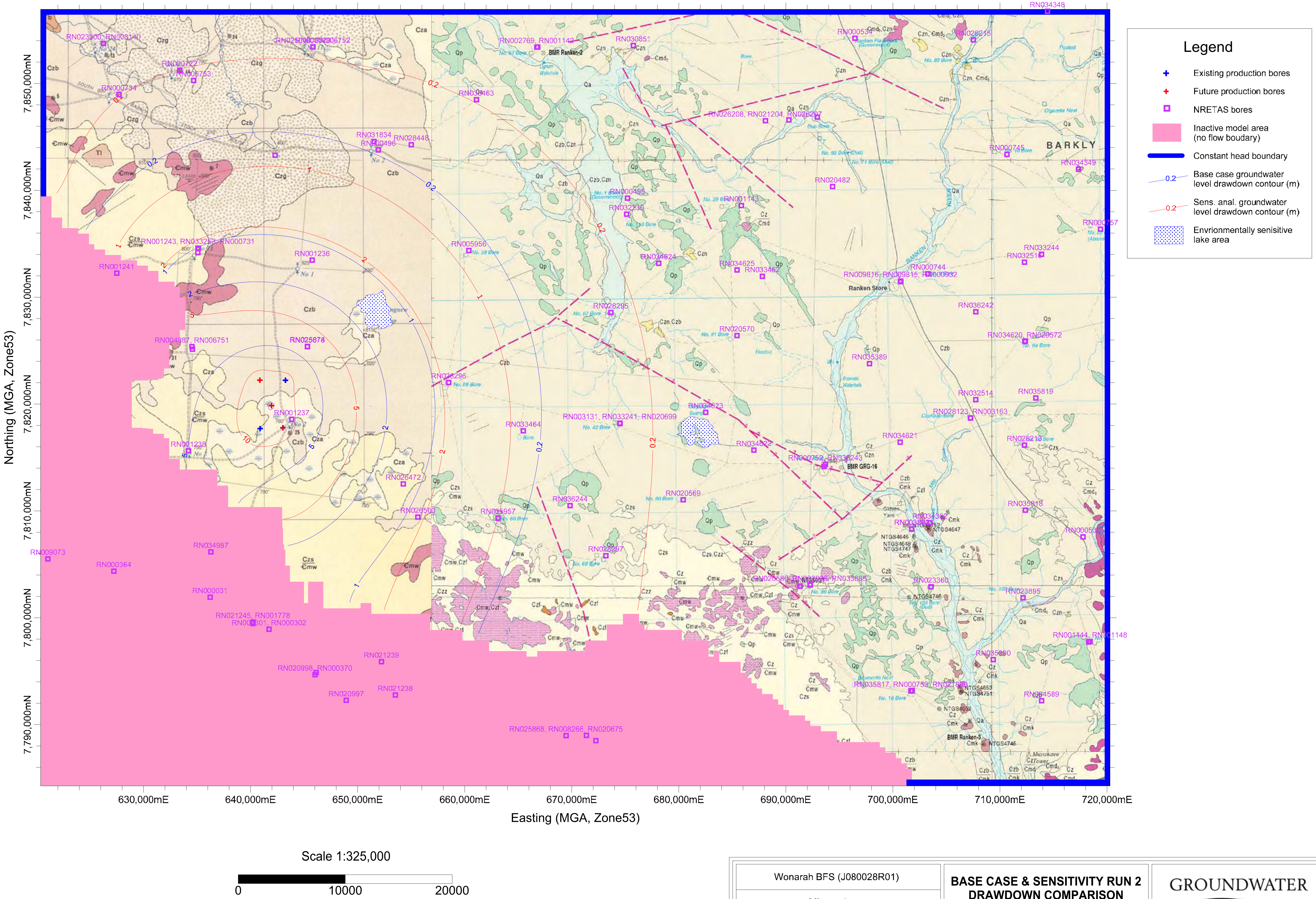
GROUNDWATER RESOURCE MANAGEMENT

J080028/figures/surfer/J080028R01Surfer/SR1DrawdownL2Comparison.srf



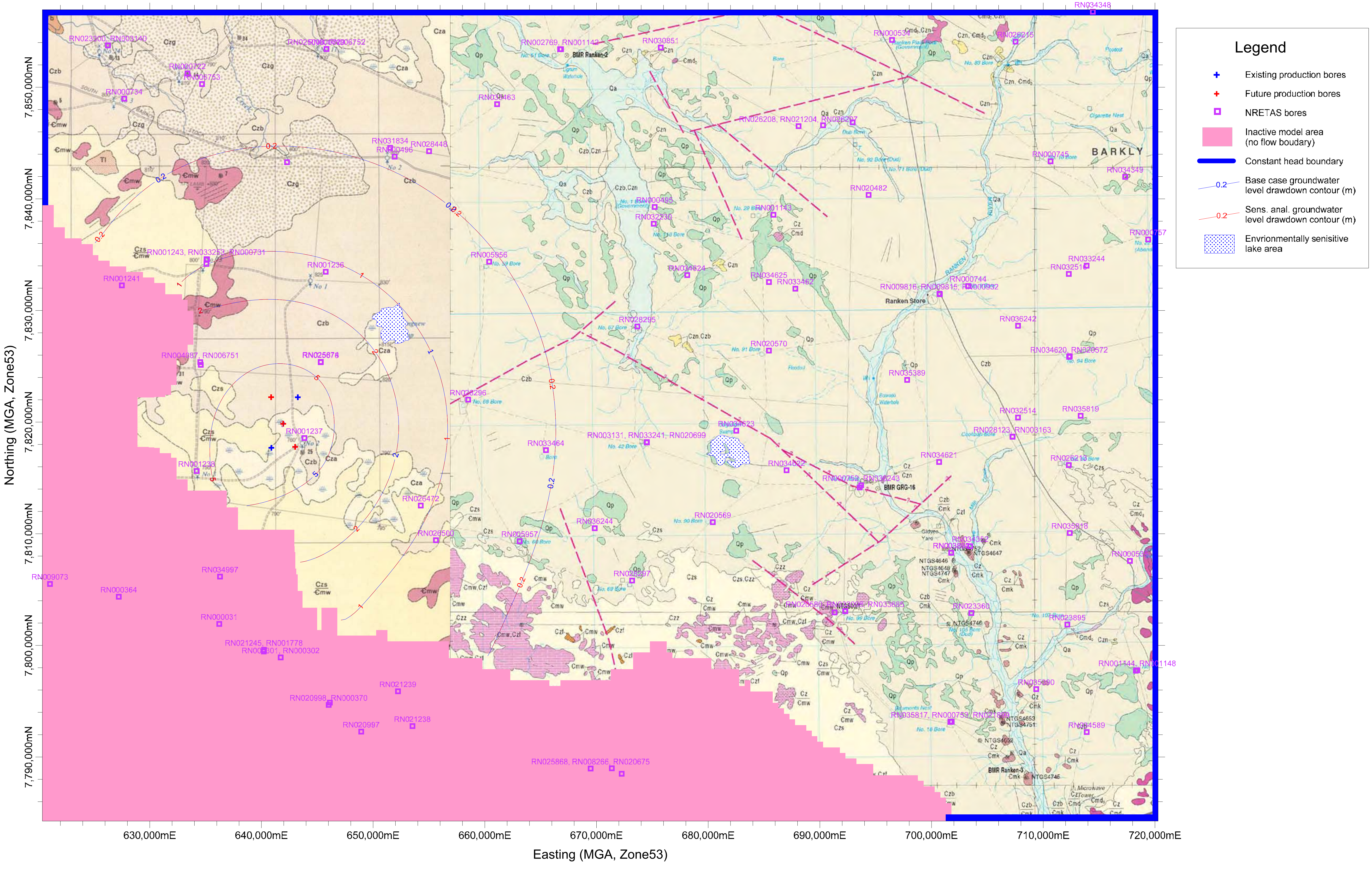
Wonarah BFS (J080028R01)	**BASE CASE & SENSITIVITY RUN 2 DRAWDOWN COMPARISON AFTER 10 YEARS LAYER 1**	GROUNDWATER RESOURCE MANAGEMENT
Minemakers		
RG Sep 09 **FIGURE 19**		

J080028/figures/surfer/J080028R01Surfer/SR2DrawdownL1Comparison.srf



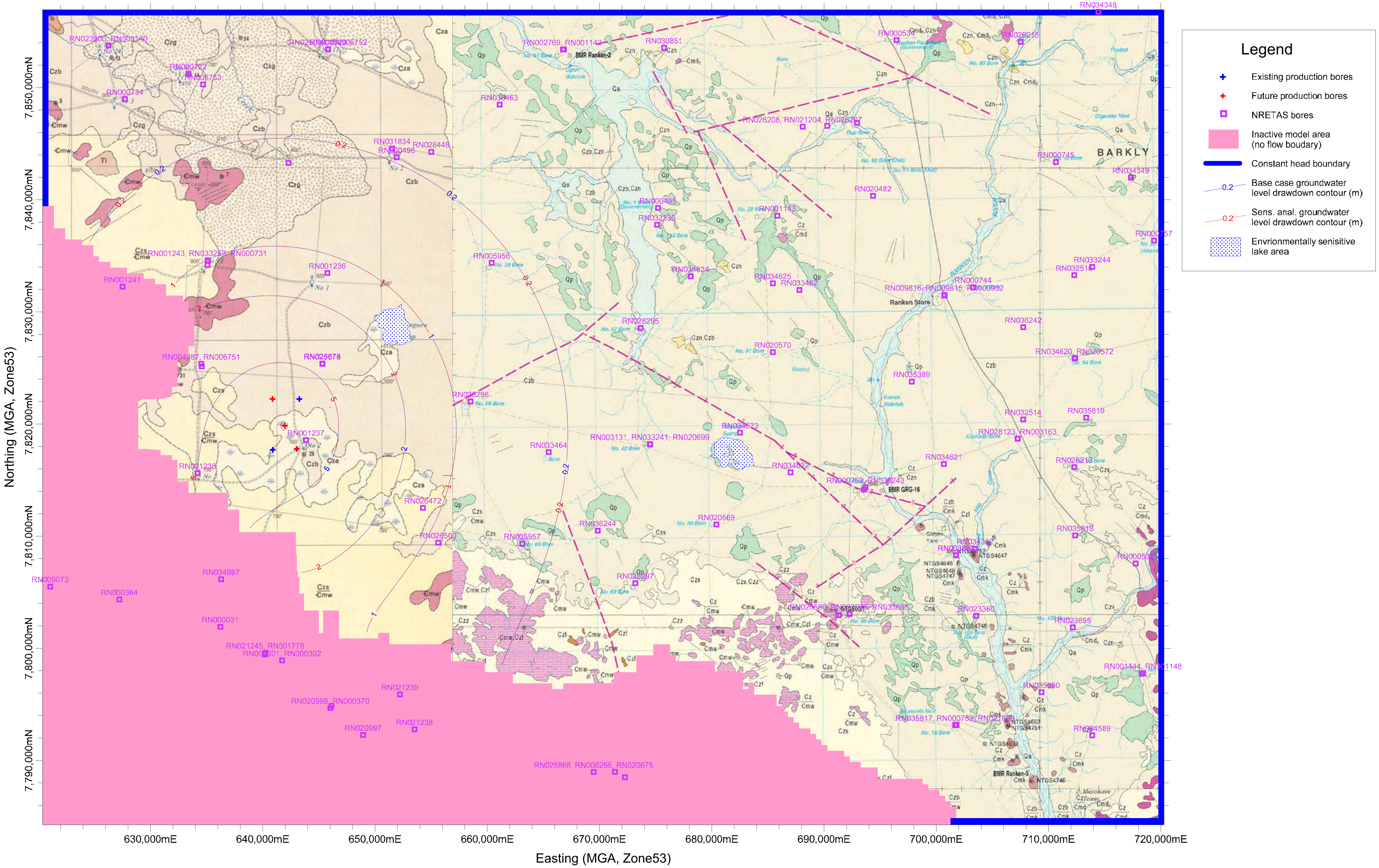
Wonarah BFS (J080028R01)			BASE CASE & SENSITIVITY RUN 2 DRAWDOWN COMPARISON AFTER 10 YEARS LAYER 2	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 20**		

J080028/figures/surfer/J080028R01Surfer/SR2DrawdownL2Comparison.srf



Wonarah BFS (J080028R01)			BASE CASE & SENSITIVITY RUN 3 DRAWDOWN COMPARISON AFTER 10 YEARS LAYER 1	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
RG	Sep 09	**FIGURE 21**		

J080028/figures/surfer/J080028R01Surfer/SR3DrawdownL1Comparison.srf

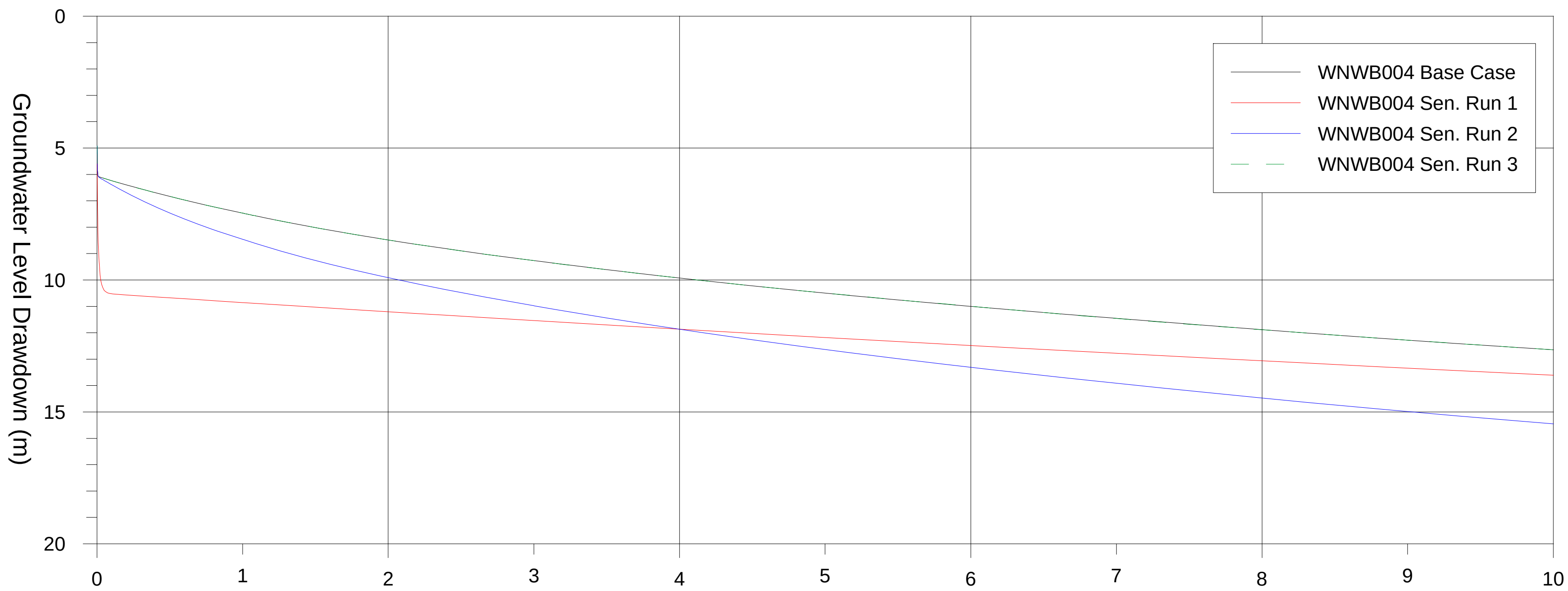


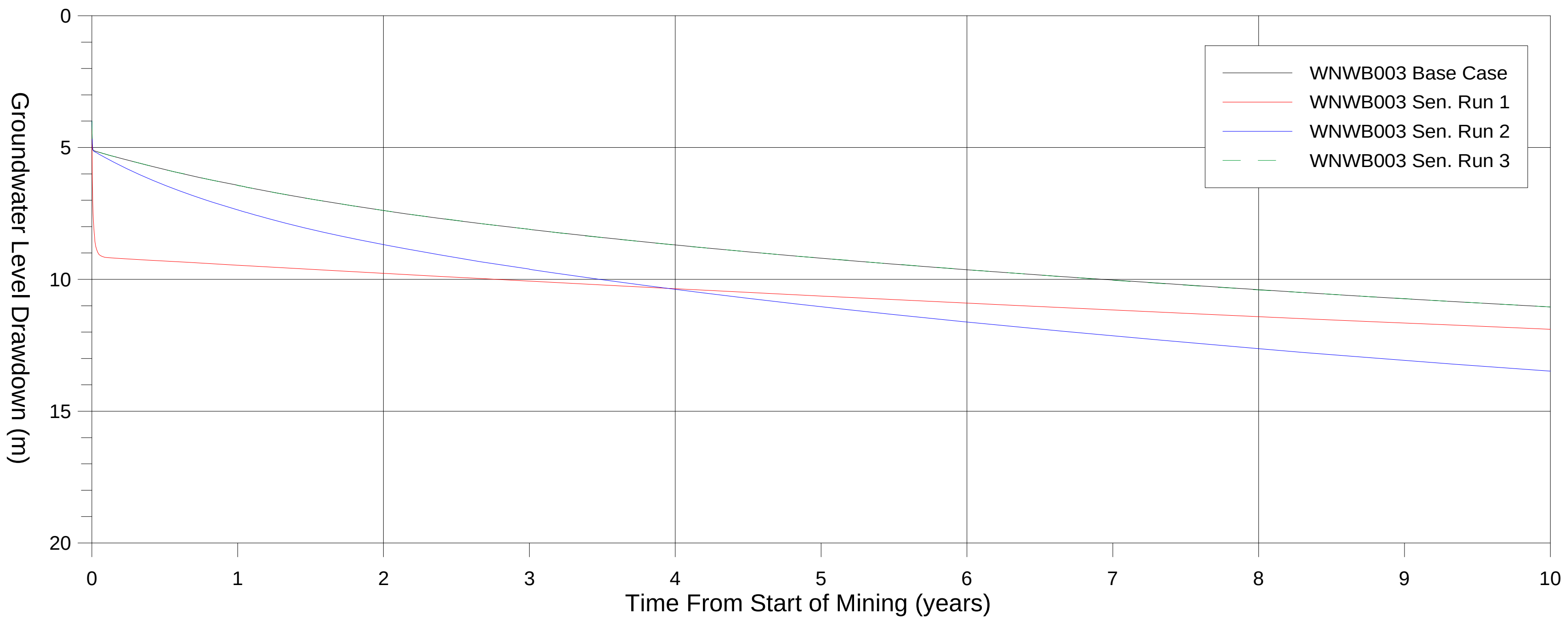
Scale 1:325,000

0 10000 20000

Wonarah BFS (J080028R01)	BASE CASE & SENSITIVITY RUN 3 DRAWDOWN COMPARISON AFTER 10 YEARS LAYER 2	GROUNDWATER RESOURCE MANAGEMENT
Minemakers		
RG · Sep 09 · **FIGURE 22**		

J080028/figures/surfer/J080028R01Surfer/SR3DrawdownL2Comparison.srf





Wonarah BFS (J090028R01)

Minemakers

RG

Sep 09

FIGURE 23

PREDICTED GROUNDWATER DRAWDOWNS BORES WNWB003 &004

GROUNDWATER

RESOURCE MANAGEMENT

\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\ModelHydrograph1.grf

Wonarah BFS (J090028R01)

Minemakers

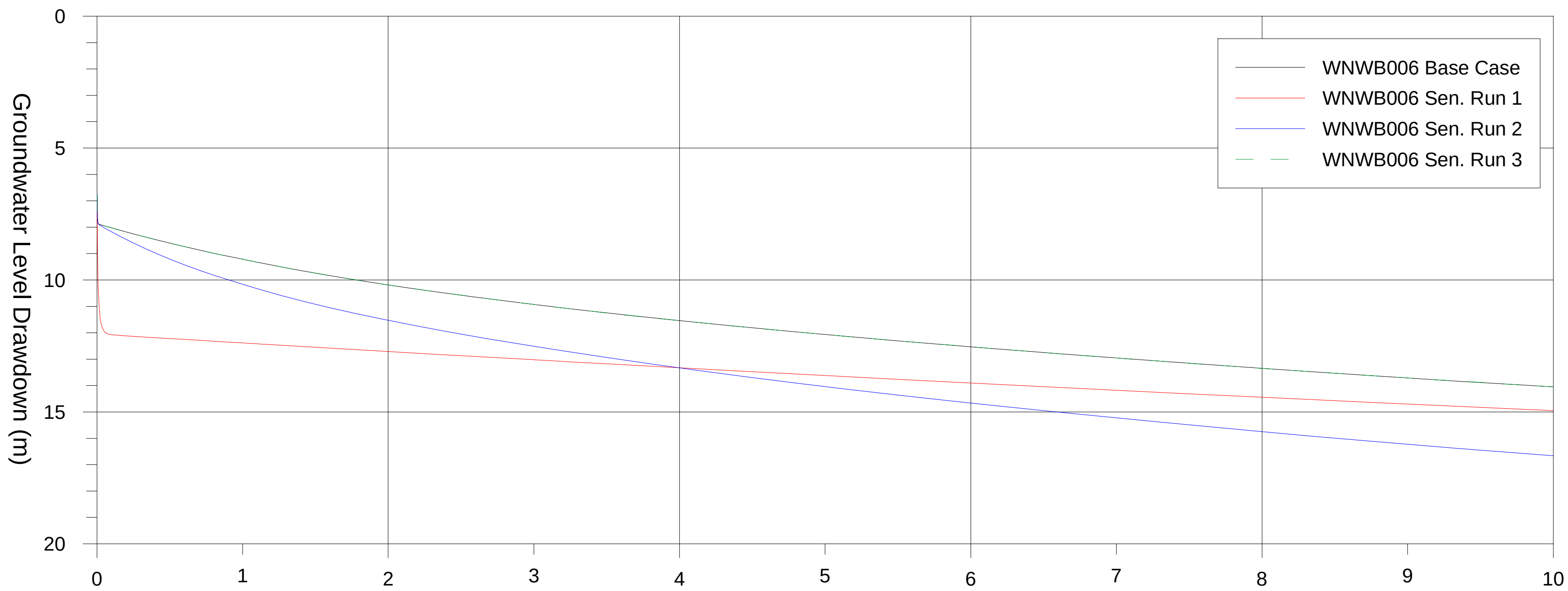
RG

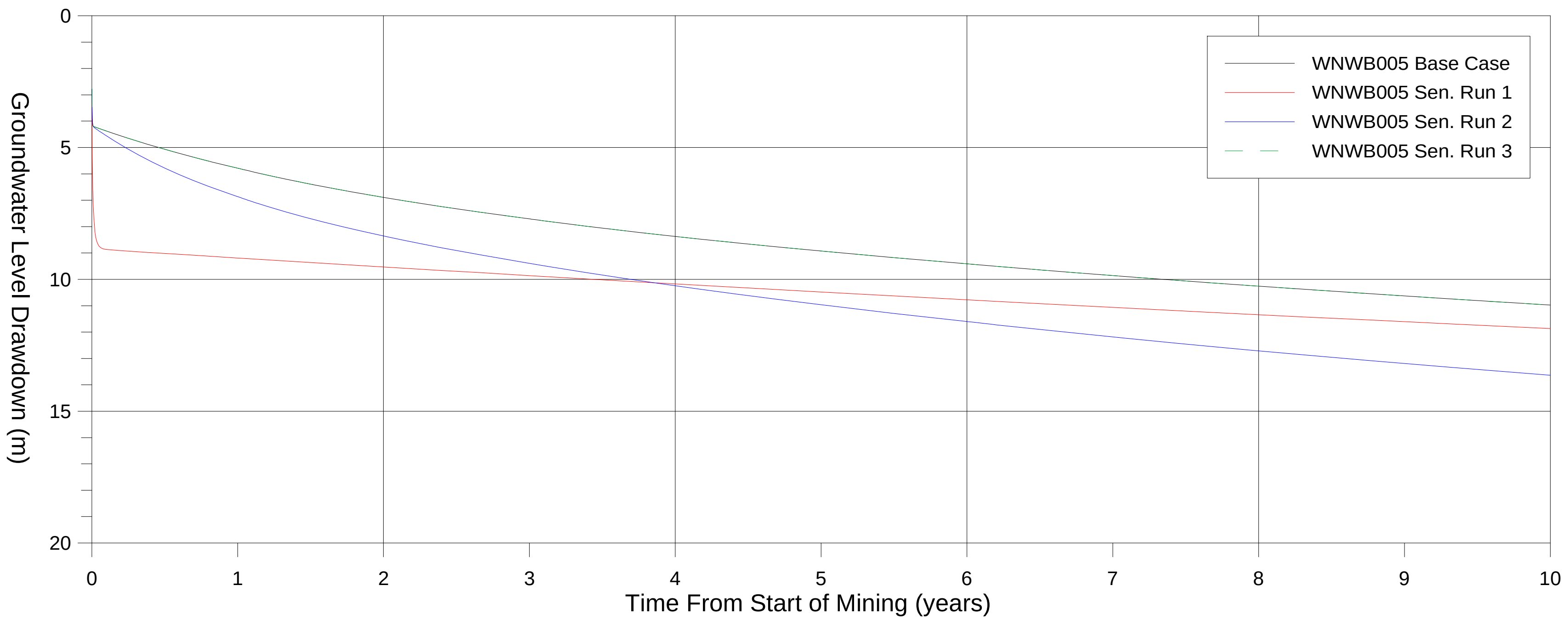
Sep 09

FIGURE 24

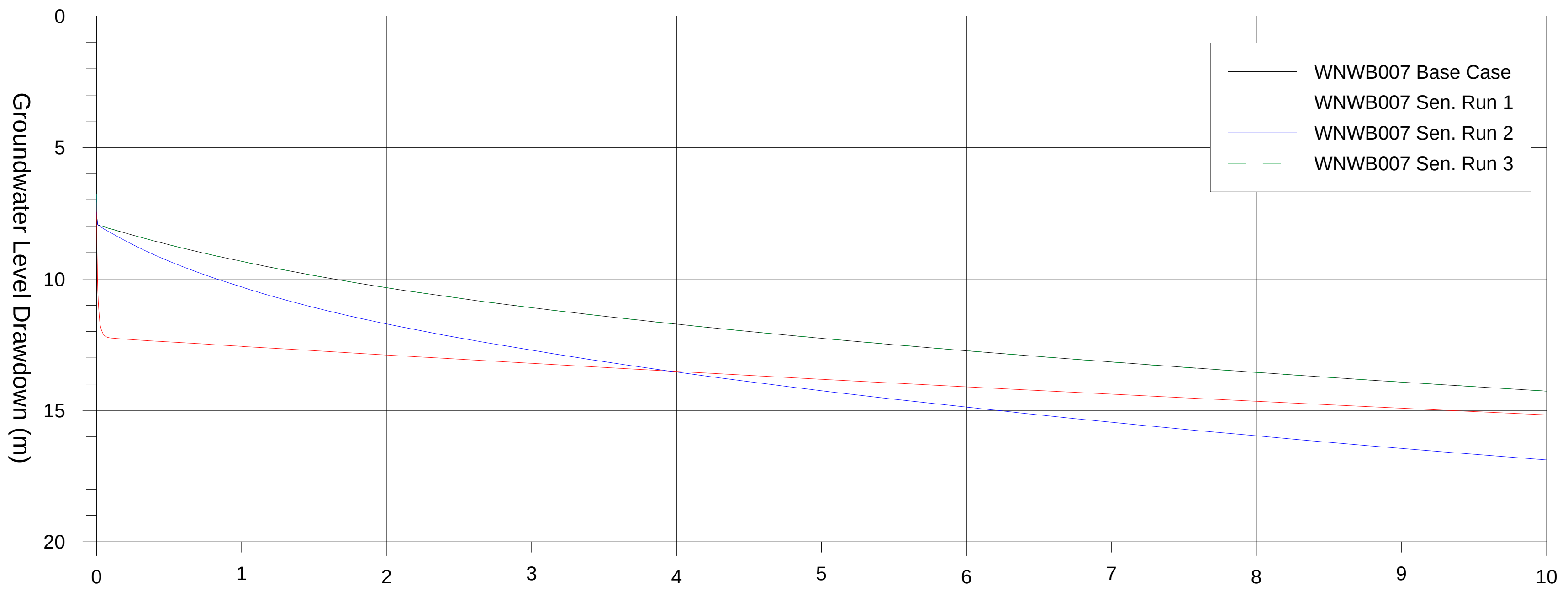
PREDICTED GROUNDWATER DRAWDOWNS BORES WNWB005 &006

GROUNDWATER RESOURCE MANAGEMENT





\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\ModelHydrograph2.grf



Wonarah BFS (J090028R01)

Minemakers

RG

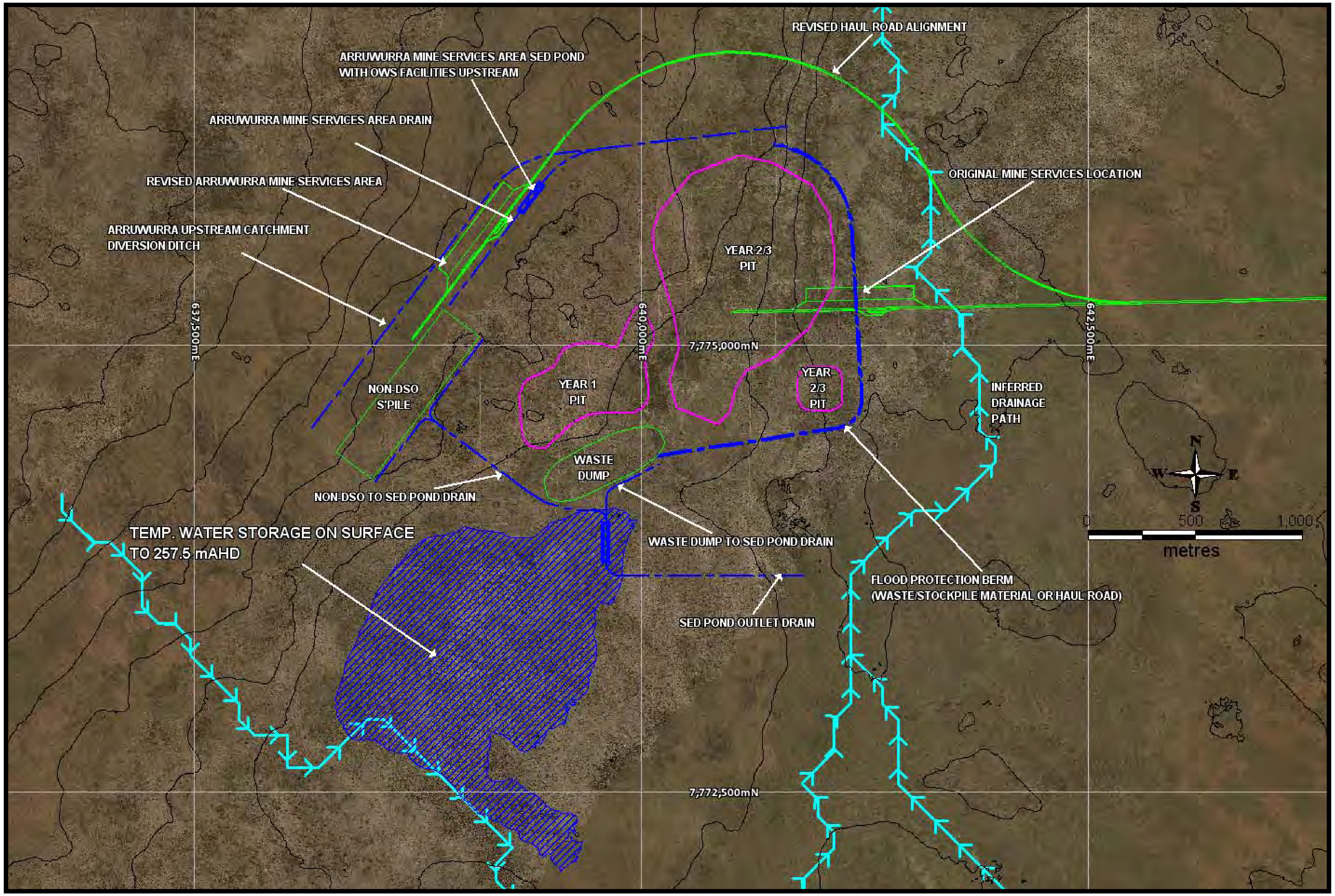
Sep 09

FIGURE 25

PREDICTED GROUNDWATER DRAWDOWNS BORE WNWB007

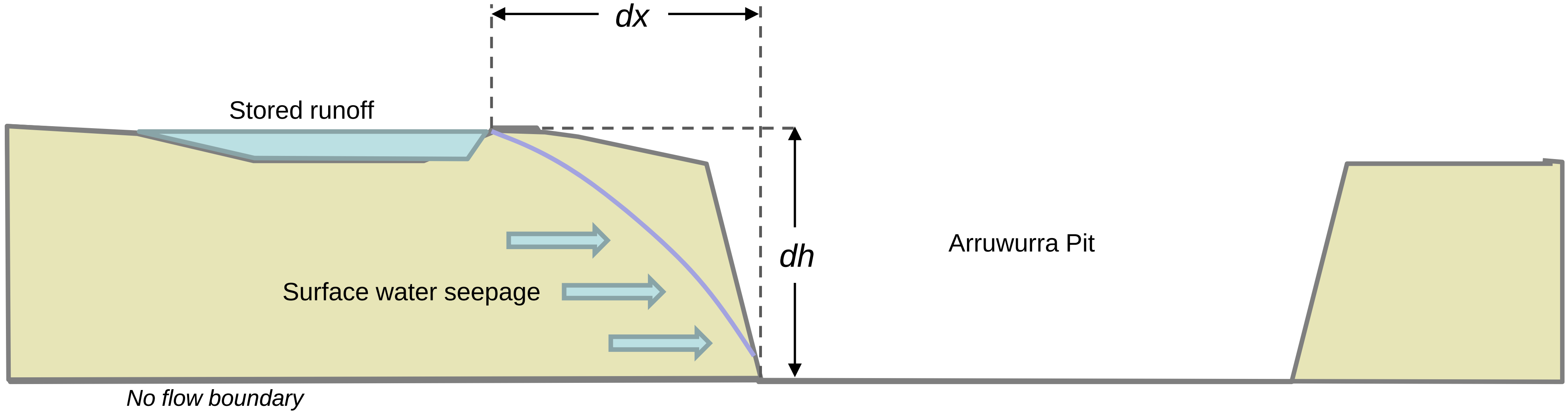
GROUNDWATER RESOURCE MANAGEMENT

\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\grapher\ModelHydrograph3.grf



Notes:
1. Base Mapping provided by Minemakers Australia (GDA'94 Zone 53).
2. Drawing not to scale (2.5 km grid shown).
3. Contour interval is 2.5 m.

Wonarah BFS (J080028R01)			ARRUWURRA FLOOD PROTECTION AND IMPOUNDED AREA	GROUNDWATER RESOURCE MANAGEMENT
Minemakers				
ARL	Oct 09	**FIGURE 26**		



Wonarah BFS (J080028R01)		
Minemakers		
RG	Sep 09	**FIGURE 27**

CONCEPTUAL SEEPAGE MODEL ARRUWURRA PIT

GROUNDWATER
RESOURCE MANAGEMENT

FILE:\\Toaster\grm\Jobs2008\J080028_Wonarah\figures\powerpoint\ConceptualArruwurraSeepageModel.ppt

APPENDIX A

Ministerial Approval to Drill and Construct Production Bores

Minerals and Energy Titles Division
Postal address GPO Box 3000
Darwin NT 0801
Tel 08 8999 5322
Fax 08 8981 7106
titles.info@nt.gov.au

Our file ref ML
Your file ref 09.061

Minemakers Australia Pty Ltd
c/- McColl Exploration & Mining Title Services Pty Ltd
PO Box 2545
PALMERSTON NT 0831

Dear Sir/Madam

I refer to your application dated 9th July 2009 for the Minister's approval pursuant to section 182 of the *Mining Act,* to enter upon;

a) Mining tenement area; and
b) Crown land, for the purpose of sinking five (5) water bores.

I am pleased to advise that pursuant to the powers delegated to me, I authorise entry onto the land as specified in the enclosed Authorisation instrument under section 182(2) of the *Mining Act.*

The Authorisation is granted subject to the *Mining Act*, the Regulations thereunder, the *Mining Management Act* and all other laws of the Northern Territory as applicable.

In considering your application I have taken into account your advice you are consulting with the pastoral landholders in respect of proposed water usage and access.

I also considered an objection by FSL World Holdings Pty Ltd, the details of which you have previously been provided with. While I am satisfied "Minemakers" have made a reasonable attempt to find water of the quantities required within the application for Mineral Lease 27244, I am advised by the Department of Natural Resources, Environment, The Arts and Sport (NRETAS) Water Resources Division that it would be beneficial to construct a number of test bores within the application area and to pump test these bores.

I request you seriously consider this advice.

It would be appreciated if the Department and NRETAS, Water Resources Division receive a copy of the results from the water exploration carried out both on the (5) five bores and within the mineral lease application area.

Yours sincerely

JP WHITFIELD
Principal Registrar
As Delegate of the Minister Primary Industry,
Fisheries and Resources

13 August 2009

NORTHERN TERRITORY OF AUSTRALIA

Mining Act

AUTHORISATION UNDER SECTION 182

I, JEREMY PAUL WHITFIELD, Principal Registrar, as Delegate of the Minister for Primary Industry, Fisheries and Resources pursuant to section 18(2) of the *Mining Act*, authorise Minemakers Australia Pty Ltd its servants and agents, to enter upon a mining tenement area, specifically Exploration Licences 26054 and 26055 in the Barkly Shire locality, held by FSL World Holdings Pty Ltd, and to enter upon Pastoral Lease Land, specifically NT Portion 773 in the Dalmore Downs locality, held by Baldy Bay Pty Ltd as Trustee for the Long Yard Trust and to enter upon Pastoral Lease Land, specifically NT Portion 2 in the Ranken locality, held by The North Australian Pastoral Company Pty Limited for the purpose of sinking five (5) water bores.

Dated 13 August 2009

....

Principal Registrar

APPENDIX B

Graphical Drill and Bore Logs
(Presented digitally on enclosed CD ROM)

APPENDIX C

Test Pumping Analyses
(Presented digitally on enclosed CD ROM)

APPENDIX D

Groundwater Risk Register

RISK REGISTER REV 1.0 (GROUNDWATER ASPECTS)

WONARAH PHOSPHATE FEASIBILITY STUDY REPORT													
PRIMARY RISK ANALYSIS										RESIDUAL RISK ANALYSIS			
Risk No.	Initiator	Primary Risk Description	Likelihood	Consequence	Risk Rank	Causes	Impact of Risk (if it occurs)	Existing and/or Proposed Control Strategies	Responsible for Control Strategy	Control Effectiveness (Good/Fair/Weak)	Likelihood	Consequence	Residual Rank
6.0		**Hydrology**											
6.1	RG	Groundwater supply failure	2	3	M	Acquifer not able to supply long term. Over-extraction of bores.	No dust suppression available	Borefield monitoring Install additional bores	MAK	Good	1	3	M
6.2	RG	Unacceptable reduction in groundwater supply quality	2	2	L	Lack of understanding of aquifer. Over-extraction of bores	Local leaseholders lose supply additional bores and pumping required	Borefield monitoring Install additional bores	MAK	Good	1	2	L
6.5	RG	Pit dewatering from groundwater	1	1	L	Water table rises due to flooding event	Production stops until pits pumped out	Install pumping system to cope with identified flood levels. Maintain adequate stockpiles	MAK/AMC	Good	1	2	L
6.6	RG	Pit dewatering infiltrating rainfall	3	1	L	Water flows into pit from ponded surface water outside pit	Production stops until pits pumped out	Install pumping system to cope with identified flood levels. Maintain adequate stockpiles	MAK/AMC	Good	1	2	L
6.7	RG	Unacceptable impacts upon the environment from groundwater production	1	3	M	Extraction of water or use of water causes environmental changes	Local leaseholders lose supply additional bores and pumping required	Borefield monitoring Install additional bores	MAK	Good	1	3	M
6.8	RG	Unacceptable impacts upon third parties from groundwater production	2	1	L	Lack of understanding of aquifer. Over-extraction of bores	Local leaseholders lose supply additional bores and pumping required	Borefield monitoring Install additional bores	MAK	Good	1	1	L

APPENDIX E

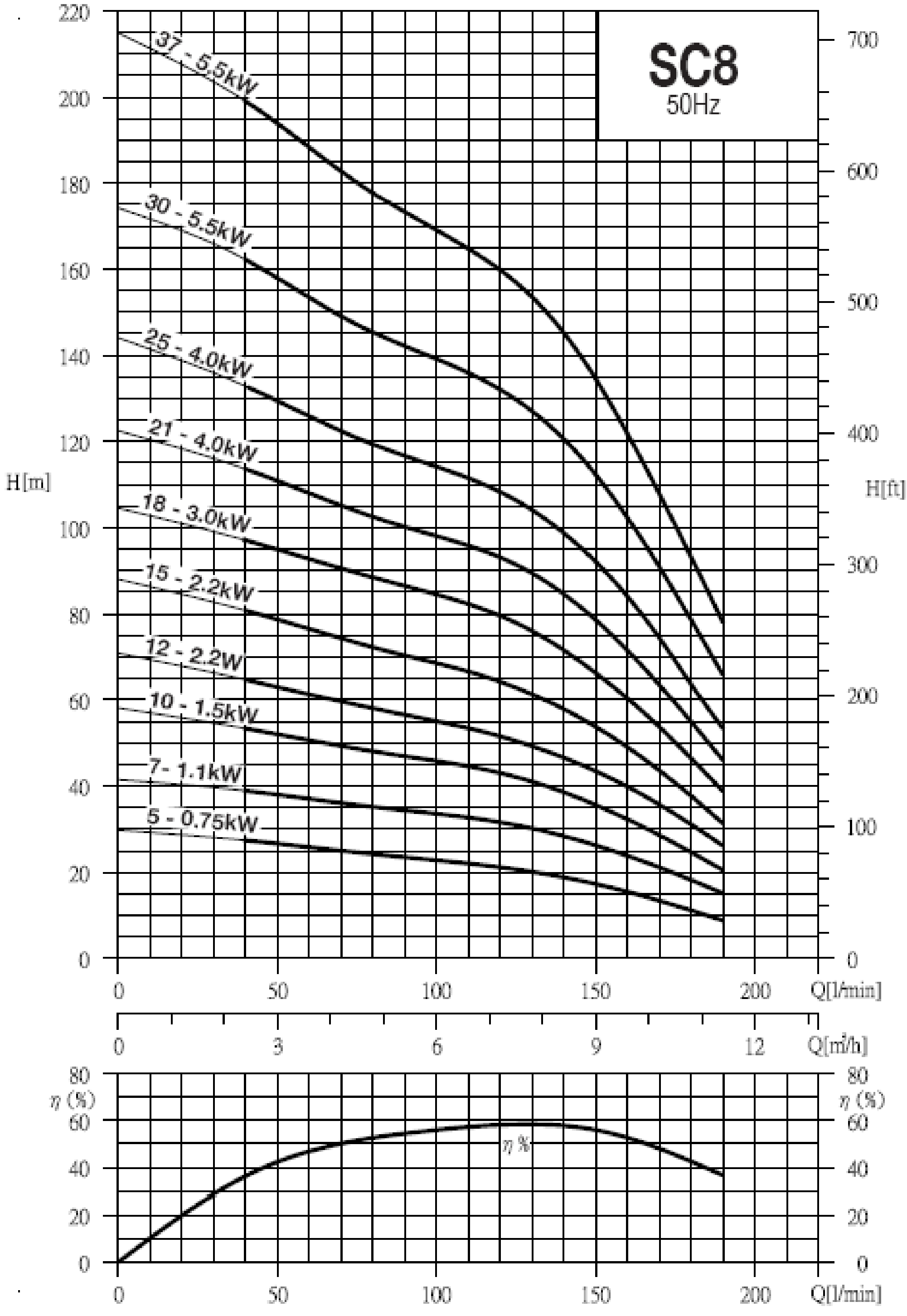
Bore Pump Performance Data

Southern Cross

"SC" Series
4 inch (100mm)
Submersible Borehole Pumps

MODEL
SC8

PERFORMANCE DATA



July 2006

MODEL
SC8

"SC" Series
4 inch (100mm)
Submersible Borehole Pumps

Southern Cross

TECHNICAL DATA

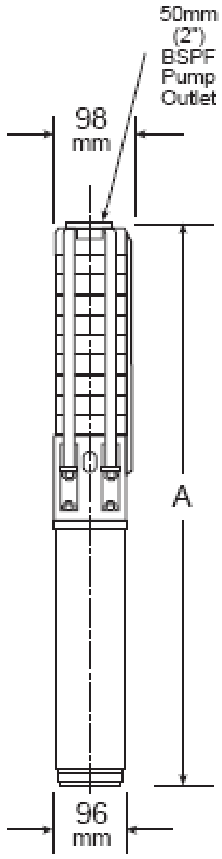
DIMENSIONS & WEIGHTS

Single Phase Units

MODEL	No. of Stages	Motor kW	2 Wire Single Phase Length A mm	2 Wire Single Phase Unit Weight kg	3 Wire Single Phase Length A mm	3 Wire Single Phase Unit Weight kg
With Single Phase *FRANKLIN* Motors						
SC8-05	5	0.75	710	15.2	710	15.2
SC0-07	7	1.10	000	19.4	041	21
SC8-10	10	1.50	–	–	1006	21.8
SC8-12	12	2.20	–	–	1190	26.4
SC8-15	15	2.20		–	1316	27.9
SC8-18	18	3.7	–	–	1674	42.6
With Single Phase *COVERCO* Motors						
SC8-05	5	0.75	–	–	862	15
SC8-07	7	1.10	–	–	986	17.7
SC8-10	10	1.50	–	–	1182	21.4
SC8-12	12	2.20	–	–	1306	26.2
SC8-15	15	2.20	–	–	1432	27.7
SC8-18	18	3.7	–	–	1703	35.8

Three Phase Units

MODEL	No. of Stages	Motor kW	3 Phase *FRANKLIN* Length A mm	3 Phase *FRANKLIN* Unit Weight kg	3 Phase *COVERCO* Length A mm	3 Phase *COVERCO* Unit Weight kg
SC8-05	5	0.75	710	15.2	832	13.7
SC8-07	7	1.10	794	16.2	946	16
SC8-10	10	1.50	967	19.5	1112	19.2
SC8-12	12	2.20	1113	23.7	1266	22.4
SC8-15	15	2.20	1239	25.2	1392	23.9
SC8-18	18	3.0	1522	35.8	1518	26.9
SC8-21	21	4	1711	40	1744	33.7
SC8-25	25	4	1879	42	1912	35.7
SC8-30	30	5.5	2178	48.6	2207	41.8
SC8-37	37	5.5	2468	62.1	2498	45.3



ELECTRICAL DATA

Motor kW	(1Ph) Single Phase Motor Type	(1Ph) Single Phase Full Load Amps	(1Ph) Single Phase Lock Rotor Amps	(1Ph) Single Phase Control Box	(3Ph) Three Phase Full Load Amps	(3Ph) Three Phase Lock Rotor Amps
			FRANKLIN Motors			
0.37	2 wire	4.1	26	Not reqd.	1.1	4.3
0.55	2 wire	6.5	37	Not reqd.	1.5	6.2
0.75	2 wire	7.6	44	Not reqd.	2	8.5
1.1	2 wire	10.8	53	Not reqd.	3	14
0.75	3 wire	7.0	27	Franklin	–	–
1.1	3 wire	8.9	37	Franklin	–	–
1.5	3 wire	10.7	51	Franklin	4	21
2.2	PSC 3 wire	15.9	82	Franklin	6	27
3	—	—	—	—	7.3	42
3.7	3 wire	23.4	109	Franklin	9	46
4	–	–	–	–	10.4	59
5.5	–	–	–	–	13	70
7.5	–	–	–	–	18.7	99

ELECTRICAL DATA

Motor kW	(1Ph) Single Phase Motor Type	(1Ph) Single Phase Full Load Amps	(1Ph) Single Phase Lock Rotor Amps	(1Ph) Single Phase Control Box	(3Ph) Three Phase Full Load Amps	(3Ph) Three Phase Lock Rotor Amps
			COVERCO Motors			
0.37	3 wire	3.4	11.2	Coverco	1.2	5.6
0.55	3 wire	4.4	14	Coverco	1.8	8
0.75	3 wire	5.6	19	Coverco	2.1	11
1.1	3 wire	8.1	26	Coverco	3	16
1.5	3 wire	10.1	34	Coverco	4.5	24
2.2	3 wire	14.1	44	Coverco	6	32
3.0	—	—	—	—	7.7	37
3.7	3 wire	23.4	77	Coverco	—	—
4	—	—	—	—	10.3	48
5.5	—	—	—	—	13.1	64
7.5	—	—	—	—	18.7	99

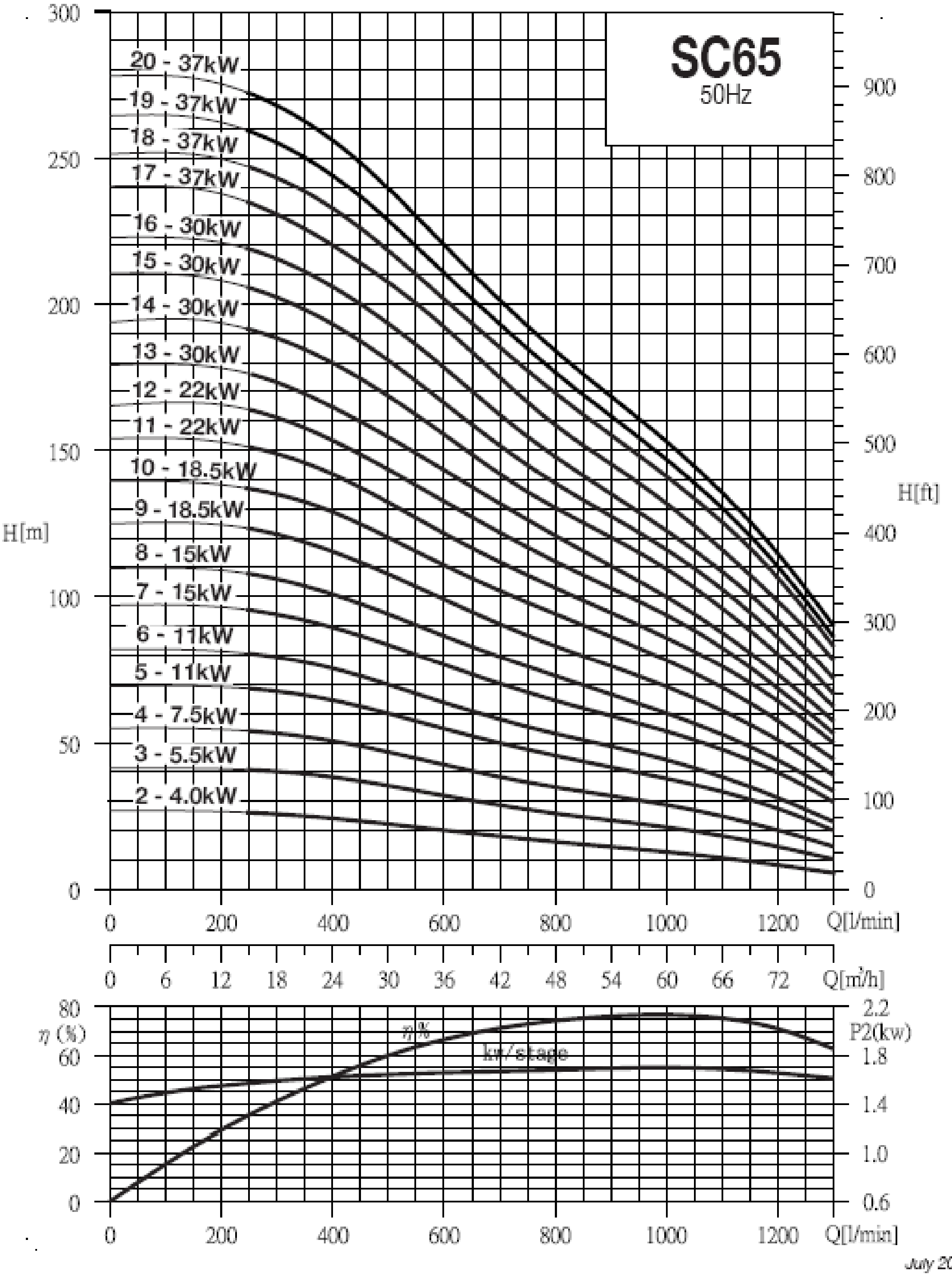
July 2006

Southern Cross

"SC" Series
6 inch (150mm)
Submersible Borehole Pumps

MODEL
SC65

PERFORMANCE DATA



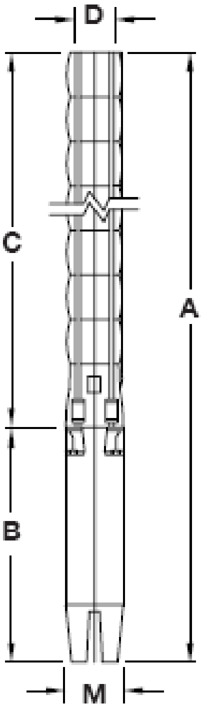
July 2006

MODEL
SC65

"SC" Series
6 inch (150mm)
Submersible Borehole Pumps

Southern Cross

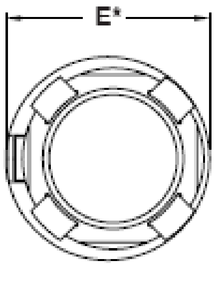
TECHNICAL DATA

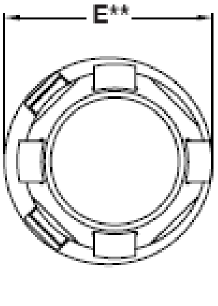


SC65 DIMENSIONS & WEIGHTS

MODEL	NO. OF STAGES	MOTOR kW	MOTOR DIAM	DIMENSIONS (mm) A	B	C	D	E*	E**	M	MASS (kg) PUMP	MASS (kg) MOTOR
SC65-02	2	4.0	4"	1059	563	496		146		96	9.2	25
SC65-03	3	5.5	4"	1324	715	609		146		96	11.5	48
SC65-04	4	7.5	6"	1368	646	722		149	152	138	13.7	52
SC65-05	5	11	6"	1546	711	835		149	152	138	16	58
SC65-06	6	11	6"	1659	711	948		149	152	138	18.3	58
SC65-07	7	15	6"	1837	776	1061		149	152	138	20.6	64
SC65-08	8	15	6"	1950	776	1174		149	152	138	22.9	64
SC65-09	9	18.5	6"	2128	841	1287		149	152	138	25.1	70
SC65-10	10	18.5	6"	2241	841	1400	4" BSPF	149	152	138	27.4	70
SC65-11	11	22	6"	2419	906	1513		149	152	138	29.7	76
SC65-12	12	22	6"	2532	906	1626		149	152	138	32	76
SC65-13	13	30	6"	2775	1036	1739		149	152	138	34.3	92
SC65-14	14	30	6"	2888	1036	1852		149	152	138	36.5	92
SC65-15	15	30	6"	3001	1036	1965		149	152	138	38.8	92
SC65-16	16	30	6"	3114	1036	2078		149	152	138	41.1	92
SC65-17	17	37	6"	3596	1405	2191		149	152	138	43.4	136
SC65-18	18	37	6"	3709	1405	2304		149	152	138	45.7	136
SC65-19	19	37	6"	3822	1405	2417		149	152	138	48	136
SC65-20	20	37	6"	3935	1405	2530		149	152	138	50.2	136

E: Maximum diameter of pump with single motor cable.*
*E**: Maximum diameter of pump with two motor cables.*
Motor dimensions are for standard Franklin Motors.





ELECTRICAL DATA 4 & 6 INCH MOTORS
415V 50 Hz 3 PHASE

MOTOR kW	THRUST kg	FULL LOAD AMPS	NOMINAL RPM	LOCK ROTOR AMPS
		4 INCH **FRANKLIN** MOTORS		
4.0	680	10.4	2875	59
5.5	680	13.0	2875	70
		6 INCH **FRANKLIN** MOTORS		
7.5	1600	16.2	2875	91
11	1600	24.1	2875	133
15	1600	31.0	2875	174
18.5	1600	38.5	2875	215
22	1600	45.5	2875	278
30	1600	64.6	2875	397
37	2800	77.9	2875	434

July 2006

Appendix 6

Hydrological Baseline Assessment

REPORT ON

HYDROLOGICAL BASELINE ASSESSMENT

WONARAH PHOSPHATE PROJECT

Prepared for

Minemakers Limited

Level 2, 34 Colin Street

WEST PERTH, WA 6005

Report Distribution

No. Copies

1	Minemakers Ltd. (electronic copies enclosed)
1	Groundwater Resource Management Pty Ltd

J090004R01(Final) July 2009

EXECUTIVE SUMMARY

Minemakers Australia Pty Ltd (MAPL) are planning to develop the Wonarah Phosphate Project, located about 240 km east of Tennant Creek in the Northern Territory. Operations are currently scheduled to start in mid 2010 with mining commencing in the Arruwurra Prospect situated in the south-western part of the project area. Initially in the order of 1.0 Mtpa of direct shipped ore will be trucked to Tennant Creek for onward rail haulage to Darwin and export from Darwin port.

MAPL has commissioned Groundwater Resource Management Pty Ltd to complete a baseline hydrological assessment to assist with the planning for this development.

The project is located within the internally draining Barkly Surface Water Management Area (SWMA), immediately west of the Georgina River catchment. Although situated in a semi-arid region with average annual rainfalls of between 300 and 400 mm, significant short duration rainfall events can and do occur, with daily rainfalls in excess of 200 mm having been recorded locally. Therefore runoff will report to the minor on-site creeks and drainages and appropriate surface water management will be required to minimise operational interruptions and potential asset loss.

The purpose of this report is therefore to present the findings from a desktop study of regional hydro-meteorological data that can be used in the future analyses and design of water management measures at the Wonarah Project. In particular this information may be used in the design of water management measures required for the proposed developments at Arruwurra and Main Zone .

The following key findings were made:

- The regional climate is one of extremes and droughts and major floods can occur in the same area within a few years of each other. The climate in this region is highly variable, both spatially and temporally, and this can make hydrologic analysis and the design of water management measures difficult.

- Climatic conditions in the region are monsoonal with well-defined wet and dry seasons, with nearly all rain falling between November and March and the greatest incidence during January and February. Light rains are sometimes received during the dry season, but the period between April and September is frequently rainless.

- Although tropical cyclones may bring heavy rains to the Barkly region, they are erratic in nature and occur relatively infrequently. An analysis of cyclone data for the last 98 years shows that, on average, one cyclone will pass within 200 km of the project every 6 or 7 years, or approximately every 50 years one will pass within 50 km of the site. However, it should be noted that this analysis only considered cyclone track location and not rainfall intensity.

- The Bureau of Meteorology (BoM) station at Ranken River is the closest to the Wonarah Project with a comparatively long record. Its mean and median annual rainfalls of 361 and 326 mm are considered to be representative of conditions at the project and their use is recommended for design purposes.

- Locally the wettest day on record occurred on 29 January 2000 as a result of Tropical Cyclone (TC) Steve when 215 mm was recorded at Annitowa. Significant rainfall across the region that day with four other local rainfall stations recording depths in excess of 120 mm. It is estimated that the rainfall associated with TC

Steve had an average recurrence interval (ARI) in excess of 100 years in the vicinity of the project.

- Short duration rainfall intensities due to cyclones and other tropical depression related events can be significant. The regional maximum six minute intensity of 192 mm/hr was recorded at Tennant Creek Airport in February 1982. This intensity has an ARI in excess of 50 years.

- In the absence of an acceptably long site evaporation record it is recommended that the average of pan evaporation data for the Brunette Downs and Camooweal Township stations be used for design purposes for the Wonarah project. This gives a mean annual pan evaporation of some 3,114 mm.

- A review of the BoM Wonarah temperature data indicates that typically there are in the order of 39 days each year with daily maximum temperatures in excess of 40°C, over half of which occur during December and January.

- BoM Wonarah relative humidity data show that mornings are more humid than afternoons. However, the general aridity of the region can be appreciated when it is noted that the mean 9 am relative humidity for January and February, the wettest months, is only about 50%.

- Streamflow data are very sparse for the region, with no reliable gauged data within the Barkly SWMA. A review of the available streamflow data showed that it is highly variable. The peak instantaneous flows at Ranken River at Soudan Homestead and Georgina River at Roxborough Downs of >2,000 and 3,833 m^3/sec are of similar magnitude despite the fact that the catchment for the latter is over 25 times larger.

- The mean annual flow at the Ranken and Georgina River stations is 172.1 GL and 1,042.3 GL respectively. This is equivalent to mean annual specific yields ranging between 0.2 and 1.2 x 10^{-3} m^3/sec/km^2 which is equivalent to mean annual runoff rates of about 10 to 40 mm. Assuming an average annual rainfall across the region of approximately 400 mm these runoff rates represent in the order of 2.5% to over 10% of the annual rainfall.

- A rainfall intensity-frequency-duration (IFD) relationship was developed for the Wonarah Project. In summary, the 100 Year ARI intensities for 1 hr, 3 hr, 12 hr, 24 hr and 72 hrs are 78.0, 37.2, 14.4, 9.3 and 7.3 mm/hr respectively (i.e. giving equivalent storm depths of 78, 112, 173, 223 and 526 mm).

- All of the on-site creeks and drainages are relatively minor and ephemeral in nature and likely only carry runoff following significant rainfall events. However, flows will occur periodically during the summer months from January to March, when the potential exposure to high intensity cyclonic or tropical depression related rainfall is greatest. Consequently runoff will report to the watercourses in the vicinity of the project and, on occasion, flows may be high and may cause flooding if appropriate measures are not in place.

- A preliminary catchment delineation has been carried out over the project, however peak flow estimates have not been calculated given the current preliminary nature of the mine facility layout plan. Such calculations will be necessary once the facility plan is more advanced in order to design flood protection diversions and bunds etc.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Minemakers Australia Pty Ltd (MAPL) are planning to develop the Wonarah Phosphate Project, located about 240 km east of Tennant Creek in the Northern Territory (Figure1). Operations are currently scheduled to start in mid 2010 with mining commencing in the Arruwurra Prospect situated in the south-western part of the project area. Initially in the order of 1.0 Mtpa of direct shipped ore will be trucked to Tennant Creek for onward rail haulage to Darwin and ultimate exportation from Darwin port.

MAPL has commissioned Groundwater Resource Management Pty Ltd to complete a baseline hydrological assessment to assist with the planning for this development.

Although the project is situated in a semi-arid region with average annual rainfalls of between 300 and 400 mm, significant short duration rainfall events can and do occur, with daily rainfalls in excess of half the annual average having been recorded locally. Therefore runoff will on occasion report to on-site creeks and drainages and appropriate surface water management measures will be required to minimise operational interruptions and asset damage or loss.

The purpose of this report is to present the findings from a desktop study of hydro-meteorological data from the region that can be used in the future analyses and design of water management measures at the Wonarah Project. In particular this information may be used in the design of the measures required for the developments at Arruwurra and Main Zone The results of the desktop study are presented in this report. An electronic copy of this report is provided on CD ROM at the back of the report.

2.0 DESKTOP HYDRO-METEOROLOGICAL STUDY

2.1 Data Sources

Climate data were obtained from the Wonarah Project automatic weather station (AWS) for approximately nine months from mid May 2008 to early March 2009. Given the limited nature of this data it was not possible to subject it to frequency analysis or draw longer term conclusions about the local climate. The AWS data were therefore excluded from the desktop study.

Apart from the limited AWS site data no other meteorological or steamflow data were available for the project. The desktop study therefore made extensive use of available local and regional data from the following sources (refer to Figures 1 and 2 for location maps):

2.1.1 Bureau of Meteorology (BoM) Data:

The following BoM data were obtained and used in the completion of the desktop study (all distances and directions measured from what is referred to on site as "Arruwurra Junction" at the junction of the main site tracks):

Table 1: Daily Rainfall Records for Local BoM Stations (All within 150 km of Site)

BoM Station Name	Station No.	Data Period	% Complete[1]	Distance from Site
Austral Downs	15004	1/7/1914 - 20/1/2009	73.0%	146.8 km SE
Avon Downs	15005	1/1/1909 - 26/6/2007	95.0%	108.3 km E
Ranken River	15026	1/1/1909 - 31/3/2008	72.6%	68.4 km NE
Wonarah	15034	1/4/1946 - 31/8/1974	98.8%	20.4 km NW
Alroy Downs	15036	1/10/1950 - 28/5/2004	98.9%	92.3 km NW
Alexandria	15088	1/1/1886 - 24/2/2009	87.8%	112.8 km N
Barkly Homestead	15145	1/3/1987 - 31/1/2007	82.0%	75.2 km NW
Number 36 Bore	15151	1/11/1982 - 31/3/2008	98.5%	118.4 km NE
Annitowa	15587	1/1/1966 - 30/11/2008	85.1%	129.7 km S
Epenarra	15657	1/1/1963 - 31/12/2007	96.2%	132.0 km SW

Note 1:. % Complete = No. of Days Recorded ÷ (End Date of Record - Start Date of Record).

Table 2: Pluviograph Data for Regional BoM Stations

BoM Station Name	Station No.	Data Period	Distance from Site
Brunette Downs	15085	20/12/1968 – 31/01/2006	165.3 km NW
Tennant Creek Airport	15135	15/10/1969 – 30/11/2005	241.7 km W
Ali Curung	15502	28/06/1988 – 31/05/2007	238.7 km SW
Camooweal Township	37010	27/09/1964 – 30/09/1997	174.7 km E

Table 3: Daily Evaporation for Regional BoM Stations

BoM Station Name	Station No.	Data Period	% Complete[1]	Distance from Site
Brunette Downs	15085	11/12/1968 – 24/2/2009	91	165.3 km NW
Camooweal Township	37010	13/06/1969 – 31/08/1997	86	174.7 km E

Note 1: % Complete = No. of Days Recorded ÷ (End Date of Record - Start Date of Record).

Table 4: Climate Summaries for Regional BoM Stations

BoM Station Name	Station No.	Distance from Site
Wonarah	15034	20.4 km NW
Brunette Downs	15085	165.3 km NW
Tennant Creek Post Office	15087	240.9 km W
Tennant Creek Airport	15135	241.7 km W
Ali Curung	15502	238.7 km SW
Camooweal Township	37010	174.7 km E

Note : Length of record and % Complete varies depending on parameter of interest.

Listing of Australian Cyclones 1907-2005 with full, published details and partial listing for 2005/2006 cyclone season with preliminary path details were also obtained from the BoM and reviewed as part of this study.

2.1.2 Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS):

Stage and flow data were extracted from NRETA's database for the following surface water gauging stations:

Table 5: NRETAS Surface Water Data

Station Name	Station No.	Data Period	Distance from Site
Playford River at Alroy Downs Homestead	G0290004	19/11/75 – Present	92.5 km NW
Ranken River at Soudan Homestead	G0010005	9/08/65 – Present	59.1 km E
James River at Avon Downs Police	G0010006	14/04/65 – 28/04/87	109.7 km E
Shakespeare Creek at Lily Waterhole	G0010009	15/08/69 – 14/01/87	128.4 km SE

The Playford River station is located within the Barkly Surface Water Management Area (SWMA), while the other three stations are all located in the Georgina River SWMA to the east of the NT/QLD border. Unfortunately only approximate streamflow gaugings exist for the Playford and James River stations, while the Shakespeare Creek station has not been gauged at all. Rating curves have therefore not been developed for any of the three stations and only stage (level) data were available. Daily maximum, minimum and mean flow data were available however for the Ranken River station.

2.1.3 Queensland Department of Environment and Resource Management (DERM)

Summary flow data were also obtained for the Georgina River gauging station at Roxborough Downs (Station No. 001203A). This station is located within the part of the Georgina SWMA that lies with Queensland, approximately 364 km south east of the project site. This station commenced recording in October 1967, was closed in September 1988 and reopened in June 2005.

2.1.4 Mapping Data

The following mapping data were used in the completion of the desktop study:

- 1:250,000 scale electronic topographic survey data for Alroy (SE5315), Ranken (SE5316), Frew River (SF 5303) and Avon Downs (SF5304) sheets.
- Airborne photography and laser scanning/Lidar data to produce ortho imagery, 0.5 m interval contours and key spot heights.
- Miscellaneous preliminary proposed infrastructure shape files.

2.2 Desktop Study Findings

2.2.1 General

The Wonarah Project is located about 230 km east of Tennant Creek in the Northern Territory (Figure 1). It is situated within the internally draining Barkly SWMA which covers an area of some 123,000 km2 and has an estimated mean annual runoff volume in the order of 600,000 ML/year1. There is no major water storage, diversion or supply infrastructure within the Barkly SWMA and the volume of surface water used is less than 0.1% of the mean annual runoff available. No surface water licenses are current within the SWMA and what little surface water that is used, is used for stock watering. About 77% of the area is pastoral leasehold land, 12% is Aboriginal land, and the remaining land is for other mixed uses.

The SWMA area is bounded by the Barkly Tableland in the east, while in the west the management area borders the Whittington, Murchison and Davenport Ranges. The south-central part of the SWMA, within which the project is located, comprises gently undulating sand ridges and semi-desert of low relief. All rivers and creeks within the SWMA are ephemeral and tend to flow only for short periods following heavy rainfall. Only the larger rivers such as the Ranken and Playford have permanent water holes. The main rivers in the south are Elkedra and Frew, which originate from the ranges along the western boundary, and flow into the sand dune country. Most of the main rivers and creeks in the northern half of the SWMA, that originate from the Barkly Tableland and from the north western boundary flow into seasonally flooded swamps and lakes.

The northern half of the SWMA has a humid climate with mean annual rainfall in the order of 550 mm, while the southern half has an arid climate with a mean annual rainfall of some 250 mm. Taking an average rainfall of 400 mm per year across the whole 123,000 km^2 SWMA and comparing it to the estimated mean annual runoff volume of 600,000 ML/year indicates that in the order of 2% of annual rainfall reports to creeks and rivers as runoff.

Despite such comparatively low annual runoff, runoff rates can be significantly higher for the short duration rainfall events that can occur in the region; daily rainfalls in excess of 200 mm have been recorded close to the project. During such events significant runoff will report to

[1] Australian Natural Resources Atlas, Department of the Environment, Water, Heritage and the Arts, see http://www.anra.gov.au/index.html for more information.

minor creeks and drainages on the site and appropriate surface water management will be required to minimise operational interruptions and potential asset loss.

2.3 Meteorological Conditions

2.3.1 General

The climate of much of the Barkly region is semi-arid, merging into an arid zone at the southern limit and into a narrow sub-humid northern strip adjoining the Gulf of Carpentaria[2]. The climate is monsoonal with well-defined wet and dry seasons, with nearly all rain falling between November and March and the greatest incidence during January and February. Light rains are sometimes received during the dry season, but the period between April and September is frequently dry.

Although tropical cyclones may bring heavy rains to the Barkly region, they are erratic in nature and occur relatively infrequently. Typically they track either from east to west or from north-west to south-east. Disturbances following the former track usually develop in the Coral Sea and enter the region after passing across the Cape York Peninsula; those following the latter track usually arise in the Arafura Sea and enter the region after crossing Arnhem Land or the Gulf of Carpentaria.

Day temperatures are high throughout the year, particularly in October, November and December prior to the onset of the wet season. With the occurrence of wetter conditions and slightly lower temperatures in January and February, humidity rises and reaches its highest levels.

2.3.2 Regional Rainfall

The annual rainfall distribution in the Barkly region is strongly seasonal and the year may be divided into two main seasons, a short, wet summer and a long, dry winter, with two subsidiary transitional periods between them. By the latter part of January, the wet summer season, under the influence of the north-west monsoon, is usually established. Over the drier, southern parts of the region the monsoonal influence typically lasts only for a few weeks and is characterized by widespread but intermittent rainfall with more humid and slightly cooler conditions than those prevailing earlier. In the sub-humid, northern areas adjacent to the coast, the rainfall tends to be more persistent and the associated temperature and humidity effects more marked.

The monsoon usually wanes in March and a period of calm and variable winds commences and continues for about one month. Thunderstorms, with or without accompanying rains, are a feature of this period. As the temperature and humidity gradually fall the frequency and intensity of the thunderstorms decrease and the commencement of the dry season is soon indicated by the onset of steady south-easterly winds. In the south-eastern part of the region, within which the site is located, additional light rains can sometimes occur during the early winter months.

The dry season, characterized by south-easterly winds, cooler day temperatures, greater diurnal temperature variation, and low humidity, persists until late September or October when the south-east winds subside and a second transitional period of calm and variable

[2] Survey of the Barkly Region, Northern Territory and Queensland, 1947-48, C. S. Christian, L. C. Noakes, R. A. Perry, R. O. Slatyer, G. A. Stewart, and D. M. Traves, Land Research Series No.3. CSIRO, Melbourne 1954

winds commences. Day temperatures become hotter and thunderstorms occur with increasing frequency and violence until the monsoon sets in once again.

Dry season weather is normally very regular, and variations in the annual weather regime are mainly due to differences in the intensity of the monsoonal influence from year to year. Often when the monsoon is strongly developed, the rains that occur during the transition periods also tend to be more extensive and frequent; and conversely, when monsoonal development is weak, transitional period rains are often of sporadic occurrence and confined to the months closest to the monsoon period.

The wetter-north/drier-south rainfall distribution is evident in the median annual rainfall values of 373 mm and 325 mm for Brunette Downs and Ali Curung located some 165 km northwest and 238 km south west of the project respectively (see Figure 1 for location of regional rainfall stations).

2.3.3 Local Rainfall

In order to analyse rainfall conditions local to the project daily rainfall data were obtained for the ten closest BoM rainfall stations (refer to Table 2 for details). All of these stations fall within an approximately 150 km radius of the site as shown in Figure 2. Unfortunately the record obtained from the Wonarah project AWS was too short to make a meaningful comparison with any of the BoM stations. However, such a comparison should be made once the on-site record is of sufficient length, say 3-5 years minimum.

Annual Rainfall

Table 6 gives the maximum, minimum, mean and median annual rainfall for the local rainfall stations considered in the desktop review. Only full or complete years of data were used in the analysis given the difficulties in "patching" gaps in records. This meant that length of some of the data sets had to be reduced by as much as 40% in order to remove years where data were incomplete.

Table 6: Annual Rainfall at Local BoM Stations

Station Name	Minimum Annual Rainfall (mm)	Maximum Annual Rainfall (mm)	Mean Annual Rainfall (mm)	Median Annual Rainfall (mm)	No. of Complete Years
Austral Downs	98	858	334	293	61
Avon Downs	111	1,145	348	302	79
Ranken River	100	828	361	326	62
Wonarah	106	572	326	310	23
Alroy Downs	82	1,009	363	295	42
Alexandria	109	1,317	393	359	76
Barkly Homestead	177	737	346	340	12
Number 36 Bore	157	1,227	398	380	18
Annitowa	56	609	257	214	28
Epenarra	104	995	366	329	38

Note 1: All Annual Rainfall values above were calculated using complete years of data only.

It should also be noted that despite the data gaps it was possible to produce a continuous 102 year long rainfall record from 1907 to 2008 comprising only complete years of data from local rainfall stations. Data from the local stations has been selected in order of increasing distance from the site and is presented as Annual Series values in Appendix A.

Median annual rainfall was also calculated in addition to mean values as it is generally considered to represent rainfall central tendency better in areas with skewed rainfall data. This is the case in regions where exposure to a few, or even a single, extreme cyclonic rainfall event can have a disproportionate effect on the mean, but has much less effect on the median, given that it is based on ranked data.

Table 6 shows that the mean annual rainfalls for the local stations range from about 257 to 398 mm, while the median values range from approximately 214 to 380 mm. Given that the Ranken River station is the closest station to the project with a comparatively long record, its mean and median annual rainfalls of 361 and 326 mm are considered representative of conditions at the project and their use is recommended in water balance and other calculations until a record of sufficient length is collected on site[3].

Points of note from the analysis of the complete annual rainfall data sets for the local stations are as follows:

- Typically there is a one order of magnitude range between maximum and minimum annual rainfalls for most of the local rainfall stations with longer records.

- Minimum and maximum annual rainfalls of 106 mm and 572 mm were recorded at Wonarah in 1961 and 1962 respectively. Similarly maximum and minimum annual rainfalls of 737 mm and 177 mm were recorded at Barkly Homestead in 1993 and 1994 respectively. Such ranges in successive years reflects the highly variable nature of annual rainfall in the region.

- A preliminary frequency analysis of the 62 years of complete Ranken River annual rainfall data indicates that the 828 mm maximum annual rainfall that occurred in 1941 has an average recurrence interval (ARI) in excess of 50 years. The 100 year ARI wettest year would see in the order of 900 to 1000 mm of rainfall recorded at Ranken River. The annual minimum rainfall of 100 mm that fell in 1928 is in excess of the 100 year ARI annual drought for the area.

- The Alexandria station, some 113 km north of the project, recorded the local maximum annual rainfall of 1,317 mm in 2000. The annual rainfall data from this station are positively skewed due to the effect of this significantly wet year caused primarily by a 48 hour rainfall of 317 mm recorded during the 8 and 9 December 2000 as a result of Tropical Cyclone Sam (refer to discussion on cyclones below). Austral Downs and Number 36 Bore stations also recorded their wettest year in 2000.

- The Annitowa Mile station, some 130 km south of the project, recorded the local minimum annual rainfall of 56 mm in 1988. However the driest year in the region occurred in 1928 at Austral Downs, Avon Downs and Ranken River. The 1928 annual rainfall represents in excess of the 100 year ARI annual dry for much of the region.

[3] Although the Wonarah gauge is closer to the project site than Ranken River it was closed in 1974 and it is therefore not possible to determine if data from the Wonarah gauge is representative of the project site under contemporary meteorological conditions.

Monthly Rainfall

Mean, maximum and minimum monthly rainfall values were determined for all ten local BoM daily rainfall stations discussed above (refer to monthly rainfall tables and graphs in Appendix A). However only the values for Ranken River, the site considered to be most representative of the project, are shown in Table 7.

Table 7: Ranken River Monthly Rainfall - Data set comprising all 866 complete months

Month	Mean Monthly Rainfall[1] (mm)	Median Monthly Rainfall (mm)	Maximum Monthly Rainfall (mm)	Minimum Monthly Rainfall (mm)	No. of Complete Months
January	85.6	61.5	273.6	5.0	73
February	82.9	65.3	270.6	0	73
March	46.1	32.5	312.0	0	74
April	13.4	0.0	156.2	0	73
May	9.5	0.0	127.8	0	74
June	9.0	0.0	102.6	0	72
July	3.9	0.0	46.5	0	71
August	2.2	0.0	83.9	0	70
September	4.2	0.0	66.9	0	73
October	14.2	8.1	101.3	0	73
November	26.7	15.7	118.0	0	70
December	61.9	39.3	430.6	0	70

Note 1: The sum of the mean monthly rainfalls above does not equal the mean annual rainfall exactly due to differences in the length of the two data sets.

The Ranken River values were developed using 866 complete months of data. This is a larger data set than the 62 years of complete annual data presented above (i.e. 62 years x 12 months = 744 months) as data for complete months within incomplete years were used in the analysis.

Table 7 shows that the wettest months are typically from December to March, with the greatest rainfall generally occurring in January and February. August is the driest month with a combined total of only 153 mm recorded for the month in the 70 months for which there is data.

Comparison of the mean and median monthly values show the skewing effect that a few significant cyclone or tropical depression related rainfall events can have on the mean rainfall values. The maximum monthly values, particularly during the drier winter months, are due to rare short duration (less than 72 hours) tropical depression related events that skew the monthly mean.

Zero precipitation or dry months have been recorded at Ranken River throughout the year, with only the wettest month of January recording minimum values greater than zero.

Daily Rainfall

An analysis of daily rainfall data was carried out for the ten local BoM stations listed above. The ten wettest days on record are shown in Table 8 along with the station name, date and, where related, the tropical cyclone name.

Table 8: Maximum Daily Rainfall - Data set comprising all records for all local stations

Station Name	Date	Precipitation to 9am (mm)	Rank	Event Name
Annitowa	29/2/2000	215.0	1	TC Steve
Austral Downs	16/1/1953	209.8	2	Unnamed 1952 #4
Alexandria	19/3/1901	180.3	3	-
Austral Downs	8/2/1953	174.5	4	-
Alexandria	9/12/2000	172.4	5	TC Sam
Alroy Downs	4/2/1976	170.0	6	TC Alan
Epenarra	23/3/1982	170.0	7	-
Alexandria	4/2/1976	167.5	8	TC Alan
Alexandria	22/1/1941	166.4	9	-
Avon Downs	18/2/1934	162.6	10	-

Note: Prior to 1964 Tropical Cyclones were unnamed and were instead assigned a sequential number by BoM.

A preliminary annual frequency analysis was carried out on the daily rainfall record for Annitowa station. This showed that the wettest day on record of 215 mm which occurred on 29 February 2000 as a result of TC Steve had an ARI in excess of 100 years.

A listing of the ten wettest days at each of the local rainfall stations is provided in Appendix A. An intensity-frequency-duration (IFD) relationship has been developed for the project for design purposes and is discussed further in Section 3 of this report.

Sub-Daily Rainfall

Rainfall intensity data from the four automatic pluviograph stations closest to the site were inspected (refer to Table 2 for station details). Unfortunately little reliable data were available from these stations, with the automatic gauges being unavailable for much of the time. An analysis of the available data produced the maximum six minute intensities shown in Table 9.

Table 9: Maximum Six Minute Rainfall Intensities from Local BoM Stations

BoM Station Name	Approx. Record Length (yrs)	Maximum Six Minute Intensity (mm/hr)	Date of Occurrence
Brunette Downs	37	170	5 Jan 1974
Tennant Creek Airport	36	192	9 Feb 1982
Ali Curung	18	64	12 Mar 1989
Camooweal Township	33	166	1 Feb 1979

The analysis showed that short duration rainfall intensities in excess of 150 mm/hr have been recorded at local BoM stations and is indicative of intensities that might be experienced at the project. The 192 mm/hr maximum six minute intensity recorded at Tennant Creek in February 1982 is of particular note. That intensity has an ARI in excess of 50 years (refer to the development of the IFD relationship later in this report).

2.3.4 Cyclone Swept Path Analysis

As mentioned above, although the project is located within a region that is occasionally subject to tropical cyclones and tropical depressions, they are erratic in nature and occur relatively infrequently. Typically they track either from east to west developing in the Coral Sea and entering the region after passing across the Cape York Peninsula, or from north-west to south-east arising in the Arafura Sea and crossing Arnhem Land or the Gulf of Carpentaria.

Of particular significance to the area surrounding the Wonarah project was TC Sam in early December 2000 which gave rise to one of the top ten wettest days on record at five of the local BoM stations. Also of note is the local maximum daily rainfall of 215 mm which was recorded at Annitowa during TC Steve in February 2000. Such events cause flooding, road closures and operational interruptions and other problems in the region and will require careful planning to mitigate such effects on the proposed project facilities.

In order to estimate the frequency that cyclones might be expected in the region the swept paths of all cyclones from January 1907 to April 2006 were plotted and those that passed within a 2 degree radius (or approximately 200 km) of the project were noted. This 4-degree (or approximately 400 km) band of influence was arbitrarily chosen as the width within which a cyclone would cause some degree of operational impact on the proposed project, even if only minor.

This initial assessment showed that some 16 tropical cyclones entered the 4-degree wide band during the 98-year period of record, or that the long-term regional average is approximately one cyclone every six or seven years. The 2000/2001 cyclone season is of particular interest with TC Sam and Wylva both passing within 200 km of the project within eight weeks of each other.

A second assessment was carried out to determine the number of cyclones crossing within a 0.5 degree radius (or approximately 50 km) either side of the project. It was considered that cyclones crossing within this 1-degree band would have more significant impacts on the project, likely leading to some degree of production loss. This assessment showed that two cyclones passed within this narrower band over the 98-year period of record, or one approximately every 50 years.

The results of the cyclone swept path analyses are provided in Appendix B.

It should be noted that the above analyses are somewhat subjective as they only consider the cyclone frequency and not its intensity. Cyclone intensity varies from a gale force category 1 with wind speeds up to 125 km/hr to severe category 5 cyclones with gusts of more than 280 km/hr. Obviously a more intense cyclone passing further away may cause greater damage than a less intense cyclone in the immediate vicinity of the project. This is illustrated by the fact that the 215 mm maximum daily rainfall recorded at Annitowa on 29 Feb 2000 occurred as a result of TC Steve which was passing along the southern coast of the Gulf of Carpentaria, some 600 km to the north.

2.3.5 Evaporation

Brunette Downs and Camooweal Township are the closest reliable evaporation gauging sites to the Wonarah project. Mean monthly Class A bird-guarded pan evaporation for both stations is shown in Table 10 for complete months only[4] (plots of mean, maximum and minimum monthly evaporation are also presented in Appendix A).

Inspection of the data shows mean annual pan evaporation measured at both stations is one order of magnitude greater than mean annual rainfall for the region and that mean monthly evaporation is significantly greater than mean monthly rainfall throughout the year. Evaporation is highest in the early summer months of October, November and December with mean monthly evaporation in the range of 317 to 347 mm recorded at both stations. Mean monthly evaporation reduces to approximately half this amount during the winter months of June and July. Maximum daily pan evaporation rates of 67.4 mm and 63.5 mm have been recorded at Brunette Downs and Camooweal Township respectively.

Given that the proposed project is roughly equidistant between the Brunette Downs and Camooweal Township stations and in the absence of acceptable site evaporation data, it is recommended that the average of pan evaporation data for both stations be used for design purposes for the Wonarah Project.

Table 10: Mean Monthly Pan Evaporation at Brunette Downs and Camooweal Township and Estimated Values for Wonarah Project

Month	**Mean Monthly Pan Evaporation (mm)**		
	Brunette Downs	**Camooweal**	***Wonarah Estimate***
January	294	332	313
February	243	264	254
March	241	275	258
April	229	250	240
May	203	209	206
June	164	164	164
July	180	180	180
August	220	222	221
September	280	272	276
October	333	347	340
November	317	330	324
December	331	345	338
Mean Annual Evaporation (mm)	**3,035**	**3,189**	**3,114**

[4] It should be noted that the mean monthly evaporation rates shown in Table 10 are slightly different than those presented in BoM Climate Summaries for Brunette Downs and Camooweal Township (refer Appendix A). This is due to the fact that incomplete months were excluded in the analysis completed for this study, while the BoM do not exclude incomplete months from their analysis.

2.3.6 Temperature

The monthly temperature data for the Wonarah station, some 20 km northwest of the project, are summarised in Table 11 below.

Table 11: Monthly Temperature Data for Wonarah Station (°C)

Month	Mean daily maximum Temp	Mean daily minimum Temp	Highest daily Max Temp	Lowest daily Min Temp	Mean no. of days where Max Temp ≥ 30°C	Mean no. of days where Max Temp ≥ 40°C
Jan	38.2	24.2	45.8	15.0	26.7	10.3
Feb	37.1	23.6	44.3	16.8	24.0	6.0
Mar	35.6	22.0	42.3	14.5	25.6	2.3
Apr	33.1	18.9	39.2	8.3	21.7	0
May	28.2	14.4	36.1	2.8	10.4	0
Jun	25.8	11.1	35.0	-0.2	3.3	0
Jul	25.1	9.9	32.6	1.1	2.9	0
Aug	27.8	11.5	37.8	0.6	9.9	0
Sep	31.9	15.5	39.6	6.0	19.1	0
Oct	35.9	19.9	42.2	9.2	25.5	3.0
Nov	37.9	22.2	44.9	12.2	24.9	7.2
Dec	38.8	23.6	44.4	13.1	27.1	10.5

Note: Wonarah temperature values based on approximately 17 years of data years of data (1957-1974) approximately 81% complete.

Inspection of the data provides the following points of note regarding temperature:

- Mean daily maximum temperatures range from 38.8°C in December to 25.1°C in July.
- Mean daily minimum temperatures range from 24.2°C in January to 9.9°C in July.
- Highest and lowest daily temperatures of 45.8°C (5 Jan 1971) and -0.2°C (26 Jun 1965) respectively have been recorded at Wonarah.
- Days with daily maximum temperatures in excess of 30°C occur throughout the year with an average of approximately 221 days with maximum temperatures above 30°C.
- Typically Wonarah will have in the order of 39 days each year with daily maximum temperatures in excess of 40°C, over half of which will occur during December and January.

2.3.7 Relative Humidity

Mean 9 am and 3 pm relative humidity data are summarised in Table 12 below for the Wonarah station, some 20 km northwest of the project.

Table 12: Monthly Relative Humidity Data[5] for Wonarah Station (%)

Month	Mean 9 am Relative Humidity	Mean 3 pm Relative Humidity
Jan	45	28
Feb	***51***	***30***
Mar	43	27
Apr	38	23
May	41	26
Jun	45	27
Jul	41	25
Aug	33	20
Sep	***26***	***16***
Oct	30	18
Nov	31	19
Dec	36	23

Notes: Wonarah temperature values based on approximately 19 years of data years of data between 1950 and 1970.

Inspection of the data shows that, as expected, mornings are more humid than afternoons, but that the general aridity of the region can be appreciated when it is noted that the mean 9 am relative humidity for January and February, the wettest months, is only about 50%.

The data show that highest and lowest relative humidities can be expected during the months of February and September respectively. The highest values coincide with the occurrence of wetter conditions and slightly lower temperature in January and February, while the lowest humidities and temperatures are recorded during the dry season. All local stations record their lowest mean relative humidities during the months of July, August, and September. During the dry season, dews are not uncommon on clear nights, but frost occurrence is rare, being confined to the months of June, July, and August.

2.3.8 Wind Speed and Direction

Prior to closing in 1974 the Wonarah station, some 20 km northwest of the site, was the nearest BoM station that recorded mean daily wind speed and direction. The closest operational, long-term wind recording station, that also records maximum instantaneous wind gust speed, is at Tennant Creek Airport, approximately 240 km to the west[6]. Mean daily 9 am and 3 pm wind data are available for the Wonarah station from January 1957 to closure in August 1974 and for the Tennant Creek Airport from July 1969 to the present.

The mean monthly 9 am and 3 pm wind speeds for both Wonarah and Tennant Creek Airport and the maximum wind gusts for Tennant Creek Airport are shown in Table 13.

[5] It should be noted that while relative humidity is a traditional indicator of the air's moisture content it is not a measure of the actual amount of atmospheric moisture as it depends on the air temperature i.e. at 50% RH there is much more moisture in the air at an air temperature of 25°C than there is at 15°C. BoM do not take this dependence into account in their calculations and the above values should therefore be regarded as approximations only.

[6] Wind gust data were also obtained for Camooweal Township, some 175 km northeast of the project site, but were discarded due to its brevity (5.4 years) and poor level of completeness (11%).

Table 13: Mean Monthly 9 am and 3 pm Wind Speed for Wonarah and Tennant Creek Airport and Maximum Wind Gusts for Tennant Creek Airport

	Mean 9am Wind Speed (km/h)		Mean 3pm Wind Speed (km/h)		Highest Recorded Wind Gust (km/h)
Month	Wonarah	Tennant Creek Airport	Wonarah	Tennant Creek Airport	Tennant Creek Airport
Jan	11.5	17.0	12.0	15.4	117
Feb	13.6	16.7	12.0	15.9	102
Mar	14.3	19.6	13.6	17.6	95
Apr	17.2	23.7	13.0	17.3	98
May	16.9	24.7	13.3	16.7	81
Jun	15.5	24.4	12.4	16.5	78
Jul	17.7	23.7	13.8	15.5	80
Aug	19.1	25.3	12.9	16.1	78
Sep	19.2	25.6	13.1	16.0	76
Oct	18.0	24.9	12.6	14.5	104
Nov	16.4	21.7	11.6	13.8	100
Dec	16.5	18.3	12.2	14.1	106

Note: Wonarah mean monthly wind speed values based on some 17 years of data approximately 81% complete. Tennant Creek Airport mean monthly wind speed and maximum wind gust values based on some 38 years of data approximately 97% and 99% complete respectively.

Inspection of the mean monthly data shows that although wind speeds are typically higher at Tennant Creek than at Wonarah, the annual distribution is similar at both stations, with average wind speeds peaking in late winter months of August and September. Winds are fresher in the morning, with the 9 am observations typically higher than those for 3 pm.

Annual wind roses for the 9 am and 3 pm observations at Wonarah are provided in Appendix A[7]. These show that south-easterly's predominate in both the morning and afternoons throughout the year. Calm conditions were noted less than 10% of the time for both morning and afternoon observations.

Five months have recorded maximum gust speeds in excess of 100 km/h at Tennant Creek Airport with the maximum speed of 117 km/hr being recorded on 4 January 2004. Unfortunately it is not possible to compare these maximum gust speeds with the Wonarah BoM station as it was never equipped to record wind gust speed. However the Tennant Creek maximum gust speeds are typical of what may be expected at the project.

2.4 Hydrological Conditions

2.4.1 Review of Existing Data

Daily flow and stage (i.e. water surface level) data were extracted for the surface water stations shown in Table 14. Only the Playford River station is located within the Barkly SWMA; all of the others located within the adjoining Georgina River SWMA.

[7] The wind rose for Tennant Creek Airport was also obtained, but has not been presented as the distribution of wind direction is significantly different to the Wonarah site which is much closer to the project site.

Table 14: Regional Flow Gauging Stations

Station Name	Playford River	Ranken River	James River	Shakespeare Creek	Georgina River
Distance from Site (km)	92.5 km NW	59.1 km E	109.7 km E	128.4 km SE	364.0 km SE
Data Record Length (years)	~33	~42	~23	~17	~21
Catchment Area (km^2)	6,620	4,360	506	398	118,398
Mean Annual Flow (GL)	N/A	172.1	N/A	N/A	1,042.3
Median Annual Flow (GL)	N/A	39.9	N/A	N/A	328.7
Maximum Annual Flow (GL)	N/A	2,035.7 (2000)	N/A	N/A	6,288.0 (1976/77)
Minimum Annual Flow (GL)	N/A	0.6 (1972)	N/A	N/A	9.9 (1968/69)
Maximum Daily Flow (m^3/sec)	N/A (13/12/00)	1,720.9 (16/12/84)	N/A (24/1/77)	N/A (24/1/77)	3692.7 (24/2/77)
Peak Instantaneous Flow (m^3/sec)	N/A (13/12/00)	>>2,000 (4/1/09)	N/A (15/12/84)	N/A (24/1/77)	3,832.8 (24/2/77)

Note 1: Only stage data were available for the Playford River, James River and Shakespeare Creek stations. Consequently these records could only be used to indicate when large flow events occurred, rather than their magnitude.

Inspection of the data provides the following points of note:

- The annual flow data for the Ranken and Georgina River stations highlight the hydrological variability of the region, with both stations demonstrating the right-hand or positive skewness typical of all flow gauging stations in the region. It is interesting to note that there is one order of magnitude between mean and median annual flow volumes and some three orders between the minimum and maximum annual volumes.

- The mean annual flow at the Ranken and Georgina River stations is 172.1 GL and 1,042.3 GL respectively. This is equivalent to mean annual specific yields in the range of 0.2-1.2 x 10^{-3} $m^3/sec/km^2$ or mean annual runoff rates in the order of 10 to 40 mm which is comparable with inland catchments in the Pilbara region[8]. Assuming an average annual rainfall across the region of approximately 400 mm these runoff rates typically represent 2.5% to over 10% of the annual rainfall. It should be noted however that during short-duration, high-intensity localised rainfall events runoff rates will exceed these annual rates significantly.

- Ranken and Georgina River stations recorded their lowest annual flows in 1972 and 1968/69 with 0.6 and 9.9 GL respectively. This coincided with a sustained period of low rainfall with several of the regional stations recording their lowest annual rainfall depths during this period. However, the lowest regional streamflow likely occurred

[8] Median annual runoff rates in the order of 15 mm are reported for the De Grey River area in *Surface Hydrology of the Pilbara Region*, Ruprecht, J.K. and Ivansecu, S., Water and Rivers Commission (1996).

in 1928 (prior to construction of the flow monitoring stations) which saw annual rainfalls of 100 mm or less over much of the region. The average recurrence interval of the 1928 annual rainfall is in excess of 100 years.

- The hydrological variability in this extreme drought/flood climate is demonstrated by the peak instantaneous flows at both the Ranken and Georgina River stations which are of similar magnitude despite the fact that the latter catchment area is over 25 times larger.

- Significant rainfall-runoff events have occurred across the region and are reflected in the streamflow data. Of particular note is the peak instantaneous flow well in excess of 2,000 m^3/sec which was recorded at Ranken River in early January 2009[9]. This event was likely a pre-cursor to TC Charlotte which formed from a monsoon trough over the Gulf of Carpentaria during early January.

- Although flow data were unavailable for the Playford River, James River and Shakespeare Creek stations, an inspection of their stage data provided maximum flow depths of 4.6, 3.5 and 4.8 m respectively. The maximum depth at Playford River occurred on 13 December 2000 likely as a result of TC Sam following significant rainfalls across the region (172 mm was recorded at Alexandria four days earlier on 9 December 2000). The maximum stages at James River and Shakespeare Creek were attributable to the same regional runoff event that caused the maximum daily and instantaneous flows at the Georgina River gauging station.

The flow data reported above are used in the following section to estimate peak flows that might be expected in the creeks that cross the Wonarah project.

[9] The maximum gauged flow at the Ranken River station was 1,734 m^3/sec which had a stage of 3.69 m recorded on 27 Jan 1977. The event of early January 2009 peaked at 5.51 m stage.

3.0 WATER MANAGEMENT CONSIDERATIONS

3.1 General

Although the design of specific water management measures was not included in the scope of this baseline hydrological assessment, rainfall and streamflow design parameters are presented in this section for future use.

All the watercourses and drainages in the immediate vicinity of the Wonarah Project are ephemeral. However, flows will occur periodically during the summer months from January to March, when the potential exposure to high intensity rainfall is greatest. Consequently runoff will report to the watercourses in the vicinity of the project and, on occasion, flows may be high and may cause flooding if appropriate measures are not in place.

The hazard that such flooding poses to on-site facilities depends, amongst other things, on the following:

- the magnitude of the flood event;
- the proximity of the facility to the watercourse in flood;
- the sensitivity of the facility to flooding; and,
- the level of protective flood measures provided to the facility.

While the latter three factors can be controlled or engineered to some degree, the magnitude of the naturally occurring rainfall-runoff events that may lead to flooding cannot be controlled.

Although significant rainfall-runoff events do not occur cyclically, especially in a climatic region as variable as the Barkly SWMA, their probability of occurrence within any given period can be estimated. The reciprocal of this probability is typically expressed as an average recurrence interval (ARI) or return period and is the time that, on average, elapses between two events that equal or exceed the magnitude in question.

Table 15 shows the percentage probability for a range of different ARI flood events that could occur during the envisaged 10 year operational life of Stage 1 of the project.

Table 15: Percentage Probability of N-Year ARI Flood Event Occurring During 10 Year Operational Life of Stage 1 of the Project

Average Recurrence Interval (ARI) in Years	**5**	**10**	**20**	**50**	**100**	**200**
Probability of Occurrence	89%	65%	40%	18%	10%	5%

Typically a range of ARI events are used for the design of various mine facilities, depending on their sensitivity to flooding and the period of exposure. For example a temporary drain around a laydown area used during construction may be designed for a 2 year ARI event, while culverts below a main plant access road might be designed for the 10 or 20 year ARI event, depending on the consequences of failure. Good practice suggests that when preparing earthworks pads for mine facilities that they be kept above the 20 year ARI flood level as minimum[10].

The selection of a certain recurrence interval "design" event is generally left to the mine owners to determine based on industry practice and their attitude towards risk. The relevant regulatory authorities review the resulting facility design and make recommendations as necessary.

3.2 Preliminary Flow Estimates for On-site Creeks

Generally flow statistics at any location of interest can be generated using three different approaches (in order of preference):

- *Site Measured Streamflow Analysis* - from long-term streamflow records collected at the location of interest;

- *Regional Hydrological Analysis* - from streamflow records collected at the nearby watersheds with similar hydrological characteristics (e.g., similar drainage area, soils, vegetation and slopes); or,

- *Hydrological calculation/modelling* – using published regional methods applied to site specific rainfall and catchment characteristics.

Given the non-availability of site streamflow data and the paucity of suitable regional streamflow data, it is likely that hydrological calculations using the published methods will have to be used for the future design of on-site water management facilities.

Currently the most commonly applied calculation methods to Australian conditions are those presented in ARR97[11]. These typically involve the development of a rainfall intensity-frequency-duration (IFD) relationship for the site of interest and its application to specific catchment characteristics such as area, gradient, soil type, vegetation cover etc. in various forms of the Rational and Regional Frequency methods.

The IFD has been developed for the site and is presented in the following section. In addition a preliminary site catchment delineation has been prepared and is presented in Figure 3. Given the preliminary nature of the proposed mine facility layout however, peak flow estimates for the relatively minor on-site creeks have not been prepared. Once the proposed layout is more advanced peak flow estimates will be made for use in the design of flood diversion channels, protection bunds etc.

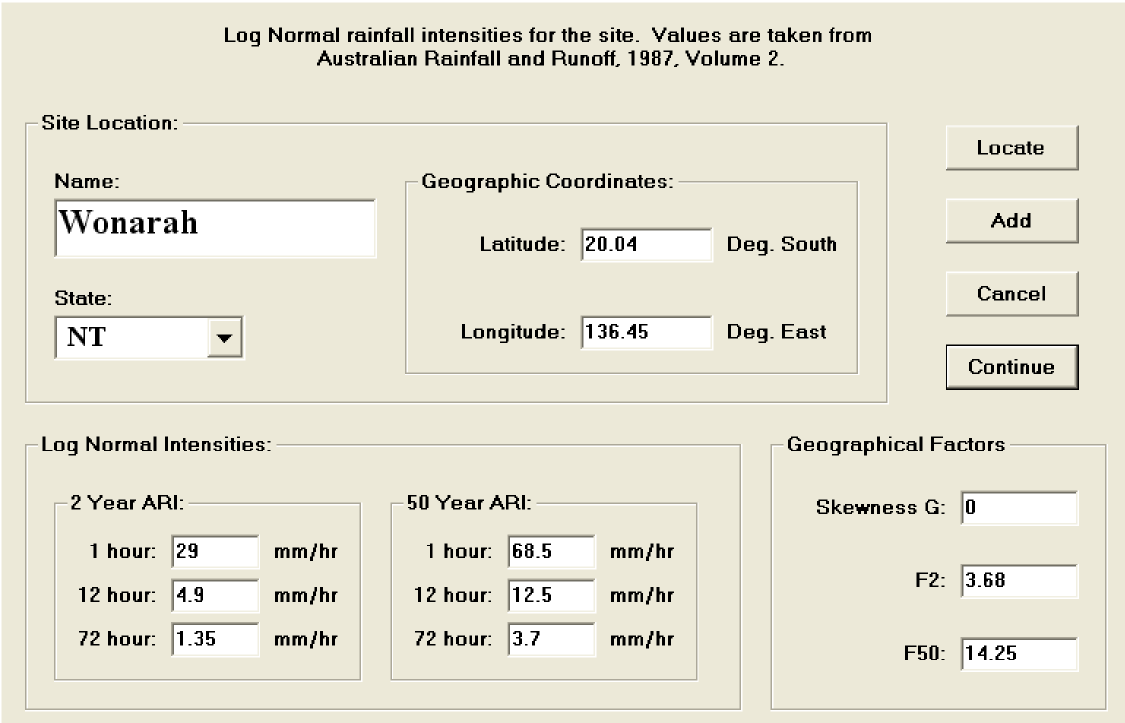
---

[10] Water and Rivers Commission, Western Australia, 2000, *Water Quality Protection Guidelines No. 6, Mining and Mineral Processing Minesite Stormwater*

[11] Institution Of Engineers Of Australia, 1997, Australian Rainfall And Runoff, Volume One, Book Four, Estimation Of Design Peak Discharges.

3.2.1 Intensity-Frequency-Duration Relationship

Point Intensity-Frequency-Duration (IFD) data were developed for Wonarah in accordance with Chapter 2 of ARR97 using the AUS-IFD computer software. The input parameters shown below were selected using Volume 2 of ARR97.



The resulting IFD relationship is presented in Appendix C of this report.

In summary, the 100 Year ARI intensities for 1, 3, 12, 24 and 72 hr duration events are 78.0, 37.2, 14.4, 9.3 and 7.3 mm/hr respectively i.e. giving equivalent storm depths of 78, 112, 173, 223 and 526 mm. An ARI of approximately 100 years could therefore be applied to the maximum regional daily rainfall depth of 215 mm which was recorded at Annitowa on 29 February 200 during TC Steve (refer to Table 8 earlier in report).

4.0 CLOSING REMARKS

A desktop hydro-meteorological study was completed to develop information that may be used in the future analyses and design of water management measures at the Wonarah Project. In particular this information may be used in the design of water management measures required for the proposed development of the initial Arruwurra Prospect.

We trust that this report satisfies Minemakers current requirements and we look forward to discussing the future development of the project with you.

Groundwater Resource Management Pty Ltd

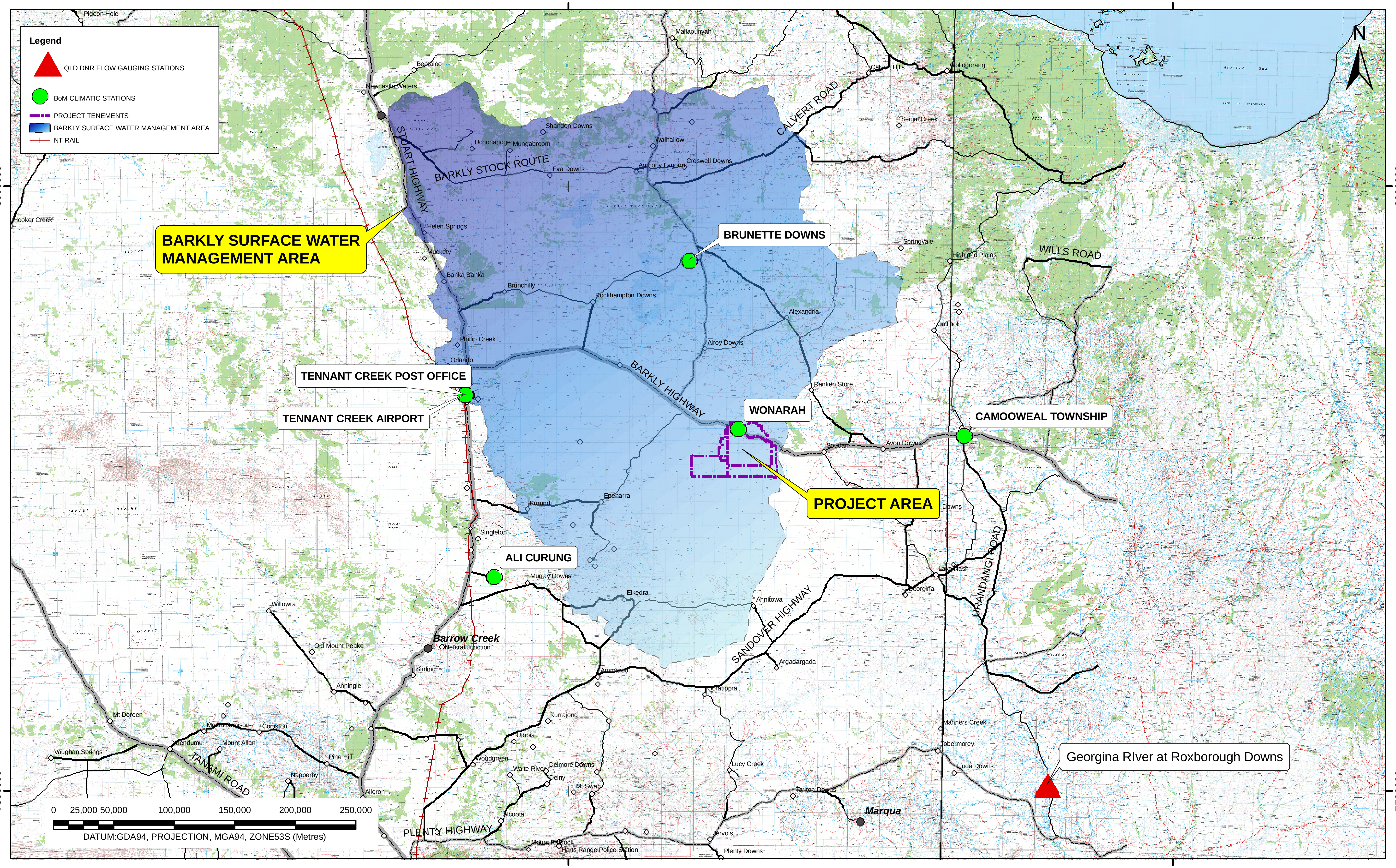
Alistair Lowry R. Garnham

Alistair Lowry **Rob Garnham**

Senior Water Resources Engineer **Principal Hydrogeologist**

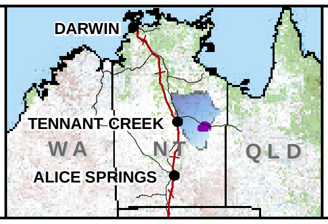
Z:\JOBS2009\J090004_WONARAHSURFACEWATER\REPORT\FINAL\J090004R01\090004R01_FINAL.DOC

This report has been printed on paper that contains a proportion of recycled material as a gesture of Groundwater Resource Management's commitment to sustainable management of the environment.



NOTES:

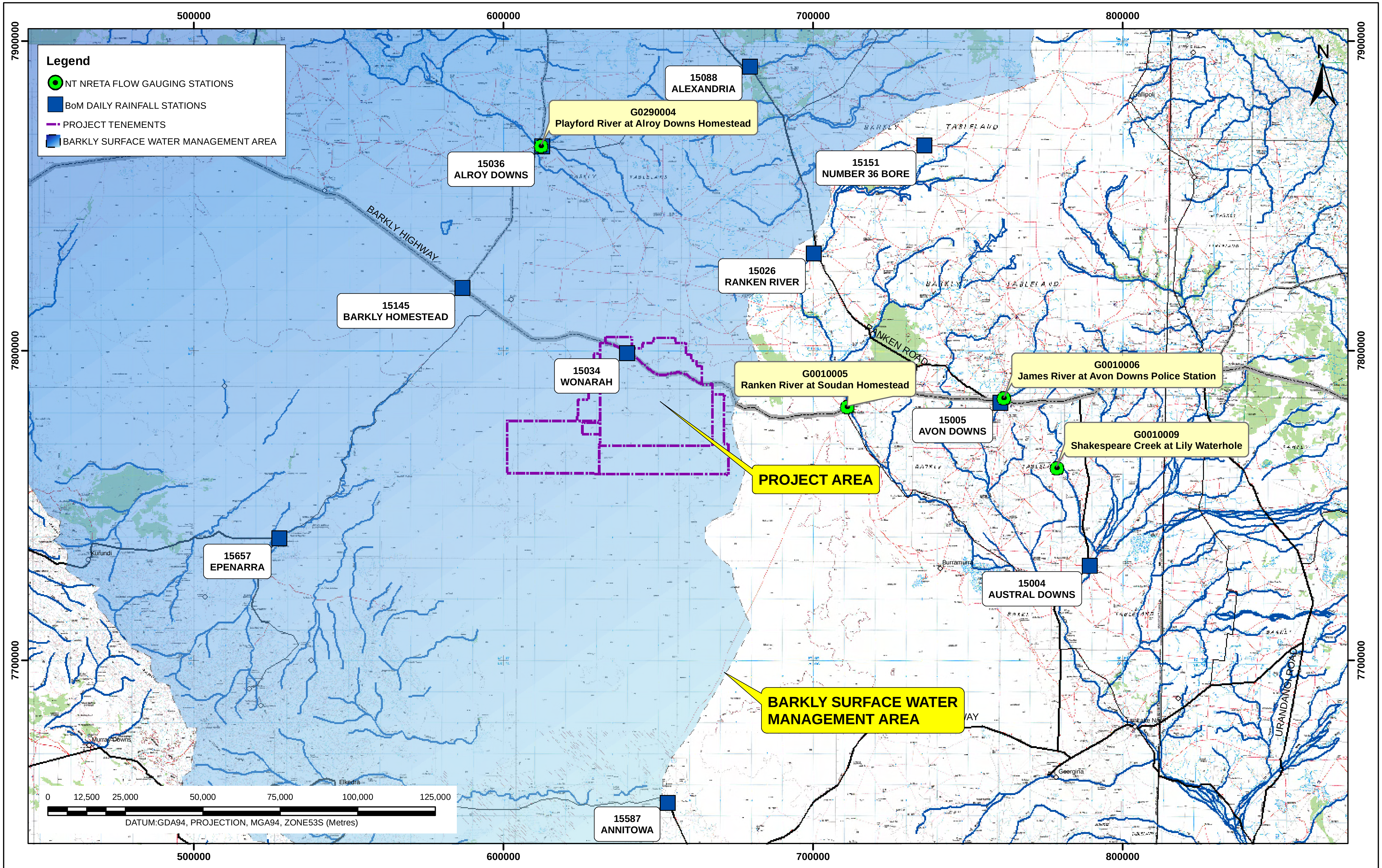
1. BASE MAP SHOWN GEOSCIENCE AUSTRALIA 250K TOPOGRAPHIC MOSIAC



GROUNDWATER RESOURCE MANAGEMENT

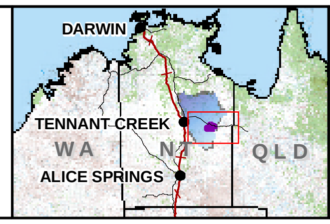
CLIENT: MINEMAKERS LIMITED		PROJECT: WONARAH PROJECT	
DRAWN: DFH	DATE: 28.04.2009	TITLE: REGIONAL SITE LOCATION PLAN	
CHECKED: ARL	DATE: 30.04.2009		
SCALE: 1:3,000,000 @ A3		PROJECT No: J090004	FIGURE No: 1

File Location : I:\CarrickConsulting\J090004_Wonarah_NT\03_ProjectData\01_Workspace



NOTES:

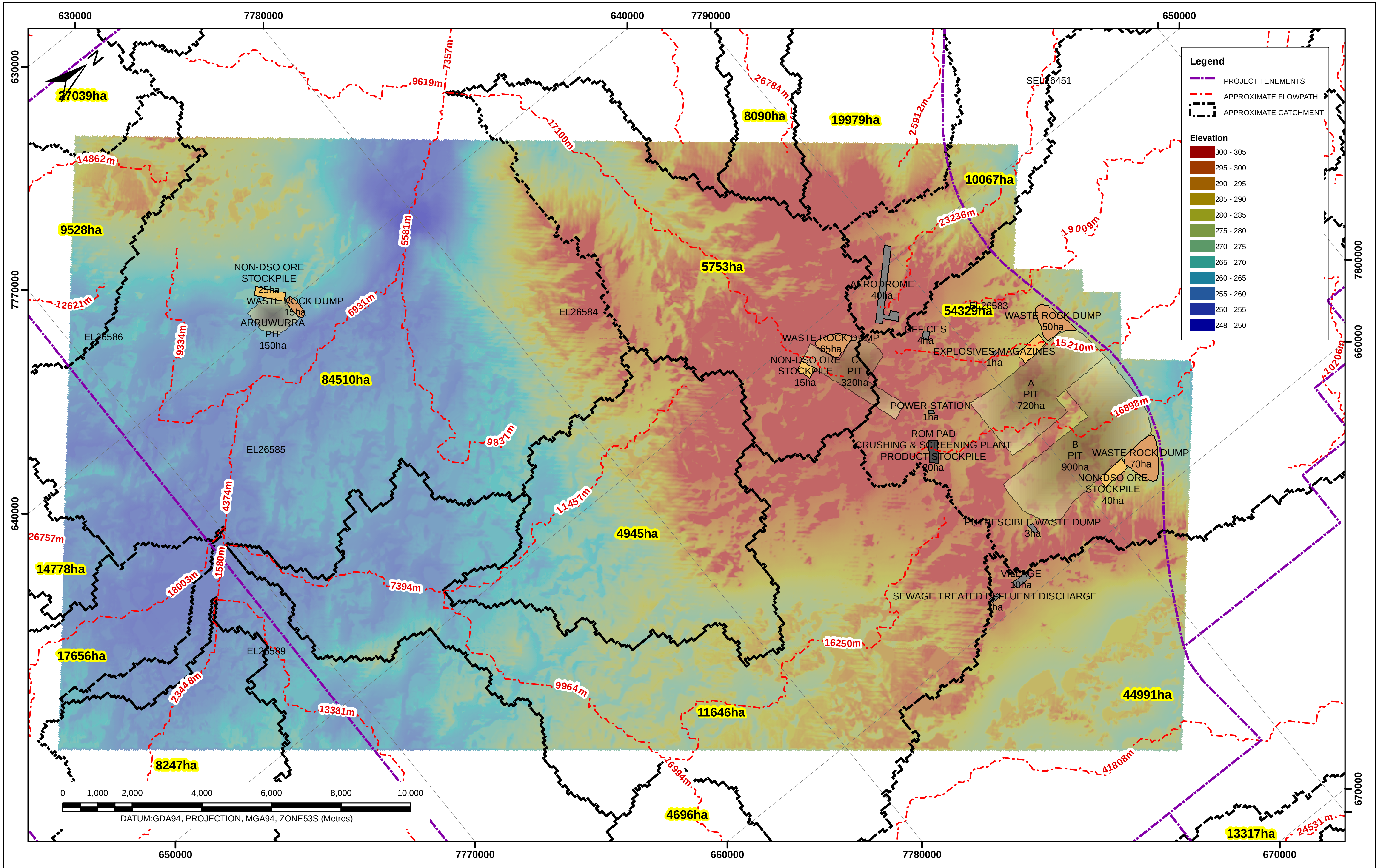
1. BASE MAP SHOWN GEOSCIENCE AUSTRALIA 250K TOPOGRAPHIC MOSIAC



GROUNDWATER
RESOURCE MANAGEMENT

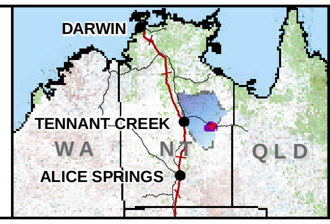
CLIENT MINEMAKERS LIMITED		PROJECT WONARAH PROJECT	
DRAWN DFH	DATE 28.04.2009	TITLE **LOCAL SITE LOCATION PLAN**	
CHECKED ARL	DATE 30.04.2009		
SCALE 1:1,125,000 @ **A3**		PROJECT No J090004	FIGURE No **2**

File Location : I:\CarrickConsulting\J090004_Wonarah_NT\03_ProjectData\01_Workspace



NOTES:

1. ELEVATION TIN, FLOWPATHS AND CATCHMENT AREAS DEVELOPED USING GIS TOOLS TO BE CONFIRMED IN FIELD.



GROUNDWATER RESOURCE MANAGEMENT

CLIENT MINEMAKERS LIMITED		PROJECT WONARAH PROJECT	
DRAWN DFH	DATE 28.04.2009	TITLE LOCAL CATCHMENT DELINEATION PLAN	
CHECKED ARL	DATE 30.04.2009		
SCALE 1:100,000 @ A3		PROJECT No J090004	FIGURE No 3

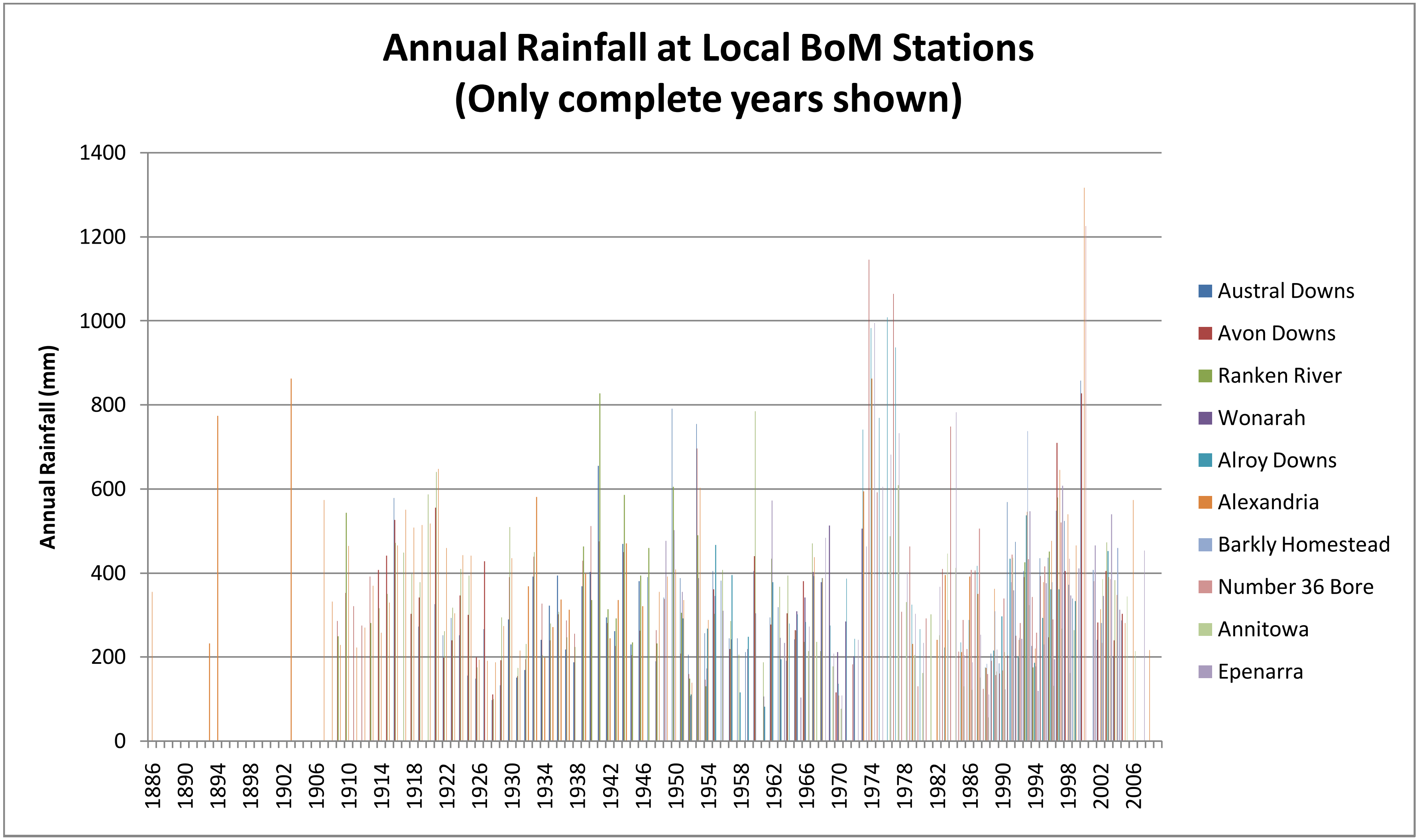
File Location : I:\CarrickConsulting\J090004_Wonarah_NT\03_ProjectData\01_Workspace

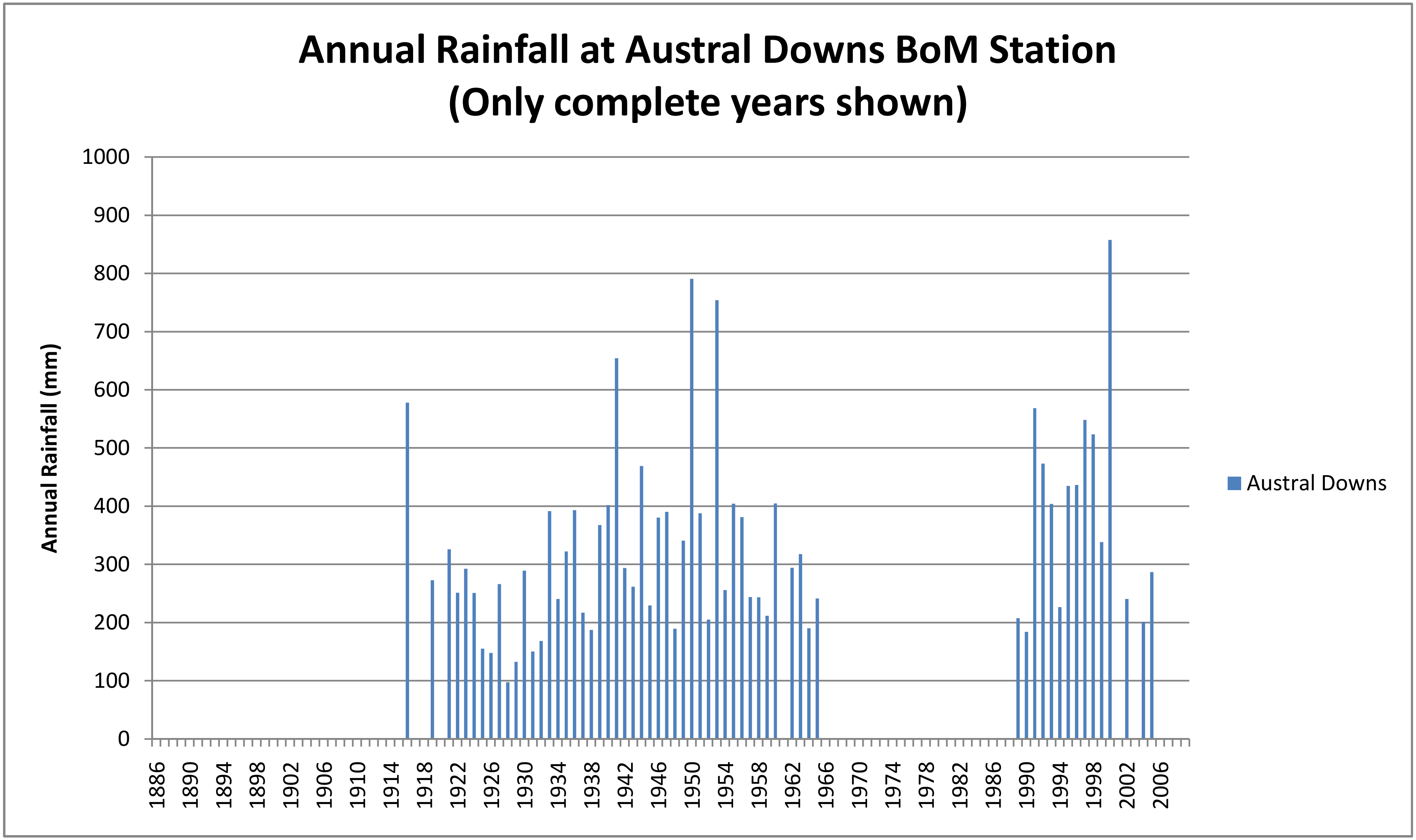
APPENDIX A

Hydro-meteorological Data

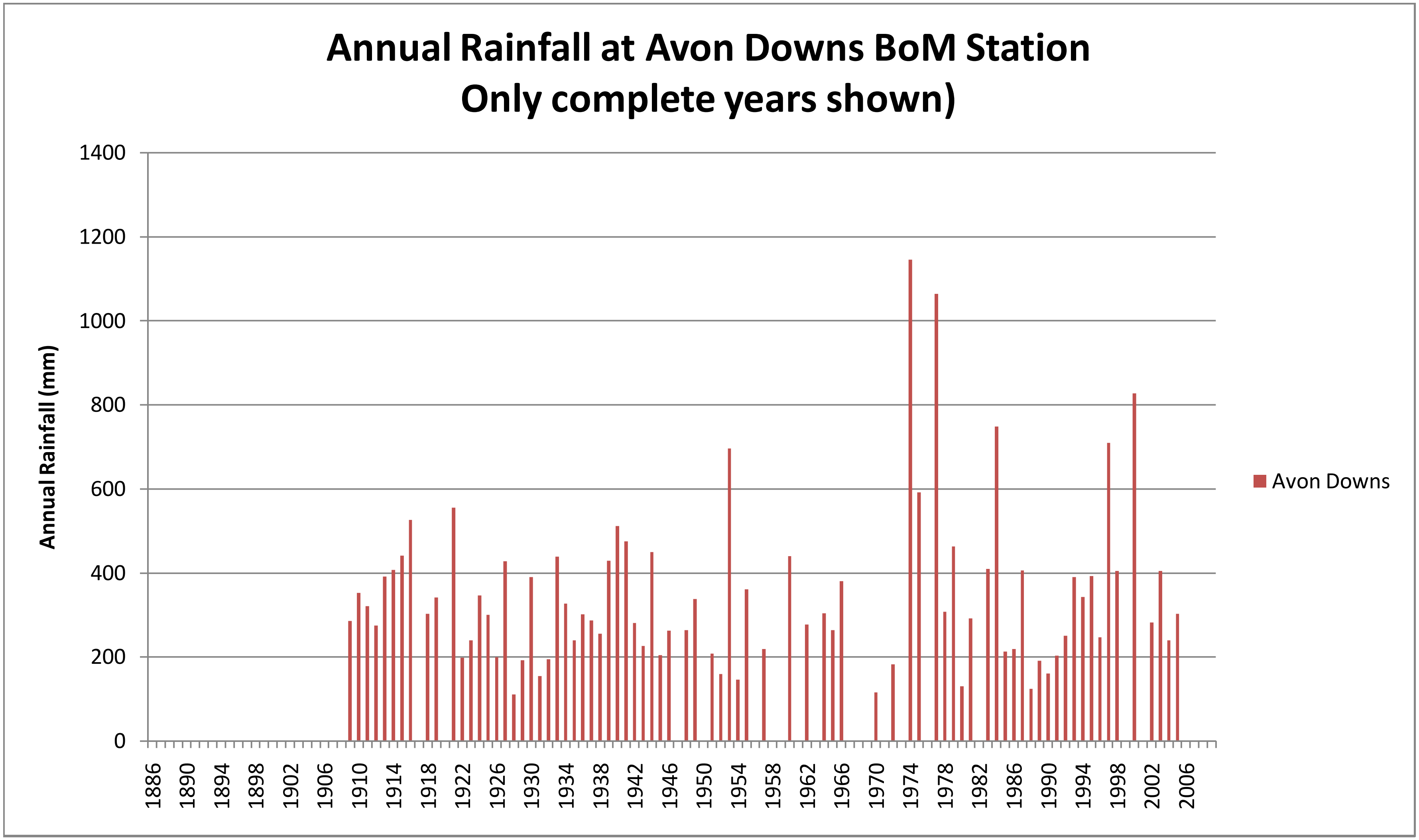
Annual Rainfalls at Local Rainfall Stations (Only complete years considered)										
YEAR	Austral Downs	Avon Downs	Ranken River	Wonarah	Alroy Downs	Alexandria	Barkly Homestead	Number 36 Bore	Annitowa	Epenarra
1886	-	-	-	-	-	354.4	-	-	-	-
1887	-	-	-	-	-	Incomplete	-	-	-	-
1888	-	-	-	-	-	Incomplete	-	-	-	-
1889	-	-	-	-	-	Incomplete	-	-	-	-
1890	-	-	-	-	-	Incomplete	-	-	-	-
1891	-	-	-	-	-	Incomplete	-	-	-	-
1892	-	-	-	-	-	Incomplete	-	-	-	-
1893	-	-	-	-	-	232.6	-	-	-	-
1894	-	-	-	-	-	774.7	-	-	-	-
1895	-	-	-	-	-	Incomplete	-	-	-	-
1896	-	-	-	-	-	Incomplete	-	-	-	-
1897	-	-	-	-	-	Incomplete	-	-	-	-
1898	-	-	-	-	-	Incomplete	-	-	-	-
1899	-	-	-	-	-	Incomplete	-	-	-	-
1900	-	-	-	-	-	Incomplete	-	-	-	-
1901	-	-	-	-	-	Incomplete	-	-	-	-
1902	-	-	-	-	-	Incomplete	-	-	-	-
1903	-	-	-	-	-	863.2	-	-	-	-
1904	-	-	-	-	-	Incomplete	-	-	-	-
1905	-	-	-	-	-	Incomplete	-	-	-	-
1906	-	-	-	-	-	Incomplete	-	-	-	-
1907	-	-	-	-	-	573.5	-	-	-	-
1908	-	-	-	-	-	331.4	-	-	-	-
1909	-	285.4	249	-	-	228.2	-	-	-	-
1910	-	352.5	542.8	-	-	463.7	-	-	-	-
1911	-	321.4	Incomplete	-	-	223	-	-	-	-
1912	-	274.7	Incomplete	-	-	269.2	-	-	-	-
1913	-	390.8	280.2	-	-	369.7	-	-	-	-
1914	Incomplete	407.6	316.5	-	-	257.8	-	-	-	-
1915	Incomplete	440.9	349.9	-	-	329.7	-	-	-	-
1916	578.3	526.4	472.1	-	-	465.8	-	-	-	-
1917	Incomplete	Incomplete	448.8	-	-	551.1	-	-	-	-
1918	Incomplete	302.2	397.1	-	-	508.2	-	-	-	-
1919	272.8	341.6	378.4	-	-	514.5	-	-	-	-
1920	Incomplete	Incomplete	586.6	-	-	518	-	-	-	-
1921	326.3	555.3	639.9	-	-	647.5	-	-	-	-
1922	251.4	197.7	261.5	-	-	459.7	-	-	-	-
1923	292.6	239.1	317.3	-	-	303.5	-	-	-	-
1924	251.2	346.2	409.4	-	-	442.9	-	-	-	-
1925	155.5	300.5	393.9	-	-	440.6	-	-	-	-
1926	147.9	199.2	174.5	-	-	193.4	-	-	-	-
1927	266.4	427.7	Incomplete	-	-	190.7	-	-	-	-
1928	97.8	111.1	100.1	-	-	187.6	-	-	-	-
1929	132.8	192.2	294.4	-	-	273.5	-	-	-	-
1930	289.3	390.5	508.9	-	-	435.2	-	-	-	-
1931	150.6	154.8	173.8	-	-	215.4	-	-	-	-
1932	168.7	194.7	231.2	-	-	367.7	-	-	-	-
1933	391.8	439	449.1	-	-	581.4	-	-	-	-
1934	241	327.3	203.9	-	-	198.6	-	-	-	-
1935	322.3	238.9	279.2	-	-	270.6	-	-	-	-
1936	393.6	300.8	307.3	-	-	337.1	-	-	-	-
1937	217.2	286.8	247.1	-	-	311.8	-	-	-	-
1938	187.6	254.8	224.1	-	-	Incomplete	-	-	-	-
1939	367.7	428.8	463.4	-	-	398.5	-	-	-	-
1940	402.1	512.1	335.6	-	-	Incomplete	-	-	-	-
1941	654.5	475.6	827.9	-	-	Incomplete	-	-	-	-
1942	293.9	281.1	314.1	-	-	244.2	-	-	-	-
1943	261.7	226.5	292.1	-	-	335.2	-	-	-	-
1944	469.1	449.2	585.9	-	-	470.8	-	-	-	-
1945	229.6	203.8	234.5	-	-	Incomplete	-	-	-	-
1946	380.7	262.5	393.8	Incomplete	-	321	-	-	-	-
1947	390.4	Incomplete	459.6	Incomplete	-	Incomplete	-	-	-	-

YEAR	Austral Downs	Avon Downs	Ranken River	Wonarah	Alroy Downs	Alexandria	Barkly Homestead	Number 36 Bore	Annitowa	Epenarra
1948	189.6	263.9	232.7	Incomplete	-	355.3	-	-	-	-
1949	341.1	337.5	Incomplete	476.6	-	390.8	-	-	-	-
1950	791	Incomplete	604.9	501.7	Incomplete	408	-	-	-	-
1951	388.2	207.9	304.5	354.7	291.4	335.4	-	-	-	-
1952	205.3	158.6	148.5	107.4	110.8	138.6	-	-	-	-
1953	754.1	695.9	489.8	387.3	Incomplete	602.4	-	-	-	-
1954	256.1	145.8	129.6	172.6	266.8	288.1	-	-	-	-
1955	404.5	360.8	302.6	345.3	466.7	Incomplete	-	-	-	-
1956	381.6	Incomplete	407.6	309.7	Incomplete	Incomplete	-	-	-	-
1957	244.1	218.8	285	242.3	394.4	Incomplete	-	-	-	-
1958	243.8	Incomplete	205.4	Incomplete	115.6	Incomplete	-	-	-	-
1959	211.9	Incomplete	Incomplete	219.2	248.2	Incomplete	-	-	-	-
1960	404.9	439.8	784.7	304.1	Incomplete	Incomplete	-	-	-	-
1961	Incomplete	Incomplete	187.2	106.2	81.5	Incomplete	-	-	-	-
1962	294.5	277.4	433.8	572.2	377.8	Missing	-	-	-	-
1963	318.1	Incomplete	367.3	246	194.2	Missing	-	-	-	232.9
1964	190.5	303.9	394	Incomplete	279	Incomplete	-	-	-	Missing
1965	241.8	263.9	261.9	308.3	301.3	Incomplete	-	-	-	103.9
1966	Incomplete	380	235.6	341.1	283.6	Missing	-	-	213.9	271.9
1967	Missing	Incomplete	470.4	402	392.1	437	-	-	236.2	Incomplete
1968	Missing	Missing	213.4	378.4	387.7	387.6	-	-	Incomplete	483.5
1969	Missing	Incomplete	Incomplete	512.8	274.1	Incomplete	-	-	177.6	207.9
1970	Missing	116	Missing	212	136.7	108.6	-	-	76.8	108.2
1971	Missing	Incomplete	Missing	284.2	385.9	Incomplete	-	-	Incomplete	Incomplete
1972	Missing	182.8	Missing	202	242.5	Incomplete	-	-	Missing	240.1
1973	Missing	Incomplete	Missing	506.1	741	594.2	-	-	Incomplete	463.6
1974	Missing	1145.4	Missing	Incomplete	982.7	863	-	-	Incomplete	995.2
1975	Missing	591.3	Missing	Closed	769.2	Incomplete	-	-	Incomplete	605.6
1976	Missing	Incomplete	Missing	Closed	1008.9	Incomplete	-	-	487.2	681.2
1977	Missing	1064.9	Missing	Closed	936.6	Incomplete	-	-	609.4	733.2
1978	Missing	307.8	Missing	Closed	Incomplete	Incomplete	-	-	330.8	402.1
1979	Missing	463.2	Missing	Closed	325	230.5	-	-	204	302.5
1980	Missing	129.5	Missing	Closed	265.8	Incomplete	-	-	161.6	232.8
1981	Missing	291.6	Missing	Closed	Incomplete	Incomplete	-	-	300.8	Incomplete
1982	Missing	Incomplete	Missing	Closed	Incomplete	241	-	Incomplete	251	367
1983	Missing	409.6	Missing	Closed	223	394.6	-	Incomplete	446.6	287.9
1984	Incomplete	749	Missing	Closed	Incomplete	Incomplete	-	Incomplete	412.5	782.6
1985	Missing	213.2	Missing	Closed	234.3	211.7	-	288.2	130.4	204.2
1986	Missing	218.6	Missing	Closed	288.2	391.8	-	406.6	121	187.3
1987	Missing	405.8	Missing	Closed	417.4	349.4	Incomplete	505.6	150.2	253
1988	Missing	124	Missing	Closed	175.6	173.2	184.1	159.8	56.2	110.5
1989	207.9	191	Missing	Closed	214.6	362	309	157.2	165.6	218
1990	184.4	161	Missing	Closed	296.2	167.8	Missing	338.5	211.7	122.9
1991	568.8	203	Missing	Closed	434.3	Incomplete	378.4	444	436.1	358.2
1992	473.4	249.9	Incomplete	Closed	201.8	241	245	280.2	Incomplete	242.6
1993	404.1	389.6	424.9	Closed	536.6	545.9	737.3	433.2	323.2	546.8
1994	226.6	342.7	175.5	Closed	186	219.5	177.2	257.9	Incomplete	119
1995	435	393.1	Incomplete	Closed	293	377.6	229.7	416.2	Incomplete	375.3
1996	436.5	246.2	450.3	Closed	360.5	476.9	377.6	289.4	131.1	194.4
1997	548.3	709.8	579.2	Closed	361	645.9	Incomplete	520	267	607.4
1998	523.6	404.4	Incomplete	Closed	Incomplete	539.8	371.8	434.3	162	346.4
1999	338.7	Incomplete	263.4	Closed	332.5	464.9	Incomplete	Incomplete	Incomplete	411
2000	857.9	827.6	Incomplete	Closed	Incomplete	1317.1	Incomplete	1226.8	Incomplete	Incomplete
2001	Incomplete	Incomplete	Incomplete	Closed	Incomplete	Incomplete	406.7	379.9	Incomplete	465.6
2002	240.7	281.5	Incomplete	Closed	Incomplete	313.3	280.2	233.3	385	345.4
2003	Incomplete	404.2	472.3	Closed	451.5	390.3	Incomplete	385.5	203.5	539.9
2004	201.6	239.1	382.6	Closed	Incomplete	347.4	459.9	Incomplete	Incomplete	312.4
2005	287	303.1	Incomplete	Closed	Missing	281.2	Incomplete	Incomplete	344.5	Incomplete
2006	Incomplete	Incomplete	Incomplete	Closed	Missing	574	Incomplete	Incomplete	214	Incomplete
2007	Incomplete	Incomplete	Missing	Closed	Missing	Incomplete	Incomplete	Incomplete	Missing	453.3
2008	Missing	Missing	Missing	Closed	Missing	216.7	Missing	Incomplete	Incomplete	Missing
2009	Incomplete	Missing	Missing	Closed	Missing	Incomplete	Missing	Incomplete	Missing	Missing

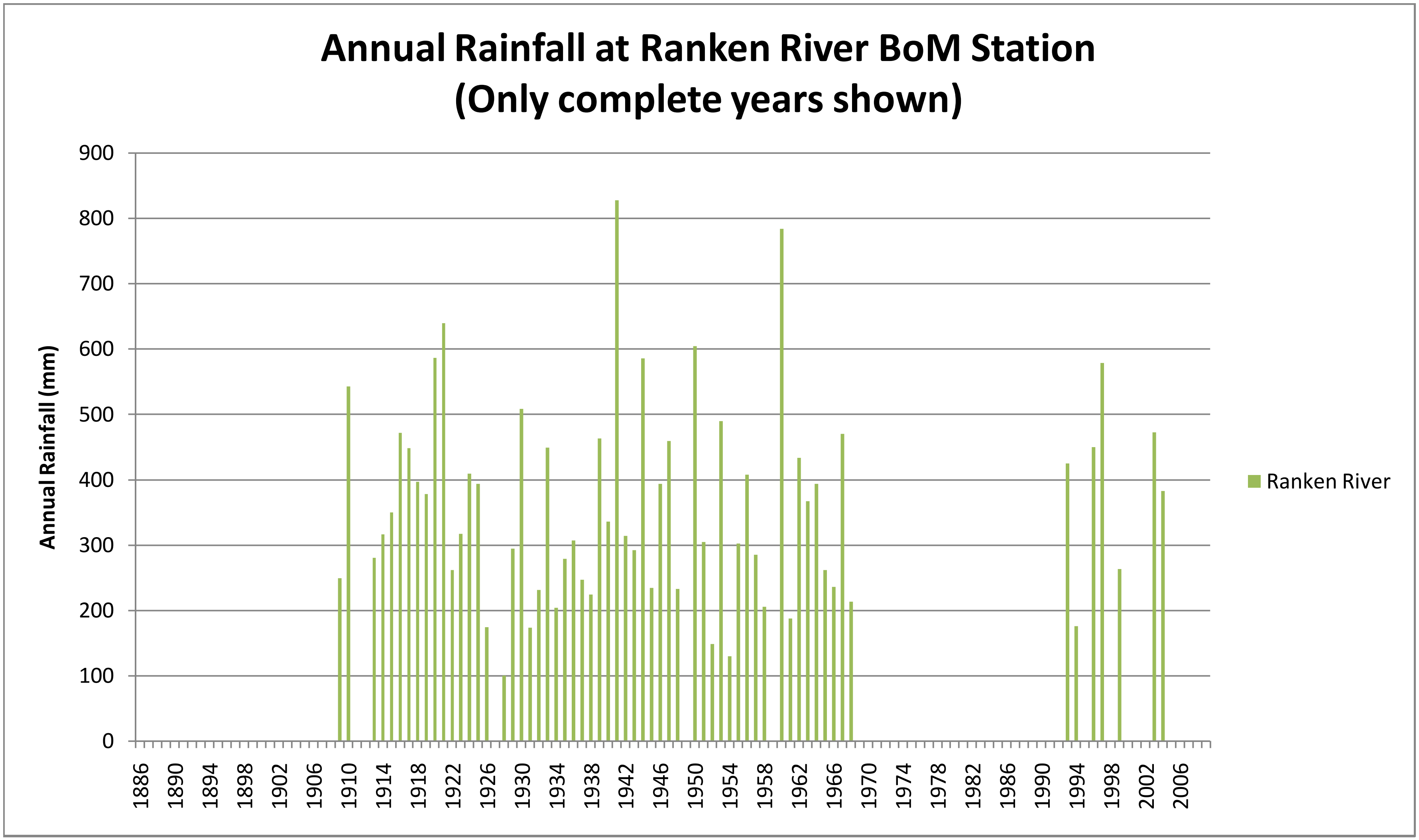

Annual Rainfall at Local BoM Stations
(Only complete years shown)
Annual Rainfall (mm)
1400
1200
1000
800
600
400
200
0
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Austral Downs
Avon Downs
Ranken River
Wonarah
Alroy Downs
Alexandria
Barkly Homestead
Number 36 Bore
Annitowa
Epenarra

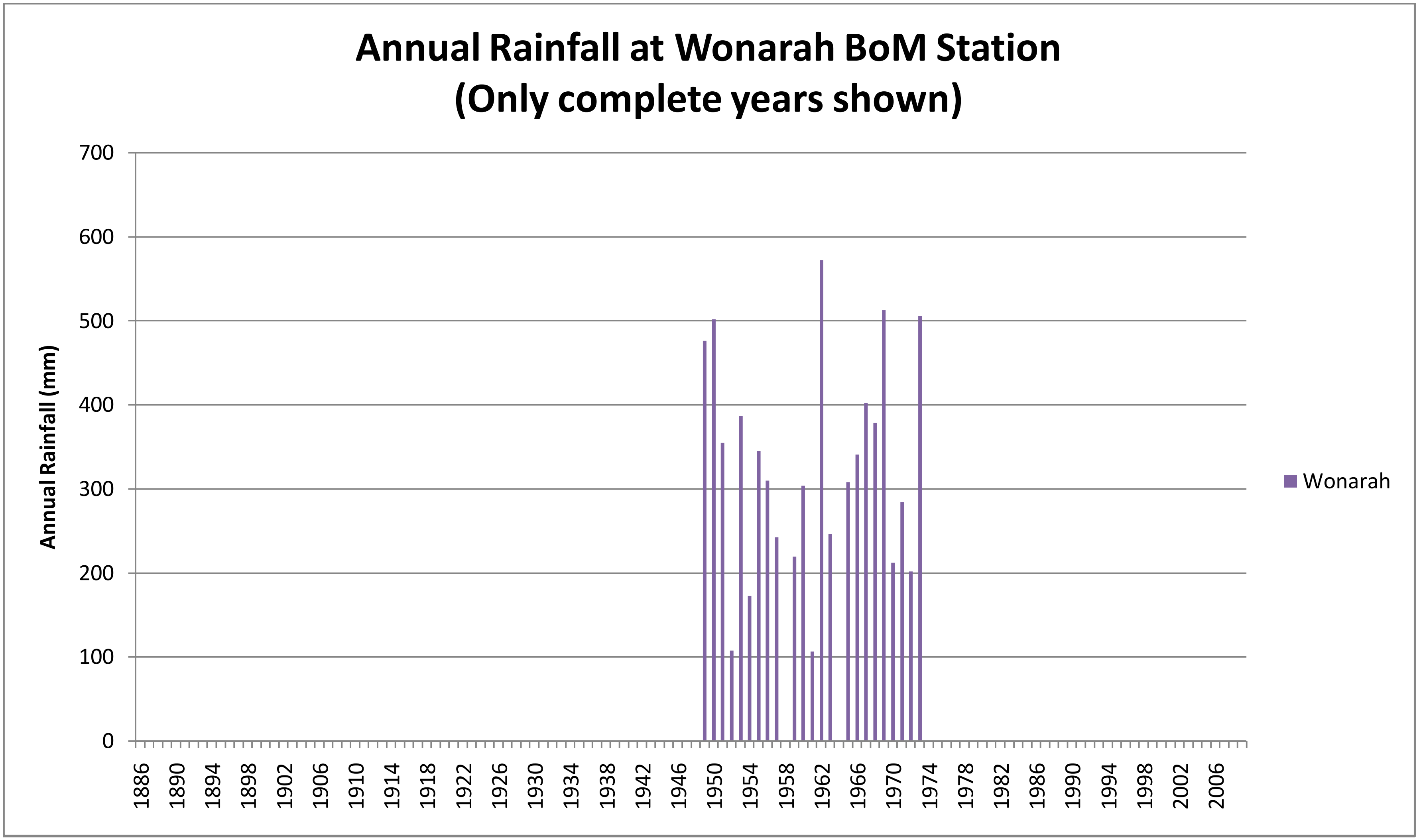


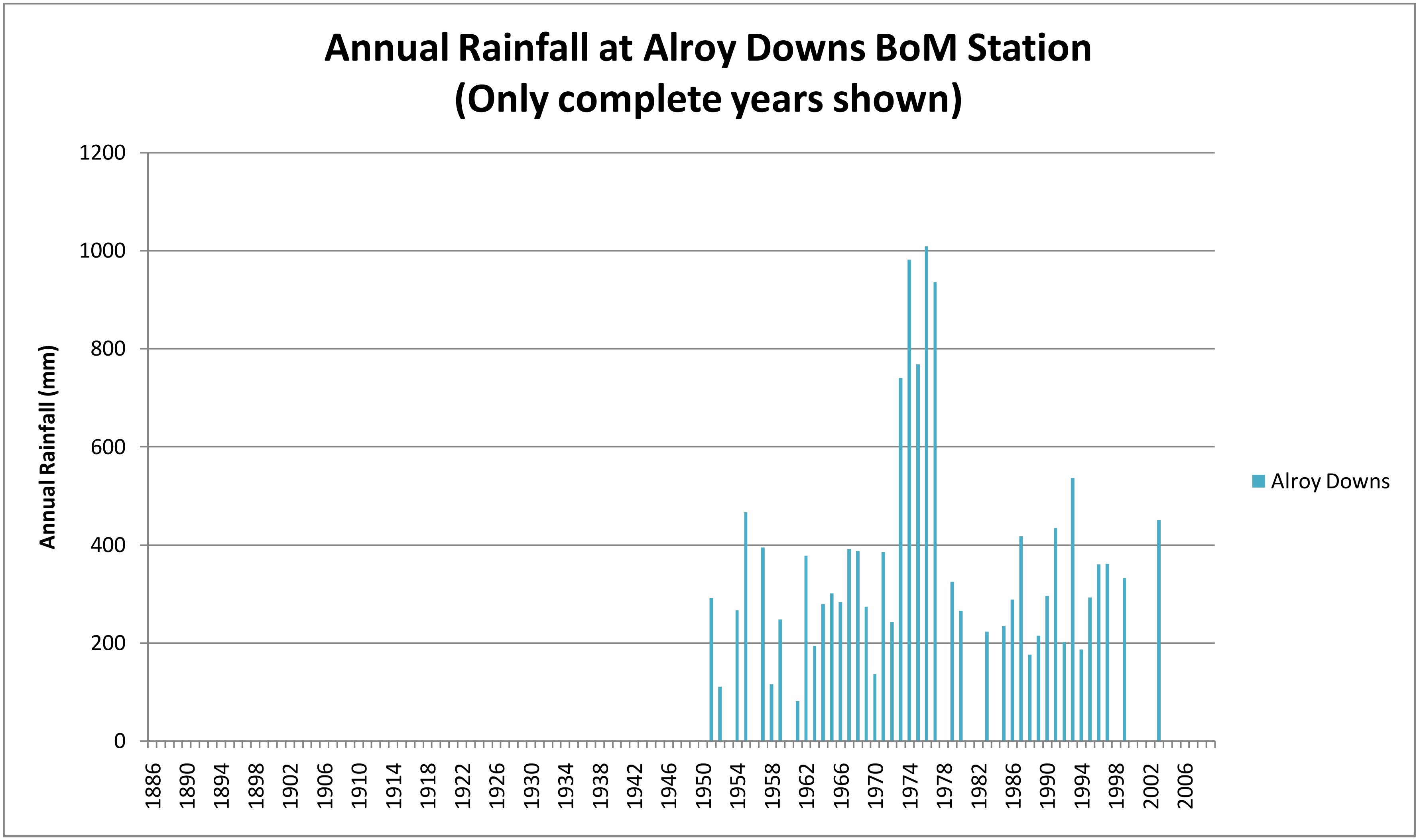
Annual Rainfall at Austral Downs BoM Station
(Only complete years shown)
Annual Rainfall (mm)
0
100
200
300
400
500
600
700
800
900
1000
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Austral Downs



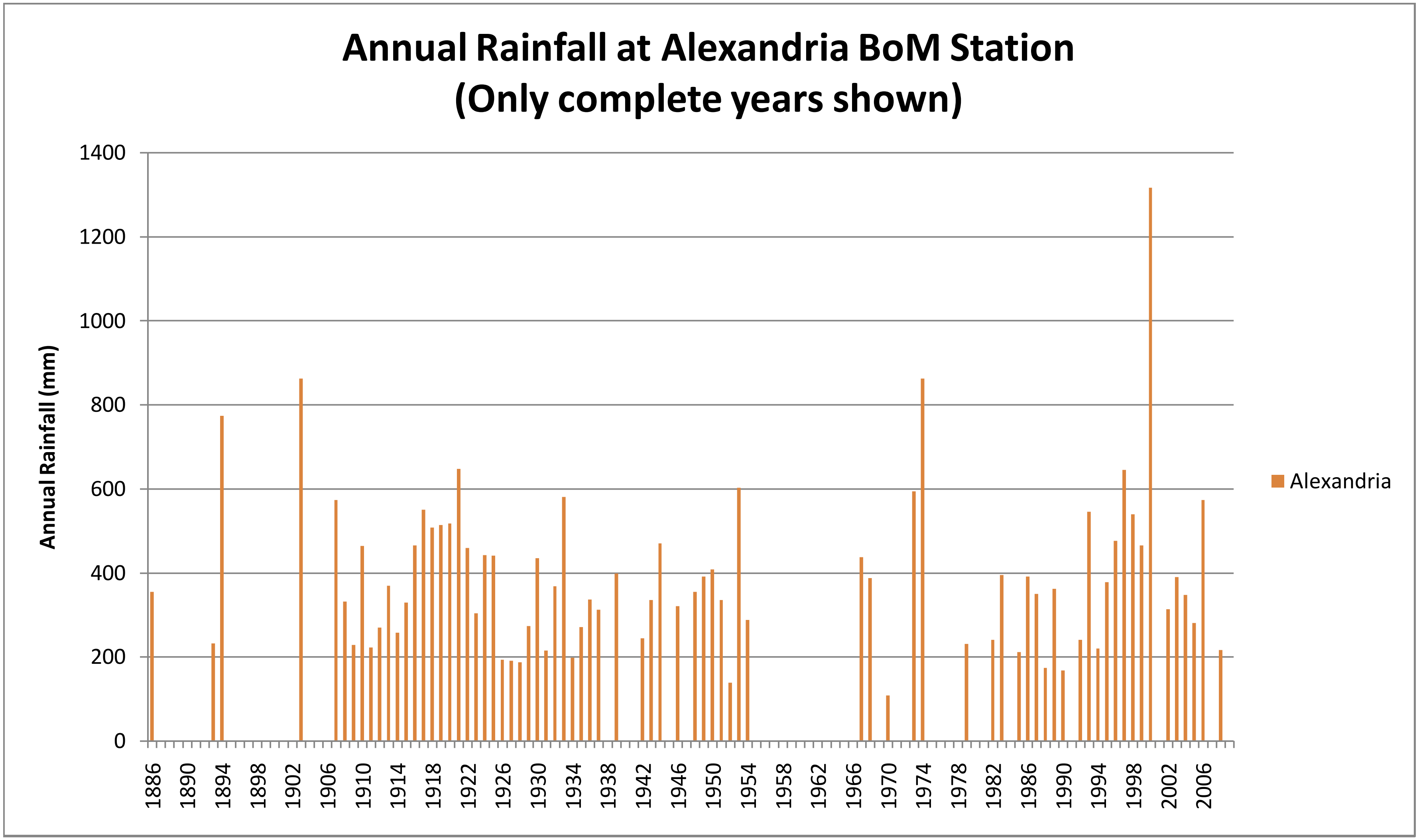
Annual Rainfall at Avon Downs BoM Station
Only complete years shown)
Annual Rainfall (mm)
1400
1200
1000
800
600
400
200
0
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Avon Downs

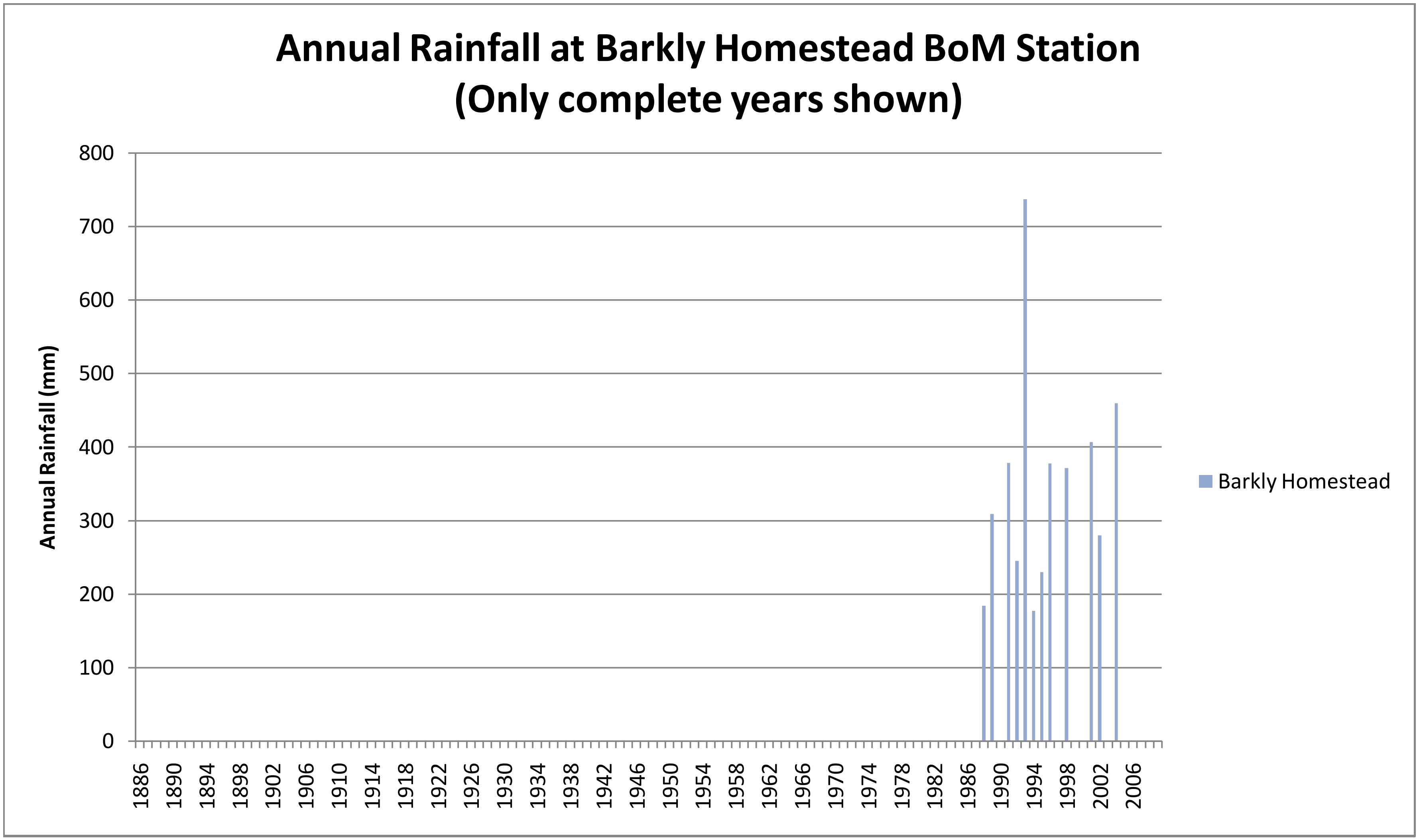

Annual Rainfall at Ranken River BoM Station
(Only complete years shown)
Annual Rainfall (mm)
Ranken River
0
100
200
300
400
500
600
700
800
900
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006


Annual Rainfall at Wonarah BoM Station
(Only complete years shown)
Annual Rainfall (mm)
700
600
500
400
300
200
100
0
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Wonarah

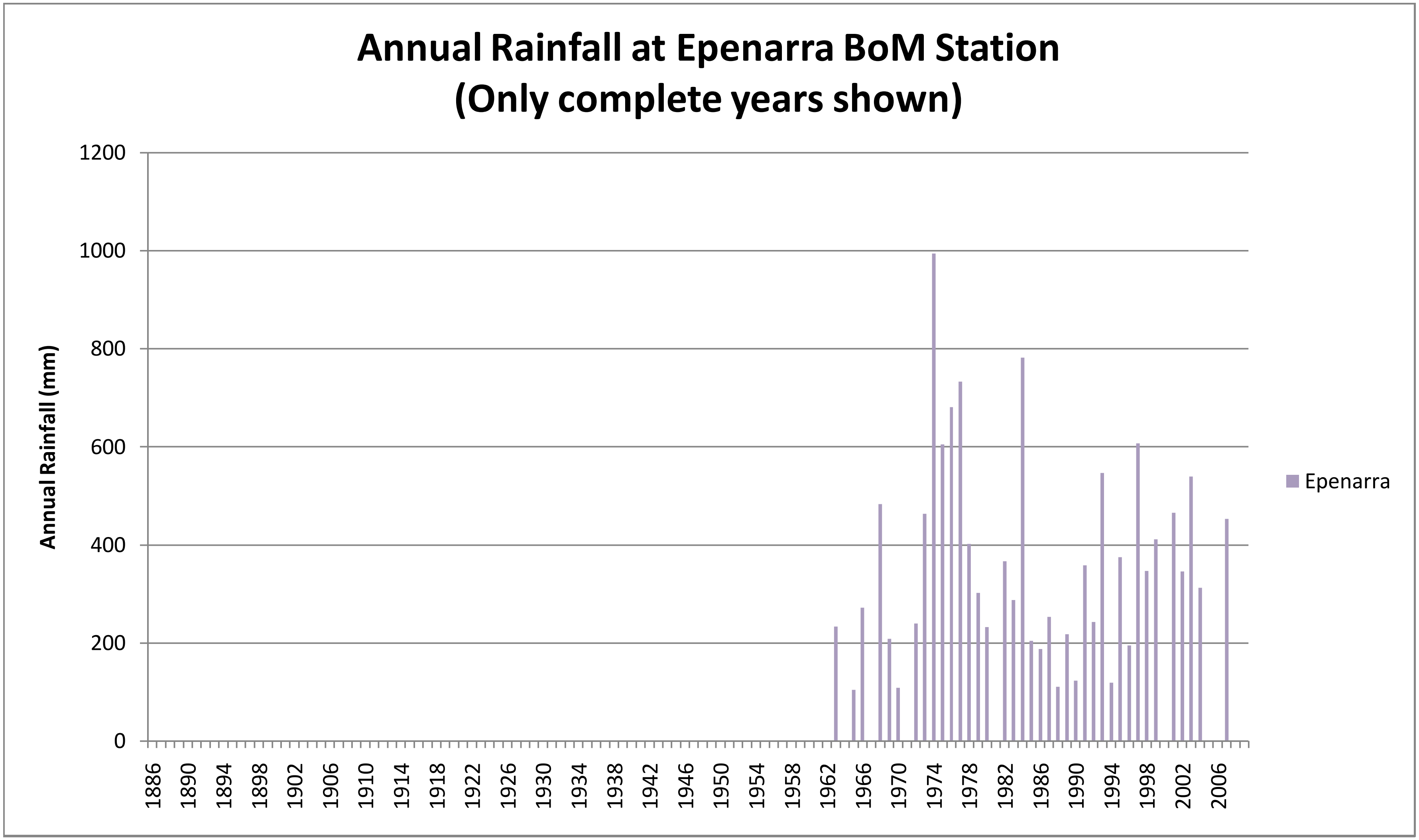


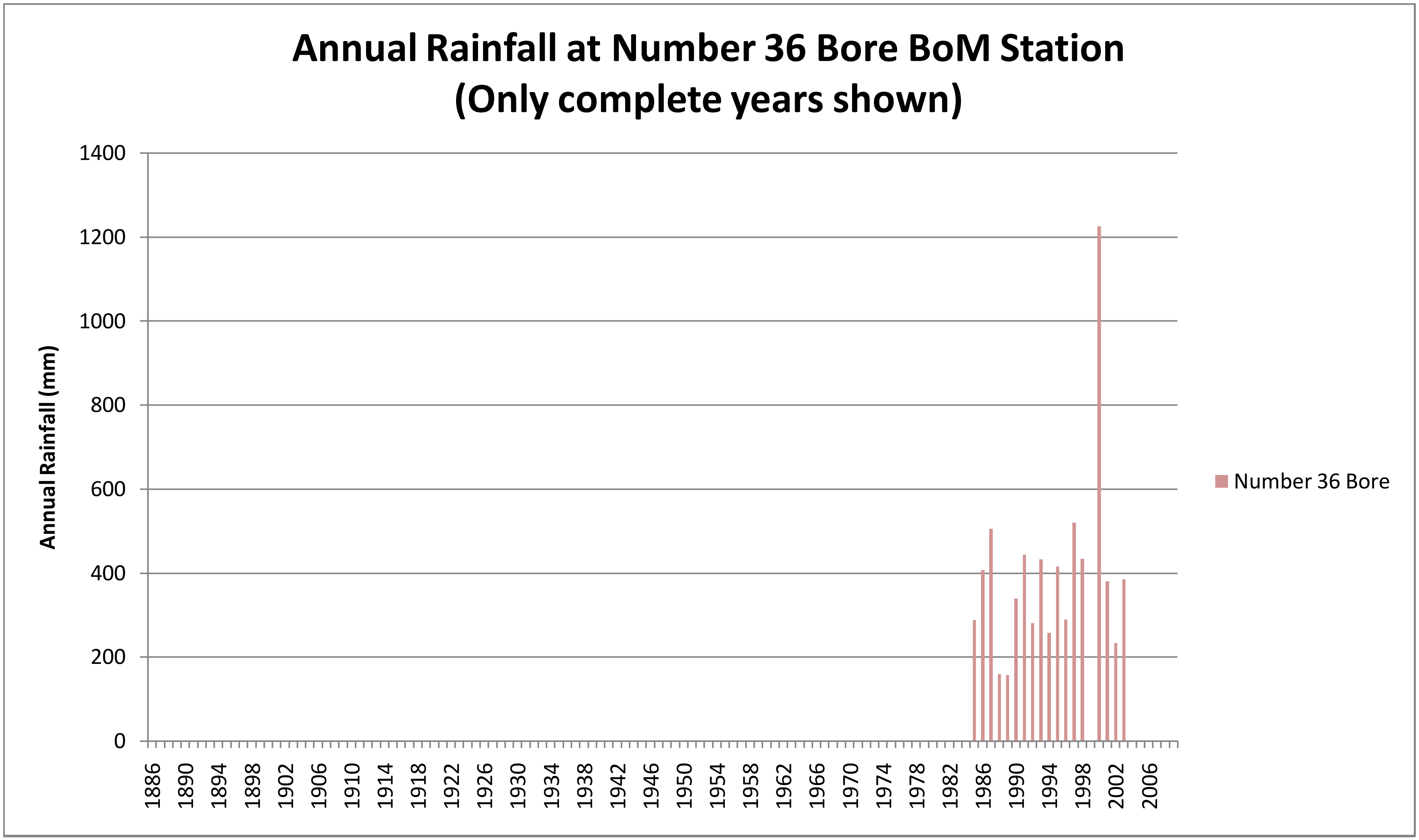
Annual Rainfall at Alroy Downs BoM Station
(Only complete years shown)
Annual Rainfall (mm)
1200
1000
800
600
400
200
0
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Alroy Downs

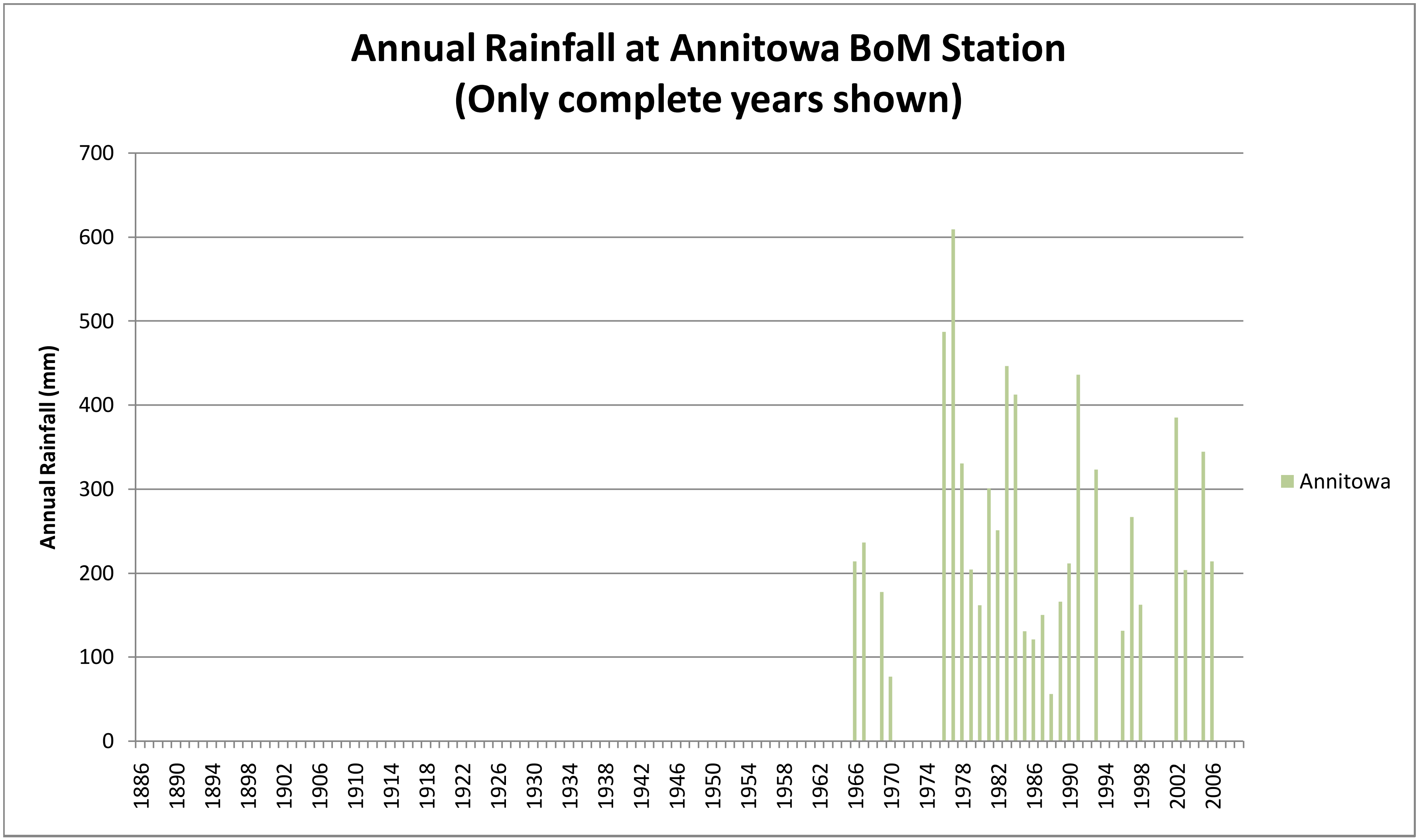

Annual Rainfall at Alexandria BoM Station
(Only complete years shown)
Annual Rainfall (mm)
0
200
400
600
800
1000
1200
1400
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Alexandria



Annual Rainfall at Barkly Homestead BoM Station
(Only complete years shown)
Annual Rainfall (mm)
800
700
600
500
400
300
200
100
0
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Barkly Homestead


Annual Rainfall at Epenarra BoM Station
(Only complete years shown)
Annual Rainfall (mm)
1200
1000
800
600
400
200
0
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Epenarra


Annual Rainfall at Number 36 Bore BoM Station
(Only complete years shown)
Annual Rainfall (mm)
1400
1200
1000
800
600
400
200
0
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Number 36 Bore



Annual Rainfall at Annitowa BoM Station
(Only complete years shown)
Annual Rainfall (mm)
0
100
200
300
400
500
600
700
1886
1890
1894
1898
1902
1906
1910
1914
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Annitowa

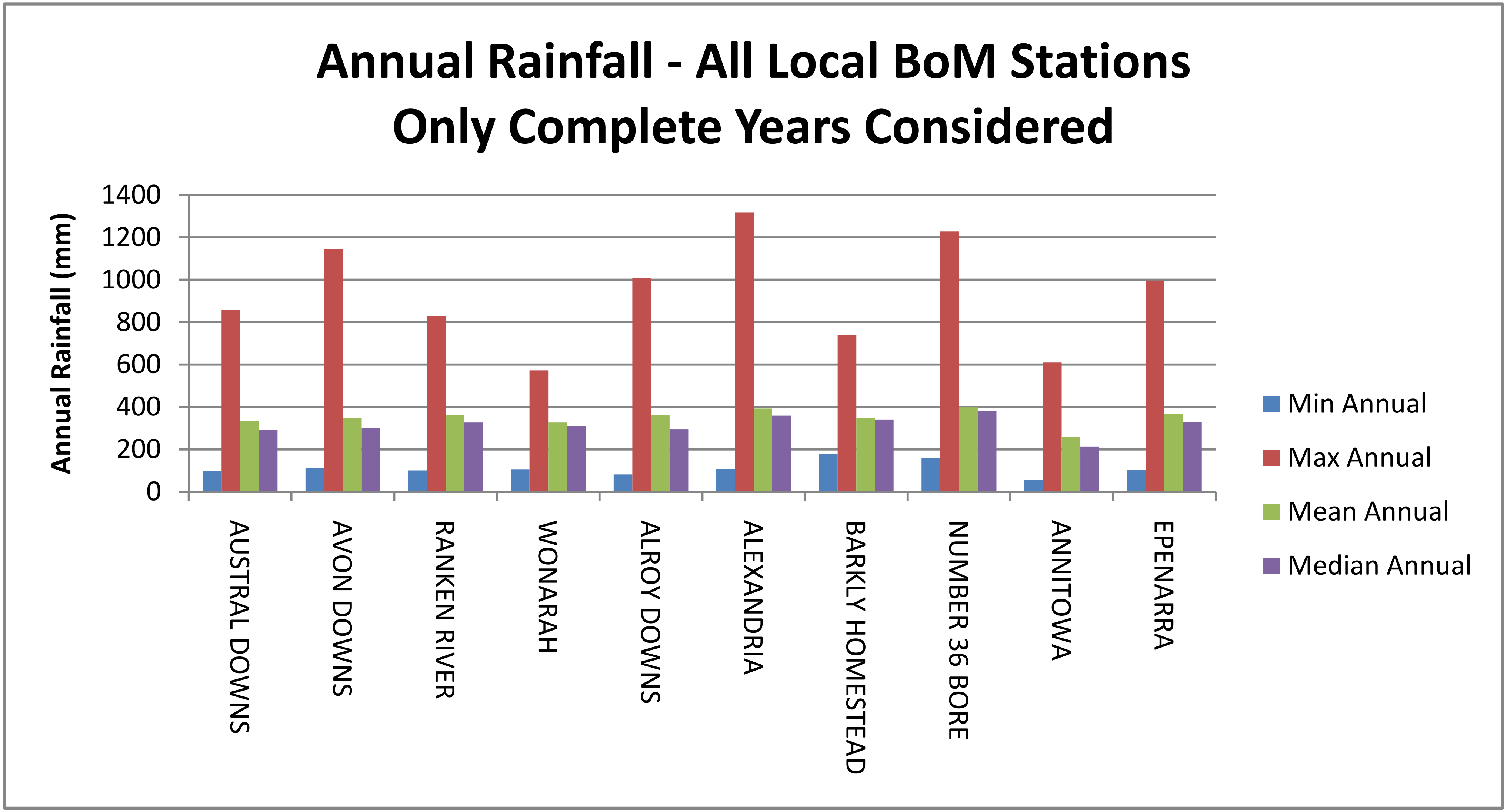
Monthly and Annual Rainfall Values

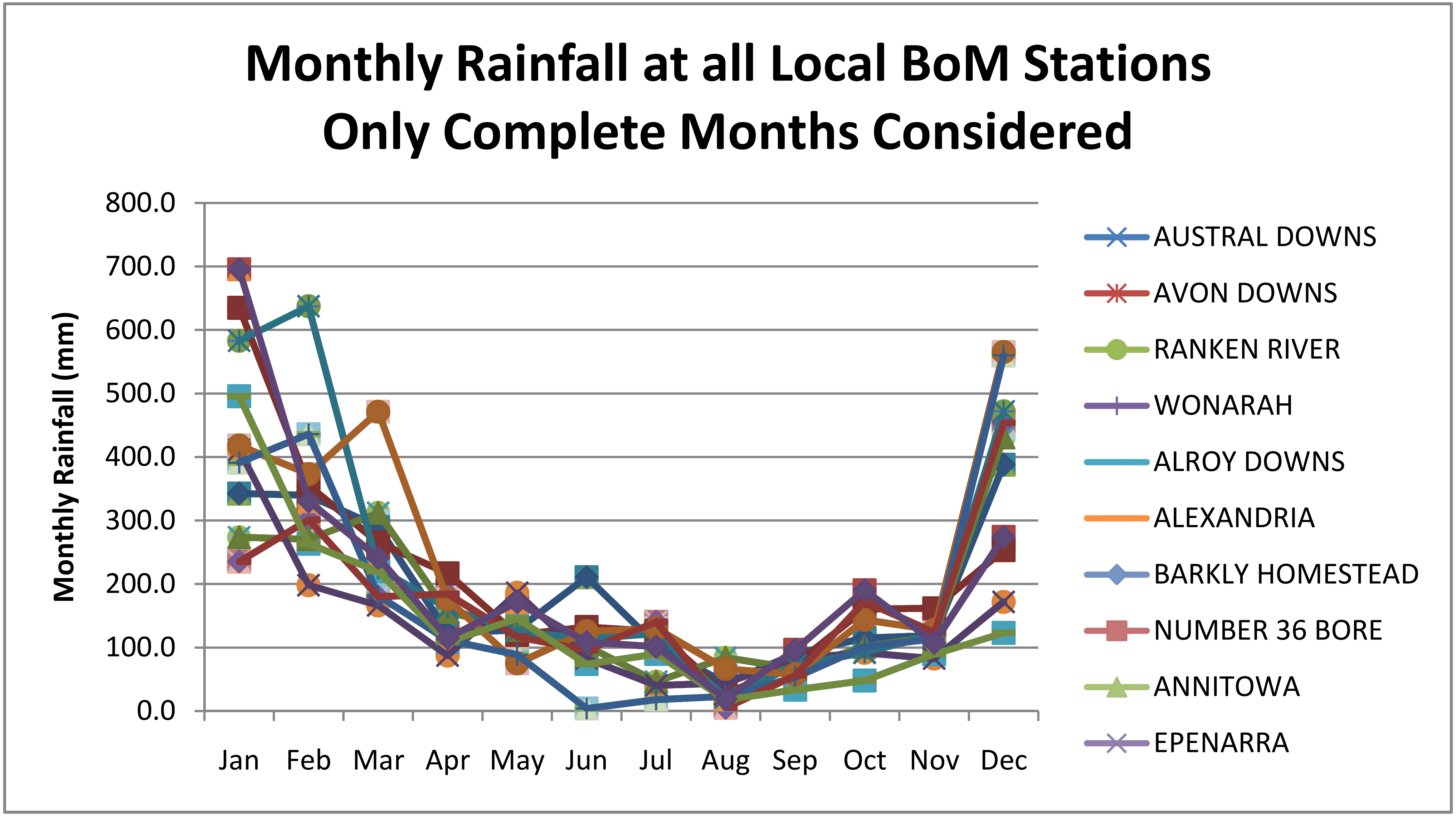
for Local Rainfall stations (all within 150 km of Site)

	Local BoM Rainfall Stations[1,2]																											
	AUSTRAL DOWNS			**AVON DOWNS**			**RANKEN RIVER**			**WONARAH**			**ALROY DOWNS**			**ALEXANDRIA**			**BARKLY HOMESTEAD**			**NUMBER 36 BORE**			**ANNITOWA**			
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Jan	0	342.5	70.3	0	635.0	87.7	5.0	273.6	85.6	0.8	411.4	73.4	0	583.0	93.9	0	418.1	94.4	4.1	391.1	109.1	0	235.3	90.3	0	495.6	74.1	0
Feb	0	339.6	86.6	0	355.2	81.1	0	270.6	82.9	3.6	198.3	61.0	0	637.4	107.4	0	373.1	92.3	0.0	436.0	98.6	0	301.2	82.8	0	263.4	69.1	0
Mar	0	289.9	39.3	0	265.5	46.2	0	312.0	46.1	0	166.4	48.4	0	224.9	48.0	0	471.4	56.7	0.0	181.8	36.3	0	180.0	51.3	0	220.2	22.1	0
Apr	0	123.0	11.3	0	216.9	12.4	0	156.2	13.4	0	87.3	11.7	0	162.0	16.1	0	175.7	12.9	0.0	111.4	14.7	0	184.5	17.3	0	108.6	10.5	0
May	0	127.6	12.1	0	119.9	9.3	0	127.8	9.5	0	186.1	19.1	0	125.5	12.2	0	75.1	7.1	0.0	88.6	12.4	0	117.0	11.7	0	145.8	13.6	0
Jun	0	210.9	12.4	0	132.3	10.2	0	102.6	9.0	0	82.6	6.7	0	114.1	4.6	0	125.5	9.0	0.0	4.0	0.4	0	96.0	8.0	0	74.0	4.7	0
Jul	0	104.1	4.8	0	125.6	5.5	0	46.5	3.9	0	40.5	4.7	0	122.0	5.7	0	130.2	3.5	0.0	18.0	1.7	0	140.4	6.7	0	90.0	7.4	0
Aug	0	43.7	2.7	0	27.5	2.0	0	83.9	2.2	0	44.2	4.5	0	21.4	1.8	0	66.3	2.3	0.0	23.2	3.7	0	5.1	0.4	0	17.8	1.2	0
Sep	0	90.2	4.7	0	73.7	6.0	0	66.9	4.2	0	83.2	6.8	0	72.0	6.5	0	57.7	5.4	0.0	53.0	6.4	0	56.4	4.2	0	33.5	4.4	0
Oct	0	114.9	14.0	0	160.4	16.4	0	101.3	14.2	0	91.6	16.2	0	92.4	15.9	0	143.6	13.0	0.0	101.4	21.7	0	172.8	22.5	0	48.2	12.5	0
Nov	0	119.1	24.4	0	161.8	24.1	0	118.0	26.7	0	82.8	20.0	0	120.2	27.3	0	127.8	28.3	0.0	113.6	32.4	0	123.8	33.2	0	89.4	23.5	0
Dec	0	387.9	49.4	0	253.5	55.0	0	430.6	61.9	0	172.0	53.3	0	472.0	64.6	0	565.4	63.7	4.0	560.0	96.0	3.0	453.8	89.1	0	123.0	35.3	0
Min Annual		**97.8**			**111.1**			**100.1**			**106.2**			**81.5**			**108.6**			**177.2**			**157.2**			**56.2**		
Max Annual		**857.9**			**1,145.4**			**827.9**			**572.2**			**1,008.9**			**1,317.1**			**737.3**			**1,226.8**			**609.4**		
Mean Annual		**334.1**			**347.5**			**360.5**			**325.7**			**363.5**			**392.6**			**346.4**			**398.3**			**257.5**		
Median Annual		***292.6***			***302.2***			***326.45***			***309.7***			***294.6***			***358.65***			***340.4***			***379.9***			***213.95***		

Notes:

1. Monthly values based on complete months only.
2. Annual values based on complete years only.


Annual Rainfall - All Local BoM Stations
Only Complete Years Considered
Annual Rainfall (mm)
0
200
400
600
800
1000
1200
1400
AUSTRAL DOWNS
AVON DOWNS
RANKEN RIVER
WONARAH
ALROY DOWNS
ALEXANDRIA
BARKLY HOMESTEAD
NUMBER 36 BORE
ANNITOWA
EPENARRA
Min Annual
Max Annual
Mean Annual
Median Annual


Monthly Rainfall at all Local BoM Stations
Only Complete Months Considered
Monthly Rainfall (mm)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
AUSTRAL DOWNS
AVON DOWNS
RANKEN RIVER
WONARAH
ALROY DOWNS
ALEXANDRIA
BARKLY HOMESTEAD
NUMBER 36 BORE
ANNITOWA
EPENARRA

Top 10 Wettest Days at Local BoM Stations

Station No.	Rainfall Station	Date	Precipitation to 9am (mm)	Rank
15004	AUSTRAL DOWNS	16/1/1953	209.8	1
15004	AUSTRAL DOWNS	8/2/1953	174.5	2
15004	AUSTRAL DOWNS	5/1/2005	140	3
15004	AUSTRAL DOWNS	12/2/1951	130	4
15004	AUSTRAL DOWNS	4/2/1916	116.3	5
15004	AUSTRAL DOWNS	28/2/1992	116	6
15004	AUSTRAL DOWNS	3/6/1944	115.6	7
15004	AUSTRAL DOWNS	23/1/1941	114.3	8
15004	AUSTRAL DOWNS	6/3/1950	107.2	9
15004	AUSTRAL DOWNS	8/2/1951	106.2	10
15005	AVON DOWNS	18/2/1934	162.6	1
15005	AVON DOWNS	24/1/1977	152	2
15005	AVON DOWNS	14/2/1927	147.3	3
15005	AVON DOWNS	6/1/1999	130	4
15005	AVON DOWNS	22/1/1915	129	5
15005	AVON DOWNS	18/1/1953	118.1	6
15005	AVON DOWNS	21/1/1974	115	7
15005	AVON DOWNS	19/2/1939	113.5	8
15005	AVON DOWNS	5/2/1967	112.5	9
15005	AVON DOWNS	30/12/1916	111.5	10
15026	RANKEN RIVER	25/12/1960	154.4	1
15026	RANKEN RIVER	22/1/1915	144.3	2
15026	RANKEN RIVER	4/3/1996	140	3
15026	RANKEN RIVER	9/12/2000	139.4	4
15026	RANKEN RIVER	14/1/1964	127.8	5
15026	RANKEN RIVER	17/2/1942	119.4	6
15026	RANKEN RIVER	21/2/1910	111	7
15026	RANKEN RIVER	1/3/1962	103.1	8
15026	RANKEN RIVER	15/2/1950	100.3	9
15026	RANKEN RIVER	18/3/1960	96.5	10
15034	WONARAH	14/1/1962	130.6	1
15034	WONARAH	7/2/1953	126.2	2
15034	WONARAH	21/1/1974	122.7	3
15034	WONARAH	23/12/1969	119.1	4
15034	WONARAH	2/1/1948	117.3	5
15034	WONARAH	29/12/1962	108	6
15034	WONARAH	26/3/1973	91.9	7
15034	WONARAH	9/1/1957	86.9	8
15034	WONARAH	12/1/1962	84.8	9
15034	WONARAH	20/5/1959	78	10
15036	ALROY DOWNS	4/2/1976	170	1
15036	ALROY DOWNS	20/12/1977	158	2
15036	ALROY DOWNS	30/12/1957	124	3
15036	ALROY DOWNS	9/12/2000	121	4
15036	ALROY DOWNS	5/2/1976	120.6	5
15036	ALROY DOWNS	7/1/1974	114	6
15036	ALROY DOWNS	25/4/1955	113.8	7
15036	ALROY DOWNS	27/3/1973	99.3	8
15036	ALROY DOWNS	8/7/1978	98	9
15036	ALROY DOWNS	2/7/1986	97	10

15088	ALEXANDRIA	19/3/1901	180.3	1
15088	ALEXANDRIA	9/12/2000	172.4	2
15088	ALEXANDRIA	4/2/1976	167.5	3
15088	ALEXANDRIA	22/1/1941	166.4	4
15088	ALEXANDRIA	25/12/1960	154.9	5
15088	ALEXANDRIA	8/12/2000	144.4	6
15088	ALEXANDRIA	23/1/1941	140	7
15088	ALEXANDRIA	5/3/1967	139.2	8
15088	ALEXANDRIA	24/1/1977	139	9
15088	ALEXANDRIA	24/1/1907	138.9	10
15145	BARKLY HOMESTEAD	9/12/2000	154	1
15145	BARKLY HOMESTEAD	17/2/1993	114.6	2
15145	BARKLY HOMESTEAD	19/1/2007	112	3
15145	BARKLY HOMESTEAD	28/4/2006	107	4
15145	BARKLY HOMESTEAD	19/1/2003	105	5
15145	BARKLY HOMESTEAD	22/3/1989	91	6
15145	BARKLY HOMESTEAD	4/1/1999	90	7
15145	BARKLY HOMESTEAD	8/12/2000	86	8
15145	BARKLY HOMESTEAD	21/2/1993	80.2	9
15145	BARKLY HOMESTEAD	5/1/1997	78	10
15151	NUMBER 36 BORE	27/3/1983	135	1
15151	NUMBER 36 BORE	3/12/1999	121	2
15151	NUMBER 36 BORE	11/4/2006	112	3
15151	NUMBER 36 BORE	22/5/1990	107	4
15151	NUMBER 36 BORE	1/7/1986	106.4	5
15151	NUMBER 36 BORE	22/2/2000	101.4	6
15151	NUMBER 36 BORE	8/12/1990	94.6	7
15151	NUMBER 36 BORE	9/12/2000	91	8
15151	NUMBER 36 BORE	1/3/1991	87	9
15151	NUMBER 36 BORE	29/1/1997	82.6	10
15587	ANNITOWA	29/2/2000	215	1
15587	ANNITOWA	22/1/1974	129	2
15587	ANNITOWA	15/12/2001	102	3
15587	ANNITOWA	7/1/2002	102	4
15587	ANNITOWA	7/11/2005	87	5
15587	ANNITOWA	7/1/2000	85	6
15587	ANNITOWA	26/11/2001	84	7
15587	ANNITOWA	17/1/1995	76.2	8
15587	ANNITOWA	18/2/1975	76	9
15587	ANNITOWA	29/01/1997	75	10
15657	EPENARRA	23/3/1982	170	1
15657	EPENARRA	6/2/1976	119.5	2
15657	EPENARRA	20/12/1993	114.2	3
15657	EPENARRA	21/1/1974	112.7	4
15657	EPENARRA	8/3/1974	103.3	5
15657	EPENARRA	7/1/1974	102.3	6
15657	EPENARRA	17/1/2007	100.8	7
15657	EPENARRA	20/2/1981	96.3	8
15657	EPENARRA	7/3/1972	96	9
15657	EPENARRA	31/10/1976	95	10

Top 100 Wettest Days at Local BoM Stations

Station No.	BoM Rainfall Station	Date	Precipitation to 9am (mm)	Rank
15587	ANNITOWA	29/2/2000	215.0	1
15004	AUSTRAL DOWNS	16/1/1953	209.8	2
15088	ALEXANDRIA	19/3/1901	180.3	3
15004	AUSTRAL DOWNS	8/2/1953	174.5	4
15088	ALEXANDRIA	9/12/2000	172.4	5
15036	ALROY DOWNS	4/2/1976	170.0	6
15657	EPENARRA	23/3/1982	170.0	7
15088	ALEXANDRIA	4/2/1976	167.5	8
15088	ALEXANDRIA	22/1/1941	166.4	9
15005	AVON DOWNS	18/2/1934	162.6	10
15036	ALROY DOWNS	20/12/1977	158.0	11
15088	ALEXANDRIA	25/12/1960	154.9	12
15026	RANKEN RIVER	25/12/1960	154.4	13
15145	BARKLY HOMESTEAD	9/12/2000	154.0	14
15005	AVON DOWNS	24/1/1977	152.0	15
15005	AVON DOWNS	14/2/1927	147.3	16
15088	ALEXANDRIA	8/12/2000	144.4	17
15026	RANKEN RIVER	22/1/1915	144.3	18
15004	AUSTRAL DOWNS	5/1/2005	140.0	19
15026	RANKEN RIVER	4/3/1996	140.0	20
15088	ALEXANDRIA	23/1/1941	140.0	21
15026	RANKEN RIVER	9/12/2000	139.4	22
15088	ALEXANDRIA	5/3/1967	139.2	23
15088	ALEXANDRIA	24/1/1977	139.0	24
15088	ALEXANDRIA	24/1/1907	138.9	25
15151	NUMBER 36 BORE	27/3/1983	135.0	26
15034	WONARAH	14/1/1962	130.6	27
15004	AUSTRAL DOWNS	12/2/1951	130.0	28
15005	AVON DOWNS	6/1/1999	130.0	29
15005	AVON DOWNS	22/1/1915	129.0	30
15587	ANNITOWA	22/1/1974	129.0	31
15026	RANKEN RIVER	14/1/1964	127.8	32
15034	WONARAH	7/2/1953	126.2	33
15036	ALROY DOWNS	30/12/1957	124.0	34
15034	WONARAH	21/1/1974	122.7	35
15036	ALROY DOWNS	9/12/2000	121.0	36
15151	NUMBER 36 BORE	3/12/1999	121.0	37
15036	ALROY DOWNS	5/2/1976	120.6	38
15657	EPENARRA	6/2/1976	119.5	39
15026	RANKEN RIVER	17/2/1942	119.4	40
15034	WONARAH	23/12/1969	119.1	41
15005	AVON DOWNS	18/1/1953	118.1	42
15034	WONARAH	2/1/1948	117.3	43
15004	AUSTRAL DOWNS	4/2/1916	116.3	44
15004	AUSTRAL DOWNS	28/2/1992	116.0	45
15004	AUSTRAL DOWNS	3/6/1944	115.6	46
15005	AVON DOWNS	21/1/1974	115.0	47
15145	BARKLY HOMESTEAD	17/2/1993	114.6	48
15004	AUSTRAL DOWNS	23/1/1941	114.3	49
15657	EPENARRA	20/12/1993	114.2	50
15036	ALROY DOWNS	7/1/1974	114.0	51
15036	ALROY DOWNS	25/4/1955	113.8	52

15005	AVON DOWNS	19/2/1939	113.5	53
15657	EPENARRA	21/1/1974	112.7	54
15005	AVON DOWNS	5/2/1967	112.5	55
15145	BARKLY HOMESTEAD	19/1/2007	112.0	56
15151	NUMBER 36 BORE	11/4/2006	112.0	57
15005	AVON DOWNS	30/12/1916	111.5	58
15026	RANKEN RIVER	21/2/1910	111.0	59
15034	WONARAH	29/12/1962	108.0	60
15004	AUSTRAL DOWNS	6/3/1950	107.2	61
15145	BARKLY HOMESTEAD	28/4/2006	107.0	62
15151	NUMBER 36 BORE	22/5/1990	107.0	63
15151	NUMBER 36 BORE	1/7/1986	106.4	64
15004	AUSTRAL DOWNS	8/2/1951	106.2	65
15145	BARKLY HOMESTEAD	19/1/2003	105.0	66
15657	EPENARRA	8/3/1974	103.3	67
15026	RANKEN RIVER	1/3/1962	103.1	68
15657	EPENARRA	7/1/1974	102.3	69
15587	ANNITOWA	15/12/2001	102.0	70
15587	ANNITOWA	7/1/2002	102.0	71
15151	NUMBER 36 BORE	22/2/2000	101.4	72
15657	EPENARRA	17/1/2007	100.8	73
15026	RANKEN RIVER	15/2/1950	100.3	74
15036	ALROY DOWNS	27/3/1973	99.3	75
15036	ALROY DOWNS	8/7/1978	98.0	76
15036	ALROY DOWNS	2/7/1986	97.0	77
15026	RANKEN RIVER	18/3/1960	96.5	78
15657	EPENARRA	20/2/1981	96.3	79
15657	EPENARRA	7/3/1972	96.0	80
15657	EPENARRA	31/10/1976	95.0	81
15151	NUMBER 36 BORE	8/12/1990	94.6	82
15034	WONARAH	26/3/1973	91.9	83
15145	BARKLY HOMESTEAD	22/3/1989	91.0	84
15151	NUMBER 36 BORE	9/12/2000	91.0	85
15145	BARKLY HOMESTEAD	4/1/1999	90.0	86
15151	NUMBER 36 BORE	1/3/1991	87.0	87
15587	ANNITOWA	7/11/2005	87.0	88
15034	WONARAH	9/1/1957	86.9	89
15145	BARKLY HOMESTEAD	8/12/2000	86.0	90
15587	ANNITOWA	7/1/2000	85.0	91
15034	WONARAH	12/1/1962	84.8	92
15587	ANNITOWA	26/11/2001	84.0	93
15151	NUMBER 36 BORE	29/1/1997	82.6	94
15145	BARKLY HOMESTEAD	21/2/1993	80.2	95
15034	WONARAH	20/5/1959	78.0	96
15145	BARKLY HOMESTEAD	5/1/1997	78.0	97
15587	ANNITOWA	17/1/1995	76.2	98
15587	ANNITOWA	18/2/1975	76.0	99
15587	ANNITOWA	29/01/1997	75.0	100

Top 100 Wettest Days at Local BoM Stations in Date Order

Station No.	Rainfall Station	Date	Precipitation to 9am (mm)	Date Order
15088	ALEXANDRIA	19/3/1901	180.3	1
15088	ALEXANDRIA	24/1/1907	138.9	2
15026	RANKEN RIVER	21/2/1910	111	3
15026	RANKEN RIVER	22/1/1915	144.3	4
15005	AVON DOWNS	22/1/1915	129	5
15004	AUSTRAL DOWNS	4/2/1916	116.3	6
15005	AVON DOWNS	30/12/1916	111.5	7
15005	AVON DOWNS	14/2/1927	147.3	8
15005	AVON DOWNS	18/2/1934	162.6	9
15005	AVON DOWNS	19/2/1939	113.5	10
15088	ALEXANDRIA	22/1/1941	166.4	11
15088	ALEXANDRIA	23/1/1941	140	12
15004	AUSTRAL DOWNS	23/1/1941	114.3	13
15026	RANKEN RIVER	17/2/1942	119.4	14
15004	AUSTRAL DOWNS	3/6/1944	115.6	15
15034	WONARAH	2/1/1948	117.3	16
15026	RANKEN RIVER	15/2/1950	100.3	17
15004	AUSTRAL DOWNS	6/3/1950	107.2	18
15004	AUSTRAL DOWNS	8/2/1951	106.2	19
15004	AUSTRAL DOWNS	12/2/1951	130	20
15004	AUSTRAL DOWNS	16/1/1953	209.8	21
15005	AVON DOWNS	18/1/1953	118.1	22
15034	WONARAH	7/2/1953	126.2	23
15004	AUSTRAL DOWNS	8/2/1953	174.5	24
15036	ALROY DOWNS	25/4/1955	113.8	25
15034	WONARAH	9/1/1957	86.9	26
15036	ALROY DOWNS	30/12/1957	124	27
15034	WONARAH	20/5/1959	78	28
15026	RANKEN RIVER	18/3/1960	96.5	29
15026	RANKEN RIVER	25/12/1960	154.4	30
15088	ALEXANDRIA	25/12/1960	154.9	31
15034	WONARAH	12/1/1962	84.8	32
15034	WONARAH	14/1/1962	130.6	33
15026	RANKEN RIVER	1/3/1962	103.1	34
15034	WONARAH	29/12/1962	108	35
15026	RANKEN RIVER	14/1/1964	127.8	36
15005	AVON DOWNS	5/2/1967	112.5	37
15088	ALEXANDRIA	5/3/1967	139.2	38
15034	WONARAH	23/12/1969	119.1	39
15657	EPENARRA	7/3/1972	96	40
15034	WONARAH	26/3/1973	91.9	41
15036	ALROY DOWNS	27/3/1973	99.3	42
15036	ALROY DOWNS	7/1/1974	114	43
15657	EPENARRA	7/1/1974	102.3	44
15034	WONARAH	21/1/1974	122.7	45
15657	EPENARRA	21/1/1974	112.7	46
15005	AVON DOWNS	21/1/1974	115	47
15587	ANNITOWA	22/1/1974	129	48
15657	EPENARRA	8/3/1974	103.3	49
15587	ANNITOWA	18/2/1975	76	50
15036	ALROY DOWNS	4/2/1976	170	51
15088	ALEXANDRIA	4/2/1976	167.5	52

15036	ALROY DOWNS	5/2/1976	120.6	53
15657	EPENARRA	6/2/1976	119.5	54
15657	EPENARRA	31/10/1976	95	55
15005	AVON DOWNS	24/1/1977	152	56
15088	ALEXANDRIA	24/1/1977	139	57
15036	ALROY DOWNS	20/12/1977	158	58
15036	ALROY DOWNS	8/7/1978	98	59
15657	EPENARRA	20/2/1981	96.3	60
15657	EPENARRA	23/3/1982	170	61
15151	NUMBER 36 BORE	27/3/1983	135	62
15151	NUMBER 36 BORE	1/7/1986	106.4	63
15036	ALROY DOWNS	2/7/1986	97	64
15145	BARKLY HOMESTEAD	22/3/1989	91	65
15151	NUMBER 36 BORE	22/5/1990	107	66
15151	NUMBER 36 BORE	8/12/1990	94.6	67
15151	NUMBER 36 BORE	1/3/1991	87	68
15004	AUSTRAL DOWNS	28/2/1992	116	69
15145	BARKLY HOMESTEAD	17/2/1993	114.6	70
15145	BARKLY HOMESTEAD	21/2/1993	80.2	71
15657	EPENARRA	20/12/1993	114.2	72
15587	ANNITOWA	17/1/1995	76.2	73
15026	RANKEN RIVER	4/3/1996	140	74
15145	BARKLY HOMESTEAD	5/1/1997	78	75
15587	ANNITOWA	29/01/1997	75	76
15151	NUMBER 36 BORE	29/1/1997	82.6	77
15145	BARKLY HOMESTEAD	4/1/1999	90	78
15005	AVON DOWNS	6/1/1999	130	79
15151	NUMBER 36 BORE	3/12/1999	121	80
15587	ANNITOWA	7/1/2000	85	81
15151	NUMBER 36 BORE	22/2/2000	101.4	82
15587	ANNITOWA	29/2/2000	215	83
15088	ALEXANDRIA	8/12/2000	144.4	84
15145	BARKLY HOMESTEAD	8/12/2000	86	85
15145	BARKLY HOMESTEAD	9/12/2000	154	86
15088	ALEXANDRIA	9/12/2000	172.4	87
15026	RANKEN RIVER	9/12/2000	139.4	88
15036	ALROY DOWNS	9/12/2000	121	89
15151	NUMBER 36 BORE	9/12/2000	91	90
15587	ANNITOWA	26/11/2001	84	91
15587	ANNITOWA	15/12/2001	102	92
15587	ANNITOWA	7/1/2002	102	93
15145	BARKLY HOMESTEAD	19/1/2003	105	94
15004	AUSTRAL DOWNS	5/1/2005	140	95
15587	ANNITOWA	7/11/2005	87	96
15151	NUMBER 36 BORE	11/4/2006	112	97
15145	BARKLY HOMESTEAD	28/4/2006	107	98
15657	EPENARRA	17/1/2007	100.8	99
15145	BARKLY HOMESTEAD	19/1/2007	112	100

Monthly Climate Statistics for 'WONARAH' [015034

Created on [28 Jan 2009 17:39:00 GMT]

015034 WONARAH
Commenced: 1946
Last Record: 1974
Latitude: 19.90 Degrees South
Longitude: 136.34 Degrees East
Elevation: 240 m
State: NT

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Num	Start	End Year
Mean maximum temperature (Degrees C)	38.2	37.1	35.6	33.1	28.2	25.8	25.1	27.8	31.9	35.9	37.9	38.8	32.9	23	1950	1974
Highest temperature (Degrees C)	45.8	44.3	42.3	39.2	36.1	35	32.6	37.8	39.6	42.2	44.9	44.4	45.8	17	1957	1974
Date of Highest temperature	5-Jan-71	18-Feb-70	5-Mar-70	2-Apr-66	16-May-58	1-Jun-62	19-Jul-64	27-Aug-70	24-Sep-71	29-Oct-60	9-Nov-65	31-Dec-59	5-Jan-71	N/A	1957	1974
Lowest maximum temperature (Degrees C)	23.9	26.7	22.8	20.6	14.4	16.6	12.8	17.1	21.5	22.7	25	23.9	12.8	17	1957	1974
Date of Lowest maximum temperature	9-Jan-57	28-Feb-72	3-Mar-62	27-Apr-60	22-May-59	23-Jun-65	13-Jul-68	7-Aug-66	6-Sep-73	4-Oct-66	9-Nov-61	31-Dec-57	13-Jul-68	N/A	1957	1974
Decile 1 maximum temperature (Degrees C) for years 1957 to 1974	34.2	33.3	31.1	29.3	22.9	21.2	20.6	22.3	26.8	31.3	33.4	34.4		16	1957	1974
Decile 9 maximum temperature (Degrees C) for years 1957 to 1974	42.3	41.1	39.5	36.9	32.8	30.1	30	33	36.2	40	41.4	42.2		16	1957	1974
Mean number of days >= 30 Degrees C	26.7	24	25.6	21.7	10.4	3.3	2.9	9.9	19.1	25.5	24.9	27.1	221.1	17	1957	1974
Mean number of days >= 35 Degrees C	23.6	20.1	17.1	9.2	0.5	0.1	0	0.6	5.8	17.4	21.1	24	139.5	17	1957	1974
Mean number of days >= 40 Degrees C	10.3	6	2.3	0	0	0	0	0	0	3	7.2	10.5	39.3	17	1957	1974
Mean minimum temperature (Degrees C)	24.2	23.6	22	18.9	14.4	11.1	9.9	11.5	15.5	19.9	22.2	23.6	18.1	23	1950	1974
Lowest temperature (Degrees C)	15	16.8	14.5	8.3	2.8	-0.2	1.1	0.6	6	9.2	12.2	13.1	-0.2	17	1957	1974
Date of Lowest temperature	4-Jan-70	23-Feb-66	23-Mar-70	16-Apr-69	25-May-67	26-Jun-65	13-Jul-60	4-Aug-67	7-Sep-67	5-Oct-66	7-Nov-69	31-Dec-57	26-Jun-65	N/A	1957	1974
Highest minimum temperature (Degrees C)	30.6	30	29.3	26.7	25	21.1	19.9	20	26.4	30.6	31.7	31.1	31.7	17	1957	1974
Date of Highest minimum temperature	14-Jan-69	25-Feb-62	4-Mar-73	5-Apr-58	15-May-58	3-Jun-63	5-Jul-66	30-Aug-65	1-Sep-64	31-Oct-67	3-Nov-65	17-Dec-59	3-Nov-65	N/A	1957	1974
Decile 1 minimum temperature (Degrees C) for years 1957 to 1974	21.6	21.1	18.6	14.9	9.4	6.2	5.5	7.2	11	15.8	18.5	19.8		16	1957	1974
Decile 9 minimum temperature (Degrees C) for years 1957 to 1974	27.5	26.7	25.4	22.8	19.4	16.2	14.7	16.2	20.1	23.9	26.1	26.8		16	1957	1974
Mean number of days <= 2 Degrees C	0	0	0	0	0	0.2	0.2	0.1	0	0	0	0	0.5	17	1957	1974
Mean number of days <= 0 Degrees C	0	0	0	0	0	0.1	0	0	0	0	0	0	0.1	17	1957	1974
Mean daily ground minimum temperature Degrees C																
Lowest ground temperature Degrees C																
Date of Lowest ground temperature														N/A		
Mean number of days ground min. temp. <= -1 Degrees C																
Mean rainfall (mm)	71.8	61	47.8	11.7	19.2	6.7	4.7	4.5	6.8	16	20	54.4	317.5	28	1946	1974
Highest rainfall (mm)	411.4	198.3	166.4	87.3	186.1	82.6	40.5	44.2	83.2	91.6	82.8	172	572.2	28	1946	1974
Date of Highest rainfall	1974	1967	1965	1971	1968	1973	1956	1947	1947	1954	1949	1969	1962	N/A	1946	1974
Lowest rainfall (mm)	0.8	3.6	0	0	0	0	0	0	0	0	0	0	106.2	28	1946	1974
Date of Lowest rainfall	1949	1961	1963	1969	1973	1974	1974	1972	1972	1972	1968	1951	1961	N/A	1946	1974
Decile 1 monthly rainfall (mm) for years 1946 to 1974	7.5	4.5	0	0	0	0	0	0	0	0	0	2.7	184.4	28	1946	1974
Decile 5 (median) monthly rainfall (mm) for years 1946 to 1974	33	51.2	21.6	1.1	0	0	0	0	0	8.8	14.2	40.1	308.3	28	1946	1974
Decile 9 monthly rainfall (mm) for years 1946 to 1974	175.7	140.6	140	44.9	50.7	10.2	18.5	11	18.9	49.3	50.5	116.8	504.3	28	1946	1974
Highest daily rainfall (mm)	130.6	126.2	91.9	39.4	78	68.1	22.6	44.2	47.5	73.4	33.8	119.1	130.6	28	1946	1974
Date of Highest daily rainfall	14-Jan-62	7-Feb-53	26-Mar-73	13-Apr-71	20-May-59	16-Jun-73	11-Jul-56	17-Aug-47	5-Sep-47	27-Oct-69	30-Nov-58	23-Dec-69	14-Jan-62	N/A	1946	1974
Mean number of days of rain	6.1	6.2	4.5	1.4	1.2	0.7	0.8	0.6	0.9	2	3	5.1	32.5	28	1946	1974
Mean number of days of rain >= 1 mm	5	5.4	3.8	1	0.9	0.6	0.7	0.5	0.8	1.6	2.6	4	26.9	28	1946	1974
Mean number of days of rain >= 10 mm	1.8	1.9	1.5	0.4	0.5	0.2	0.1	0.1	0.2	0.4	0.7	1.5	9.3	28	1946	1974
Mean number of days of rain >= 25 mm	0.8	0.5	0.6	0.1	0.2	0.1	0	0	0	0.1	0.1	0.6		28	1946	1974
Mean daily wind run (km)																
Maximum wind gust speed (km/h)																
Date of Maximum wind gust speed														N/A		
Mean daily sunshine (hours)																
Mean daily solar exposure (MJ/(m*m))	25.8	24.6	23.9	21.6	18.8	17.2	18.2	21	23.9	25.3	27	26.8	22.8	19	1990	2009
Mean number of clear days	6.3	5.3	6.6	13.2	15	16.1	18.1	19.3	16.6	15.6	9.6	8	149.7	17	1957	1974
Mean number of cloudy days	8.2	8.6	8.2	3.5	5.1	2.8	2.4	1.1	1.5	3.4	4.3	6.9	56	17	1957	1974
Mean daily evaporation (mm)																
Mean 9am temperature (Degrees C)	30.2	29.4	28.2	25.5	20.6	17.6	16.5	19	23.6	27.9	30.1	31	25	23	1950	1974
Mean 9am wet bulb temperature (Degrees C)	21.6	21.6	19.9	16.9	13.2	11.4	10.1	11.1	13.5	17	19.1	20.2	16.3	21	1950	1974
Mean 9am dew point temperature (Degrees C)	15.6	15.9	13.5	8.3	5.4	3.9	2	0.7	1.4	5.2	7.8	10.7	7.5	13	1957	1970
Mean 9am relative humidity (%)	45	51	43	38	41	45	41	33	26	30	31	36	38	19	1950	1970
Mean 9am cloud cover (okas)	3.3	3.5	3.1	1.9	2.2	1.5	1.3	1	1.3	1.8	2.5	2.7	2.2	23	1950	1974
Mean 9am wind speed (km/h) for years 1957 to 1974	11.5	13.6	14.3	17.2	16.9	15.5	17.7	19.1	19.2	18	16.4	16.5	16.3	15	1957	1974
Mean 3pm temperature (Degrees C)	36.5	35.9	34.4	32.3	27.6	25.2	24.4	27.3	31.1	34.9	36.8	37.2	32	23	1950	1974
Mean 3pm wet bulb temperature (Degrees C)	22.5	22.7	21.2	19	16	14.9	13.8	14.7	16.3	19.1	20.5	21.7	18.5	21	1950	1974
Mean 3pm dew point temperature (Degrees C)	12.7	13.3	11.5	7.5	4.6	3.2	1.4	0.3	-0.1	3.3	5.8	9.6	6.1	13	1957	1970
Mean 3pm relative humidity (%)	28	30	27	23	26	27	25	20	16	18	19	23	23	19	1950	1970
Mean 3pm cloud cover (oktas)	4.8	4.8	4.5	3	2.5	1.7	1.2	1	1.5	2.6	3.5	4.1	2.9	23	1950	1974
Mean 3pm wind speed (km/h) for years 1957 to 1974	12	12	13.6	13	13.3	12.4	13.8	12.9	13.1	12.6	11.6	12.2	12.7	14	1957	1974

Monthly Climate Statistics for 'BRUNETTE DOWNS' [015085]																
Created on [28 Jan 2009 13:58:35 GMT]																
015085 BRUNETTE DOWNS																
Commenced: 1891																
Last Record: 2008																
Latitude: 18.64 Degrees South																
Longitude: 135.95 Degrees East																
Elevation: 218 m																
State: NT																
Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C)	37.2	36.4	35.2	33.6	29.9	26.8	26.7	29.5	33.5	36.7	38	38.5	33.5	44	1957	2008
Highest temperature (Degrees C)	44.3	45.5	42.5	39.1	38.1	34.7	35.8	37.4	40.3	44.2	44.3	45.5	45.5	44	1957	2008
Date of Highest temperature	20-Jan-85	19-Feb-83	1-Mar-83	22-Apr-80	6-May-07	22-Jun-96	17-Jul-95	28-Aug-85	26-Sep-97	23-Oct-87	28-Nov-82	2-Dec-07	2-Dec-07	N/A	1957	2008
Lowest maximum temperature (Degrees C)	23.5	22.7	22.9	19	13.3	10.8	14.4	15.6	19.5	15.5	19.9	21.5	10.8	44	1957	2008
Date of Lowest maximum temperature	17-Jan-03	29-Feb-96	25-Mar-73	26-Apr-83	23-May-59	21-Jun-07	2-Jul-99	17-Aug-07	5-Sep-78	20-Oct-00	17-Nov-81	26-Dec-06	21-Jun-07	N/A	1957	2008
Decile 1 maximum temperature (Degrees C) for years 1957 to 2008	32.4	32	31.2	29.6	25.1	21.7	22	24.5	28.2	32.4	34	34.2		43	1957	2008
Decile 9 maximum temperature (Degrees C) for years 1957 to 2008	41.3	40.6	38.8	36.8	33.9	31.6	31.1	33.8	37.5	40	41.4	41.9		43	1957	2008
Mean number of days >= 30 Degrees C	28.8	25.9	28	26.3	16.7	6.8	5.9	15.1	24.1	29.1	27.6	28.4	262.7	44	1957	2008
Mean number of days >= 35 Degrees C	22.7	18.5	17.3	10.6	1.2	0	0	1.3	11.9	23.8	24.1	25.2	156.6	44	1957	2008
Mean number of days >= 40 Degrees C	7.1	4.8	1	0	0	0	0	0	0.1	3.5	8.7	10.6	35.8	44	1957	2008
Mean minimum temperature (Degrees C)	24.5	24.2	22.3	19.2	15	11.4	10.5	12.5	16.6	20.7	23	24.3	18.7	44	1957	2008
Lowest temperature (Degrees C)	16.5	16.1	11.4	8.7	4	1.7	1.4	1.7	5	7.5	13.2	15	1.4	44	1957	2008
Date of Lowest temperature	6-Jan-05	7-Feb-62	31-Mar-70	30-Apr-99	28-May-08	27-Jun-71	10-Jul-83	16-Aug-57	2-Sep-86	11-Oct-82	18-Nov-81	27-Dec-69	10-Jul-83	N/A	1957	2008
Highest minimum temperature (Degrees C)	31	30.6	28.8	27.2	25	24.3	21.7	23.2	25.8	29	30.4	31.2	31.2	44	1957	2008
Date of Highest minimum temperature	3-Jan-94	9-Feb-86	12-Mar-85	11-Apr-86	17-May-58	19-Jun-05	28-Jul-93	26-Aug-99	28-Sep-97	23-Oct-87	21-Nov-87	3-Dec-07	3-Dec-07	N/A	1957	2008
Decile 1 minimum temperature (Degrees C) for years 1957 to 2008	22	21.9	19	15	10.1	6.4	5.9	7.5	11.4	15.8	18.9	21.2		43	1957	2008
Decile 9 minimum temperature (Degrees C) for years 1957 to 2008	27.2	26.7	25.2	23	19.8	16.6	15.5	17.5	21.8	25.1	26.7	27.4		43	1957	2008
Mean number of days <= 2 Degrees C	0	0	0	0	0	0	0.1	0	0	0	0	0	0.1	44	1957	2008
Mean number of days <= 0 Degrees C	0	0	0	0	0	0	0	0	0	0	0	0	0	44	1957	2008
Mean daily ground minimum temperature Degrees C	22.5	22.9	20.8	17.4	12.3	8.7	7.2	8.9	14.4	18.3	20.4	22.3	16.3	10	1999	2008
Lowest ground temperature Degrees C	14.1	13.6	10	6.5	3.4	-1.9	-4.2	-3.1	3.9	6.4	10.2	12.5	-4.2	10	1999	2008
Date of Lowest ground temperature	6-Jan-05	5-Feb-05	23-Mar-03	24-Apr-01	29-May-02	19-Jun-04	27-Jul-01	15-Aug-02	14-Sep-04	1-Oct-02	14-Nov-01	13-Dec-02	27-Jul-01	N/A	1999	2008
Mean number of days ground min. temp. <= -1 Degrees C	0	0	0	0	0	0.1	0.9	0.4	0	0	0	0	1.4	10	1999	2008
Mean rainfall (mm)	104.3	98.7	54.9	14.7	8.1	7.2	4.5	1.4	6.1	15.4	29	67.5	411.8	114	1891	2008
Highest rainfall (mm)	473.2	620.9	317.9	220.5	201.4	107.9	164.6	40.1	125.9	130.7	187.7	393	1200.4	114	1891	2008
Date of Highest rainfall	1919	1976	1941	1896	1955	1973	1986	1947	1978	1975	1941	2000	1976	N/A	1891	2008
Lowest rainfall (mm)	0	0	0	0	0	0	0	0	0	0	0	0	85.1	114	1891	2008
Date of Lowest rainfall	1911	1965	2008	2008	2008	2008	2008	2008	2007	2004	1964	1951	1897	N/A	1891	2008
Decile 1 monthly rainfall (mm) for years 1891 to 2008	12	13.4	0	0	0	0	0	0	0	0	1.4	8.1	199	109	1891	2008
Decile 5 (median) monthly rainfall (mm) for years 1891 to 2008	76.8	71.4	29.5	1.9	0	0	0	0	0	4.6	22.8	46	373.2	109	1891	2008
Decile 9 monthly rainfall (mm) for years 1891 to 2008	232.6	219.1	160.6	37.2	23.9	17.1	7.2	2.2	18.1	45.8	58.1	155.3	692.3	109	1891	2008
Highest daily rainfall (mm)	182.4	261.8	164.2	70.4	95	83.6	142.2	27.9	65.3	75.2	92.5	120.7	261.8	109	1891	2009
Date of Highest daily rainfall	22-Jan-19	4-Feb-76	1-Mar-84	20 Apr 18	24-May-55	3-Jun-44	2-Jul-86	18-Aug-66	28-Sep-78	21-Oct-00	20-Nov-41	25-Dec-60	4-Feb-76	N/A	1891	2009
Mean number of days of rain	8.1	8.2	4.9	1.6	0.9	0.7	0.6	0.3	0.8	2	3.8	6.2	38.1	109	1891	2008
Mean number of days of rain >= 1 mm	6.5	6.6	3.8	1.2	0.7	0.6	0.4	0.2	0.6	1.5	2.9	4.6	29.6	109	1891	2009
Mean number of days of rain >= 10 mm	2.7	2.7	1.5	0.4	0.2	0.2	0.1	0.1	0.2	0.4	0.8	1.8	11.1	109	1891	2009
Mean number of days of rain >= 25 mm	1.1	1.1	0.6	0.1	0.1	0.1	0	0	0.1	0.2	0.2	0.7	4.3	109	1891	2009
Mean daily wind run (km)																
Maximum wind gust speed (km/h)														0	2008	2008
Date of Maximum wind gust speed														N/A	2008	2008
Mean daily sunshine (hours)																
Mean daily solar exposure (MJ/(m*m))	25	24.4	24	21.6	19.2	17.6	18.6	21.3	24.1	25.6	27	25.9	22.9	19	1990	2009
Mean number of clear days	4.4	3.5	7.2	11.1	16.2	18	20.6	21.5	19.3	14.7	8.4	5.2	150.1	44	1957	2008
Mean number of cloudy days	13.5	11.2	9.4	5.4	3.9	2.7	1.6	1.4	2.4	4.3	6.4	10.1	72.3	44	1957	2008
Mean daily evaporation (mm)	9.3	8.3	7.8	7.7	6.4	5.7	5.8	7.3	9	10.6	10.6	10.4	8.2	38	1968	2008
Mean 9am temperature (Degrees C)	29	28.2	26.7	24.4	19.9	16	15.2	18.4	23.5	27.8	29.5	30.1	24.1	44	1957	2008
Mean 9am wet bulb temperature (Degrees C)	23.3	23.2	21.1	17.4	13.8	10.8	9.8	11.5	14.9	18.2	20.5	22.5	17.2	41	1957	2008
Mean 9am dew point temperature (Degrees C)	19.7	20.3	17.1	11.3	7.5	4.8	2.6	2.8	5.7	9.4	13.5	17.3	11	41	1957	2008
Mean 9am relative humidity (%)	61	65	59	47	47	49	44	38	35	36	42	50	48	41	1957	2008
Mean 9am cloud cover (okas)	4.5	4.4	3.8	2.7	2.2	1.8	1.6	1.4	1.6	2.2	3.1	3.9	2.8	44	1957	2008
Mean 9am wind speed (km/h) for years 1957 to 2008	10.7	9.5	10	13.4	14.4	14.2	14.3	15.6	16.5	15.7	14.8	12	13.4	42	1957	2008
Mean 3pm temperature (Degrees C)	35.8	35.1	34.2	32.8	29.2	26.2	26	28.8	32.7	35.8	36.9	37.1	32.6	44	1957	2008
Mean 3pm wet bulb temperature (Degrees C)	23.9	24.2	22.5	20.1	17.6	15.4	14.6	15.8	17.8	20.2	21.9	23.3	19.8	41	1957	2008
Mean 3pm dew point temperature (Degrees C)	16.6	17.8	14.8	10.3	7.4	4.8	2.2	2.2	3.3	7.2	11	14.3	9.3	41	1957	2008
Mean 3pm relative humidity (%)	37	40	35	28	27	27	23	20	18	20	24	30	27	41	1957	2008
Mean 3pm cloud cover (oktas)	5.3	5.4	4.7	3.8	2.7	2	1.5	1.5	2	3.1	4.1	5	3.4	44	1957	2008
Mean 3pm wind speed (km/h) for years 1957 to 2008	11.7	10.6	11.2	11.9	12.2	12.9	12.9	13	12.9	11.5	11.3	10.8	11.9	42	1957	2008

Monthly Climate Statistics for 'TENNANT CREEK POST OFFICE' [015087]
Created on [28 Jan 2009 17:13:54 GMT]

015087 TENNANT CREEK POST OFFICE
Commenced: 1874
Last Record: 2000
Latitude: 19.65 Degrees South
Longitude: 134.19 Degrees East
Elevation: 377 m
State: NT

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C)	37.3	36.3	35	32	27.7	24.7	24.4	27.4	31.4	35	37	37.7	32.2	61	1910	1970
Highest temperature (Degrees C)	46.1	45.2	43.9	40	37.8	34.2	33.3	36.4	38.9	42.8	44.2	44.9	46.1	61	1910	1970
Date of Highest temperature	3-Jan-39	18-Feb-70	23-Mar-61	1-Apr-42	5-May-42	1-Jun-62	31-Jul-43	27-Aug-70	30-Sep-55	20-Oct-57	2-Nov-35	18-Dec-25	3-Jan-39	N/A	1910	1970
Lowest maximum temperature (Degrees C)	19.7	17.2	18.9	16.6	12.2	9.2	9.4	14.7	18.3	17.7	20	21.7	9.2	61	1910	1970
Date of Lowest maximum temperature	12-Jan-21	23-Feb-49	19-Mar-49	27-Apr-20	22-May-59	28-Jun-35	2-Jul-38	6-Aug-66	2-Sep-29	29-Oct-45	4-Nov-56	31-Dec-57	28-Jun-35	N/A	1910	1970
Decile 1 maximum temperature (Degrees C) for years 1910 to 1970	32.8	31.1	31	27.8	22.8	20	19.6	22.2	26.7	30	32.8	33.3		62	1910	1970
Decile 9 maximum temperature (Degrees C) for years 1910 to 1970	41.6	40.6	38.8	36	31.7	29.4	29.4	32.2	35.6	38.9	40.6	41.2		62	1910	1970
Mean number of days >= 30 Degrees C	29.6	26.5	28.9	22.7	9.5	2.5	2.4	9	20.8	27.9	28.4	29.7	237.9	61	1910	1970
Mean number of days >= 35 Degrees C	24.2	19.8	18.3	6.2	0.3	0	0	0.1	5.1	18.1	23.2	25.3	140.6	61	1910	1970
Mean number of days >= 40 Degrees C	7.8	4	1	0	0	0	0	0	0	1.4	5.3	8.7	28.2	61	1910	1970
Mean minimum temperature (Degrees C)	24.6	23.9	22.5	19.3	15.2	12	11	12.7	16.4	20.5	23	24.2	18.8	61	1910	1970
Lowest temperature (Degrees C)	15.7	11.1	11.9	10	5.4	2.8	2.4	2.8	5.6	10.7	13.3	11.7	2.4	61	1910	1970
Date of Lowest temperature	12-Jan-21	25-Feb-49	25-Mar-66	30-Apr-52	31-May-25	25-Jun-13	30-Jul-19	26-Aug-31	17-Sep-51	2-Oct-24	26-Nov-55	31-Dec-57	30-Jul-19	N/A	1910	1970
Highest minimum temperature (Degrees C)	31.7	30.8	29.4	26.1	25.1	22.5	21.1	22.8	26.6	29.4	30.6	32.5	32.5	61	1910	1970
Date of Highest minimum temperature	6-Jan-52	19-Feb-70	8-Mar-58	16-Apr-68	5-May-42	3-Jun-63	23-Jul-38	24-Aug-55	20-Sep-42	28-Oct-59	21-Nov-29	16-Dec-25	16-Dec-25	N/A	1910	1970
Decile 1 minimum temperature (Degrees C) for years 1910 to 1970	21.6	21.1	19.4	15	10.6	7.8	7	8.3	11.9	15.8	19.4	21.1		61	1910	1970
Decile 9 minimum temperature (Degrees C) for years 1910 to 1970	27.8	26.7	25.6	23.2	19.4	16.6	15.3	17.2	20.6	24.9	26.7	27.2		61	1910	1970
Mean number of days <= 2 Degrees C	0	0	0	0	0	0	0	0	0	0	0	0	0	61	1910	1970
Mean number of days <= 0 Degrees C	0	0	0	0	0	0	0	0	0	0	0	0	0	61	1910	1970
Mean daily ground minimum temperature Degrees C																
Lowest ground temperature Degrees C																
Date of Lowest ground temperature														N/A		
Mean number of days ground min. temp. <= -1 Degrees C																
Mean rainfall (mm)	88.4	90.4	50.6	15.1	11.5	6.6	5.5	2.8	6.7	15.4	27.9	50.7	369.8	124	1874	2000
Highest rainfall (mm)	389.9	379.8	430.6	196.4	172.4	82.8	94.4	83.3	70.9	77.7	170.8	198.8	864.8	124	1874	2000
Date of Highest rainfall	1957	1919	1930	1896	1968	1973	1895	1886	1877	1880	2000	1888	1930	N/A	1874	2000
Lowest rainfall (mm)	0	0	0	0	0	0	0	0	0	0	0	0	93.9	124	1874	2000
Date of Lowest rainfall	1989	1937	1997	1995	2000	1999	2000	2000	2000	1994	1986	1981	1935	N/A	1874	2000
Decile 1 monthly rainfall (mm) for years 1874 to 2000	7	3	0	0	0	0	0	0	0	0	2	4.8	182.7	116	1874	2000
Decile 5 (median) monthly rainfall (mm) for years 1874 to 2000	69.4	64.4	19.6	2.8	0	0	0	0	0	10.8	21.5	37.5	336	116	1874	2000
Decile 9 monthly rainfall (mm) for years 1874 to 2000	196.2	222.4	150	41.5	36.5	22.5	20.2	7.4	23.8	42.6	61.8	117	569.1	116	1874	2000
Highest daily rainfall (mm)	186.7	234.2	166.4	101.6	69.3	47.2	40.6	36.3	32.8	47.1	75.2	102.9	234.2	117	1875	2000
Date of Highest daily rainfall	5-Jan-13	28-Feb-10	3-Mar-30	05 Apr 1896	12-May-68	15-Jun-73	3-Jul-00	04 Aug 188	15-Sep-75	29-Oct-75	22-Nov-42	30 Dec 1888	28-Feb-10	N/A	1875	2000
Mean number of days of rain	6.2	6.2	3.7	1.4	1.1	0.9	0.6	0.4	1	2.4	3.8	5.5	33.2	116	1874	2000
Mean number of days of rain >= 1 mm	5.2	5	3	1.2	0.9	0.7	0.5	0.3	0.7	1.8	2.9	4.2	26.4	117	1875	2000
Mean number of days of rain >= 10 mm	2.2	2.2	1.2	0.4	0.3	0.2	0.2	0.1	0.2	0.4	0.8	1.3	9.5	117	1875	2000
Mean number of days of rain >= 25 mm	1	1	0.5	0.1	0.1	0.1	0	0	0	0.1	0.2	0.5	3.6	117	1875	2000
Mean daily wind run (km)																
Maximum wind gust speed (km/h)																
Date of Maximum wind gust speed														N/A		
Mean daily sunshine (hours)																
Mean daily solar exposure (MJ/(m*m))	25.7	24.7	24.1	21.9	18.9	17.2	18.4	21.2	23.8	25.4	26.6	26.3	22.8	19	1990	2009
Mean number of clear days	9.7	10.2	13.3	19.3	20.2	21.2	23	24.2	20.9	17	13.8	11.1	203.9	59	1910	1970
Mean number of cloudy days	7.3	6.9	5.1	2.7	3.2	2.4	2	0.8	1.1	3.2	4	5.9	44.6	59	1910	1970
Mean daily evaporation (mm)	12.1	11.8	11.7	10.7	8.7	6.9	6.8	8.3	10.4	11.8	13.2	12.8	10.4	10	1958	1970
Mean 9am temperature (Degrees C)	30	29	27.8	24.7	20.2	16.8	16.1	18.7	23.3	27.5	29.9	30.6	24.6	60	1910	1970
Mean 9am wet bulb temperature (Degrees C)	21.1	21.2	19.1	15.7	12.9	10.8	9.8	11	13.7	16.7	19	20.5	16	58	1910	1970
Mean 9am dew point temperature (Degrees C)	14.8	15.6	12.2	7.2	5	3.6	1.6	1.1	2.8	6.2	9.8	12.9	7.7	58	1910	1970
Mean 9am relative humidity (%)	46	50	42	36	39	44	40	33	29	30	34	39	39	58	1910	1970
Mean 9am cloud cover (okas)	3.3	3.1	2.5	1.7	1.9	1.6	1.5	1.1	1.4	2	2.3	3	2.1	59	1910	1970
Mean 9am wind speed (km/h) for years 1910 to 1970	13.2	12.7	14.3	17.8	17.5	16.8	17.4	17.3	18.1	17.7	16.7	14.7	16.2	59	1910	1970
Mean 3pm temperature (Degrees C)	36	35.2	34.2	31.4	27.1	24.1	23.9	26.7	30.7	34	35.9	36.4	31.3	60	1910	1970
Mean 3pm wet bulb temperature (Degrees C)	22	22.1	20.8	18.2	15.8	14	13.5	14.6	16.7	19	20.6	21.7	18.2	58	1910	1970
Mean 3pm dew point temperature (Degrees C)	12.3	13.3	10.8	6.9	4.7	3.3	1.5	1.2	2.2	5.5	8.5	11	6.8	58	1910	1970
Mean 3pm relative humidity (%)	29	32	28	24	26	28	25	21	19	20	22	26	25	58	1910	1970
Mean 3pm cloud cover (oktas)	4.4	4.1	3.6	2.3	2.2	1.7	1.4	1.1	1.5	2.7	3.4	3.9	2.7	59	1910	1970
Mean 3pm wind speed (km/h) for years 1910 to 1970	11.7	11.8	11.9	12.2	11.4	11.3	11.3	10.7	11.2	11.4	11.3	11.3	11.5	59	1910	1970

Monthly Climate Statistics for 'TENNANT CREEK AIRPORT' [015135]
Created on [28 Jan 2009 17:13:40 GMT]

015135 TENNANT CREEK AIRPORT
Commenced: 1969
Last Record: 2008
Latitude: 19.64 Degrees South
Longitude: 134.18 Degrees East
Elevation: 376 m
State: NT

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C)	36.8	35.8	34.4	31.7	27.7	24.5	24.6	27.4	31.5	34.8	36.5	37.3	31.9	39	1969	2008
Highest temperature (Degrees C)	44	44.5	40.7	38.4	36.4	32.9	34.7	35.5	38.9	41.6	43.4	45.4	45.4	39	1969	2008
Date of Highest temperature	5-Jan-71	18-Feb-70	3-Mar-88	9-Apr-05	4-May-07	15-Jun-02	16-Jul-95	29-Aug-92	27-Sep-97	22-Oct-87	30-Nov-96	2-Dec-07	2-Dec-07	N/A	1969	2008
Lowest maximum temperature (Degrees C)	24.2	24	20	15.1	16.1	8	11.9	14.1	15.7	14.8	15.5	20.4	8	39	1969	2008
Date of Lowest maximum temperature	19-Jan-06	2-Feb-04	9-Mar-00	25-Apr-83	14-May-79	20-Jun-07	14-Jul-84	14-Aug-78	9-Sep-74	20-Oct-00	17-Nov-81	25-Dec-06	20-Jun-07	N/A	1969	2008
Decile 1 maximum temperature (Degrees C) for years 1969 to 2008	31.8	30.8	30.2	27.6	23.1	19.8	20.3	22.6	26.2	29.7	31.9	32.7		40	1969	2008
Decile 9 maximum temperature (Degrees C) for years 1969 to 2008	40.9	39.9	38	35.2	31.7	29.3	29	32.1	36	38.9	40.1	40.9		40	1969	2008
Mean number of days >= 30 Degrees C	29.4	26.2	28.2	23	8.5	1.9	1.7	8.1	21	27.7	28.8	30	234.5	39	1969	2008
Mean number of days >= 35 Degrees C	22.6	17.3	14.7	3.6	0.2	0	0	0.2	5.8	17.4	21.6	24.8	128.2	39	1969	2008
Mean number of days >= 40 Degrees C	6.1	2.8	0.3	0	0	0	0	0	0	0.9	3.5	6.2	19.8	39	1969	2008
Mean minimum temperature (Degrees C)	25	24.6	23.3	20.4	16.4	12.9	12.2	14.4	18.4	21.8	23.8	24.9	19.8	39	1969	2008
Lowest temperature (Degrees C)	17.2	17.2	14.6	11.6	6.7	5.3	4.5	6	7.4	11.6	10.7	15.7	4.5	39	1969	2008
Date of Lowest temperature	14-Jan-02	3-Feb-04	31-Mar-73	26-Apr-83	27-May-74	27-Jun-77	14-Jul-78	3-Aug-90	16-Sep-77	21-Oct-00	19-Nov-81	28-Dec-06	14-Jul-78	N/A	1969	2008
Highest minimum temperature (Degrees C)	33.2	31.4	29.7	27.8	24.5	21.3	21.9	23.8	27.6	30.2	31.6	32.1	33.2	39	1969	2008
Date of Highest minimum temperature	5-Jan-71	26-Feb-86	7-Mar-88	21-Apr-98	6-May-88	22-Jun-96	16-Jul-90	29-Aug-92	30-Sep-88	15-Oct-87	23-Nov-90	31-Dec-86	5-Jan-71	N/A	1969	2008
Decile 1 minimum temperature (Degrees C) for years 1969 to 2008	22.1	22	20.4	16.6	12.3	8.7	8.3	10.4	13.3	17.7	20.1	21.8		40	1969	2008
Decile 9 minimum temperature (Degrees C) for years 1969 to 2008	28	27.5	26	23.9	20.4	17.3	16.2	18.9	22.9	25.7	27.1	28		40	1969	2008
Mean number of days <= 2 Degrees C	0	0	0	0	0	0	0	0	0	0	0	0	0	39	1969	2008
Mean number of days <= 0 Degrees C	0	0	0	0	0	0	0	0	0	0	0	0	0	39	1969	2008
Mean daily ground minimum temperature Degrees C	24	23.7	22	18.9	14.8	11.2	10.3	12.5	16.5	20.2	22.5	23.7	18.4	39	1969	2008
Lowest ground temperature Degrees C	16.3	14.9	12.5	10	4	2.3	2.1	2.7	4.5	9.6	11.1	12.8	2.1	39	1969	2008
Date of Lowest ground temperature	22-Jan-07	9-Feb-73	25-Mar-76	30-Apr-76	27-May-74	24-Jun-81	10-Jul-74	3-Aug-90	16-Sep-77	19-Oct-74	18-Nov-81	28-Dec-06	10-Jul-74	N/A	1969	2008
Mean number of days ground min. temp. <= -1 Degrees C	0	0	0	0	0	0	0	0	0	0	0	0	0	39	1969	2008
Mean rainfall (mm)	107.5	121	55.7	15.8	7.6	5.6	4.6	1.7	8.1	20.2	38	67.6	451.9	39	1969	2008
Highest rainfall (mm)	357.4	377	237.6	135.4	50.8	85.3	74.2	18.2	55.6	107.2	159.8	249.8	1004.2	39	1969	2008
Date of Highest rainfall	2006	2003	2001	2000	1978	1973	1978	2003	1975	2005	2000	2000	2000	N/A	1969	2008
Lowest rainfall (mm)	2.2	1	0	0	0	0	0	0	0	0	1.8	1.8	170	39	1969	2008
Date of Lowest rainfall	1985	1989	1991	2008	2008	2006	2008	2008	2006	2008	1986	1981	1970	N/A	1969	2008
Decile 1 monthly rainfall (mm) for years 1969 to 2008	12.9	9.9	1.8	0	0	0	0	0	0	0	5	11.8	225.9	39	1969	2008
Decile 5 (median) monthly rainfall (mm) for years 1969 to 2008	92.8	87	32	1.8	0	0	0	0	1	14.9	31.3	43.9	415.2	39	1969	2008
Decile 9 monthly rainfall (mm) for years 1969 to 2008	250.7	315.3	148.8	52.9	29.1	16.8	9.8	6.4	26.5	48.7	72.2	149.2	727.5	39	1969	2008
Highest daily rainfall (mm)	138.4	153.6	96.4	102.8	22.6	45.5	62.2	17.6	29.6	51.6	71.6	134.8	153.6	40	1969	2009
Date of Highest daily rainfall	26-Jan-82	17-Feb-03	25-Mar-07	22-Apr-00	7-May-86	15-Jun-73	9-Jul-78	15-Aug-03	29-Sep-79	29-Oct-75	13-Nov-00	23-Dec-93	17-Feb-03	N/A	1969	2009
Mean number of days of rain	9.6	9.3	6.1	1.9	1.4	0.9	0.7	0.7	1.8	3.9	5.8	7.6	49.7	39	1969	2008
Mean number of days of rain >= 1 mm	7.6	7.6	4.4	1.4	1	0.6	0.4	0.4	1.1	2.9	4.1	5.7	37.2	40	1969	2009
Mean number of days of rain >= 10 mm	3.2	3.4	1.8	0.4	0.4	0.2	0.1	0	0.2	0.6	1.1	2.1	13.5	40	1969	2009
Mean number of days of rain >= 25 mm	1.4	1.5	0.5	0.1	0	0.1	0.1	0	0.1	0.1	0.4	0.8		40	1969	2009
Mean daily wind run (km)	388	371	395	426	427	442	415	433	416	420	401	382	410	17	1992	2008
Maximum wind gust speed (km/h)	117	102	95	98	81	78	80	78	76	104	100	106	117	38	1969	2008
Date of Maximum wind gust speed	4-Jan-04	24-Feb-87	12-Mar-02	14-Apr-84	30-May-00	29-Jun-02	18-Jul-98	16-Aug-70	22-Sep-08	15-Oct-69	19-Nov-04	1-Dec-96	4-Jan-04	N/A	1969	2008
Mean daily sunshine (hours)	9.3	9	9.2	9.9	9.7	9.9	10.2	10.5	10.2	10.1	9.7	9.6	9.8	39	1969	2008
Mean daily solar exposure (MJ/(m*m))	25.7	24.7	24.1	21.9	18.9	17.2	18.4	21.2	23.8	25.4	26.6	26.3	22.8	19	1990	2009
Mean number of clear days	6.5	5.4	10.4	15.6	18.9	20.5	23.3	22.8	20.3	16.6	11.3	8.1	179.7	39	1969	2008
Mean number of cloudy days	12.2	12	9.1	5.3	4.2	2.7	1.9	1.7	2.4	4.6	6.2	10	72.3	39	1969	2008
Mean daily evaporation (mm)	12.7	11.5	11.4	11	8.7	7.3	7.5	9.3	11.7	13.2	13.6	13.3	10.9	37	1969	2008
Mean 9am temperature (Degrees C)	29.2	28.4	27.1	24.3	20	16.2	15.8	18.6	23.2	27.1	29	29.8	24.1	39	1969	2008
Mean 9am wet bulb temperature (Degrees C)	21.1	21.3	19	15.6	12.7	10.1	9.3	10.5	13.3	16.1	18.5	20.3	15.6	39	1969	2008
Mean 9am dew point temperature (Degrees C)	15.1	16.1	12.5	7.3	4.8	2.7	0.5	-0.2	1.8	4.7	9.1	12.9	7.3	39	1969	2008
Mean 9am relative humidity (%)	49	54	46	37	40	42	38	31	28	29	35	41	39	39	1969	2008
Mean 9am cloud cover (okas)	4.3	4.4	3.4	2.4	2.2	1.8	1.3	1.4	1.7	2.2	3	3.7	2.6	39	1969	2008
Mean 9am wind speed (km/h) for years 1969 to 2008	17	16.7	19.6	23.7	24.7	24.4	23.7	25.3	25.6	24.9	21.7	18.3	22.1	40	1969	2008
Mean 3pm temperature (Degrees C)	35.4	34.5	33.4	30.8	27	23.8	23.9	26.6	30.6	33.6	35.2	35.8	30.9	39	1969	2008
Mean 3pm wet bulb temperature (Degrees C)	21.9	22.2	20.5	18	15.6	13.5	12.9	14	16.1	18.2	19.9	21.2	17.8	39	1969	2008
Mean 3pm dew point temperature (Degrees C)	12.4	13.8	10.9	7.1	4.5	2.1	-0.1	-0.9	0.6	3.5	7.3	10.4	6	39	1969	2008
Mean 3pm relative humidity (%)	31	35	30	25	26	26	22	18	17	19	22	26	25	39	1969	2008
Mean 3pm cloud cover (oktas)	4.8	5	4.2	3.1	2.4	1.8	1.4	1.4	1.9	2.8	3.7	4.5	3.1	39	1969	2008
Mean 3pm wind speed (km/h) for years 1969 to 2008	15.4	15.9	17.6	17.3	16.7	16.5	15.5	16.1	16	14.5	13.8	14.1	15.8	39	1969	2008

Monthly Climate Statistics for 'ALI CURUNG' [015502]																
Created on [28 Jan 2009 13:33:31 GMT]																
015502 ALI CURUNG																
Commenced: 1967																
Last Record: 2008																
Latitude: 21.00 Degrees South																
Longitude: 134.40 Degrees East																
Elevation: 375 m																
State: NT																
Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C)	38	36.8	35.4	32.2	27.5	24.2	24.4	27	32.3	35.2	36.8	37.7	32.3	21	1988	2008
Highest temperature (Degrees C)	45	44.8	41.9	39.3	36.6	33.3	34.2	35.4	40.4	42.1	44.5	46	46	21	1988	2008
Date of Highest temperature	29-Jan-90	3-Feb-98	22-Mar-93	2-Apr-05	5-May-07	9-Jun-05	16-Jul-95	28-Aug-96	22-Sep-03	18-Oct-02	17-Nov-90	2-Dec-07	2-Dec-07	N/A	1988	2008
Lowest maximum temperature (Degrees C)	24.1	25	20.2	18.6	15.4	8	13.4	17.8	19.2	18.8	22	21	8	21	1988	2008
Date of Lowest maximum temperature	28-Jan-97	18-Feb-01	9-Mar-00	18-Apr-90	29-May-04	20-Jun-07	2-Jul-98	1-Aug-90	21-Sep-93	4-Oct-97	14-Nov-01	25-Dec-06	20-Jun-07	N/A	1988	2008
Decile 1 maximum temperature (Degrees C) for years 1988 to 2008	33	31.8	31.1	27.5	22.5	19.1	19.7	21.6	26.4	29.5	31.8	32.8		20	1988	2008
Decile 9 maximum temperature (Degrees C) for years 1988 to 2008	42	41.1	39	36.2	32.2	30	29.4	32.5	36.9	39.8	41.1	41.7		20	1988	2008
Mean number of days >= 30 Degrees C	29.2	25.1	28.2	22.9	8.4	2.9	2	7.7	21	26.2	27.2	26.7	227.5	21	1988	2008
Mean number of days >= 35 Degrees C	24.9	19.2	19	6.2	0.3	0	0	0.2	8.8	18.2	20.4	22.7	139.9	21	1988	2008
Mean number of days >= 40 Degrees C	10.7	5.6	1.4	0	0	0	0	0	0	2.6	5.7	7.9	33.9	21	1988	2008
Mean minimum temperature (Degrees C)	23.8	23.3	21	16.6	11.9	8.3	7.2	9.1	14.8	18.7	21.3	23.2	16.6	21	1988	2008
Lowest temperature (Degrees C)	15.8	15.3	10.1	5.9	1	-2.5	-1.2	-1	4.2	7.3	12.4	14.8	-2.5	21	1988	2008
Date of Lowest temperature	22-Jan-07	2-Feb-90	25-Mar-97	30-Apr-99	31-May-00	23-Jun-88	1-Jul-02	2-Aug-90	3-Sep-03	1-Oct-02	24-Nov-96	28-Dec-06	23-Jun-88	N/A	1988	2008
Highest minimum temperature (Degrees C)	31.1	30.7	28.5	26.3	21.6	18.5	18.4	20.5	27.3	28.6	30.6	30.7	31.1	21	1988	2008
Date of Highest minimum temperature	19-Jan-89	3-Feb-98	2-Mar-92	11-Apr-05	2-May-94	3-Jun-04	20-Jul-98	29-Aug-04	23-Sep-03	26-Oct-89	30-Nov-96	30-Dec-02	19-Jan-89	N/A	1988	2008
Decile 1 minimum temperature (Degrees C) for years 1988 to 2008	20.3	20	16.2	11.8	7	3.3	3	4.2	8.9	13.5	17	19.2		20	1988	2008
Decile 9 minimum temperature (Degrees C) for years 1988 to 2008	27.1	26.3	24.9	21.6	17.5	14	12	15	20.5	23.5	25.5	27		20	1988	2008
Mean number of days <= 2 Degrees C	0	0	0	0	0.2	1	1.5	0.4	0	0	0	0	3.1	21	1988	2008
Mean number of days <= 0 Degrees C	0	0	0	0	0	0.2	0.2	0.1	0	0	0	0	0.5	21	1988	2008
Mean daily ground minimum temperature Degrees C	21.2	21.2	18.6	14	9.2	5.5	4.1	6	11.3	15.4	18.2	20.7	13.8	20	1988	2008
Lowest ground temperature Degrees C	10	10.2	6.5	1.3	-2.4	-6	-5.8	-5.5	-2	0.2	7.4	8.5	-6	20	1988	2008
Date of Lowest ground temperature	11-Jan-92	2-Feb-90	16-Mar-94	27-Apr-92	29-May-02	29-Jun-04	1-Jul-02	17-Aug-02	14-Sep-04	1-Oct-02	4-Nov-89	17-Dec-89	29-Jun-04	N/A	1988	2008
Mean number of days ground min. temp. <= -1 Degrees C	0	0	0	0	0.2	2.4	3	1.6	0.1	0	0	0	7.3	20	1988	2008
Mean rainfall (mm)	80.4	101.4	32.3	19.1	18.2	5.8	5.3	3.9	8.1	22.5	31.5	63.8	386.9	30	1967	2008
Highest rainfall (mm)	442.7	379.8	141.4	83.3	154.3	43.4	34.4	25.6	55.6	122.2	99.4	375.5	905	30	1967	2008
Date of Highest rainfall	1974	1975	2001	2000	1968	2005	2006	1973	1993	2005	2001	2000	2000	N/A	1967	2008
Lowest rainfall (mm)	0.6	0	0	0	0	0	0	0	0	0	0	0	153.7	30	1967	2008
Date of Lowest rainfall	1989	1989	2002	2008	2008	2006	2008	2007	2006	2004	1969	1972	1969	N/A	1967	2008
Decile 1 monthly rainfall (mm) for years 1967 to 2008	2.8	10.5	2	0	0	0	0	0	0	0	1	10.5	191.9	30	1967	2008
Decile 5 (median) monthly rainfall (mm) for years 1967 to 2008	56.8	53.7	19.4	0.4	0	0	0.2	0	1.3	7.2	25.2	48.5	325.8	30	1967	2008
Decile 9 monthly rainfall (mm) for years 1967 to 2008	152.5	219.1	82.1	58.1	55.1	28.2	18.5	20.1	22.4	48	69.7	109.6	708	30	1967	2008
Highest daily rainfall (mm)	132	126.2	68	46.5	58.4	21.7	29.4	13.7	48.8	62.9	56	98.2	132	30	1967	2009
Date of Highest daily rainfall	21-Jan-74	12-Feb-97	17-Mar-75	2-Apr-71	21-May-90	20-Jun-05	14-Jul-06	23-Aug-71	28-Sep-93	21-Oct-05	18-Nov-97	13-Dec-00	21-Jan-74	N/A	1967	2009
Mean number of days of rain	6.9	7.9	4	2	1.8	1.2	1	1	1.5	3.8	4.6	6.8	42.5	30	1967	2008
Mean number of days of rain >= 1 mm	5.9	6.7	3.2	1.6	1.4	0.7	0.8	0.7	0.9	2.9	3.4	5.2	33.4	30	1967	2009
Mean number of days of rain >= 10 mm	2.5	2.6	1	0.7	0.5	0.2	0.1	0.1	0.2	0.6	1.1	1.9	11.5	30	1967	2009
Mean number of days of rain >= 25 mm	1.1	1.1	0.3	0.2	0.3	0	0	0	0.1	0.1	0.3	0.7		30	1967	2009
Mean daily wind run (km)																
Maximum wind gust speed (km/h)																
Date of Maximum wind gust speed														N/A		
Mean daily sunshine (hours)																
Mean daily solar exposure (MJ/(m*m))	26.5	25.1	24.5	21.4	18.1	16.6	17.9	20.7	23.5	25.4	27.1	27.1	22.8	19	1990	2009
Mean number of clear days	7.7	7.4	13.6	15.5	17.8	18.5	22.4	21.3	17.4	15.7	10.6	8.1	176	21	1988	2008
Mean number of cloudy days	7.9	8.2	5.3	3.6	4.1	2.5	1.3	1.8	2.7	4.6	4.7	8.2	54.9	21	1988	2008
Mean daily evaporation (mm)	10.4	9.1	8.8	7.6	5.4	4.5	4.6	6.2	8.3	9.6	10.4	10	7.9	20	1988	2008
Mean 9am temperature (Degrees C)	30.5	29.3	27.7	23.8	18.4	14.5	13.9	17.1	23.7	27.5	29.3	30.4	23.8	21	1988	2008
Mean 9am wet bulb temperature (Degrees C)	21.3	21.4	18.9	15.4	12.4	9.4	8.6	10	13.8	16.5	18.6	20.5	15.6	16	1988	2008
Mean 9am dew point temperature (Degrees C)	14.9	16.2	12.3	8	6.3	3.8	1.9	0.9	3.6	6.2	9.9	13.5	8.1	16	1988	2008
Mean 9am relative humidity (%)	44	51	42	40	48	52	46	35	30	31	37	42	41	16	1988	2008
Mean 9am cloud cover (okas)	3.3	3.5	2.4	2	2	1.8	1.1	1.1	1.5	2	2.7	3.3	2.2	21	1988	2008
Mean 9am wind speed (km/h) for years 1988 to 2008	12.4	11	13.4	13.7	12.8	12.4	11.6	14.2	15.8	16.7	15.8	12.9	13.6	19	1988	2008
Mean 3pm temperature (Degrees C)	36.8	35.6	34.5	31.3	26.7	23.5	23.8	26.3	31.4	34.1	35.5	36.4	31.3	21	1988	2008
Mean 3pm wet bulb temperature (Degrees C)	22.5	22.8	21	18.5	16.1	13.7	13.3	14.1	17.1	18.8	20.5	21.9	18.4	16	1988	2008
Mean 3pm dew point temperature (Degrees C)	13	14.8	11.5	8	6.5	3.8	1.8	0.4	3.4	5.5	9.1	11.8	7.5	16	1988	2008
Mean 3pm relative humidity (%)	29	35	29	27	31	30	25	20	19	21	26	28	27	16	1988	2008
Mean 3pm cloud cover (oktas)	4.6	4.5	3.5	2.8	2.3	1.9	1	1.2	2	2.8	3.7	4.5	2.9	21	1988	2008
Mean 3pm wind speed (km/h) for years 1988 to 2008	11.5	11.4	12.1	11.3	11	11	10.8	12.6	12.3	12	12	11.1	11.6	19	1988	2008

Monthly Climate Statistics for 'CAMOOWEAL TOWNSHIP' [037010]

Created on [29 Jan 2009 01:05:59 EST]

037010 CAMOOWEAL TOWNSHIP

Commenced: 1891

Last Record: 2008

Latitude: 19.92 Degrees South

Longitude: 138.12 Degrees East

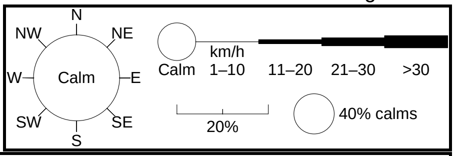
Elevation: 231 m

State: QLD

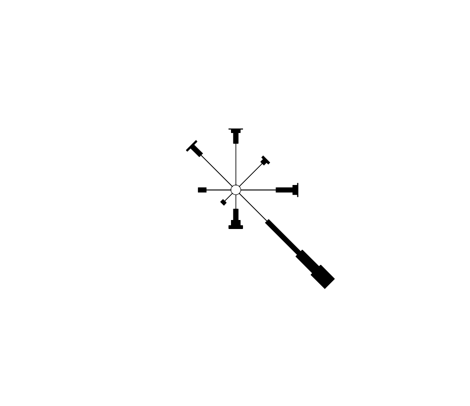
Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C)	37.4	36.2	35.3	33	28.9	25.9	25.8	28.3	32.3	35.8	37.5	38.1	32.9	100	1907	2008
Highest temperature (Degrees C)	45.4	45.5	42.8	40	38.2	35.6	35.7	37.3	41	44	44.5	46.6	46.6	68	1939	2008
Date of Highest temperature	11-Jan-71	19-Feb-83	2-Mar-51	5-Apr-66	4-May-07	1-Jun-62	17-Jul-95	28-Aug-85	30-Sep-00	23-Oct-87	27-Nov-82	23-Dec-90	23-Dec-90	N/A	1939	2008
Lowest maximum temperature (Degrees C)	24	15	20.7	19.1	13.3	9.8	11	15	15.2	17	20.7	19.4	9.8	68	1939	2008
Date of Lowest maximum temperature	17-Jan-03	24-Feb-49	29-Mar-56	26-Apr-83	23-May-59	20-Jun-07	24-Jul-84	8-Aug-96	8-Sep-87	20-Oct-00	17-Nov-81	21-Dec-50	20-Jun-07	N/A	1939	2008
Decile 1 maximum temperature (Degrees C) for years 1939 to 2008	32.8	31.7	31.4	29	24.3	21.1	21.2	23.3	27.2	31.3	33.5	33.7		68	1939	2008
Decile 9 maximum temperature (Degrees C) for years 1939 to 2008	41.7	40.6	39	36.7	33.3	30.6	30.4	33	36.7	39.7	41.1	42		68	1939	2008
Mean number of days >= 30 Degrees C	28.7	26.5	28.1	25.2	14.4	4.5	4.3	11.5	23	28.8	28.7	29.4	253.1	68	1939	2008
Mean number of days >= 35 Degrees C	23.8	19.8	19.7	9.9	0.9	0	0	0.8	8.6	21.6	24.6	25.5	155.2	68	1939	2008
Mean number of days >= 40 Degrees C	8.7	4.6	1.3	0	0	0	0	0	0.1	2.6	7.9	10.9	36.1	68	1939	2008
Mean minimum temperature (Degrees C)	24.3	23.7	21.8	18	13.4	9.9	8.8	10.9	15.1	19.5	22.3	23.8	17.6	100	1907	2008
Lowest temperature (Degrees C)	13.5	12.8	10	4.4	2.4	-2.2	-0.3	0	3.9	5.7	7.5	14.4	-2.2	68	1939	2008
Date of Lowest temperature	30-Jan-78	25-Feb-49	27-Mar-46	30-Apr-52	30-May-74	27-Jun-71	20-Jul-04	1-Aug-77	1-Sep-43	2-Oct-41	2-Nov-74	14-Dec-52	27-Jun-71	N/A	1939	2008
Highest minimum temperature (Degrees C)	33.3	29.7	30.5	27.5	23.9	21.7	21.8	22.4	26.6	31.1	30.6	31.4	33.3	68	1939	2008
Date of Highest minimum temperature	2-Jan-43	19-Feb-86	1-Mar-83	12-Apr-86	3-May-64	3-Jun-63	27-Jul-93	25-Aug-95	25-Sep-89	29-Oct-48	22-Nov-08	31-Dec-90	2-Jan-43	N/A	1939	2008
Decile 1 minimum temperature (Degrees C) for years 1939 to 2008	21.2	21	18	13	8	4	3.6	5.6	9.3	14.1	18	20		68	1939	2008
Decile 9 minimum temperature (Degrees C) for years 1939 to 2008	27.3	26.7	25.3	22.8	19	15.4	14.4	16.7	20.8	24.4	26.3	27.3		68	1939	2008
Mean number of days <= 2 Degrees C	0	0	0	0	0	0.8	1.2	0.3	0	0	0	0	2.3	68	1939	2008
Mean number of days <= 0 Degrees C	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0.2	68	1939	2008
Mean daily ground minimum temperature Degrees C	23.3	22.6	20.7	16.6	11.8	8.4	7.3	9	13.2	18.1	21.2	22.6	16.2	32	1938	1970
Lowest ground temperature Degrees C	6.7	10.6	7.2	-15	-0.6	-5	-2.2	-3	2.3	3.3	10.4	12	-15	30	1939	1970
Date of Lowest ground temperature	27-Jan-59	11-Feb-59	27-Mar-46	27-Apr-43	31-May-51	20-Jun-49	13-Jul-60	15-Aug-41	13-Sep-41	2-Oct-41	28-Nov-55	10-Dec-41	27-Apr-43	N/A	1939	1970
Mean number of days ground min. temp. <= -1 Degrees C	0	0	0	0	0	0.4	0.4	0.1	0	0	0	0	0.9	30	1939	1970
Mean rainfall (mm)	95.5	90.9	54.7	14.3	11.1	10	5.5	2.9	6	14.2	28.8	59.3	392.4	116	1891	2008
Highest rainfall (mm)	592.8	384.6	311.1	239	147.1	116.8	82.1	88.4	80.2	125.3	137.5	289.2	1003.3	116	1891	2008
Date of Highest rainfall	1974	2000	1903	2006	1955	1937	1900	1893	1947	1930	1917	2000	1974	N/A	1891	2008
Lowest rainfall (mm)	0	0	0	0	0	0	0	0	0	0	0	0	100.4	116	1891	2008
Date of Lowest rainfall	1972	2001	2001	2008	2008	2006	2008	2008	2007	2006	1968	1938	2001	N/A	1891	2008
Decile 1 monthly rainfall (mm) for years 1891 to 2008	14.5	12.6	1.5	0	0	0	0	0	0	0	1.4	9.7	199.6	117	1891	2008
Decile 5 (median) monthly rainfall (mm) for years 1891 to 2008	66.1	71.2	36	2	0.6	0	0	0	0	5.3	21.6	47	368.3	117	1891	2008
Decile 9 monthly rainfall (mm) for years 1891 to 2008	196.1	194.4	140.1	45.3	29.2	33.9	14.4	8.8	22.6	41.8	64.9	121.5	598	117	1891	2008
Highest daily rainfall (mm)	226.1	112.8	191.3	110	70.4	57	76.7	53.3	36.3	85	130	116.3	226.1	116	1891	2009
Date of Highest daily rainfall	30-Jan-08	28-Feb-92	31-Mar-58	29-Apr-06	24-May-55	29-Jun-98	2-Jul-00	17 Aug 189	5-Sep-47	21-Oct-00	16-Nov-12	19-Dec-50	30-Jan-08	N/A	1891	2009
Mean number of days of rain	8.2	8.1	5.3	1.6	1.3	1.1	0.8	0.5	1.1	2.6	4.2	6.1	40.9	117	1891	2008
Mean number of days of rain >= 1 mm	7.1	6.8	4.3	1.2	1	0.8	0.6	0.3	0.8	2	3.1	5	33	116	1891	2009
Mean number of days of rain >= 10 mm	2.6	2.6	1.5	0.4	0.4	0.3	0.1	0.1	0.2	0.4	1	1.8	11.4	116	1891	2009
Mean number of days of rain >= 25 mm	1.1	1	0.6	0.2	0.1	0.1	0	0	0	0.1	0.2	0.6	4	116	1891	2009
Mean daily wind run (km)														6	2003	2008
Maximum wind gust speed (km/h)														6	1963	2008
Date of Maximum wind gust speed														N/A	1963	2008
Mean daily sunshine (hours)														0	1963	1964
Mean daily solar exposure (MJ/(m*m))	25.2	24.4	23.8	21.3	18.6	17.1	18.2	21	23.9	25.5	26.5	26.4	22.7	19	1990	2009
Mean number of clear days	8.2	6.5	10.5	15.5	17.4	20.6	23.1	24	21.4	16.9	12.8	10.5	187.4	57	1939	1997
Mean number of cloudy days	8.4	8.6	6.7	3.2	3.4	2.2	1.9	1.3	1.9	3.2	3.8	6	50.6	57	1939	1997
Mean daily evaporation (mm)	9.8	8.5	8.2	7.7	6.3	5.3	5.5	7.1	9.1	10.9	11.1	10.8	8.4	25	1969	1997
Mean 9am temperature (Degrees C)	29.6	28.6	27.5	24.8	20.3	16.1	15.4	18.5	23.5	27.9	30	30.6	24.4	99	1907	2008
Mean 9am wet bulb temperature (Degrees C)	22.3	22.4	20.2	16.9	13.8	10.9	9.8	11.2	14	17.3	19.5	21.3	16.6	88	1907	2008
Mean 9am dew point temperature (Degrees C)	17.7	18.4	14.7	9.9	6.3	4.3	2	1.2	2.9	6.9	10.4	14.4	9.1	61	1939	2008
Mean 9am relative humidity (%)	55	61	51	44	45	51	47	36	30	32	36	44	44	62	1938	2008
Mean 9am cloud cover (okas)	3.1	3.3	2.4	1.6	1.7	1.5	1.1	0.8	1	1.6	2.1	2.5	1.9	90	1907	1997
Mean 9am wind speed (km/h) for years 1939 to 2008	10.3	9.2	10.2	12.4	12.3	11.1	10.9	13.4	14.9	14.7	13.2	11.5	12	68	1939	2008
Mean 3pm temperature (Degrees C)	35.6	34.7	34.1	32	28.1	25.1	24.9	27.4	31.3	34.5	36.1	36.5	31.7	97	1907	2008
Mean 3pm wet bulb temperature (Degrees C)	23.1	23.3	21.8	19.3	17.1	15	14.2	15.1	16.9	19.3	20.9	22.2	19	87	1907	2008
Mean 3pm dew point temperature (Degrees C)	14.9	15.9	12.9	8.9	6	3.7	1.4	0.3	1.1	4.9	8.1	11.7	7.5	61	1939	2008
Mean 3pm relative humidity (%)	34	37	32	26	27	27	24	19	17	19	22	27	26	62	1938	2008
Mean 3pm cloud cover (oktas)	4.4	4.5	3.8	2.6	2.2	1.6	1	0.9	1.4	2.4	3.3	3.9	2.7	88	1907	1997
Mean 3pm wind speed (km/h) for years 1939 to 2008	11.7	11.3	11.8	12.6	12.8	13.4	13.6	13.6	13.4	12.6	11.6	11.3	12.5	67	1939	2008

Wind Roses using data between Jan 1957 and Aug 1974 for
Wonarah

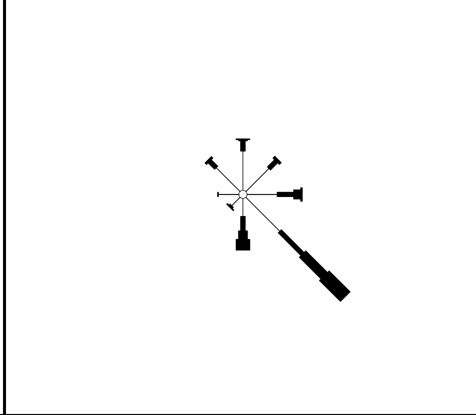
Site Number 015034 • Locality: Ranken • Opened Apr 1946 • Closed 31 Dec 1974
Latitude 19°53'54"S • Longitude 136°20'09"E • Elevation 240m



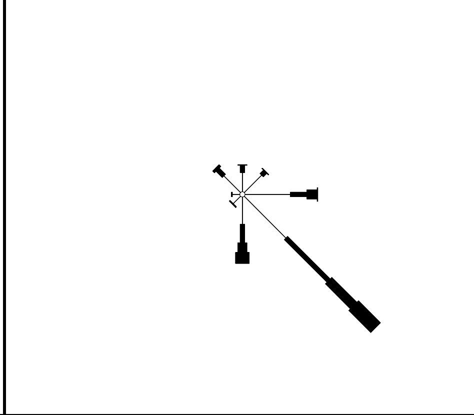
9 am January 484 observations



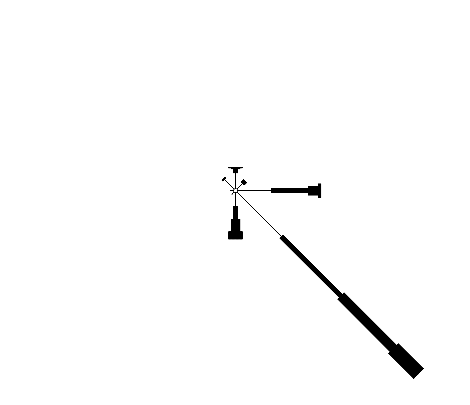
9 am February 448 observations



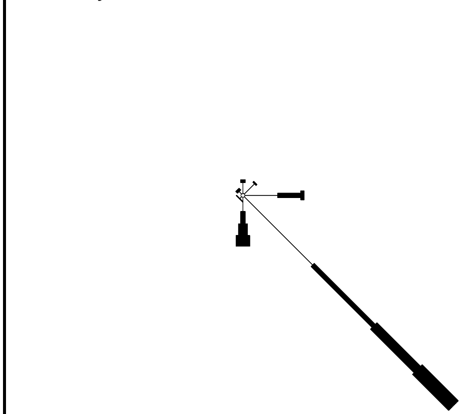
9 am March 466 observations



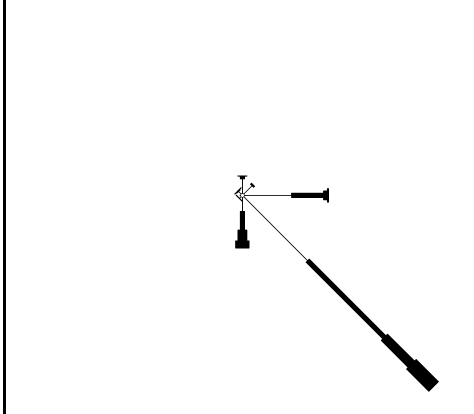
9 am April 458 observations



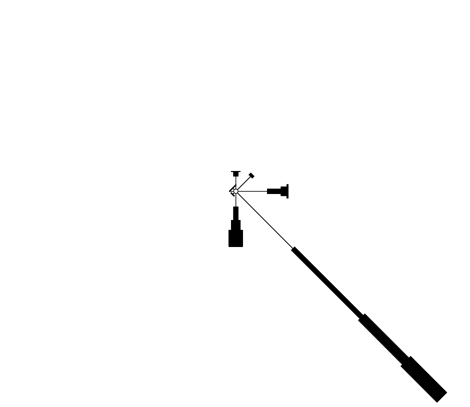
9 am May 467 observations



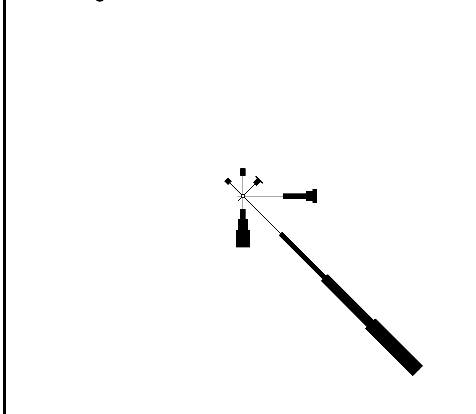
9 am June 456 observations



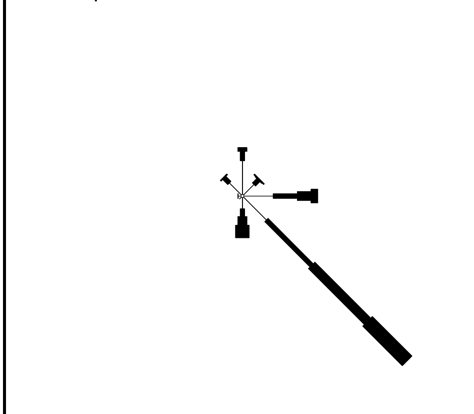
9 am July 462 observations



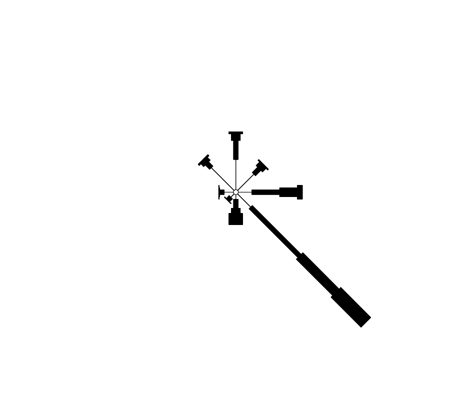
9 am August 482 observations



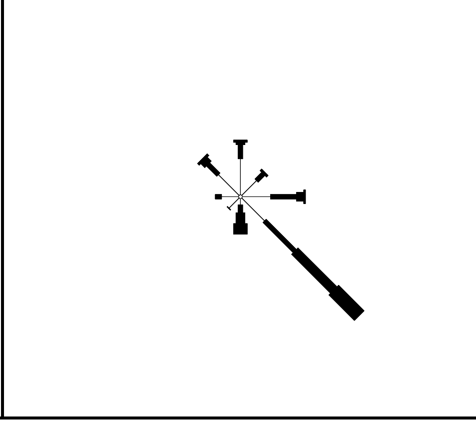
9 am September 446 observations



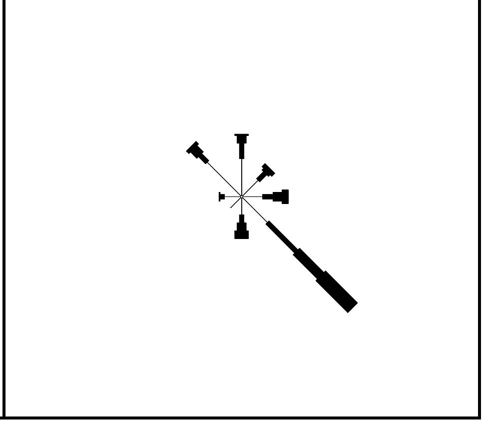
9 am October 454 observations



9 am November 406 observations



9 am December 385 observations



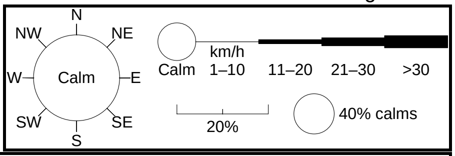
Australian Government
Bureau of Meteorology

Prepared by Climate Services Section in the WA Office of the Bureau of Meteorology. Contact us by phone on (08) 9263 2222, by fax on (08) 9263 2233, or by email on climate.wa@bom.gov.au

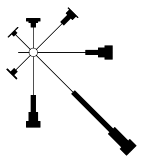
Prepared on 24 February 2009

Wind Roses using data between Jan 1957 and Aug 1974 for Wonarah

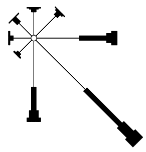
Site Number 015034 • Locality: Ranken • Opened Apr 1946 • Closed 31 Dec 1974
Latitude 19°53'54"S • Longitude 136°20'09"E • Elevation 240m



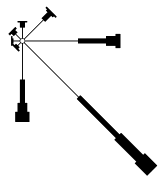
3 pm January — 456 observations



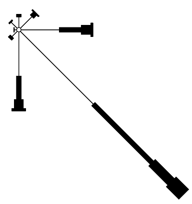
3 pm February — 414 observations



3 pm March — 433 observations

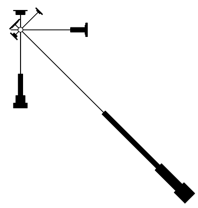


3 pm April — 430 observations

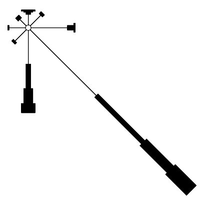


3 pm May — 453 observations

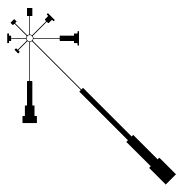
3 pm June — 428 observations



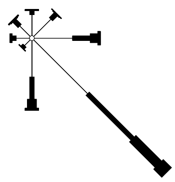
3 pm July — 428 observations



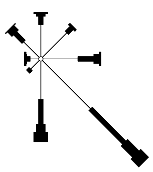
3 pm August — 443 observations



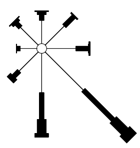
3 pm September — 402 observations



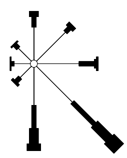
3 pm October — 436 observations



3 pm November — 390 observations



3 pm December — 374 observations



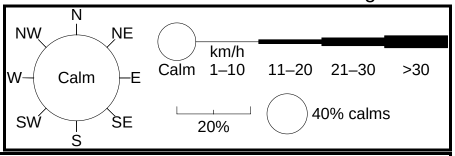
Australian Government
Bureau of Meteorology

Prepared by Climate Services Section in the WA Office of the Bureau of Meteorology. Contact us by phone on (08) 9263 2222, by fax on (08) 9263 2233, or by email on climate.wa@bom.gov.au
 Prepared on 24 February 2009

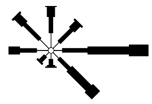
Wind Roses using data between Jul 1969 and Feb 2009 for

Tennant Creek Airport

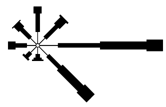
Site Number 015135 • Locality: Barkly South • Opened Jan 1969 • Still Open
Latitude 19°38'32"S • Longitude 134°11'00"E • Elevation 375.7m



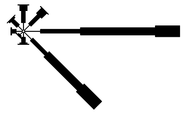
9 am January 1302 observations



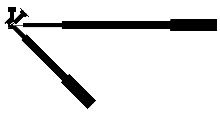
9 am February 1181 observations



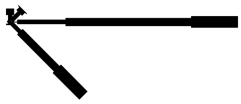
9 am March 1243 observations



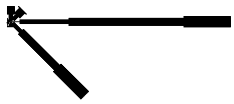
9 am April 1200 observations



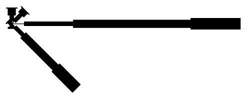
9 am May 1207 observations



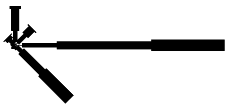
9 am June 1170 observations



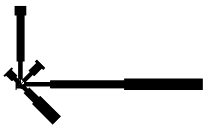
9 am July 1243 observations



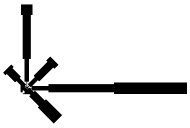
9 am August 1265 observations



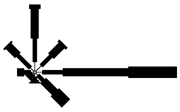
9 am September 1227 observations



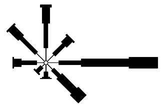
9 am October 1272 observations



9 am November 1260 observations



9 am December 1301 observations

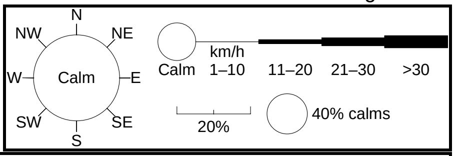


Australian Government
Bureau of Meteorology

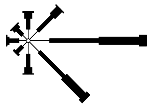
Prepared by Climate Services Section in the WA Office of the Bureau of Meteorology. Contact us by phone on (08) 9263 2222, by fax on (08) 9263 2233, or by email on climate.wa@bom.gov.au
 Prepared on 24 February 2009

Wind Roses using data between Jul 1969 and Feb 2009 for
Tennant Creek Airport

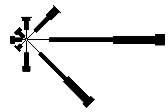
Site Number 015135 • Locality: Barkly South • Opened Jan 1969 • Still Open
Latitude 19°38'32"S • Longitude 134°11'00"E • Elevation 375.7m



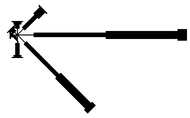
3 pm January 1301 observations



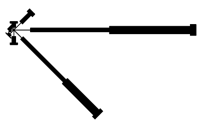
3 pm February 1163 observations



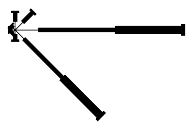
3 pm March 1213 observations



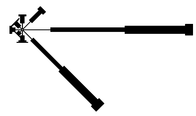
3 pm April 1174 observations



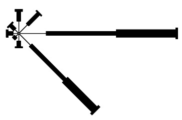
3 pm May 1193 observations



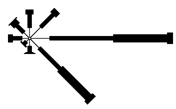
3 pm June 1155 observations



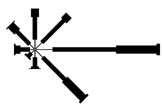
3 pm July 1233 observations



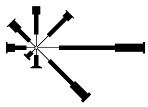
3 pm August 1253 observations



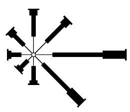
3 pm September 1216 observations



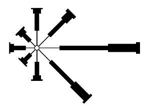
3 pm October 1252 observations



3 pm November 1222 observations



3 pm December 1289 observations



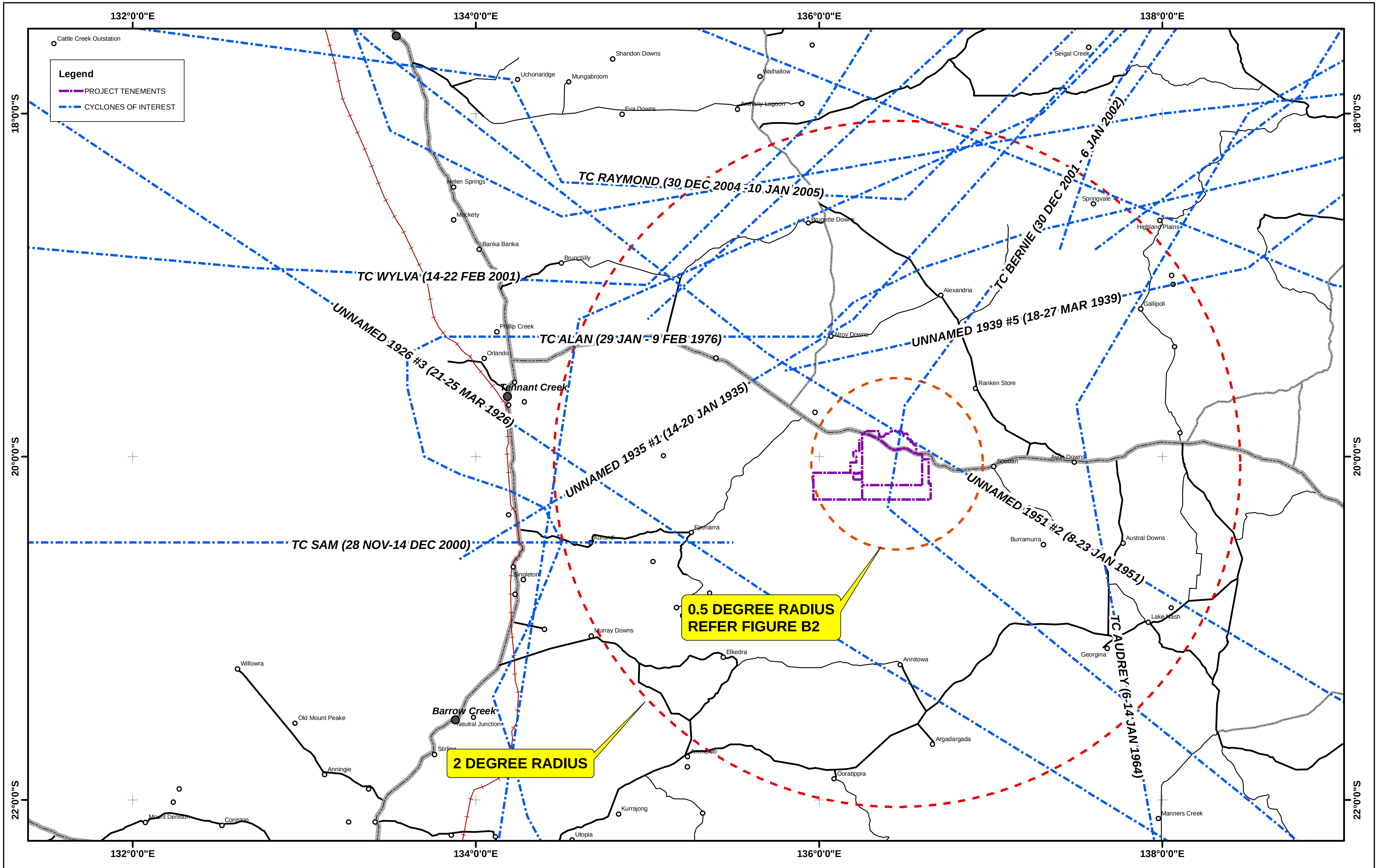
Australian Government
Bureau of Meteorology

Prepared by Climate Services Section in the WA Office of the Bureau of Meteorology. Contact us by phone on (08) 9263 2222, by fax on (08) 9263 2233, or by email on climate.wa@bom.gov.au

Prepared on 24 February 2009

APPENDIX B

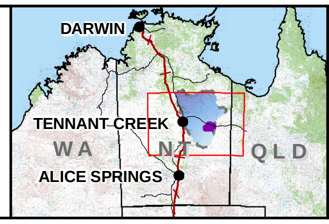
Cyclone Swept Path Analysis



N

0 12,500 25,000 50,000 75,000 100,000 125,000 150,000

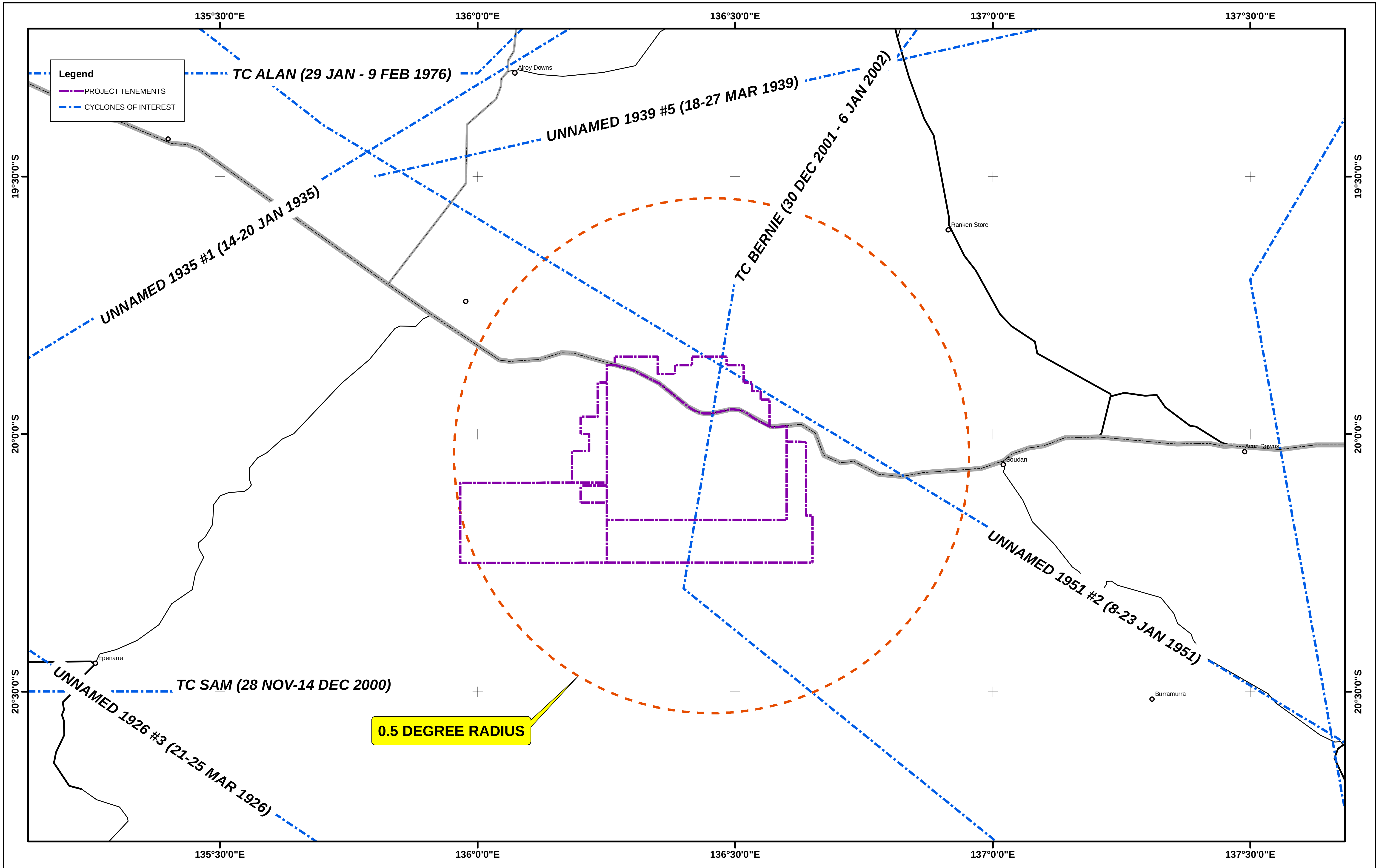
DATUM:GDA94, PROJECTION, MGA94, ZONE53S (Metres)



GROUNDWATER
RESOURCE MANAGEMENT

CLIENT MINEMAKERS LIMITED		PROJECT WONARAH PROJECT	
DRAWN DFH	DATE 28.04.2009	TITLE CYCLONE SWEPT PATH ANALYSIS 2 DEGREE RADIUS	
CHECKED ARL	DATE 30.04.2009		
SCALE 1:2,250,000 @ A3		PROJECT No J090004	FIGURE No B1

File Location : I:\CarrickConsulting\J090004_Wonarah_NT\03_ProjectData\01_Workspace



GROUNDWATER RESOURCE MANAGEMENT

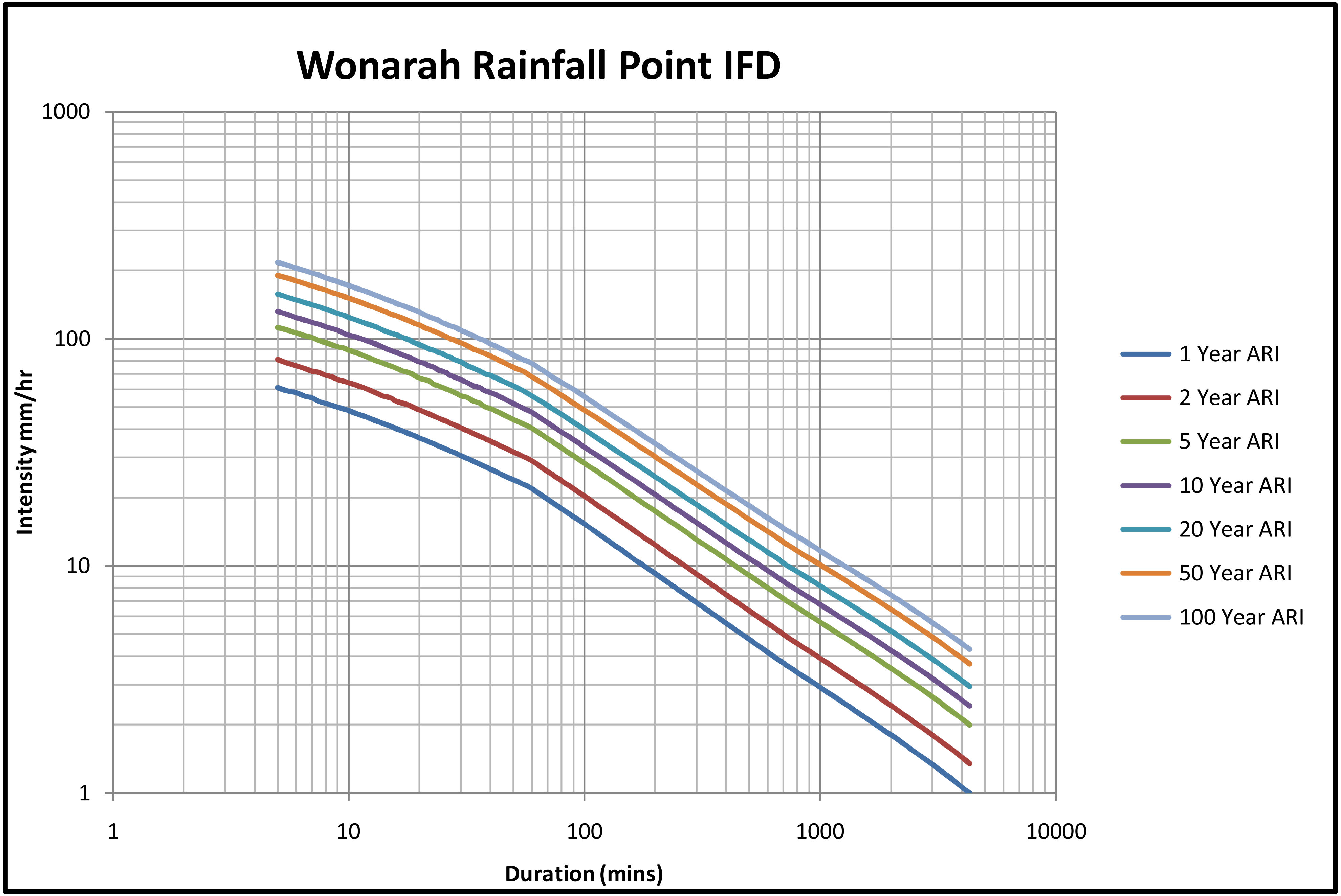
CLIENT	MINEMAKERS LIMITED	PROJECT	WONARAH PROJECT
DRAWN	DFH	DATE 28.04.2009	TITLE CYCLONE SWEPT PATH ANALYSIS 0.5 DEGREE RADIUS
CHECKED	ARL	DATE 30.04.2009	
SCALE	1:750,000 @ A3	PROJECT No J090004	FIGURE No B2

File Location : I:\CarrickConsulting\J090004_Wonarah_NT\03_ProjectData\01_Workspace

APPENDIX C

Point Intensity Frequency Duration Relationship for Wonarah

Rainfall Intensity Frequency Duration data for; Wonarah NT							
Geographic Location: , 20.04 , Deg. South, 136.45 , Deg. East							
AUSIFD, Version 2.0, 19 February,2009							
Duration	1 Year ARI	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI
(mins)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)
5	61	81	112	132	157	190	217
5.5	59	78	109	128	152	185	211
6	58	76	106	124	148	180	205
6.5	56	74	103	121	144	175	200
7	55	72	101	118	141	171	195
7.5	53	71	98	116	138	167	191
8	52	69	96	113	135	164	186
8.5	51	68	94	111	132	160	182
9	50	66	92	109	129	157	179
9.5	49.2	65	91	106	127	154	175
10	48.3	64	89	104	124	151	172
11	46.6	62	86	101	120	146	166
12	45.1	60	83	98	116	141	161
13	43.7	58	80	95	113	137	156
14	42.5	56	78	92	109	133	151
15	41.3	55	76	89	106	129	147
16	40.2	53	74	87	104	126	143
17	39.2	52	72	85	101	123	140
18	38.3	51	71	83	99	120	137
19	37.5	49.6	69	81	96	117	134
20	36.6	48.5	67	79	94	115	131
21	35.9	47.5	66	78	92	112	128
22	35.2	46.6	65	76	90	110	125
23	34.5	45.7	63	75	89	108	123
24	33.8	44.8	62	73	87	106	121
25	33.2	44	61	72	86	104	118
26	32.6	43.3	60	71	84	102	116
27	32.1	42.5	59	69	83	100	114
28	31.6	41.8	58	68	81	99	113
29	31.1	41.2	57	67	80	97	111
30	30.6	40.5	56	66	79	96	109
32	29.7	39.3	55	64	76	93	106
34	28.9	38.2	53	62	74	90	103
36	28.1	37.2	52	61	72	88	100
38	27.4	36.3	50	59	70	86	98
40	26.7	35.4	49.2	58	69	84	95
45	25.2	33.4	46.5	55	65	79	90
50	24	31.8	44.1	52	62	75	85
55	22.9	30.3	42.1	49.5	59	72	81
60	21.9	29	40.3	47.4	56	68	78
75	18.7	24.8	34.6	40.7	48.5	59	67
90	16.5	21.9	30.5	36	42.9	52	60
105	14.8	19.6	27.4	32.3	38.6	47.1	54
120	13.4	17.8	25	29.5	35.2	43	49.1
135	12.3	16.4	23	27.2	32.4	39.6	45.3
150	11.4	15.2	21.3	25.2	30.2	36.9	42.2
165	10.6	14.2	19.9	23.6	28.2	34.5	39.5
180	9.99	13.3	18.7	22.2	26.6	32.5	37.2
195	9.43	12.6	17.7	21	25.1	30.8	35.2
210	8.94	11.9	16.8	19.9	23.9	29.2	33.5
225	8.5	11.3	16	19	22.7	27.9	31.9
240	8.11	10.8	15.3	18.1	21.7	26.6	30.5
270	7.44	9.93	14.1	16.7	20	24.6	28.2
300	6.89	9.2	13	15.5	18.6	22.8	26.2
360	6.04	8.07	11.5	13.6	16.4	20.1	23.1
420	5.4	7.22	10.3	12.2	14.7	18.1	20.8
480	4.9	6.56	9.35	11.1	13.4	16.5	19
540	4.5	6.02	8.61	10.3	12.4	15.2	17.5
600	4.17	5.59	7.99	9.54	11.5	14.2	16.3
660	3.89	5.22	7.47	8.92	10.8	13.3	15.3
720	3.66	4.9	7.03	8.4	10.1	12.5	14.4
840	3.29	4.42	6.35	7.59	9.17	11.3	13.1
960	3.01	4.04	5.81	6.96	8.41	10.4	12
1080	2.77	3.73	5.38	6.44	7.79	9.65	11.1
1200	2.58	3.47	5.01	6.01	7.28	9.02	10.4
1320	2.42	3.25	4.7	5.65	6.84	8.48	9.79
1440	2.27	3.06	4.43	5.33	6.46	8.01	9.25
1800	1.94	2.62	3.81	4.58	5.56	6.92	8
2160	1.71	2.3	3.35	4.04	4.91	6.12	7.08
2520	1.52	2.05	3.01	3.63	4.41	5.5	6.37
2880	1.38	1.86	2.73	3.3	4.01	5.01	5.8
3240	1.26	1.7	2.5	3.02	3.68	4.6	5.33
3600	1.16	1.57	2.3	2.79	3.4	4.25	4.94
3960	1.07	1.45	2.14	2.59	3.16	3.96	4.6
4320	1	1.35	1.99	2.42	2.95	3.7	4.3



Wonarah Rainfall Point IFD
Intensity mm/hr
1000
100
10
1
1
10
100
1000
10000
Duration (mins)
1 Year ARI
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI