PF FORMATION

HITCHCOCK ROAD SAND EXTRACTION AND REHABILITATION PROJECT, MAROOTA

TECHNICAL PAPERS
Volume Three

Air quality
Flora and Fauna
Cultural heritage assessment
Visual impacts

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DFA Consultants

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TECHNICAL PAPER

AIR QUALITY

AIR QUALITY IMPACT ASSESSMENT
MAROOTA SAND QUARRY – HITCHCOCK ROAD

19 October 2006 FINAL

Prepared for
DFA Consultants

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GLOSSARY OF TERMS

BoM	Bureau of Meteorology
g/m^2/month	grams per square metre per month
Gaussian dispersion model	computer based model that simulates dispersion of pollutants in the atmosphere
ISCST3	Industrial Source Complex – Short Term Version 3 (Dispersion Model)
Isopleth	line drawn on a map through all points of equal value of some measurable quantity
μg/m^3	micrograms per cubic metre
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measures
NHMRC	National Health and Medical Research Council
NSW DEC	New South Wales Department of Environment and Conservation (now Department of Environment and Climate Change)
Pasquill-Gifford curves	empirically derived curves which show rate of plume dispersion under different dispersion conditions
$PM_{2.5}$	particulate matter less than 2.5 μm in diameter
PM_{10}	particulate matter less than 10 μm in diameter
Prognostic	predictive
TSP	Total suspended particulates
US EPA	United States Environment Protection Agency

1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for DFA Consultants, who are in turn acting on behalf of PF Formation (the proponent). The proponent is proposing to extend the current operations for the extraction of sand from the Hitchcock Road site, Maroota. The annual quantity of material to be extracted is not proposed to increase. The main source of emissions from the proposed extension will be dust. The purpose of this report is to quantitatively assess dust impacts that may be associated with the extended extraction area.

The assessment is based on the use of a computer-based dispersion model to predict ground-level dust concentrations and deposition levels in the vicinity of the Project Site. To assess the effect that the dust emissions would have on existing air quality, the dispersion model predictions have been compared to relevant air quality goals. Dispersion modelling procedures follow NSW Department of Environment and Conservation (DEC) guidelines (**NSW DEC, 2005**)

Predictions of dust concentration and deposition levels have been made using a modified version of the US EPA's short-term industrial source complex dispersion model ISCST3 (**US EPA, 1995a**) which will be referred to in this report as ISCMOD.

Since the assessment was undertaken, one property (Lot 2 DP555184) has been removed from the proposal. This would have the effect of changing the location of some of the operations used as the basis for the predictions. These have not been remodeled and the predictions reported in this technical paper and in Volume One of the EA can be considered to represent worst-case conditions. These changes do not alter the conclusions of this report.

2. PROJECT DESCRIPTION

The location of the site is shown in **Figure 1**. The surrounding landuse is primarily rural residential, although there is significant sand extraction activity in the area, both by the proponent and other companies. There are a number of residences in the proximity of the site and the local school is located approximately 500 m north of the most northerly section of the site. **Figure 2** shows the location of the school and other nearby residences.

The site is located at approximately 200 m above sea level. The topography of the area is characterised by undulating terrain which is steep in parts. **Figure 3** shows a pseudo three-dimensional plot of the area.

The proposal includes clearing vegetation prior to the staged extraction of sand from an extended area from the current operations.

All Tertiary sand would be extracted using an excavator and transferred to articulated dump trucks to transport the material to the existing slurry plant located at the northern end of the site. Here it would be mixed with water and pumped via pipeline to the central process plant located on Lot 198. The wash water would be returned to the site for settlement in a series of clay lined basins prior to recirculation from the clean water pond at the lowest point in the system and subsequent reuse.

The sand would be processed at the central plant. It would then be sent to market following checking at the weighbridge. There would be no transport of Tertiary sand by truck from the site to the central wash plant except during periods of routine maintenance or as a result of plant breakdown.

As per the current operations, a maximum of 400,000 tonnes of processed Tertiary sand would be exported from the site each year for a maximum period of 30 years from November 1998 (until October 2028). The average extraction rate is 250,000 tonnes per year (t/y) and it is not anticipated that this will increase.

3. AIR QUALITY GOALS

3.1 Introduction

In its modelling and assessment guidelines, New South Wales Department of Environment and Conservation (NSW DEC) specifies air quality assessment criteria relevant for assessing impacts from dust generating activities (**NSW DEC, 2005**).

These criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (referred to as the Ambient Air-NEPMs (see **NEPC, 1998**)). However, the NSW DEC's criteria include averaging periods, which are not included in the Air-NEPMs and references to other measures of air quality, namely dust deposition and total suspended particulate matter (TSP).

Table 1 and **Table 2** summarise the air quality goals relevant to this study. The air quality goals relate to the total dust burden in the air and not just the dust from the project. Therefore, some consideration of background levels needs to be made when using these goals to assess impacts. This is discussed further in **Section 4.4**.

3.2 Health effects of particulate matter

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. The health effects of particles are largely related to the extent to which they can penetrate the respiratory tract. Larger particles, those greater than 10 μm, generally adhere to the mucus in the nose, mouth, pharynx and larger bronchi and from there are removed by either swallowing or expectorating. Finer particles can enter bronchial and pulmonary regions of the respiratory tract, with increased deposition during mouth breathing which increases during exercise. The very fine particles can be deposited in the pulmonary region and it is these which are of particular concern. However, the proportion of fine particulates in dust emitted from quarrying activities is low compared with other sources such as emissions from combustion processes.

The health effects of particulate matter are further complicated by the chemical nature of the particles and by the possibility of synergistic effects with other air pollutants such as sulphur dioxide.

Much of the recent concern over the health effects of fine particulate matter is based on investigations carried out in the United States, with the view to quantifying the health risks associated with both long-term and short-term exposure to airborne

particulate matter. The study is colloquially referred to as "The Six Cities Study" from the original work by **Dockery et al. (1993)**, which determined a relationship between fine particulate matter (defined as particles smaller than 2.5 μm in diameter, and referred to as $PM_{2.5}$) in the air and mortality in six United States cities.

The basic finding of the Six Cities Study is that there is an increase in mortality with increasing concentrations of fine particulate matter. The conclusions appear to be robust and have been supported by subsequent studies and, as far as can be determined, are not confounded by other known variables. However, subsequent analysis of the Six Cities Study data (**HEI, 2000**) suggests the increase in mortality is not as great as first thought.

In May 2003, NEPC released a variation to the NEPM (**NEPC, 2003**). The advisory reporting standards for $PM_{2.5}$ are a 24-hour average of 25 μg/m³ and an annual average of 8 μg/m³. There is no time line for compliance. The goal is to gather sufficient data nationally to facilitate the review of the Air Quality NEPM scheduled to commence in 2005. The variation includes a protocol setting out monitoring and reporting requirements for particles as $PM_{2.5}$.

The US EPA has not changed its PM_{10} (particles less than 10 μm in diameter) goal but has introduced new goals for fine particles ($PM_{2.5}$) with a 24-hour limit of 65 μg/m³ and an annual limit of 15 μg/m³. The DEC has historically noted the US EPA 24-hour air quality standard of 150 μg/m³ and annual average standard of 50 μg/m³ for PM_{10}. It now adopts the NEPM 24-hour standard of 50 μg/m³, and references an annual average of 30 μg/m³ as a long-term reporting goal.

The DEC also continues to note the NHMRC's 90 μg/m³ annual average goal for total suspended particulate matter (TSP). This level is recommended as the maximum permissible level in urban environments.

Table 1 – Air quality standards/goals for particulate matter concentrations

POLLUTANT	STANDARD / GOAL	AVERAGING PERIOD	AGENCY
Total suspended particulate matter (TSP)	90 μg/m³	Annual mean	NHMRC
Particulate matter < 10 μm (PM_{10})	50 μg/m³	24-hour maximum	NSW DEC
	30 μg/m³	Annual mean	NSW DEC long-term reporting goal
	50 μg/m³	(24-hour average, 5 exceedances permitted per year)	NEPM
Particulate matter < 2.5 μm ($PM_{2.5}$)	8 μg/m³	Annual mean	NEPM*
	25 μg/m³	24-hour maximum	NEPM*

**Advisory reporting standards, not yet applied to projects in NSW*

Also included in **Table 1** are the NEPM advisory reporting standards goals for $PM_{2.5}$. Epidemiological studies (**Dockery et al, 1993** for example) indicate that it is the finer particles, those below 2.5 μm in diameter, which cause health impacts as they are taken deeper into the lungs. As yet, Australia has no ambient goal for $PM_{2.5}$ applied on a project basis.

In addition to health impacts, airborne dust also has the potential to cause nuisance impacts by depositing on surfaces and possibly on vegetation/crops. **Table 2** shows the dust deposition criteria set out in the DEC procedures for modelling air pollutants from stationary sources (**NSW DEC, 2005**).

Table 2 – NSW EPA criteria for dust fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

4. EXISTING ENVIRONMENT

This section describes the dispersion meteorology, local climatic conditions and existing dust levels in the area.

4.1 Dispersion Meteorology

The Gaussian dispersion model used for this assessment, ISCMOD (discussed in **Section 6**), requires information about the dispersion characteristics of the area. In particular, data are required on topography, wind speed, wind direction, atmospheric stability class[1] and mixing height[2].

The model requires a year of data and as there are no on-site data available, a set of site-specific, synthetic meteorological data for the site was created using The Air Pollution Model (TAPM) (Version 2) developed by CSIRO.

TAPM is a prognostic model which includes synoptic information determined from the six hourly Limited Area Prediction System (LAPS) (**Puri et al., 1997**). The model is discussed further in the accompanying user manual (see **Hurley, 2002**).

Wind roses prepared from these data are shown in **Figure 4**. The data are considered to contain information that would be representative of the conditions experienced in the Maroota area.

[1] In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme, as used in this study, there are six stability classes A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

[2] The term mixing height refers to the height of the turbulent layer of air near the earth's surface into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

The synthetic data shows the predominant wind direction to be from the east on an annual basis, although there are also significant contributions from the western and southern quadrants. Easterlies are dominant in summer while in winter there are predominantly westerly winds. The mean annual wind speed is 3.5 m/s.

4.2 Atmospheric stability

Table 3 presents a frequency of atmospheric stability classes at the site. Stable conditions (E and F) under which emissions will disperse slowly are estimated to prevail for approximately 38.9% of the time. There is also a high percentage of D-class stability (32.8%) which will mean higher wind speeds. This may increase emissions from wind erosion but aid in dispersing emissions quickly.

Table 3: Frequency of atmospheric stability classes for the Maroota site

Stability class	Frequency (%)
A	3.7
B	9.4
C	15.2
D	32.8
E	21.2
F	17.7
TOTAL	100.0

Joint wind speed, wind direction and stability class frequency tables for the extraction site are presented in **Appendix A**.

4.3 Temperature, humidity and rainfall

Table 4 presents the temperature, humidity and rainfall data for the closest Bureau of Meteorology site which is located at Peats Ridge, approximately 14 km northeast of the site. Humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of raindays per month.

The annual average maximum and minimum temperatures experienced are 21.8°C and 11.3°C, respectively. The maximum monthly average temperature is recorded in January at 26.9°C. July is the coldest month, with an average minimum temperature of 6.0°C.

The annual average humidity reading collected at 9 am is 75%. The month with the highest 9 am humidity on average is March with 82%. At 3 pm the annual average humidity reading is 62%, with the highest average in March with 67%.

Rainfall data collected show that March is on average the wettest month, with a mean rainfall reading of 145.6 mm. March also has the highest average number of raindays with 14.7. September is the driest month with an average rainfall of 68.0 mm. The average annual rainfall is 1241.7 mm and the average number of raindays is 140.9.

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Table 4: Temperature, humidity and rainfall data for Peats Ridge (Waratah Road)

(Station Number: 061351 Commenced: 1981; Last record: 2004; Latitude (deg S): -33.3102; Longitude (deg E): 151.2443; Elevation: 280 m)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Relative Humidity (%)													
Dry-bulb	21.0	20.5	19.0	17.3	14.1	11.3	10.5	12.0	15.1	17.7	18.3	20.2	16.5
Wet-bulb	18.3	18.3	17.0	15	12.2	9.4	8.4	9.3	11.5	13.8	15.1	17.1	13.8
Humidity	78	81	82	78	80	77	75	69	64	65	71	73	75
3 pm Mean Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	25.0	24.7	22.9	20.4	17.4	15.0	14.4	16.1	18.6	20.6	21.8	24.0	20.2
Wet-bulb	20.0	20	18.6	16.1	14	11.5	10.5	11.4	13.1	15.3	16.8	18.9	15.6
Humidity	64	66	67	65	68	65	60	55	53	58	61	63	62
Daily Maximum Temperature (°C) (86 Years of record)													
Mean	26.9	26.3	24.5	22.1	19.0	16.4	15.8	17.5	20.4	22.8	23.9	25.9	21.8
Daily Minimum Temperature (°C)													
Mean	16.0	16.2	14.5	12.0	9.7	7.1	6.0	6.5	8.5	10.7	12.5	14.8	11.3
Rainfall (mm) (120 Years of record)													
Mean	120.1	145.0	145.6	131.6	108.0	73.9	71.1	86.8	68.0	90.9	110.2	90.4	1241.7
Raindays (Number)													
Mean	13.8	14.3	14.7	11.7	12.6	10.2	9.8	9.2	9.0	10.5	12.9	12.3	140.9

Source: ***Bureau of Meteorology (2005)***

4.4 Existing air quality

4.4.1 Introduction

Air quality standards and goals refer to pollutant levels which include the project and existing sources. To fully assess impacts against all the relevant air quality standards and goals (detailed in **Section 3**) it is necessary to have information or estimates of existing dust concentration and deposition levels in the project area.

The following section reviews the available monitoring data in the area and provides some extrapolation from measurements at other sites.

Local air quality monitoring data includes the effects of the current extraction operations in the area.

4.4.2 Dust deposition

There are three dust deposition gauges located in the vicinity of the Hitchcock Road site, as shown on **Figure 5**. D1 is located at Maroota Public School, D2 is located at the Vucko residence and D3 is located at the former Jurd residence.

Table 5 shows annual average insoluble solids deposition rates at each of the three deposition gauges from July 1998 to April 2006 inclusive. An annual average dust deposition level above 4 g/m^2/month indicates a level of air quality unsuitable for residential purposes. Levels measured at these sites are affected by dust from other extraction activities in the area (including the current operations from the Hitchcock Road site) as well as other sources of dust normally expected in rural areas.

The annual average dust deposition levels in the vicinity of the proposed quarry have been measured to be a maximum of 4.8 g/m^2/month at D1. The maximum annual levels at D2 have been measured to be 4.4 g/m^2/month and 4.9 at D3 g/m^2/month.

The maximum annual averages are all above the criterion of 4 g/m^2/month but it is important to note that these levels include existing operations at the Hitchcock Road site and it is not proposed to increase the current extraction rate.

Additionally, as will be outlined in **Section 7**, the predicted annual average dust deposition levels at all the residences due to the proposed operations are less than 0.2 g/m^2/month, and therefore the dust deposition level would only be marginally impacted.

Table 5: Annual average dust deposition data (g/m²/month)

Year	Month	D1 Maroota Public School		D2 Vucko's House		D3 Jurd Residence	
		Insoluble Solids	Running annual average	Insoluble Solids	Running annual average	Insoluble Solids	Running annual average
1998	July	2.29				3.88	
	August	5.15				4.59	
	September	2.87				3.04	
	October	2.62				2.13	
	November	3.63				2.99	
	December	4.47				4.27	
1999	January	5.04				3.94	
	February	6.49				8.01	
	March	2.92				3.50	
	April	3.73				3.05	
	May	2.67				8.63	
	June	2.62	3.71			1.65	4.14
	July	2.96	3.76			2.64	4.04
	August	2.64	3.56			2.75	3.88
	September	2.97	3.56			3.57	3.93
	October	4.00	3.68			4.79	4.15
	November	2.15	3.56			5.35	4.35
	December	4.88	3.59			9.19	4.76
2000	January	2.33	3.36			2.93	4.67
	February	10.20	3.67			3.55	4.30
	March	5.65	3.90			9.08	4.77
	April		3.92				4.92
	May	1.80	3.84			3.04	4.41
	June	1.12	3.70			1.34	4.38
	July	1.52	3.57			1.28	4.26
	August	0.69	3.39			1.20	4.12
	September	1.87	3.29			3.99	4.16
	October	2.44	3.15			3.44	4.04
	November	1.98	3.13			5.28	4.03
	December	3.33	2.99			4.62	3.61
2001	January	3.11	3.06			5.07	3.81
	February	4.05	2.51			7.67	4.18
	March	10.01	2.90			3.73	3.70
	April	3.42	2.95			3.49	3.68
	May	2.34	2.99			3.31	3.70
	June	0.64	2.95			1.06	3.68
	July	2.97	3.07			4.44	3.94
	August	0.69	3.07			2.42	4.04
	September	1.80	3.07			2.81	3.95
	October	1.26	2.97			3.37	3.94
	November	2.59	3.02			8.46	4.20
	December	3.84	3.06			5.48	4.28
2002	January	6.46	3.34			6.04	4.36
	February	2.73	3.23			4.23	4.07
	March	4.35	2.76			3.12	4.02
	April		2.70				4.07
	May	2.96	2.75	2.08	2.08	3.30	4.07
	June	1.22	2.81	1.02	1.55	Invalid data	4.37
	July	2.55	2.77	1.21	1.44	2.11	4.13
	August	2.32	2.92	5.49	2.45	4.02	4.29
	September	2.78	3.01	3.65	2.69	3.46	4.36
	October	2.65	3.13	7.58	3.51	2.41	4.26
	November	5.44	3.39	4.41	3.63	6.20	4.04
	December	6.75	3.66	5.27	3.84	6.34	4.12
2003	January	3.03	3.34	2.17	3.65	2.32	3.75
	February	4.51	3.51	5.13	3.80	4.58	3.79

	March	3.38	3.42	5.44	3.95	3.72	3.85
	April	5.23	3.57	4.88	4.03	3.38	3.80
	May	Invalid data	3.62	5.10	4.28	4.29	3.89
	June	1.41	3.64	1.92	4.35	2.35	3.77
	July	1.05	3.50	0.88	4.33	1.47	3.71
	August	2.29	3.50	1.74	4.01	4.00	3.71
	September	2.91	3.51	3.01	3.96	4.46	3.79
	October	4.63	3.69	4.57	3.71	6.63	4.15
	November	2.82	3.46	2.48	3.55	3.28	3.90
	December	3.09	3.12	7.00	3.69	4.03	3.71
2004	January	4.07	3.22	7.21	4.11	4.36	3.88
	February	Invalid data	3.09	5.15	4.12	4.48	3.87
	March	4.76	3.23			2.95	3.81
	April	5.23	3.23			3.38	3.81
	May	3.57	3.26			2.55	3.66
	June	1.45	3.26			2.51	3.68
	July	6.79	3.78			6.73	4.11
	August	4.42	3.98			2.47	3.99
	September	3.68	4.05			3.89	3.94
	October	5.11	4.09			4.06	3.72
	November	4.01	4.20			3.81	3.77
	December	4.96	4.37			5.18	3.86
2005	January	8.24	4.75			5.90	3.99
	February	5.16	4.78			7.38	4.23
	March	1.96	4.55			2.47	4.19
	April	1.03	4.20			2.01	4.08
	May	2.01	4.07	3.69	3.69	2.85	4.11
	June	2.64	4.17	-	3.69	3.31	4.17
	July	0.96	3.68	1.10	2.40	5.12	4.04
	August	1.98	3.48	4.43	3.07	3.22	4.10
	September	3.23	3.44	4.80	3.51	4.84	4.18
	October	2.21	3.20	5.67	3.94	3.52	4.13
	November	3.78	3.18	4.25	3.99	3.96	4.15
	December	2.87	3.01	3.59	3.93	3.63	4.02
2006	January	3.57	2.62	4.50	4.00	4.24	3.88
	February	6.80	2.75	2.90	3.88	4.35	3.63
	March	3.34	2.87	6.53	4.15	2.34	3.62
	April	3.32	3.06	3.06	4.05	2.75	3.68

4.4.3 TSP and PM_{10} concentrations

There are no data for the immediate area from which to establish local annual average TSP and PM_{10} concentrations. However, a review of PM_{10} monitoring data collected at NSW DEC monitoring sites is provided in **Table 6**. The annual average concentration for the years 2001 to September 2005 are presented for 16 sites in the Sydney basin. The data includes bushfire events as well as data collected in the Sydney Central Business District. The overall average for all sites for the four years in question is 20.4 $\mu g/m^3$. This is below the DEC goal of 30 $\mu g/m^3$.

A continuous PM_{10} monitor was recently installed at Maroota Public School and according to NSW DEC there have been no exceedances of the 24-hour goal of 50 $\mu g/m^3$.

This would suggest that the TSP annual average concentrations in the area are also complying with the DEC goal of 90 $\mu g/m^3$.

Table 6: NSW DEC monitoring sites annual average concentrations of PM_{10} ($\mu g/m^3$) (2001 to 2005)

	2001	2002	2003	2004	2005*	Average, 2001 to 2005
Chullora	*No data*		23.8	22.6	21.8	22.7
Earlwood	20.7	24.2	21.3	22.5	22.1	22.0
Lidcombe	19.3	19.8	*No data*			19.5
Lindfield	15.9	18.6	15.9	15.8	16.6	16.8
Randwick	18.2	20.3	19.0	19.9	19.2	19.2
Rozelle	*No data*		20.0	20.1	19.3	19.8
Sydney CBD	28.9	31.7	*No data*			30.3
Woolooware	18.0	20.2	17.6	17.8	18.4	18.6
Blacktown	20.7	21.8	19.0	22.8	21.1	20.5
Richmond	17.8	21.8	18.1	18.8	18.6	19.2
St Mary's	17.3	21.3	16.5	17.0	18.0	18.4
Vineyard	17.8	21.7	18.1	18.0	18.5	19.2
Westmead	19.9	21.2	29.3	21.8	23.1	23.5
Bringelly	17.8	21.3	18.2	19.7	19.3	19.1
Campbelltown	17.5	19.6	16.6	19.0	18.2	17.9
Liverpool	19.3	25.0	21.0	21.5	21.6	21.8
Average of all sites, 2001 to 2003						**20.4**

*data available to September 2005

As the annual PM_{10} concentrations across the Sydney basin are approximately two-thirds of the DEC goal, it has been therefore assumed that the following background concentrations apply at the nearest residences.

- Annual average TSP of 60 $\mu g/m^3$
- Annual average PM_{10} of 20 $\mu g/m^3$
- Annual average dust deposition of 4 g/m^2/month

5. ESTIMATED EMISSIONS

5.1 Dust emissions

Dust emissions will arise from the operation of the extraction activities. As presented below, there are four phases to the proposed operations (see **Figure 6** for the location of the areas discussed):

Phase One (2007-2011)

- Continuation of extraction westward from Area B;
- Extraction eastward from the haul road (overburden backfilled into Area B);
- Construction of Pond 11;
- Completion of Pond 9;
- Partial rehabilitation of Pond 5;
- Continuing extraction of the area adjacent to Old Northern Road;
- Extraction on Lot 2 DP752039 and Lot 1 DP34599;
- Rehabilitation (planting) in the area of former ponds 3, 4 and 6;
- Completion of Pond 10 (overburden backfilled into Area B).

Phase Two (2012-2016)

- Extraction southwards from Area A;
- Construction of Pond 12;
- Extraction on Lot 2 DP555184 and Lot 2 DP570966;
- Rehabilitation of area adjacent to Old Northern Road;
- Overburden backfilled into extracted areas to the south;
- Rehabilitation of Pond 11;
- Extraction to the south.

Phase Three (2017-2021)

- Continuation of extraction to the south;
- Backfilling of clay overburden into extracted areas to the north and south;
- Completion of Pond 13;
- Continuation of extraction on Lot 2 DP570966
- Rehabilitation of northern section of the northern extraction area;
- Rehabilitation of the western part of the southern extraction area.

Phase Four (2022-2025)

- Continuation of extraction southwards;
- Backfilling of clay overburden into extraction to the north;
- Continuation of extraction in the southern area;
- Extraction on Lot 1 DP1013943, Lots 1 and 2 DP1063296 and Lot 2 DP570966;
- Construction of Pond 14;
- Rehabilitation of southern extraction area;
- Rehabilitation of northern extraction area;
- Rehabilitation of ponds leaving one to drain each catchment;
- Completion of land reformation and landscape planting;
- Removal of all fixed infrastructure and formation of final land form.

(Note that these activities would be amended following the exclusion of Lot 2 DP555184).

Total dust emissions due to the operation have been estimated by analysing the activities taking place during Phase 1 and Phase 2 of the proposed operations as these are the phases with the most operations closest to the residences. Both the maximum and average extraction rates of 400,000 t/y and 250,000 t/y respectively have been assessed.

The operations which apply in each case have been combined with emission factors developed, both locally and by the US EPA, to estimate the amount of dust produced by each activity. These emission factors applied are considered to be the most up-to-date methods for determining dust generation rates.

Details of the activities and estimated dust emissions during the two phases are presented in **Table 7**. These estimates assume that an appropriate level of control of dust emissions is achievable through the use of watering carts on all unsealed areas of the active extraction area. Details of the calculations of the dust emissions are presented in **Appendix B**.

Table 7: Estimated dust emissions from Phase 1 of the proposed activities (kg/y)

ACTIVITY	Phase 1 – Average extraction rate	Phase 1 – Maximum extraction rate
Removal of top soil and overburden	13,095	13,095
Extraction of tertiary sand (excavator) to trucks from Area B	60	100
Hauling tertiary sand to slurry plant from AreaB	3,477	5,848
Dumping tertiary sand to slurry plant from AreaB	60	100
Extraction of tertiary sand (excavator) to trucks from2007-09 tertiary	111	187
Hauling tertiary sand to slurry plant from2007-09 tertiary	12,916	21,723
Dumping tertiary sand to slurry plant from2007-09 tertiary	111	187
Extraction of sand (excavator) to trucks from2006-10 friable	23	23
Hauling sand to slurry plant from2006-10 friable	3,677	3,677
Dumping sand to slurry plant from2006-10 friable	23	23
Dumping processed tertiary sand to stockpile	60	100
Loading processed tertiary sand to road trucks	60	100
Transporting processed tertiary sand product off-site by road	4,968	8,355
TOTAL DUST (kg)	**56,161**	**71,039**

Table 8: Estimated dust emissions from Phase 2 of the proposed activities (kg/y)		
ACTIVITY	**Phase 2 – Average extraction rate**	**Phase 2 – Maximum extraction rate**
Removal of top soil and overburden	13,095	13,095
Extraction of tertiary sand (excavator) to trucks_AreaA & 2010-20	68	109
Hauling tertiary sand to slurry plant_AreaA & 2010-20	2,823	4,516
Dumping tertiary sand to slurry plant_AreaA & 2010-20	68	109
Extraction of tertiary sand (excavator) to trucks_2010-15_tertiary	126	202
Hauling tertiary sand to slurry plant_2010-15_tertiary	20,968	33,548
Dumping tertiary sand to slurry plant_2010-15_tertiary	126	202
Dumping processed tertiary sand to stockpile	68	109
Loading processed tertiary sand to road trucks	68	109
Transporting processed tertiary sand product off-site by road	5,645	9,032
Wind erosion from exposed areas (inc stockpiles)	28,032	28,032
TOTAL DUST (kg)	**71,086**	**89,061**

6. APPROACH TO ASSESSMENT

6.1 Introduction

In August 2005, the DEC published guidelines for the assessment of air pollution sources using dispersion models (**NSW DEC, 2005**). The guidelines specify how assessments based on the use of air dispersion models should be undertaken. They include guidelines for the preparation of meteorological data to be used in dispersion models, the way in which emissions should be estimated and the relevant air quality criteria for assessing the significance of predicted concentration and deposition rates from the proposal. The approach taken in this assessment follows as close as possible to the approaches suggested by the guidelines.

This section is provided so that technical reviewers can appreciate how the modelling of different particle size categories was carried out.

The model used was a modified version of the US EPA ISCST3 model (ISCMOD). ISCST3 is fully described in the user manual and the accompanying technical description (**US EPA, 1995a**).

The ISC model has a tendency to overestimate short-term (24-hour) PM_{10} concentrations (see for example **Holmes Air Sciences, 2002 and 2006**). To overcome this difficulty it has been modified to create ISCMOD. ISCMOD is identical to ISC except that the horizontal plume spreading dispersion curves have been modified to adopt the recommendations of the American Meteorological Society's (AMS) expert panel on dispersion curves (**Hanna, 1977**) and the suggestions made by **Arya (1999)**. The suggested changes were recommended because, as the AMS panel notes, the original horizontal dispersion curves relate to an averaging time of three minutes and they recommend that these be adjusted to the one hour curves required by ISC. The change involves increasing the horizontal plume widths by a factor of 1.82 (60 minutes / 3 minute)$^{0.2}$. The modifications improve the performance

of the model in predicting 24-hour concentrations and make almost no difference to the annual average predictions.

A similar adjustment has been applied to account for the local surface roughness being different at the sites compared with the site where the original curves were developed. The sites have been taken to have a surface roughness of 0.3 m compared with 0.03 m for the original curves. The adjustment leads to an increase in the horizontal and vertical curves by a factor of $(0.3 \text{ m}/ 0.03 \text{ m})^{0.2}$ namely 1.6.

The modelling has been based on the use of three particle-size categories (0 to 2.5 μm - referred to as $PM_{2.5}$, 2.5 to 10 μm - referred to as CM (coarse matter) and 10 to 30 μm - referred to as the Rest). Emission rates of TSP have been calculated using emission factors developed both within NSW and by the US EPA (see **Appendix B**).

The distribution of particles has been derived from measurements published by the SPCC **(SPCC, 1986)**. The distribution of particles in each particle size range is as follows:

- $PM_{2.5}$ (FP) is 4.7% of the TSP;
- $PM_{2.5-10}$ (CM) is 34.4% of TSP; and
- PM_{10-30} (Rest) is 60.9% of TSP.

Modelling was done using three ISC source groups with each group corresponding to a particle size category. Each source in the group was assumed to emit at the full TSP emission rate and to deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mean of the limits of the particle size range, except for the $PM_{2.5}$ group, which was assumed to have a particle size of 1 μm. The predicted concentration in the three plot output files for each group were then combined according to the weightings in the dot points above to determine the concentration of PM_{10} and TSP.

The ISC model also has the capacity to take into account dust emissions that vary in time, or with meteorological conditions. This has proved particularly useful for simulating emissions on mining operations where wind speed is an important factor in determining the rate at which dust is generated.

Estimates of emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of activity and the wind speed. It is important to do this in the ISC model to ensure that long-term average emission rates are not combined with worst-case dispersion conditions which are associated with light winds. Light winds at a mine site would correspond with periods of low dust generation because wind erosion and other wind dependent emissions rates will be low. Light winds also correspond with periods of poor dispersion. If these measures are not taken into account, the model has the potential to significantly overstate impacts.

Extraction operations were represented by a series of volume sources located according to the location of activities for the modelled scenario (as shown on **Figure 7** and **Figure 8**).

Dust concentrations and deposition rates have been predicted in the vicinity of the project site for the two stages of the proposed operations. The local terrain has been taken into consideration for the modelling.

The modelling has been performed using the meteorological data discussed in **Section 4.1** and the dust emission estimates from **Section 4.4.3**. As an example, the ISCMOD input file is provided in **Appendix C**.

All activities have been modelled only during day-time hours (7am to 6pm), except for wind erosion type activities which have been modelled for 24 hours per day. **Appendix B** provides a summary of dust emissions, hours of emission and allocation of sources for each activity.

7. ASSESSMENT OF IMPACTS

7.1 Introduction

This section provides an interpretation of the predicted dust concentrations and deposition levels. The model runs were undertaken using the meteorological data described in **Section 4.1** and the emissions data described in **Section 4.4.3**. Receptors were positioned across a grid 2 km by 2.4 km in size and at the closest residences and the school, as shown in **Figure 2**.

Dust concentrations and deposition rates due to the sand quarry operations for the existing and proposed operations have been presented as isopleth diagrams showing the following:

1. Predicted maximum 24-hour average PM_{10} concentration;
2. Predicted annual average PM_{10} concentration;
3. Predicted annual average TSP concentration; and
4. Predicted annual average dust deposition.

The maximum 24-hour average contour plots do not represent the dispersion pattern for any particular day, but show the highest predicted 24-hour average concentration that occurred at each location. The maxima are used to show concentrations which can possibly be reached under the modelled conditions.

Dust impacts and model predictions using ISCMOD are presented in **Figure 9** to **Figure 24**.

7.2 Proposal impacts

Table 9 and **Table 10** summarise the model predictions at each of the residential receptors for both the average and maximum extraction in Phase 1 and Phase 2.

The maximum predicted 24-hour average PM_{10} concentrations at the closest residences are predicted be 11.0 $\mu g/m^3$. It is unlikely that the DEC 24-hour average

goal of 50 μg/m^3 would be exceeded due to the proposed operations even with existing PM_{10} concentrations.

Annual average PM_{10} concentrations at the closest residences are predicted to be a maximum of 1.6 μg/m^3. It is unlikely that the DEC annual average goal of 30 μg/m^3 would be exceeded due to the proposed operations even with existing PM_{10} concentrations.

Annual average TSP concentrations at the closest residences are predicted to be a maximum of 3.4 μg/m^3. It is unlikely that the 90 μg/m^3 NHMRC goal would be exceeded due to the proposed operations even with existing annual average TSP concentrations.

The predicted annual average dust deposition levels at the nearest residence are predicted to be a maximum of 0.2 g/m^2/month. Therefore it is unlikely that the project would result in any additional exceedances of the DEC goal of 4 g/m^2/month.

Table 9: Summary of dispersion model predictions due to Phase 1 of the project

	Pollutant		**PM_{10} (μg/m^3)**		**TSP (μg/m^3)**	**Dust deposition (g/m^2/month)**
	Averaging Period		**24-hour**	**Annual**	**Annual**	**Annual**
	Air Quality Goal		*50*	*30*	*90*	*2*
Residence ID	**MGA**		***Average extraction rate of 250,000 t/y***			
	X (m)	**Y(m)**				
R1	313862	6295073	4.6	0.8	1.7	0.1
R2	314215	6294874	3.2	0.5	1.1	0.1
R3	314381	6294614	3.8	0.5	1.1	0.1
R4	312984	6294967	5.3	0.9	2.1	0.1
R5	312883	6294831	4.3	0.7	1.6	0.1
R6	312664	6294849	3.4	0.5	1.0	0.1
R7	312900	6295043	4.5	0.8	1.7	0.1
R8	312792	6294995	3.6	0.6	1.3	0.1
R9	312896	6295104	4.4	0.8	1.7	0.1
R10	313475	6295764	3.4	0.6	1.2	0.1
R11	313507	6295835	2.8	0.5	1.0	0.1
R12	313685	6295685	3.0	0.5	1.0	0.1
R13	313314	6296059	2.1	0.3	0.7	0.0

R14	313361	6296110	1.9	0.3	0.6	0.0
R15	313587	6296086	1.9	0.3	0.6	0.0
R16	313642	6296128	1.8	0.2	0.5	0.0
R17	313840	6296115	1.8	0.2	0.4	0.0
R18	313413	6296253	2.3	0.4	0.8	0.0
R19	313656	6296378	1.4	0.2	0.4	0.0
School	313354	6295991	1.6	0.2	0.5	0.0
Residence	**MGA**					
ID	**X (m)**	**Y (m)**	***Maximum extraction rate of 400,000 t/y***			
R1	313862	6295073	6.3	1.0	2.1	0.1
R2	314215	6294874	4.3	0.6	1.3	0.1
R3	314381	6294614	4.6	0.6	1.3	0.1
R4	312984	6294967	7.2	1.3	2.8	0.2
R5	312883	6294831	6.2	0.9	2.1	0.1
R6	312664	6294849	4.9	0.6	1.3	0.1
R7	312900	6295043	6.1	1.0	2.3	0.1
R8	312792	6294995	5.4	0.8	1.7	0.1
R9	312896	6295104	6.2	1.1	2.3	0.1
R10	313475	6295764	5.0	0.8	1.6	0.1
R11	313507	6295835	4.1	0.6	1.3	0.1
R12	313685	6295685	4.2	0.6	1.3	0.1
R13	313314	6296059	3.0	0.5	1.0	0.1
R14	313361	6296110	2.8	0.4	0.9	0.0
R15	313587	6296086	2.6	0.4	0.7	0.0
R16	313642	6296128	2.5	0.3	0.7	0.0
R17	313840	6296115	2.5	0.3	0.6	0.0
R18	313413	6296253	3.4	0.5	1.1	0.1
R19	313656	6296378	2.0	0.2	0.5	0.0
School	31335	629599	2.2	0.3	0.6	0.0

	4	1				

Table 10: Summary of dispersion model predictions due to Phase 2 of the project

		Pollutant	PM_{10} ($\mu g/m^3$)		TSP ($\mu g/m^3$)	Dust deposition (g/m^2/month)
		Averaging Period	24-hour	Annual	Annual	Annual
		Air Quality Goal	50	30	90	2
Residence ID	**MGA**					
	X (m)	**Y(m)**	***Average extraction rate of 250,000 t/y***			
R1	313862	6295073	10.8	1.3	2.9	0.2
R2	314215	6294874	5.9	1.1	2.4	0.2
R3	314381	6294614	6.7	0.7	1.5	0.1
R4	312984	6294967	4.2	0.8	1.7	0.1
R5	312883	6294831	3.5	0.6	1.2	0.1
R6	312664	6294849	3.2	0.4	0.9	0.0
R7	312900	6295043	4.5	0.7	1.6	0.1
R8	312792	6294995	3.9	0.5	1.2	0.1
R9	312896	6295104	4.9	0.8	1.7	0.1
R10	313475	6295764	4.6	0.9	1.9	0.1
R11	313507	6295835	3.8	0.7	1.5	0.1
R12	313685	6295685	4.4	0.8	1.7	0.1
R13	313314	6296059	2.5	0.5	1.0	0.1
R14	313361	6296110	2.3	0.4	0.9	0.1
R15	313587	6296086	2.3	0.4	0.8	0.0
R16	313642	6296128	2.1	0.3	0.7	0.0
R17	313840	6296115	2.1	0.3	0.6	0.0
R18	313413	6296253	2.8	0.5	1.2	0.1
R19	313656	6296378	1.6	0.2	0.5	0.0
School	313354	6295991	1.9	0.3	0.7	0.0
Residence ID	**MGA**					
	X (m)	**Y (m)**	***Maximum extraction rate of 400,000 t/y***			
R1	313862	6295073	11.0	1.6	3.4	0.2

R2	314215	6294874	7.3	1.3	2.8	0.2
R3	314381	6294614	6.9	0.9	1.9	0.1
R4	312984	6294967	6.0	1.1	2.4	0.1
R5	312883	6294831	5.0	0.8	1.7	0.1
R6	312664	6294849	4.5	0.6	1.2	0.1
R7	312900	6295043	6.3	1.0	2.1	0.1
R8	312792	6294995	5.4	0.7	1.6	0.1
R9	312896	6295104	6.8	1.0	2.3	0.1
R10	313475	6295764	6.0	1.1	2.4	0.1
R11	313507	6295835	5.0	0.9	1.9	0.1
R12	313685	6295685	5.6	1.0	2.0	0.1
R13	313314	6296059	3.3	0.6	1.3	0.1
R14	313361	6296110	3.0	0.5	1.1	0.1
R15	313587	6296086	3.0	0.5	1.0	0.1
R16	313642	6296128	2.8	0.4	0.9	0.1
R17	313840	6296115	2.8	0.4	0.8	0.0
R18	313413	6296253	3.7	0.7	1.5	0.1
R19	313656	6296378	2.1	0.3	0.6	0.0
School	313354	6295991	2.4	0.4	0.8	0.0

7.3 Cumulative impacts

In addition to the current extraction activities in the vicinity of Hitchcock Road, a development consent has been granted to Dixons Quarry to extract from the Haerses Road site located to the west of the Hitchcock Road site. As there are currently no extraction activities occurring at this site, the impact on the local air quality is not known.

Additionally, as the Haerses Road extraction activities are proposed to gradually replace the existing extraction activities on Lots 29 and 196 (located to the north of Lot 198), it is unlikely there will be any significant change in local air quality.

8. CONCLUSIONS

This study has assessed air quality impacts due to the extension of current sand extraction activities at Hitchcock Road in Maroota. The emissions of dust from the proposed activities have been the focus of this assessment. The primary sources of dust would be from equipment used for the excavation of material from the site, on-site transport, processing activities and wind erosion. Potential air quality impacts of PM_{10}, TSP and deposition of insoluble solids due to dust emissions from the proposed operations have been assessed. Computer-based dispersion modelling has been used to predict the dust impacts due to the quarry operations.

Results from the dispersion modelling indicated that off-site dust concentrations at all nearby residences due to the proposed operations would be below relevant air quality goals. Dust deposition levels are currently measured to be above the DEC assessment criteria in the area. However, the predicted additional impacts due to this project are minimal.

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Appendix A: Joint wind speed, wind direction and stability class frequency tables for Maroota, TAPM file (2003)

STATISTICS FOR FILE: C:\Jobs\Maroota\Met\Maroota_TAPM_03.isc
MONTHS: All
HOURS : All
OPTION: Frequency

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001484	0.003539	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.005594
NE	0.001484	0.002055	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.003881
ENE	0.001256	0.002968	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.004909
E	0.000571	0.001370	0.001256	0.000000	0.000000	0.000000	0.000000	0.000000	0.003196
ESE	0.000228	0.000571	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.001256
SE	0.000457	0.000114	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.001027
SSE	0.000228	0.000457	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.000913
S	0.000342	0.000342	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.000913
SSW	0.000342	0.000685	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.001484
SW	0.000114	0.000685	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000913
WSW	0.000457	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001370
W	0.000571	0.000571	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.001370
WNW	0.000342	0.000457	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.001142
NW	0.000685	0.000342	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.001370
NNW	0.001027	0.001142	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002283
N	0.000799	0.001941	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.003311
CALM									0.001826
TOTAL	0.010388	0.018151	0.006393	0.000000	0.000000	0.000000	0.000000	0.000000	0.036758

MEAN WIND SPEED (m/s) = 2.04
NUMBER OF OBSERVATIONS = 322

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001256	0.002511	0.003082	0.000228	0.000000	0.000000	0.000000	0.000000	0.007078
NE	0.000913	0.001941	0.002397	0.000342	0.000000	0.000000	0.000000	0.000000	0.005594
ENE	0.000114	0.001484	0.002626	0.000913	0.000000	0.000000	0.000000	0.000000	0.005137
E	0.000457	0.003767	0.008562	0.002626	0.000000	0.000000	0.000000	0.000000	0.015411
ESE	0.000228	0.001712	0.001712	0.000457	0.000000	0.000000	0.000000	0.000000	0.004110
SE	0.000571	0.001598	0.001712	0.000228	0.000000	0.000000	0.000000	0.000000	0.004110
SSE	0.000457	0.002283	0.001598	0.000342	0.000000	0.000000	0.000000	0.000000	0.004680
S	0.000228	0.001712	0.001484	0.000457	0.000000	0.000000	0.000000	0.000000	0.003881
SSW	0.000457	0.002626	0.001256	0.000342	0.000000	0.000000	0.000000	0.000000	0.004680
SW	0.000342	0.002397	0.001484	0.000342	0.000000	0.000000	0.000000	0.000000	0.004566
WSW	0.001256	0.001256	0.002283	0.001370	0.000000	0.000000	0.000000	0.000000	0.006164
W	0.001027	0.001598	0.001598	0.001370	0.000000	0.000000	0.000000	0.000000	0.005594
WNW	0.000685	0.001826	0.001142	0.000457	0.000000	0.000000	0.000000	0.000000	0.004110
NW	0.000913	0.001142	0.001142	0.000228	0.000000	0.000000	0.000000	0.000000	0.003425
NNW	0.000913	0.002055	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.003653
N	0.001256	0.004909	0.003425	0.000114	0.000000	0.000000	0.000000	0.000000	0.009703
CALM									0.002397
TOTAL	0.011073	0.034817	0.036187	0.009817	0.000000	0.000000	0.000000	0.000000	0.094292

MEAN WIND SPEED (m/s) = 2.97
NUMBER OF OBSERVATIONS = 826

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000913	0.001027	0.000342	0.000228	0.000000	0.000000	0.000000	0.000000	0.002511
NE	0.001598	0.000799	0.001027	0.000114	0.000000	0.000000	0.000000	0.000000	0.003539
ENE	0.000799	0.001826	0.001941	0.001712	0.001484	0.000000	0.000000	0.000000	0.007763
E	0.000457	0.004795	0.005594	0.006507	0.003425	0.000228	0.000000	0.000000	0.021005
ESE	0.000799	0.005137	0.006164	0.002854	0.001941	0.000000	0.000000	0.000000	0.016895
SE	0.000571	0.002854	0.005251	0.003082	0.001256	0.000000	0.000000	0.000000	0.013014
SSE	0.000685	0.004338	0.006279	0.001484	0.000228	0.000114	0.000000	0.000000	0.013128
S	0.000685	0.002740	0.004795	0.001826	0.000000	0.000000	0.000000	0.000000	0.010046
SSW	0.000342	0.002169	0.003082	0.001142	0.000228	0.000000	0.000000	0.000000	0.006963
SW	0.001027	0.002283	0.002169	0.003881	0.000799	0.000000	0.000000	0.000000	0.010160
WSW	0.000913	0.001142	0.002283	0.003082	0.001370	0.001256	0.000000	0.000000	0.010046
W	0.000571	0.000913	0.003881	0.002968	0.001370	0.000457	0.000000	0.000000	0.010160
WNW	0.000457	0.001484	0.003082	0.002626	0.000799	0.000342	0.000000	0.000000	0.008790
NW	0.000913	0.001027	0.002055	0.001598	0.000228	0.000000	0.000000	0.000000	0.005822
NNW	0.001256	0.001142	0.001712	0.000342	0.000342	0.000000	0.000000	0.000000	0.004795
N	0.001370	0.002626	0.000457	0.000913	0.000114	0.000000	0.000000	0.000000	0.005479
CALM									0.002283
TOTAL	0.013356	0.036301	0.050114	0.034361	0.013584	0.002397	0.000000	0.000000	0.152397

MEAN WIND SPEED (m/s) = 3.79
NUMBER OF OBSERVATIONS = 1335

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001826	0.002626	0.001142	0.001027	0.000000	0.000000	0.000000	0.000000	0.006621
NE	0.001826	0.003196	0.002626	0.000913	0.000228	0.000000	0.000000	0.000000	0.008790
ENE	0.001142	0.003881	0.003425	0.004338	0.001484	0.000114	0.000000	0.000000	0.014384
E	0.002397	0.007648	0.010388	0.004909	0.000571	0.000000	0.000000	0.000000	0.025913
ESE	0.001484	0.012215	0.004680	0.004680	0.000457	0.000685	0.000114	0.000000	0.024315
SE	0.001941	0.010388	0.009018	0.002283	0.000114	0.000000	0.000000	0.000114	0.023858
SSE	0.001941	0.014155	0.007877	0.004680	0.001027	0.000913	0.000228	0.000000	0.030822
S	0.001142	0.011530	0.011301	0.005936	0.000228	0.000228	0.000000	0.000000	0.030365
SSW	0.002397	0.007420	0.006735	0.004224	0.000913	0.000000	0.000000	0.000000	0.021689
SW	0.001941	0.006621	0.003767	0.002968	0.001598	0.000913	0.000114	0.000000	0.017922
WSW	0.000799	0.004110	0.004680	0.002968	0.002968	0.002740	0.001712	0.001598	0.021575
W	0.000799	0.003767	0.004680	0.004795	0.004452	0.005708	0.003539	0.001598	0.029338
WNW	0.000913	0.001712	0.005137	0.005251	0.004110	0.003082	0.001826	0.003082	0.025114
NW	0.001941	0.003082	0.005251	0.006279	0.002397	0.001256	0.000571	0.000799	0.021575
NNW	0.002169	0.003425	0.003311	0.001598	0.000457	0.000342	0.000114	0.000228	0.011644
N	0.001027	0.005251	0.001370	0.000571	0.000685	0.000799	0.000000	0.000000	0.009703
CALM									0.003881
TOTAL	0.025685	0.101027	0.085388	0.057420	0.021689	0.016781	0.008219	0.007420	0.327511

MEAN WIND SPEED (m/s) = 4.11
NUMBER OF OBSERVATIONS = 2869

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001484	0.001826	0.001598	0.001142	0.000000	0.000000	0.000000	0.000000	0.006050
NE	0.000799	0.004110	0.003767	0.001256	0.000000	0.000000	0.000000	0.000000	0.009932
ENE	0.000571	0.001826	0.009703	0.002626	0.000000	0.000000	0.000000	0.000000	0.014726
E	0.000457	0.004224	0.012900	0.001256	0.000000	0.000000	0.000000	0.000000	0.018836
ESE	0.000799	0.004338	0.004795	0.001142	0.000000	0.000000	0.000000	0.000000	0.011073
SE	0.000457	0.002055	0.005365	0.000457	0.000000	0.000000	0.000000	0.000000	0.008333
SSE	0.000228	0.004909	0.005251	0.001712	0.000000	0.000000	0.000000	0.000000	0.012100
S	0.000685	0.003995	0.013356	0.003196	0.000000	0.000000	0.000000	0.000000	0.021233
SSW	0.000228	0.001027	0.005936	0.001598	0.000000	0.000000	0.000000	0.000000	0.008790
SW	0.000457	0.001712	0.010502	0.001484	0.000000	0.000000	0.000000	0.000000	0.014155
WSW	0.001142	0.001712	0.011644	0.001256	0.000000	0.000000	0.000000	0.000000	0.015753
W	0.000685	0.000913	0.013470	0.001484	0.000000	0.000000	0.000000	0.000000	0.016553
WNW	0.001142	0.000913	0.009703	0.004909	0.000000	0.000000	0.000000	0.000000	0.016667
NW	0.001712	0.002511	0.007763	0.001826	0.000000	0.000000	0.000000	0.000000	0.013813
NNW	0.002511	0.003767	0.007078	0.001826	0.000000	0.000000	0.000000	0.000000	0.015183
N	0.002397	0.001941	0.002169	0.000342	0.000000	0.000000	0.000000	0.000000	0.006849
CALM									0.002283
TOTAL	0.015753	0.041781	0.125000	0.027511	0.000000	0.000000	0.000000	0.000000	0.212329

MEAN WIND SPEED (m/s) = 3.48
NUMBER OF OBSERVATIONS = 1860

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.005023	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.005822
NE	0.000114	0.005023	0.001256	0.000000	0.000000	0.000000	0.000000	0.000000	0.006393
ENE	0.000000	0.008447	0.005137	0.000000	0.000000	0.000000	0.000000	0.000000	0.013584
E	0.000114	0.008790	0.006621	0.000000	0.000000	0.000000	0.000000	0.000000	0.015525
ESE	0.000000	0.007306	0.002283	0.000000	0.000000	0.000000	0.000000	0.000000	0.009589
SE	0.000000	0.006507	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.007420
SSE	0.000114	0.008790	0.001484	0.000000	0.000000	0.000000	0.000000	0.000000	0.010388
S	0.000000	0.006050	0.001712	0.000000	0.000000	0.000000	0.000000	0.000000	0.007763
SSW	0.000000	0.002511	0.002397	0.000000	0.000000	0.000000	0.000000	0.000000	0.004909
SW	0.000000	0.006735	0.004338	0.000000	0.000000	0.000000	0.000000	0.000000	0.011073
WSW	0.000342	0.007534	0.008105	0.000000	0.000000	0.000000	0.000000	0.000000	0.015982
W	0.000685	0.005023	0.010616	0.000000	0.000000	0.000000	0.000000	0.000000	0.016324
WNW	0.000228	0.006393	0.009475	0.000000	0.000000	0.000000	0.000000	0.000000	0.016096
NW	0.000228	0.006849	0.003311	0.000000	0.000000	0.000000	0.000000	0.000000	0.010388
NNW	0.000114	0.007991	0.008333	0.000000	0.000000	0.000000	0.000000	0.000000	0.016438
N	0.000000	0.005936	0.003082	0.000000	0.000000	0.000000	0.000000	0.000000	0.009018
CALM									0.000000
TOTAL	0.001941	0.104909	0.069863	0.000000	0.000000	0.000000	0.000000	0.000000	0.176712

MEAN WIND SPEED (m/s) = 2.86
NUMBER OF OBSERVATIONS = 1548

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.006963	0.016553	0.007534	0.002626	0.000000	0.000000	0.000000	0.000000	0.033676
NE	0.006735	0.017123	0.011416	0.002626	0.000228	0.000000	0.000000	0.000000	0.038128
ENE	0.003881	0.020434	0.023516	0.009589	0.002968	0.000114	0.000000	0.000000	0.060502
E	0.004452	0.030594	0.045320	0.015297	0.003995	0.000228	0.000000	0.000000	0.099886
ESE	0.003539	0.031279	0.020091	0.009132	0.002397	0.000685	0.000114	0.000000	0.067237
SE	0.003995	0.023516	0.022717	0.006050	0.001370	0.000000	0.000000	0.000114	0.057763
SSE	0.003653	0.034932	0.022717	0.008219	0.001256	0.001027	0.000228	0.000000	0.072032
S	0.003082	0.026370	0.032877	0.011416	0.000228	0.000228	0.000000	0.000000	0.074201
SSW	0.003767	0.016438	0.019863	0.007306	0.001142	0.000000	0.000000	0.000000	0.048516
SW	0.003881	0.020434	0.022374	0.008676	0.002397	0.000913	0.000114	0.000000	0.058790
WSW	0.004909	0.016667	0.028995	0.008676	0.004338	0.003995	0.001712	0.001598	0.070890
W	0.004338	0.012785	0.034475	0.010616	0.005822	0.006164	0.003539	0.001598	0.079338
WNW	0.003767	0.012785	0.028881	0.013242	0.004909	0.003425	0.001826	0.003082	0.071918
NW	0.006393	0.014954	0.019863	0.009932	0.002626	0.001256	0.000571	0.000799	0.056393
NNW	0.007991	0.019521	0.021233	0.003767	0.000799	0.000342	0.000114	0.000228	0.053995
N	0.006849	0.022603	0.011073	0.001941	0.000799	0.000799	0.000000	0.000000	0.044064
CALM									0.012671
TOTAL	0.078196	0.336986	0.372945	0.129110	0.035274	0.019178	0.008219	0.007420	1.000000

MEAN WIND SPEED (m/s) = 3.52
NUMBER OF OBSERVATIONS = 8760

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 3.7%
B : 9.4%
C : 15.2%
D : 32.8%
E : 21.2%
F : 17.7%

Appendix B: Estimated dust emissions

MAROOTA SAND QUARRY – HITCHCOCK ROAD

DUST EMISSIONS INVENTORY

Introduction
The proponent proposes to extract and process sand from a number of areas within the existing sand quarry located at Hitchcock Road, Maroota.

The dust emissions inventory has been formulated based on the description of the sand extraction and processing operations provided on behalf of the proponent and summarised below. Emission factors have been developed using emission factor equations provided in the **US EPA (1985)** (and subsequent updates) publication referred to as AP-42 and from factors determined by **SPCC (1983)**.

Estimated emissions are presented for all significant dust generating activities associated with the extraction and processing operations.

It has been assumed that activities occur 11 hours a day, 6 days a week, 48 weeks per year. Dust from wind erosion is assumed to occur over 24 hours per day, 52 weeks a year.

Extraction and processing methods
A maximum of 400,000 tonnes per year (t/y) of sand would be extracted for 30 years from November 1998 (until October 2028). This would represent no change from the current consent. The average rate is 250,000 tonnes per year (t/y).

The proposal includes clearing vegetation prior to the staged extraction of sand.

All sand would be extracted using an excavator and transferred to articulated dump trucks to transport the material to the existing slurry plant located at the northern end of the site. Here it would be mixed with water and pumped via pipeline to the central process plant located on Lot 198. The wash water would be returned to the site for settlement in a series of clay lined basins prior to recirculation from the clean water pond at the lowest point in the system and subsequent reuse.

The sand would be processed at the central plant. It would then be sent to market following checking at the weighbridge. There would be no transport of sand by truck from the site to the central wash plant except during periods of routine maintenance or as a result of plant breakdown.

Dust inventories have been prepared for the proposed extraction from the two phases (Phase 1 and Phase 2). The extraction point from each of these stages was assumed to be located closest to the nearest residences in order to present a worst-case assessment.

Emission estimates
Estimated emissions are presented for all significant dust generating activities associated with the operations. The relevant emission factors used for the study are described below.

Bulldozer activity
The rate at which dust will be generated by a bulldozer working is calculated using **Equation 1**.

Equation 1

$$E_{TSP} = \frac{2.6 \times s^{1.2}}{M^{1.3}} \qquad \text{kg/hour}$$

where,

s = silt content (%), and

M = moisture content (%)

It was assumed that the moisture content is 8% and that the silt content is 14%.

Loading material with FELs
Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 2** shows the relationship between these variables.

Equation 2

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where :

E_{TSP} = *emissionfactor (TSP)*

$k = 0.74$

U = *wind speed(m/s)*

M = *moisture content (%)*

[where $0.25 \leq M \leq 4.8$*]*

For the Maroota meteorological data set used in the modelling, the annual average value of $(u/2.2)^{1.3}$ has been calculated using only the hours that the bulldozer would be operating, namely 11 hours per day. It is calculated to be 2.232.

The moisture is likely to be approximately 8%. However the limit of the equation is 4.8%, therefore this is the value used.

Hauling material on unsealed surfaces
Haul trucks with an average capacity of 31t will be used to take the product off-site. The uncontrolled emission factor is 4.0 kg/VKT, and it has been assumed there is control of 75% due to the application of water.

Wind erosion from exposed areas
The **SPCC (1983)** emission factor for wind erosion is 0.4kg/h/ha.

Emission estimates from Phase 1 – average extraction of 250,000 t/y													
ACTIVITY	**TSP (kg/y)**	**Intensity**	**Units**	**Emission factor**	**Units**	**Variable 1**	**Units**	**Variable 2**	**Units**	**Variable 3**	**Units**	**Variable 4**	**Units**
Removal of top soil and overburden	**13,095**	3,168	h/y	4.1	kg/h	14	silt content in %	8	moisture content (%)				
Extraction of tertiary sand (excavator) to trucks_AreaB	**60**	77,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary sand to slurry plant_Area B	**3,477**	77,000	t/y	0.18065	kg/t	31	t/truck load	1.4	km/return trip	4.0	kg/VKT	75	% control
Dumping tertiary sand to slurry plant_Area B	**60**	77,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Extraction of tertiary sand (excavator) to trucks_2007-09_tertiary	**111**	143,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary sand to	**12,916**	143,000	t/y	0.36129	kg/t	31	t/truck load	2.8	km/return trip	4.0	kg/VKT	75	% control

slurry plant_2007-09_tertiary													
Dumping tertiary sand to slurry plant_2007-09_tertiary	**111**	143,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Extraction of sand (excavator) to trucks_2006-10_friable	**23**	30,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling sand to slurry plant_2006-10_friable	**3,677**	30,000	t/y	0.49032	kg/t	31	t/truck load	3.8	km/return trip	4.0	kg/VKT	75	% control
Dumping sand to slurry plant_2006-10_friable	**23**	30,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Dumping processed tertiary sand to stockpile	**60**	77,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Loading processed tertiary sand to road trucks	**60**	77,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Transporting processed tertiary sand	**4,968**	77,000	t/y	0.25806	kg/t	31	t/truck load	2	km/return trip	4.0	kg/VKT	75	% control

product off-site by road													
Wind erosion from exposed areas (inc stockpiles)	**17,520**	5.0	ha	0.4	kg/ha /h	8,760	h						

Note:

It was assumed that 30,000 t/y of friable sand would be extracted, and of the remainder 220, 000 t/y of tertiary sand, 35%woulkd be extracted from Area B, and 65% would be extracted from the area 2007-09 tertiary.

This section of the Appendix shows the estimated dust emission calculated using the emission factors discussed above and the quantities of material handled.

Apart from the first block of data, each successive block shows the estimated annual average emission in kg/y for each activity and nominates if the activity is (1) insensitive to wind speed (2) sensitive to wind speed (3) or is a wind erosion source. In addition the blocks specify how many sources the dust emission is assumed to be spread over and which sources have been used to specify the locations of the emissions.

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  DUST EMISSION CALCULATIONS V2
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 Output emissions file  :
C:\Jobs\Htchcock\ISC\phase1.dat
 Meteorological file    :
C:\Jobs\Htchcock\Met\Maroota.isc
 Number of dust sources : 93
 Number of activities   : 14
 No-blast conditions    : None
 Wind sensitive factor  : 1.931 (2.232
adjusted for activity hours)
 Wind erosion factor    : 88.060

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : Removal of top soil and
overburden
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 13095 kg/y
 FROM SOURCES  : 31
1 2 3 4 5 6 7 8 9 10 22 23 24 25 26 27
28 29 30 31 32 33 48 49 50 51 52 53 54
55 56
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_AreaB
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 60 kg/y
 FROM SOURCES  : 10
1 2 3 4 5 6 7 8 9 10
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Hauling tertiary sand
to slurry plant_AreaB
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 3477 kg/y
 FROM SOURCES  : 11
11 12 13 14 15 16 17 18 19 20 21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Dumping tertiary sand
to slurry plant_AreaB
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 60 kg/y
 FROM SOURCES  : 1
21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_2007-
09_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 111 kg/y
 FROM SOURCES  : 12
22 23 24 25 26 27 28 29 30 31 32 33
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Hauling tertiary sand
to slurry plant_2007-09_tertiary
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 12916 kg/y
 FROM SOURCES  : 25
11 12 13 14 15 16 17 18 19 20 21 34 35
36 37 38 39 40 41 42 43 44 45 46 47
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Dumping tertiary sand
to slurry plant_2007-09_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 111 kg/y
 FROM SOURCES  : 1
21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Extraction of sand
(excavator) to trucks_2006-10_friable
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 23 kg/y
 FROM SOURCES  : 9
48 49 50 51 52 53 54 55 56
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Hauling sand to slurry
plant_2006-10_friable
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 3677 kg/y
 FROM SOURCES  : 36
11 12 13 14 15 16 17 18 19 20 21 37 38
39 40 41 42 43 44 45 46 47 57 58 59 60
61 62 63 64 65 66 67 68 69 70
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Dumping sand to slurry
plant_2006-10_friable
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 23 kg/y
 FROM SOURCES  : 1
21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Dumping processed
tertiary sand to stockpile
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 60 kg/y
 FROM SOURCES  : 4
71 72 73 74
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Loading processed
tertiary sand to road trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 60 kg/y
 FROM SOURCES  : 4
```

```
71 72 73 74
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Transporting processed
tertiary sand product off-site by road
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 4968 kg/y
 FROM SOURCES  : 19
75 76 77 78 79 80 81 82 83 84 85 86 87
88 89 90 91 92 93
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0

 ACTIVITY NAME : Wind erosion from
exposed areas (inc stockpiles)
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 17520 kg/y
 FROM SOURCES  : 93
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
17 18 19 20 21 22 23 24 25 26 27 28 29
30 31 32 33 34 35 36 37 38 39 40 41 42
43 44 45 46 47 48 49 50 51 52 53 54 55
56 57 58 59 60 61 62 63 64 65 66 67 68
69 70 71 72 73 74 75 76 77 78 79 80 81
82 83 84 85 86 87 88 89 90 91 92 93
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1
```

Emission estimates from Phase 1 – maximum extraction of 400,000 t/y													
ACTIVITY	**TSP (kg/y)**	**Intensity**	**Units**	**Emission factor**	**Units**	**Variable 1**	**Units**	**Variable 2**	**Units**	**Variable 3**	**Units**	**Variable 4**	**Units**
Removal of top soil and overburden	**13,095**	3,168	h/y	4.1	kg/h	14	silt content in %	8	moisture content (%)				
Extraction of tertiary sand (excavator) to trucks_AreaB	**100**	129,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary sand to slurry plant_Area B	**5,848**	129,500	t/y	0.18065	kg/t	31	t/truck load	1.4	km/return trip	4.0	kg/VKT	75	% control
Dumping tertiary sand to slurry plant_Area B	**100**	129,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Extraction of tertiary sand (excavator) to trucks_2007-09_tertiary	**187**	240,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary sand to slurry plant_2007-	**21,723**	240,500	t/y	0.36129	kg/t	31	t/truck load	2.8	km/return trip	4.0	kg/VKT	75	% control

09_tertiary													
Dumping tertiary sand to slurry plant_2007-09_tertiary	**187**	240,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Extraction of sand (excavator) to trucks_2006 -10_friable	**23**	30,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling sand to slurry plant_2006-10_friable	**3,677**	30,000	t/y	0.49032	kg/t	31	t/truck load	3.8	km/return trip	4.0	kg/VKT	75	% control
Dumping sand to slurry plant_2006-10_friable	**23**	30,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Dumping processed tertiary sand to stockpile	**100**	129,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Loading processed tertiary sand to road trucks	**100**	129,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Transportin g processed tertiary sand product	**8,355**	129,500	t/y	0.25806	kg/t	31	t/truck load	2	km/return trip	4.0	kg/VKT	75	% control

off-site by road													
Wind erosion from exposed areas (inc stockpiles)	**17,520**	5.0	ha	0.4	kg/ha /h	8,760	h						

Note:

It was assumed that 30,000 t/y of friable sand would be extracted, and of the remaining 370, 000 t/y of tertiary sand, 35%woulkd be extracted from Area B, and 65% would be extracted from the area 2007-09 tertiary

This section of the Appendix shows the estimated dust emission calculated using the emission factors discussed above and the quantities of material handled.

Apart from the first block of data, each successive block shows the estimated annual average emission in kg/y for each activity and nominates if the activity is (1) insensitive to wind speed (2) sensitive to wind speed (3) or is a wind erosion source. In addition the blocks specify how many sources the dust emission is assumed to be spread over and which sources have been used to specify the locations of the emissions.

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  DUST EMISSION CALCULATIONS V2
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 Output emissions file  :
C:\Jobs\Htchcock\ISC\P1Max.dat
 Meteorological file    :
C:\Jobs\Htchcock\Met\Maroota.isc
 Number of dust sources : 93
 Number of activities   : 14
 No-blast conditions    : None
 Wind sensitive factor  : 1.931 (2.232
adjusted for activity hours)
 Wind erosion factor    : 88.060

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : Removal of top soil and
overburden
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 13095 kg/y
 FROM SOURCES  : 31
1 2 3 4 5 6 7 8 9 10 22 23 24 25 26 27 28
29 30 31 32 33 48 49 50 51 52 53 54 55 56
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_AreaB
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 100 kg/y
 FROM SOURCES  : 10
1 2 3 4 5 6 7 8 9 10
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Hauling tertiary sand to
slurry plant_AreaB
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 5848 kg/y
 FROM SOURCES  : 11
11 12 13 14 15 16 17 18 19 20 21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping tertiary sand to
slurry plant_AreaB
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 100 kg/y
 FROM SOURCES  : 1
21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_2007-09_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 187 kg/y
 FROM SOURCES  : 12
22 23 24 25 26 27 28 29 30 31 32 33
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Hauling tertiary sand to
slurry plant_2007-09_tertiary
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 21723 kg/y
 FROM SOURCES  : 25
11 12 13 14 15 16 17 18 19 20 21 34 35 36
37 38 39 40 41 42 43 44 45 46 47
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping tertiary sand to
slurry plant_2007-09_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 187 kg/y
 FROM SOURCES  : 1
21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Extraction of sand
(excavator) to trucks_2006-10_friable
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 23 kg/y
 FROM SOURCES  : 9
48 49 50 51 52 53 54 55 56
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Hauling sand to slurry
plant_2006-10_friable
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 3677 kg/y
 FROM SOURCES  : 36
11 12 13 14 15 16 17 18 19 20 21 37 38 39
40 41 42 43 44 45 46 47 57 58 59 60 61 62
63 64 65 66 67 68 69 70
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping sand to slurry
plant_2006-10_friable
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 23 kg/y
 FROM SOURCES  : 1
21
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping processed tertiary
sand to stockpile
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 100 kg/y
 FROM SOURCES  : 4
71 72 73 74
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Loading processed tertiary
sand to road trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 100 kg/y
 FROM SOURCES  : 4
71 72 73 74
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0
```

```
 ACTIVITY NAME : Transporting processed
tertiary sand product off-site by road
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 8355 kg/y
 FROM SOURCES  : 19
75 76 77 78 79 80 81 82 83 84 85 86 87 88
89 90 91 92 93
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Wind erosion from exposed
areas (inc stockpiles)
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 17520 kg/y
 FROM SOURCES  : 93
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
18 19 20 21 22 23 24 25 26 27 28 29 30 31
32 33 34 35 36 37 38 39 40 41 42 43 44 45
46 47 48 49 50 51 52 53 54 55 56 57 58 59
60 61 62 63 64 65 66 67 68 69 70 71 72 73
74 75 76 77 78 79 80 81 82 83 84 85 86 87
88 89 90 91 92 93
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
```

Emission estimates from Phase 2 – average extraction of 250,000 t/y													
ACTIVITY	**TSP (kg/y)**	**Intensity**	**Units**	**Emission factor**	**Units**	**Variable 1**	**Units**	**Variable 2**	**Units**	**Variable 3**	**Units**	**Variable 4**	**Units**
Removal of top soil and overburden	**13,095**	3,168	h/y	4.1	kg/h	14	silt content in %	8	moisture content (%)				
Extraction of tertiary sand (excavator) to trucks_AreaA & 2010-20	**68**	87,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary sand to slurry plant_Area A & 2010-20	**2,823**	87,500	t/y	0.12903	kg/t	31	t/truck load	1	km/return trip	4.0	kg/VKT	75	% control
Dumping tertiary sand to slurry plant_Area A & 2010-20	**68**	87,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)		1		
Extraction of tertiary sand (excavator) to trucks_2010-15_tertiary	**126**	162,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary	**20,968**	162,500	t/y	0.51613	kg/t	31	t/truck load	4	km/return trip	4.0	kg/VKT	75	% control

sand to slurry plant_2010-15_tertiary													
Dumping tertiary sand to slurry plant_2010-15_tertiary	**126**	162,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Dumping processed tertiary sand to stockpile	**68**	87,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Loading processed tertiary sand to road trucks	**68**	87,500	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Transporting processed tertiary sand product off-site by road	**5,645**	87,500	t/y	0.25806	kg/t	31	t/truck load	2	km/return trip	4.0	kg/VKT	75	% control
Wind erosion from exposed areas (inc stockpiles)	**28,032**	8.0	ha	0.4	kg/ha/h	8,760	h						

Note:

It was assumed that 35%would be extracted from Area A and 2010-20, and 65% would be extracted from the area 2010-15 tertiary.

This section of the Appendix shows the estimated dust emission calculated using the emission factors discussed above and the quantities of material handled.

Apart from the first block of data, each successive block shows the estimated annual average emission in kg/y for each activity and nominates if the activity is (1) insensitive to wind speed (2) sensitive to wind speed (3) or is a wind erosion source. In addition the blocks specify how many sources the dust emission is assumed to be spread over and which sources have been used to specify the locations of the emissions.

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  DUST EMISSION CALCULATIONS V2
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 Output emissions file  :
C:\Jobs\Htchcock\ISC\phase2.dat
 Meteorological file    :
C:\Jobs\Htchcock\Met\Maroota.isc
 Number of dust sources : 83
 Number of activities   : 11
 No-blast conditions    : None
 Wind sensitive factor  : 1.931 (2.232
adjusted for activity hours)
 Wind erosion factor    : 88.060

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : Removal of top soil and
overburden
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 13095 kg/y
 FROM SOURCES  : 21
1 2 3 4 5 6 7 8 9 10 11 12 13 15 16 17 18
19 20 21 22
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_AreaA & 2010-20
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 68 kg/y
 FROM SOURCES  : 13
1 2 3 4 5 6 7 8 9 10 11 12 13
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Hauling tertiary sand to
slurry plant_AreaA & 2010-20
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 2823 kg/y
 FROM SOURCES  : 7
14 55 56 57 58 59 60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping tertiary sand to
slurry plant_AreaA & 2010-20
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 68 kg/y
 FROM SOURCES  : 1
60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_2010-15_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 126 kg/y
 FROM SOURCES  : 8
15 16 17 18 19 20 21 22
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Hauling tertiary sand to
slurry plant_2010-15_tertiary
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 20968 kg/y
 FROM SOURCES  : 38
23 24 25 26 27 28 29 30 31 32 33 34 35 36
37 38 39 40 41 42 43 44 45 46 47 48 49 50
51 52 53 54 55 56 57 58 59 60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping tertiary sand to
slurry plant_2010-15_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 126 kg/y
 FROM SOURCES  : 1
60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping processed tertiary
sand to stockpile
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 68 kg/y
 FROM SOURCES  : 3
61 62 63
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Loading processed tertiary
sand to road trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 68 kg/y
 FROM SOURCES  : 3
61 62 63
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Transporting processed
tertiary sand product off-site by road
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 5645 kg/y
 FROM SOURCES  : 20
64 65 66 67 68 69 70 71 72 73 74 75 76 77
78 79 80 81 82 83
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Wind erosion from exposed
areas (inc stockpiles)
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 28032 kg/y
 FROM SOURCES  : 83
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
18 19 20 21 22 23 24 25 26 27 28 29 30 31
32 33 34 35 36 37 38 39 40 41 42 43 44 45
46 47 48 49 50 51 52 53 54 55 56 57 58 59
60 61 62 63 64 65 66 67 68 69 70 71 72 73
74 75 76 77 78 79 80 81 82 83
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
```

Emission estimates from Phase 2 – maximum extraction of 400,000 t/y													
ACTIVITY	**TSP (kg/y)**	**Intensity**	**Units**	**Emission factor**	**Units**	**Variable 1**	**Units**	**Variable 2**	**Units**	**Variable 3**	**Units**	**Variable 4**	**Units**
Removal of top soil and overburden	**13,095**	3,168	h/y	4.1	kg/h	14	silt content in %	8	moisture content (%)				
Extraction of tertiary sand (excavator) to trucks_AreaA & 2010-20	**109**	140,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary sand to slurry plant_Area A & 2010-20	**4,516**	140,000	t/y	0.12903	kg/t	31	t/truck load	1	km/return trip	4.0	kg/VKT	75	% control
Dumping tertiary sand to slurry plant_Area A & 2010-20	**109**	140,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)		1		
Extraction of tertiary sand (excavator) to trucks_2010-15_tertiary	**202**	260,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Hauling tertiary	**33,548**	260,000	t/y	0.51613	kg/t	31	t/truck load	4	km/return trip	4.0	kg/VKT	75	% control

sand to slurry plant_2010-15_tertiary													
Dumping tertiary sand to slurry plant_2010-15_tertiary	**202**	260,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Dumping processed tertiary sand to stockpile	**109**	140,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Loading processed tertiary sand to road trucks	**109**	140,000	t/y	0.00078	kg/t	2.232	average of (wind speed/2.2)^ 1.3 in m/s	4.8	moisture content (%)				
Transporting processed tertiary sand product off-site by road	**9,032**	140,000	t/y	0.25806	kg/t	31	t/truck load	2	km/return trip	4.0	kg/VKT	75	% control
Wind erosion from exposed areas (inc stockpiles)	**28,032**	8.0	ha	0.4	kg/ha/h	8,760	h						

Note:

It was assumed that 35%would be extracted from Area A and 2010-20, and 65% would be extracted from the area 2010-15 tertiary.

This section of the Appendix shows the estimated dust emission calculated using the emission factors discussed above and the quantities of material handled.

Apart from the first block of data, each successive block shows the estimated annual average emission in kg/y for each activity and nominates if the activity is (1) insensitive to wind speed (2) sensitive to wind speed (3) or is a wind erosion source. In addition the blocks specify how many sources the dust emission is assumed to be spread over and which sources have been used to specify the locations of the emissions.

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  DUST EMISSION CALCULATIONS V2
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 Output emissions file  :
C:\Jobs\Htchcock\ISC\P2Max.dat
 Meteorological file    :
C:\Jobs\Htchcock\Met\Maroota.isc
 Number of dust sources : 83
 Number of activities   : 11
 No-blast conditions    : None
 Wind sensitive factor  : 1.931 (2.232
adjusted for activity hours)
 Wind erosion factor    : 88.060

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : Removal of top soil and
overburden
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 13095 kg/y
 FROM SOURCES  : 21
1 2 3 4 5 6 7 8 9 10 11 12 13 15 16 17 18
19 20 21 22
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_AreaA & 2010-20
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 109 kg/y
 FROM SOURCES  : 13
1 2 3 4 5 6 7 8 9 10 11 12 13
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Hauling tertiary sand to
slurry plant_AreaA & 2010-20
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 4516 kg/y
 FROM SOURCES  : 7
14 55 56 57 58 59 60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping tertiary sand to
slurry plant_AreaA & 2010-20
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 109 kg/y
 FROM SOURCES  : 1
60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Extraction of tertiary
sand (excavator) to trucks_2010-15_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 202 kg/y
 FROM SOURCES  : 8
15 16 17 18 19 20 21 22
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Hauling tertiary sand to
slurry plant_2010-15_tertiary
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 33548 kg/y
 FROM SOURCES  : 38
23 24 25 26 27 28 29 30 31 32 33 34 35 36
37 38 39 40 41 42 43 44 45 46 47 48 49 50
51 52 53 54 55 56 57 58 59 60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping tertiary sand to
slurry plant_2010-15_tertiary
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 202 kg/y
 FROM SOURCES  : 1
60
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Dumping processed tertiary
sand to stockpile
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 109 kg/y
 FROM SOURCES  : 3
61 62 63
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Loading processed tertiary
sand to road trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 109 kg/y
 FROM SOURCES  : 3
61 62 63
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Transporting processed
tertiary sand product off-site by road
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 9032 kg/y
 FROM SOURCES  : 20
64 65 66 67 68 69 70 71 72 73 74 75 76 77
78 79 80 81 82 83
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0 0

 ACTIVITY NAME : Wind erosion from exposed
areas (inc stockpiles)
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 28032 kg/y
 FROM SOURCES  : 83
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
18 19 20 21 22 23 24 25 26 27 28 29 30 31
32 33 34 35 36 37 38 39 40 41 42 43 44 45
46 47 48 49 50 51 52 53 54 55 56 57 58 59
60 61 62 63 64 65 66 67 68 69 70 71 72 73
74 75 76 77 78 79 80 81 82 83
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
```

Appendix C: ISCMOD Input File

```
**  ISCST3 model input runstream : Dust
CO STARTING
   TITLEONE ISCST3 Dust Model Run
   MODELOPT RURAL CONC DDEP DRYDPLT
   AVERTIME 24 PERIOD
   POLLUTID TSP
   ERRORFIL error.log
   TERRHGTS ELEV
   RUNORNOT RUN
CO FINISHED

SO STARTING
   LOCATION  POINT1  VOLUME  313471.5406 6294977.77 204.753911
   LOCATION  POINT2  VOLUME  313473.1758 6294943.43 202.7877171
   LOCATION  POINT3  VOLUME  313474.811 6294887.831 199.4670097
   LOCATION  POINT4  VOLUME  313432.2944 6294886.196 195.1507774
   LOCATION  POINT5  VOLUME  313437.2005 6294938.524 199.02595
   LOCATION  POINT6  VOLUME  313443.7413 6294977.77 202.1407916
   LOCATION  POINT7  VOLUME  313399.5895 6294981.04 198.0873839
   LOCATION  POINT8  VOLUME  313393.0487 6294940.159 194.7733915
   LOCATION  POINT9  VOLUME  313388.1426 6294902.549 191.7319526
   LOCATION  POINT10  VOLUME  313370.155 6294887.831 188.854939
   LOCATION  POINT11  VOLUME  313321.0976 6294899.278 184.7033142
   LOCATION  POINT12  VOLUME  313290.0279 6294941.795 184.9886101
   LOCATION  POINT13  VOLUME  313272.0398 6295012.11 188.4489208
   LOCATION  POINT14  VOLUME  313267.1342 6295082.426 192.2822454
   LOCATION  POINT15  VOLUME  313254.0521 6295139.66 194.2365611
   LOCATION  POINT16  VOLUME  313260.5934 6295198.529 197.6198484
   LOCATION  POINT17  VOLUME  313273.675 6295249.222 200.702828
   LOCATION  POINT18  VOLUME  313304.7451 6295301.55 204.9408067
   LOCATION  POINT19  VOLUME  313334.1797 6295347.337 208.5722709
   LOCATION  POINT20  VOLUME  313368.5198 6295384.948 212.181001
   LOCATION  POINT21  VOLUME  313425.7536 6295414.382 217.6571844
   LOCATION  POINT22  VOLUME  313126.6161 6294512.927 139.2207801
   LOCATION  POINT23  VOLUME  313175.4094 6294509.442 137.3950007
   LOCATION  POINT24  VOLUME  313213.7468 6294508.571 137.6743716
   LOCATION  POINT25  VOLUME  313215.4892 6294463.263 134.7814367
   LOCATION  POINT26  VOLUME  313171.0528 6294465.877 134.8775772
   LOCATION  POINT27  VOLUME  313130.9727 6294466.748 136.2454685
   LOCATION  POINT28  VOLUME  313135.3293 6294437.995 134.3504614
   LOCATION  POINT29  VOLUME  313162.3396 6294431.025 132.8395421
   LOCATION  POINT30  VOLUME  313212.0041 6294425.797 131.8017426
   LOCATION  POINT31  VOLUME  313259.0544 6294427.54 133.2706592
   LOCATION  POINT32  VOLUME  313286.065 6294442.352 136.6776235
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   LOCATION  POINT40  VOLUME  313462.9396 6294601.801 181.4765364
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   LOCATION  POINT42  VOLUME  313425.4737 6294638.395 178.926762
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   LOCATION  POINT66  VOLUME  313654.6885 6294325.305 150.0592451
   LOCATION  POINT67  VOLUME  313664.5001 6294358.01 156.67719
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** Point Source       QS   RH  IL   IV
** Parameters        ----  --- ---  ---
   HOUREMIS  C:\Jobs\htchcock\ISC\phase1.dat POINT1-POINT279
   SRCPARAM  POINT1   1.0 2.0  20.  2.
   SRCPARAM  POINT2   1.0 2.0  20.  2.
   SRCPARAM  POINT3   1.0 2.0  20.  2.
   SRCPARAM  POINT4   1.0 2.0  20.  2.
   SRCPARAM  POINT5   1.0 2.0  20.  2.
   SRCPARAM  POINT6   1.0 2.0  20.  2.
   SRCPARAM  POINT7   1.0 2.0  20.  2.
   SRCPARAM  POINT8   1.0 2.0  20.  2.
   SRCPARAM  POINT9   1.0 2.0  20.  2.
   SRCPARAM  POINT10   1.0 2.0  20.  2.
   SRCPARAM  POINT11   1.0 2.0  20.  2.
   SRCPARAM  POINT12   1.0 2.0  20.  2.
   SRCPARAM  POINT13   1.0 2.0  20.  2.
   SRCPARAM  POINT14   1.0 2.0  20.  2.
   SRCPARAM  POINT15   1.0 2.0  20.  2.
   SRCPARAM  POINT16   1.0 2.0  20.  2.
   SRCPARAM  POINT17   1.0 2.0  20.  2.
   SRCPARAM  POINT18   1.0 2.0  20.  2.
   SRCPARAM  POINT19   1.0 2.0  20.  2.
   SRCPARAM  POINT20   1.0 2.0  20.  2.
   SRCPARAM  POINT21   1.0 2.0  20.  2.
   SRCPARAM  POINT22   1.0 2.0  20.  2.
   SRCPARAM  POINT23   1.0 2.0  20.  2.
   SRCPARAM  POINT24   1.0 2.0  20.  2.
   SRCPARAM  POINT25   1.0 2.0  20.  2.
   SRCPARAM  POINT26   1.0 2.0  20.  2.
   SRCPARAM  POINT27   1.0 2.0  20.  2.
   SRCPARAM  POINT28   1.0 2.0  20.  2.
   SRCPARAM  POINT29   1.0 2.0  20.  2.
   SRCPARAM  POINT30   1.0 2.0  20.  2.
```

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SRCPARAM  POINT31   1.0 2.0  20.  2.
SRCPARAM  POINT32   1.0 2.0  20.  2.
SRCPARAM  POINT33   1.0 2.0  20.  2.
SRCPARAM  POINT34   1.0 2.0  20.  2.
SRCPARAM  POINT35   1.0 2.0  20.  2.
SRCPARAM  POINT36   1.0 2.0  20.  2.
SRCPARAM  POINT37   1.0 2.0  20.  2.
SRCPARAM  POINT38   1.0 2.0  20.  2.
SRCPARAM  POINT39   1.0 2.0  20.  2.
SRCPARAM  POINT40   1.0 2.0  20.  2.
SRCPARAM  POINT41   1.0 2.0  20.  2.
SRCPARAM  POINT42   1.0 2.0  20.  2.
SRCPARAM  POINT43   1.0 2.0  20.  2.
SRCPARAM  POINT44   1.0 2.0  20.  2.
SRCPARAM  POINT45   1.0 2.0  20.  2.
SRCPARAM  POINT46   1.0 2.0  20.  2.
SRCPARAM  POINT47   1.0 2.0  20.  2.
SRCPARAM  POINT48   1.0 2.0  20.  2.
SRCPARAM  POINT49   1.0 2.0  20.  2.
SRCPARAM  POINT50   1.0 2.0  20.  2.
SRCPARAM  POINT51   1.0 2.0  20.  2.
SRCPARAM  POINT52   1.0 2.0  20.  2.
SRCPARAM  POINT53   1.0 2.0  20.  2.
SRCPARAM  POINT54   1.0 2.0  20.  2.
SRCPARAM  POINT55   1.0 2.0  20.  2.
SRCPARAM  POINT56   1.0 2.0  20.  2.
SRCPARAM  POINT57   1.0 2.0  20.  2.
SRCPARAM  POINT58   1.0 2.0  20.  2.
SRCPARAM  POINT59   1.0 2.0  20.  2.
SRCPARAM  POINT60   1.0 2.0  20.  2.
SRCPARAM  POINT61   1.0 2.0  20.  2.
SRCPARAM  POINT62   1.0 2.0  20.  2.
SRCPARAM  POINT63   1.0 2.0  20.  2.
SRCPARAM  POINT64   1.0 2.0  20.  2.
SRCPARAM  POINT65   1.0 2.0  20.  2.
SRCPARAM  POINT66   1.0 2.0  20.  2.
SRCPARAM  POINT67   1.0 2.0  20.  2.
SRCPARAM  POINT68   1.0 2.0  20.  2.
SRCPARAM  POINT69   1.0 2.0  20.  2.
SRCPARAM  POINT70   1.0 2.0  20.  2.
SRCPARAM  POINT71   1.0 2.0  20.  2.
SRCPARAM  POINT72   1.0 2.0  20.  2.
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SRCPARAM  POINT74   1.0 2.0  20.  2.
SRCPARAM  POINT75   1.0 2.0  20.  2.
SRCPARAM  POINT76   1.0 2.0  20.  2.
SRCPARAM  POINT77   1.0 2.0  20.  2.
SRCPARAM  POINT78   1.0 2.0  20.  2.
SRCPARAM  POINT79   1.0 2.0  20.  2.
SRCPARAM  POINT80   1.0 2.0  20.  2.
SRCPARAM  POINT81   1.0 2.0  20.  2.
SRCPARAM  POINT82   1.0 2.0  20.  2.
SRCPARAM  POINT83   1.0 2.0  20.  2.
SRCPARAM  POINT84   1.0 2.0  20.  2.
SRCPARAM  POINT85   1.0 2.0  20.  2.
SRCPARAM  POINT86   1.0 2.0  20.  2.
SRCPARAM  POINT87   1.0 2.0  20.  2.
SRCPARAM  POINT88   1.0 2.0  20.  2.
SRCPARAM  POINT89   1.0 2.0  20.  2.
SRCPARAM  POINT90   1.0 2.0  20.  2.
SRCPARAM  POINT91   1.0 2.0  20.  2.
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SRCPARAM  POINT93   1.0 2.0  20.  2.
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SRCPARAM  POINT95   1.0 2.0  20.  2.
SRCPARAM  POINT96   1.0 2.0  20.  2.
SRCPARAM  POINT97   1.0 2.0  20.  2.
SRCPARAM  POINT98   1.0 2.0  20.  2.
SRCPARAM  POINT99   1.0 2.0  20.  2.
SRCPARAM  POINT100   1.0 2.0  20.  2.
SRCPARAM  POINT101   1.0 2.0  20.  2.
SRCPARAM  POINT102   1.0 2.0  20.  2.
SRCPARAM  POINT103   1.0 2.0  20.  2.
SRCPARAM  POINT104   1.0 2.0  20.  2.
SRCPARAM  POINT105   1.0 2.0  20.  2.
SRCPARAM  POINT106   1.0 2.0  20.  2.
SRCPARAM  POINT107   1.0 2.0  20.  2.
SRCPARAM  POINT108   1.0 2.0  20.  2.
SRCPARAM  POINT109   1.0 2.0  20.  2.
SRCPARAM  POINT110   1.0 2.0  20.  2.
SRCPARAM  POINT111   1.0 2.0  20.  2.
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SRCPARAM  POINT113   1.0 2.0  20.  2.
SRCPARAM  POINT114   1.0 2.0  20.  2.
SRCPARAM  POINT115   1.0 2.0  20.  2.
SRCPARAM  POINT116   1.0 2.0  20.  2.
SRCPARAM  POINT117   1.0 2.0  20.  2.
SRCPARAM  POINT118   1.0 2.0  20.  2.
SRCPARAM  POINT119   1.0 2.0  20.  2.
SRCPARAM  POINT120   1.0 2.0  20.  2.
SRCPARAM  POINT121   1.0 2.0  20.  2.
SRCPARAM  POINT122   1.0 2.0  20.  2.
SRCPARAM  POINT123   1.0 2.0  20.  2.
SRCPARAM  POINT124   1.0 2.0  20.  2.
SRCPARAM  POINT125   1.0 2.0  20.  2.
SRCPARAM  POINT126   1.0 2.0  20.  2.
SRCPARAM  POINT127   1.0 2.0  20.  2.
SRCPARAM  POINT128   1.0 2.0  20.  2.
SRCPARAM  POINT129   1.0 2.0  20.  2.
SRCPARAM  POINT130   1.0 2.0  20.  2.
SRCPARAM  POINT131   1.0 2.0  20.  2.
SRCPARAM  POINT132   1.0 2.0  20.  2.
SRCPARAM  POINT133   1.0 2.0  20.  2.
SRCPARAM  POINT134   1.0 2.0  20.  2.
SRCPARAM  POINT135   1.0 2.0  20.  2.
SRCPARAM  POINT136   1.0 2.0  20.  2.
SRCPARAM  POINT137   1.0 2.0  20.  2.
SRCPARAM  POINT138   1.0 2.0  20.  2.
SRCPARAM  POINT139   1.0 2.0  20.  2.
SRCPARAM  POINT140   1.0 2.0  20.  2.
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SRCPARAM  POINT146   1.0 2.0  20.  2.
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SRCPARAM  POINT149   1.0 2.0  20.  2.
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SRCPARAM  POINT151   1.0 2.0  20.  2.
SRCPARAM  POINT152   1.0 2.0  20.  2.
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SRCPARAM  POINT155   1.0 2.0  20.  2.
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SRCPARAM  POINT159   1.0 2.0  20.  2.
SRCPARAM  POINT160   1.0 2.0  20.  2.
SRCPARAM  POINT161   1.0 2.0  20.  2.
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SRCPARAM  POINT163   1.0 2.0  20.  2.
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SRCPARAM  POINT165   1.0 2.0  20.  2.
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SRCPARAM  POINT189   1.0 2.0  20.  2.
SRCPARAM  POINT190   1.0 2.0  20.  2.
SRCPARAM  POINT191   1.0 2.0  20.  2.
SRCPARAM  POINT192   1.0 2.0  20.  2.
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SRCPARAM  POINT235   1.0 2.0  20.  2.
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SRCPARAM  POINT238   1.0 2.0  20.  2.
SRCPARAM  POINT239   1.0 2.0  20.  2.
SRCPARAM  POINT240   1.0 2.0  20.  2.
SRCPARAM  POINT241   1.0 2.0  20.  2.
SRCPARAM  POINT242   1.0 2.0  20.  2.
SRCPARAM  POINT243   1.0 2.0  20.  2.
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SRCPARAM  POINT245   1.0 2.0  20.  2.
SRCPARAM  POINT246   1.0 2.0  20.  2.
SRCPARAM  POINT247   1.0 2.0  20.  2.
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SRCPARAM  POINT253   1.0 2.0  20.  2.
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SRCPARAM  POINT257   1.0 2.0  20.  2.
SRCPARAM  POINT258   1.0 2.0  20.  2.
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SRCPARAM  POINT268   1.0 2.0  20.  2.
SRCPARAM  POINT269   1.0 2.0  20.  2.
SRCPARAM  POINT270   1.0 2.0  20.  2.
SRCPARAM  POINT271   1.0 2.0  20.  2.
SRCPARAM  POINT272   1.0 2.0  20.  2.
SRCPARAM  POINT273   1.0 2.0  20.  2.
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   SRCPARAM  POINT276   1.0 2.0  20.  2.
   SRCPARAM  POINT277   1.0 2.0  20.  2.
   SRCPARAM  POINT278   1.0 2.0  20.  2.
   SRCPARAM  POINT279   1.0 2.0  20.  2.
   PARTDIAM  POINT1-POINT93  1.0
   PARTDIAM  POINT94-POINT186  5.0
   PARTDIAM  POINT187-POINT279  17.3
   MASSFRAX  POINT1-POINT279  1.0
   PARTDENS  POINT1-POINT279  2.5
   SRCGROUP  FP  POINT1-POINT93
   SRCGROUP  CM  POINT94-POINT186
   SRCGROUP  REST  POINT187-POINT279
SO FINISHED

RE STARTING
RE DISCCART 313085.5482 6294523.171 142.0735435
RE DISCCART 313105.5801 6294524.423 140.9910912
RE DISCCART 313133.1237 6294525.675 139.7511762
RE DISCCART 313153.1556 6294525.675 138.8670278
RE DISCCART 313210.747 6294523.171 138.3246555
RE DISCCART 313255.8186 6294520.667 141.3552473
RE DISCCART 313312.1581 6294510.651 147.4162501
RE DISCCART 313340.954 6294501.887 150.3400929
RE DISCCART 313396.0416 6294486.863 155.7190088
RE DISCCART 313418.5774 6294465.579 154.4469906
RE DISCCART 313359.7336 6294440.54 143.3127962
RE DISCCART 313340.954 6294473.091 146.1678469
RE DISCCART 313315.914 6294486.863 144.9727715
RE DISCCART 313290.8743 6294469.336 140.0816812
RE DISCCART 313274.5986 6294461.824 137.9101244
RE DISCCART 313240.7949 6294509.399 139.2477423
RE DISCCART 313240.7949 6294481.855 137.1428622
RE DISCCART 313237.0387 6294449.304 134.4621149
RE DISCCART 313228.275 6294430.524 132.5379384
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RE DISCCART 313170.6832 6294464.327 134.7915662
RE DISCCART 313154.4075 6294498.131 137.0489629
RE DISCCART 313139.3838 6294489.367 137.1280297
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RE DISCCART 313138.1318 6294436.784 134.1268659
RE DISCCART 313135.6276 6294411.744 132.7809619
RE DISCCART 313114.3437 6294431.776 135.1430163
RE DISCCART 313070.5244 6294516.911 142.6232371
RE DISCCART 313089.304 6294474.343 138.9675168
RE DISCCART 313099.32 6294436.784 136.245137
RE DISCCART 313116.848 6294410.492 133.8283729
RE DISCCART 313215.7552 6294409.24 130.4955829
RE DISCCART 313249.5589 6294478.099 137.2151253
RE DISCCART 313258.3225 6294499.383 139.8930221
RE DISCCART 313323.426 6294489.367 146.2675506
RE DISCCART 313344.7099 6294459.32 144.5712489
RE DISCCART 313393.5373 6294441.792 147.1992525
RE DISCCART 313446.121 6294440.54 152.4880329
RE DISCCART 313462.3967 6294499.383 166.1665754
RE DISCCART 313483.6805 6294469.336 161.8667972
RE DISCCART 313537.5161 6294440.54 160.5961138
RE DISCCART 313582.5877 6294440.54 164.2205764
RE DISCCART 313600.1157 6294366.672 151.9742142
RE DISCCART 313608.8794 6294350.396 149.8216973
RE DISCCART 313607.6274 6294420.508 162.5622017
RE DISCCART 313585.0916 6294392.964 155.5057712
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RE DISCCART 313573.8237 6294404.232 156.6339906
RE DISCCART 313646.4393 6294379.192 158.6158001
RE DISCCART 313658.9591 6294415.5 165.9512926
RE DISCCART 313625.1554 6294433.028 166.2364005
RE DISCCART 313595.1076 6294453.06 167.4983594
RE DISCCART 313537.5161 6294460.572 164.4736738
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RE DISCCART 313616.3914 6294344.136 149.4423167
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RE DISCCART 313685.2508 6294286.545 146.9564474
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RE DISCCART 313683.9988 6294309.081 150.5095969
RE DISCCART 313628.9113 6294350.396 151.8230112
RE DISCCART 313622.6515 6294364.168 153.6863702
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FIGURES

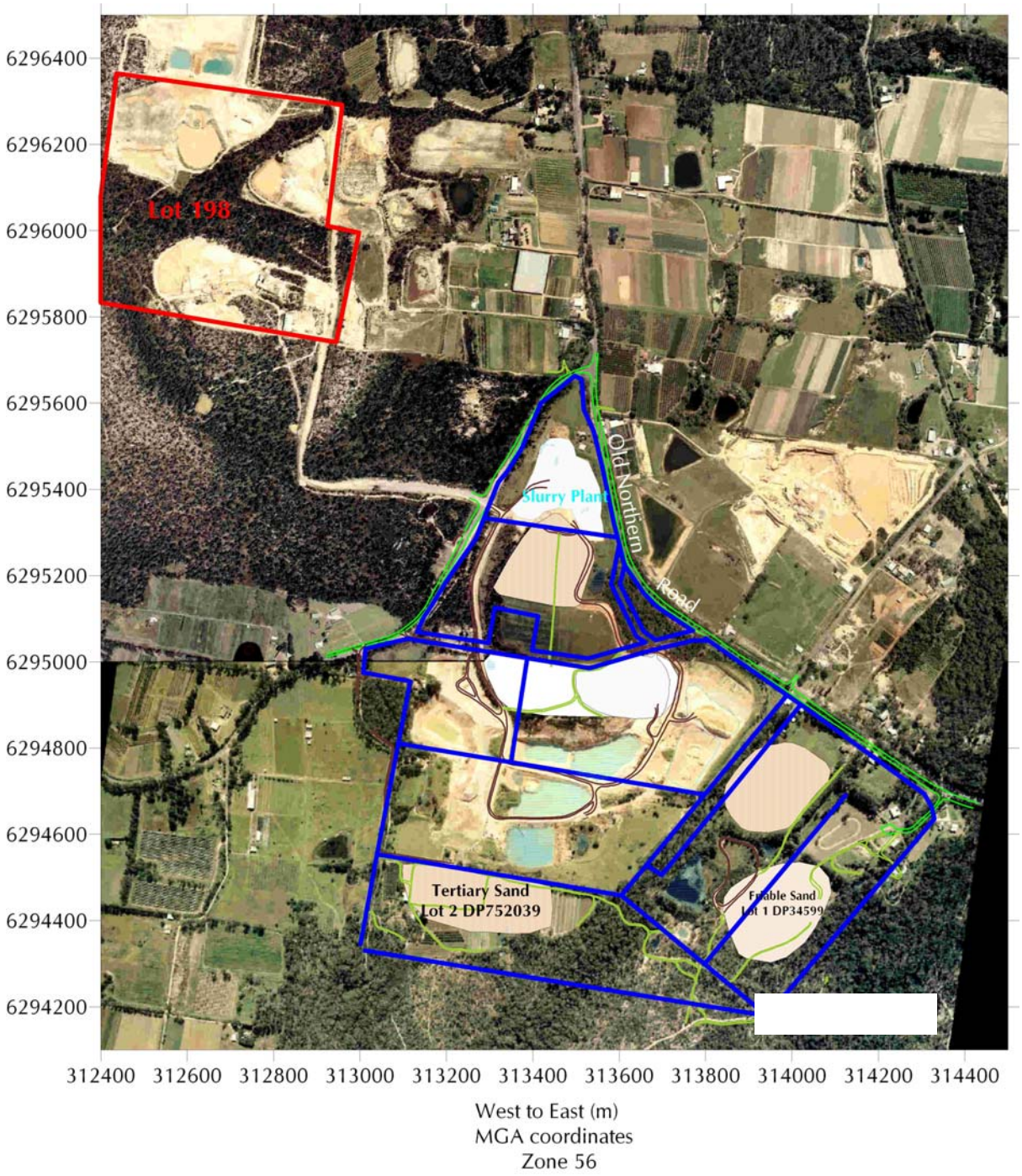

Figure 1: Site layout

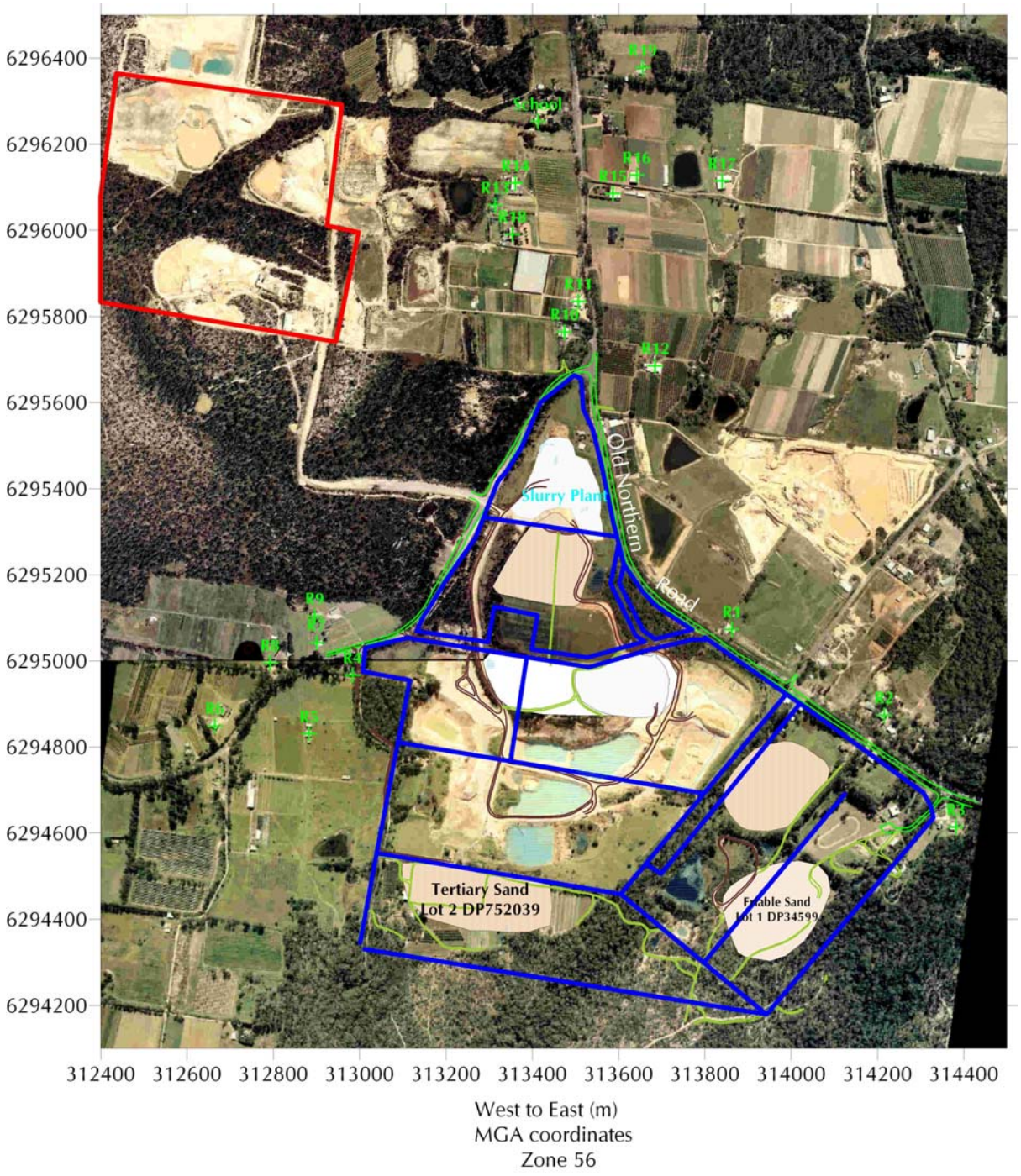

Figure 2: Location of residences

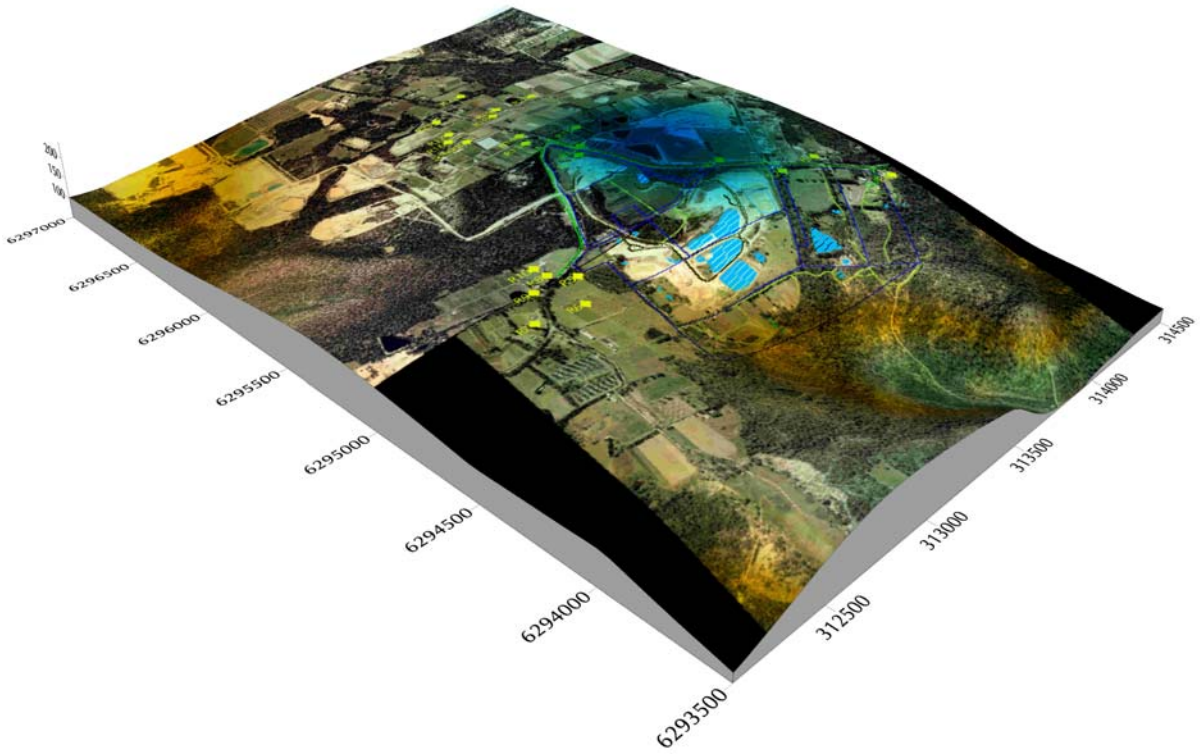

Figure 3: Pseudo 3-dimensional plot of area

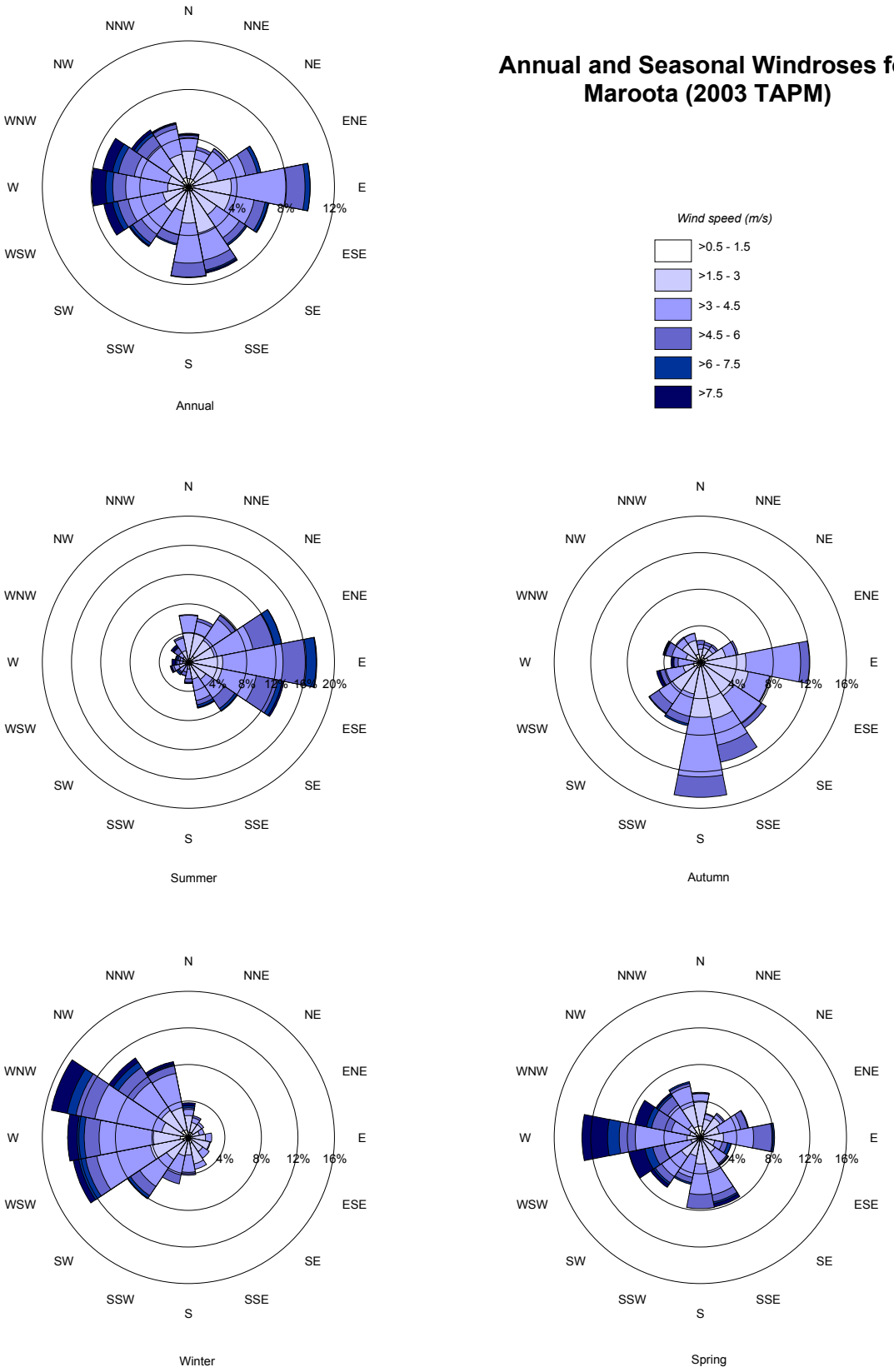

Figure 4: Annual and seasonal windroses for Maroota (TAPM 2003)

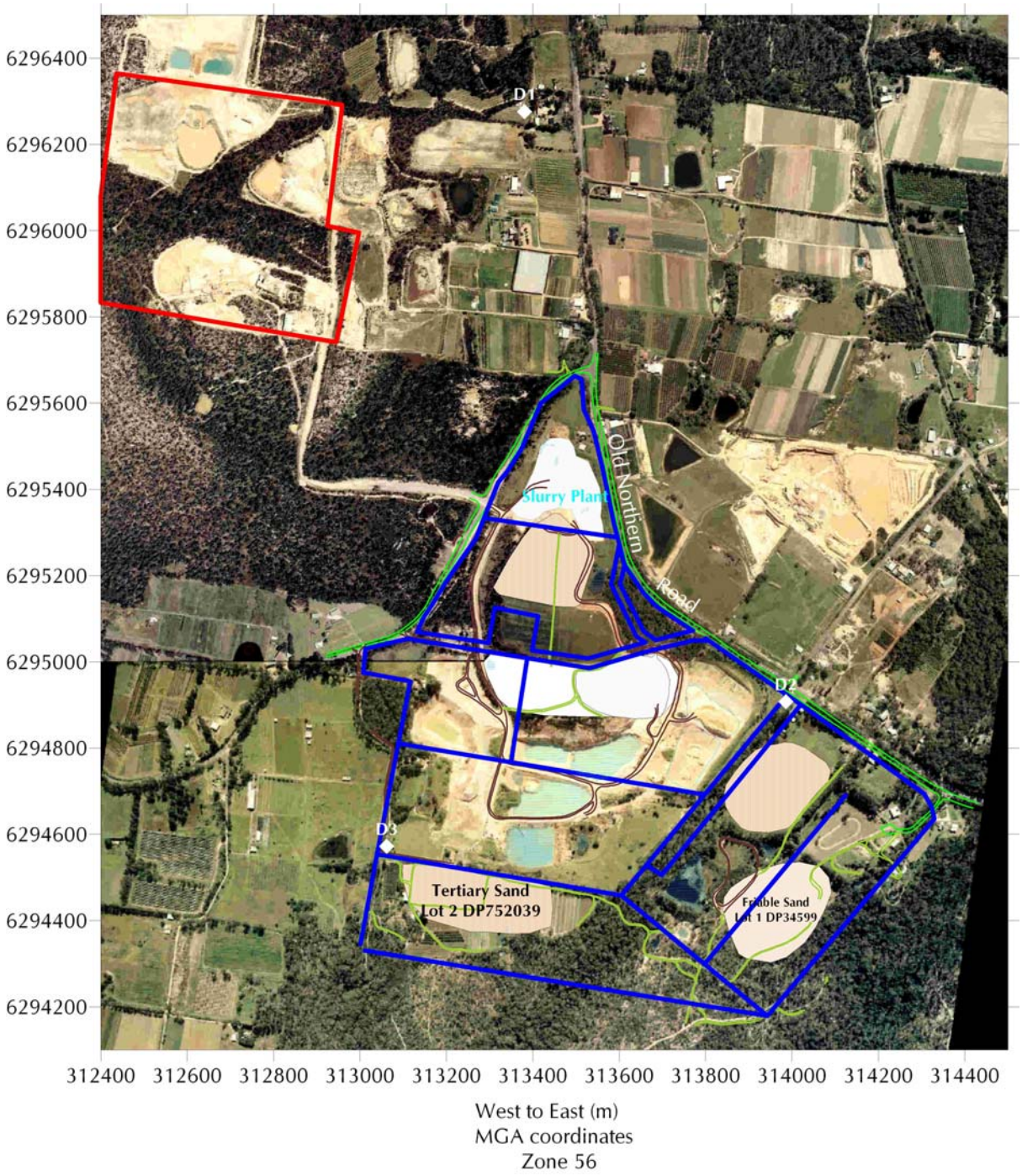

Figure 5: Location of dust gauges

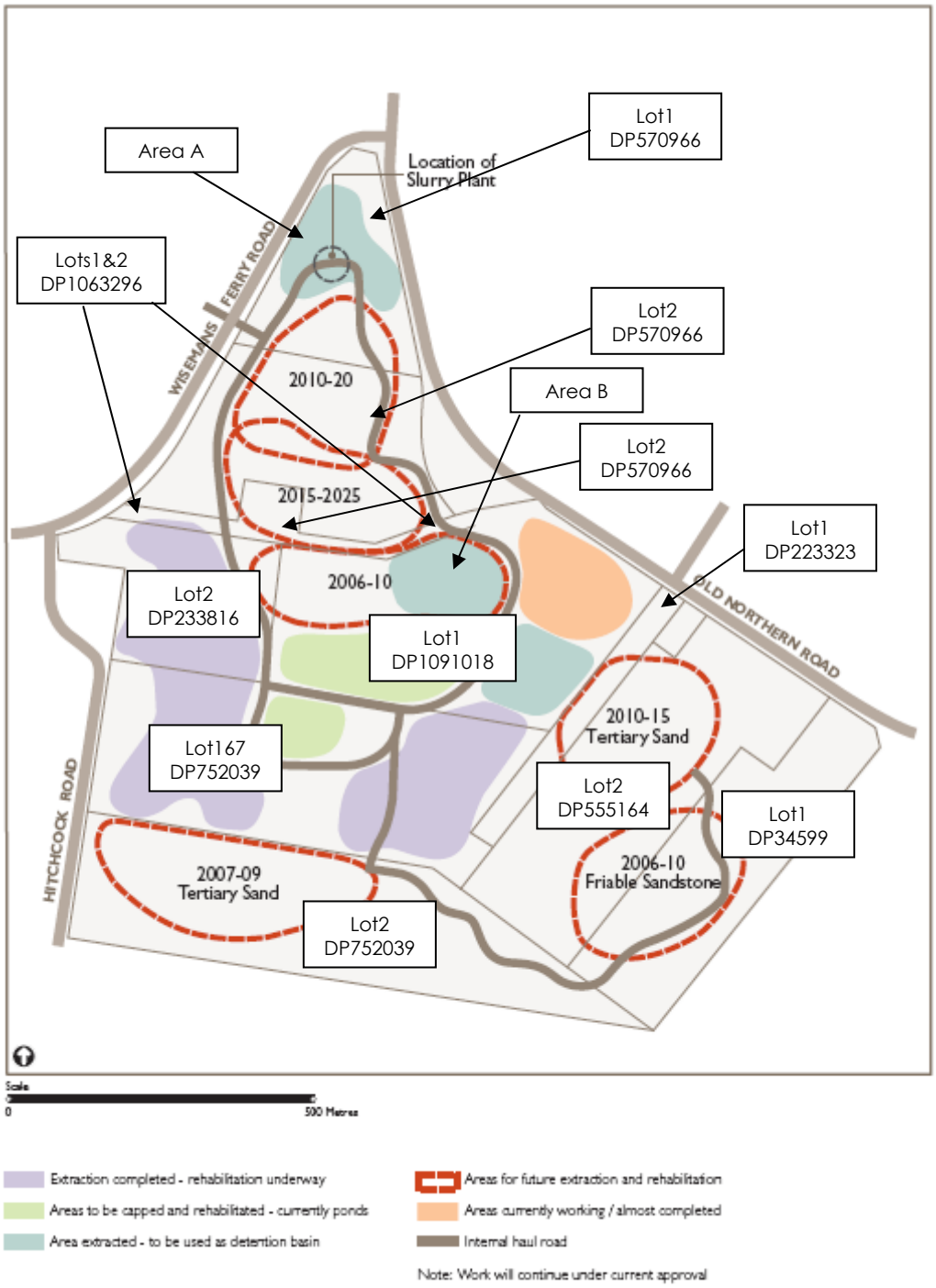

Figure 6: Phasing of extraction

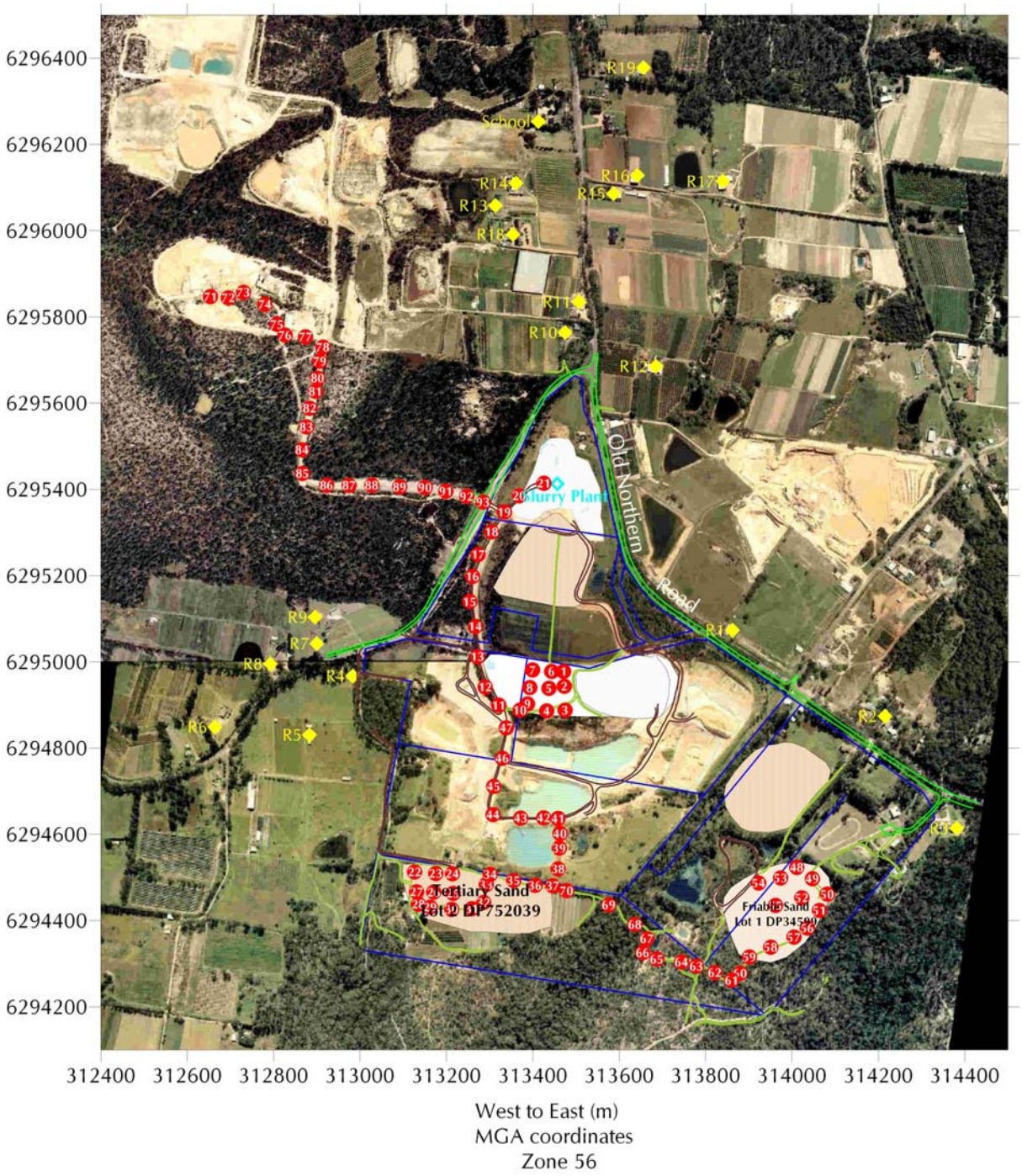

Figure 7: Phase 1 source locations

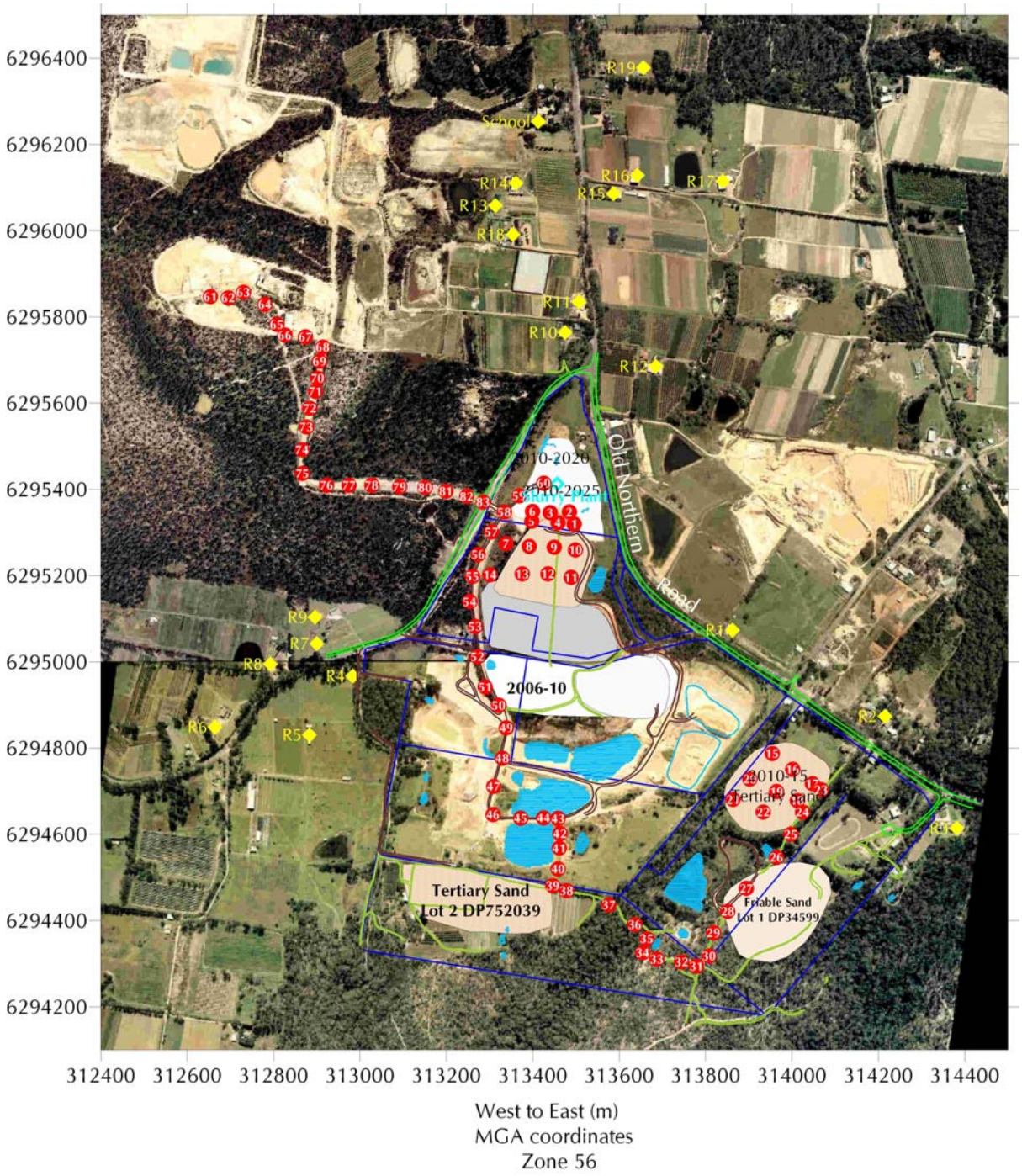

Figure 8: Phase 2 source locations

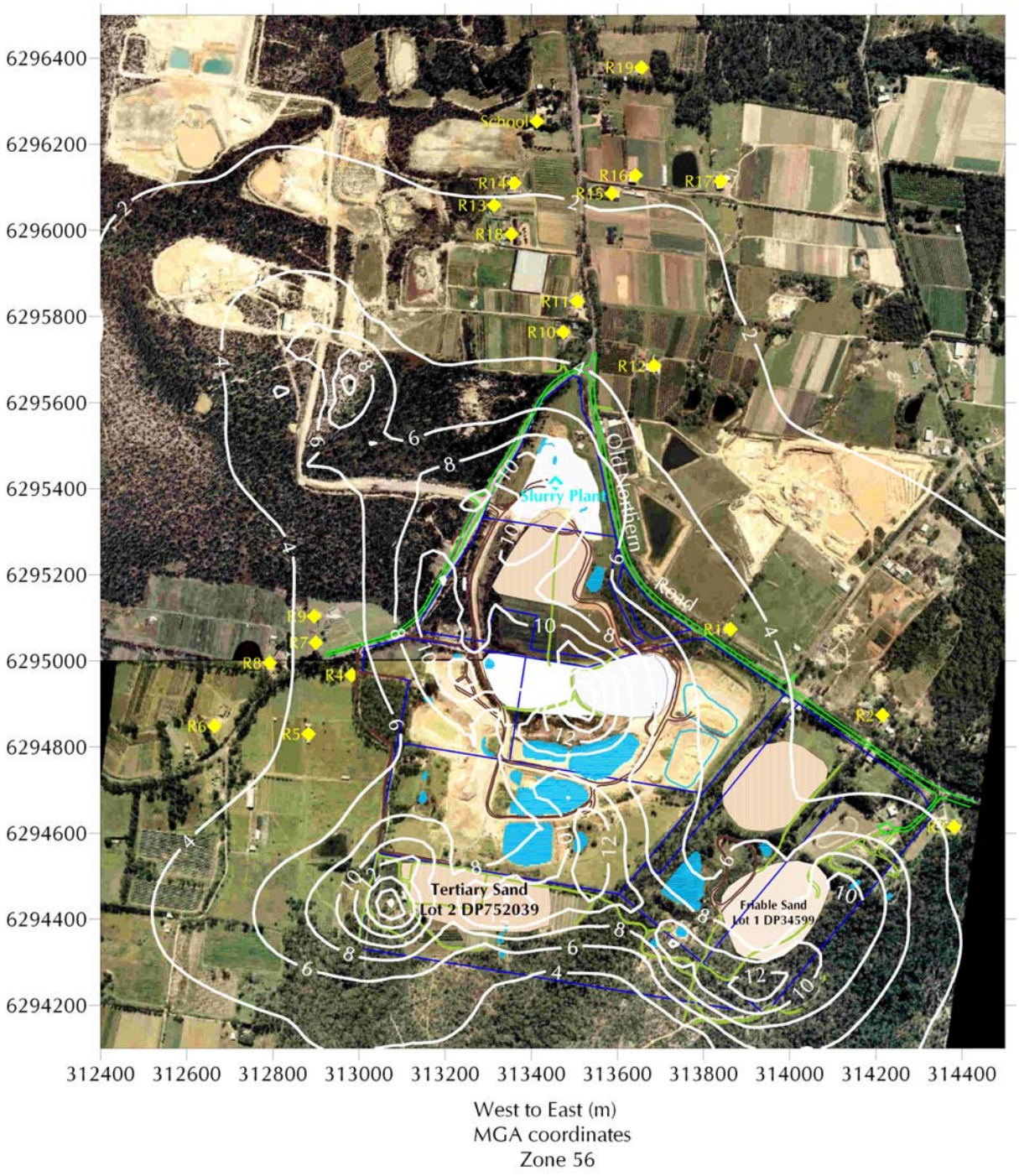

Figure 9: Phase 1 – average extraction rate – predicted maximum 24-hour average PM_{10} concentrations ($\mu g/m^3$)

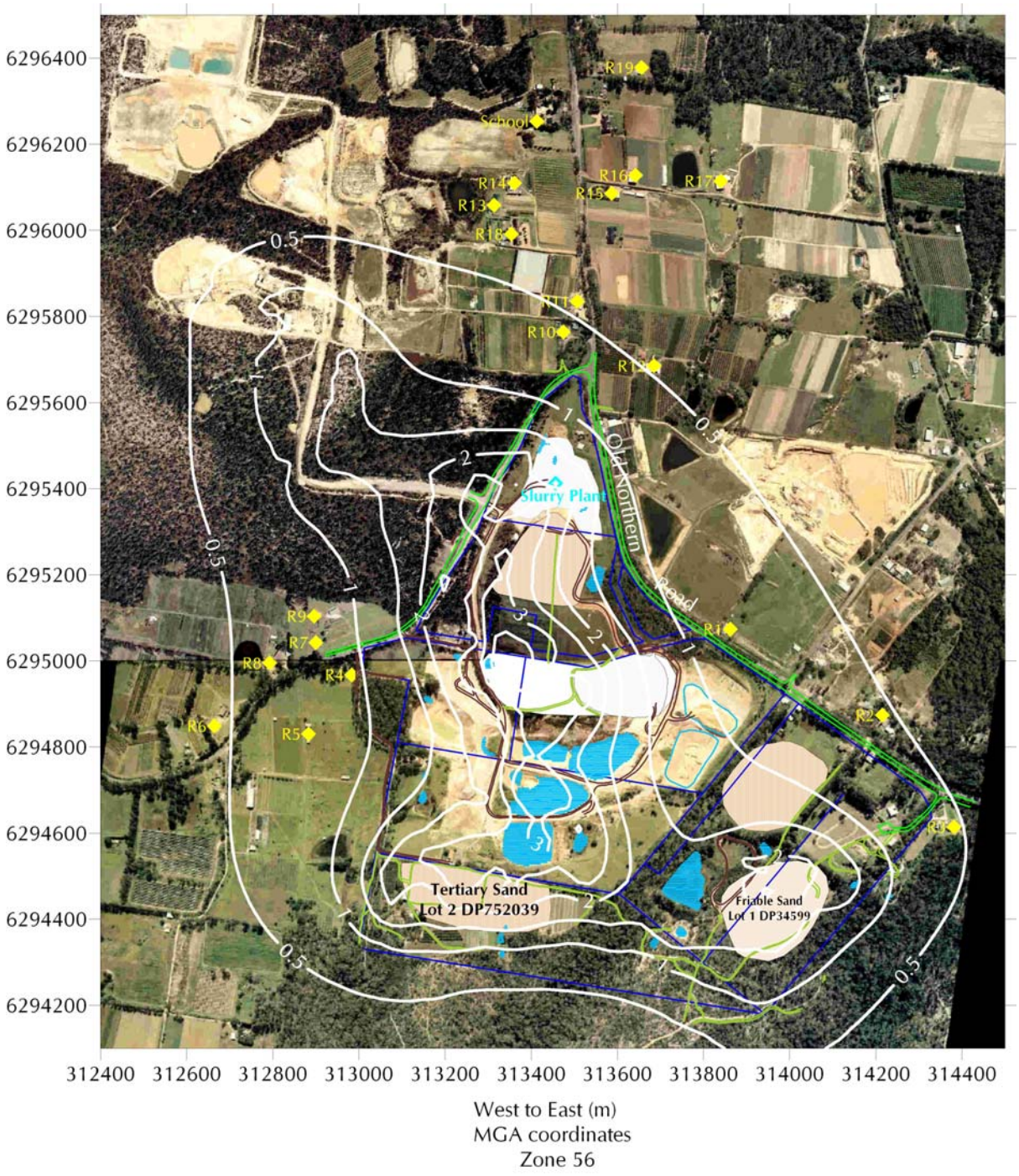

Figure 10: Phase 1 – average extraction rate – predicted annual average PM_{10} concentrations ($\mu g/m^3$)

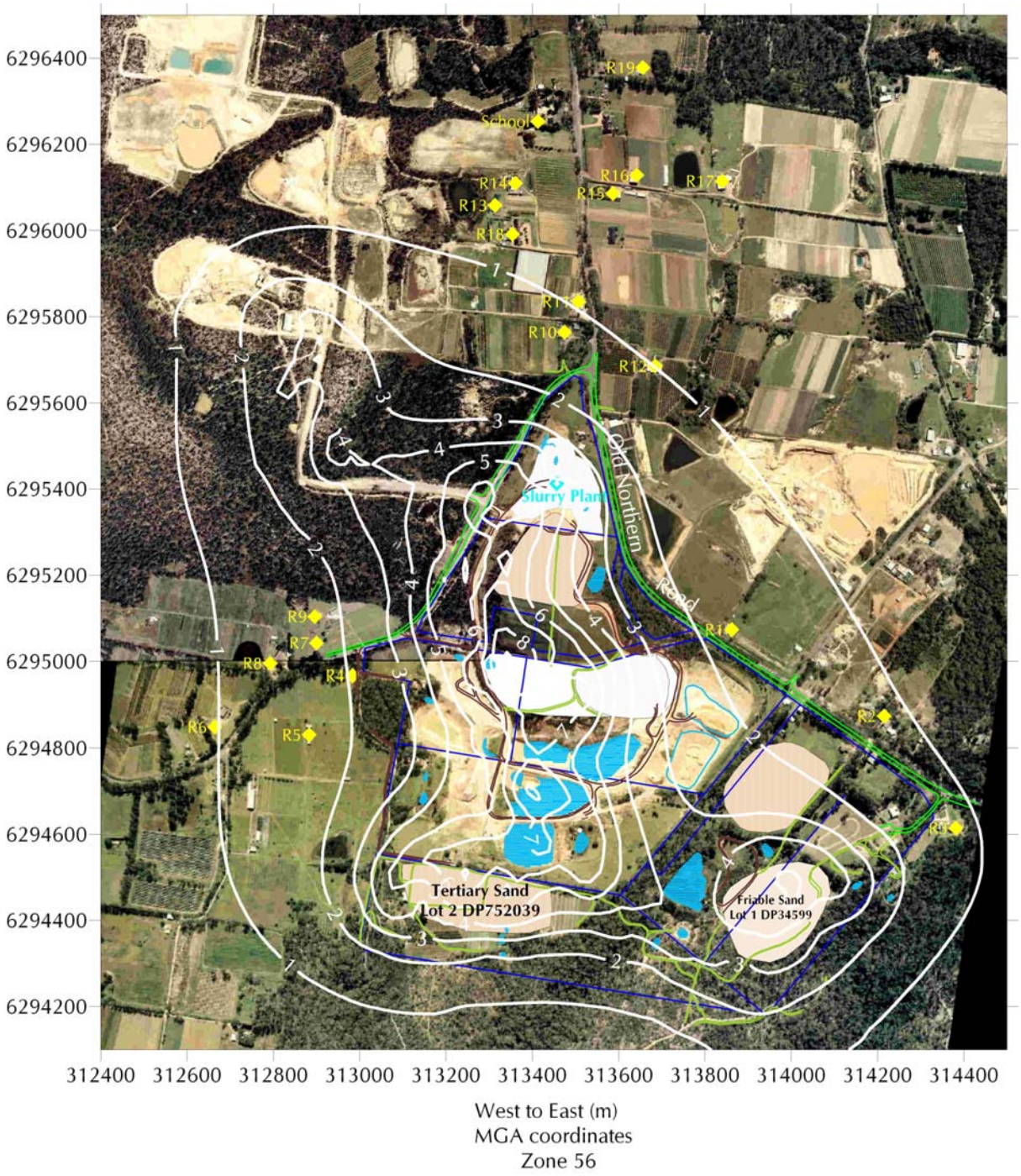

Figure 11: Phase 1 – average extraction rate – predicted annual average TSP concentrations (μg/m³)

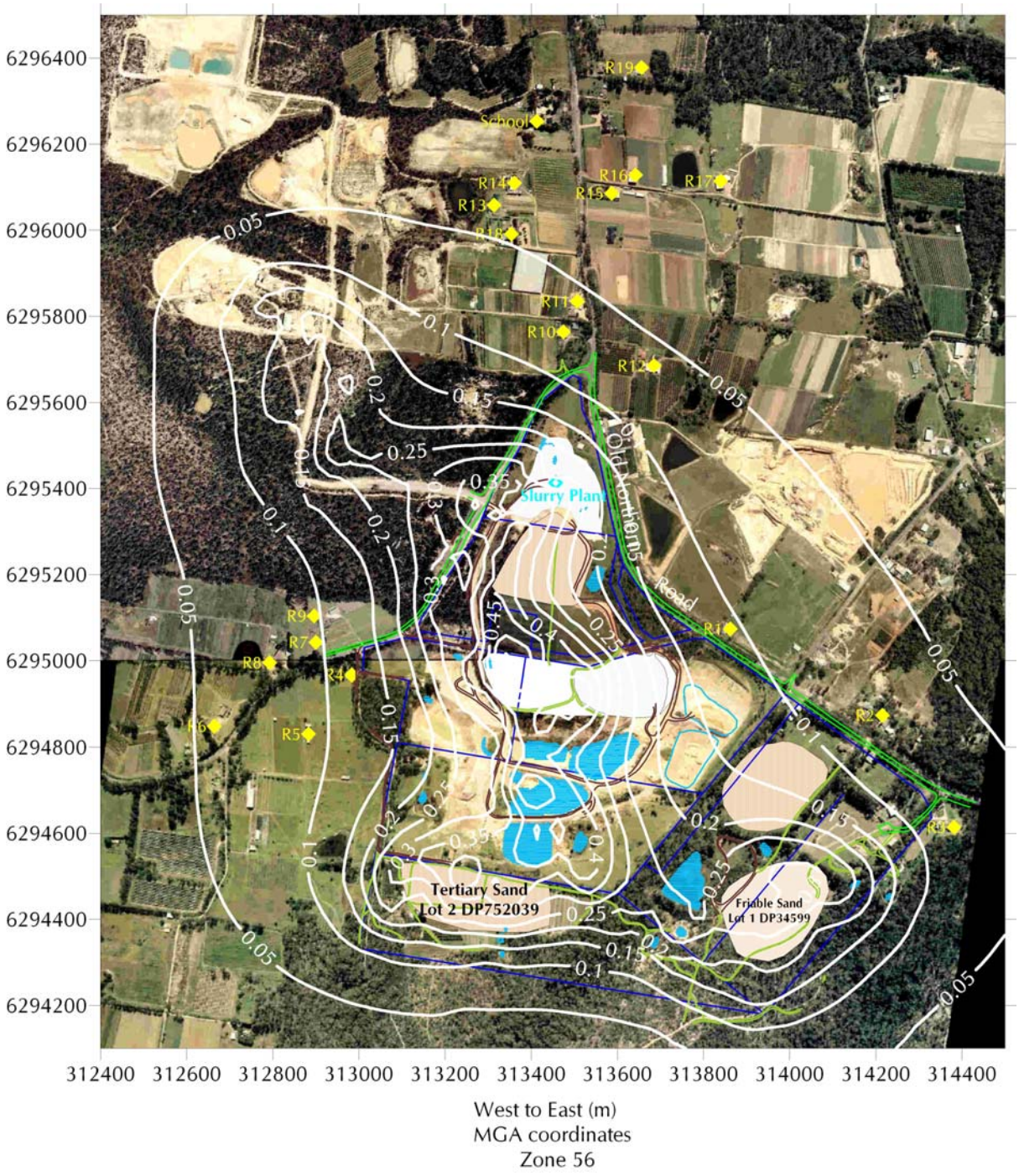

Figure 12: Phase 1 – average extraction rate – predicted annual average dust deposition levels (g/m²/month)

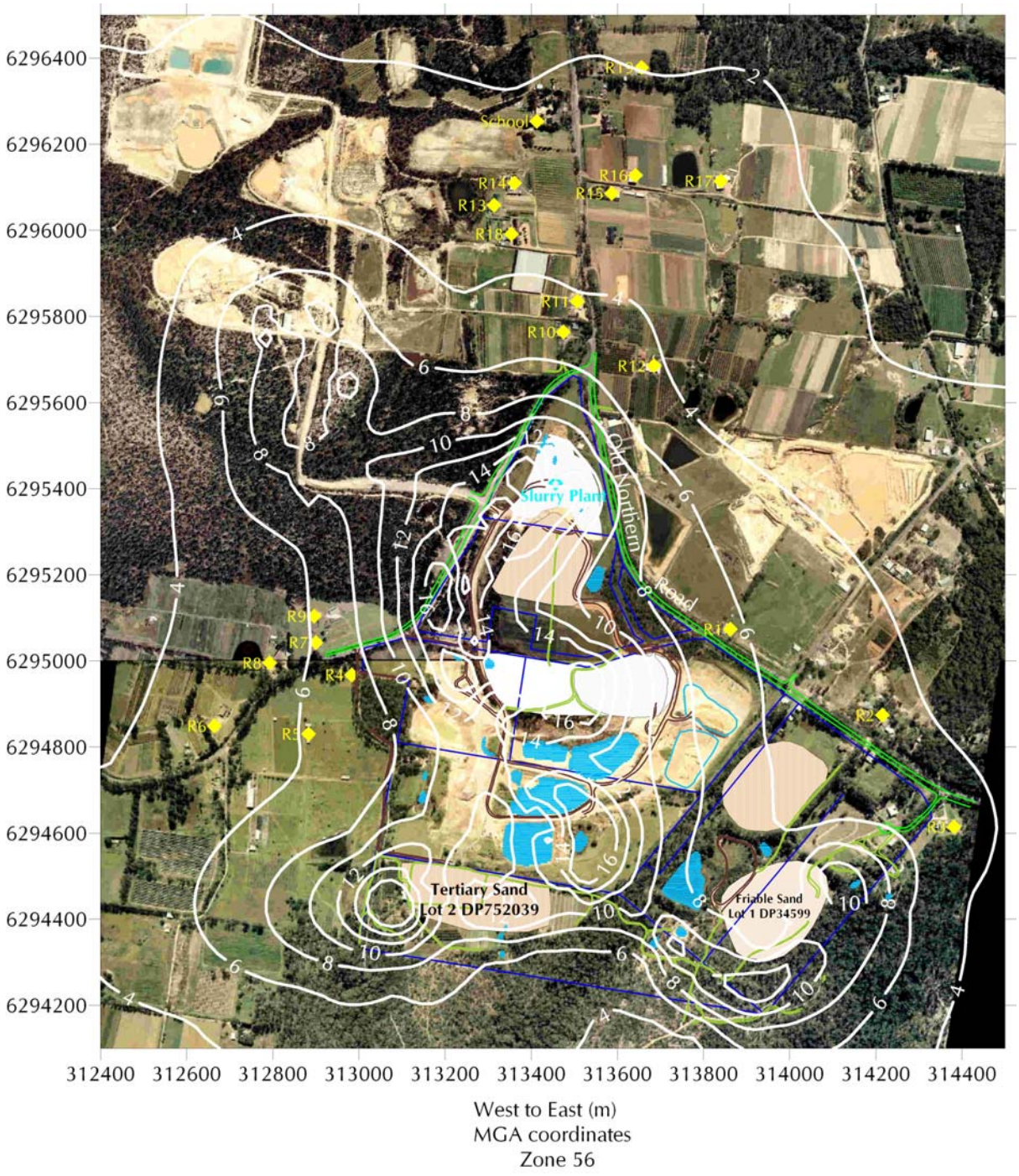

Figure 13: Phase 1 – maximum extraction rate – predicted maximum 24-hour average PM_{10} concentrations ($\mu g/m^3$)

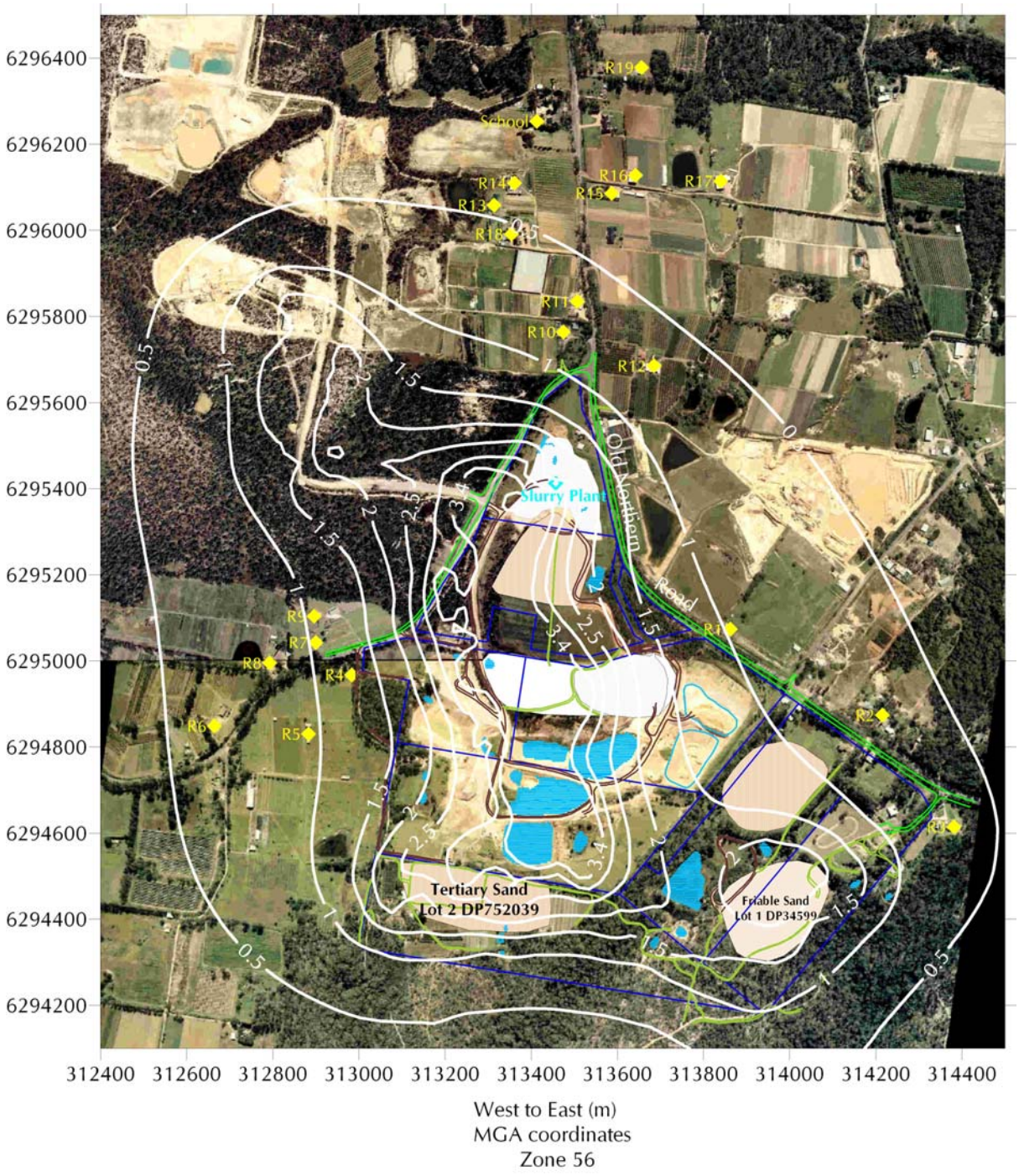

Figure 14: Phase 1 – maximum extraction rate – predicted annual average PM_{10} concentrations ($\mu g/m^3$)

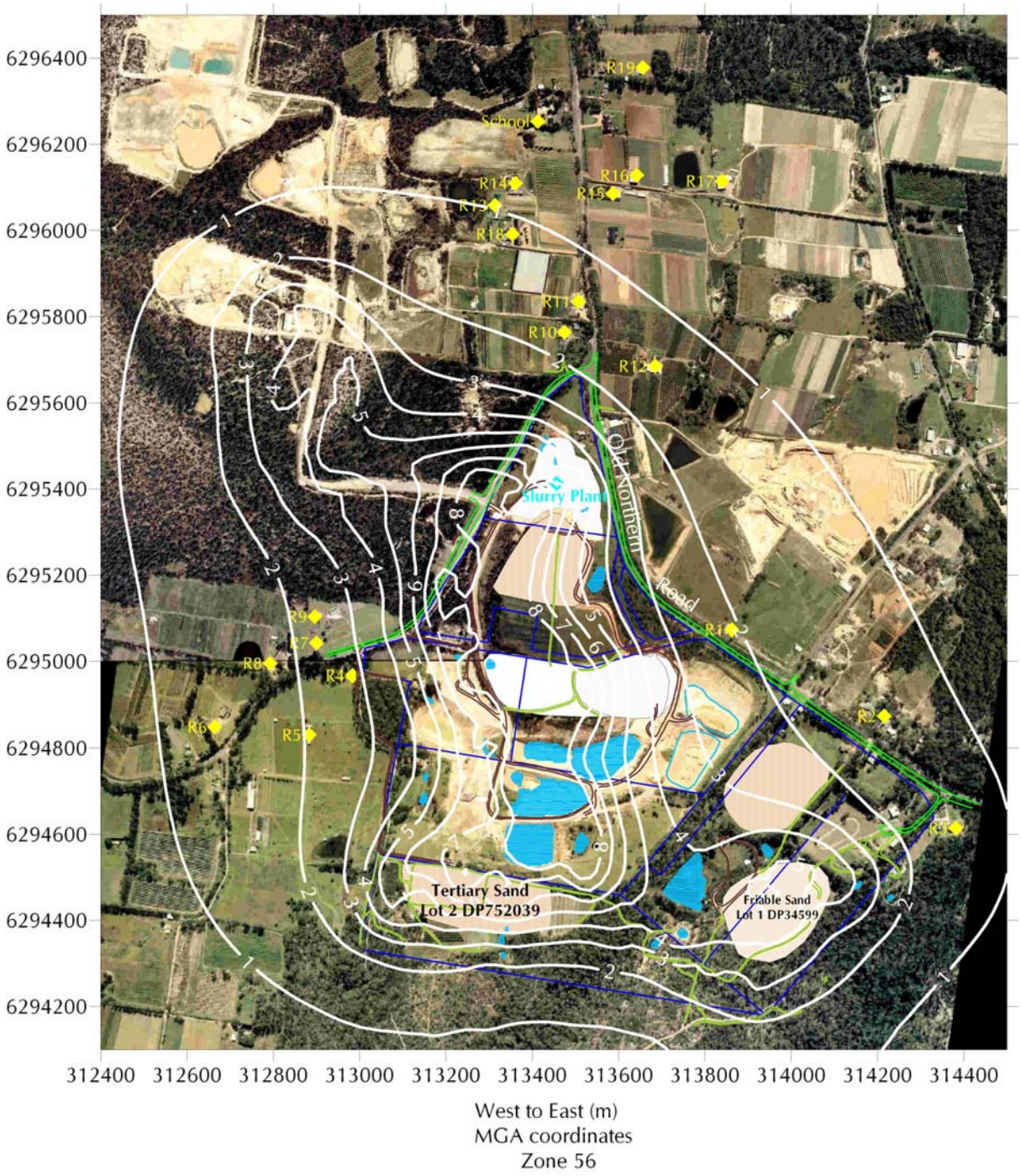

Figure 15: Phase 1 – maximum extraction rate – predicted annual average TSP concentrations (μg/m³)

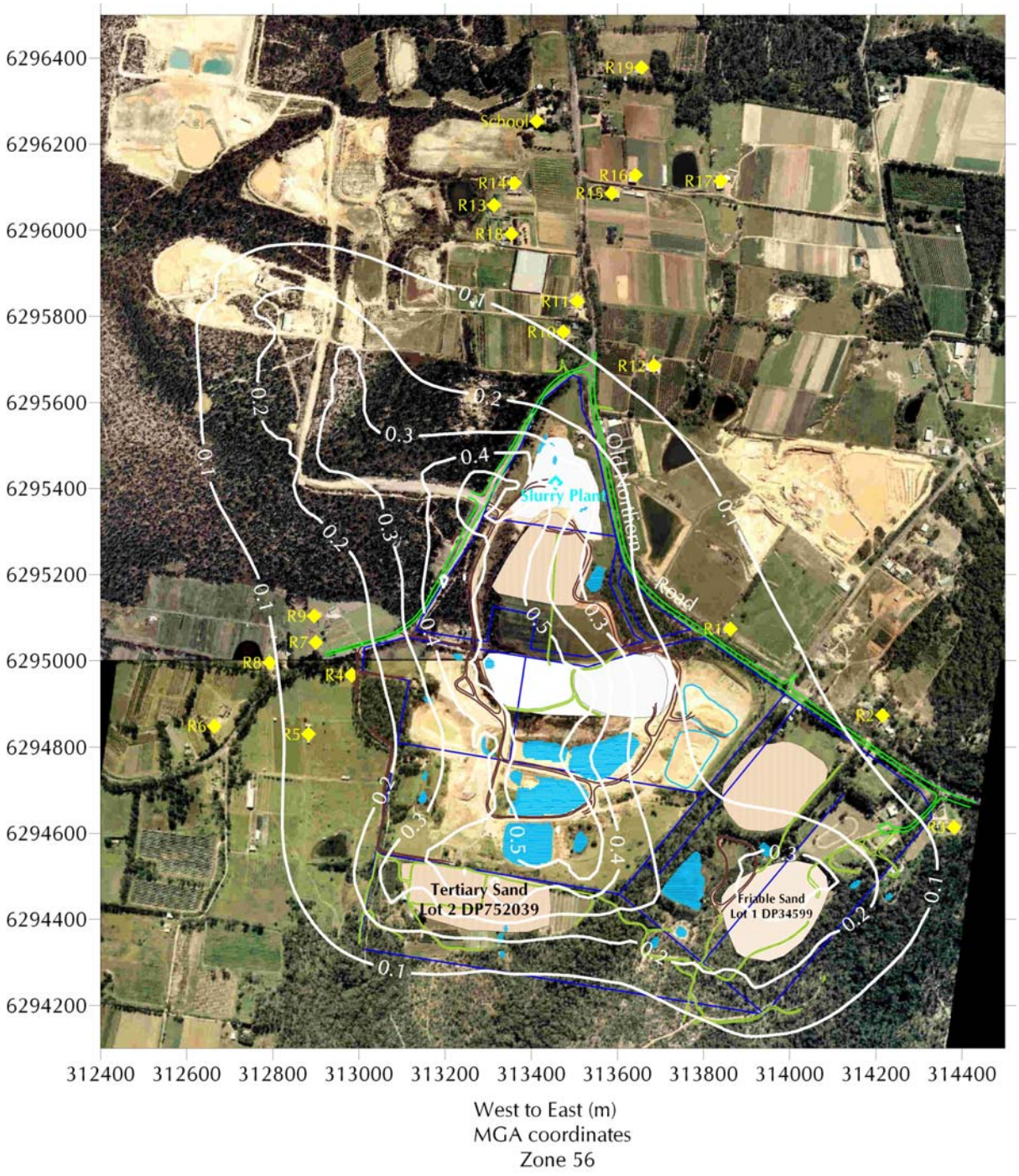

Figure 16: Phase 1 – maximum extraction rate – predicted annual average dust deposition levels (g/m²/month)

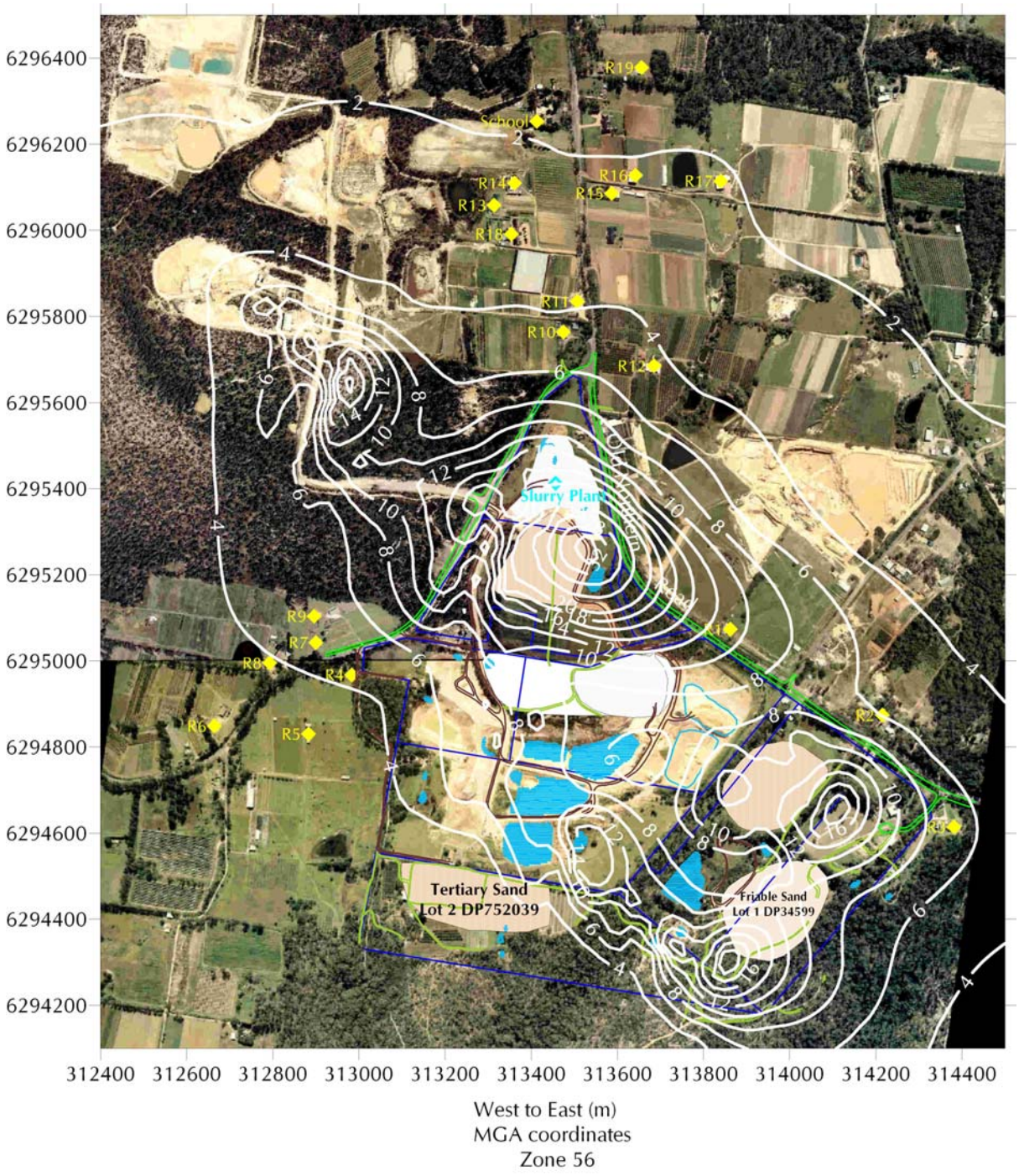

Figure 17: Phase 2 – average extraction rate – predicted maximum 24-hour average PM_{10} concentrations (μg/m³)

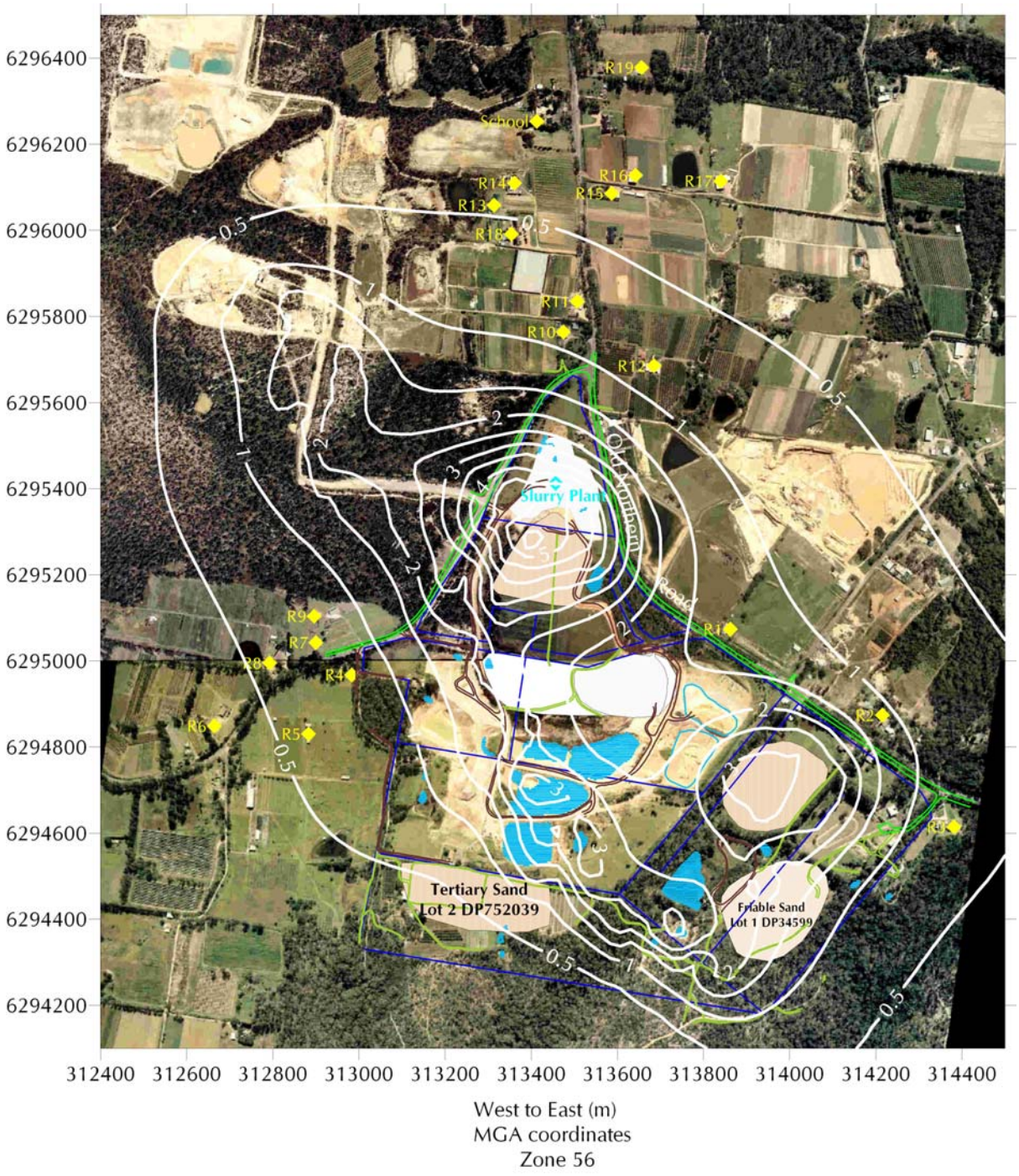

Figure 18: Phase 2 – average extraction rate – predicted annual average PM_{10} concentrations ($\mu g/m^3$)

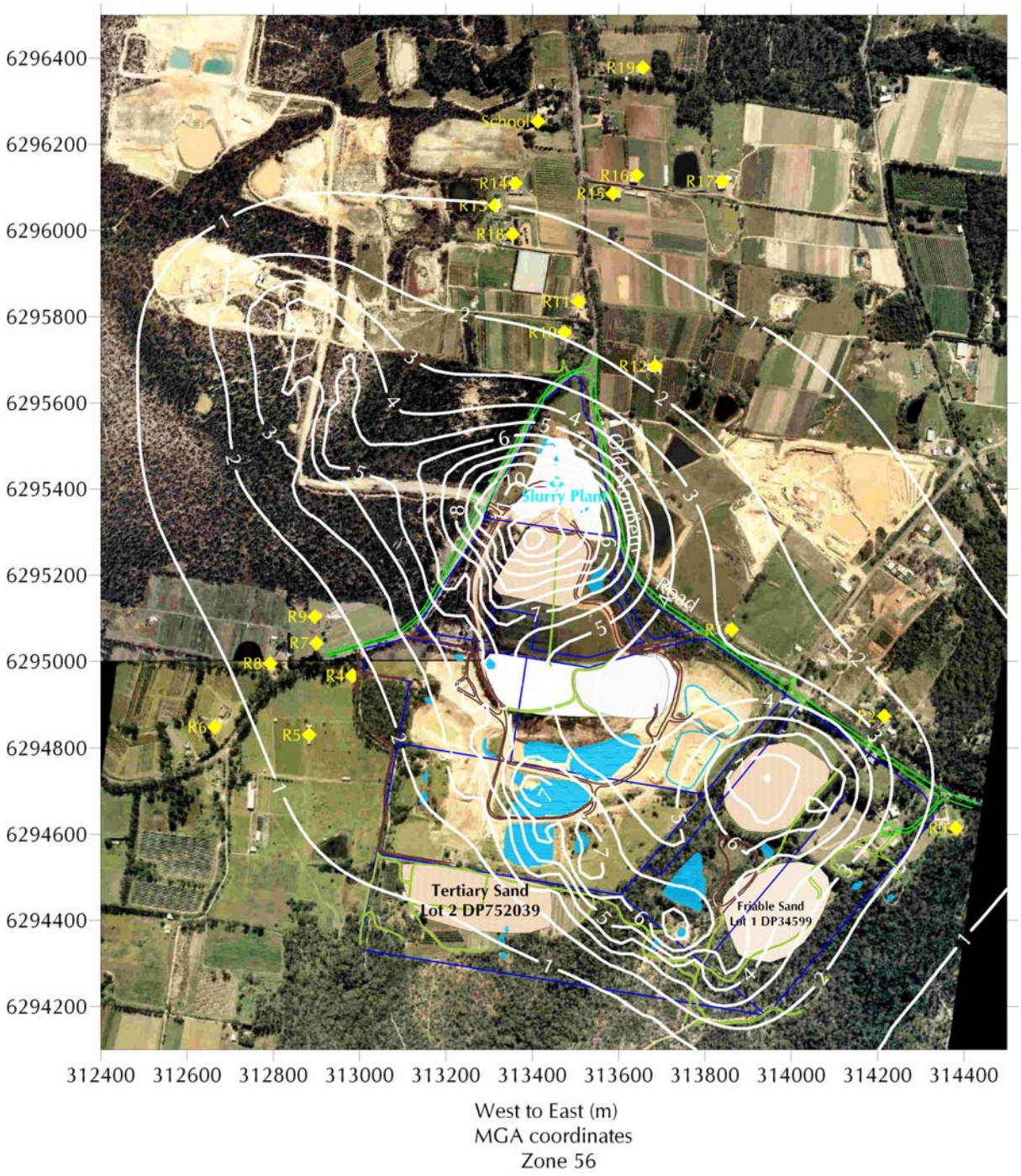

Figure 19: Phase 2 – average extraction rate – predicted annual average TSP concentrations (μg/m³)

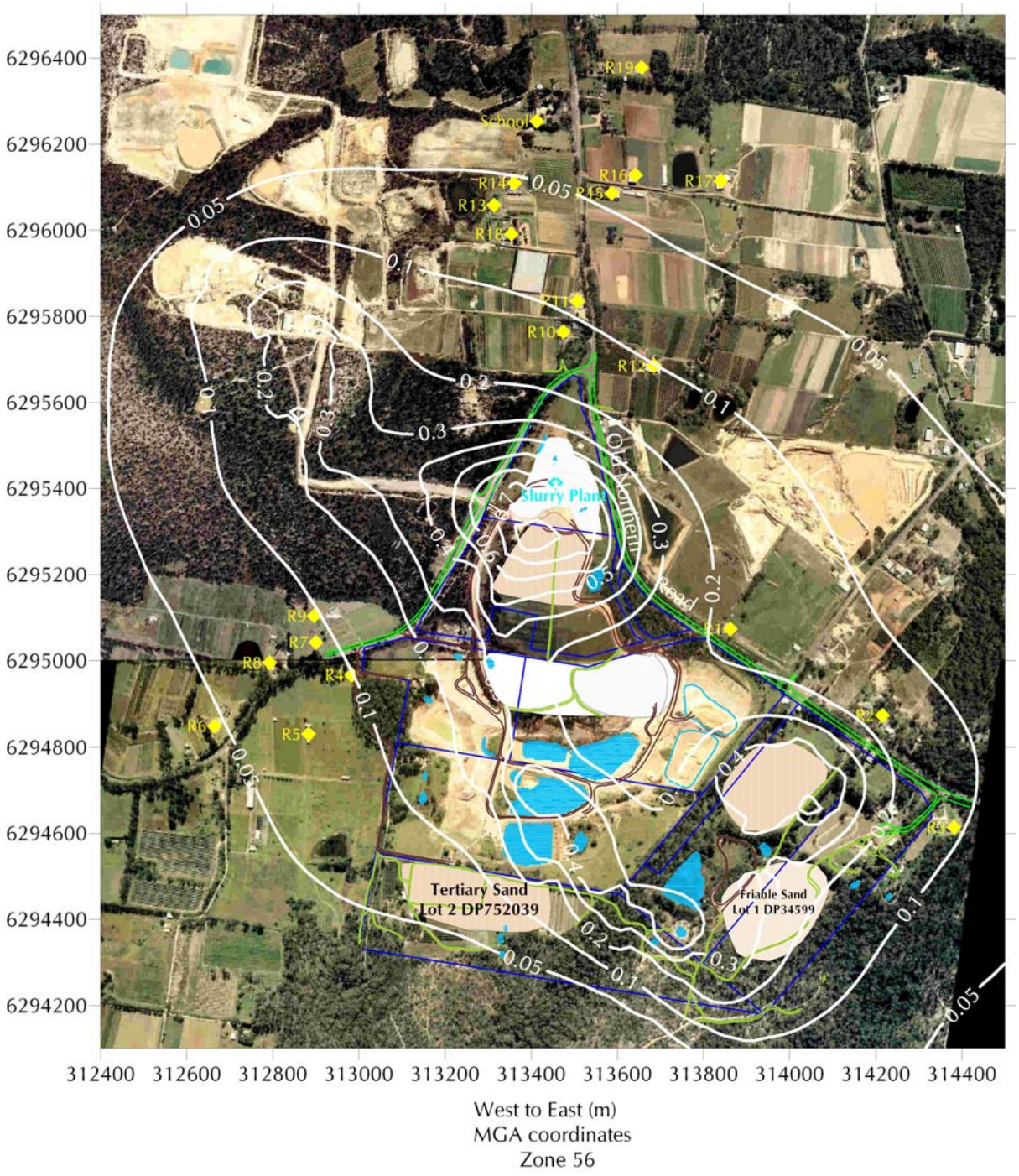

Figure 20: Phase 2 – average extraction rate – predicted annual average dust deposition levels (g/m²/month)

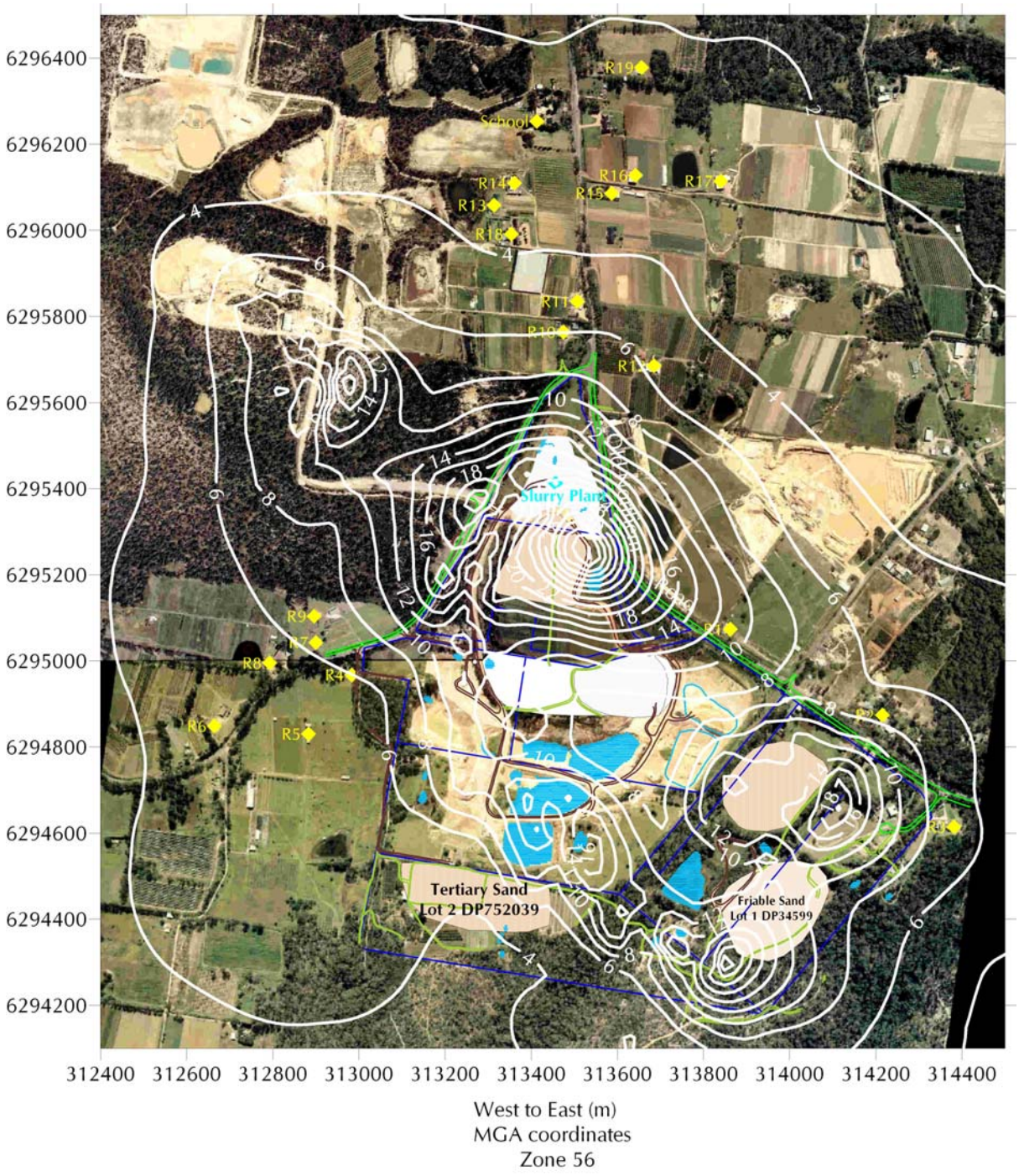

Figure 21: Phase 2 – maximum extraction rate – predicted maximum 24-hour average PM_{10} concentrations (μg/m³)

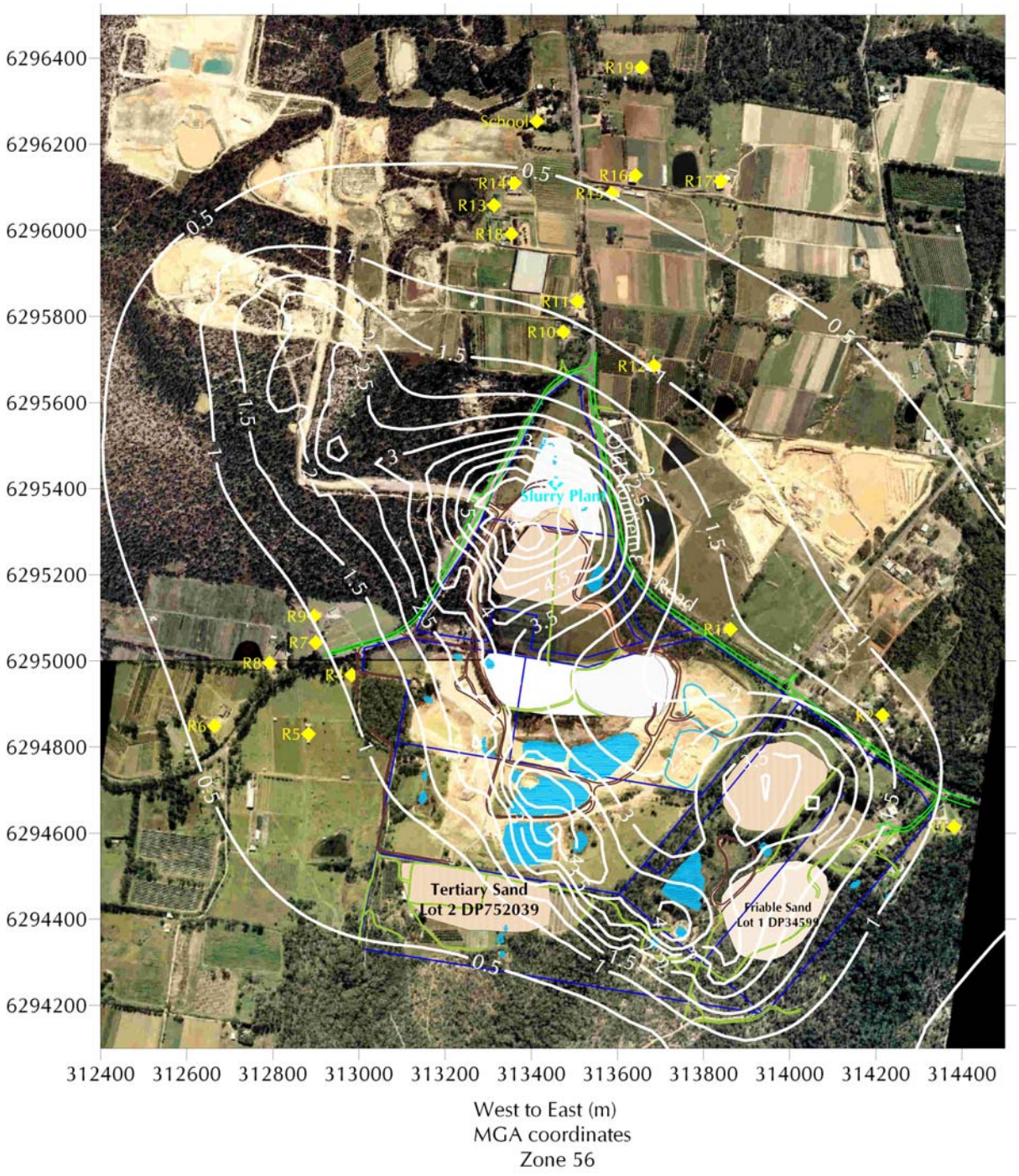

Figure 22: Phase 2 – maximum extraction rate – predicted annual average PM_{10} concentrations (μg/m³)

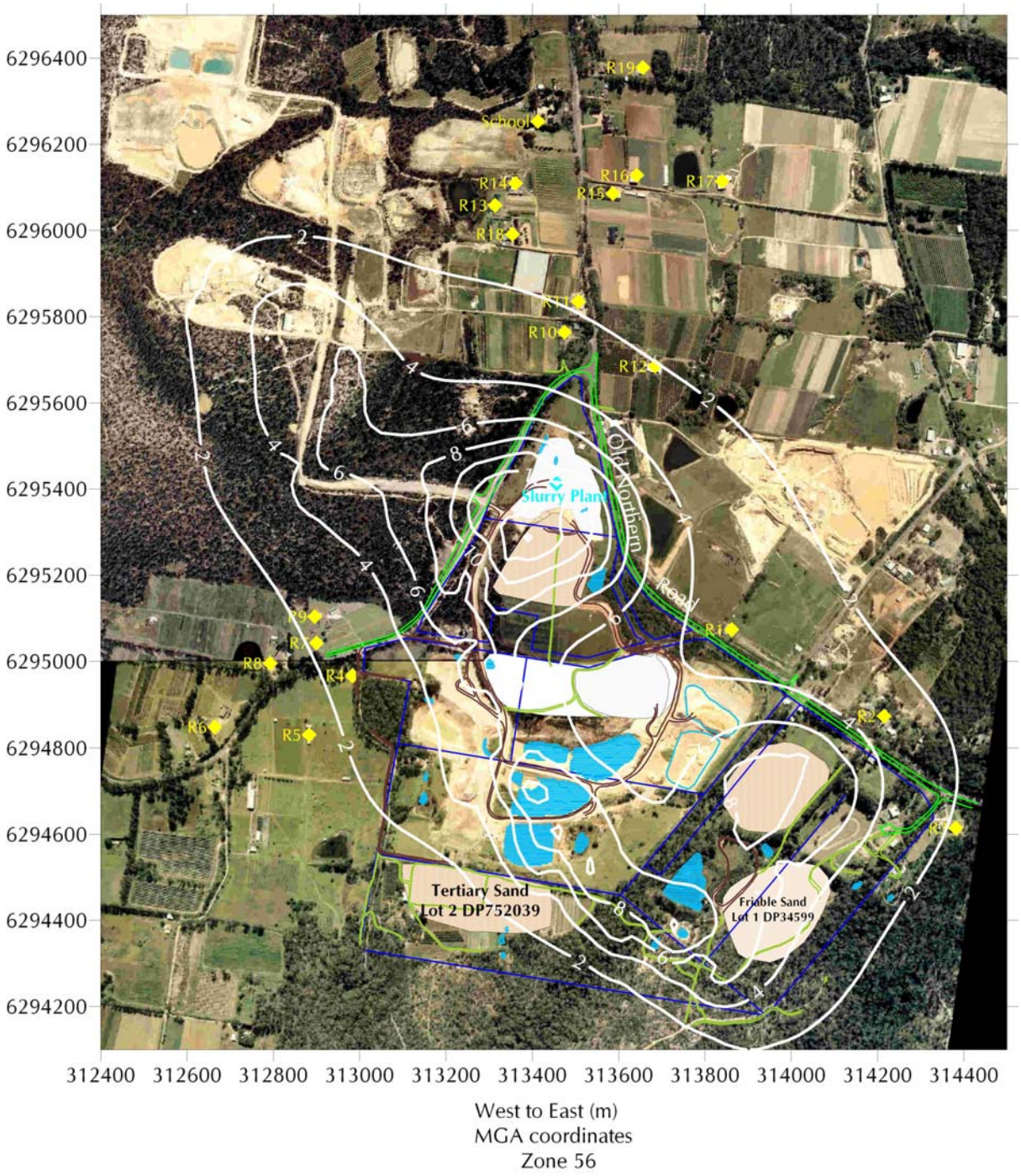

Figure 23: Phase 2 – maximum extraction rate – predicted annual average TSP concentrations (μg/m³)

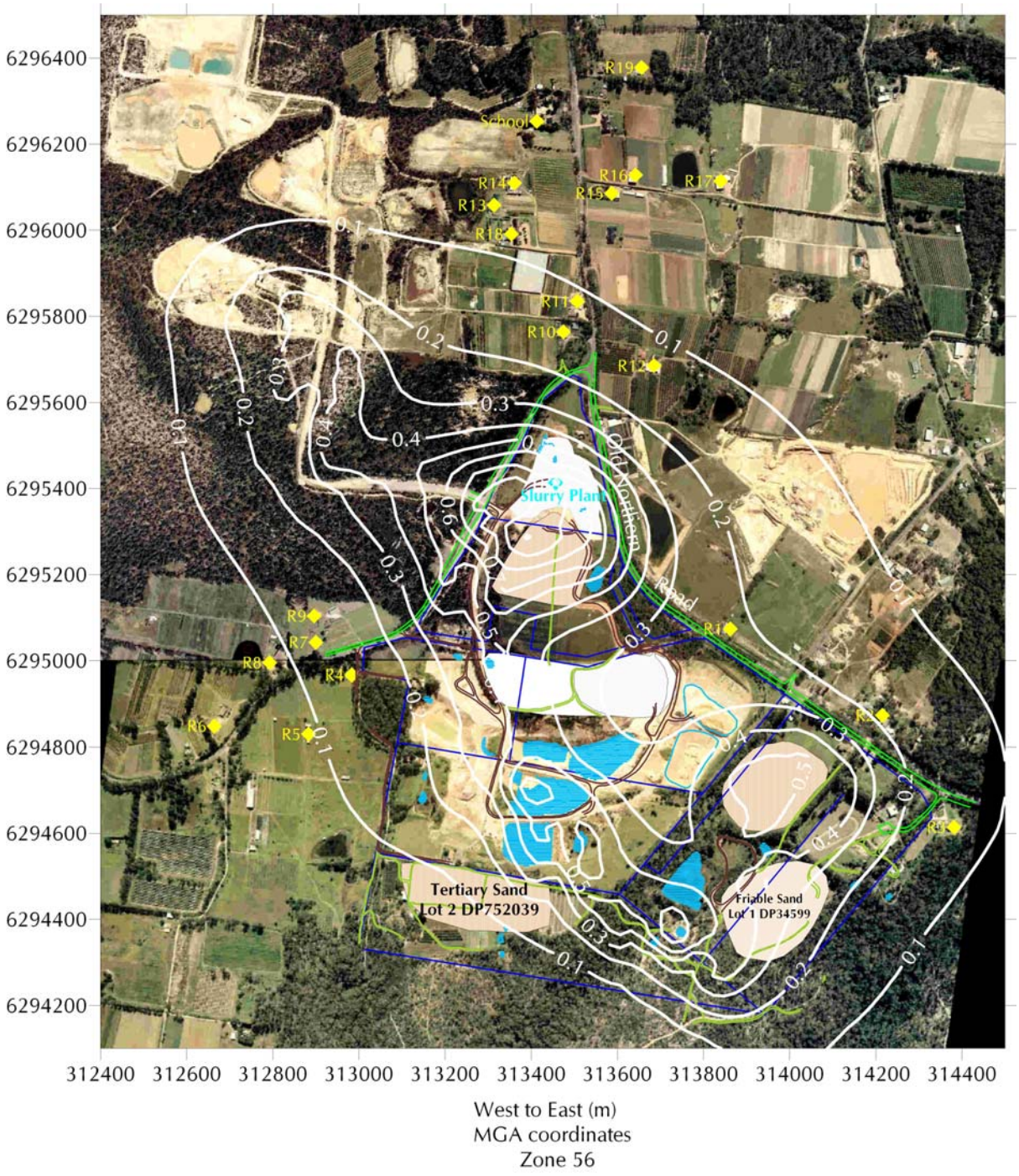

Figure 24: Phase 2 – maximum extraction rate – predicted annual average dust deposition levels (g/m²/month)

6

TECHNICAL PAPER

FLORA AND FAUNA

Flora and Fauna Assessment of the Sand Extraction and Rehabilitation Project at Hitchcock Road, Maroota

November 2007

PF Formation

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Date: ..... 12 November 2007

Distribution: ..... PF Formation, DFA Consultants, PB File

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Acronyms and Abbreviations

EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
TSC Act	*Threatened Species Conservation Act 1995*
EP&A Act	*Environmental Planning and Assessment Act 1979*
EA	Environmental Assessment
DECC	NSW Department of Environment and Climate Change (formerly the Department of Environment and Conservation)
DEW	Commonwealth Department of the Environment and Water Resources (formerly the Department of the Environment and Heritage)
LGA	Local Government Area
LEP	Local Environment Plan
SEPP	State Environmental Planning Policy
ROTAP	Rare or Threatened Australian Plant

Executive Summary

Parsons Brinckerhoff was commissioned by DFA Consultants to carry out a flora and fauna assessment as part of an environmental assessment for the proposed sand extraction and rehabilitation project at Hitchcock Road, Maroota. This assessment considered environmental legislation including the New South Wales Environmental Planning and Assessment Act 1979 and Threatened Species Conservation Act 1995, and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

A total of five vegetation communities occurred on site, including Shale Sandstone Transition Forest, Sydney Sandstone Gully Forest, Sydney Sandstone Ridgetop Woodland, regrowth vegetation and cleared areas. The condition of the Shale Sandstone Transition Forest was moderate, while the Sydney Sandstone Gully Forest and Sydney Sandstone Ridgetop Woodland were in good condition. The regrowth vegetation and cleared areas were in moderate and poor condition, respectively. Two threatened species of plant, Tetratheca glandulosa *and* Grevillea parviflora *were recorded during detailed surveys of the study area.*

Fauna habitats in the Sydney Sandstone Gully Forest were generally in good condition, while those in the Shale Sandstone Transition Forest and Sydney Sandstone Ridgetop Woodland were moderate. The regrowth vegetation and the cleared areas contained fauna habitats in poor condition. The threatened Glossy Black-cockatoo was recorded on site. However, this species would likely only use the site for foraging area and would not be dependent on the site's habitat resources.

The proposal includes an extension of existing sand extraction within the site and involves the removal of approximately 10.6 hectares of native vegetation. Haulage of sand will be along existing tracks and there will be only a minor need for further clearing of vegetation for this component of the project. The site is already the subject of sand mining activities and the proposed expansion is unlikely to increase disturbances such as noise or changes in groundwater.

Impact assessments as required under the Threatened Species Conservation Act 1995 and Environment Protection and Biodiversity Conservation Act 1999 were carried out for Shale Sandstone Transition Forest (an Endangered Ecological Community), Glossy Black-cockatoo, Brown Treecreeper, two threatened species of plant, five microchiropteran bats and nocturnal birds. These assessments concluded that the proposed sand mine extraction and rehabilitation is unlikely to have a significant impact on threatened biodiversity.

Overall, with the implementation of appropriate mitigation measures, the proposed mine expansion would be unlikely to have a significant impact on terrestrial biodiversity.

1. Introduction

1.1 Study Area and Project Background

Parsons Brinckerhoff was commissioned by DFA Consultants to carry out a flora and fauna assessment of the sand extraction and rehabilitation project at Hitchcock Road, Maroota. The purpose of this assessment was to determine the existing natural environment and likely impacts of the proposed sand extraction on plants and animals of the area, and in particular, threatened species listed under the *Threatened Species Conservation Act 1995 (TSC Act)* and *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).*

The site is located immediately to the south of the intersection of Old Northern Road and Wisemans Ferry Road, approximately eight kilometres south of Wisemans Ferry (*Figure 1*) and covers 93 hectares. It is within the Maroota sector of *Sydney Regional Environment Plan No 9-Extractive Industry (No 2)* and is zoned Rural 1(b) under the Baulkham Hills Local Environment Plan 1991. The area is within the Sydney Basin bioregion (Thackway and Creswell, 1995) and the Central Coast botanical subdivision (Anderson 1961, 1968).

The site is subject to current sand extraction activities that were the subject of an Environmental Impact Statement in 1996 and contains an Endangered Ecological Community (Shale Sandstone Transition Forest) adjacent to the former Maroota Trigonometrical Reserve, which was previously excluded from the area to be extracted.

The proposal includes a more extensive area of extraction within the same site boundary (*Figure 1*), including four new areas. Sand would be extracted to a maximum depth of 183 metres AHD. Extracted sand would be transported to the existing wash plant on Lot 198 approximately one kilometre to the north-west of the site. Access routes are in place and have been upgraded for heavy vehicles. No additional extraction of groundwater would be necessary for the processing of extracted sand.

The proposal involves excavation of four pits covering approximately 35 hectares. Approximately 10.6 hectares of this area is covered by native vegetation. Cleared vegetation would be placed under the stockpile of excavated material within the immediate vicinity of the sand extraction area, allowing the indigenous seed to exist in the underground seed bank. The previously excavated areas adjacent to the proposed sand extraction areas would be rehabilitated by returning the contours of the area to those shown in the rehabilitation plan. Slopes in these areas would be revegetated with indigenous native plants.

The final landform will comprise two large, gently sloping bowls with slopes defining their boundaries. Smaller pits would be excavated in the southern and eastern part of the site and subsequently rehabilitated. Where slopes are too steep for subsequent agricultural use they would be planted with local native species and allowed to regenerate.

Rehabilitation would continue as before in the proposed expansion and would take place in a number of stages phased over the life of the project. These would include the construction of peripheral mounds (mostly complete), the drying and capping of the sediment ponds (this can take a number of years), the formation of the batter slopes and the planting and maintenance of native species on the batters and along drainage lines.

1.2 Aims

The draft *Guidelines for Threatened Species Assessment under Part 3A* (Department of Environment and Conservation 2005b) state that the objective of the assessment process under Part 3A is to provide information to enable decision-makers to ensure that developments deliver the following environmental outcomes:

- maintain or improve biodiversity values (i.e. there is no net impact on threatened species or native vegetation)
- conserve biological diversity and promote ecologically sustainable development
- protect areas of high conservation value (including areas of critical habitat)
- prevent the extinction of threatened species
- protect the long-term viability of local populations of a species, population or ecological community
- protect aspects of the environment that are Matters of National Environmental Significance.

With these objectives in mind, the aims of this technical paper are to:

- determine and describe the characteristics and condition of the vegetation communities and flora and fauna habitats within the study area
- determine the occurrence, or likelihood of occurrence, of Threatened biodiversity listed under the *Threatened Species Conservation Act 1995, Fisheries Management Act 1994* and *Environment Protection and Biodiversity Conservation Act 1999* within the study area
- undertake significance impact assessments for Threatened biodiversity that occur or are considered likely to occur within the study area in accordance with the heads of consideration outlined in *Draft guidelines for Threatened species assessment under Part 3A* (Department of Environment and Conservation 2005b) and the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of the Environment and Heritage 2006)
- determine likely impacts of the proposed sand extraction on flora and fauna
- propose further investigations and/or amelioration measures to mitigate impacts on the ecological values of the study area.

2. Legislation and Policies

The project is being assessed under Part 3A of the *Environmental Planning and Assessment Act 1979.* Part 3A consolidates the assessment and approval regime for major projects addressed previously under Part 4 or Part 5 (Environmental Assessment) of the *Environmental Planning and Assessment Act 1979.*

Commonwealth and state legislation and planning policies relevant to the protection of flora, fauna and biodiversity include:

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Threatened Species Conservation Act 1995*
- *Fisheries Management Act 1994*
- *National Parks and Wildlife Act 1974*
- *Water Management Act 2000 and Rivers and Foreshores Improvement Act 1948.*

Proposals approved under Part 3A are not required to obtain a number of authorisations under other statutory instruments relating to biodiversity and conservation including:

- permits under the *Fisheries Management Act 1994* to dredge or undertake reclamation works (s.201), harm marine vegetation including mangroves (s.205) or block fish passage (s.219)
- authorisation to clear native vegetation under the *Native Vegetation Act 2003* (s.12)
- permits under Part 3A of the *Rivers and Foreshores Improvement Act 1948* to undertake works within 40 metres from the top of the bank or shore of protected waters

Although these authorisations are not required in addition to approval under Part 3A of the *Environmental Planning and Assessment Act 1979*, consideration should still be given to their intent.

3. Methods

The flora and fauna assessment included both desk-based searches of standard databases and field surveys as described below. Initial assessment of the site was completed in 2004. Following a change in the project boundary, the project was reassessed in 2007.

3.1 Personnel

Names and qualifications of team members undertaking the field studies and preparing the report are shown in *Table 3-1*.

Table 3-1 Personnel Involved in the Field Studies and Report Preparation

Name	Qualifications	Years Experience	Role
Selga Harrington	BSc(Hons)	7	Ecologist/ Botanist
Alex Fraser	BSc(Hons)	2	Ecologist/ Zoologist
Martin Predavec	BSC (Hons), PhD	17	Project review

All work was carried out under the appropriate licences including a scientific licence as required under Clause 22 of the National Parks and Wildlife Regulations 2002 and Section 132C of the *National Parks and Wildlife Act 1974* as well as an animal research authority issued by the Department of Primary Industries (Agriculture).

3.2 Nomenclature

Names of plants used in this document follow Harden (Harden 1992, 1993, 2000, 2002) with updates from PlantNet (Royal Botanic Gardens 2006). Scientific names are used in this report for species of plant. Scientific and common names (where available) are provided in plant lists in Appendix B and D.

Names of vegetation communities used in this report are based on the dominant species and structure of the community. Where practical the names follow those used in the existing vegetation mapping or Threatened community listings under the *Threatened Species Conservation Act 1995* and/or the *Environment Protection and Biodiversity Conservation Act 1999.*

Names of vertebrates follow the Census of Australian Vertebrates (CAVS) database maintained by the Department of Environment and Water Resources, formerly the Department of the Environment and Heritage (Department of Environment and Heritage 2004). Common names are used in the report for species of animal. Scientific names are included in species lists found in Appendix C and E.

3.3 Database Searches and Literature Reviews

Relevant and available documents were reviewed for information on surrounding land uses and the presence of vegetation communities and flora and fauna.

Records of threatened species of plant and animal were obtained from the Department of Environment and Climate Change (formerly the Department of Environment and Conservation) Atlas of NSW Wildlife for an area within 10 kilometre radius of the study site, using the Sydney, Penrith, St Albans and Gosford 1:100 000 map sheets (accessed 8th of October 2004 and updated in July 2006). Records for threatened species, populations and communities and migratory species listed on the *EPBC Act* that could potentially occur in the area were obtained from the Department of the Environment and Water Resources Protected Matters Search Tool (accessed 8th of October 2004 and updated in July 2006), again within a 10 kilometre radius of the study area. Details of the accuracy of each database are shown in *Appendix A*.

Other sources of information considered in the preparation of this report include:

- Royal Botanic Gardens PlantNet System
- Australian Museum's FaunaNet System
- aerial photographs
- topographic maps (Lower Portland 9031-2-S 1: 25,000)
- Vegetation mapping (Ryan *et al.* 1996)
- Relevant earlier studies including the earlier EIS prepared for both sites.

A site one kilometre to the north-west was investigated at the same time (Lot198) and is subject of a separate flora and fauna assessment. Where considered appropriate, data from these studies have been used to provide local context.

3.4 Survey

A detailed targeted survey for threatened species of plant and animal was carried out from the 11 to 14 October 2004. The weather was hot and dry with maximum daily temperatures ranging between 26 and 39 degrees Celsius. A habitat assessment of an additional property (DP 223323) was carried out on 13 July, 2006. During this visit the weather was cool and clear with a maximum temperature of 13 degrees.

All work was carried out under a Department of Environment and Climate Change Scientific Licence (S10445) and a New South Wales Department of Primary Industries Animal Research Authority (AW01/1380).

3.4.1 Flora

Flora surveys were conducted using both the random meander technique and transects to describe the condition of vegetation communities and identify threatened species.

The random meander technique as described by Cropper (1993) involves the area to be traversed in no set pattern while searching for plants. Generally species encountered were recorded, providing a species list of the area.

A detailed systematic field survey was done for threatened species of plant by systematically inspecting the vegetation along transects spaced approximately 10 metres apart. While conducting the survey, notes were made on vegetation structure, dominant canopy species, and common plant species in the area.

The survey also assessed the quality of vegetation using parameters such as intactness, diversity, history of disturbance, weed invasion and health.

Three categories were used to describe the condition of vegetation communities:

Good: Vegetation still retains the species complement and structural characteristics of the pre-European equivalent. Such vegetation has usually changed very little over time and displays resilience to weed invasion due to intact ground cover, shrub and canopy layers.

Moderate: Vegetation generally still retains its structural integrity but has been highly disturbed and has lost some component of its original species complement. Weed invasion can be significant in such remnants.

Poor: Vegetation that has lost most of its species and is significantly modified structurally. Often such areas now have a discontinuous canopy of the original tree cover, very few shrubs and exotic species, such as introduced pasture grasses or weeds, replacing much of the indigenous ground cover. Environmental weeds are often co-dominant with the original indigenous species. It can often be difficult to assign a vegetation type to such remnants as they are so species poor.

3.4.2 Fauna

3.4.2.1 Overall Approach

Fauna surveys in the study area included both general habitat based surveys and targeted surveys for threatened species of animal. While recording threatened species within survey results can confirm their presence in a study area, the lack of threatened species records cannot necessarily be used to argue for the absence of the species from the site when suitable habitat is present: by the very nature of their rarity, threatened species are often difficult to detect. Suitable habitat is therefore the most important factor to consider when determining the potential presence of threatened species.

The condition of fauna habitats were assessed by examining characteristics such as native vegetation, ground and litter layers, breeding, nesting, feeding and roosting resources and

evidence of fauna presence. The following categories were used to describe the condition of fauna habitats:

Good: Fauna habitat components are usually all present (for example, old-growth trees, fallen timber, feeding and roosting resources) and habitat linkages to other remnant ecosystems in the landscape are intact.

Moderate: Some fauna habitat components are often missing (for example, old-growth trees, fallen timber), although linkages with other remnant habitats in the landscape are usually intact, although often degraded.

Poor: Many fauna habitat elements in low quality remnants have been lost, including old-growth trees (for example, due to past timber harvesting or land clearing) and fallen timber, and tree canopies are often highly fragmented. Habitat linkages with other remnant ecosystems in the landscape have usually been severely compromised by extensive past clearing.

Species of animal present on the site were recorded opportunistically during the flora surveys, and included direct observations as well as indirect evidence such as identification of scats, tracks and other signs.

3.4.2.2 Targeted Surveys

Targeted surveys were used to supplement the habitat-based assessment and these are detailed below. The location of targeted surveys is shown in (Figure 2).

Call Playback Surveys

Call playback was used to survey for a range of nocturnal fauna using the methods of Kavanagh and Peake (1993) and Debus (1995). An initial listening period of 10 to 15 minutes was undertaken, followed by a spotlight search for 10 minutes to detect any animals in the immediate vicinity. The calls of the target species were then played intermittently for 5 minutes followed by a 10 minute listening period. After the calls were played, another 10 minutes of spotlighting and listening was conducted in the vicinity to check for birds attracted by the calls but not vocalising. Calls played during the survey included Powerful Owl (*Ninox strenua*), Barking Owl (*Ninox connivens*), Masked Owl (*Tyto novaehollandiae*) and Sooty Owl (*Tyto tenebricosa*).

Elliott trapping

Elliott trapping followed the Department of Primary Industries Director-General's Policy of Cage Trapping and the Animal Research Review Panel's 'Animal Care Guidelines for Wildlife Surveys'. Small ground-dwelling mammals were targeted using Elliott traps (Type A), positioned on the ground near the base of trees, within understorey vegetation, dead wood and rocky outcrops. In addition, tree-mounted Elliott traps (Type B) were placed on wooden platforms approximately three metres above the ground on large trees. A plastic bag was placed over the closed end of all traps in order to keep any captured animals dry and warm. Each trap was baited with a mixture of rolled oats, peanut butter and honey. A mixture of honey and water was sprayed onto the trunk of the tree above the tree-mounted Elliott traps.

A total of 25 ground traps (Elliott Type A) and 10 tree-mounted traps (Elliott Type B) were placed along a transect with the ground traps placed approximately 10 metres apart, and the tree-mounted traps approximately 30 metres apart. All traps remained open for three nights and were checked

each morning within two hours of sunrise. All captured animals were identified to species, sexed and released at the site of capture.

Spotlighting

Spotlighting for arboreal and ground-dwelling mammals and amphibians was undertaken on two non-consecutive nights at sites throughout the study area. Surveys were on foot using two handheld 100 watt spotlights. The speed of survey was approximately one kilometre per hour. Any sighted animal was identified to the species level.

Anabat recordings

Anabat detection was used to record and identify the echolocation calls of microchiropteran bats and was used at three different sites on consecutive nights. The detector was attached to a time delay switch allowing bats to be identified throughout the night, with the recording starting at dusk. Recorded calls were analysed by Ray Williams of Ecotone Pty Ltd.

Incidental sightings

Species of animal present in the study area were recorded through observation methods including incidental sightings, bird surveys, spotlighting, identification of bird and frog calls, searches for ground-dwelling reptile species under logs and leaf litter, and by sighting indirect evidence of species presence such as scats, feathers, tracks and hair.

3.4.3 Survey Effort

The location of survey effort is described in *Figure 2* and below in *Table 3-2*.

Table 3-2 Survey effort and location of targeted survey methods

Date(s)	Survey Method	Effort (Number or Time)	Easting (WGS 84)	Northing (WGS 84)
11-14/10/04	Elliott Type A (ground traps)	75 trap nights	Start: 313724	Start: 6294467
			End: 313803	End: 6294516
11-14/10/04	Elliott Type B (tree traps)	30 trap nights	Start: 313724	Start: 6294467
			End: 313803	End: 6294516
11/10/04	Spotlighting	4 person hours	Start: 313724	Start: 6294467
			End: 313803	End: 6294516
13/09/04	Spotlighting	4 person hours	Start: 313704	Start: 6294640
			End: 313865	End: 6294575
11/10/04	Anabat[1]	1 night	313789	6294550
12/10/04	Anabat[1]	1 night	313920	6294628
13/10/04	Anabat[1]	1 night	314220	6294498
13/10/04	Anabat[1]	1 night	313591	6295089
11/09/04	Call Playback	1 night	313798	6294544
13/09/04	Call Playback	1 night	313481	6295001
11-14	Fauna habitat	30 person hours	Study area, excluding DP223323	
11-13	Flora habitat	30 person hours		
11-14	Flora transects	15 person hours		
13/7/06	Biodiversity survey	4 hours	DP 223323	

Notes: 1 – Anabat bat detectors were set with a delay switch and had the potential to record throughout the entire night if bats were present.

3.5 Conservation Significance

Assessment of the conservation significance of native terrestrial flora and fauna is done according to the hierarchy:

- national
- state
- regional
- local.

Meaningful comparisons of significance or value at a variety of scales rely on widely accepted criteria (for example, International Union for the Conservation of Nature 2001). The following criteria were used to assign the site to an appropriate conservation significance category.

National: Matters dealt with under the *Environment Protection and Biodiversity Conservation Act 1999*. These include:

- Important areas of habitat for migratory species covered under international agreements to which Australia is a signatory, such as *the China Australian Migratory Bird Agreement* (CAMBA), *Japan Australian Migratory Bird Agreement* (JAMBA) and the *Bonn Convention on the Conservation of Migratory Species of Wild Animals.*
- Ramsar Wetlands.
- World Heritage properties that contain natural heritage considered to be of outstanding value to humanity as listed under the Convention Concerning the Protection of the World Cultural and Natural Heritage.
- Species populations or communities considered Vulnerable or Endangered and listed pursuant to the *Environment Protection and Biodiversity Conservation Act 1999.*
- Flora listed as threatened and rare in Rare or Threatened Australian Plants (Briggs & Leigh 1996).
- Species listed as endangered, vulnerable or rare in Australia in an Action Plan published by the Department of the Environment and Heritage.

State: Remnant ecosystems containing populations of plant or animal species, or vegetation or animal communities considered threatened in NSW, including species and communities listed pursuant to the *Threatened Species Conservation Act 1995*. This category also includes flora listed as poorly known in Australia in Rare or Threatened Australian Plants (Briggs & Leigh 1996).

Regional: There are no widely accepted criteria for regional significance in New South Wales. The state is divided into bioregions (Thackway & Cresswell 1995) and much of the listing of *Endangered Ecological Communities under the Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999* are based around these regions. New South Wales Catchment Management Authorities direct natural resource management within thirteen general catchments and include information on the extent of various

vegetation communities. Also numerous published studies and vegetation mapping projects have indicated the importance of vegetation and species at various spatial scales.

Local: All remnant native vegetation and fauna habitat that does not fall into the categories above is considered to be of at least local significance as most of these areas have been reduced in extent since European settlement. The overall significance of the site on a local scale can take into consideration factors such as the size of remnants, degree of intactness and connectivity.

Potentially Significant: Often the limitations of field methods, seasonal factors or time constraints make it impossible to confirm the presence of a significant species or population. However, the habitat of an area being investigated may closely match that used by the significant species in areas nearby where it is known to occur. In these circumstances, the level of significance that would otherwise apply is qualified by "potential". In addition, some species or communities may possess characteristics that make them eligible for listing as threatened at either the State or National levels, although the listing has not taken place. Again, the level of significance for these species and communities is qualified by the term "potential".

3.6 Impact Assessment

For the purpose of the impact assessments the following definitions apply:

Subject site: the area that is proposed for development or activity. In this case it is the areas proposed for additional sand extraction activities.

Study area: the subject site and any additional areas likely to be affected by the proposal either directly or indirectly.

Locality: the area within a 10 kilometre radius of the study area.

Region: a bioregion defined in a national system of bioregionalisation. For this study this is the Sydney Basin Bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).

Subject species for which significance assessments were completed were determined based on the following criteria:

- species recorded in the study area
- species recorded in the locality that have potential to occur within the study area.

Projects assessed under Part 3A of the *Environmental Planning and Assessment Act 1979* require assessments of significance based against heads of consideration detailed in the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation 2005a), indicating the significance of the impacts relative to the conservation importance of the habitat, individuals and populations likely to be affected. Impacts are considered more significant if:

- areas of high conservation value are affected
- individual animals and/or plants and/or subpopulations that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community

- habitat features that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community
- the impacts are likely to be long-term in duration
- impacts are likely to be permanent and irreversible.

Threatened biodiversity listed under the *Environment Protection and Biodiversity Conservation Act 1999* were assessed following the *Principal Significant Impact Guidelines* (Department of the Environment and Heritage 2006).

Significance assessments were completed based on the known and likely presence of Threatened species, populations and communities (Chapter 4); the potential impacts of the development (Chapter 5); and the mitigation measures proposed (Chapter 5).

3.7 Limitations

On all sites, varying degrees of non-uniformity of flora and fauna habitats are encountered. Hence no sampling technique can totally eliminate the possibility that a species is present on site (e.g. species of plant present in the seed bank). The conclusions are based upon data acquired for the site and the environmental field surveys and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of species. Also, it should be recognised that site conditions, including the presence of threatened species, can change with time.

4. Results

4.1 Existing Environment

4.1.1 Vegetation Communities

The site contained five vegetation communities (*Figure 3*):

- Shale Sandstone Transition Forest
- Sydney Sandstone Ridgetop Woodland
- Sydney Sandstone Gully Forest
- regrowth vegetation
- cleared areas.

Shale Sandstone Transition Forest

Shale Sandstone Transition Forest occurred primarily as three remnants of open forest in the central section of the site near the former Trigonometrical Reserve (*Photograph 1* and *Figure 3*) and within DP223323. Only two of these would be affected by the project. The study area also includes small sections of three further remnants of this community (refer *Figure 3*). This community is listed as endangered under both the *TSC* and *EPBC Acts.*

The canopy consisted of *Eucalyptus eugenioides, E. punctata, E. resinifera, Angophora costata, E. gummifera, E. globoidea* and *Syncarpia glomulifera.* The shrub layer was regenerating following a fire in December 2002 and included *Acacia parramattensis, Oxylobium ulicifolium, Gompholobium latifolium, Bossiaea lenticularis, Ceratopetalum gummiferum, Telopea speciosissima, Lomatia silaifolia, Xylomelum pyriforme, Boronia pinnata* and *Boronia ledifolia*. Ground cover was dominated by native grasses and herbs such as *Lomandra longifolia* and *Themeda australis.*

The extent of this community within the study area is 7.8 hectares. The three main remnants are small (approximately 1.0, 2.6 and 3.7 hectares), narrow and had a high edge to area ratio. The remnants were almost entirely subject to edge effects such as weed invasion. Weeds in this community include the noxious Bridal Creeper, Small-leaved Privet, Prickly Pear and Blackberry. The remnants were in poor to moderate condition.

Sydney Sandstone Gully Forest

Sydney Sandstone Gully Forest occurred in the southern section of the site in the Little Cattai Creek Valley (*Photograph 2*). This community corresponds to Sydney Sandstone Gully Forest (Map Unit 10ag) as described by Benson and Howell (1994) and Gully Open Forest as described by DFA Consultants (2003).

The canopy was dominated by *Angophora costata, Eucalyptus piperita, Syncarpia glomulifera* and *Corymbia maculata.* The shrub layer was sparse and was regenerating from fire and includes

a tall shrub layer consisting of *Allocasuarina littoralis, Callicoma serratifolia* and *Banksia serrata a*nd a low shrub layer of *Acacia myrtifolia, Telopea speciosissima, Lomatia silaifolia and Boronia pinnata* and *Gompholobium latifolium*. The ground cover consisted of grasses, herbs, ferns and sedges including *Entolasia stricta, Themeda australis, Adiantum aethiopicum, Tetratheca thymifolia* and *Smilax australis.*

It has been suggested that the Sydney Sandstone Gully Forest found in the Maroota area is a unique variant of this community due to deep sediment accumulation and the presence of permanent groundwater seepage in gullies (ECOHORT Consultants Pty Ltd 2000).

Very few introduced species were recorded and this community is in good condition.

Sydney Sandstone Ridgetop Woodland

Sydney Sandstone Ridgetop Woodland occurred on the ridge top in the east of the site (*Photograph 3*). This community corresponds to Sydney Sandstone Ridgetop Woodland (Map Unit 10ar) as described by Benson (Benson & Howell 1994) and Woodland /Low woodland as described by DFA Consultants (2003).

The canopy was dominated by *Angophora costata, Corymbia gummifera, Eucalyptus sparsifolia, Eucalyptus punctata* and *Eucalyptus haemastoma.* The shrub layer contained tall shrubs such as *Leptospermum trinervium, Persoonia levis, Acacia linifolia* and *Kunzea ambigua* as well as low shrubs such as *Grevillea buxifolia, Acacia ulicifolia, Bossaea heterophylla* and *Lambertia formosa. The ground cover consists of grasses, herbs and sedges including Scaevola ramosissima, Billardiera scandens, Themeda australis, Anisopogon avenaceus, Cyathochaeta diandra* and *Ptilothrix deustum.*

Very few introduced species were recorded and these were largely restricted to the edges of patches. This community is considered to be in good condition.

Two threatened species were recorded within this community: *Tetratheca glandulosa* and *Grevillea parviflora*.

Regrowth

Regrowth vegetation occurs in the eastern section of the site in the vicinity of the dams. These areas had been cleared previously but are adjacent to native vegetation and have been allowed to regenerate (*Photograph 4*).

This community consisted of a low dense canopy dominated by *Allocasuarina littoralis* and *Kunzea ambigua.* The understorey was sparse and includes both native and introduced species of grasses and herbs such as *Themeda australis, Sida rhombifolia* and *Pennisetum clandestinum.*

This community was in moderate condition and given time is likely to regenerate well.

Cleared Areas

The cleared areas covered the majority of the site. Much of the vegetation within the site had been cleared previously for grazing, cropping and mining (*Photograph 5*).

The cleared areas were dominated by weeds and introduced grasses such as *Verbena bonariensis, Asparagus asparagoides, Sida rhombifolia, Pennisetum clandestinum* and *Chloris virgata.*

The vegetation within the cleared areas had been highly disturbed and modified and is not considered to represent a native vegetation community.

4.1.2 Species of Plant

A total of 207 species of plant was recorded on site (*Appendix B*). The majority of species (87%) are native. Five weeds (Crofton Weed, Prickly Pear, Bridal Creeper, Small-leaved Privet and Blackberry) declared noxious for the Hawkesbury River County Council control area (which includes Baulkham Hills Shire) were recorded on site.

Tetratheca glandulosa, which is listed as threatened under both the *EPBC Act* and the *TSC Act*, was recorded during the current survey. During the current survey a total of 43 individuals were recorded scattered over seven locations within the bushland in the southern section of the site (*Figure 3*). Eighty individuals were previously recorded adjacent to the proposed haulage track in the south eastern section of the site. Since this species is cryptic and difficult to detect, population sizes are generally underestimated and vary depending on the time of year of survey and proportion of population flowering at any given time.

One *Grevillea parviflora* individual, listed under both the EPBC and the TSC Acts, was recorded within the site. However, this individual was outside the development footprint (*Figure 3*).

4.1.3 Fauna Habitats

The size and condition of fauna habitats generally correspond to the vegetation communities described above.

Shale Sandstone Transition Forest

Relatively undisturbed and moderately dense upper storey canopy of tall Eucalypt trees characterised the fauna habitats available within the community. There were moderate numbers of large senescent trees containing small to medium sized tree hollows and a small number of standing dead stags were present. The understorey vegetation consisted of a dense shrub layer in most areas, and there was an abundance of grasses and herbs scattered throughout the forest that emerged from the limited amounts of rocky outcrops which were present on the steeper areas.

There was a relatively thick layer of leaf litter and decorticating bark and a moderate amount of fallen dead timber accumulated on the forest floor. A small pond (approximately 12 square metres) containing emergent vegetation was present in the south of the site, but was in poor condition due to weed infestation and eutrophication.

The tree hollows provided nesting and roosting habitat for hollow-dwelling fauna (e.g. cockatoos, parrots, possums and bats), and the tall trees provided roosting, nesting and foraging resources for generalist/ forest species of bird. Foraging resources were also available for reptiles and macropods such as the Swamp Wallaby and microchiropteran bats were likely to use the community as marginal foraging area.

Although the community contained a variety of microhabitat resources for native species of animal, it is unlikely that habitat for threatened species of animal exist in the community due to the relatively small size (approximately 1.0, 2.6 and 3.7 hectares) and isolated nature of the remnant from other bushland. Fauna habitats in the Shale Sandstone Transition Forest community were in moderate condition.

Sydney Sandstone Gully Forest

This community was relatively undisturbed and contained high quality microhabitat resources that would be suitable for a variety of native species of animal. The dense upper storey canopy was dominated by a diversity of large senescent Eucalypt trees that contained a high number of medium sized tree hollows. Standing dead stags and fallen dead timber were both abundant. There was a tall and sparse regenerating shrub layer throughout the understorey of the forest, with a groundcover of grasses, herbs and sedges scattered amongst rocky outcrops and along the dry ephemeral drainage line. The forest floor contained a thick layer of leaf litter and decorticated bark was scattered throughout the community.

The community contained foraging, nesting and roosting resources for a variety of native species of animal which included the Swamp Wallaby, small ground-dwelling mammals (rodents and Antechinus), reptiles, and generalist/forest species of bird. Insectivorous microchiropteran bats would be likely to use the temporary roosting resources in some of the tree hollows and forage along the open drainage lines and the outer margins of the forest. Fauna habitats in the Sydney Sandstone Gully Forest were in good condition.

Sydney Sandstone Ridgetop Woodland

The majority of the community was transitional to fauna habitats of the Sydney Sandstone Gully Forest and was relatively undisturbed, while some of the eastern areas of the upper ridgetop were regenerating and lack a canopy cover of tall and emergent myrtaceous trees and associated tree hollows.

The upper storey canopy cover from tall myrtaceous trees was relatively dense throughout most of the community and there was a moderate number of small sized tree hollows present in mature senescent trees. There was a small amount standing tree stags and moderate amount of fallen dead timber. The understorey vegetation consisted of a low-lying shrub layer that was relatively dense throughout the community and a dense groundcover of grasses, herbs and sedges were prolific throughout the woodland. The woodland floor contained a moderately thick layer of leaf litter that was scattered amongst small areas of rocky outcrops.

The community contained foraging, roosting, and nesting resources for generalist woodland and nectivorous species of bird, reptiles, microchiropteran bats, small ground dwelling mammals and macropods (such as the Swamp Wallaby). The eastern areas of the community were connected to extensive areas of remnant bushland outside the proposed area to be cleared (*Figure 3*). The condition of fauna habitats in the Sydney Sandstone Ridgetop Woodland was moderate.

Regrowth Areas

The low-lying and sparse canopy cover of Casuarina trees provided foraging resources for generalist species of bird. The sparse understorey of grasses and herbs provided foraging and sheltering resources for reptiles and small ground dwelling mammals. The groundcover layer of the community generally contained a thin layer of leaf litter. The area did not contain any significant tree hollows or standing tree stags, although fallen dead timber was present in small amounts. There was a limited availability of rocky outcrops. There were two dams within the study area.

The regenerating regrowth areas were likely to support a variety of native species of animal through the ecological development of fauna habitat resources over time. However, the condition of fauna habitats in the regrowth areas was poor.

Cleared Areas

The habitat in the cleared areas was highly disturbed and offered limited habitat resources for native species of animal due to the absence of over storey tree cover and native shrub layer. The shrub overgrowth of weeds in some areas was used by fairywrens and scrubwrens as nesting and foraging resources, and the small amount of scattered rocks provided general foraging resources for common species of reptile. A relatively small and highly degraded dam/waterbody provided limited habitat for common species of duck and habitat for common species of amphibian.

The condition of fauna habitat in the cleared areas was poor.

4.1.4 Species of Animal

A total of 44 species of animal was recorded on site (*Appendix C*), comprising three species of amphibian, three species of reptile, twenty eight species of bird, seven species of native mammals and three introduced species.

While no threatened species of animal was recorded on site, the threatened Glossy Black-cockatoo was recorded flying overhead.

4.1.5 Corridors and Connectivity

Wildlife corridors can be defined as “retained and/or restored systems of (linear) habitat which, at a minimum enhances connectivity of wildlife populations and may help them overcome the main consequences of habitat fragmentation” (Wilson & Lindenmayer 1995). Corridors can provide ecological functions at a variety of spatial and temporal scales from daily foraging movements of individuals, to broad-scale genetic gradients across biogeographical regions.

Corridors serve a number of different functions in terms of conservation including:

- providing increased foraging area for wide-ranging species
- providing cover for movement between habitat patches, and enhancing the movement of animals through sub-optimal habitats
- reducing genetic isolation
- facilitating access to a mix of habitats and successional stages to those species which require them for different activities (for example, foraging or breeding)
- providing refuge from disturbances such as fire
- providing habitat in itself
- linking wildlife populations and maintaining immigration and recolonisation between otherwise isolated patches. This in turn may help reduce the risk of population extinction (Wilson & Lindenmayer 1995).

The Sydney Sandstone Ridgetop Woodland and Sydney Sandstone Gully Forest vegetation communities displayed good connectivity to relatively large areas of adjacent bushland (*Figure 3*). The Shale Sandstone Transition Forest was highly fragmented from continuous connective vegetation and is largely surrounded by cleared land and current sand extraction activities, displaying low structural and functional connectivity (*Photograph* 6).

The location of the proposed clearing would not result in the further fragmentation of vegetation or habitats within the site.

4.2 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems are defined as those that have their species composition and their natural ecological processes determined by groundwater (Department of Land and Water Conservation 2002). The extent of dependency of ecosystems on groundwater resources covers a wide spectrum ranging from opportunistic use of groundwater to total dependency (Sinclair Knight Mertz 2001). A number of vegetation communities have been identified in the Maroota area with varying degrees of groundwater dependency (ECOHORT Consultants Pty Ltd 2000). Those present in or close to the subject site include:

- Sydney Sandstone Gully Forest (Maroota variant)
- Maroota Sand Swamp Forest.

There are three groundwater systems within the Hitchcock Road Site (URS 2004). The Maroota sands are deposited mainly in two palaeochannels eroded into the exposed surface of the Hawkesbury Sandstone, one of which runs through the Hitchcock road site. The presence of clay and cemented layers gives rise to localised perched water tables, while around the Trigonometrical reserve there is a substantial aquifer open to direct rainfall infiltration (URS 2004). Small aquifer zones have developed within the alluvial sands, often forming perched aquifer systems. This is equivalent to the shallow aquifer of the Maroota Groundwater Study Technical Status Report (Department of Land and Water Conservation 2001). A deep aquifer occurs within the Hawkesbury Sandstone (Department of Land and Water Conservation 2001), which lies beneath the alluvial sands.

Impacts of the proposal on groundwater and potential groundwater dependent ecosystems are discussed in Section 5.1.

4.3 Species, Populations and Communities of Conservation Concern

4.3.1 Threatened Ecological Communities

Threatened Ecological Communities are listed as Critically Endangered, Endangered or Vulnerable under Schedule 1, Part 3 of the *TSC Act* or under the *EPBC Act*. Shale Sandstone Transition Forest is listed as an endangered ecological community under both the *TSC Act* and the *EPBC Act*. This community is located on the Trig Reserve (*Figure 3*) as well as other small remnants within the Hitchcock Road site.

4.3.2 Endangered Populations

Endangered Populations are listed under Schedule 1 Part 2 of the *TSC Act*. *Dillwynia tenuifolia*, and *Darwinia fascicularis* subsp. *oligantha* in the Baulkham Hills Local Government Area are listed as endangered populations and are known to be located in the Maroota area. Land clearing is recognised as a threatening process for both the *Dillwynia tenuifolia* and *Darwinia fascicularis* subsp. *Oligantha* populations (NSW National Parks and Wildlife Service 2000a, 2003d). *Darwinia fascicularis subsp. oligantha* habitat has been affected and reduced to small isolated remnants by sand mining which has been extensive in the Maroota area (NSW National Parks and Wildlife Service 2000a).

Both species are found around rock platforms and in rocky heath associated with friable sandstone. No individuals of this species were found in the study area despite targeted surveys of sufficient detail in order to detect these species if present

Wahlenbergia multicaulis is also listed as an endangered population within the Baulkham Hills Local Government Area. It is a coloniser of disturbed sites and grows in a variety of habitats including forest, woodland, scrub, grassland and the edges of watercourses and wetlands. It typically occurs in damp, disturbed sites. It is closely aligned with the Villawood Soil Series, which is a poorly drained, yellow podsolic extensively permeated with fine, concretionary ironstone (laterite) with sites in Hornsby on the 'Hawkesbury' soil landscape (Department of Environment and Conservation 2006). This species has not been recorded within 10 kilometres of the site and the site does not provide potential habitat.

4.3.3 Threatened Plants

A total of 29 species of threatened plant listed under the *TSC Act* (*Figure 4*) and/or the *EPBC Act* are considered in this study (*Appendix D*).

Based on habitat assessment and the known distribution of these species in the Sydney Basin Bioregion, 23 species do not have potential habitat within the site. The remaining six occur in environments similar to those on site. Targeted surveys identified only two of these threatened species of plant within the site *(Tetratheca glandulosa* and *Grevillea parviflora).* Surveys were considered to be of sufficient detail in order to detect the other threatened species had they been present.

Tetratheca glandulosa and *Grevillea parviflora* were recorded within the Sydney Sandstone Ridgetop Woodland (*Figure 3*). *Tetratheca glandulosa* was recorded at seven locations within Sydney Sandstone Ridgetop Woodland in the southern section of the site (*Photograph 7*). One *Grevillea parviflora* plant was recorded in the vicinity of an existing track outside the study site. Significance assessments have been completed for these two species.

4.3.4 Threatened Animals

A total of 45 threatened species of animal has been recorded or has the potential to occur within 10 kilometres of the site, including six species of amphibian, 21 species of birds, two species of mammal and two species of reptile (*Appendix E*). All species are listed under the *TSC Act* and eleven are also listed under the *EPBC Act* (*Appendix E*).

It is, however, highly unlikely that all these species occur at or near the proposed development sites on a regular basis, and even fewer species would be affected by the proposed expansion of sand mining activities (*Appendix E*).

Despite the occurrence of local records or predicted habitat, 34 threatened species are unlikely to be significantly affected by the proposal for one or more of the following reasons:

- habitats were not recorded in the study area
- the species is not endemic to the area and is therefore a vagrant
- the species is unlikely to occur on a regular basis; or
- the species is considered locally extinct.

Full details of species requirements are shown in *Appendix E*. Impact assessments as required under the *TSC Act* and/or the *EPBC Act* have been completed for the remaining species (*Appendix F*).

4.3.5 Migratory Species

A total of ten migratory species has been predicted to occur within 10 kilometres of the study area based on the Environment Protection and Biodiversity Conservation Protected Matter Search Tool *(Appendix E).* No migratory species listed on the *EPBC Act* was recorded on site. While terrestrial migratory species of bird may potentially use the area, the area is not classed as an 'important habitat' as defined under the Significant Impact Guidelines of the *EPBC Act* (Department of the Environment and Heritage 2006) in that the site does not contain:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- habitat utilised by a migratory species which is at the limit of the species range; or
- habitat within an area where the species is declining.

As such there is unlikely to be an impact on migratory species and this group is not considered further.

4.3.6 Key Threatening Processes

Key threatening processes are listed under Schedule 3 of the *TSC Act* and also under the *EPBC Act*. Clearing of native vegetation is listed as a key threatening process under the *TSC Act* and land clearance is listed under the *EPBC Act*. Removal of dead wood, dead trees and logs is listed as a key threatening process under the *TSC Act* as is the removal of hollow-bearing trees.

The proposed action involves all three processes however, this is unlikely to further threaten any listed species.

4.3.7 Critical Habitat

Critical Habitat is listed under both the *TSC Act* and *EPBC Act* and both the State and Federal Directors-General maintain a register of this habitat. Critical habitat is the whole or any part or parts of an area or areas of land comprising the habitat of an endangered species, an endangered population or an endangered ecological community that is critical to the survival of the species, population or ecological community (NPWS, 1996).

There is no listed critical habitat within the study area and none is likely to be affected by the proposed subdivision.

4.3.8 SEPP 44 – Koala Habitat

Although Baulkham Hills Shire Council is not listed in Schedule 1 of State Environmental Planning Policy 44 and this policy does not apply to projects assessed under Part 3A of the *Environmental Planning and Assessment Act 1979*, an assessment of the site has been applied as a precaution. The site contains *Eucalyptus punctata* (Large-fruited Grey Gum), *Eucalyptus haemastoma* (Broad-leaved Scribbly Gum) and *Eucalyptus tereticornis* (Forest Red Gum), which are preferred Koala feed tree listed in Schedule 2 of SEPP 44.

Appendix 1 of the Draft Koala Recovery Plan categorises Koala feed trees as primary, secondary and supplementary. Primary feed trees exhibit a level of use that is significantly higher than that of other Eucalypt species and independent of tree density. Secondary and or supplementary food trees are generally used less than that of primary food trees (except where primary food trees are absent), and use appears to be dependent on both the density and size of the trees (NSW National Parks and Wildlife Service 2002b). The draft Koala recovery plan identifies *Eucalyptus punctata* (Grey Gum) and *Eucalyptus resinifera* (Red Mahogany) as secondary feed tree species, and *Eucalyptus eugenoides* (Thin-leaved Stringybark) and *Eucalyptus oblonga* as supplementary species, all of which have been recorded on site.

The density of feed trees is not greater than 15 percent on site, and does not fit the criteria for potential Koala habitat as defined within SEPP 44. The nearest Koala record is approximately 1.5 kilometres to the north-west of the site. No Koalas were observed and there was no indirect evidence suggesting the presence of the species.

The site is not considered as either potential or core Koala habitat.

4.4 Conservation Significance

The study area has National conservation significance due to the presence of Shale Sandstone Transition Forest (covering 7.8 hectares of the study area), which is listed as an Endangered Ecological Community listed under both the *EPBC Act* and the *TSC Act*. However, the remnants of Shale Sandstone Transition Forest within the development footprint are relatively small, isolated, have a large edge:area ratio and is almost entirely subject to edge effects. The removal of areas of this community (covering an area of 5.2 hectares) is unlikely to have a significant impact on the overall recovery of this community.

Further, the study area has National conservation significance due to the presence of *Tetratheca glandulosa* which is listed as Vulnerable under the *EPBC Act* and the *TSC Act*. However the population of *Tetratheca glandulosa* within the study area is not considered to be viable or significant given its small size, patchy distribution and relative isolation.

5. Impact and Amelioration

5.1 Impacts of the Proposal

5.1.1 Vegetation clearing

Given the nature of the proposal, clearing of native vegetation is unavoidable. The proposed sand mine expansion will result in the clearing of approximately 10.6 hectares of native vegetation including 5.2 hectares of Shale Sandstone Transition Forest and 5.4 hectares of Sydney Sandstone Ridgetop Woodland.

5.1.2 Habitat fragmentation and edge effects

The Shale Sandstone Transition Forest to be cleared is already isolated from larger tracts of bushland and is subject to edge effects from past mining activities. The Sydney Sandstone Ridgetop Woodland to be cleared in the south-eastern area of the site is largely surrounded by cleared area and regrowth vegetation from past mining activities to the north and connectivity to remnant bush land to the south will remain (*Figure 1*).

The sand extraction in the south-eastern part of the site is likely to increase edge effects in the Sydney Sandstone Ridgetop Woodland.

5.1.3 Changes in groundwater and surface water

Impacts of sand mining on groundwater resources are discussed fully in the EIS (URS 2004) as well as in the Maroota Groundwater Study (Department of Land and Water Conservation 2001). Impacts of mining on groundwater and surface water are discussed below.

Reduction in groundwater availability

The extraction of sand would be limited to a depth that is at least two metres above the water table. It has been suggested that the extraction of sand may increase the groundwater recharge to the deep aquifer due to greater permeability (URS 2004), although this may be reduced to some extent by the creation of water holding dams. In such dams fine sediments at the base may act as a barrier to groundwater recharge (Department of Land and Water Conservation 2001).

Mining would not be carried out below water table, the aquifer would not be disturbed and no groundwater would be extracted for the purpose of mining from the shallow aquifer, apart from the amount already licensed by the Department of Natural Resources.

Reduced flow to streams

Groundwater from perched water tables in the three aquifers may contribute to stream flows where streams have eroded though to the water table (URS 2004), although the relative contribution of groundwater as apposed to runoff is unclear (Department of Land and Water Conservation 2001).

The southern part of the proposed development area falls within the catchment of Little Cattai Creek, which joins the Hawkesbury River through Broadwater Swamp approximately 15 kilometres southwest of the site. However, the current mining operations have modified the original drainage and at present most of the mined area is internally drained. A drainage line

approximately 250 metres long cuts portion 214 at right angle and joins the upper reaches of Little Cattai Creek. Removal of perched groundwater bodies may cause a reduction of stream flow, but the increased amount of recharge to the aquifers as a result of mining activities is likely to compensate for the reduction (URS 2004).

Increased turbidity to streams and pollution

The mining operations have the potential to increase sediment loads to streams if not appropriately managed. This can occur as a result of runoff from surface areas or from overflow of detention basins, and should it occur, may have a potential impact on the water courses downstream from the area. Although the central part of the site will be reduced from its current elevation of 240 metres AHD to 210 metres AHD, however, it is inward draining and there would be no natural discharge of surface water beyond its boundaries. It is highly unlikely that any release of turbid water to streams will occur (URS 2004).

As part of the operations there is also the potential for pollution, most likely from fuel spills, to enter streams and possibly the shallow aquifer (Department of Land and Water Conservation 2001). Groundwater quality has been monitored at production bores at Hitchcock Road since 1996 and no oil and grease was detected in all other sampling occasions or in any of the other bores. Therefore, it is considered that such occurrences do not represent a cause of concern (URS 2004).

Water table lowering

There will be no lowering of the water table as a result of the proposed mining activities (URS 2004).

5.1.4 Noise

Construction and operational impacts would result from the use of heavy machinery creating noise impacts on native wildlife in the adjacent bushland. However given that mining-related activity already exists at Hitchcock Road, it is unlikely that the proposed change would result in an overall increase in noise levels and the level of disturbance. Potential noise impacts are discussed more fully in the EIS.

5.2 Impact Amelioration

A general principle of environmental management is to, in order of preference;

- **Avoid** environmental impacts
- **Minimise** impacts
- **Mitigate** the impacts
- as a last resort once the above options have been investigated, **compensate** for the residual impacts.

In order to minimise impacts on ecological values of the site, it is recommended that;

- colour tape or ‘parawebbing’ should be used to delineate the maximum work area permitted. This should be implemented prior to any work commencing on site. If any tape is disturbed then it should immediately be replaced along the appropriate alignment

- a clearing management plan should be prepared and implemented including inspection of tree hollows. The clearing protocols should include the following:
  - shaking the tree using a bulldozer
  - slowly pushing the tree to the ground so that it largely remains intact
  - having a trained ecologist inspect hollows and removing any animals if possible (this should be discussed with the Department of Environment and Climate Change)
  - leaving the tree in place once felled for at least one day/night before removing to allow animals to relocate to nearby vegetation
  - all contractors having the contact numbers of wildlife rescue groups should animals be injured during clearing
  - undertaking vegetation clearing during September/October or in March/May to avoid summer breeding seasons and the winter hibernation for hollow dependent species.
- sediment control devices should be installed prior to clearing vegetation to ensure that no impacts affect surrounding vegetation
- to ensure that a revegetation and rehabilitation plan should be prepared. This plan should include an integrated strategy of methods such as the direct seeding of local native grasses, transplanting or translocating native vegetation and maintenance weeding along constructed batter slopes and drainage lines. Salvaged materials such as dead wood and tree hollows should be considered for use in rehabilitation areas along with the use of artificial nest boxes. This rehabilitation could form part of the overall vegetation offset plan to be prepared as part of the environmental assessment
- locally indigenous species should be used in landscaping and revegetation works
- topsoil from areas of native vegetation that are free of weeds should be removed and stockpiled for use in rehabilitation
- a flora and fauna monitoring program should be prepared that will assess the health and condition of vegetation communities and fauna habitats adjacent to the proposed extraction sites as well as the success of rehabilitation programs.

5.3 Impact Assessments

5.3.1 Flora

Impact assessments were carried out for threatened plants and vegetation communities, including Shale Sandstone Transition Forest, *Tetratheca glandulosa*, and *Grevillea parviflora (Section 4.3.3* and *Appendix F).*

Two remnants of Shale Sandstone Transition Forest occurred within the development footprint. These were small (totalling approximately 5.2 hectares), isolated, had a large edge to area ratio and were almost entirely subject to edge effects. The removal of this vegetation is unlikely to have a significant impact on the recovery of this community.

Tetratheca glandulosa was found at seven locations within the study area, three of which could be affected by the proposal (consisting of at least 5, 11 and 26 plants). The proposed development also involves the clearing of 5.4 hectares of habitat for this species (*Figure 3*). The site is not at

the limit of distribution for *Tetratheca glandulosa* and the species is well represented within conservation reserves across its range, including stronghold populations and populations at the limit of distribution. The removal of 5.4 hectares of habitat and 42 plants is unlikely to significantly interfere with the recovery of the species. The impact assessment concluded that the proposed sand mining activities is unlikely to have a significant impact on this species.

Only one individual of *Grevillea parviflora* was recorded within the site in the vicinity of an existing track and is unlikely to be part of a viable population. This individual is not within the development footprint and as such this species is unlikely to be significantly affected by the proposed development.

5.3.2 Fauna

The Glossy Black –cockatoo was recorded flying over the site. Further, it is likely that five species of microchiropteran bat (East Coast Freetail Bat, Common Bent-wing Bat, Southern Myotis, Yellow-bellied Sheathtail Bat and the Large-eared Pied Bat) and four species of nocturnal bird (Masked Owl, Powerful Owl, Barking Owl and Sooty Owl) use habitat on site for foraging. Impact assessments under Part 3A of the *EP&A Act* concluded that the proposed mining activities would not have a significant impact on threatened species of microchiropteran bat or nocturnal bird (*Appendix F*).

5.3.3 Summary of impact assessments

Table 5-1 Summary of significance assessments completed

Name	TSC Act[1]	EPBC Act[2]	Likely significant impact
Endangered Ecological Communities			
Shale Sandstone Transition Forest	E	E	No
Threatened plants			
Tetratheca glandulosa	V	V	No
Grevillea parviflora	V/E*	V	No
Threatened animals			
East Coast Freetail Bat – *Mormopterus norfolkensis*	V		No
Common Bent-wing Bat – *Miniopterus schreibersii*	V	CD	No
Large-eared Pied Bat – *Chalinobus dwyeri*	V	V	No
Large-footed Myotis – *Myotis adversus*	V		No
Yellow-bellied Sheathtail Bat - *Saccolaimus flaviventris*	V		No
Masked Owl – *Tyto novaehollandiae*	V		No
Powerful Owl – *Ninox strenua*	V		No
Barking Owl – *Ninox connivens*	V		No
Glossy Black-cockatoo – *Calyptorhynchus lathami*	V		No
Brown Treecreeper – *Climacteris picumnus*	V		No

Notes: 1. V= Vulnerable, E1 = Endangered species, E2 = Endangered population, E* = 2 subspecies listed (Threatened Species Conservation Act 1995)

2. V = Vulnerable, E = Endangered, CD = Conservation Dependent (Environment Protection and Biodiversity Conservation Act 1999)

6. Summary and Conclusions

A total of five vegetation communities occur on site including Sydney Sandstone Gully Forest, Sydney Sandstone Ridgetop Woodland, regrowth vegetation, cleared areas and Shale Sandstone Transition Forest which is listed as an Endangered Ecological Community under the *TSC Act* and the *EPBC Act*. The condition of vegetation in the Shale Sandstone Transition Forest was moderate, while the Sydney Sandstone Gully Forest and Sydney Sandstone Ridgetop Woodland were in good condition. The regrowth vegetation and cleared areas are respectively in moderate and poor vegetation condition. Two threatened species of plant (*Tetratheca glandulosa* and *Grevillea parviflora)* were recorded on site.

The threatened Glossy Black-cockatoo was recorded on site and the site is likely to provide habitat for other threatened species including microchiropteran bats and large forest owls. However, these species are likely to use the site primarily for foraging and would not depend on its habitat resources.

The proposal involves the removal of approximately 10.6 hectares of native vegetation, which includes 5.2 hectares of Shale Sandstone Transition Forest, 24.8 hectares of agricultural land and 5.4 hectares of Sydney Sandstone Ridgetop Woodland. The areas of Shale Sandstone Transition Forest are small (3.7 and 1.6 hectares), isolated, have a large edge to area ratio and are almost entirely subject to edge effects and the removal of these remnants is unlikely to have a significant impact on the recovery of this community. Given the high degree of land disturbance in the vicinity of the areas to be cleared, it is unlikely that impacts such as noise and pollution would be further exacerbated by the proposed mining expansion. A study of the groundwater resources within the study area has suggested that there would be no impacts on groundwater dependent ecosystems within the vicinity of the site.

Impact assessments as required under Part 3A of the *EP&A Act* were carried out for three threatened plant species and communities, the Glossy Black-cockatoo, the Brown Treecreeper, microchiropteran bats (as a group) and nocturnal birds (as a group). The assessments concluded that the proposed extension of sand mining activities and rehabilitation was unlikely to have significant impact on threatened species, population or communities.

General mitigation measures have been proposed to minimise impacts to biodiversity.

Under the draft *Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979*, the objective of the biodiversity assessment process is to provide information to enable decision-makers to ensure that developments deliver the following environmental outcomes.

Maintain or improve biodiversity values

The proposed development is located in a previously disturbed area. Much of the vegetation has been cleared for agriculture (grazing and cropping) and mining.

The proposal however would require the clearing of approximately 10.6 hectares of native vegetation including one endangered ecological community. These areas also provide potential habitat for a range of threatened species of plant and animal.

In order to maintain or improve biodiversity a vegetation offset plan will be developed for the project.

Prevent the extinction of threatened species

No Threatened species are likely to become extinct as a result of the Proposal. Mitigation measures have been included to minimise impacts on Threatened species and biodiversity in general.

Protect the long-term viability of local populations of a species, population or ecological community

There is one endangered ecological community at the development site: Shale Sandstone Transition Forest. Surveys also found that two threatened plant species occurred within the area, only one of which was recorded within the development site. Ten species of threatened animal were either found at the site, were recorded flying over, or are considered likely to occur in the area. Impact assessments were completed for each of these (see Appendix F). The assessments concluded that there would be no significant impacts on any of the communities or species.

Protect areas of high conservation value (including areas of critical habitat)

There is no critical habitat defined within the proposal locality nor are there areas of high conservation value in the study area. The areas of native vegetation however, and the associated habitats, are important habitat at the local and regional scale. Impacts to these values have been minimised through the commitment to ensure new plantings replace the vegetation that would be cleared.

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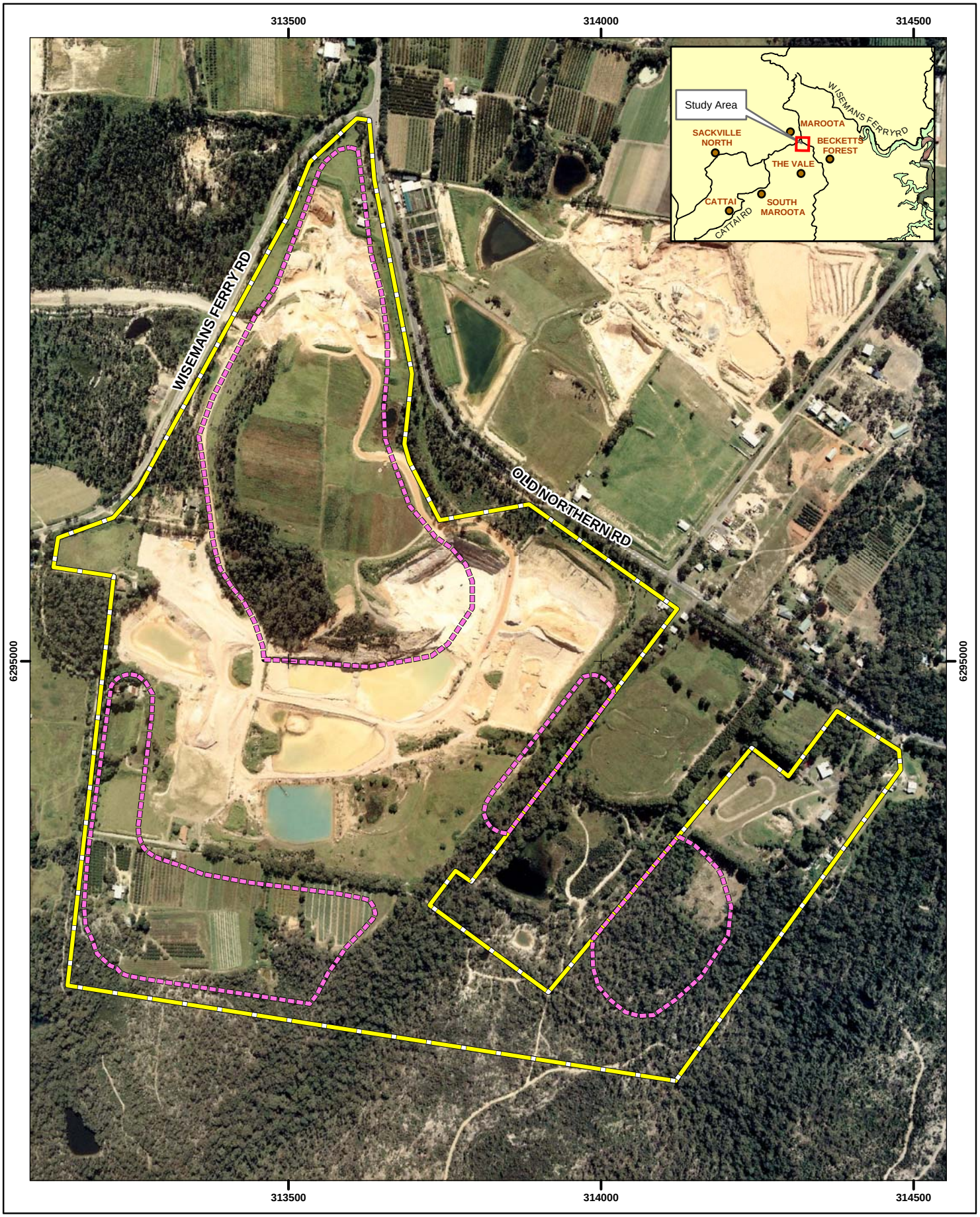
Figures



Extraction Area

Study Area

N

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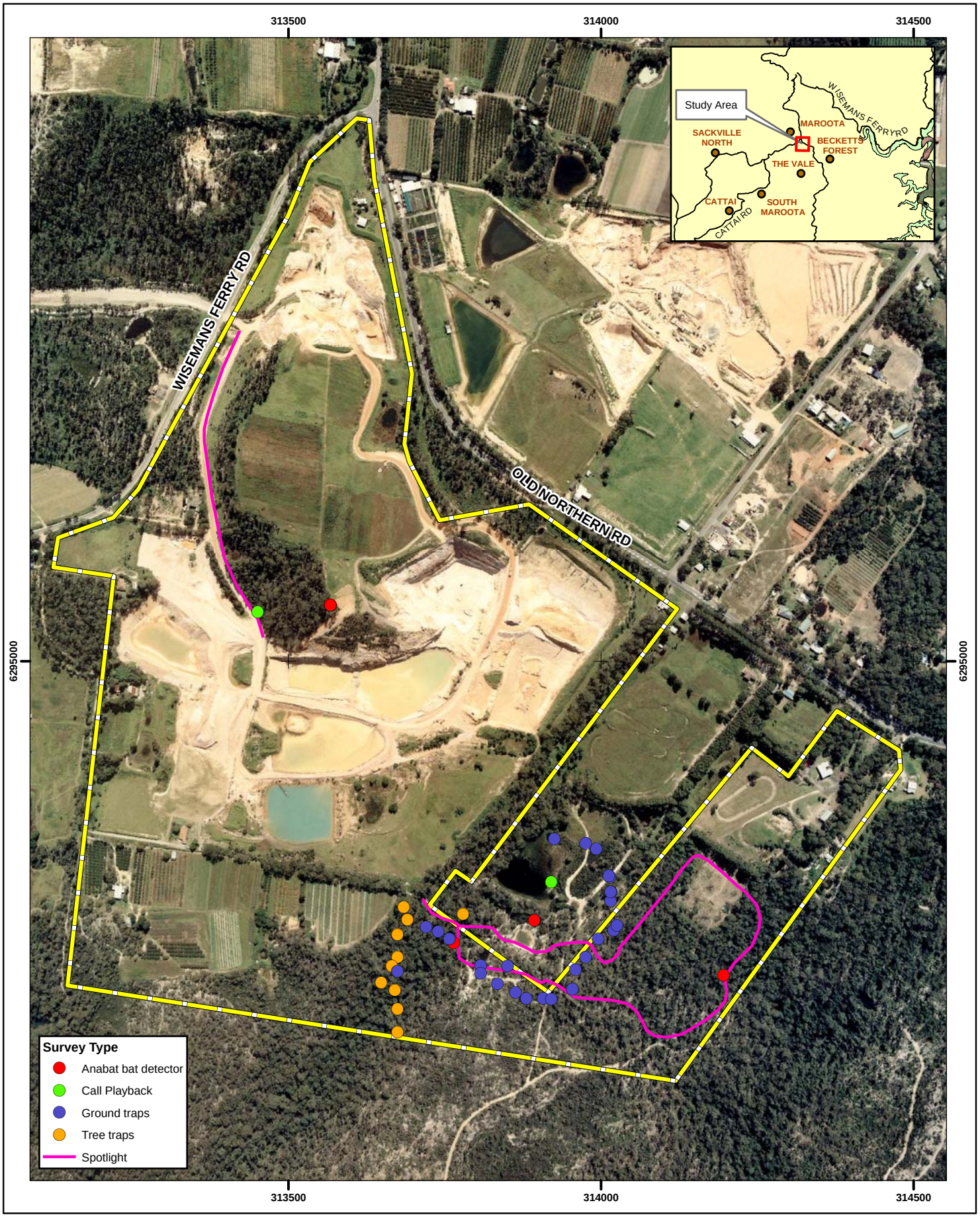

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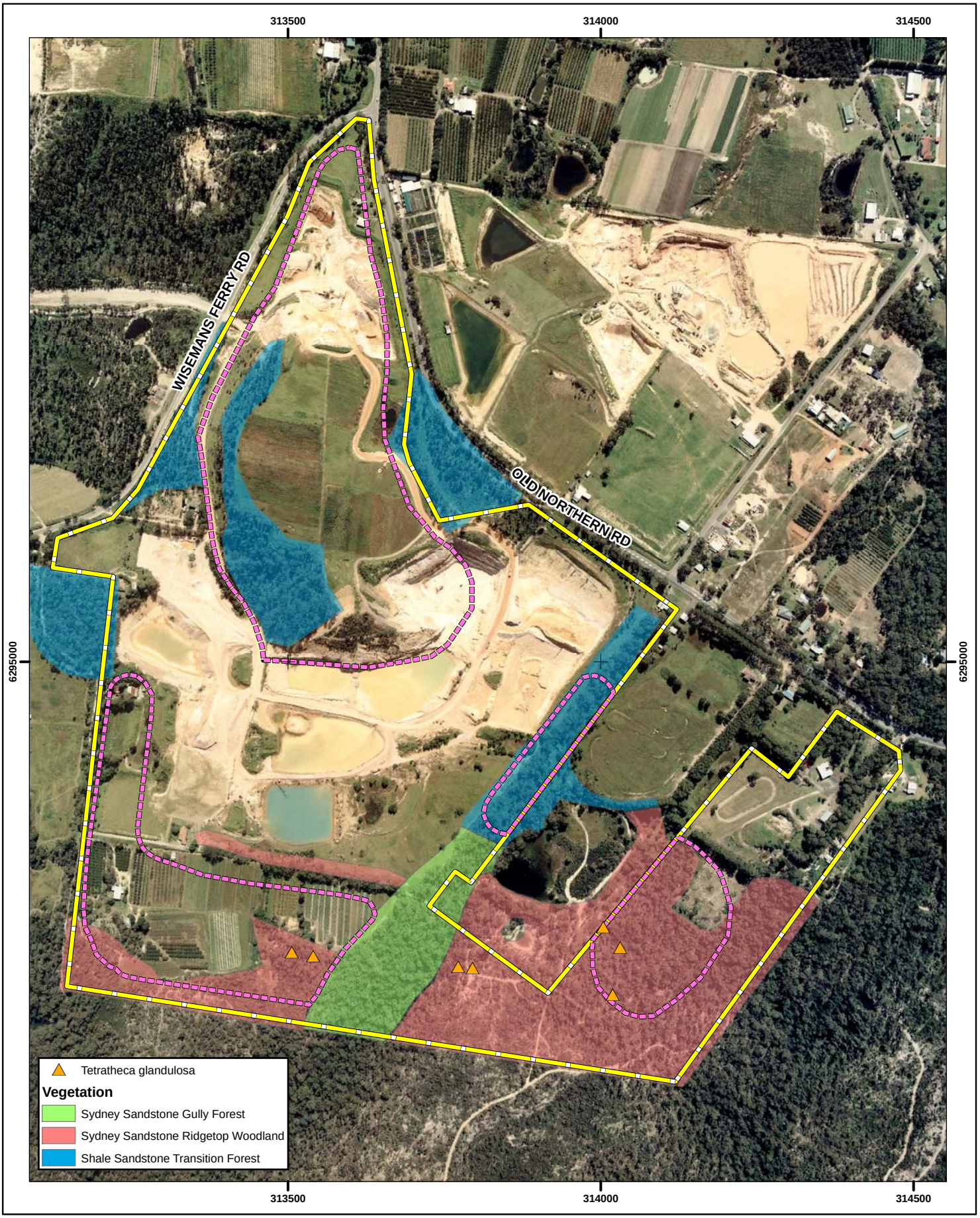

Extraction Area

Study Area

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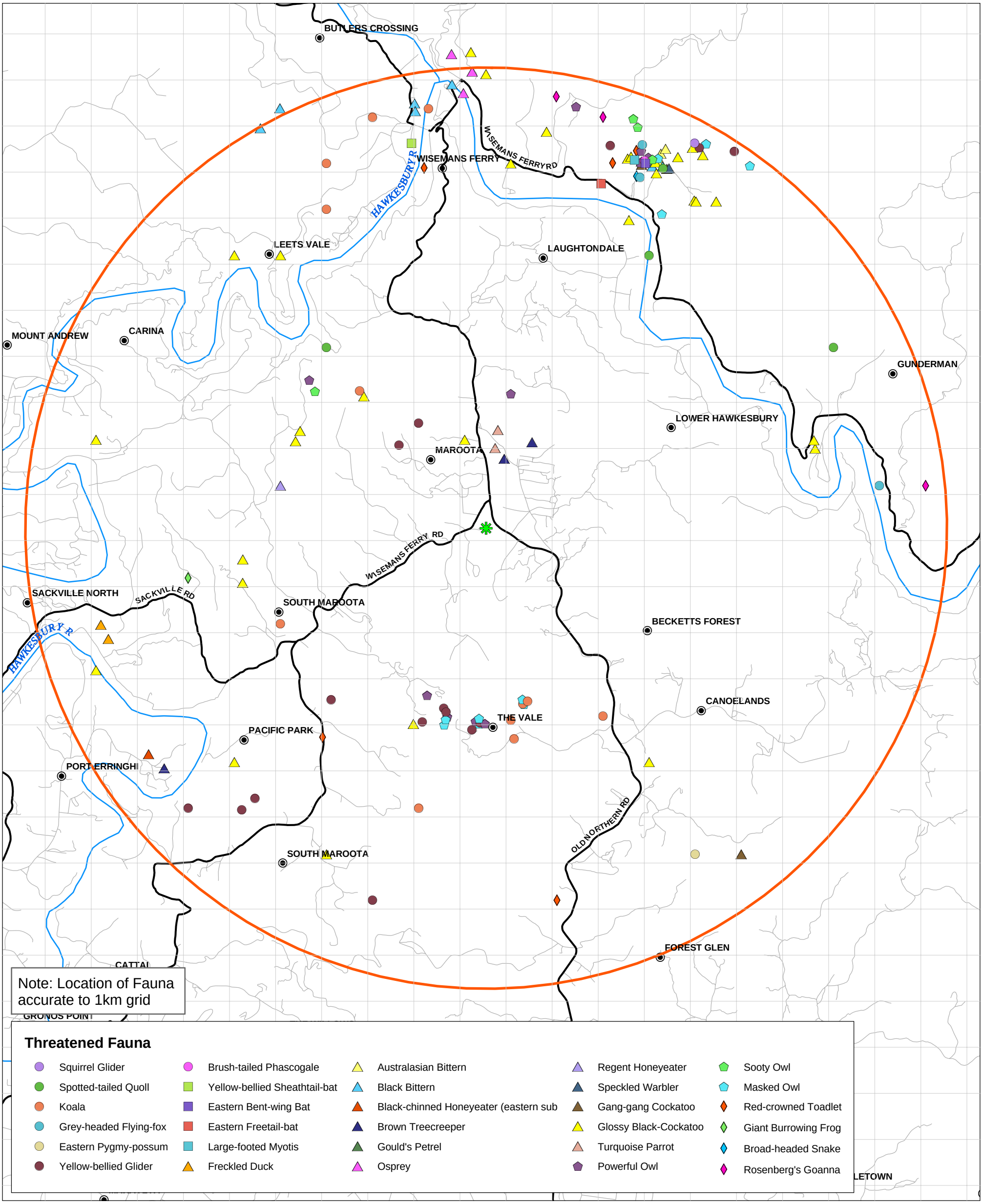

Hitchcock Road Study Centre

Town

Drainage

Main Road

Local Road

10 Km Buffer

N

0 0.5 1 2 3 Km

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Threatened Fauna Recorded
Within 10 kilometres of the Site
(DEC Atlas of NSW Wildlife)

PARSONS BRINCKERHOFF

Project: Hitchcock Road Sand Mine Flora and Fauna Study

Client: PF Formations

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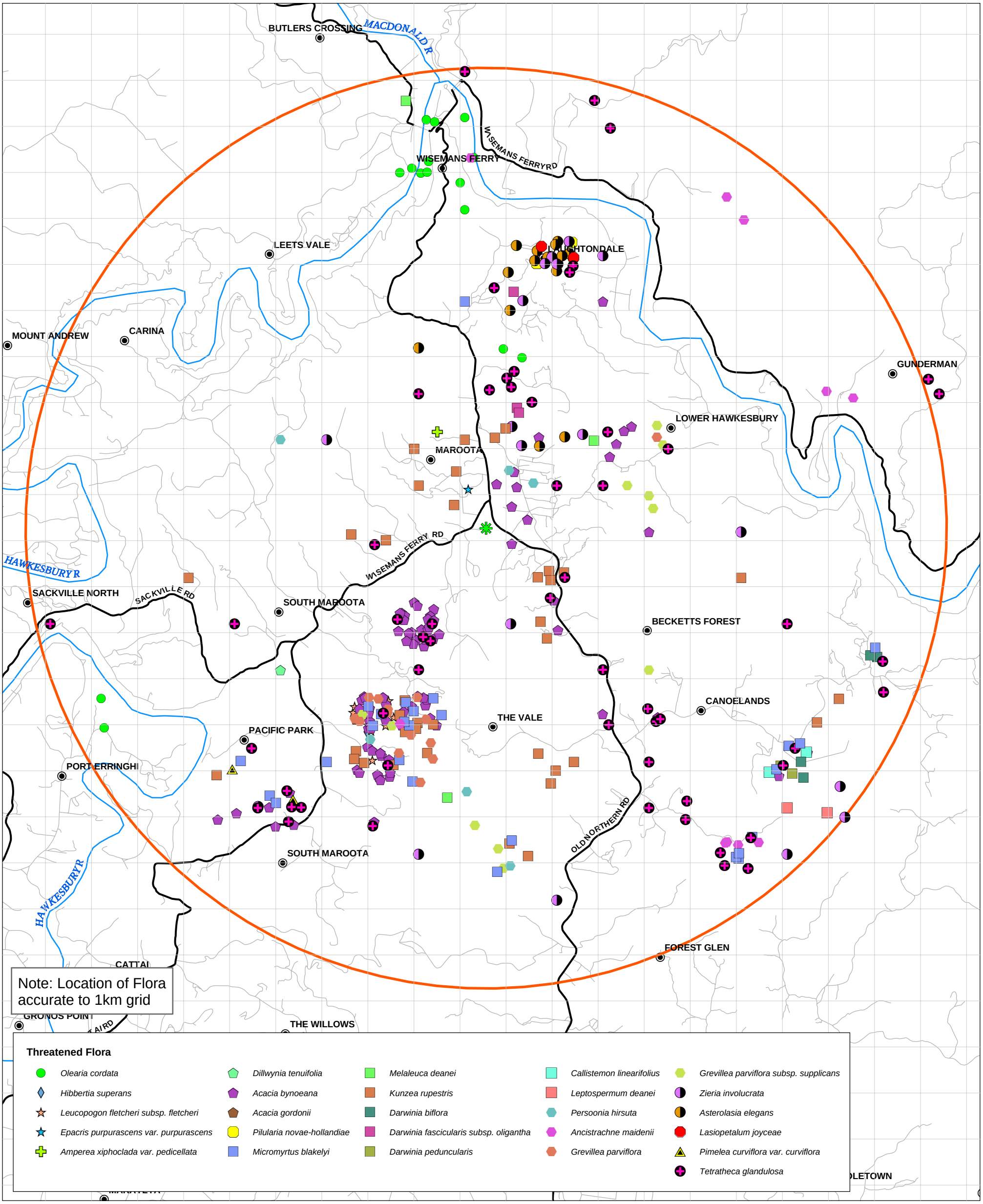

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Photographs

Photograph 1: Shale Sandstone Transition Forest

Photograph 2: Sydney Sandstone Gully Forest

Photograph 3: Sydney Sandstone Ridgetop Woodland

Photograph 4: Regrowth

Photograph 5: Cleared area

Photograph 6: Fragmented Shale Sandstone Transition Forest

Photograph 7: Tetratheca glandulosa recorded in Sydney Sandstone Ridgetop Woodland

Appendix A

Accuracy of searched databases

This appendix details the types of data obtained from the Department of Environment and Climate Change Atlas of NSW Wildlife and the EPBC Protected Matter Search Tool and the accuracy of both datasets.

Atlas of NSW Wildlife

The Atlas of NSW Wildlife is based on records of specific sightings. Each point is entered on a 1 km grid and hence location is only accurate to within 1 km. The Atlas of NSW Wildlife is not based on systematic surveys across New South Wales and the number of records is generally biased towards coastal sites and areas where people commonly visit, such as National Parks. It is also biased towards particular species, reserves and roads.

Department of the Environment and Water Resources Protected Matters Search Tool

The Department of the Environment and Water Resources Protected Matters Search Tool is based on predicted distributions compiled from a number of sources at various resolutions. Generally, where distributions are well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and detailed habitat studies. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps. For species whose distributions are less well known, point locations are collated from various sources and bioclimatic distribution models generated and then validated by experts. In some cases, distribution maps are based solely on expert knowledge.

The following species and ecological communities have not been mapped and do not appear in reports produced from the EPBC database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- cetaceans which are not listed as threatened
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent.

Appendix B

Plants recorded on site

This appendix details the plants recorded on site during the current surveys**.**

Family	Scientific Name	Common name	Native	TSC Act[1]	EPBC Act[2]	ROTAP[3]
Adiantaceae						
	Adiantum aethiopicum	Common Maidenhair	Y	P13		
	Adiantum hispidulum	Rough Maidenhair	Y	P13		
	Cheilanthes sieberi		Y			
	Pellaea falcata	Sickle Fern	Y			
Apiaceae						
	Actinotus minor	Lesser Flannel Flower	Y			
	Hydrocotyle bonariensis		N			
	Platysace linearifolia		Y			
	Xanthosia tridentata		Y			
Araliaceae						
	Polyscias sambucifolia	Elderberry Panax	Y			
Asparagaceae						
	Asparagus asparagoides	Bridal Creeper	N			
Asteraceae						
	Ageratina adenophora	Crofton Weed	N			
	Arctotheca calendula	Capeweed	N			
	Bidens pilosa	Cobbler's Pegs	N			
	Cassinia uncata	Sticky Cassinia	Y			
	Conyza albida	Tall Fleabane	N			
	Gnaphalium indutum	Tiny Cudweed	Y			
	Hypochaeris radicata	Catsear	N			
	Ozothamnus diosmifolius	White Dogwood	Y			
	Senecio madagascariensis	Fireweed	N			
	Sonchus oleraceus	Common Sowthistle	N			
	Tagetes minuta	Stinking Roger	N			
	Taraxacum officinale	Dandelion	N			
Azollaceae						
	Azolla pinnata		Y			
Baueraceae						
	Bauera rubioides		Y			
Blechnaceae						
	Blechnum cartilagineum	Gristle Fern	Y			
Cactaceae						
	Opuntia stricta		N			
Casuarinaceae						
	Allocasuarina littoralis	Black Sheoak	Y			
Chenopodiaceae						
	Einadia hastata	Berry Saltbush	Y			
Commelinaceae						
	Commelina cyanea	Native Wandering Jew	Y			
Cunoniaceae						
	Callicoma serratifolia	Black Wattle	Y			
	Ceratopetalum gummiferum	Christmas Bush	Y	P13		
Cyperaceae						
	Caustis flexuosa	Curly Wig	Y	P13		
	Cyathochaeta diandra		Y			
	Eleocharis sphacelata	Tall Spike Rush	Y			
	Gahnia clarkei		Y			
	Isolepis prolifera		N			
	Lepidosperma laterale		Y			
	Ptilothrix deusta		Y			
	Schoenoplectus mucronatus		Y			

Family	Scientific Name	Common name	Native	TSC Act[1]	EPBC Act[2]	ROTAP[3]
	Schoenus ericetorum		Y			
	Schoenus melanostachys		Y			
Dennstaedtiaceae						
	Pteridium esculentum	Bracken	Y			
Dicksoniaceae						
	Calochlaena dubia	Common Ground Fern	Y			
Dilleniaceae						
	Hibbertia aspera		Y			
	Hibbertia bracteata		Y			
	Hibbertia cistiflora		Y			
	Hibbertia diffusa		Y			
Droseraceae						
	Drosera peltata		Y			
Elaeocarpaceae						
	Elaeocarpus reticulatus	Blueberry Ash	Y			
Epacridaceae						
	Astroloma humifusum	Native Cranberry	Y			
	Epacris pulchella	NSW Coral Heath	Y			
	Leucopogon lanceolatus	Lance Beard Heath	Y			
	Leucopogon microphyllus		Y			
	Leucopogon muticus		Y			
	Lissanthe strigosa	Peach Heath	Y			
	Monotoca scoparia		Y			
	Styphelia tubiflora		Y			
Euphorbiaceae						
	Amperea xiphoclada var. papillata		Y			3K
	Breynia oblongifolia	Coffee Bush	Y			
	Phyllanthus hirtellus	Thyme Spurge	Y			
Fabaceae (Faboideae)						
	Bossiaea heterophylla		Y			
	Bossiaea lenticularis		Y			
	Bossiaea obcordata		Y			
	Daviesia genistifolia	Broom Bitter Pea	Y			
	Daviesia ulicifolia	Gorse Bitter Pea	Y			
	Dillwynia floribunda		Y			
	Dillwynia retorta		Y			
	Glycine tabacina		Y			
	Gompholobium glabratum	Dainty Wedge Pea	Y			
	Gompholobium grandiflorum	Large Wedge Pea	Y			
	Gompholobium latifolium	Golden Glory Pea	Y			
	Gompholobium pinnatum	Pinnate Wedge Pea	Y			
	Hardenbergia violacea	False Sarsaparilla	Y			
	Hovea linearis		Y			
	Kennedia rubicunda	Red Kennedy Pea	Y			
	Mirbelia rubiifolia		Y			
	Mirbelia speciosa		Y			
	Oxylobium ilicifolium	Prickly Shaggy Pea	Y			
	Pultenaea flexilis		Y			
	Pultenaea linophylla		Y			
	Pultenaea polifolia		Y			
	Swainsona galegifolia	Smooth Darling Pea	Y			
	Trifolium dubium	Yellow Suckling Clover	N			
Fabaceae (Mimosoideae)						
	Acacia brownii	Heath Wattle	Y			
	Acacia decurrens	Black Wattle	Y			

Family	Scientific Name	Common name	Native	TSC Act[1]	EPBC Act[2]	ROTAP[3]
	Acacia falcata		Y			
	Acacia linifolia	Flax-leaved Wattle	Y			
	Acacia longifolia	Sydney Golden Wattle	Y			
	Acacia myrtifolia	Red-stemmed Wattle	Y			
	Acacia parramattensis	Parramatta Wattle	Y			
	Acacia stricta	Straight Wattle	Y			
	Acacia suaveolens	Sweet Wattle	Y			
	Acacia terminalis	Sunshine Wattle	Y			
	Acacia ulicifolia	Prickly Moses	Y			
Fumariaceae						
	Fumaria indica		N			
Gleicheniaceae						
	Gleichenia dicarpa		Y			
	Sticherus flabellatus	Umbrella Fern	Y			
Goodeniaceae						
	Dampiera purpurea		Y			
	Dampiera stricta		Y			
	Scaevola ramosissima		Y			
Haemodoraceae						
	Haemodorum planifolium		Y			
Haloragaceae						
	Gonocarpus teucrioides		Y			
Iridaceae						
	Patersonia glabrata		Y			
Juncaceae						
	Juncus sp.		Y			
Lauraceae						
	Cassytha glabella		Y			
Lindsaeaceae						
	Lindsaea linearis	Screw Fern	Y			
	Lindsaea microphylla	Lacy Wedge Fern	Y			
Lobeliaceae						
	Pratia purpurascens	Whiteroot	Y			
Lomandraceae						
	Lomandra glauca	Pale Mat-rush	Y			
	Lomandra gracilis		Y			
	Lomandra longifolia	Spiny-headed Mat-rush	Y			
	Lomandra multiflora		Y			
	Lomandra obliqua		Y			
Malvaceae						
	Sida rhombifolia	Paddy's Lucerne	N			
Menispermaceae						
	Stephania japonica		Y			
Myrtaceae						
	Angophora bakeri	Narrow-leaved Apple	Y			
	Angophora costata	Sydney Red/Rusty Gum	Y			
	Angophora hispida	Dwarf Apple	Y			
	Baeckea diosmifolia		Y			
	Baeckea ramosissima	Rosy Baeckea	Y			
	Corymbia eximia	Yellow Bloodwood	Y			
	Corymbia gummifera	Red Bloodwood	Y			
	Eucalyptus eugenioides	Thin-leaved Stringybark	Y			
	Eucalyptus globoidea	White Stringybark	Y			
	Eucalyptus haemastoma	Broad-leaved Scribbly Gum	Y			
	Eucalyptus punctata	Grey Gum	Y			

Family	Scientific Name	Common name	Native	TSC Act[1]	EPBC Act[2]	ROTAP[3]
	Eucalyptus resinifera	Red Mahogany	Y			
	Eucalyptus sparsifolia	Narrow-leaved Stringybark	Y			
	Kunzea ambigua	Tick Bush	Y			
	Leptospermum polygalifolium		Y			
	Syncarpia glomulifera	Turpentine	Y			
Oleaceae	*Ligustrum sinense*	Small-leaved Privet	N			
Orchidaceae						
	Caleana major	Large Duck Orchid	Y			
	Glossodia major	Waxlip Orchid	Y			
	Pterostylis sp.		Y			
Osmundaceae						
	Todea barbara	King Fern	Y	P13		
Passifloraceae						
	Passiflora sp.		Y			
Philydraceae						
	Philydrum lanuginosum	Frogsmouth	Y			
Phormiaceae						
	Dianella caerulea		Y			
	Dianella caerulea var. producta		Y			
	Dianella prunina		Y			
	Dianella revoluta		Y			
Phytolaccaceae						
	Phytolacca octandra	Inkweed	N			
Pinaceae						
	Pinus sp.		N			
Pittosporaceae						
	Billardiera scandens	Appleberry	Y			
	Bursaria spinosa	Native Blackthorn	Y			
	Pittosporum undulatum	Sweet Pittosporum	Y			
Plantaginaceae						
	Plantago lanceolata	Lamb's Tongues	N			
Poaceae						
	Agrostis avenacea	Blown Grass	Y			
	Andropogon virginicus	Whisky Grass	N			
	Anisopogon avenaceus	Oat Speargrass	Y			
	Aristida vagans	Threeawn Speargrass	Y			
	Cortaderia selloana	Pampas Grass	N			
	Dichelachne rara		Y			
	Echinopogon caespitosus		Y			
	Entolasia stricta	Wiry Panic	Y			
	Eragrostis brownii	Brown's Lovegrass	Y			
	Imperata cylindrica		Y			
	Panicum simile	Two-colour Panic	Y			
	Paspalum dilatatum	Paspalum	N			
	Paspalum urvillei	Vasey Grass	N			
	Themeda australis	Kangaroo Grass	Y			
Polygalaceae						
	Comesperma ericinum		Y			
Potamogetonaceae						
	Potamogeton tricarinatus	Floating Pondweed	Y			
Primulaceae						
	Anagallis arvensis	Scarlet/Blue Pimpernel	N			
Proteaceae						
	Banksia ericifolia	Heath Banksia	Y			
	Banksia oblongifolia		Y			

Family	Scientific Name	Common name	Native	TSC Act[1]	EPBC Act[2]	ROTAP[3]
	Banksia serrata		Y			
	Banksia spinulosa		Y			
	Conospermum longifolium		Y			
	Conospermum taxifolium		Y			
	Grevillea buxifolia	Grey Spider Flower	Y			
	Grevillea parviflora		Y	V		
	Grevillea sericea		Y			
	Grevillea speciosa	Red Spider Flower	Y			
	Hakea dactyloides	Broad-leaved Hakea	Y			
	Hakea sericea		Y			
	Isopogon anemonifolius		Y			
	Lambertia formosa	Mountain Devil	Y			
	Lomatia silaifolia	Crinkle Bush	Y	P13		
	Persoonia levis	Broad-leaved Geebung	Y			
	Persoonia linearis	Narrow-leaved Geebung	Y			
	Persoonia oblongata		Y			
	Petrophile pulchella		Y			
	Telopea speciosissima	Waratah	Y	P13		
	Xylomelum pyriforme		Y	P13		
Ranunculaceae						
	Clematis aristata		Y			
Restionaceae						
	Lepyrodia scariosa		Y			
Rhamnaceae						
	Cryptandra amara		Y			
Rosaceae						
	Rubus fruiticosus	Blackberry complex	N			
Rubiaceae						
	Pomax umbellata		Y			
Rutaceae						
	Boronia ledifolia	Sydney Boronia	Y	P13		
	Boronia pinnata		Y	P13		
Santalaceae						
	Exocarpos cupressiformis	Native Cherry	Y			
Schizaeaceae						
	Schizaea bifida	Forked Comb Fern	Y			
Scrophulariaceae						
	Verbascum virgatum	Twiggy Mullein	N			
Smilacaceae						
	Smilax australis	Sarsaparilla	Y			
	Smilax glyciphylla	Sweet Sarsparilla	Y			
Stylidiaceae						
	Stylidium graminifolium	Grass Triggerplant	Y			
Thymelaeaceae						
	Pimelea linifolia		Y			
Tremandraceae						
	Tetratheca glandulosa		Y	V	V	2V
	Tetratheca thymifolia	Black-eyed Susan	Y			
Typhaceae						
	Typha sp.		Y			
Verbenaceae						
	Verbena bonariensis	Purpletop	N			
Xanthorrhoeaceae						
	Xanthorrhoea media		Y			
	Xanthorrhoea sp.		Y			

Family	Scientific Name	Common name	Native	TSC Act[1]	EPBC Act[2]	ROTAP[3]
Zamiaceae						
	Macrozamia spiralis		Y			

1: V= Vulnerable, E1 = Endangered (Threatened Species Conservation Act 1995), P13 = protected under the National Parks and Wildlife Act
2: V = Vulnerable, E = Endangered (Environment Protection and Biodiversity Conservation Act 1999)
3: ROTAP (Rare or Threatened Australian Plants, Briggs and Leigh 1996) is a conservation rating for Australian plants. Codes are:

- 1 Species only known from one collection
- 2 Species with a geographic range of less than 100km in Australia
- 3 Species with a geographic range of more than 100km in Australia
- X Species presumed extinct; no new collections for at least 50 years
- E Endangered species at risk of disappearing from the wild state if present land use and other causal factors continue to operate
- V Vulnerable species at risk of long-term disappearance through continued depletion.
- R Rare, but not currently considered to be endangered.
- K Poorly known species that are suspected to be threatened.
- C Known to be represented within a conserved area.
- a At least 1,000 plants are known to occur within a conservation reserve(s).
- i Less than 1,000 plants are known to occur within a conservation reserve(s).
- - The reserved population size is unknown.
- t The total known population is reserved.
- + The species has a natural occurrence overseas.

Appendix C

Animals recorded on site

This appendix details the animals recorded on site during the current and previous surveys.

Common Name	Latin Name	Observation Type[1]	TSC Act[2]
Amphibians			
Common Eastern Froglet	*Crinia signifera*	W	
Smooth Toadlet	*Uperoleia laevigata*	W	
Spotted Grass Frog	*Limnodynastes tasmaniensis*	O	
Reptiles			
Copper-tailed Skink	*Ctenotus taeniolatus*	W	
Eastern Water Skink	*Eulamprus quoyii*	O	
Garden Skink	*Lampropholis guichenoti*	O	
Native Birds			
Australian Magpie	*Gymnorhina tibicen*	O	
Australian Raven	*Corvus coronoides*	O	
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O	
Brown Falcon	*Falco berigora*	O	
Brown Thornbill	*Acanthiza pusilla*	O	
Chestnut Teal	*Anas castanea*	O	
Dusky Moorhen	*Gallinula tenebrosa*	O	
Eastern Rosella	*Platycercus eximius*	O	
Eastern Yellow Robin	*Eopsaltria australis*	O	
Galah	*Cacatua roseicapilla*	O	
Glossy Black-cockatoo	*Calyptorhynchus lathami*	O	V
Grey Fantail	*Rhipidura fuliginosa*	O	
Jacky Winter	*Microeca fascinans*	O	
Laughing Kookaburra	*Dacelo novaeguineae*	O	
Masked Lapwing	*Vanellus miles*	W	
Pacific Black Duck	*Anas superciliosa*	O	
Pied Currawong	*Strepera graculina*	O	
Red Wattlebird	*Anthochaera carunculata*	O	
Red-browed Finch	*Neochmia temporalis*	O	
Rufous Whistler	*Pachycephala rufiventris*	O	
Southern Boobook	*Ninox novaeseelandiae*	W	
Spotted Pardalote	*Pardalotus punctatus*	O	
Sulphur-crested Cockatoo	*Cacatua galerita*	O	
Superb Fairy-wren	*Malurus cyaneus*	O	
Welcome Swallow	*Hirundo neoxena*	O	
White-throated Gerygone	*Gerygone olivacea*	O	
Willie Wagtail	*Rhipidura leucophrys*	O	
Yellow-faced Honeyeater	*Lichenostomus chrysops*	O	
Introduced Birds			
Spotted Turtle-Dove	*Streptopelia chinensis*	O	U
Native Mammals			
Brown Antechinus	*Antechinus stuartii*	O	
Swamp Wallaby	*Wallabia bicolor*	P	
Bush Rat	*Rattus rattus*	O	
Common Ringtail Possum	*Pseudocheirus peregrinus*	O	
Gould's Wattled Bat	*Chalinobus gouldii*	W	
White-striped Freetail Bat	*Tadarida australis*	W	
Little Forest Bat	*Vespadelus vulturnus*	W	

Common Name	Latin Name	Observation Type[1]	TSC Act[2]
Introduced Mammals			
Fox	*Vulpes vulpes*	P	U
Cat (feral)	*Felis catus*	P	U

Notes:
1. O = Observed, P = Indirect Evidence, L = Literature, W= Heard call.
2. V= Vulnerable, E1 = Endangered, U= Unprotected (Threatened Species Conservation Act 1995)

Appendix D

Threatened species of plant in the local area

This appendix details the threatened species of plant that have either been recorded in the local area, or that have the potential to occur, based on the NPWS Atlas of NSW Wildlife and the EPBC Protected Matters Search Tool.

Scientific Name (Common Name)	TSC Act[1]	EPBC Act[2]	ROTAP[3]	Preferred Habitat	Likely to occur within site
Acacia bynoeana (Bynoe's Wattle)	E1	V	3V	Occurs south of Dora Creek-Morisset area to Berrima and the Illawarra region and west to the Blue Mountains. It grows mainly in heath and dry sclerophyll forest on sandy soils (Harden 2002).Seems to prefer open, sometimes disturbed sites such as trail margins and recently burnt areas. Typically occurs in association with Corymbia gummifera, Eucalyptus haemastoma, E. gummifera, E. parramattensis, E. sclerophylla, Banksia serrata and Angophora bakeri (NSW National Parks and Wildlife Service 1999e).	No
Acacia gordonii	E1	E	2K	Occurs in the lower Blue Mountains from Bilpin to Faulconbridge and also in the Glenorie district. Grows on sandstone outcrops and amongst rock platforms in dry sclerophyll forest and heath (Harden 2002; NSW Scientific Committee 1997). Specifically this species occurs in Sydney Sandstone Ridgetop Communities (James 1997).	No. Although suitable habitat present, this species was not recorded within site during detailed targeted surveys.
Amperea xiphoclada var pedicellata	E4	X	1X	This species is presumed extinct but previously known to occur in Central Coast region in heath, woodland and forest on low fertility sandy soils (Harden 1993).	No
Ancistrachne maidenii	V		2K	Occurs north of Sydney where it grows on sandstone derived soils (Harden 1993). Thought to have specific habitat requirements, with populations occurring in distinct bands in areas associated with a transitional geology between Hawkesbury and Watagan soil landscapes (NSW Scientific Committee 1999c).	No
Asterolasia elegans	E1	E	2Ea	Only known to occur in one locality, north of Maroota, where it grows in wet sclerophyll forest on moist hillsides (Harden 2002).	No
Caladenia tessellata (Thick Lip Spider Orchid)	E1	V	3V	Occurs south of Swansea where it grows on clay loam or sandy soils (Harden 1993). Prefers low open forest with a heathy or sometimes grassy understorey (Bishop 2000).	No. This species has not been previously recorded within 10 kilometres of the site and was not recorded within site during targeted surveys
Callistemon linearifolius	V		2Ri	Occurs chiefly from Georges to the Hawkesbury River where it grows in dry sclerophyll forest, open forest, scrubland or woodland on sandstone. Found in damp places, usually in gullies (Fairley & Moore 2002; Harden 2002; Robinson 1994). Within the Sydney region, recent records are limited to the Hornsby Plateau area near the Hawkesbury River (NSW Scientific Committee 1999d).	No
Cryptostylis hunteriana (Leafless Tongue Orchid)	V	V	3V	Occurs mostly in coastal districts south of the Gibraltar Range where it grows in swamp-heath on sandy soils (Harden 1993).	No
Darwinia biflora	V	V	2Va	Occurs from Cheltenham to Hawkesbury River where it grows in heath on sandstone or in the understorey of woodland on shale-capped ridges (Harden 2002).	No
Darwinia fascicularis ssp oligantha	E2			Occurs in the higher parts of the Blue Mountains where it grows in heath on shallow soils (Harden 2002).	No
Darwinia peduncularis	V		3Ri	Occurs from Hornsby to Hawkesbury River and west to Glen Davies where it grows in dry sclerophyll forest on sandstone hillsides and ridges (Harden 2002). Known to occur along watercourses (Benson 2001).	No

Scientific Name (Common Name)	TSC Act[1]	EPBC Act[2]	ROTAP[3]	Preferred Habitat	Likely to occur within site
Dillwynia tenuifolia	V E2	V	2Vi	Occurs on the Cumberland Plain from the Blue Mountains to Howes Valley area where it grows in dry sclerophyll woodland on sandstone, shale or laterite (Harden 2002). Specifically, occurs within Castlereagh woodlands, particularly in shale gravel transition forest. Associated species include Eucalyptus fibrosa, E. sclerophylla, Melaleuca decora, Daviesia ulicifolia, Dillwynia juniperina and Allocasuarina littoralis (James 1997).	No
Epacris purpurascens var purpurascens	V		2K	Occurs in Gosford and Sydney districts where it grows in sclerophyll forest, scrub and swamps (Harden 1992). Usually found in sites with a strong shale influence (NSW National Parks and Wildlife Service 2002a).	No
Eucalyptus camfieldii (Heart-leaved Stringybark)	V	V	2Vi	Occurs from Tomago to the Royal National Park where it grows in coastal shrub heath in sandy soils on sandstone (Harden 2002).	No
Grevillea parviflora	V/E*	V		Mainly for the prospect area (now extinct there) and lower Georges River to Camden, Appin and Cordeaux Dam area with a disjunct population near Putty, Cessnock and Cooranbong. Grows in heath or shrubby woodland in sandy or light clay soils usually over thin shales (Harden 2002; NSW Scientific Committee 1998a).	Recorded but not within footprint
Grevillea parviflora subsp *supplicans*	E			Has a very restricted distribution (approximately 8 by 10 km) and is confined to the north-west of Sydney near Arcadia and the Maroota Marramarra Creek area. It grows in heathy woodland on skeletal sandy soil over sandstone (NSW Scientific Committee 2000b). It is strongly associated with clay-capped ridged of the Lucas Heights and Faulconbridge soil landscapes, suggesting it has a preference for yellow clays with periodically impeded drainage. It may have an affinity with disturbance margins such as trail and road verges where soils are suitable and the availability of light due to clearing has promoted its growth. May be associated with the margins of the Sydney Turpentine Ironbark Forest endangered ecological community and, to a greater extent, with Shale/Sandstone Transition Forest endangered ecological community (Department of Environment and Conservation 2005b).	Recorded but not within footprint
Hibbertia superans	E			Occurs from Castle Hill to South Maroota where it grows in ridgetop woodlands usually near Shale/Sandstone Transition Forest. It is often associated with other threatened flora including *Pimelea curviflora* var. *curviflora*, *Darwinia biflora*, *Epacris purpurascens* var. *purpurascens*, *Leucopogon fletcheri* subsp. *f*letcheri, Acacia bynoeana, Eucalyptus sp. Cattai and *Persoonia hirsuta* (NSW Scientific Committee, 2001).	No
Kunzea rupestris	V	V	2Va	Only known to occur between Glenorie and Maroota where it grows in heath on rock platforms (Harden 2002).	No
Lasiopetalum joyceae	V	V	2R	Occurs on lateritic to shaley ridgetops of the Hornsby Plateau where it grows in heath and open woodland in sandy soils on sandstone (Fairley & Moore 2002; Harden 2000; NSW Scientific Committee 1999a).	No
Leptospermum deanei	V	V	2V	Only occurs near the watershed of Lane Cove River where it grows on forested slopes (Harden 2002).	No
Leucopogon fletcheri ssp fletcheri	E1		2R	Occurs in the Springwood area where it grows in woodland on lateritic soils (Harden 1992).	No
Melaleuca deanei	V	V	3R	Occurs in coastal districts from Berowra to Nowra where it grows in wet heath on sandstone (Harden 2002).	No

Scientific Name (Common Name)	TSC Act[1]	EPBC Act[2]	ROTAP[3]	Preferred Habitat	Likely to occur within site
Micromyrtus blakelyi	V	V	2V	Restricted to areas near the Hawkesbury River where it grows in heath in depressions on sandstone rock platforms (Harden 2002).	No
Olearia cordata	V	V	2Ra	Occurs chiefly from Wiseman's Ferry to Wollombi where it grows on sandstone in dry sclerophyll forest and open shrubland (Harden 1992).	No
Persoonia hirsuta	E1	E	3Ki	Occurs in central coast and central tableland districts where it grows in woodland to dry sclerophyll forest on sandstone (Harden 2002) and rarely shale (NSW Scientific Committee 1998c). Often occurs in areas with clay influence, in the ecotone between shale and sandstone (James 1997).	No. Although suitable habitat present, this species was not recorded within site during targeted surveys
Pilularia novae-hollandiae (Austral Pillwort)	E1			Grows in seasonally dry depressions and margins of marshes and may grow submerged (Harden 2000).	No
Pimelea curviflora var *curviflora*	V	V		Confined to coastal areas around Sydney where it grows on sandstone (Harden 2000) and laterite soils (NSW Scientific Committee 1998b). Usually occurs in woodland in the transition between shale and sandstone (James et al. 1999).	No. Although suitable habitat present, this species was not recorded within site during targeted surveys
Pomaderris brunnea	V	V	2V	Confined to the Colo and Upper Nepean Rivers where it grows in open forest (Harden 2000).	No
Tetratheca glandulosa	V	V	2V	Occurs from Mangrove Mountain to the Blue Mountains where it grows in sandy or rocky heath or scrub (Harden 1992).	Recorded
Zieria involucrata	E1	V	2Va	Occurs in the Blue Mountains where it grows in wet sclerophyll forest (Harden 2002).	No

Notes:
1. V= Vulnerable, E1 = Endangered; E2= Endangered Population, E4 = Extinct; * two supspecies listed (Threatened Species Conservation Act 1995);
2. V = Vulnerable, E = Endangered (Environment Protection and Biodiversity, X = Extinct Conservation Act 1999)
3. ROTAP (Rare or Threatened Australian Plants, Briggs and Leigh 1996) is a conservation rating for Australian plants. Codes are:
   - 1 Species only known from one collection
   - 2 Species with a geographic range of less than 100km in Australia
   - 3 Species with a geographic range of more than 100km in Australia
   - X Species presumed extinct; no new collections for at least 50 years
   - E Endangered species at risk of disappearing from the wild state if present land use and other causal factors continue to operate
   - V Vulnerable species at risk of long-term disappearance through continued depletion.
   - R Rare, but not currently considered to be endangered.
   - K Poorly known species that are suspected to be threatened.
   - C Known to be represented within a conserved area.
   - a At least 1,000 plants are known to occur within a conservation reserve(s).
   - i Less than 1,000 plants are known to occur within a conservation reserve(s).
   - - The reserved population size is unknown.
   - t The total known population is reserved.
   - + The species has a natural occurrence overseas.

Appendix E

Threatened and migratory species of animal in the local area

This appendix details the threatened and migratory species of animal that have either been recorded in the local area or that have the potential to occur based on the NSW Atlas of NSW Wildlife and the EPBC Online Database.

Latin Name	Common Name	TSC Act[1]	EPBC Act[2]	Habitat	Likely to occur within site
Amphibians					
Heleioporus australiacus	Giant Burrowing Frog	V	V	In the northern population there is a marked preference for sandstone ridgetop habitat and broader upland valleys. In these locations the frog is associated with small headwater creeklines and along slow flowing to intermittent creeklines. The vegetation is typically woodland, open woodland and heath and may be associated with 'hanging swamp' seepage lines and where small pools form from the collected water. In the southern population, records from Narooma, Bega, Bombala and eastern Victoria appear to be associated with Devonian igneous and sedimentary formations and Ordovician metamorphics and are generally from more heavily timbered areas. Breed in summer and autumn in burrows in the banks of small creeks (Cogger 2000; NSW National Parks and Wildlife Service 2001a).	No
Litoria aurea	Green and Golden Bell Frog	E1	V	The Green and Golden Bell Frog inhabits marshes, dams and stream sides, particularly those containing bullrushes Typha spp. or spikerushes Eleocharis spp. Optimum habitat includes water bodies which are unshaded, free of predatory fish Gambusia holbrooki, have a grassy area nearby and diurnal sheltering sites available such as vegetation and/or rocks (NSW National Parks and Wildlife Service 1999h).	No
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Distributed along the eastern slopes of the Great Dividing Range from Watagan State Forest near Wyong, south to Buchan in north-eastern Victoria. It occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops. It appears to be restricted to mid to high altitude. It forages both in the tree canopy and on the ground, and it has been observed sheltering under rocks on high exposed ridges during summer. It is not known from coastal habitats (NSW Scientific Committee 2000a).	No
Mixophyes balbus	Stuttering Frog	E1	V	Terrestrial species, found in rainforest, Antarctic beech forest or wet sclerophyll forest. The species depends on freshwater streams and riparian vegetation for breeding and habitation. No records are known from riparian habitat that has been disturbed (Cogger 2000; NSW Scientific Committee 2003).	No
Mixophyes iteratus	Giant Barred Frog	E1	E	Terrestrial species which occurs in rainforests, antarctic beech or wet sclerophyll forests. Feeds on insects and smaller frogs (Cogger 2000). The species is associated with permanent flowing drainages, from shallow rocky rainforest streams to slow-moving rivers in lowland open forest. It is not known to utilise still water areas (NSW Scientific Committee 1999b).	No
Pseudophryne australis	Red-crowned Toadlet	V		Occurs within 160 km of Sydney where it is restricted to Hawkesbury Sandstone. It breeds in deep grass and debris adjacent to ephemeral drainage lines. When not breeding individuals are found scattered on sandstone ridges under rocks and logs (Cogger 2000).	No

Latin Name	Common Name	TSC Act[1]	EPBC Act[2]	Habitat	Likely to occur within site
Native Birds					
Botaurus poiciloptilus	Australasian Bittern	V		Occurs in shallow, vegetated freshwater or brackish swamps. When breeding, pairs are found in areas with a mixture of tall and short sedges but will also feed in more open territory (Garnett & Crowley 2000).	No
Calyptorhynchus lathami	Glossy Black-cockatoo	V		Occurs in eucalypt woodland and forest with Casuarina/Allocasuarina spp. Characteristically inhabits forests on sites with low soil nutrient status, reflecting the distribution of key Allocasuarina species. The drier forest types with intact and less rugged landscapes are preferred by the species. Nests in tree hollows (Garnett & Crowley 2000; NSW National Parks and Wildlife Service 1999g).	Yes- foraging area. Impact assessment conducted (refer to *Appendix F*)
Climacteris picumnus	Brown Treecreeper	V		Occurs in eucalypt woodland and adjoining vegetation. Feeds on ants, beetles and larvae on trees and from fallen timber and leaf litter. Usually nests in hollows (Garnett & Crowley 2000).	Yes- foraging area. Impact assessment conducted (refer to *Appendix F*)
Haliaeetus leucogaster	White-bellied Sea-Eagle		M	Occurs in coastal areas including islands, estuaries, inlets, large rivers, inland lakes and reservoirs. Builds a huge nest of sticks in tall trees near water, on the ground on islands or on remote coastal cliffs (Pizzey & Knight 1997).	Flyover area No suitable habitat present on site.
Hirundapus caudacutus	White-throated Needletail		M	Occurs in airspace over forests, woodlands, farmlands, plains, lakes, coasts and towns. Breeds in the northern hemisphere and migrates to Australia in October-April (Pizzey & Knight 1997).	Flyover area No suitable habitat present on site.
Ixobrychus flavicollis	Black Bittern	V		Occurs in vegetated wetlands and feeds on aquatic fauna along streams, in estuaries and beside billabongs and pools. It nests in trees (Garnett & Crowley 2000).	No
Lathamus discolor	Swift Parrot	E1	EM	Occur in eucalypt forests and woodlands, particularly in box-ironbark forests. Prefer sites with flowering Acacia pycnantha or highly fertile soils where large trees have high nectar production (including drainage lines and isolated trees in rural or urban landscapes). Breeding occurs in Tasmania (Garnett & Crowley 2000).	No
Melithreptus gularis gularis	Black-chinned Honeyeater	V		Found in dry eucalypt woodland particularly those containing ironbark and box. Occurs within areas of annual rainfall between 400-700 mm. Feed on insects, nectar and lerps (Garnett & Crowley 2000).	No
Monarcha melanopsis	Black-faced Monarch		M	Occurs in rainforests, eucalypt woodlands, coastal scrubs, damp gullies in rainforest, eucalypt forest and in more open woodland when migrating (Pizzey & Knight 1997).	No
Myiagra cyanoleuca	Satin Flycatcher		M	Occurs in heavily vegetated gullies, in forests and taller woodlands. During migration it is found in coastal forests, woodlands, mangroves, trees in open country and gardens (Pizzey & Knight 1997).	No
Neophema pulchella	Turquoise Parrot	V		Occurs in the foothills of the great dividing range in eucalypt woodlands and forests with a grassy or sparsely shrubby understorey. Nests in hollows in trees, stumps or even fence posts. It feeds on seeds of both native and introduced grass and herb species (Garnett & Crowley 2000).	No

Latin Name	Common Name	TSC Act[1]	EPBC Act[2]	Habitat	Likely to occur within site
Ninox connivens	Barking Owl	V		Occurs in dry sclerophyll woodland. In the south west it is often associated with riparian vegetation while in the south east it generally occurs on forest edges. It nests in large hollows in live eucalypts, often near open country. It feeds on insects in the non-breeding season and on birds and mammals in the breeding season (Garnett & Crowley 2000).	Yes-impact assessment conducted (refer to *Appendix F*)
Ninox strenua	Powerful Owl	V		A sedentary species with a home range of approximately 1000 hectares it occurs within open eucalypt, casuarina or callitris pine forest and woodland. It often roosts in denser vegetation including rainforest of exotic pine plantations. Generally feeds on medium-sized mammals such as possums and gliders but will also eat birds, flying-foxes, rats and insects. Prey are generally hollow dwelling and require a shrub layer and owls are more often found in areas with more old trees and hollows than average stands (Garnett & Crowley 2000).	Yes-impact assessment conducted (refer to *Appendix F*)
Pandion haliaetus	Osprey	V	M	A coastal species it occurs in estuaries, bays, inlets, islands and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Sometimes ascends larger rivers and far inland. Builds nests high in tree, on pylon or on ground on islands. Feeds on fish (Pizzey & Knight 1997).	Flyover area No suitable habitat present on site.
Pyrrholaemus sagittata	Speckled Warbler	V		Occurs in a wide range of eucalypt dominated vegetation with a grassy understorey and is often found on rocky ridges or in gullies. It feeds on seeds and insects and builds domed nests on the ground (Garnett & Crowley 2000).	No
Rhipidura rufifrons	Rufous Fantail		M	Occurs in a range of habitats including the undergrowth of rainforests/wetter eucalypt forests/gullies, monsoon forests paperbarks, sub-inland and coastal scrubs, mangroves, watercourses, parks and gardens. When migrating they may also be recorded on farms streets and buildings. Migrates to SE Australia in October-April to breed, mostly in or on the coastal side of the Great Dividing Range (Pizzey & Knight 1997).	No
Rostratula benghalensis	Painted Snipe	E	VM	Inhabits shallow, vegetated, temporary or infrequently filled wetlands, including where there are trees such as Eucalyptus camaldulensis (River Red Gum), E. populnea (Poplar Box) or shrubs such as Muehlenbeckia florulenta (Lignum) or Sarcocornia quinqueflora (Samphire). Feeds at the water's edge and on mudlflats on seeds and invertebrates, including insects, worms, molluscs and crustaceans. Males incubate eggs in a shallow scrape nest (Garnett & Crowley 2000).	No
Stictonetta naevosa	Freckled Duck	V	M	In most years this species appear to be nomadic between ephemeral inland wetlands. In dry years they congregate on permanent wetlands while in wet years they breed prolifically and disperse widely, generally towards the coast. In inland eastern Australia, they generally occur in brackish to hyposaline wetlands that are densely vegetated with Lignum (Muehlenbeckia cunninghamii) within which they build their nests (Garnett & Crowley 2000).	No

Latin Name	Common Name	TSC Act[1]	EPBC Act[2]	Habitat	Likely to occur within site
Tyto novaehollandiae	Masked Owl	V		Occurs within a diverse range of wooded habitats including forests, remnants and almost treeless inland plains. This species requires large-hollow bearing trees for roosting and nesting and nearby open areas for foraging. They typically prey on terrestrial mammals including rodents and marsupials but will also take other species opportunistically. Also known to occasionally roost and nest in caves (Garnett & Crowley 2000).	Yes-impact assessment conducted (refer to *Appendix F*)
Tyto tenebricosa	Sooty Owl	V		Occurs in wet eucalypt forest and rainforest on fertile soils with tall emergent trees. Typically found in old growth forest with a dense understorey but also occurs in younger forests if nesting trees are present nearby. It nests in large hollows within eucalypts and occasionally caves. It hunts in open and closed forest for a range of arboreal and terrestrial mammals including introduced species and sometimes birds (Garnett & Crowley 2000).	Yes-impact assessment conducted (refer to *Appendix F*)
Xanthomyza phrygia	Regent Honeyeater	E1	EM	Occur mostly in box-ironbark forests and woodland and prefer the wet, fertile sites such as along creek flats, broad river valleys and foothills. Riparian forests with Casuarina cunninghamiana and Amyema cambagei are important for feeding and breeding. Important food trees include Eucalyptus sideroxylon (Mugga Ironbark), E. albens (White Box) , E. melliodora (Yellow Box) and E. leucoxylon (Yellow Gum). This species usually lays 2-3 eggs in cup nests (Garnett & Crowley 2000).	No
Native Mammals					
Cercartetus nanus	Eastern Pygmy-possum	V		Found in a range of habitats from rainforest through sclerophyll forest to tree heath. It feeds largely on the nectar and pollen of banksias, eucalypts and bottlebrushes and sometimes soft fruits. It nests in very small tree holes, between the wood and bark of a tree, abandoned birds nests and shredded bark in the fork of trees (Turner & Ward 1995).	No
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Occurs in moderately wooded habitats and roosts in caves, mine tunnels and the abandoned, bottle-shaped mud nests of Fairy Martins. Thought to forage below the forest canopy for small flying insects (Churchill 1998).	Yes-impact assessment conducted (refer to *Appendix F*)
Dasyurus maculatus	Spotted-tailed Quoll	V	E	Occurs in sclerophyll forests and rainforests. Nests in rock caves and hollow logs or trees. Feeds on a variety of prey including birds, terrestrial and arboreal mammals, small macropods, reptiles and arthropods (NSW National Parks and Wildlife Service 1999d).	No
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V		Usually roosts in tree hollows in higher rainfall forests. Sometimes found in caves (Jenolan area) and abandoned buildings (Churchill 1998).	No
Isoodon obesulus	Southern Brown Bandicoot	E1	E	Occurs in a variety of habitats in south-eastern Australia, including heathland, shrubland, dry sclerophyll forest with heathy understorey, sedgeland and woodland. Many of the habitats are prone to fire (NSW National Parks and Wildlife Service 1999c).	No
Miniopterus schreibersii	Common Bent-wing Bat	V	C	Usually found in well timbered valleys where it forages on small insects above the canopy. Roosts in caves, old mines, stormwater channels and sometimes buildings and often return to a particular nursery cave each year (Churchill 1998).	No

Latin Name	Common Name	TSC Act[1]	EPBC Act[2]	Habitat	Likely to occur within site
Mormopterus norfolkensis	East Coast Freetail Bat	V		Thought to live in sclerophyll forest and woodland. Small colonies have been found in tree hollows or under loose bark. It feeds on insects above the forest canopy or in clearings at the forest edge (Churchill 1998).	Yes-impact assessment conducted (refer to *Appendix F*)
Myotis adversus	Large-footed Myotis	V		Colonies occur in caves, mines, tunnels, under bridges and buildings. Colonies always occur close to bodies of water where this species feeds on aquatic insects (Churchill 1998).	Yes-impact assessment conducted (refer to *Appendix F*)
Petaurus australis	Yellow-bellied Glider	V		Restricted to tall, mature eucalypt forest in high rainfall areas of temperate to sub-tropical eastern Australia. Feeds on nectar, pollen, the sap of eucalypts and sometimes insects. Preferred habitats are productive, tall open sclerophyll forests where mature trees provide helter and nesting hollows and year round food resources are available from a mixture of eucalypt species (NSW National Parks and Wildlife Service 1999b, 2003a).	No
Petaurus norfolcensis	Squirrel Glider	V		Found in dry sclerophyll forest and woodland but not found in dense coastal ranges. Nests in hollows and feeds on gum of acacias, eucalypt sap and invertebrates (NSW National Parks and Wildlife Service 1999f).	No
Petrogale penicillata	Brush-tailed Rock-wallaby	E1	V	Occurs in inland and sub-coastal south eastern Australia where it inhabits rock slopes. It has a preference for rocks which receive sunlight for a considerable part of the day. Windblown caves, rock cracks or tumbled boulders are used for shelter. Occur in small groups or 'colonies' each usually separated by hundreds of metres (NSW National Parks and Wildlife Service 2003b).	No
Phascogale tapoatafa	Brush-tailed Phascogale	V		Largely arboreal it occurs in a range of habitats which have reliable rainfall (500-2000mm), but has preference for open dry sclerophyll forest on ridges (up to 600 m alt) with little/sparse ground cover. It nests in tree hollows and feeds at dusk on arthropods and small vertebrates (Strahan 1995).	No
Phascolarctos cinereus	Koala	V		Found in sclerophyll forest. Throughout New South Wales, Koalas have been observed to feed on the leaves of approximately 70 species of eucalypt and 30 non-eucalypt species. However, in any one area, Koalas will feed almost exclusively on a small number of preferred species. The preferred tree species vary widely on a regional and local basis. Some preferred species in NSW include Forest Red Gum Eucalyptus tereticornis, Grey Gum E. punctata, Monkey Gum E. cypellocarpa and Ribbon Gum E. viminalis. In coastal areas, Tallowwood E. microcorys and Swamp Mahogany E. robusta are important food species, while in inland areas White Box E. albens, Bimble Box E. populnea and River Red Gum E. camaldulensis are favoured (NSW National Parks and Wildlife Service 1999a, 2003c).	No
Potorous tridactylus	Long-nosed Potoroo	V	V	It occurs within coastal heath and sclerophyll forests generally in areas with rainfall greater than 760 mm. Relatively thick ground cover is a major habitat requirement and it seems to prefer areas with light sandy soils. Feeds at dusk on roots, tubers, fungi, insects and their larvae and other soft bodied animals in the soil (Johnston 1995).	No

Latin Name	Common Name	TSC Act[1]	EPBC Act[2]	Habitat	Likely to occur within site
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps. Urban gardens and cultivated fruit crops also provide habitat for this species. Feeds on the flowers and nectar of eucalypts and native fruits including lilly pillies. It roosts in the branches of large trees in forests or mangroves (Churchill 1998; NSW National Parks and Wildlife Service 2001b).	No
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	V		Occurs in eucalypt forest where it feeds above the canopy and in mallee or open country where it feeds closer to the ground. Generally a solitary species but sometimes found in colonies of up to 10. It roosts in tree hollows. Thought to be a migratory species (Churchill 1998).	Yes-impact assessment conducted (refer to *Appendix F*)
Reptiles					
Hoplocephalus bungaroides	Broad-headed Snake	E1	V	A nocturnal species that occurs in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they generally use rock crevices and exfoliating rock during the cooler months and tree hollows during summer (Webb, J.K. & Shine 1994; Webb, J.K & Shine 1998).	No
Varanus rosenbergi	Heath Monitor	V		Found in coastal heaths, humid woodlands, wet and dry sclerophyll forests. Mostly a terrestrial species it shelters in burrows, hollow logs and rock crevices (Cogger 2000).	No

Notes:
1. V= Vulnerable, E1 = Endangered (Threatened Species Conservation Act 1995)
2. V = Vulnerable, E = Endangered, M = Migratory, C = Conservation Dependent (Environment Protection and Biodiversity Conservation Act 1999).
3. Actual is taken to be when the species is recorded on site. Likely is when there is a real chance or probability of the species occurring based on the habitat present.

Appendix F

Impact significance assessments

For threatened biodiversity listed under the *Threatened Species Conservation Act 1995*, this appendix details the heads of consideration for Threatened species assessment as suggested in the Department of Environment and Climate Change/ Department of Primary Industries draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation 2005a). The guidelines present methods to consider the impacts on biodiversity of projects assessed under Part 3A of *the Environmental Planning and Assessment Act 1979*, including presenting heads of consideration for determining the significance of impacts.

For threatened biodiversity listed under the *Environment Protection and Biodiversity Conservation Act 1999* significance assessment have been completed in accordance with the *EPBC Act* Significant Impact Guidelines (Department of the Environment and Heritage 2006).

Threatened biodiversity listed under both the *Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999* have been assessed using both assessment guidelines separately.

Table F-1 provides a summary of the threatened biodiversity for which significance assessments were completed. The following groups of species were assessed in groups because of their similarity of habitats, habits and potential impacts:

- Microchiropteran bats
- Nocturnal birds.

Table F-1 Summary of significance assessments completed

Name	TSC Act[1]	EPBC Act[2]	Likely significant impact
Endangered Ecological Communities			
Shale Sandstone Transition Forest	E	E	No
Threatened plants			
Tetratheca glandulosa	V	V	No
Grevillea parviflora	V/E*	V	No
Threatened animals			
East Coast Freetail Bat – *Mormopterus norfolkensis*	V		No
Common Bent-wing Bat – *Miniopterus schreibersii*	V	CD	No
Large-eared Pied Bat – *Chalinobus dwyeri*	V	V	No
Large-footed Myotis – *Myotis adversus*	V		No
Yellow-bellied Sheathtail Bat - *Saccolaimus flaviventris*	V		No
Masked Owl – *Tyto novaehollandiae*	V		No
Powerful Owl – *Ninox strenua*	V		No
Barking Owl – *Ninox connivens*	V		No
Glossy Black-cockatoo – *Calyptorhynchus lathami*	V		No
Brown Treecreeper – *Climacteris picumnus*	V		No

Notes: 1.V= Vulnerable, E1 = Endangered species, E2 = Endangered population, E* = 2 subspecies listed (*Threatened Species Conservation Act 1995*)

2. V = Vulnerable, E = Endangered (*Environment Protection and Biodiversity Conservation Act 1999*)

Shale Sandstone Transition Forest

Shale Sandstone Transition Forest occurred as three remnants of open forest in the central section of the site near the former Trigonometrical Reserve (*Photograph 1*) and within DP223323. Only two of these would be cleared. This community is listed as endangered under both the *TSC* and *EPBC Acts.*

The canopy consisted of *Eucalyptus eugenioides, E. punctata, E. resinifera, Angophora costata, E. gummifera, E. globoidea* and *Syncarpia glomulifera.* The shrub layer was regenerating following a fire in December 2002 and included *Acacia parramattensis, Oxylobium ulicifolium, Gompholobium latifolium, Bossiaea lenticularis, Ceratopetalum gummiferum, Telopea speciosissima, Lomatia silaifolia, Xylomelum pyriforme, Boronia pinnata* and *Boronia ledifolia*. Ground cover was dominated by native grasses and herbs such as *Lomandra longifolia* and *Themeda australis.*

The remnants were small (1.0, 2.6 and 3.7 hectares), narrow and had a high edge to area ratio. The remnants were almost entirely subject to edge effects such as weed invasion. Weeds in this community include the noxious Bridal Creeper, Small-leaved Privet, Prickly Pear and Blackberry. The remnants were in poor to moderate condition.

Environmental Planning and Assessment Act 1979

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposed sand mine expansion will remove two isolated remnant patches of shale sandstone transition forest totalling 5.2 hectares. These patches are surrounded by current sandmining activities and cleared land. Small patches of shale sandstone transition forest occur in the vicinity of the remnants to be removed although these are also isolated by tracks and mining activities.

Prior to European settlement Shale Sandstone Transition Forest was extensive at the edges of the Cumberland Plain and covered approximately 43,990 hectares. It has been extensively cleared and has been reduced to approximately 22.6% of its original extent.

Approximately 5.2 hectares of this community would be removed as part of the proposed sand mine expansion. This corresponds to less than 0.04% of the current distribution of this community.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Shale Sandstone Transition forest exists on the outskirts of metropolitan Sydney, from Parramatta to Richmond, to Picton and Liverpool (DEH, 2005). It is not at the limit of its known distribution.

How is the proposal likely to affect current disturbance regimes?

The Shale Sandstone Transition Forest ecological community in the study area is highly fragmented and subject to a range of edge effects and a modified disturbance regime. The proposal is likely to increase disturbance regimes slightly. No new disturbance regimes will be introduced (Table F-2).

Table F-2: Threats to *Shale Sandstone Transition Forest*

Threat	Key Threatening Process	Development likely to increase threat
Clearing of native vegetation	Yes	Yes
Physical damage from recreational activities	No	No
Rubbish Dumping	No	No
Grazing	No	No
Mowing	No	No
Invasion of native plant communities by exotic perennial grasses	Yes	No
Ecological consequences of high frequency fires. In particular fire control activities such as frequent prescribed burning and mechanical fuel reduction.	Yes	No
Weed invasion	Invasion by vines and scramblers is listed Invasion by exotic perennial grasses is listed Invasion by Lantana camara has a preliminary listing	No
Habitat fragmentation	No	No

How is the proposal likely to affect habitat connectivity?

Patches in the vicinity occur approximately 50 metres to the west, 200 metres to the east and south west. The proposed development will not isolate currently interconnecting areas of habitat.

How is the proposal likely to affect critical habitat?

The Director-General of the Department of Environment and Climate Change maintains a register of critical habitat. No critical habitat has been listed for Shale Sandstone Transition Forest.

Conclusion

The proposed mine expansion will result in the clearing of 5.2 hectares of shale Sandstone Transition Forest. These impacts are unlikely to result in significant impact on the ecological community that would threaten its long term survival in the locality.

Mitigation measures will be implemented to rehabilitate the habitats and offset the loss of all mature trees.

Environment Protection and Biodiversity Conservation Act 1999

Is the action likely to reduce the extent of a community?

The proposed development will remove two remnants totalling 5.2 hectares of Shale Sandstone Transition Forest.

Is the action likely to fragment an occurrence of the community?

The proposed sand mine expansion will remove two remnants of Shale Sandstone Transition Forest., totalling 5.2 hectares. These remnants are isolated and are surrounded by current sandmining activities and cleared land. Small patches of shale sandstone transition forest occur in the vicinity of the patch to be removed although these are isolated by existing tracks and mining activities. Patches in the vicinity occur approximately 50 metres to the west, 200 metres to the east and south west. The action will not result in further fragmentation of the community.

Is the action likely to adversely affect habitat critical to the survival of an ecological community?

The proposed sand mine expansion will remove two remnants of 5.2 hectares of Shale Sandstone Transition Forest. This patch is isolated and is surrounded on all sides by current sandmining activities and almost the entire remnant is subject to edge effects. This remnant is unlikely to be viable in the long term without revegetation of adjacent areas with locally indigenous species. It is not considered to be critical to the survival of the community.

Is the action likely to modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for the community's survival?

The proposed sand mine expansion will remove two remnant patches of Shale Sandstone Transition Forest totalling 5.2 hectares and destroy the abiotic factors necessary for the community's survival within the site. Nearby locations of this community would not be impacted by the proposal.

Is the action likely to result in invasive species that are harmful to the critically endangered or endangered community becoming established in an occurrence of the community?

The proposed development will remove an entire remnant of isolated shale sandstone transition forest. Other remnants within the vicinity are small and occur on the edge of sandmining activities. The proposed development is unlikely to increase the occurrence of invasive species within any remnants of this community.

Is the action likely to interfere with the recovery of an ecological community?

The proposed sand mine expansion will remove two remnant patches of Shale Sandstone Transition Forest totalling 5.2 hectares. These remnants are isolated and surrounded by current sandmining activities and cleared land. These remnants are almost entirely subject to edge effects. This remnant is unlikely to be viable in the long term without revegetation of adjacent areas with locally indigenous species. The removal of this remnant is unlikely to significantly interfere with the recovery of this community.

Conclusion

The remnant of Shale Sandstone Transition Forest within the development footprint is small (5.2 hectares), isolated, has a large edge to area ratio and is almost entirely subject to edge effects including weed invasion. The removal of this remnant is unlikely to have a significant impact on the recovery of this community.

Tetratheca glandulosa

Tetratheca glandulosa is listed as a Vulnerable species under both the *TSC* and *EPBC Acts*. It was recorded within Sydney Sandstone Ridgetop Woodland in the southern section of the site. A total of 43 plants were recorded across seven locations of which five will be affected.

Tetratheca glandulosa is a small spreading shrub to 20 centimetres high. It has small linear leaves (3-20 millimetres long and 1-2 millimetres wide) with recurved (rolled under) margins and stiff hairs along the margins (appearing toothed). Leaf position varies (Royal Botanic Gardens 2006), however, individuals within the site generally have leaves opposite or in whorls of three.

Flowering occurs mostly in July to November but flowers may persist until December. Flowering time varies between years and is influenced by weather as well as local site characteristics. Flowers are solitary or paired (rarely), and have four lilac-pink petals (Royal Botanic Gardens 2006).

This species produces wedge-shaped flattened fruit generally containing two brownish-whitish seeds. Flower petals are persistent and surround the fruit (NSW National Parks and Wildlife Service 2000b).

Very little is known about the ecology of this species. Pollination and seed bank dynamics are unknown. Juveniles appear to be uncommon and this species is thought to clonal. *Tetratheca* spp. can be propagated with cuttings; however, the long term survival of these clones is unknown.

Following fire, *Tetratheca glandulosa* is thought to resprout. The role of fire in germination is unknown. Previously this species was estimated to have a life span of six to ten years, however, this is likely to be an underestimate as it did not take into account its ability to resprout following fire.

Environmental Planning and Assessment Act 1979

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

This species was recorded at seven locations within the study area, five of these would be removed by the proposed development, consisting of approximately 40 plants spread across the locations. Populations of less than 20 plants are considered to be small while strongholds of this species contain more than 200 plants (NSW National Parks and Wildlife Service 2000b).

Given the small number of plants within each location and the isolation of these locations from each other, the study area, it is unlikely that the population within them would be viable in the long term. The loss of approximately 40 plants is not likely to affect the lifecycle of the remaining populations.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Most of the proposed mine expansion is within previously cleared or highly modified areas, however it also includes two areas of native vegetation that provide habitat for this species. The habitat to be removed is adjacent to areas which have been previously cleared and is unlikely to result in further isolation of habitat.

Given the extent of reservation within the region and the small number of plants present within the study area, the habitat to be removed is considered to be of low importance for the long-term survival of the species.

Tetratheca glandulosa is restricted to the Central Coast bioregion. Habitat for this species is sandy or rocky heath, scrub (Harden 1992) or woodlands. Broadly, this species occurs within Sydney Sandstone Ridgetop Woodland (NSW National Parks and Wildlife Service 2000b). This community is well represented in conservation reserves throughout the range of this species and approximately 90 populations have been recorded within conservation reserves. The removal of 5.4 hectares of habitat is not considered to be a significant area.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Tetratheca glandulosa is known to occur in the Hawkesbury/Napean catchment, the Hunter/Central Rivers catchment, and in Cumberland and Pittwater sub-regions of the Sydney Metropolitan catchment area. This species is not at the limit of its known distribution.

How is the proposal likely to affect current disturbance regimes?

The patches of potential habitats for *T. glandulosa* in the study area are highly fragmented and subject to a range of edge effects as a result of past land uses and clearing patters that would have modified the natural disturbance regime.

While the proposal is likely to increase disturbance regimes slightly, no new disturbance regimes will be introduced (Table F-3).

Table F-3: Threats to *Tetratheca glandulosa* (NSW National Parks and Wildlife Service 2000b)

Threat	Key Threatening Process	Development likely to increase threat
Clearing of native vegetation	Yes	Yes
Invasion of native plant communities by exotic perennial grasses	Yes	No
Ecological consequences of high frequency fires. In particular fire control activities such as frequent prescribed burning and mechanical fuel reduction.	Yes	No
Construction and maintenance of fire access tracks	No	No
Maintenance of transmission line easements	No	No
Habitat fragmentation	No	No

How is the proposal likely to affect habitat connectivity?

The small areas of potential habitats for *Tetratheca glandulosa* that will be cleared are unlikely to cause a further decrease in connectivity in the already fragmented local populations. The project is unlikely to create a barrier to the ecological processes occurring in this community such as pollination and/or seed dispersal by birds, mammals or insects.

How is the proposal likely to affect critical habitat?

The Director-General of the Department of Environment and Climate Change maintains a register of critical habitat. No critical habitat has been listed for *Tetratheca glandulosa*. The populations to be removed are small (generally less than 20 plants) and are unlikely to be critical to the survival of this species.

Conclusion

The proposed development involves the clearing of 5.4 hectares of habitat and the disturbance to plants at five out of seven locations within the study area, consisting approximately 40 *Tetratheca glandulosa* plants. The site is not at the limit of distribution for *Tetratheca glandulosa.* This species is well represented within conservation reserves across its range including stronghold

populations and populations at the limit of distribution. The removal of 5.4 hectares of habitat and 40 plants is unlikely to significantly interfere with the recovery of the species.

Environment Protection and Biodiversity Conservation Act 1999

Important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity; and/or
- at or near the limit of the species range.

Tetratheca glandulosa occurring within the site is not considered to be an important population because it is not likely to be a key source population, unlikely to be necessary for maintaining genetic diversity and is not at the limit of the species range. Populations of less than 20 plants are considered to be small while strongholds of this species contain more than 200 plants (NSW National Parks and Wildlife Service 2000b).

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

The site is not considered to contain an important population.

Is the action likely to reduce the area of occupancy of an important population?

The population within the site is not considered to be an important population.

Is the action likely to fragment an existing important population into two or more populations?

The site is not considered to contain an important population.

Is the action likely to adversely affect habitat critical to the survival of a species?

The proposed development will remove approximately 5.4 hectares of habitat for this species. Forty *Tetratheca glandulosa* plants were recorded within the development footprint during the current survey. Populations of less than 20 plants are considered to be small while strongholds of this species contain more than 200 plants (NSW National Parks and Wildlife Service 2000b). The population within the site is relatively small, is not a stronghold for this species and is not likely to be critical to the survival of this species.

The habitat within the site is not considered to be critical to the survival of this species.

Is the action likely to disrupt the breeding cycle of an important population?

The site is not considered to contain an important population.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The proposed development will remove approximately 5.4 hectares of habitat for this species. This will result in the removal of approximately 40 plants. This is unlikely to result in the overall decline of the species.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

The proposed development is likely to increase edge effects and also weed invasion in areas of habitat for this species. However, the proposal is largely restricted areas that have already been cleared, are adjacent to existing cleared land or have a high degree of weed invasion. The increaser in weed invasion is therefore likely to be low.

Is the action likely to interfere substantially with the recovery of the species?

The proposed development involves the removal of five locations, consisting of up to 40 plants and 5.4 hectares of habitat for this species. Populations of less than twenty plants are considered to be small and a number of populations larger than 200 plants occur within region. The population within the site is relatively small, is not a stronghold for this species and is not likely to be critical to the survival of this species.

Conclusion

The proposed development involves the clearing of 5.4 hectares of habitat and the disturbance to plants at five out of seven locations within the study area, consisting of approximately 40 *Tetratheca glandulosa* plants. The site is not at the limit of distribution for *Tetratheca glandulosa.* This species is well represented within conservation reserves across its range including stronghold populations and populations at the limit of distribution. The removal of 5.4 hectares of habitat and 40 plants is unlikely to significantly interfere with the recovery of the species.

Grevillea parviflora

Grevillea parviflora is listed as a vulnerable species on the *EPBC Act.* Recent taxonomic revisions have identified two supspecies, both of which area listed under the *TSC Act. Grevillea parviflora* ssp. *parviflora* is listed as vulnerable and *Grevillea parviflora* ssp *supplicans* is listed as Endangered.

One individual of this species was recorded within the site. This individual could not be identified to subspecies level as it was not flowering at the time of the survey and positive identification requires flowering material. While most of the records of this species in the locality have been identified as the Endangered subspecies, some records have not been identified to this level. For the sake of this assessment, the individual recorded within the site is assumed to be the Endangered subspecies.

Although the individual recorded was outside the development footprint, impact assessments are provided below as a precaution.

Environmental Planning and Assessment Act 1979

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Grevillea parviflora ssp. *supplicans* has not been recorded within the development footprint despite targeted surveys. It is considered unlikely that this species would have remained undetected if a viable population were present within the footprint. One individual was recorded however it occurs outside the development footprint and is unlikely to be affected by the proposed development. The proposed development is unlikely to disrupt a viable population of this species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Grevillea parviflora ssp. *supplicans* has not been recorded within the development footprint despite targeted surveys. It is considered unlikely that this species would have remained undetected if a viable population were present within the footprint. One individual was recorded however it occurs outside the development footprint and is unlikely to be affected by the proposed development.

The potential habitat to be removed is unlikely to be important for the long term survival of this species.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Many records of this species occur within local conservation reserves including Marramarra Nature Reserve and habitat for this species is likely to be well represented in conservation reserves. The removal of 10.6 hectares of habitat is not considered to be a significant area.

Grevillea parviflora ssp *supplicans* is not at the limit of its known distribution.

How is the proposal likely to affect current disturbance regimes?

The patches of potential habitats for *Grevillea parviflora* ssp *supplicans* in the study area are highly fragmented and subject to a range of edge effects as a result of past land uses and clearing patters that would have modified the natural disturbance regime.

While the proposal is likely to increase disturbance regimes slightly, no new disturbance regimes will be introduced (Table F4).

Table F 4: Threats to *Grevillea parviflora* ssp. *supplicans (NSW Scientific Committee 2000b)*

Threat	Key Threatening Process	Development likely to increase threat
Clearing of native vegetation	Yes	Yes
Altered fire regime (increased frequency)	Yes	No
Fragmentation	No	No
Direct loss of plants	No	No
Road widening and maintenance works	No	Yes
Human-induced climate change	Yes	No
Maintenance of transmission line and gas pipeline easements	No	No
Legal or illegal bush rock removal	Yes	Yes
Rubbish dumping	No	No
Recreational activities, particularly trail bikes	No	No
Weed invasion	Invasion by vines and scramblers is listed	No, mitigation measures provided
	Invasion by exotic perennial grasses is listed	
	Invasion by Lantana camara is listed	

How is the proposal likely to affect habitat connectivity?

The proposed development will remove habitat that is on the edge of already cleared areas and will not result in isolation of currently interconnecting or proximate areas of habitat for this species.

How is the proposal likely to affect critical habitat?

The Director-General of the Department of Environment and Climate Change maintains a register of critical habitat. No critical habitat has been listed for *Grevillea parviflora* ssp. *supplicans.*

Conclusion

No individuals of *Grevillea parviflora* ssp. *supplicans* were identified in the study area. As such, no individuals of these species are likely to be directly or indirectly impacted by the proposal.

The proposal will however result in the clearing of a small area of suitable habitat for these species.

The clearing of a small area of potential habitat is unlikely affect current disturbance regimes, affect habitat connectivity or affect critical habitat or otherwise result in a significant impact to these species such that would threaten their long term survival in the locality.

Environment Protection and Biodiversity Conservation Act 1999

Important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity; and/or

- at or near the limit of the species range.

Only one individual was recorded within the site and this is not considered to be part of an important population.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

The site is not considered to contain an important population.

Is the action likely to reduce the area of occupancy of an important population?

The site is not considered to contain an important population.

Is the action likely to fragment an existing important population into two or more populations?

The site is not considered to contain an important population.

Is the action likely to adversely affect habitat critical to the survival of a species?

Only one individual was recorded within the site and does not occur within the development footprint. Although the proposed development will remove 10.6 hectares of potential habitat, this habitat within the site is not considered to be critical to the survival of this species.

Is the action likely to disrupt the breeding cycle of an important population?

The site is not considered to contain an important population.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Only one individual was recorded within the site and does not occur within the development footprint. Although the proposed development will remove 10.6 hectares of potential habitat, this habitat within the site is not considered to be critical to the survival of this species and is unlikely to result in a decline of the species.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

The proposed development is likely to increase edge effects and also weed invasion in areas of habitat for this species. However, the individual recorded occurs in close proximity to an existing track and is vulnerable to weed invasion. The proposal is unlikely to significantly increase the risk of weed invasion.

Is the action likely to interfere substantially with the recovery of the species?

Only one individual was recorded within the site and does not occur within the development footprint. Although the proposed development will remove 10.6 hectares of potential habitat, this habitat within the site is not considered to be critical to the survival of this species and is unlikely to substantially interfere with the recovery of the species.

Conclusion

Only one individual was recorded within the site in the vicinity of an existing track and is unlikely to be part of a viable population. This individual is not within the development footprint and as such this species is unlikely to be significantly affected by the proposed development.

Glossy Black-cockatoo *(Calyptorhynchus lathami)*

The Glossy Black-cockatoo is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

The Riverina population of Glossy Black-cockatoos is listed as Endangered under Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995*. The local population within the study area does not form part of this population and is consequently not listed as endangered.

The Glossy Black-cockatoo is a dusky brown to black cockatoo with a massive, bulbous bill and a broad, red band through the tail. The red in the tail is barred black and edged with yellow. The female usually has irregular pale-yellow markings on the head and neck and yellow flecks on the underparts and underwing. They are smaller than other black cockatoos (about 50 cm in length), with a smaller crest (Pizzey & Knight 1997).

The species forages arboreally among branches of fruiting Allocasuarina. Prefers mature, sparse trees, between 2 and 10 m tall; dense regrowth (e.g. after bushfire.) It rarely forages in other shrubs or small trees of low woodlands or understorey (Arnett & Pepper 1997).

The Glossy Black-cockatoo was recorded flying over the project site.

Environmental Planning and Assessment Act 1979

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Glossy Black-cockatoos mostly roost in the canopy of live, leafy trees; preferring eucalypt trees, but will use other species, usually a kilometre from feeding site and during breeding season, within 30 metres of nesting trees. Glossy Black-cockatoos feed exclusively on the seeds of mature *Allocasuarina* trees, occasionally taking wood-boring insect larvae, seeds of eucalypts, angophoras, hakeas and acacias (Higgins 1999).

Glossy Black-cockatoos are dependent on large hollow-bearing eucalypts for nest sites. One or two eggs are laid between March and August (Garnett et al. 1999).

The proposed development would clear 5.2 hectares of Shale Sandstone Transition Forest and 5.4 hectares of Sydney Sandstone Ridgetop Woodland. Although these forests contain *Allocasuarina*, it is unlikely that the clearing of these relatively small, isolated forest remnants would alter the lifecycle of the Glossy Black-cockatoo. In addition, only small to medium hollows were found within the study site; there are no large hollows present to be used for breeding.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Glossy Black-cockatoo is dependent on *Allocasuarina* trees, and prefers woodland dominated by Allocasuarina, or open sclerophyll forests or woodlands, with middle stratum of *Allocasuarina* below *Eucalyptus* or *Angophora*; often confined to remnant patches in hills and gullies, surrounded by cleared agricultural land (Higgins 1999). Glossy Black-cockatoos prefer to live in rugged country, where extensive clearing has not taken place (NSW National Parks and Wildlife Service 1999d).

The development involves the clearing of 10.6 hectares of native vegetation. There are A*llocasuarina* trees present within the Sydney Sandstone Gully Forest. This area would not, however, be cleared during development. It is unlikely that the project site is used as habitat by the Glossy Black-cockatoo as the forest remnants are relatively small and are isolated from other bushland by extensive clearing for agriculture and mining. Also, the hollows found at the site were not suitable for the nesting of this specie.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Glossy Black-cockatoo has a patchy distribution in Australia, having once been widespread across most of the south-eastern part of the country. It is now distributed throughout an area which extends from the coast near Eungella in eastern Queensland to Mallacoota in Victoria. In New South Wales, the current distribution of the Glossy Black-cockatoo covers areas from the coast to the tablelands, and as far west as the Riverina and Pilliga Scrub (NSW National Parks and Wildlife Service 1999d).

The population of Glossy Black Cockatoos that may be present in the area are not at the limit of their known distribution.

How is the proposal likely to affect current disturbance regimes?

The patches of potential habitats for Glossy Black-cockatoo in the study area are highly fragmented and subject to a range of edge effects as a result of past land uses and clearing patters that would have modified the natural disturbance regime.

While the proposal is likely to increase disturbance regimes slightly, no new disturbance regimes will be introduced.

How is the proposal likely to affect habitat connectivity?

The development involves the clearing of relatively small areas of native vegetation that are already isolated from other bushland. The Glossy Black-cockatoo is a highly mobile species and is, hence, less sensitive to habitat fragmentation. Large areas of suitable habitat are present within the National Parks that surround the project site.

How is the proposal likely to affect critical habitat?

The Director-General of the Department of Environment and Climate Change maintains a register of critical habitat. The habitat within the site is not listed as a critical habitat for the Glossy Black-cockatoo.

Conclusion

The proposal would remove a small area of possible foraging habitat for this species. Due to past clearing, the study area is not likely to be used by birds for nesting. There is an absence of suitable (large) nesting hollows within the site and the required habitat resources are more available in the local and regional areas. It is unlikely that the development would have a significant impact on the Glossy Black- cockatoo.

Brown Treecreeper *(Climacteris picumnus victoriae)*

Brown Treecreepers occur in eucalypt woodland and adjoining vegetation. Sometimes this species is recorded in semi-cleared pasture; in grasslands scattered with trees in cleared paddocks outside woodlands or in shelterbelts fringing cleared lands (Higgins et al. 2001). It is sedentary and nests in tree hollows (Garnett & Crowley 2000) breeding in pairs or communally in small groups within territories ranging in size up to 11 ha. The nest is a collection of grasses, feathers and other soft material, placed in a suitable tree hollow or similar site (Higgins et al. 2001). Birds forage on tree trunks and on the ground amongst leaf litter and on fallen logs for ants, beetles and larvae (Pizzey & Knight 1997).

The Brown Treecreeper was not found within the study site. It is, however, likely to be found in the local area and the development site provides suitable habitat for the species.

Environmental Planning and Assessment Act 1979

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The land surrounding the development area has been previously disturbed for grazing, cropping and mining purposes. Grazing by stock in woodland areas leads to a decrease the diversity of ground-dwelling invertebrates (Bromham et al. 1999) decreasing the availability of food. It is likely, therefore, that the development site does not provide suitable foraging habitat for the Brown Treecreeper.

Small to medium hollows are present within the development site. These may be used by the Brown Treecreeper for nesting. Suitable habitat is present within the local area, however, and is accessible by the Brown Treecreeper.

The proposal is not likely to disrupt the lifecycle components of the Brown Treecreeper

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The development involves the clearing of 10.6 hectares of remnant native vegetation, surrounded by cleared agricultural and mining land. The Brown Treecreeper appears unable to maintain viable populations in remnants less then 200ha (Barrett et al, 1994). It is therefore unlikely that the removal of this relatively small forested area will affect the habitat of the birds.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Brown Treecreeper has a broad range that has remained unchanged. It is now, however, extinct in parts of its range. Population declines in have been recorded from the Cumberland Plain (Hoskin 1991; Keast 1995; Egan et al. 1997), the New England Tablelands (Barrett et al. 1994), the Inverell district (Baldwin 1975), from Munghorn Gap Nature Reserve near Mudgee, and from travelling stock routes in the Parkes district (N. Schrader, unpublished).

The Brown Treecreeper population that is likely to occur within the development area is not at the limit of its known distribution.

How is the proposal likely to affect current disturbance regimes?

The patches of potential habitats for Brown Treecreeper in the study area are highly fragmented and subject to a range of edge effects as a result of past land uses and clearing patters that would have modified the natural disturbance regime.

While the proposal is likely to increase disturbance regimes slightly, no new disturbance regimes will be introduced.

How is the proposal likely to affect habitat connectivity?

The development involves the clearing of relatively small areas of native vegetation that are already isolated from other bushland. The Brown Treecreeper is highly mobile and is less sensitive to habitat fragmentation. Large areas of suitable habitat are present within the local and regional areas that surround the development site.

How is the proposal likely to affect critical habitat?

The Director-General of the Department of Environment and Climate Change maintains a register of critical habitat. The habitat within the site is not listed as a critical habitat for the Brown Treecreeper.

Conclusion

The Brown Treecreeper was not recorded within the development site during surveys. Suitable habitat for the specie, in the form of eucalypt woodland and adjoining vegetation, is however present within the development site. It is not however likely that the birds are inhabiting the area due the relatively small remnant sizes and the highly disturbed nature of the site. The development, therefore, is unlikely to significantly impact the Brown Treecreeper.

Microchiropteran Bats

A total of five threatened species of microchiropteran bat are likely to use the site as marginal foraging area, although they were not recorded during field surveys. These species include the East Coast Freetail Bat (*Mormopterus norfolkensis*), Common Bent-wing Bat (*Miniopterus schreibersii*), Southern Myotis (*Myotis adversus*), Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) and the Large-eared Pied Bat (*Chalinobus dwyeri*). All species have been grouped in this assessment due to the similar habitat requirements and the impacts associated with the proposed development activity. Despite the large ranges of each species, there is a general lack of detailed ecological knowledge for the species (Churchill 1995). All species have been listed as Vulnerable under Schedule 2 of the *TSC Act.* The habitat requirements, distribution and threats of each species are described in the following table.**Error! Reference source not found.**.

Table F-5 Details of threatened species of microchiropteran bat

Common name (***Scientific name***)	**Threats**	**Habitat and distribution**	**TSC Act[1]**	**EPBC Act[2]**
East Coast Freetail Bat (*Mormopterus norfolkiensis)*	Vulnerable to loss of tree hollows and loss of feeding grounds by forestry activities, clearing for agriculture and housing. Its population is suspected to have been reduced. It is an ecological specialist and depends on particular types of diet or habitat (Churchill 1998).	Thought to live in sclerophyll forest and woodland. Small colonies have been found in tree hollows or under loose bark. It feeds on insects above the forest canopy or in clearings at the forest edge (Churchill 1998).	V	
Common Bent-wing Bat (*Miniopterus schreibersii*)	Loss of habitat, feral predators such as cats and foxes, disturbances of winter roosts, relies on very few nursery caves at high density (Dwyer 1998).	Distributed across the east coast of Australia, Rests in caves, old mines, stormwater channels and comparable structures including occasional buildings (Dwyer 1998). Typically found in well-timbered valleys where it forages, above tree canopy on small insects (Churchill 1998).	V	CD
Large-eared Pied Bat (*Chalinobus dwyeri*)	Lack of knowledge on the roosting requirements, foraging habits and other aspects of its biology make it difficult to accurately determine current threats to the species (Hoye & Dwyer 1998). Destruction or interference of subterranean roosts is a confirmed threat. In the dissected sandstone escarpments of New South Wales underground coal mining is a potential threat, since mining induced subsidence would appear to affect availability of roost sites (Hoye & Dwyer 1998). Other possible threats include habitat clearance for agriculture, urban developments, impact of forestry operations (direct mortality of individuals from tree felling, reduction in the availability of suitable hollows, forest fragmentation) and predation by feral animals (Duncan et al. 1999).	Distributed from central coast of QLD to Southern NSW. Found in variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range (Churchill 1998). May tolerate a range of habitats. Daytime roots include caves, mine tunnels, bottle-shaped mud nests of fairy wrens. Roosts in shallow sandstone caves close to entrance. It also possibly roosts in tree hollows. Currently, no maternity sites are known (Hoye & Dwyer 1998).	V	V

Common name (*Scientific name*)	Threats	Habitat and distribution	TSC Act[1]	EPBC Act[2]
Large-footed Myotis (*Myotis adversus*)	Not certain. Is likely to be susceptible to changes in water quality, which may result from vegetation clearing and logging (sedimentation), sewage and fertilizer run-off (eutrophication), pesticide/herbicide leakage (chemical pollution) and altered flow regimes (changes to river ecology). Where populations concentrate in roosts which are susceptible to disturbance, human activities such as recreational use of caves and removal of old wooden bridges would also be a threat (Duncan et al. 1999). The species may have been subject of over-collection in the past (Richards 1998b).	Found in roosting caves, tunnels, tree hollows and possibly dense vegetation (Churchill 1998). Roosts have been located in hanging trees, buildings and underneath bridges have also been listed as roost sites for the species. The species is always associated with permanent, usually slow-flowing water bodies. Forages over small creeks, coastal rivers, estuaries lakes and inland rivers. Records come from a wide range of vegetation communities associated with water (Richards 1998b).	V	
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	Vulnerable to loss of tree hollows and loss of feeding grounds by forestry activities, clearing for agriculture and housing. Its population is suspected to have been reduced. It is an ecological specialist (it depends on particular types of diet or habitat) (Churchill 1998).	Occurs in eucalypt forest where it feeds above the canopy and in mallee or open country where it feeds closer to the ground. Generally a solitary species but sometimes found in colonies of up to 10. It roosts in tree hollows. Thought to be a migratory species (Churchill 1998).	V	

1: V= Vulnerable, E1 = Endangered (*TSC Act*)

2: V = Vulnerable, E = Endangered, M = Migratory, C = Conservation Dependent (*EPBC Act*).

Environmental Planning and Assessment Act 1979

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The species of microchiropteran bat occupy similar habitat types which are mostly dry sclerophyll forests that provide a variety of roost sites including tree hollows, caves and derelict mine shafts. It is considered that the bats forage in and around the Sydney Sandstone Ridgetop Woodland, Sydney Sandstone Gully Forest and the Shale Sandstone Transition Forest as well as water bodies such as the onsite dams (particularly for the Southern Myotis).

No maternity caves were recorded during opportunistic searches for fauna habitat. There are a moderate number of tree hollows (that function as roosting resources) in the Sydney Sandstone Gully Forest which will not be significantly affected by the proposed development. The site contains foraging areas for bats, especially on top of the forest canopy (for the Common Bent-wing Bat), over water bodies (for the Southern Myotis) and along the forest margins (all species).

The development action proposes the removal of 5.2 hectares of Shale Sandstone Transition Forest, 24.8 hectares of agricultural land, and 5.4 hectares of Sydney Sandstone Ridgetop Woodland. These areas do not contain important roosting resources in the form of tree hollows or caves, and the large range of each species allows widely available offsite foraging resources to be used. Although the removal of foraging habitat would disrupt the local population, the loss of habitat would not disrupt important lifecycle components of each species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposed clearing of 10.62 hectares of forested habitat is considered to be relatively small in terms of its size and the area does not contain significant communal roosting or nursery sites. However, the forest contains a moderate number of temporary roosting resources in the form of tree hollows. Similar foraging and roosting habitat for all five species of microchiropteran bat are

adequately represented in local and regional conservation reserves within adjacent National Park and continuous bushland in the area, which are within the species' range.

Although the proposal may temporarily affect the dynamics of the local population, the development action will not remove a significant area of known foraging, roosting and breeding habitat for the five species of bat.

Nursery caves are considered to be particularly important for the Common Bent-wing Bat where young bats are nursed and reared at densities of up to 3000 individuals per square metre in locations such as Yesabah Caves near Kempsey (Churchill 1998). The Large-eared Pied Bat, Southern Myotis, Yellow-bellied Sheathtail bat, and the east Coast Freetail Bat do not have well recorded maternity sites within conservation reserves (Richards 1998a), (Hoye & Dwyer 1998) and (Duncan et al. 1999). Although foraging resources are widely available, it is unlikely that habitat containing an abundance of tree hollows and maternity/roosting caves are adequately represented in conservation reserves throughout the local and wider areas of the Sydney Basin bioregion.

The nature of the clearing will not fragment habitat and the microchiropteran bat species' high mobility allows the exploitation of other offsite habitat resources that are within their relatively large range.

The habitat to be cleared is unlikely to be important for the survival of these species.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

None of the 5 microchiropteran bats are at the limits of their known distributions. The Eastern Freetial Bat's distribution extends from south Queensland to southern NSW, along the coast. The Common Bentwing Bat is found throughout northern and eastern Australia from northern WA to south-eastern SA. The Large-eared Pied Bat inhabits areas with extensive cliffs and caves, from Queensland wouth to the NSW Southern Highlands. The Large-footed Myotis is found along the coast from the north west of Australia, across the top-end and south to western Victoria. The yellow-bellied Sheathtail Bat has a wide range across northern and eastern NSW/.

How is the proposal likely to affect current disturbance regimes?

Much of the project area has been previously disturbed due to agricultural clearing and current sand mining operations. The forested areas are, hence, fragmented and isolated with high edge to area ratios. Disturbance regimes have therefore been altered in the past and the proposed project is not likely to affect current disturbance regimes.

How is the proposal likely to affect habitat connectivity?

Suitable habitats within the study area have been significantly reduces as result of past land use patters. Microbats are highly mobile fauna and are less sensitive to habitat fragmentation than other faunal groups (such as ground dwelling species). The removal of roosting trees in the study area will not affect the overall connectively of these habitats to other areas of woodland habitat for microbats.

How is the proposal likely to affect critical habitat?

The Director-General of the Department of Environment and Climate Change maintains a register of critical habitat. The habitat within the site is not listed as a critical habitat for any microchiropteran species of bat assessed.

Conclusion

The proposed action will remove a small area of foraging and roosting habitat for the five species. The action will disrupt the local population of the five species of microchiropteran bat, however important maternity sites and significant roosting resources do not exist in the site and local populations of each species will not be placed at risk of extinction. The required habitat resources are available in the local and regional area within each of the species foraging range. As such it is unlikely that the proposed development will have a significant impact on the species.

Significant impact criteria for Large-eared Pied Bat (a vulnerable species) under the *Environment Protection and Biodiversity Conservation Act 1999*

The Large-eared Pied Bat (*Chalinobus dwyeri*) is also listed as Vulnerable under the *EPBC Act* and the *TSC Act.* The following assessment has been undertaken under the administrative guidelines of the *EPBC Act.*

Important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity; and/or
- at or near the limit of the species range.

If using the site, the Large-eared Pied Bat would not be considered an important population

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

The Large-eared Pied Bat at Hitchcock Road is not considered to be part of an important population.

Is the action likely to reduce the area of occupancy of an important population?

The Large-eared Pied Bat at Hitchcock Road is not considered to be part of an important population.

Is the action likely to fragment an existing important population into two or more populations?

The Large-eared Pied Bat at Hitchcock Road is not considered to be part of an important population.

Is the action likely to adversely affect habitat critical to the survival of a species?

The mobile nature of the species allows the Large-eared Pied Bat to occupy foraging and roosting resources outside of the development site that are adequate for the species survival. Currently no maternity sites are known for the species (Hoye and Dwyer 1998). No specialised habitat resources such as maternity and /or roosting caves have been recorded on site, hence the area to be affected cannot be considered critical to the survival of the species.

It is unlikely that the action will adversely affect habitat critical to the survival of the species.

Is the action likely to disrupt the breeding cycle of an important population?

The Large-eared Pied Bat at Hitchcock Road is not considered to be part of an important population.

The habitat to be removed and construction is unlikely to contain an established breeding population of Large-eared Pied Bat, due to the absence of suitable maternity caves and roosting resources. Foraging resources are available in similar habitat that is adequately represented in areas off the site. Although the removal of foraging habitat would temporarily disrupt the dynamics local population, the amount of habitat to be removed is not significant and would not disrupt important breeding cycle components for the species.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The availability of roosting resources is one of the critical factors influencing the likelihood of decline for the species (Hoye & Dwyer 1998). The habitat to be removed contains a relatively small number of tree hollows that may be used as roosting resources. However the availability and quality of onsite habitat resources are not critical to the survival of a local population of the species. The nature of habitat clearing will not result in the isolation of good quality habitat.

The mobile nature and wide activity range of the species means they are likely to occupy other off-site areas that contain habitat resources used for foraging and roosting. It is unlikely that the proposed action species would isolate and decrease the availability of quality habitat to the extent that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

The area of the proposed action has already been disturbed from previous clearing practices. It is unlikely that invasive species would become established and cause harm to the Large-eared Pied Bat.

Is the action likely to interfere substantially with the recovery of the species?

There is no recovery plan for this species. However, the Action Plan for Australian Bats addresses the need for further ecological research on the species and the conservation and protection of roosting and maternity sites (Duncan et al. 1999). There is moderate abundance of potential roosting sites in the form of tree hollows, however no maternity sites are present in the proposed area of clearing. It is likely that these resources exist in the adjacent undisturbed bushland within the species wide foraging range. It is unlikely that the proposed development action will interfere with the overall recovery of the species.

Conclusion

Based on the above assessment, the Large-eared Pied Bat is unlikely to be significantly affected by the proposed activity.

Nocturnal Birds

Although none of the species were recorded during targeted call playback surveys (*see section 3.6)* it is likely that the site contains foraging and roosting resources for the species (Table F.6). The four species of nocturnal birds of prey occupy similar ecological niches and habitat requirements, and therefore, they have been assessed together under Part 3A *EP&A Act* significance assessment guidelines.

Table F-6 Details of threatened nocturnal birds

Common name (***Scientific name***)	**Threats**	**Habitat and distribution**	**TSC Act[1]**	**EPBC Act[2]**
Masked Owl (*Tyto novaehollandiae*)	Clearance of agriculture is the principal listing for the species. Although food does not appear to be limiting on the east coast (Kavanagh 1996), the decline may be due to that of 50 and 200 grams. The availability of nest trees and vigorous regrowth from logging makes the habitat less suitable for foraging (Kavanagh 1995).	The Masked Owl inhabits forests, woodlands, timbered waterways and open country on the fringe of these areas. The main requirements are tall trees with suitable hollows for nesting and roosting and adjacent areas for foraging. Generally found in sub-coastal habitats. But also inland along watercourses (Garnett & Crowley 2000).	V	
Powerful Owl (*Ninox strenua)*)	The population size has declined as a result of widespread clearance for agriculture and pastoralism. Main threats include the removal of old growth forest which reduces the availability of suitable nest hollows and den site for prey (Debus & Chafer 1994). The species It is an ecological specialist (it depends on particular types of diet or habitat) Intense local wildfire can result in local loss. Poisoning, disrubance and predation by foxes on fledglings may cause nest failure and some deaths (NSW National Parks and Wildlife Service 1998).	Typically wet and hilly sclerophyll forest with dense gullies and understorey adjacent to more open forest. Will also occur in smaller, drier forest, provided that there are some large tree hollows and an adequate supply of prey. Generally confined to the forests of the Great Dividing Range and through to the coast. Tree hollows are important because a large proportion of the diet is comprised of hollow-dependent arboreal marsupials (James 1980, Kavanagh 1988, Pavey 1992, Debus & Chafer 1994). Birds, insects and some terrestrial mammals are also taken opportunistically, with some prey species being characteristic of open country, indicating that they may forage on forest margins (Garnett & Crowley 2000).	V	
Barking Owl (*Ninox connivens)*	Threats mainly include felling of old growth forest or over mature trees through the reduction in the availability of nesting and roosting hollows and shelter for breeding season prey(Debus & Rose 1994). Remaining habitat is fragmented and subject clearing removal old dead wood and grazing which resulted in little regeneration (NSW National Parks and Wildlife Service 1998).	Occurs in dry sclerophyll woodland. In the south west it is often associated with riparian vegetation while in the south east it generally occurs on forest edges. It nests in large hollows in live eucalypts, often near open country. It feeds on insects in the non-breeding season and on birds and mammals in the breeding season (Garnett & Crowley 2000).	V	

1: V= Vulnerable, E1 = Endangered (Threatened Species Conservation Act 1995)

2: V = Vulnerable, E = Endangered, M = Migratory, C = Conservation Dependent (Environment Protection and Biodiversity Conservation Act 1999).

Environmental Planning and Assessment Act 1979

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The three species of nocturnal bird occupy similar habitat types which are mostly dry sclerophyll forests that provide roosting sites and foraging/prey resources of small ground dwelling and

arboreal mammals. It is likely that the birds use the Sydney Sandstone Ridgetop Woodland, Sydney Sandstone Gully Forest and the Shale Sandstone Transition Forest habitat onsite for foraging due to the presence of prey animals (such as small arboreal mammals) and roosting resources available in larger trees. However, the site contains few suitable hollows that would be used for nesting.

It is unlikely that the loss of habitat would disrupt important lifecycle components of these species, because each species does not rely on specialised habitat resources (such as large hollows for nesting) in the site and they have a large range allowing them to forage in the wider area.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

All four species have relatively large home ranges and suitably sized tree hollows for nesting do not occur within the site. Extensive areas of relatively undisturbed Sydney Sandstone Complex, which provides habitat resources used for foraging, roosting and nesting, is located to the south-east of the site.

Although the proposed action will remove 10.6 hectares of foraging and roosting resources, it is unlikely that the area of known habitat to be removed is significant in relation to the local and regional distribution of habitat.

The potential habitat to be cleared is unlikely to be important for the long term survival of these species.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

None of the species of nocturnal birds potentially found within the project site are at the limits of their known distributions.

How is the proposal likely to affect current disturbance regimes?

Much of the project area has been previously disturbed due to agricultural clearing and current sand mining operations. The forested areas are, hence, fragmented and isolated with high edge to area ratios. Disturbance regimes have therefore been altered in the past and the proposed project is not likely to affect current disturbance regimes.

How is the proposal likely to affect habitat connectivity?

The nature of the clearing will not fragment an area of important habitat resources or known breeding population. The species' high mobility allows the exploitation of other offsite resources that are widely available within the species' relatively large range.

How is the proposal likely to affect critical habitat?

The Director-General of the Department of Environment and Climate Change maintains a register of critical habitat. The habitat within the site is not listed as a critical habitat for any threatened nocturnal species of bird assessed.

Conclusion

Important habitat resources are available in the local and regional area within each of the species foraging/home range and the four species of owl are likely to use the habitat on site as a marginal foraging and roosting area. Due to the absence of specialised habitat resources such as nesting hollows within the site, it is unlikely that the proposed development will have a significant impact on the species.

7

TECHNICAL PAPER

CULTURAL HERITAGE ASSESSMENT

Cultural Heritage Assessment

Hitchcock Road Extraction Quarry, Maroota

August 2004

A Report to DFA Consultants

Navin Officer

heritage consultants Pty Ltd

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1. SUMMARY

- DFA Consultants Pty Ltd on behalf of PF Formation is currently preparing an EIS for a proposed extension to a sand mine at Maroota. Navin Officer Heritage Consultants was commissioned by DFA Consultants to undertake a cultural heritage assessment of the proposed extension area.
- The study area has been investigated previously but no Aboriginal sites had been identified.
- The study included consultation with the three recognised Aboriginal community groups with interest in the study region. Each group participated in the field survey.
- One historical heritage site was located within the proposed mining extension area.
- The previously recorded site MR1 could not be relocated.
- It is recommended that:
- Prior to development, subsurface testing should be undertaken in the vegetated spur crest adjacent to site MR1, noted as MRPAD1 on Figure 2.
- Subsurface investigations would need to be completed by a qualified archaeologist with a Section 87 permit from the DEC. Consultation and involvement of the three Aboriginal community groups would also be required.
- Any disturbance of site MR1 would require a section 90 'Consent to Destroy' permit from the DEC. This would require agreement from the three Aboriginal community groups.
- There are no constraints to mining expansion within the rest of the proposed areas.
- If any object is found during development proceeding that is suspected of being Aboriginal in origin, then work in that area must cease and the DEC notified.

2. INTRODUCTION

2.1 The Proposed Development and Study Area

The Hitchcock Road sand mining operation at Maroota has been in operation since the 1980's. Much of the mining within the lease area has been completed and rehabilitated, while other sections are presently being mined under current approvals.

Hitchcock Road is situated about 50 km northwest of Sydney and about 8 km south of Wisemans Ferry, immediately south of the Wisemans Ferry Road and Old Northern Road intersection, Figure 1. Archaeological surveys have been undertaken previously for the current operations and included assessments of some additional areas.

The current proposal is to extend mining into Portion 214 and Lot 1 DP 34599 and also within a small former Crown Reserve encompassing Maroota Trig. These areas have not been subject to mining approval and PF Formations are seeking to expand their operations into these blocks.

DFA Consultants Pty Ltd is currently preparing an EIS for the proposed extension to the sand mine for PF Formation. Navin Officer Heritage Consultants was commissioned by DFA Consultants to undertake a cultural heritage assessment of the proposed extension area. This report documents the results of the heritage assessment.

As well as investigating heritage sites within the new proposal areas, the study also took the opportunity to reassess an area where an Aboriginal site had been previously recorded.

2.2 Study Aims

The aims of the investigation were to provide a cultural heritage assessment of the proposed mining activities within the Hitchcock Road property, Maroota. This was achieved through the following:

- Conducting background research into previous heritage assessments of the study area.
- Field survey of the subject land.
- Assessment of sites located during the survey.
- Aboriginal Consultation.

2.3 Report Outline

This report:

- Documents consultation with three relevant representative Aboriginal community groups;
- Describes the methodology employed in the study;
- Describes the environmental context of the study area;
- Provides a background of local and regional archaeology for the study area;
- Incorporates previous archaeological studies where applicable;
- Documents the results of the field surveys and literature research conducted in the context of the study; and
- Provides management and mitigation strategies to minimise the potential impact of the proposed works on the identified heritage resource of the study area.

2.4 Project Personnel

The field study was undertaken by archaeologists Matthew Barber and Charles Dearling with assistance from representatives of local Aboriginal groups.

The report was prepared by Matthew Barber.

3. ABORIGINAL PARTICIPATION

The study area falls within the boundaries and areas of interest of the Deerrubin Local Aboriginal Land Council, the Darug Tribal Aboriginal Corporation and the Darug Custodians Aboriginal Corporation. Each group was invited to participate in the field program and subsequently the groups were represented in the project as follows:

Deerubin LALC: Phil Khan and Steve Randall

Darug Tribal Aboriginal Corporation: Celestine Everingham and Gordon Morton

Darug Custodians Aboriginal Corporation: Leanne Wright

Copies of this report will be provided to each of the participating groups.

Records of Aboriginal Participation are provided in Appendix 1.

4. STUDY METHODOLOGY

4.1 Study Components

This assessment involved the following components:

- Review of existing documentation
- Liaison with relevant local Aboriginal organisations
- Field survey of the study area
- Assessment of site significance

Sources of background information included:

- Site information obtained from the DEC Aboriginal Sites Register [Aboriginal Heritage Information Management System)
- Relevant research documents, publications and consultancy reports
- Theses and documents held at the Australian National University, AIATSIS, and the National Library.

4.2 Survey Strategy

The survey strategy was designed to:

- to attain as comprehensive ground coverage as possible through the study area; and
- to identify areas of heritage potential that may be impacted by the proposals.

All survey within the study area was undertaken on foot and conducted in August 2004.

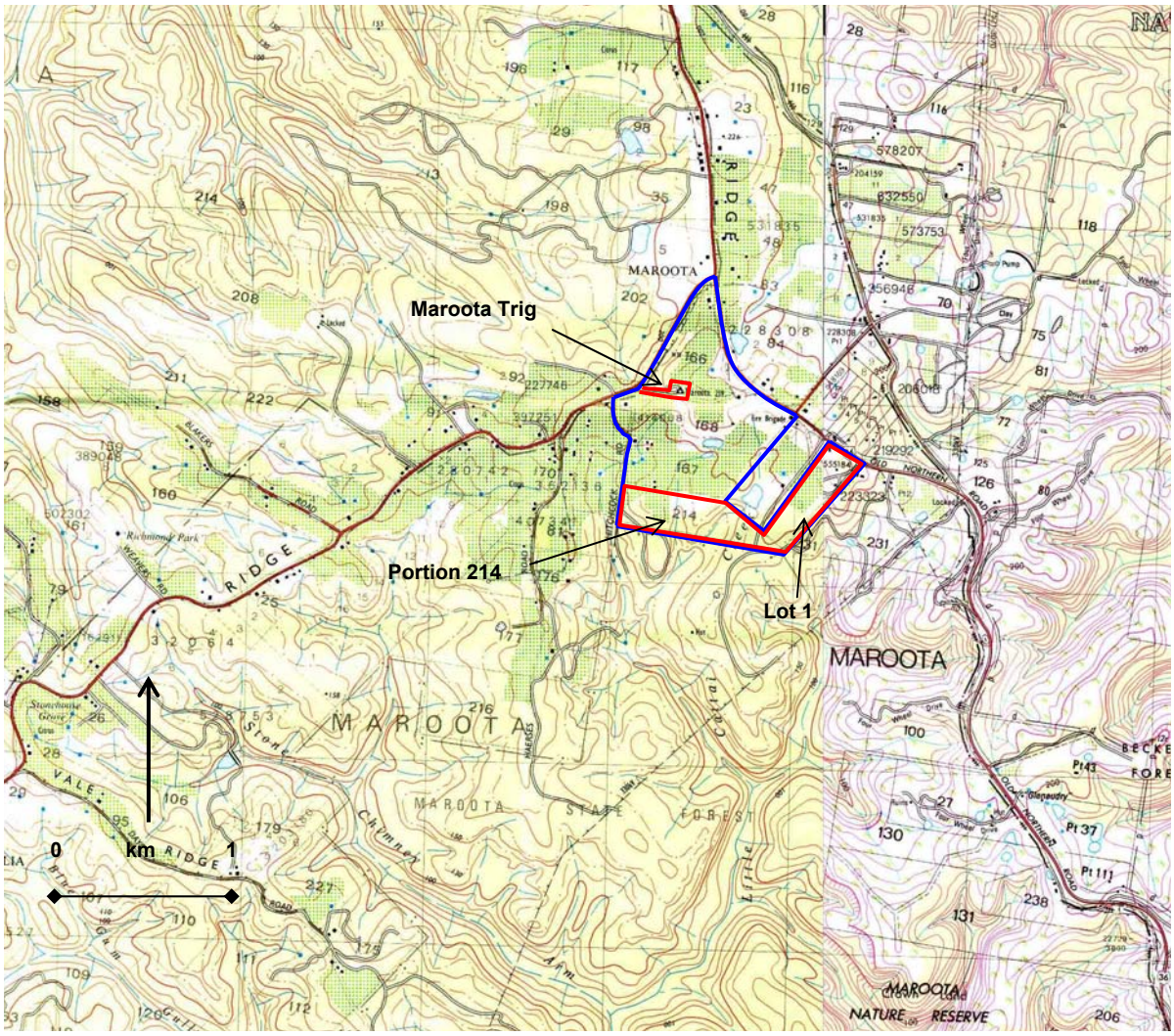


Figure 1 The Hitchcock Road lease area in blue, the current study area outlined in red. (Lower Portland and Gunderman 1:25,000 topographic maps).

5. ENVIRONMENTAL CONTEXT

5.1 Geology

The study area is situated within a portion of the Sydney Basin where the erosion of horizontally-bedded Hawkesbury sandstone has formed a dense system of incised drainage valleys. The major ridgelines are similar in elevation and relate to a common plateau level prior to dissection by valley downcutting.

The survey areas are situated on the eastern side of Maroota Ridge, which runs north-south and forms the main watershed between northeastern and southeastern alignments of the Lower Hawkesbury River corridor. Wisemans Ferry Road runs along the crest of the ridge and meets the Old Northern Road that also runs along a ridgeline. The junction of the ridges is Maroota Trig, which is the highest point in the district at 239 m AHD.

The southern part of the study area comprising block 214 and Lot 1 DP34599 are situated at the head of Little Cattai Creek and include the deep drainage gully of the creek line. The study area also contains wide, flat spur crests and gentle to steep slopes above the creekline.

Bedrock of the study area consists predominantly of Hawkesbury sandstone, overlain in elevated topographies by tertiary alluvial deposits. Within the study area, there are some outcrops of sandstone, forming platforms and also low escarpments. Exposures of sandstone within the drainage lines were not noted during the investigations, but rather they were encountered on the slopes adjacent to the creek.

Soils within the study area are typically sandy, the result of decomposing bedrock. Depth of soil appeared variable with some shallow areas identified by exposed bedrock, and other areas exhibiting potentially deed deposits.

5.2 Vegetation and Landuse

The Maroota Trig section of the study area is on the highest point of the ridgelines but the ridge area in this location has been cleared and farmed since 1957 (P. Cummins pers comm 2004). There is some remnant forest on the steep south-facing slopes of the peak but the majority of the study area has been cleared. The farming activities included orcharding and remnant rows of posts and wire suggest grape-growing was also conducted. Currently the area is covered in almost impenetrable weeds of up 1.5 m in height.

The native vegetation within Portion 214 has also been mostly cleared for orchards. There is remnant forest on the steeper slopes of the drainage line but the elevated areas are cleared and now heavily farmed with orchards and vegetables such as zucchini and pumpkins. Irrigation system and ripping along the planting lines has severely disturbed the elevated ground within Portion 214.

The second area of survey, Lot 1 DP34599, has also been subject to landscape disturbance as a result of European activity. Much of the block is also cleared of native vegetation and a part of it was formerly an orchard. There is a house and sheds on the property and what appears to be a trotting or vehicle track - an oval track of bare ground. Part of the block was also formerly used as a fuel depot for local sand mining activity and has been cleared of vegetation. A recent ‘clean up’ of the now disused site has scraped much of the grass off the surface and also pushed assorted junk and building materials into piles.

South of this area the spur crest retains its native vegetation of dry sclerophyll forest, although are numerous excavated holes through the bush, possibly sample or test pits for mining activity. Some of these are now filled with general household and assorted rubbish such as car bodies.

Overall, all of the blocks within the study area have been subject to heavy European impact, with only small areas containing relatively undisturbed ground.

6. ARCHAEOLOGICAL CONTEXT

6.1 Regional Context

The Sydney Basin has been the subject of intensive archaeological survey and assessment for many years. This research has resulted in the recording of thousands of Aboriginal sites and a wide range of site types and features. The most prevalent sites or features include: isolated finds, open artefact scatters or camp sites, middens, rock shelters containing surface artefacts and/or occupation deposit and/or rock art, open grinding groove sites, and open engraving sites. Rare site types include scarred trees, quarry and procurement sites, burials, stone arrangements, carved trees, and traditional story or other ceremonial places. Another feature recorded by archaeologists is the potential archaeological deposit, or PAD. This is an area where sub-surface artefacts are considered likely but no surface evidence exists. In an investigation of the Upper Mangrove Creek catchment, Attenbrow (1987) found that almost 90 percent of recorded PADs in rock shelters contained archaeological material.

Archaeological studies in the Sydney Basin have generated hundreds of reports and monographs and a number of academic theses. Studies generally fall into four categories - projects which have been carried out within a research-oriented academic framework, larger scale planning and management studies (eg. regional heritage studies) archaeological surveys carried out by interested amateurs, and impact assessment studies which have been carried out by professionals within a commercial contracting framework. The latter deal with specific localities subject to development proposals and constitute a large proportion of the archaeological research carried out to date. The following review draws upon all of these sources, but places emphasis on recent research and studies located within or close to the study areas.

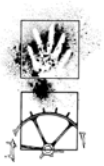
Aborigines have lived in the Sydney region for at least 20,000 years (Stockton & Holland 1974). Late Pleistocene occupation sites have been identified around the fringes of the Sydney Basin at Shaws Creek (13,000BP) in the Blue Mountain foothills (Kohen et al 1984), and at Mangrove Creek (11,000BP) at Loggers Shelter (Attenbrow 1981). Nanson et al (1987) have suggested that artefacts found in gravels of the Cranebrook Terrace indicate Aboriginal occupation over 40,000 years ago, however there is some doubt as to the contextual integrity of these artefacts.

The majority of both open and rockshelter sites in the Sydney region date to within the last 3,000 years. A similar trend in occupation age occurs in dated deposits in NSW coastal sites. This has led many researchers to propose that population and occupation intensity increased from this period (Attenbrow 1987, Kohen 1986, McDonald & Rich 1993, McDonald 1994). The increased use of shelters postdates the time when sea levels stabilised after the last ice age around 5000 years ago (the Holocene Stillstand). Following the stabilisation of sea levels, the development of coastal estuaries, mangrove flats and sand barriers would have increased the resource diversity, predicability, and the potential productivity of coastal environments for Aborigines. In contrast, occupation during the late Pleistocene (prior to 10,000BP) may have been sporadic and the Aboriginal population relatively small.

The stone technologies used by Aborigines within the Sydney Basin have not remained static and a sequence of broad scale changes through time have been consistently identified. This is known as the Eastern Regional Sequence and can be applied with various degrees of success and allowances for regional differences, to sites throughout eastern seaboard of Australia. Within the Sydney Basin the Sequence can be characterised using the following terminology and phases (based on McDonald 1994):

The Capertian: Artefacts from this period consist mostly of large heavy artefacts including unifacial pebble tools, scrapers, core tools, denticulate saws, and hammerstones. Some bipolar tools and burins also occur. The Capertian is present up to around 5000 years BP.

The Early Bondaian: Within this phase characteristics of the Capertian continue but tools on smaller blades are introduced and become predominant. Blades which are backed (one edge blunted by fine trimming) and ground edge implements are notable



introductions. There is a major shift in the type of rocks used for tool manufacture to fine grained siliceous materials (such as silcrete, chert and tuff/indurated mudstone). The Early Bondaian has been identified in deposits dating between around 5000 and around 3000 years BP.

The Middle Bondaian: In this phase the percentage of Bondi points (a type of backed blade) increases and remains greater than the percentage of bipolar artefacts. Edge ground artefacts are present in higher proportions as are quartz artefacts. This phase dates from around 3000 to as late as 1000 years BP.

The Late Bondaian: This phase is characterised by quartz either becoming the predominant rock type used or markedly increasing in proportion. Bondi points and most types of backed blades become rare or are no longer found. Eloueras, bipolar artefacts and edge ground hatchets are the predominate tool types. Bone and shell implements including fish hooks appear in this phase, particularly in some coastal sites. This phase dates from around 1600 (Attenbrow 1987), or 1000 years BP (McDonald 1994), to the cessation of stone working following contact with European Society.

McDonald notes that the introduction of ground implements around 4000 years BP and shell fishhooks in the last 1,000 years were major technological innovations (McDonald 1994:69). The significance and possible reasons for the technological changes in the Eastern Regional Sequence have been the subject of considerable research and debate since their identification. Contemporary theories postulate various changes in social behaviour, group interactions, and population dynamics either as contributing causes or as consequences of these technology changes (eg Attenbrow 1987, Beaton 1985, Lourandos 1985, Walters 1988, McDonald 1994). McDonald for example interprets the introduction of the Bondaian artefact technology in the Sydney Basin as a manifestation of social change brought about by population pressure promoted by sea level rise (1994:347).

McDonald (1994) has conducted a review of the archaeology of the Sydney Basin as part of a research program investigating the rock art in the Basin. Her investigation involved both excavations and statistical analyses of rock art recordings across the Basin. On the basis of this work McDonald has proposed a series of site type characterisations and models relating to change in occupation dynamics and rock art, across time and space, and a three phase sequence within the shelter rock art, based on a detailed study of 65 shelter art sites in the Mangrove Creek valley and correlations with stone technologies in excavated deposits (1994:335-6):

Sydney Basin Art Phase 1: pecked engravings of tracks and circles, created during the Pre- or Early Bondaian, greater than 4000 years BP.

Sydney Basin Art Phase 2: red paintings, red hand stencils, and possibly white hand stencils (red and white hand stencils do not occur together), made in the Early Bondaian from less than 4000 to around 1,600 years BP.

Sydney Basin Art Phase 3: characterised by a ‘proliferation’ of techniques and colour usage, possibly starting with drawn black and drawn red graphics and then developing into a range of paints, drawn bichromes, stencils in various colours, polychromes and incised graphics. Outline-only graphics end the sequence in many shelters. White stencils and drawn red and white outline and infill forms are also known from the contact period and hence the end of the sequence. Localised variations in the use and timing of different techniques and motifs occurred. Phase 3 extended from around 1,600 to a time soon after 1788 following European contact.

Older art sites, consistent with phase 1, are suggested to be ‘focussed’ on the middle reaches tributaries of the Hawkesbury Nepean River (1994:36). McDonald argues that the main period of shelter art production evident at most sites is also contemporaneous with the period of greatest stone

tool discard at shelter sites, the Middle Bondaian. She links this production with a model of increasing use of social mechanisms to control social interaction and symbolic behaviour defining local group social affiliation and identity (1994:348). Within the last 1000 years, the evidence from excavations indicate that the rate of artefact accumulation as well as the rate of occupation in shelters reduces significantly. There is however no corresponding evidence for a fall in population. This suggests that the type of occupation in rock shelters changed and this is reflected by a reduced artefact discard rate. McDonald suggests that a change in the 'social curtilage' of local Aboriginal groups may explain the changing role of shelter sites and that there may have been a 'shift in focus' to open sites (1994:80, 348). Larger group sizes may have required a shift away from the spatial constraints of rock shelters. Art production in shelters however, is thought to have continued into the Late Bondaian without appreciable stylistic change and continued into the time of Contact. McDonald also suggests that a large number of open engraving sites may have been produced in the last phase as a consequence of increasing social complexity and the need to symbolically demonstrate group cohesion and moderate social interchange (1994:350).

A review of comprehensive survey results from dissected sandstone plateau topographies in the Sydney Basin indicates that surface site densities range from 11 to 3.1 sites per square kilometre, with frequencies between 4 and 6 representing average rates.

Table 1 Summary of sandstone plateau surveys.

Location	No. sites per km2	Area surveyed km2	Landscape type	Reference
Maroota (Devils Rock)	14	1.6	ridgeline complex, sandstone plateau	McDonald 1986
Bardens Creek	6-7	1.2	dissected sandstone plateau	Silcox 1980 Attenbrow & Negerevich 1981
Mangrove Creek Dam Catchment	5.9	101	dissected sandstone plateau	Attenbrow 1981
Warre Warren	5.4 (8 PADs)	4.25	dissected sandstone plateau	McDonald 1988
Upper Cattai Creek	4	3.4	dissected sandstone plateau	Koettig 1985
Brimstone Colliery, Burragorang Plateau	3.1 (4.6 PADs)	14.7	dissected sandstone plateau	Navin 1995
Eastern Woronora River Catchment	2.7	42	dissected sandstone plateau	Sefton 1990
Woronora Plateau	2.1	418	dissected sandstone plateau	Sefton 1988
Holsworthy	5.29	174	dissected sandstone plateau	Navin Officer 1996
Cordeaux River Catchment	1.2	73	dissected sandstone plateau	Sefton 1990

6.2 Local Context

Within the local Maroota area, a number of archaeological impact assessments have been conducted and in an approximate 5 km radius of the study area, there have been 99 sites recorded and listed on the Aboriginal Heritage Information Management System (AHIMS) held by the DEC. Some sites however comprise multiple elements or features, such as a shelter containing art, deposit and engravings. Table 2 shows the breakdown of site elements in a five kilometre radius of the study area. Only three open sites are listed on the AHIMS register but the two isolated artefacts from the previous investigation (see below) were not included. These have been added to the open artefact site category.

Table 2 Site elements within 5 km radius of study area

Site element	Number of occurrences	% of Total
Rock engraving	40	35.7
Shelter with deposit	7	6.3
Shelter with art	31	27.7
Axe grinding groove	22	19.6
Scarred tree	2	1.8
Open artefact site	5*	4.5
Stone arrangement	4	3.6
Water hole/well	1	0.9
Total	**112**	**100**

*includes two isolated finds not on the AHIMS register.

Archaeological survey has previously been undertaken within the present study area. Edgar (1995) completed an assessment of the entire 100 ha of the Hitchcock Road mining area. The report aimed to assess the impacts of development of the sand quarry operation on Aboriginal heritage sites (Edgar 1995). Edgar found that much of the study area (50%) had been heavily disturbed by previous landuse practices such as orchard and vegetable gardens. The rest of the study area had been disturbed through sand mining, clearing and dam construction (Edgar 1995:3).

Three Aboriginal sites were identified, a scatter of five artefacts (MR1) and two isolated finds (IF1, IF2), all within the south eastern part of the study area. The isolated finds were found on the edge of a dam where visibility was 100%, but this property has now been removed from the potential mining area.

The most relevant site was therefore MR1. It consisted of five artefacts scattered within the cleared ground used as the fuel depot. The ground surface had been levelled and highly disturbed. Edgar found that there was no potential for subsurface deposits in the “immediate vicinity of MR1” and that visibility was good within the surrounding forest (Edgar 1995:11). Edgar concluded that the site had low significance due to the level of disturbance, while also acknowledging that such open sites are rare in the Hawkesbury sandstone region.

Corkill (1989) investigated about 40 ha of land comprising Portions 198 and 35 and Lot 1 of DP588936, adjoining blocks about one kilometre north of the present study area, for extension of sand mining proposals. Much of her study area was disturbed through clearing, excavation and dumping. The survey was carried out on foot, inspecting all rock exposures and areas of bare ground such as vehicle tracks. No sites were found during the survey, no areas of rock overhangs suitable

for occupation were identified, and none of the rock platforms showed engravings, despite close inspection (Corkhill 1989:7-8). Additional surveys by Corkill in the Maroota area associated with the sand mining operations also failed to find any archaeological sites (Corkill 1991a, 1991b, 1991c).

The largest survey apart from the Edgar (1995) study was a comprehensive survey of 3.45 km^2 conducted by Koettig within the upper catchment of Little Cattai Creek (Koettig 1989). This area is situated to the southwest of the present study area. The survey detected 14 archaeological sites, 97 rock shelters where past Aboriginal occupation or utilisation was considered to have been possible, and three isolated finds. The recorded sites consisted of 9 shelters with art (three with occupation deposit), one open engraving site and four open sites with grinding grooves. A small percentage of the total survey area included ridgetop contexts on the main watershed ridgeline. Within this context, and excepting shelter sites located near the break of slope, Koettig located three isolated finds and one engraving site.

About five kilometres north of the present study area, McDonald conducted a comprehensive survey of the Maroota Historic Site area which includes a complex of Aboriginal rock art sites including the large 'Devils Rock' site (NPWS 45-2-16) (McDonald 1986). This site complex which includes both open artefact scatters, engraving sites, grinding grooves and rock shelters, is located on a major spurline extension of watershed at its terminal end.

A site density of 11 sites/km^2 or 1 site/10 ha was indicated by the Devil's Rock survey. In contrast, Koettig's Little Cattai Creek upper catchment survey produced a site density of 1 site/25 ha. Neither of these results are strictly comparable to the present study area because the Devil's Rock results probably relate to the repeated and focused use of the area for ceremonial purposes, and the majority of the Little Cattai Creek sites occur outside of the ridgetop context. Those local surveys that have been conducted on the major watershed ridgeline indicate a very low density of surviving archaeological material. With regard to open artefact scatters it is probable that the absence of sites relates to the extensive degree of landscape disturbance within this zone rather than a real pattern of prehistoric utilisation of the watershed ridgelines.

Corkill (1994) surveyed another sand mining operation about 3 km north of the present study area and four new sites were identified. Site CC1 comprised two sets of grinding grooves with 9 and 11 definite grooves about 20 m apart within the bedrock of an ephemeral drainage line. Site CC2 comprised two engravings and a set of 11 grinding grooves about 10 m from the engravings. The engravings were found on a boulder about 20 m above the creek and the grooves were located within a shallow rock-lined watercourse. The third site CC3 was a shelter with deposit and a single silcrete flake. A second shelter with deposit CC4, contained two basalt flakes that showed evidence of grinding. Another shelter with potential archaeological deposit but no artefacts was also located (Corkill 1994).

A survey for a fibre optic cable line undertaken by Officer (1994) examined a 7.4 km long easement adjacent to the Old Northern Road from Wisemens Ferry road to Canoelands Road. Inspections of the entire route were carried out during the day and also selected rock platforms were inspected at night using oblique torchlight to identify any engraving sites. No additional sites were located. The previously recorded site comprising 14 motifs known as Little Devils Rock was noted. This site is situated about 3 km southeast of the present study area.

A survey by Corkill (1995) of an area at Canoelands for rehabilitation of a quarry and some additional extraction, about 6 km southeast of the Hitchcock Road area, revealed two rockshelters with art, a possible grinding groove site, one shelter with potential archaeological deposit and a potential habitation shelter.

Corkill and Edgar (1999) undertook an archaeological survey for a sand quarry of 20 ha on the eastern side of the Old Northern Road, immediately opposite of the present study area. The area had been cleared of most native vegetation and the survey found no Aboriginal sites.

A survey by Appleton (2000) of about a 10 ha area about 5 km southeast of the present study area did not find any Aboriginal sites.

6.3 Site Prediction Model

Based on the surveys undertaken within and adjacent to the study area, there is likely to be only a limited range of sites situated within the study area. The previous survey of the entire Hitchcock Road quarry located three Aboriginal sites, all open artefact sites. Based on the topographic and geological environment of the study area, there is potential for the following sites to occur.

- Open Artefact Scatters are likely to occur on dry relatively flat landforms along or adjacent to creeks and on spur crests. The density of artefacts represented in these scatters can vary dramatically. These sites are sometimes referred to as `open campsites'. This site type is rare on Hawkesbury sandstone due to the difficulty of detection in areas where ground surfaces are often obscured by surface leaf litter and organic debris.

- Isolated Finds are artefacts that occur without any associated evidence for prehistoric activity or occupation. They are defined as single artefacts located more than 60 m from any other artefact. Isolated finds can occur anywhere in the landscape and may represent the random loss or deliberate discard of artefacts, or the remains of dispersed artefact scatters.

- Grinding grooves are the by-product of the manufacture of ground edge tools. These were generally made of stone, however bone and shell were also ground to fine points. The location of grinding grooves was usually dependent on the presence of a suitable rock type, usually fine-grained homogeneous sandstone, and an accessible, but not necessarily permanent, water source. Consequently they are often associated with rock pools in creek beds and on sandstone platforms.

- Rock engravings consist of any Aboriginal mark produced in rock using an extractive technique. However, the term is generally restricted to 'rock art', which can be defined as marks which are interpreted as being the result of processes unrelated to the mechanical production of food or commodities. Rock engravings commonly occur on flat rock faces in either exposed locations or less commonly, within rock shelters. Domestic processes that create marks that could be confused with engravings include tool sharpening or shaping and food grinding or preparation.

- ‘Engraving' in this terminology is used in a general sense and can refer to direct and indirect percussion, and varying types of abrasion. The location and preservation of engraving sites is dependent on local rock types and their weathering characteristics. Engravings can occur in groups with numerous depictions or as single depictions on sandstone platforms or small rock exposures.

- Scarred Trees result when bark has been removed from a tree for a particular purpose such as shield, canoe or coolamon manufacture. Scars may also be the result of making footholds in a tree to collect foodstuffs or to facilitate the removal of bark. These sites may occur almost anywhere, and identification of scars as Aboriginal in origin can often remain problematical. Many remaining scarred trees date to the historic period when bark was removed by Aboriginals for both their own purposes and for roofing on early European houses Consequently the distinction between European and Aboriginal scarred trees is often blurred.

- Potential Archaeological Deposits (PADs) are deposits, usually associated with rock shelters and actively aggrading landform features. They exhibit no identifiable archaeological material on the surface but may contain sub-surface material. Potential deposits are usually identified by their context within, or associated with, a landscape feature that was likely to have been exploited in prehistory.

Based on previous site assessments and the geology of the study area, grinding grooves and engraving sites have some potential to occur and there is a chance that rockshelters also are present. Artefact scatters and isolated finds may also be considered potentially to occur with the study area.

7. HISTORIC OVERVIEW

By the late eighteenth century, settlers had moved into the area west of Wisemans Ferry and grain and other crops were being grown for the colony. These early farmers provided Sydney Town with a great deal of it food. The produce was delivered by boat down the Hawkesbury River - a situation which saw Wisemans Ferry rapidly develop as an important river port, out into the Pacific Ocean and around into Sydney Harbour.

The convict Solomon Wiseman arrived in Sydney on 20 August 1806. In 1817 he was granted 200 acres on the banks of the Hawkesbury River where by 1821 he had established an inn called the 'Sign of the Packet'. In 1826 he built himself a two-storey residence, Cobham Hall, which he later used as a hostelry calling it The Branch Inn (Walk About website).

During this time the main land route from Sydney to Newcastle was via Windsor, along to Wisemans Ferry and up the Putty Road to Singleton. Governor Darling had ordered the construction of a road Sydney to the Hunter Valley after receiving a petition from settlers in the Hunter Valley.

Construction of the Great North Road as it was called started in 1826 from Castle Hill and proceeded to Wisemans Ferry and on to the Hunter. It was finished in 1836 but even as the convict gangs working on the project completed their task, the Wisemans Ferry section had fallen into disuse. The road was not the most favoured route due to the threat from bushrangers, its isolation and lack of facilities such as hotels. Other routes emerged and the impact of the paddle steamer industry also meant that there were more efficient means of travel (Comber 1990).

The *Maroota Trigonometrical Station,* which forms part of the main geodetic network of NSW, was originally a stone cairn type trig that was constructed in 1880. The Maroota parish map indicates that the Maroota Trigonometrical Station was first notified in 1888. The original trig has been reported as ‘destroyed’. It was replaced in 1974 with a standard concrete pillar trigonometrical station (TS2985 [P] Maroota) which is located 3.5 m east of the original stone trig site. The trig reserve number is 6739 (pers. comm Mr Paul Neale, Survey Services, NSW Department of Lands 2004).

The Maroota Trig is typical of the ‘standard’ and most common type of trig station in NSW. The trig is less than 50 years of age and as such is not a ‘heritage item’ under the NSW Heritage Act.

Lot 1 DP34599 was originally part of Portion 19, a 100 acre block extending from the original alignment of the Great North Road in a southwesterly direction. The 1895 parish map shows the land belonging to William Jones and was one large parcel until split in two by the new alignment of the Great North Road prior to 1913.

The land of Portion 214 was originally part of a reserve designated in 1913. The land was subsequently sold in 1924 but the portion 214 did not appear until the 1960 Parish map. The remaining land was designated as State Forest. Much of the early settlement occurred along Wisemans Ferry Road and the Great Northern Road as key transport links with the major markets.

8. SURVEY RESULTS

8.1 Aboriginal Sites

No Aboriginal sites were identified during the survey.

A thorough inspection of the location of site MR1 was carried out but no artefacts were found. The area had been recently graded and debris pushed into large piles of soil and rubbish. This activity may well have removed the artefacts (Plate 1).

Potential Archaeological Deposit (MRPAD1)

A potential archaeological deposit, or PAD, is defined as any location where the potential for subsurface archaeological material is considered to be moderate or high, relative to the surrounding study area landscape. Archaeological potential is assessed using criteria developed from the results of previous surveys and excavations relevant to the region.

The boundaries of PADs are generally defined by the extent of particular landforms known to have high correlations with archaeological material. A PAD may or may not be associated with surface artefacts. In the absence of artefacts, a location with potential will be recorded as a PAD. Where one or more surface artefacts occur on a sedimentary deposit, a PAD may also be identified where there is insufficient evidence to assess the nature and content of the underlying deposit. This is mostly due to poor ground surface visibility.

The topographic location of the site MR1 was on a flat spur crest at the head of Cattai Creek, within Lot 1 DP34599 (Figure 2). The topographic feature extended beyond the disturbance into areas of more natural vegetation that had been considerably less disturbed. It is possible and even likely therefore that the artefact scatter extends beyond the heavily disturbed area into the remnant forest. Although the crest of the spurline has shallow soils, visibility was poor enough to prevent making unequivocal statements about the potential for the site to be larger, with the main area of visibility provided by a track with sandy sheetwash (Plate 2).

The section of spur crest retaining native vegetation therefore has been identified as having potential archaeological deposit, even though the actual deposits may be shallow. The crest area extends for approximately 200 x 100 m. This area is referred to as MRPAD1.

8.2 European Sites

One European site (HRH1) was located during the investigations. The site was a farm shed that appeared to be over 50 years of age and therefore of potential heritage significance.

Hiscock Road Historic 1 (HRH1)

GPS: (AGD) 313212.6294511

The site was a simple farm shed about 11.7 m long, 6.6 m wide and 2.6 m high at its northern end. It comprised a gable roof at the southern end and a simple sloping awning type roof at the northern end (Plates 3 and 4). This section had been upgraded recently with new battens and corrugated iron.

The main part of the semi-enclosed shed was constructed with upright timber slabs, probably taken from the back of sleepers. Internal posts have been squared using an adze and there was a double swinging door at the southern end for vehicles. There were also two person doors, one at the eastern side and one on the southern end of the shed.

In general the shed is in poor condition and does not appear to be in use except to house disused farm pieces and a vehicle.

Moveable items in the shed included a fruit conveyor, old rotary hoe, a ute trailer, vehicle chassis and various pieces of timber and wooden fruit boxes.

Plate 1. View south across location of MR1 to vegetated are of PAD.

Plate 2. View north along spur crest track of PAD.

Plate 3. View of shed looking south

Plate 4. View of shed looking north.

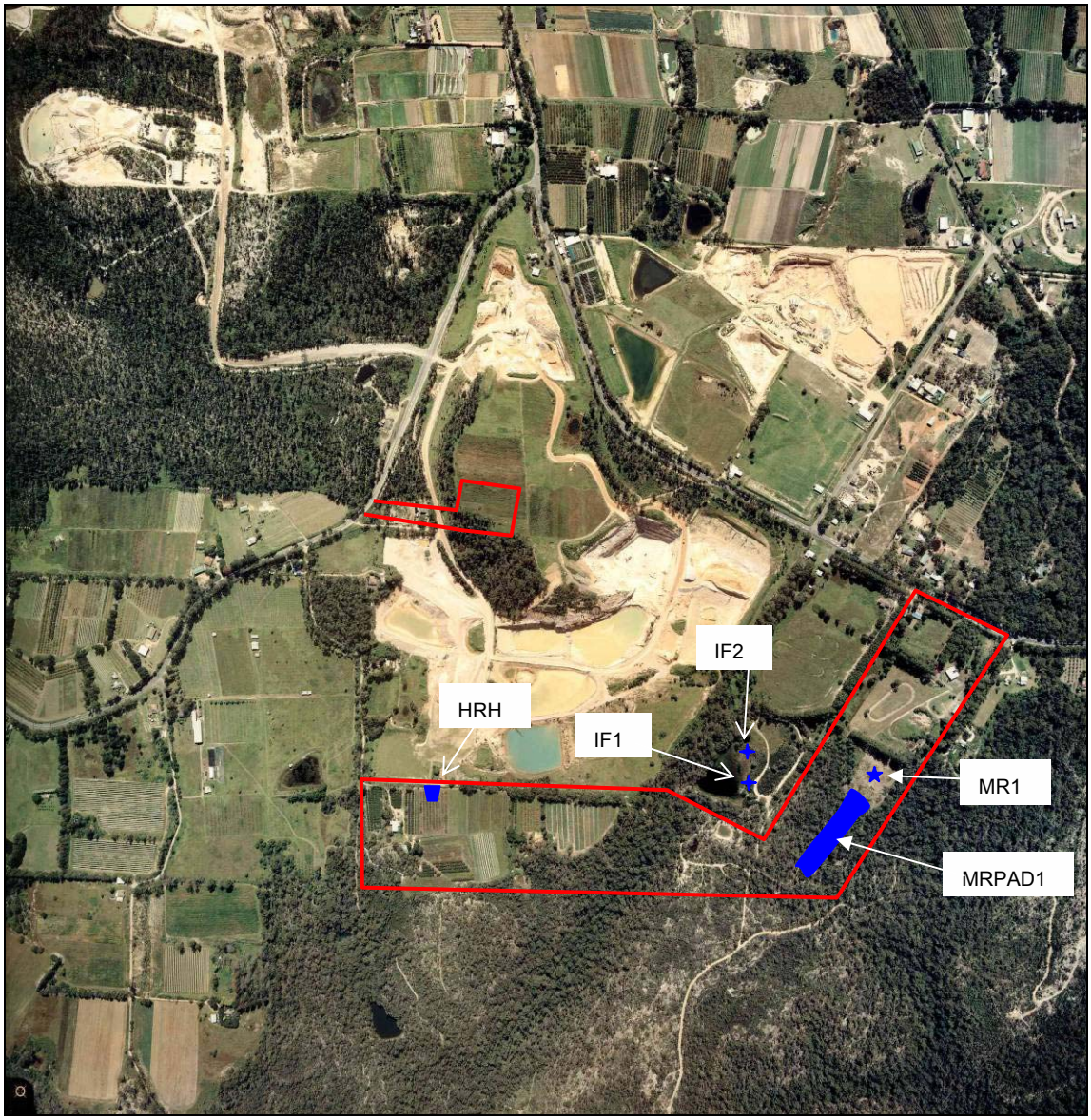


Figure 2. Aerial photo showing areas surveyed for the current investigation and sites located.

8.3 Survey Coverage and Visibility Variables

The effectiveness of archaeological field survey is to a large degree related to the obtrusiveness of the sites being looked for and the incidence and quality of ground surface visibility. Visibility variables were estimated for all areas of comprehensive survey within the study area. These estimates provide a measure with which to gauge the effectiveness of the survey and level of sampling conducted. They can also be used to gauge the number and type of sites that may not have been detected by the survey.

Ground surface visibility is a measure of the bare ground visible to the archaeologist during the survey. There are two main variables used to assess ground surface visibility, the frequency of exposure encountered by the surveyor and the quality of visibility within those exposures. The predominant factors affecting the quality of ground surface visibility within an exposure are the extent of vegetation and ground litter, the depth and origin of exposure, the extent of recent sedimentary deposition, and the level of visual interference from surface gravels. Two variables of ground surface visibility were estimated during the survey:

- a percentage estimate of the total area of ground inspected which contained useable exposures of bare ground

- a percentage estimate of the average levels of ground surface visibility within those exposures. This is a net estimate and accounts for all impacting visual and physical variables including the archaeological potential of the sediment or rock exposed.

The obtrusiveness of different site types is also an important factor in assessing the impact of visibility levels. Sites based on rock exposures, such as rock shelters, open engravings and grinding grooves are more likely to be encountered than sites with no surface relief located on, or within, sedimentary matrices. Rock platform sites are still subject to visibility constraints in the form of obscuring ground litter, flood debris and sedimentation, however, rock shelters are less likely to go uninspected. The inspection rate of rock shelters is likely to be 100% in a comprehensive survey, however the extent of leaf litter and recent sediment on a rock shelter floor may be an important factor in a recorder's ability to detect either a site, or simply a potential archaeological deposit.

In another example, artefacts made from locally occurring rock such as quartz may be more difficult to detect under usual field survey conditions than rock types that are foreign to the area. The impact of natural gravels on artefact detection was taken into account in the visibility variables estimates outlined above.

The natural incidence of sandstone platforms suitable for grinding grooves or engraving, together with the incidence of old growth trees, are important considerations in identifying both survey effectiveness and site location patterns outside of environmentally determined factors.

The following table summarises estimates for the degree to which separate landforms within the study area were examined and also indicates the exposure incidence and average ground visibility present in each case. A total of 40.9% of the ground area in the study area was inspected during the survey, with 29.7% providing useable archaeological exposures. A graphic approximation of the surface survey coverage achieved within the study area is shown in Figure 3.

Taking into account survey coverage, archaeologically useable exposures, and visibility variables, the effective survey coverage (ESC) was 6.2% of the total survey area. The ESC attempts to provide an estimate of the proportion of the total study area that provided a net 100% level of ground surface visibility to archaeological surveyors.

The ESC calculation is defined and required by the NPWS and stated to be of use in assessing and cross comparing the adequacy of archaeological surface surveys. The actual utility of the ESC calculation however is challenged by many archaeologists. The limitations of the ESC calculation are emphasised by differences in the subjective assessment of exposure and visibility levels, variations in how survey units are defined and measured, and differences in how and which variables are estimated and combined. In reality, ESC results tend only to be meaningful when compared across surveys conducted by the same surveyors and ESC measurers.

Table 3: Survey Coverage Data

Survey division	Survey unit	Landform	Survey mode	Main exposure types	Estimated Survey Unit area (ha)	Proportion of unit surveyed %	Area of unit surveyed (ha)	Exposure incidence %	Average exposure visibility %	Net effective exposure (ha)	Effective survey coverage of survey unit %	Aboriginal Archaeological recordings
Marcota Trig	1	ridge crest/knoll, ridge slopes	foot	vehicle tracks	1.5	40	0.6	5	15	0.0045	0.3	
Portion 214	1	creekline	foot	bare ground, fire	2	40	0.8	20	30	0.0480	2.4	
	2	spur crest	foot	farmland	4	75	3	30	50	0.4500	11.3	
	3	spur slopes	foot	farmland	4	40	1.6	20	30	0.0960	2.4	
Lot 1 DP34599	1	spurline	foot	vehicle tracks, disturbed ground	12	30	3.6	40	60	0.8640	7.2	
Total					*23.5*		*9.6*			*1.4625*	*6.2*	

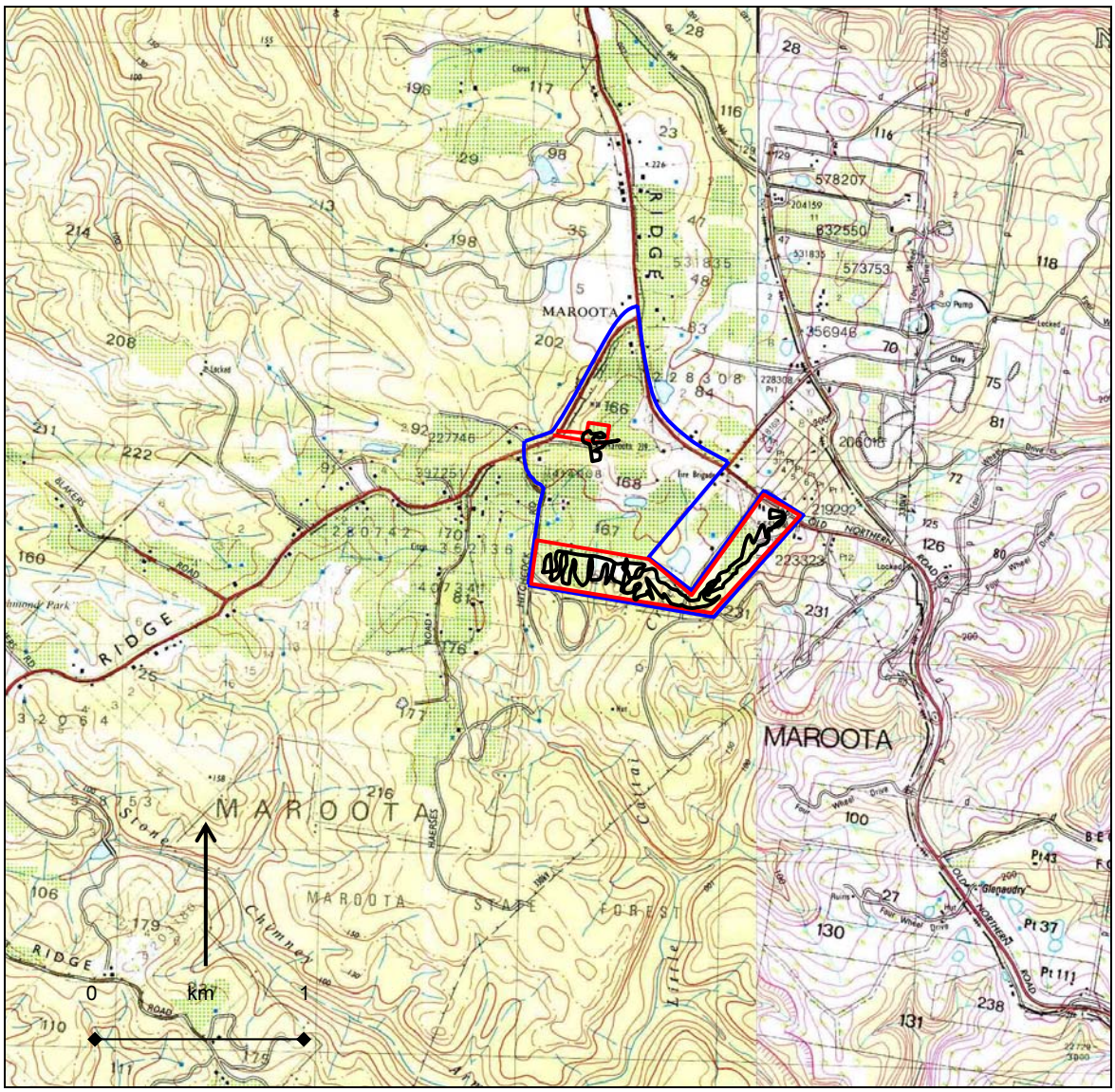


Figure 3 A graphic approximation of the surface survey coverage achieved within the study area. (Lower Portland and Gunderman 1:25,000 topographic maps).

9. SIGNIFICANCE ASSESSMENT

9.1 European Heritage

9.1.1 Assessment Criteria

The NSW Heritage Office has defined a methodology and set of criteria for the assessment of cultural heritage significance for items and places, where these do not include Aboriginal heritage from the pre-contact period (NSW Heritage Office & DUAP 1996, NSW Heritage Office 2000). The assessments provided in this report follow the Heritage Office methodology.

The following heritage assessment criteria are those set out for Listing on the State Heritage Register. In many cases items will be significant under only one or two criteria. The State Heritage Register was established under Part 3A of the Heritage Act (as amended in 1999) for listing of items of environmental heritage that are of state heritage significance. Environmental heritage means those places, buildings, works, relics, moveable objects, and precincts, of state or local heritage significance (section 4, Heritage Act 1977).

An item will be considered to be of State (or local) heritage significance if, in the opinion of the Heritage Council of NSW, it meets one or more of the following criteria:

Criterion (a) an item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (b) an item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (c) an item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area);

Criterion (d) an item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons;

Criterion (e) an item has potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (f) an item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (g) an item is important in demonstrating the principal characteristics of a class of NSW's

- cultural or natural places; or
- cultural or natural environments.
    - (or a class of the local area's
- cultural or natural places; or
- cultural or natural environments.)

An item is not to be excluded from the Register on the ground that items with similar characteristics have already been listed on the Register. Only particularly complex items or places will be significant under all criteria.

In using these criteria it is important to assess the values first, then the local or State context in which they may be significant.

Different components of a place may make a different relative contribution to its heritage value. For example, loss of integrity or condition may diminish significance. In some cases it is constructive to note the relative contribution of an item or its components. The following table provides a guide to ascribing relative value:

Grading	Justification	Status
Exceptional	Rare or outstanding item of local or State significance. High degree of intactness Item can be interpreted relatively easily.	Fulfils criteria for local or State listing.
High	High degree of original fabric. Demonstrates a key element of the item's significance. Alterations do not detract from significance.	Fulfils criteria for local or State listing.
Moderate	Altered or modified elements. Elements with little heritage value, but which contribute to the overall significance of the item.	Fulfils criteria for local or State listing.
Little	Alterations detract from significance. Difficult to interpret.	Does not fulfil criteria for local or State listing.
Intrusive	Damaging to the item's heritage significance.	Does not fulfil criteria for local or State listing.

9.1.2 The Study Area

The farm shed (HRH1) located during the survey does not meet a threshold where it would be considered significant under any of the criteria established by the NSW Heritage Office and listed above.

The site does not therefore require any additional assessment or listing on any of the local or State registers.

10. STATUTORY INFORMATION[1]

10.1 The National Parks and Wildlife Act 1974

The following summary is based on:

- the provisions of the current National Parks and Wildlife Act 1974 (as amended). It should be noted that amendments to this Act were passed by both houses of the NSW State Government in 2001 (no.130, assented 19/12/2001). Some of these amendments are yet to be proclaimed.

- Department of Environment and Conservation policy as presented in the 1997 Standards and Guidelines Kit for Aboriginal Cultural Heritage provided by the NSW NPWS, and as communicated orally to the consultants on a periodic basis. The 1997 Standards and Guidelines Kit is currently under review and subject to change in the near future.

The guideline documents presented in the 1997 Standards and Guidelines Kit were stated to be working drafts and subject to an 18 months performance review. The Standards Manual was defined not to be a draft and subject to periodic supplements.

The National Parks and Wildlife Act 1974 (as amended) provides the primary basis for the legal protection and management of Aboriginal sites within NSW. The implementation of the Aboriginal heritage provisions of the Act is the responsibility of the Department of Environment and Conservation (DEC).

The rationale behind the Act is the prevention of unnecessary or unwarranted destruction of relics, and the active protection and conservation of relics that are of high cultural significance.

With the exception of some artefacts in collections, or those specifically made for sale, the Act generally defines all Aboriginal artefacts to be 'Aboriginal Objects' and to be the property of the Crown. An Aboriginal object has a broad definition and is inclusive of most archaeological evidence The Act then provides various controls for the protection, management and disturbance of Aboriginal Objects.

An Aboriginal object is defined as:

> 'any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains.' [Section 5(1)].

In practice, archaeologists use a methodology that groups 'Aboriginal Objects' into various site classifications according to the nature, occurrence and exposure of archaeological material evidence. The archaeological definition of a site may vary according to survey objectives, however a site is not recognised or defined as a legal entity in the Act. It should be noted that even single and isolated artefacts are protected as Aboriginal Objects under the Act.

Generally it is an offence to do any of the following without a Permit from the Director-General of the Department of Environment and Conservation under Section 87: disturb or excavate any land for the purpose of discovering an Aboriginal Object; disturbing or moving an Aboriginal Object; take possession of or removing an Aboriginal Object from certain lands; and erecting a building or structure to store Aboriginal Objects on certain land (Section 86). The maximum penalty is $11,000 for individuals and $22,000 for corporations. Section 175B outlines circumstances where corporation

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[1] The following information is provided as a guide only and is accurate to the best knowledge of Navin Officer Heritage Consultants. Readers are advised that this information is subject to confirmation from qualified legal opinion.

directors may be taken to have contravened these provisions, based on the acts or omissions of that Corporation.

Consents regarding the use or destruction of Aboriginal Objects are managed through a system of Permits and Consents under the provisions of Sections 87 and 90 of the Act. The processing and assessment of Permit and Consent applications is dependent upon adequate archaeological review and assessment, together with an appropriate level of Aboriginal community liaison and involvement (refer Standards for Archaeological Practice in Aboriginal Heritage Management in 1997 NPWS Standards and Guidelines Kit).

The Minister may declare any place which, in his or her opinion, is or was of special Aboriginal significance with respect to Aboriginal culture, to be an Aboriginal place (Section 84). The Director-General has responsibility for the preservation and protection of the Aboriginal place (Section 85). An area declared to be an Aboriginal place may remain in private ownership, or be acquired by the Crown by agreement or by a compulsory process (Section 145).

The Director General may make an interim protection order and order that an action cease where that action is, or is likely to, significantly affect an Aboriginal object of Aboriginal place. Such an order is current for 40 days (Section 91AA, Schedule 3[10]). Such an order does not apply to certain actions, such as where they are in accordance with development consents or emergency procedures.

General Management Constraints and Requirements

The Act, together with the policies of the Department of Environment and Conservation provide the following constraints and requirements on land owners and managers:

- It is an offence to knowingly disturb an Aboriginal Object (or site) without an appropriate permit or consent (Sections 87 and 90);

- Prior to instigating any action which may conceivably disturb an Aboriginal Object (this generally means land surface disturbance or felling of mature trees), archaeological survey and assessment is required (refer Standards for Archaeological Practice in Aboriginal Heritage Management in 1997 NPWS Standards and Guidelines Kit).

- When the archaeological resource of an area is known or can be reliably predicted, appropriate landuse practices should be adopted which will minimise the necessity for the destruction of sites/Aboriginal Objects, and prevent destruction to sites/Aboriginal Objects which warrant conservation (refer Standards for Archaeological Practice in Aboriginal Heritage Management in 1997 NPWS Standards and Guidelines Kit).

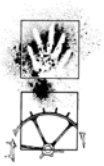
- Documented and appropriate consultation with relevant Aboriginal Community representatives is required by the Department of Environment and Conservation as part of the prerequisite information necessary for endorsement of consultant recommendations or the provision of Consents and Permits by the NPWS (refer Standards for Archaeological Practice in Aboriginal Heritage Management in 1997 NPWS Standards and Guidelines Kit).

10.2 The National Parks and Wildlife Amendment Bill 2001

Although this Act was passed by both houses of the NSW parliament in 2001, a number of its provisions with regard to Aboriginal cultural heritage have yet to be gazetted and are not yet law. These include the following provisions:

- The requirement for a section 90 ‘Consent to Destroy’ from the Director General will be replaced by a ‘heritage impact permit’ (Schedule 3[1], 3[3-8]).

- The offence under section 90 of the Principal Act of ‘knowingly’ destroying, defacing or damaging Aboriginal objects and Aboriginal Places without Consent will be changed so that the element of knowledge will be removed (Schedule 3 [2]). The amended section 90, subsection 1 will read:



'A person must not destroy, deface, damage or desecrate, or cause or permit the destruction, defacement, damage or desecration of, an Aboriginal object or Aboriginal place.'

- Section 90 subsection 1 will not apply when an Aboriginal object or Aboriginal place is dealt with in accordance with a heritage impact permit issued by the Director-General (Schedule 3[3], Section 90(1B) in amended Act).

- It will be a defence to a prosecution for an offence against subsection 1 if the defendant shows that:

- 'he or she took reasonable precautions and exercised due diligence to determine whether the action constituting the alleged offence would, or would be likely to, impact on the Aboriginal object of Aboriginal place concerned, and

- the person reasonably believed that the action would not destroy, deface, damage or desecrate the Aboriginal object or Aboriginal place.' (Schedule 3[3], Section 90(1C) in amended Act)

- A court will be able to direct a person to mitigate damage to or restore an Aboriginal object or an Aboriginal place in appropriate circumstances when finding the person guilty of an offence referred to in section 90 of the Principal Act (Schedule 3[9]).

- Schedule 4[8] of the Bill provides for the Director-General to withhold in the public interest specified documents in the possession of the NPWS which relate to the location of Aboriginal objects, or the cultural values of an Aboriginal place or Aboriginal object.

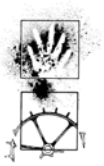
10.3 Statutory constraints arising from artefacts which constitute background scatter

Background scatter is a term used generally by archaeologists to refer to artefacts that cannot be usefully related to a place or focus of past activity. There is no single concept for background 'scatter' or discard, and therefore no agreed definition. The recognition of background material within a particular study area is dependent on an appreciation of local contextual and taphonomic factors. Artefacts within a 'background' scatter can be found in most landscape types and may vary considerably in density.

Standard archaeological methodologies cannot effectively predict the location of individual background scatter artefacts. Surface survey may detect background material either as individual artefacts ('isolated finds'), or even as small, low-density 'sites'. Subsurface testing may sample, and through analysis, characterise background material. However, beyond the scope of archaeological sampling, the potential to encounter background artefacts within the context of development related ground disturbance will always remain.

Most previous cultural resource management archaeological methodologies have acknowledged that there is little scientific justification for the conduct of archaeological salvage or ground disturbance monitoring to effect the recovery of background artefacts. The intrinsic scientific value of any recovered artefacts does not, in general, outweigh the expense of conducting the monitoring. However, low density distributions of artefacts are a current subject of interest by some heritage practitioners and DEC policy regarding this issue may change in the future. The monitoring of construction related ground works by Aboriginal groups is now increasingly practiced. The recovery of background scatter artefacts is often a probable outcome of such monitoring exercises.

Given the nature of statutory and DEC policy requirements in NSW (refer Section 9), the detection of background artefacts during monitoring can be problematic. Unless the Aboriginal object is covered by a current Consent or Permit (or Heritage Impact Permit (HIP)), from DEC, all further impact to the find, and the ground in its immediate vicinity, must cease until one is gained. It may take up to eight weeks for this to occur. In the past, however, DEC has not as a general rule granted Consents to cover artefacts within background scatters. This is because DEC only provide Consents where the



significance and location of the Aboriginal Objects to be impacted can be reliably defined. By their very nature, this cannot be done for artefacts that constitute a background scatter.

The present policies of DEC do not provide an effective or proactive means of dealing with the statutory constraints posed by the detection of background scatter artefacts during development works. It should therefore be noted, that in the event that an Aboriginal artefact ('Aboriginal object') is detected during monitoring of ground disturbance within a development study area, and that area is not covered by a Consent to Destroy (or Heritage Impact Permit), there may be considerable delays to development works while an application for a Consent to Destroy is processed.

10.4 The NSW Heritage Act (1977)

Overview

The purpose of the NSW Heritage Act 1977 is to ensure that the heritage of New South Wales is adequately identified and conserved. In practice the NSW Heritage Act has focussed on items and places of non-indigenous heritage to avoid overlap with the NPWS Act, 1974 which has primary responsibilities for nature conservation and the protection of Aboriginal relics and places in NSW.

The *Heritage Amendment Act 1998* came into effect in April 1999. This Act instigated changes to the NSW heritage system, which were the result of a substantial review begun in 1992. A central feature of the amendments was the clarification and strengthening of shared responsibility for heritage management between local government authorities, responsible for items of local significance, and the NSW Heritage Council. The Council retained its consent powers for alterations to heritage items of state significance.

The Heritage Act is concerned with all aspects of conservation ranging from the most basic protection against damage and demolition, to restoration and enhancement. It recognises two levels of heritage significance, State significance and Local significance across a broad range of values. Some key provisions of the Act are:

- the establishment and functions of the Heritage Council (Part 2),
- interim heritage orders (Part 3), the State Heritage Register (Part 3A),
- Heritage Agreements (Part 3B),
- environmental planning instruments (Part 5),
- the protection of archaeological deposits and relics (Part 6), and
- the establishment of Heritage and Conservation Registers for state government owned and managed items (Part 7).

Generally this Act provides protection to items that have been identified, assessed and listed on various registers including State government section 170 registers, local government LEPs and the State Heritage Register. The Interim Heritage Order provisions allow the minister or his delegates (local government may have delegated authority) to provide emergency protection to threatened places which have not been previously identified. The only 'blanket' protection provisions in the Act relate to the protection of archaeological deposits and relics greater than 50 years old.

Protection of Archaeological Relics and Deposits

Section 139 of the Act specifically provides protection for any item classed as a relic. A relic is defined as "...any deposit object or material evidence -

(a) which relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement; and

(b) which is 50 or more years old."

(Heritage Act 1977, Part 1, Section 4)

Section 139 of the Act disallows disturbance of a relic unless in accordance with an 'excavation permit' from the Heritage Council. Some forms of disturbance to relics may be exempt from requiring a section 139 permit (refer below).

Section 146 of the Act requires that the discovery of a previously unknown relic be reported to the Heritage Council within a reasonable time of its discovery.

Permits and Approval Requirements

The Act includes two key approval requirements;

- A permit must be obtained for works which have the potential to interfere with a heritage item or place which is either listed on the State Heritage Register or the subject of an interim heritage order (Section 57); and

- A permit must be obtained to disturb or excavate land where it is known (or there is reasonable cause to suspect) that such action will or is likely to uncover or affect a relic (Section 139).

Exemptions from Permit Requirements

Certain activities are exempted from the Section 57 and 139 permit approval requirements. Exemptions from Section 57 requirements may be granted by the Minister, and the NSW Heritage Council may provide exemptions from Section 139 requirements.

A schedule of section 57 exemptions has been formulated which includes activities such as certain types of maintenance and repair, minor excavations, changes of use, some temporary structures and 'anything which in the opinion of the Director is of a minor nature and will not adversely affect the heritage significance of the item'. In many cases notification of such proposed activities must be made by the applicant to the Director, and written notification from the Director received regarding his satisfaction that the exemption criteria have been met.

A series of exemptions have also been established for Section 139 Permit approval requirements. This includes demolition and maintenance of bridges not listed on the State Heritage Register, some forms of excavation and maintenance of underground services, conservation and repair of monuments and grave markers, and the exposing of survey marks in the course of survey operations.

On the 5th March of 2003, the following section 139 exemptions were notified:

> Excavation or disturbance of the following land does not require an excavation permit under Section 139, provided that the Director is satisfied that the criteria in (a), (b) or (c) have been met and the person to undertake the excavation or disturbance has received a notice advising that the Director is satisfied:
>
> (a) where an archaeological assessment has been prepared in accordance with Guidelines published by the Heritage Council of NSW which indicates that there is little likelihood of there being any relics in the land or that any relics in the land are unlikely to have State or local heritage significance;
>
> (b) where the excavation or disturbance of land will have a minor impact on the archaeological resource;
>
> (c) where the excavation or disturbance of land involves only the removal of fill which has been deposited on the land.

A person proposing to excavate or disturb land according to the above criteria must write to the Director and describe the proposed excavation or disturbance and set out why it satisfies the criteria. The Director shall notify the applicant if he or she is satisfied that one or more of the criteria have been met.

The Heritage Council of NSW

The role of the Heritage Council is to provide the Minister with advice on a broad range of matters relating to the conservation of the heritage of NSW. It also has a role in promoting heritage conservation through research, seminars and publications. The membership of the Heritage Council is designed to reflect a broad range of interests and areas of expertise.

Interim Heritage Orders

Under the provisions of Part 3 of the Act, the Minister can make an interim heritage order (IHO). A recommendation with respect to an order can come from the Heritage Council, either based on a request for the Minister, or the Council's own considerations. The Minister can also authorise Local Councils to make IHOs within their area. An interim conservation order may remain in force for up to 12 months, until such time as it is revoked or the item is listed on the State Heritage Register. A heritage order may control activities such as demolition of structures, damage to relics, places or land, development and alteration of buildings, works or relics.

The State Heritage Register

Changes to the Heritage Act in the 1998 amendments established the State Heritage Register which includes all places previously protected by permanent conservation orders (PCOs) and items identified as being of state significance in heritage and conservation registers prepared by State Government instrumentalities. Sites or places which are found to have a state level of heritage significance should be formally identified to the Heritage Council and considered for inclusion on the State Heritage Register.

Heritage Agreements

Under Section 39 of the Act, the Minister can enter into an Agreement with the owner of a heritage item listed on the State Heritage Register to ensure its conservation. Such an Agreement can cover a range of responsibilities including financial or specialist assistance and can be attached to the title of the land.

Environmental Planning Instruments

Part 5 of the Act gives the Heritage Council the authority to request that an environmental planning instrument be prepared covering certain lands. It also directs that the Heritage Council shall be consulted by others when preparing a draft planning instrument affecting land to which an interim heritage order applies or which includes an item listed on the State Heritage Register. In addition it gives the Heritage Council the authority to produce guidelines for the preparation of such planning instruments.

Heritage and Conservation Registers

Section 170 of the Act requires all state government instrumentalities to establish and maintain a Heritage and Conservation Register that lists items of environmental heritage. The register is to include items which are, or could potentially be, the subject of a conservation instrument, and which are owned, occupied or otherwise under the control of that instrumentality.

11. CONCLUSIONS AND RECOMMENDATIONS

The study for the proposed expansion of sand mining activity within the Maroota Trig block, Portion 214 and Lot 1 DP34599 did not locate any Aboriginal sites. One small farm shed was recorded. With respect to the farm shed (HRH1), the site was not considered to warrant protection or listing on relevant registers and therefore poses no constraints to the development.

Most of the areas of investigation had been subject to extensive European disturbance and although visibility was good in many areas, no Aboriginal sites were located. The previously recorded isolated finds are no longer in areas considered for mining and therefore not affected by the proposals.

The small artefact scatter MR1 was not relocated during the present investigation, most likely due to the recent disturbance and grading of the general location. Edgar (1995) originally stated that there was little potential for subsurface deposits to occur at the site and given the disturbance history of the immediate site location, this conclusion is accepted. However, consideration of the topography associated with the site indicates that there is potential for additional artefacts to be located on the spur crest and this are was consequently identified as a PAD.

The representatives from the Deerubin Aboriginal Land Council also expressed concern about the archaeological potential for the area and expressed a wish to conduct additional investigations in the form of subsurface testing. The potential for artefacts to occur within the topographic feature suggests that such a strategy may be prudent.

The investigation did not locate any additional areas where sites or areas of intact potential archaeological deposits were likely to occur. Both the Maroota Trig and Portion 214 were heavily disturbed with little chance of finding intact deposits.

Based on the results of the survey and the assessment of the study area, the following recommendations are provided.

1. Prior to development, subsurface testing should be undertaken in the vegetated spur crest adjacent to site MR1, noted as MRPAD1 on Figure 2.

2. Subsurface investigations would need to be completed by a qualified archaeologist with a Section 87 permit from the DEC. Consultation and involvement of the three Aboriginal community groups would also be required.

3. Any disturbance of site MR1 would require a section 90 ‘Consent to Destroy’ permit from the DEC. This would require agreement from the three Aboriginal community groups.

4. There are no constraints to mining expansion within the rest of the proposed areas.

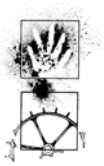
5. If any object is found during development proceeding that is suspected of being Aboriginal in origin, then work in that area must cease and the DEC notified.

6. Three copies of this report should be sent to:

   Cultural Heritage Officer
   Department of Environment and Conservation
   PO BOX 1967
   HURSTVILLE 2220

7. One copy of the report should be sent to:

   The Secretary
   Deerubin LALC
   PO Box 3184
   MT DRUITT VILLAGE 2770



Celestine Everingham
Darug Tribal Aboriginal Corporation
90 Meredith Road
KURRRAJONG HILLS 2758

Leanne Wright
Darug Custodians Aboriginal Corporation
PO Box 36
KELLYVILLE 2155

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APPENDIX 1

ABORIGINAL PARTICIPATION FORMS

Record of Aboriginal Representative Participation*

Name(s) of Aboriginal Representative: PHIL KHAN + STEVE RANDALL

Name of Aboriginal Organisation: DEERUBIN LOCAL ABORIGINAL LANDS COUNCIL

Archaeologist(s): name & address Matthew Barber
Navin Officer Heritage Consultants Pty Ltd
4/71 Leichhardt Street, Kingston, ACT 2604

Project Name: Maroota Sands: Hitchcock Road and Lot 198 Archaeological Surveys

Client: name & address David Fingland
(please send your invoice DFA Consultants
to this address) 30 Cumberland Avenue, Castle Hill, NSW 2154

Type of participation:

- ☐ Guided inspection of study area and sites
- ☒ Accompanied/participated in archaeological survey
- ☐ Separate inspection or survey
- ☐ Accompanied/participated in excavation program

Period of participation:

Date(s)	Start	Finish
~~6~~ 6-8-04	8.00	4.30
	8.00	4 30

Issues raised:

Signed *(archaeologist)*: M. Barber

Signed *(Aboriginal representative(s))*: S Randall. P Khan

* *please note this form is not an invoice. For payment, please send an invoice from your organisation to the client name and address provided above.*

Record of Aboriginal Representative Participation*

Name(s) of Aboriginal Representative: LEANNE WRIGHT

Name of Aboriginal Organisation: DARUG CUSTODIANS ABORIGINAL CORP

Archaeologist(s): name & address Matthew Barber
Navin Officer Heritage Consultants Pty Ltd
4/71 Leichhardt Street, Kingston, ACT 2604

Project Name: Maroota Sands: Hitchcock Road and Lot 198 Archaeological Surveys

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- ☐ Separate inspection or survey
- ☐ Accompanied/participated in excavation program

Period of participation:

Date(s)	Start	Finish
5-8-04	10:30	5:00

Issues raised:

Signed *(archaeologist)*: M. Barber

Signed *(Aboriginal representative(s))*: L Wright

* *please note this form is not an invoice. For payment, please send an invoice from your organisation to the client name and address provided above.*

Record of Aboriginal Representative Participation*

Name(s) of Aboriginal Representative: CELESTINE EVERINGHAM + GORDON MORTON

Name of Aboriginal Organisation: DARUG TRIBAL ABORIGINAL CORP

Archaeologist(s): name & address Matthew Barber
Navin Officer Heritage Consultants Pty Ltd
4/71 Leichhardt Street, Kingston, ACT 2604

Project Name: Maroota Sands: Hitchcock Road and Lot 198 Archaeological Surveys

Client: name & address David Fingland
(please send your invoice DFA Consultants
to this address) 30 Cumberland Avenue, Castle Hill, NSW 2154

Type of participation:

- ☐ Guided inspection of study area and sites
- ☒ Accompanied/participated in archaeological survey
- ☐ Separate inspection or survey
- ☐ Accompanied/participated in excavation program

Period of participation:

Date(s)	Start	Finish
5-8-04	10:30	5:00

Issues raised:

Signed *(archaeologist)*: M. Barber

Signed *(Aboriginal representative(s))*: C. Everingham

* *please note this form is not an invoice. For payment, please send an invoice from your organisation to the client name and address provided above.*

8

TECHNICAL PAPER

VISUAL IMPACTS

PF Formation

HITCHCOCK ROAD MAROOTA

Sand Extraction and Rehabilitation Project
Environmental Assessment

TECHNICAL PAPER 8
Visual Impacts

Prepared for:

PF Formation
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Prepared by:

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Hitchcock Road Sand Extraction and Rehabilitation Project
Environmental assessment

Technical Paper 8 Visual impacts

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Technical Paper 8 Visual impacts

1 Introduction

The objectives of the Technical Paper are to:

- determine the current sensitivity of the site as perceived from those areas to which the public and adjacent residents have access;
- determine the level of visual impact that the proposal could produce and establish appropriate guidelines to manage these impacts, if required; and
- identify visual quality objectives for the development.

2 The site

The site is bounded to the north west by Wisemans Ferry Road, to the north east by Old Northern Road, to the west by Hitchcock Road and to the south and south east by adjoining Crown land which also constitutes the boundary of the Maroota sector of *Sydney Regional Environmental Plan 9 - Extractive Industry (Number 2)*.

The dominant natural feature of the site is the former Maroota Trigonometrical Hill which reaches an elevation of 240.7 metres AHD. The lowest point on the site has a level of approximately 188 metres AHD while the majority of the area has an elevation at or above 200 metres AHD. The site is therefore generally higher than the surrounding areas. As a result, views into and across the site from peripheral roads are limited to a small number of locations along Old Northern Road, Wisemans Ferry Road and Hitchcock Road. Views from other locations are restricted by rising ground within the site or bunds constructed as part of the present development. The general topography of the area is shown on *Figure 2.1*.

The site contains a mix of vegetation types and areas cleared of vegetation, undergoing rehabilitation, previously subject to agricultural activities and those where sand extraction is active.

The site is located in a rural environment at the southern end of the Maroota Ridge which forms part of the Hornsby Plateau. The Hawkesbury River is to the north west of the site within a deeply incised valley with heavily forested steep river terraces.

A number of visual mitigation measures, predominantly earth bunds along the periphery of the site included as part of the current development, have reinforced the natural screening effects of the topography resulting in a reduction in visual sensitivity.

3 Existing visual character of the site

3.1 Overall approach

The visual sensitivity of an existing development is conventionally defined by two main considerations. These are the visual character of the site and its ability to accommodate change without compromising its qualities and the extent to which it is visible to the public and the number of people who could experience that particular view. Sensitivity therefore ranges from high where the qualities of the site are sensitive to change and is highly visible to a large number of people to low where the area can easily accommodate change and the view is limited. There are many combinations within this range which will influence the visual assessment of a site and its ability to accept change.

A visual survey was undertaken from a number of selected locations on the public roads surrounding the site from which views of the extraction area might be available. Where views could be obtained, photographs were taken from these locations. None of these were taken from private properties.

The survey included views from Old Northern Road, Wisemans Ferry Road, Hitchcock Road, Days Road, Haerses Road and the Bakers Road intersection with Wisemans Ferry Road. Views into the site were not available from any other public locations. The location of the photographs is shown on *Figure 3.1*.

3.2 Views of the site

3.2.1 Old Northern Road

The first views of the site from the south are available some 700 metres from the boundary. This is a middle-ground view of the heavily vegetated ridgeline which forms the boundary and the vegetated foreground slopes preceding it. The vegetation on the site is just visible in the background merging with that closer to the viewer. The ridge and the dense vegetation eliminate any possibility of views into the site. All the vegetation along this boundary of the site would be retained. (**Photograph 1**)

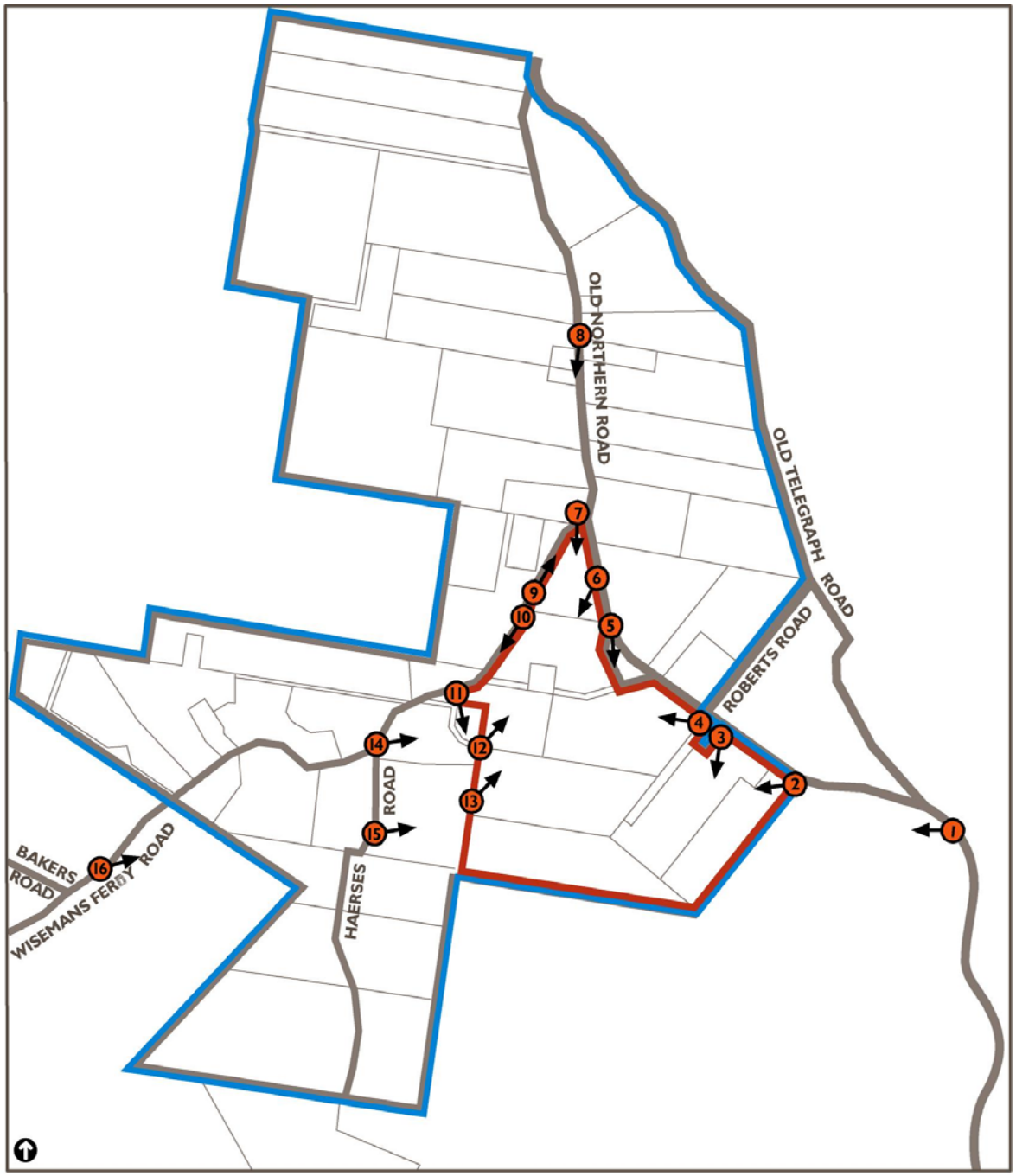

Figure 3.1
LOCATION OF PHOTOGRAPHS

The view of the south east corner of the site from Old Northern Road is also restricted by steep road-side batters and established vegetation. The site begins just beyond the turning on the left side of the road. All the vegetation along this boundary would be retained. (**Photograph 2**)

The first clear views of the site are obtained adjacent to the Scout Hall where the land falls away from the road. Here the area is cleared grassland for a distance of approximately 200 metres into the site with the view terminated by existing vegetation. Some of this vegetation would be cleared but views further into the southern part of the site which continues to fall away from the road but is heavily vegetated, would not be affected. (**Photograph 3)**

Views are available into the site immediately north of Lot 1 DP 223323 Old Northern Road but are restricted by the presence of established vegetated bunds to those areas behind the raised earth mounds. Although the land falls away from the road very little of the extraction area is visible. This is restricted to the former Trigonometrical Reserve hill approximately 300 metres to the west, glimpses of which are available from the road. Further planting and growth of the existing vegetation on the bunds will eliminate these views. (**Photograph 4**)

Further north along Old Northern Road the landform rises into the site which together with the dense existing vegetation eliminates any views into it. This vegetation screen is located outside the property boundary and would be expected to be retained. (**Photograph 5**)

The section of the site as far as the intersection with Wisemans Ferry Road comprises a rising cleared landform open to views from the road. However, mounding within the road setback effectively screens the extraction operations from view. (**Photograph 6**)

The view from the intersection of Old Northern Road and Wisemans Ferry Road shows mounding which screens the slurry plant and the adjacent extraction area. The stockpiles located immediately behind the plant are however visible and these become more intrusive when viewed from further north where Old Northern Road rises. These are temporary and will be gradually removed as extraction progresses. (**Photograph 7**)

The view from Maroota Public School located approximately 600 metres north of the Old Northern Road and Wisemans Ferry intersection shows the vegetation on the highest point of the site on the skyline and the effect of screening vegetation to the north of the site. The stockpiles seen in Photograph 7 are just visible due to the colour contrast. Boundary planting along the northern perimeter of the site would take many years to effectively screen views of the site from this location. (**Photograph 8**)

There were no other discernible views of the site from Old Northern Road.

3.2.2 Wisemans Ferry Road

The section of the site along Wisemans Ferry Road to the north of the site entrance has a continuous bund within the road setback which has been planted with native vegetation. This eliminates all views of quarry-related activities in this area. The landform to the south of the entrance rises steeply from the road and views are screened by the existing roadside vegetation. (**Photograph 9**)

Immediately south of the entrance to the site, boundary screening and the rising ground on the site will screen future extraction activities further to the east. (**Photograph 10**)

Close to the entrance to Hitchcock Road, the thickly vegetated western side of the former Trigonometrical Reserve hill can be seen above cleared grassland. Screening of this view would be difficult particularly in the short term due to the considerable difference in levels. However, existing vegetation on the western side of the haul road and new plantings in the extracted area to the west, now undergoing rehabilitation, would eliminate most views from this location in the long term. (**Photograph 11**)

3.2.3 Hitchcock Road

Hitchcock Road is the western boundary of the site. Limited views are available of the extraction area and the raised ground in the centre of the site interrupted by intervening vegetation along the eastern side of the road. However, this is the closest view of the area available to the public and the contrast between the extracted areas and the

vegetation rising to the skyline is pronounced at present. Hitchcock Road is a cul de sac and is little used by the public.(**Photograph 12**)

Views from the end of Hitchcock Road are restricted by the topography as the level of the road starts to fall to the south and the rising ground along the edge of the site allows only the highest parts of the site to be seen. (**Photograph 13**).

3.2.4 Haerses Road

The view from the intersection of Hearses Road and Wisemans Ferry Road provides glimpses of a wide panorama of the high point of the site with vegetation on the skyline and the contrasting colour of the extracted area below. Part of this area is undergoing the final stages of rehabilitation and the colour contrast will gradually diminish over the next year. Parts of the hill are clearly discernible from this location and this view would

change significantly with the removal of the skyline vegetation and the lowering of the hill. The extraction areas would be clearly visible in the short to medium term but would be gradually obscured by intervening vegetation following rehabilitation with new plantings as the level of the hill is progressively lowered. Most of the area in the foreground is included in the recently approved Haerses Road sand extraction development which will result in visual changes in the short to medium term. It will also minimise the number of people who would be able to experience this view as the public will be excluded from the active extraction area.(**Photograph 14**)

Glimpses of the extraction area are available mainly from the eastern side of Haerses Road obscured to some extent by intervening vegetation. These views are accentuated by the contrast between the cleared areas and the darker colours of the vegetation on the side of the hill and on the skyline. This relationship would change as the higher ground is lowered and the new plantings in the rehabilitated areas begin to have effect. (**Photograph 15**)

3.2.5 Blakers Road

A middle ground view of the ridge top on the site is available close to the intersection of Blakers Road and Wisemans Ferry Road. This is some two kilometres from the hill top and shows how the intervening topography and vegetation screens all but the highest point on the site. (**Photograph 16**)

There were no other discernible views of the site from Wisemans Ferry Road.

3.3 Visual Sensitivity of the Site

The determination of visual sensitivity depends on a number of factors. These relate to the visibility of the site and the operations undertaken there plus the number of people who would experience the available views. This assessment relates to the current situation at the site and takes account of the mitigation measures that have been introduced since operations started.

Views from the principal peripheral roads used by the majority of people who might experience them are very limited due to the presence of extensive bunds with maturing planting. Exceptions relate to the views to the south from Old Northern Road to the north of the intersection with Wisemans Ferry Road and local views into the site at the entrance. Neither of these is significant and can be mitigated by various measures. The only significant views are those from Hitchcock Road and, currently to a lesser extent from Haerses Road. The latter will be subject to considerable change once sand extraction commences in the immediate area. Both these are minor roads providing access to a small number of residents. Views to sensitive areas of the site are therefore restricted to a few individuals.

Overall visual sensitivity can therefore be considered at present to be low to moderate. Future changes will see additional areas, within the site and adjacent to it, subject to extraction, changes to the ground profile, including lowering of the highest points in the vicinity, maturing of new forest plantings, and further restriction of public views.

4 Assessment of Visual Impacts of the Proposal

4.1 Approach to Assessment

Commonly adopted methods have been used to minimise the subjective nature of the visual assessment. These have been developed by the United States Forest Service (1974), Queensland Department of Main Roads (1997), NSW Department of Planning (1988), the Forestry Commission of Tasmania (1983) and the State Pollution Control Commission (1981). The main elements for consideration and the terminology used as described in the following sections.

Visual Quality
Quality measures the degree to which the visual aesthetics of a landscape are valued from a human point of view. Relevant studies by others have concluded that landscapes that are relatively natural and vegetated, especially those with water features, dramatic topography and contrasting features are preferred. Least appreciated are those with a high level of human disturbance as well as those landscapes with few trees and landforms that are flat and unvaried (Wright 1973; State Pollution Control Commission 1981; and Colleran and Gearing 1980). In terms of the forested and semi-rural environment of the Maroota area, most people can be expected to prefer undisturbed forest, natural bushland, rural settings and creek lines to semi-urbanised ones such as those associated with roads and extractive industry.

Visual Sensitivity
Visual sensitivity measures the degree to which any visual change to the landscape is likely to affect humans and their responses. Locations normally most sensitive to visual change are those with high and/or fixed viewing populations, relatively natural settings and visually prominent and elevated sites. In addition, the closer the viewer is located to the site of change, the higher the potential for impact. In terms of extractive industry sites, the highest impact will be to local and foreground views (less than 500 metres) with mid-ground views (up to five kilometres) moderately sensitive and distant views (over five kilometres) the least sensitive (Queensland Department of Main Roads 1997). Permanent visual impacts to residents are also of more concern than the more transient impacts to road users.

Landscape Change
The greater the contrast between the proposed landform and the surrounding landscape, the more the type and severity of the landscape change is also an issue. Aspects of this can include dramatic alterations to the natural landform, the introduction of uncharacteristic changes to a natural or rural landscape, visual separation between adjacent areas or view prevention where wider views were formerly possible, landscape segregation between adjacent areas and loss of familiar landscape features or local identity.

Impacts over Time
Sand extraction takes place over an extended period and the assessment of visual impacts needs to take account of continuing change and the gradual maturation of the vegetation planted as part of the mitigation measures. Impacts are not necessarily at their greatest in the early years in common with other projects such as roads within a rural landscape but the passage of time results in a complex set of changes including transformation of the local topography and reduction of impact occurring as landscape plantings grow and viewers become familiar with the permanent visual changes.

4.2 Existing Visual Environment

The site is bounded to the north west by Wisemans Ferry Road, to the north east by Old Northern Road, to the west by Hitchcock Road and to the south and south east by adjoining Crown land which also constitutes the boundary of the Maroota sector of *Sydney Regional Environmental Plan 9 - Extractive Industry (Number 2)*.

The dominant natural feature of the site is the former Maroota Trigonometrical Hill which reaches an elevation of 240.7 metres AHD. The lowest point on the site has a level of approximately 188 metres AHD while the majority the area has an elevation at or above 200 metres AHD. The site is therefore generally higher than the surrounding areas. As a result, views into and across the site from the peripheral roads are limited to a small number of locations along Old Northern Road and Hitchcock Road. Views from other locations are restricted by rising ground within the site or bunds constructed as part of the present development.

The site is located in a rural environment at the southern end of the Maroota Ridge which forms part of the Hornsby Plateau. The Hawkesbury River is to the north west of the site within a deeply incised valley with heavily forested steep river terraces.

The high parts of the site provide views of the Blue Mountains to the west, the heavily forested areas to the south and across the cleared and cultivated areas to the east. However, these are only available to those with access to the site.

A number of visual mitigation measures, predominantly earth bunds along the periphery of the site included as part of the current development, have reinforced the natural screening effects of the topography resulting in a reduction in visual sensitivity.

The visual impacts of the proposal relate to several interrelated factors:

- sensitivity of the existing views in terms of visibility from public locations and the number of people who would experience them;

- ability of the landscape to accommodate the change proposed;

4.3 Visual Impacts

Sand mining results in significant changes to the topography affected by its activities, especially if a large volume of overburden needs to be removed. This also provides the opportunity to achieve a new topography which is appropriate for future uses once sand extraction ceases as well as allowing a sympathetic landform to be achieved. In this case, such a topography requires the avoidance of abrupt changes in level and unnatural formations inconsistent with the character of the area.

The extraction program would result in a large area of disturbance in the northern and central parts of the site together with two smaller pits further to the south east. The large extraction area would be remoulded to a new gently sloping central plain surrounded by slopes rising to the periphery of the site then falling to the external roads. The interior of the site would not be visible from any area with public access. Visual change would be considerable but its impact, in terms of visibility, would be minimal.

Over time, the maturing planting on the site would achieve a visual merging of the previously extracted and rehabilitated area with its surroundings, further minimising any visual impacts.

The two smaller extraction areas would be located in areas generally screened from external view both by the topography and the existing vegetation, a substantial proportion of which would be retained. On completion, the pits would be partially backfilled, reducing the slopes of the internal batters. New planting on these slopes would gradually minimise the contrast between the appearance of the extracted areas and the surrounding topography.

Visual impacts of the proposal can therefore be considered to be minor, gradually reducing over time as the vegetation matures.

4.4 Mitigation Measures

No additional mitigation measures other than those already in place or included in the proposal are considered to be necessary.

5 Conclusions

The site is only visible from publicly accessible areas at a small number of locations. This is due to the topography, peripheral bunds already in place and existing vegetation.

The highest points on the site are visible in the middle distance from Hearses Road. However, this is currently used by few people (it is not a through road) and will soon become part of a major sand extraction operation recently approved. Public access will be limited or not available depending on site activities and views to the Hitchcock Road site will be across an active sand extraction operation. There are few, isolated, long distance views to the site from Wisemans Ferry Road.

Limited views of the extraction area proposed for Lot 2 DP555184 would be available from a short section of Old Northern Road when travelling to the south. However, the introduction of intervening bunds and additional screening vegetation would eliminate these. Views of the current extraction activities on Lot 1 DP34599 are not visible from Old Northern Road due to the topography which slopes away from the road and intervening dense vegetation which would not be removed as part of the proposal.

Visual impacts of current operations on the site are minimal and the proposed development would result in minor visual changes which are unlikely to be visible to the public.

The land subject to sand extraction is private property with freehold title. Access is not available to the general public and is not expected to be, even when extraction activities are complete.

Visual access is very limited from places accessible to the public. This will continue to decrease as the peripheral vegetation planted to screen the development gradually matures. The effects of this process will be reinforced by the steady maturation of those areas where new plantings have been undertaken as part of site rehabilitation.

The visual character can therefore be considered to be relatively insensitive to change as any changes can only be experienced by those with access to the site (sand mining operatives and owners of the land) and a small number of local residents or road users who are able to experience very limited views into the site from a few locations around its periphery.