



global environmental solutions

Woodsreef Mine Major Rehabilitation Project Asbestos Exposure During Recreational Activities Human Health Risk Assessment

Report Number 610.10893.00210

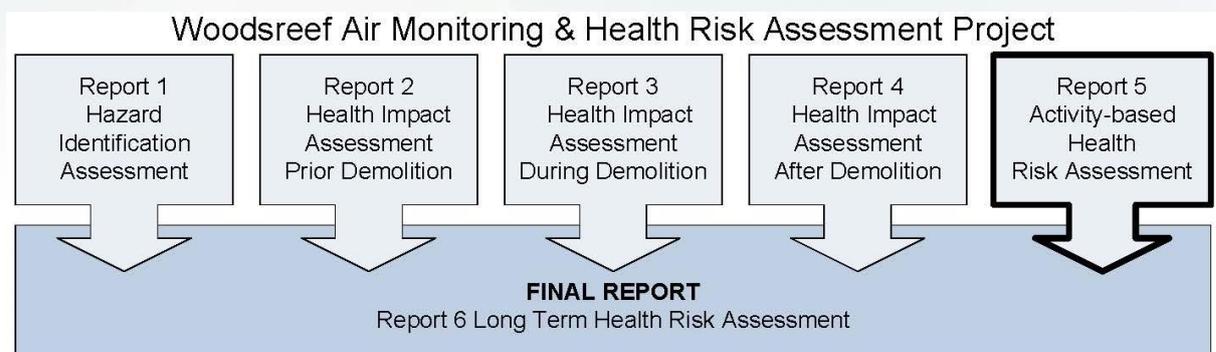
27 April 2017

Department of Planning and Environment

516 High Street

Maitland NSW 2320

Version: v0.3



Woodsreef Mine Major Rehabilitation Project

Asbestos Exposure During Recreational Activities

Human Health Risk Assessment

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
2 Lincoln Street
Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
T: +61 2 9427 8100 F: +61 2 9427 8200
sydney@slrconsulting.com www.slrconsulting.com

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with the Client. Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Department of Planning and Environment . No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
610.10893.00210	Final	27 April 2017	Craig Simpson <i>BAppSc MSc PhD</i> Nathan Redfern <i>CChem ChOHSP COH</i>	Craig Simpson <i>BAppSc MSc PhD</i> Nathan Redfern <i>CChem ChOHSP COH</i>	Craig Simpson <i>BAppSc MSc PhD</i> Nathan Redfern <i>CChem ChOHSP COH</i>

Executive Summary

NSW Department of Industry engaged SLR Consulting Australia Pty Ltd (SLR) to undertake a series of Health Impact Assessments of the Woodsreef Mine site as part of the Woodsreef Mine Major Rehabilitation Project. This current report is activity based monitoring component of the series.

The Woodsreef Mine Major Rehabilitation Project (works project) broadly consists of demolition of building structures as well as friable and bonded asbestos removal works, including demolition of the existing derelict buildings and remaining infrastructure. A series of Health Impact Assessments are to be conducted prior, during and post works.

The overall objectives of the Health Impact Assessments are to determine the public health implications for communities surrounding the mine and to members of the public who access areas adjacent to the mine site, from potential asbestos exposure arising from the abandoned mine site, during the works project.

The specific conditions of this Health Risk Assessment Report relate to the mine in the current derelict condition and people conducting recreational activities that are regularly undertaken near the mine.

Woodsreef Mine is a derelict, open cut asbestos mine located approximately 15km north east of Barraba in the Northern NSW Tablelands. The former mine extends over an area of about 290 hectares, comprising predominantly Crown land.

Woodsreef Mine is situated in an area where naturally occurring asbestos is found in significant concentrations over a broad area both inside and outside the mine site footprint. Thus the local environment may be impacted by both the effects of previous mining operations as well as areas of naturally occurring asbestos being subject to natural weathering of the parent material potentially leading to the enrichment of local soils with asbestos fibres.

The local communities closest to the Woodsreef mine are Barraba, with a population of approximately 1,150 people, located around 15km from the mine, and Woodsreef and its surrounds with a scattered population of around 134 people (2011 Census). The area in the immediate vicinity of the Woodsreef mine is rural in nature with scattered houses generally on farmland. The main population centre nearest the mine is the township of Barraba.

There is also a "community" of transient recreational users who use the area near the mine. Some of these people will be local residents and some will be residents from outside the local area, visiting the area for sightseeing or recreational purposes.

Inhalation of asbestos fibres is a potential health risk, leading to a number of lung disorders, including lung cancer and mesothelioma. The likelihood of disease arising from exposure to asbestos depends on the cumulative exposure over a lifetime. Factors that add up to the lifetime exposure include frequency of exposure, concentration of airborne asbestos during each exposure and length of exposure. Put simply a short isolated exposure at low concentration is unlikely to cause disease but long term heavy exposure such as occurred historically in some occupations, was likely to lead to asbestos related diseases in those exposed.

Persons conducting recreational activities are potentially exposed via two pathways. The first exposure pathway being from background airborne asbestos fibre concentrations. The second pathway being through localised airborne asbestos fibres made airborne by the person's activities disturbing asbestos containing soils or asbestos fibres settled on surfaces.

To classify potential public health risk for members of the public conducting recreational activities in the vicinity of the mine, activities were divided into two Exposure Groups, Exposure Group 1 – Passive Recreation (little disturbance to soils, etc) and Exposure Group 2 – Active Recreation (potential for some soil disturbance). A combined semi quantitative and qualitative method was then used based on the risk factors considered to influence the likelihood of asbestos exposure to persons. These factors were broadly divided into primary risk factors and secondary risk factors as set out below:

Primary Risk Factors

Primary risk factors were defined as risk factors where information was easily measured or well known. Such as the data from historic and current airborne asbestos fibre monitoring, how close to the mine or naturally occurring asbestos (NOA) the activity is conducted and if the recreational activity disturbs the soil.

Primary risk factors were considered to be the following:

- Airborne asbestos fibre concentrations recorded at locations near Exposure Groups from historic records and monitoring data collected during the remediation works.
- Proximity of Exposure Groups to the mine.
- Proximity of Exposure Groups to naturally occurring asbestos (NOA).
- Conducting recreational activities that disturb the soil.

Secondary Risk Factors

Secondary risk factors were defined as risk factors where less information was available or more assumptions needed to be made about a particular risk factor. Such as the possibility of elevated airborne asbestos concentrations occurring near people, the likelihood of people being near the mine or creating localized disturbances of asbestos contain soils, estimating frequency of visits to the area or estimating time spent near the mine.

Secondary risk factors were considered to be the following:

- Possibility for airborne asbestos fibre concentrations exceeding 0.01 fibres/mL air during short term disturbances (due to either natural or man-made forces) of asbestos contaminated soils at locations near Exposure Groups.
- Likelihood of Exposure Group being near mine site during short term disturbances of potentially asbestos contaminated soils by forces of nature.
- Likelihood of Exposure Group creating short term disturbances of potentially asbestos contaminated soils near the mine.
- Frequency of visits to mine site vicinity.
- Time spent near mine vicinity during each visit.

Airborne asbestos fibre monitoring in the vicinity of the mine has been undertaken a number of times from 1992 and 2016. Monitoring occurred either off mine site as background monitoring or on the mine site as part of monitoring during site works either during remediation works.

Airborne asbestos fibre concentrations above 0.01 fibres per mL air, that is the detection limit of the method, have only been recorded during three periods, 1992 (0.04 fibres per mL, sample numbers unknown), 2006 (1 sample, 0.06 fibres per mL) and 2012 (1 sample, 0.04 fibres per mL). These occurred when remediation activities have been occurring on the mine site and only at sampling locations on the mine site itself. The indicative approximation of samples above the detection limit is 1 sample above the detection limit per 140 samples taken on the mine site.

In 2013, background air monitoring was undertaken to help understand the conditions on and around the mine site prior to the contemporary site rehabilitation and demolition activities. Background airborne asbestos monitoring was conducted in the vicinity of the mine, in Barraba and at a control site at Tamworth. The monitoring indicated all locations monitored were similar with no difference in background airborne asbestos fibre concentrations between Tamworth, Barraba and locations in the vicinity of the mine. The airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air at all locations.

Remediation works including the demolition of buildings was undertaken from October 2014 to May 2015. During the remediation air monitoring was undertaken both on the mine site and off the mine site in surrounding communities. On site monitoring during the remediation works (248 rounds of daily sampling, 1545 samples) found that airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air. Off site airborne asbestos monitoring was conducted in the vicinity of the mine, in Barraba and at a control site at Tamworth (12 rounds of daily sampling, 91 samples). The monitoring indicated all locations monitored were similar with no difference in background airborne asbestos fibre concentrations between Tamworth, Barraba and locations in the vicinity of the mine. The airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air at all locations.

Background airborne asbestos fibre concentrations above 0.01 fibres per mL of air have only been recorded at sampling locations on the mine site itself and only occasionally when remediation activities have been occurring on the mine site. This data fits the assumption that asbestos fibres mainly become airborne during intermittent physical disturbance to the asbestos containing source material.

The release of airborne asbestos during these short term disturbances of asbestos contaminated soils, either on the mine site or off the mine site, will occur. However the extent of this release of asbestos is difficult to measure given the intermittent nature of the disturbances and the patchy distribution of asbestos in soils. The current site containment and restrictions to access to the mine site and The Mine Road are designed to minimise potential disturbance activities.

Activity based monitoring of both passive and active recreational activities was undertaken in December 2013 and May 2016 with SLR personnel wearing personal asbestos monitoring equipment while simulating typical recreational activities including Fossicking, Camping, Picnicking, Bird Watching, Walking the Flora Trail, Viewing the mine and Walking along the Bundarra - Barraba Road. Soil disturbance occurred during much of these activities with Fossicking creating the most soil disturbance.

Results of the Activity Based Monitoring for all activities indicated that airborne asbestos fibre concentrations were at levels likely to be less than 0.01 fibres per mL of air. As stated above this concentration is at least ten times lower than the Safe Work Australia exposure standard of 0.1 fibres per mL of air.

Based on the above mentioned Primary and Secondary risk factors, the Exposure Risks and hence public health implications to members of the public who access areas adjacent to the site, from potential asbestos exposure arising from the abandoned mine site, and during recreational activities have been set out below in **Table 1**.

Table 1 Recreational Exposure Groupings - Estimated Exposure Risks from Airborne Asbestos Fibres Associated with the Woodsreef Mine and Surrounds

Exposure Group	Estimated Exposure Risk from Airborne Asbestos Fibres
Passive Recreation conducted in proximity to the Mine	Negligible to Low
Active Recreation conducted in proximity to the Mine	Negligible to Low

A previously stated, persons conducting recreational activities are potentially exposed via two pathways. The first exposure pathway being from background airborne asbestos fibre concentrations. The second pathway being through localised airborne asbestos fibres made airborne by the person's activities disturbing asbestos containing soils or asbestos fibres settled on surfaces.

With regard to background airborne asbestos fibre exposure, it was concluded that persons undertaking recreational activities were unlikely to be exposed to background airborne asbestos fibre concentrations above 0.01 fibres per mL air, which is the detection limit of the method. Based on all available air monitoring data, historic and current, indicating detectable concentrations of airborne asbestos fibres have not been recorded outside the mine site in the surrounding communities and locations.

Therefore for all recreational users the background airborne asbestos fibre concentrations they may be routinely exposed is likely to be less than 0.01 fibres per mL of air.

Activity based monitoring, both passive and active recreation, conducted as part of the current report found recorded airborne asbestos fibre concentrations of less than 0.01 fibres per mL of air.

However for recreational users in close proximity to the mine and naturally occurring asbestos it would be prudent to assume these groups may additionally be potentially exposed to localised higher airborne asbestos concentrations possibly produced over short time periods, generated by their activities or events causing physical disturbance to asbestos containing soils.

Based on the above findings, the estimated exposure risks from airborne asbestos fibres to recreational users of the areas surrounding the Woodsreef Mine is considered to be Negligible to Low.

Table of Contents

1	GLOSSARY	10
2	INTRODUCTION	11
	2.1 Introduction	11
	2.2 Background	11
	2.2.1 Naturally Occurring Asbestos	12
	2.2.2 Woodsreef Deposit and Mine	12
3	RISK ASSESSMENT	15
	3.1 Introduction	15
	3.1.1 What is Risk Assessment	15
	3.1.2 Risk Assessment Approach	15
	3.2 Objectives	16
	3.3 Issue Identification	16
	3.3.1 Recreational Activities Undertaken Near Woodsreef Mine	16
	3.3.2 Special Populations	18
	3.3.3 Key Points - Community & Recreation	18
	3.3.4 Conceptual Site Model	18
	3.3.5 Naturally Occurring Asbestos	21
	3.3.6 Woodsreef Mine	21
	3.3.7 Key Points - Woodsreef Mine & Surrounds	22
	3.3.8 Asbestos & Land	23
	3.3.9 Key Points - Asbestos & Land	24
	3.3.10 Asbestos & Water	24
	3.3.11 Key Points - Asbestos & Water	26
	3.3.12 Asbestos & Air Quality	27
	3.3.13 Historic Airborne Asbestos Fibre Monitoring	27
	3.3.14 Contemporary Airborne Asbestos Fibre Monitoring 2013 to 2016	27
	3.3.15 Activity Based Monitoring	29
	3.3.16 Key Points - Asbestos & Air Quality	32
	3.4 Issue Identification Summary	32
	3.5 Toxicity & Carcinogenicity Assessment	32
	3.6 Exposure Assessment	33
	3.6.1 Exposure Pathways and Receptors	33
	3.6.2 Assessment of Exposure Concentrations	35
	3.7 Exposure Assessment Summary	36
4	RISK CHARACTERISATION	37
	4.1 Risk Characterisation Summary	40
5	CONCLUSIONS	41

Table of Contents

6	REFERENCES	42
---	------------	----

TABLES

Table 1	Recreational Exposure Groupings - Estimated Exposure Risks from Airborne Asbestos Fibres Associated with the Woodsreef Mine and Surrounds	6
Table 2	SLR Air Monitoring Locations – Background Monitoring	28
Table 3	Activity Based Airborne Asbestos Fibre Monitoring Rounds 1 & 2*	31
Table 4	Community Exposure Groupings - Receptors	33
Table 5	Recreational Groupings - Background Exposure Concentrations (no disturbance on mine)	36
Table 6	Definitions of Risk Ratings	39
Table 7	Community Exposure Groupings - Receptors and Estimated Exposure Risks	40
Table 8	List of SLR Activity Based Airborne Asbestos Fibre Monitoring Reports	Appendix B -1
Table 9	Estimated Ranges of Asbestos Concentrations in <2 mm Particle Size Fraction of Samples (% vol/vol)	Appendix C - 7
Table 10	Woodsreef Airborne Asbestos Fibre Monitoring 1992 to 2016	Appendix C - 9

FIGURES

Figure 1	Woodsreef Mine Location	13
Figure 2	Woodsreef Mine Location in Relation to Barraba	13
Figure 3	Woodsreef Asbestos Mine Site Plan	14
Figure 4	Conceptual Site Model for Potential Asbestos Fibre Exposure to People Undertaking Recreational Activities Near the Woodsreef Mine	20
Figure 5	Location of Ironbark Creek and Split Rock Dam in relation to Woodsreef Mine	25
Figure 6	Barraba Mean Monthly Rainfall 1881-2014	Appendix C - 2
Figure 7	Barraba Monthly Mean Maximum Temperatures 1966-2013	Appendix C - 2
Figure 8	Barraba Monthly Mean Minimum Temperatures 1966-2013	Appendix C - 3
Figure 9	Natural Topography of Area Surrounding Woodsreef Asbestos Mine	Appendix C - 4
Figure 10	Barraba Suburb Area and Location of Woodsreef Asbestos Mine	Appendix C - 5
Figure 11	Woodsreef Suburb Area and Location of Woodsreef Asbestos Mine	Appendix C - 6
Figure 12	Predicted Exposure Potential - Annual Average 2001 to 2012	Appendix E - 3
Figure 13	Predicted Exposure Potential - Spring 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)	Appendix E - 4
Figure 14	Predicted Exposure Potential - Summer 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)	Appendix E - 5
Figure 15	Predicted Exposure Potential - Autumn 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)	Appendix E - 6
Figure 16	Predicted Exposure Potential - Winter 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)	Appendix E - 7
Figure 17	Asbestos Exposure Routes and Impact Sites in the Human Body (modified from Worksafe NZ, 2015)	Appendix F - 2

Table of Contents

PHOTOGRAPHS

Photo 1	Walking along Trail	29
Photo 2	Walking along Trail	Appendix A - 2
Photo 3	Relaxing around the camp site	Appendix A - 4
Photo 4	Fishing in Iron Bark Creek	Appendix A - 4
Photo 5	Fossicking along a dry creekbed	Appendix A - 6
Photo 6	Fossicking – washing of sieved soil to reveal gold	Appendix A - 6

APPENDICES

Appendix A	Activity Based Monitoring Methodology
Appendix B	SLR Activity Based Air Monitoring Reports
Appendix C	General Information on Woodsreef Mine and Surrounding Communities
Appendix D	Scope of a Health Risk Assessment
Appendix E	Asbestos and Air Quality
Appendix F	Asbestos Toxicity, Disease and Historic Occupational Exposures
Appendix G	Uncertainties and Limitations

1 GLOSSARY

ABS	Australian Bureau of Statistics
ACGIH	American Conference of Governmental Industrial Hygienists
ATSDR	Agency for Toxic Substance and Disease Registry
F/mL	Fibres per millilitre
F/mL/year	Fibres per millilitre per year
g/s/m ²	Grams per second per square metre
IARC	International Agency for Research on Cancer
km	kilometre
m	metre
m ²	square metre
mL	millilitre
µm	micrometre, one millionth of a metre
NATA	National Association of Testing Authorities
NOA	naturally occurring asbestos
NOHSC	National Occupational Health and Safety Commission
NSW	New South Wales
PCM	Phase contrast microscopy
SEIFA	Socio-Economic Indexes for Areas
TWA	Time weighted average
US EPA	United States Environmental Protection Agency

2 INTRODUCTION

2.1 Introduction

The NSW Department of Industry engaged SLR Consulting Australia Pty Ltd (SLR) to undertake a series of Health Impact Assessments of the Woodsreef Mine site as part of the Woodsreef Mine Major Rehabilitation Project. As part of this series of reports, this document forms the Human Health Risk Assessment for asbestos exposure during recreational activities in the vicinity of the mine.

The Woodsreef Mine is a derelict open cut asbestos mine located approximately 15 km north east of Barraba in the Northern NSW Tablelands. The former mine extends over an area of about 290 hectares, comprising predominantly Crown Land.

Open cut mining for chrysotile asbestos first occurred at Woodsreef between 1918 and 1923. The Chrysotile Corporation of Australia carried out large scale mining between 1973 and 1983. The mine closed in 1983 due to high production costs and is now considered a derelict mine.

Woodsreef Mine includes a waste rock dump, a tailings dump, both of which are uncapped, and a number of open pits, some containing considerable quantities of water, until recently there were also a number of derelict buildings. These areas are all substantially unrehabilitated and uncontained asbestos fibres are found throughout the site. An amount of exposed processed asbestos still remains at the site. The derelict buildings, dilapidated structures and facilities used in the processing of this material were demolished and buried in purpose built containment cells on the mine site in 2015.

The project, known as the “Woodsreef Mine Major Rehabilitation Project”, broadly consists of a series of demolition and friable and bonded asbestos removal works, including demolition of the existing mill building, office building, product silos and remaining infrastructure.

The overall objectives of the Health Impact Assessments were to determine the public health implications from potential asbestos exposure arising from the abandoned mine site, during and following completion of the proposed demolition/remedial works, in adjacent communities and to members of the public through intermittent access to areas adjacent to the site.

The outcomes of the assessment were expected to guide priorities and activities that were required to most effectively manage and mitigate exposure to the community.

This report presents the methodology and findings of the Health Risk Assessment for asbestos exposure during recreational activities, completed for the Woodsreef Mine Major Rehabilitation Project undertaken by SLR on behalf of the NSW Department of Industry.

The Health Risk Assessment was conducted as per the recommendations contained in enHealth (2012) and the framework set out in **Appendix D**.

2.2 Background

The largest community in proximity to the mine is the town of Barraba with approximately 1,150 people usually residing in town which is located approximately 15 km to the west of the mine. Closer to the mine is the state suburb area of Woodsreef with population of approximately 134 people.

The lands adjacent to the mine and between the mine site and the town of Barraba are rural in nature and only lightly populated. Recreational activities, both passive and active are undertaken in areas ranging from adjacent to the mine to areas up to 4 km from the mine.

As well as residents usually residing in Barraba and the Woodsreef area, there will be transient population of visitors to these areas. These visitors are mostly in the area for recreational activities. Examples of these activities include camping, fishing, bird watching, fossicking, visiting the Flora Trail,

picnicking, viewing the Woodsreef mine site, etc. The time spent around the Barraba and Woodsreef areas is likely to vary from hours to days, dependent on the activities undertaken during their stay. These recreational activities will be discussed in more detail in the Risk Assessment section of this report. Transient observers and recreational users form the basis for this assessment.

2.2.1 Naturally Occurring Asbestos

Asbestos is the name given to a group of six different fibrous minerals (amosite, chrysotile, crocidolite, and the fibrous varieties of tremolite, actinolite, and anthophyllite) that occur naturally in the environment. One of these, namely chrysotile, belongs to the serpentine family of minerals, while all of the others belong to the amphibole family (ATSDR, 2001). Asbestos can be found in a fibrous asbestiform or crystalline state.

Naturally occurring asbestos (NOA) is present in many areas of eastern Australia. It has been estimated that potential asbestos containing rock accounts for approximately 0.2% of the land area of eastern New South Wales, however most deposits are small and commercial scale deposits rare (Hendrickx, 2009).

2.2.2 Woodsreef Deposit and Mine

The size and composition of the Woodsreef deposit was described by Dames & Moore (1997) as the following:

“The Woodsreef deposit is developed in a massive pod of the Great Serpentine Belt, which is approximately 8 km long and 2 km wide (Brown, et al, 1992). The mineral at Woodsreef occurs as cross fibre to chemically identical host serpentine. The reserve approximates 12.1 million tonnes of proven ore (Brown, et al, 1992). The reserve is only medium in grade averaging 4% (Brown, et al, 1992).”

The Woodsreef Mine site is situated at the locality of Woodsreef, 15km from Barraba on the Bundarra - Barraba Road (NSW Department of Primary Industries Soil Conservation Service, 2013). The mine is situated where The Mine Road (formerly known as Crow Mountain Road) joins the Bundarra - Barraba Road (See **Figure 1, Figure 2 and Figure 3**).

Figure 1 Woodsreef Mine Location



Figure 2 Woodsreef Mine Location in Relation to Barraba

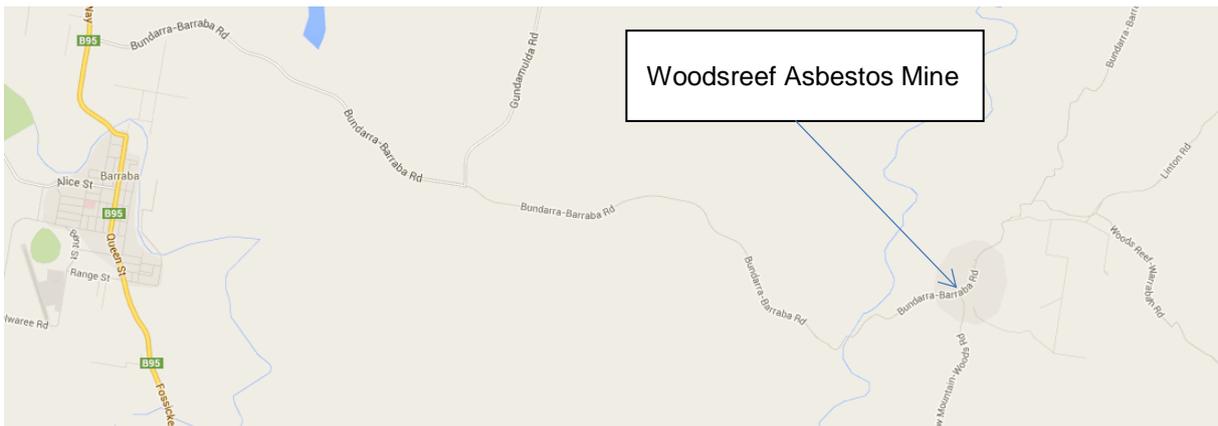
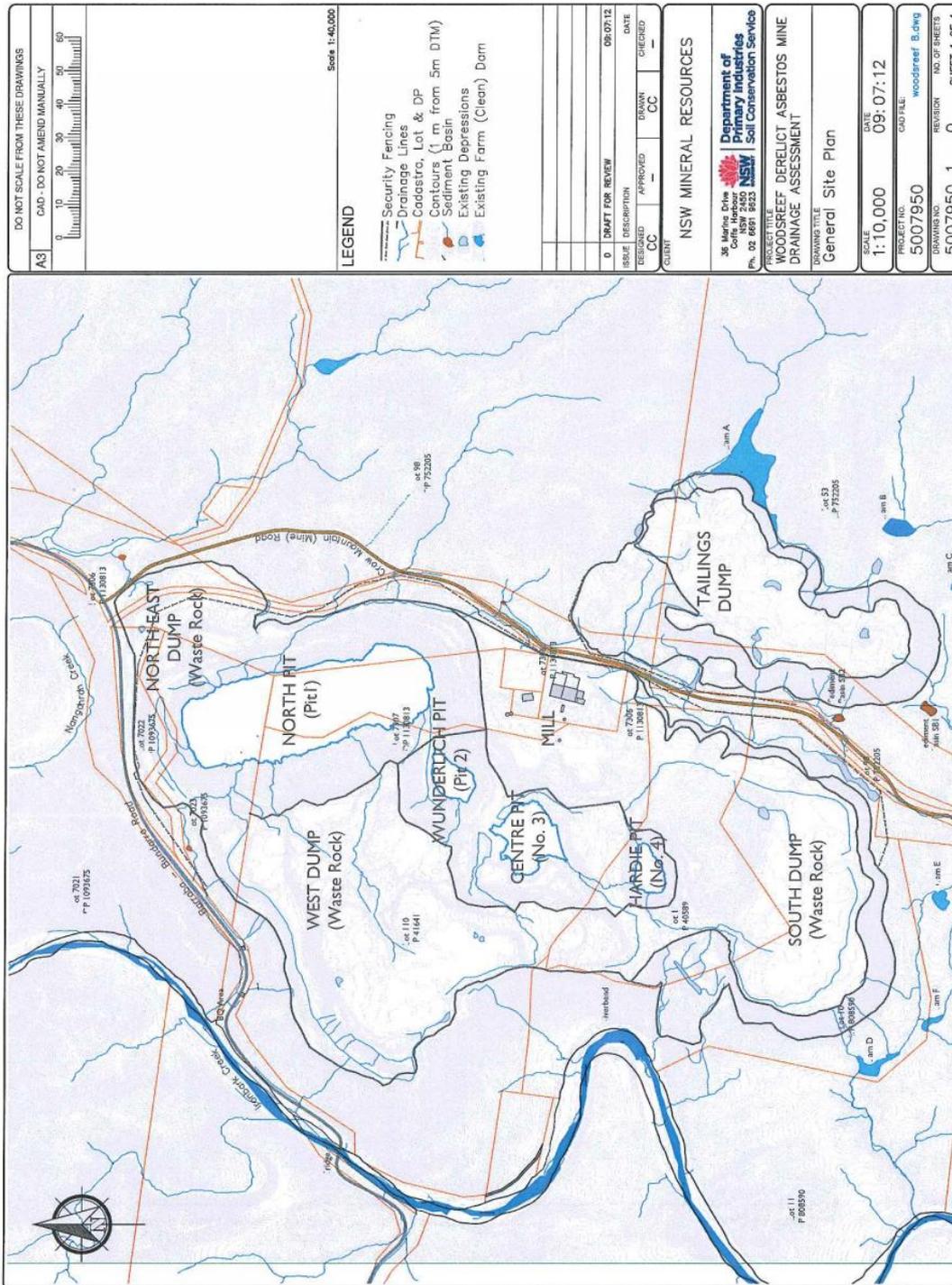


Figure 3 Woodsreef Asbestos Mine Site Plan



(Source: NSW Department of Primary Industries Soil Conservation Service, 2013)

Site History

The Woodsreef site has been actively mined for asbestos during three periods. The first from 1919 to 1923 produced 2,500 tonnes of asbestos. After a long hiatus, the second mining period started in 1970 and ceased in 1973. The third and final period of mining commenced in 1975 and continued until 1983. From 1972 to 1983 approximately 550,000 tonnes of chrysotile was produced from 100 million tonnes of mined material (*Dames & Moore, 1997; NSW Department of Primary Industries Soil Conservation Service, 2013*). The mine has remained derelict since 1983.

The scale of total asbestos production at Woodsreef, of 552,500 tonnes, dwarfed all other asbestos mines in Australia. The Woodsreef mine accounted for approximately 73% of the total asbestos production in Australia (*Hendrickx, 2009*). Based on the estimates of world production by Virta (2006) the Woodsreef asbestos production equated to approximately 0.3% of the total world production of asbestos up until 2003. In contrast the next largest Australian asbestos production occurred at the now infamous Wittenoom mine in Western Australia which produced 152,466 tonnes of crocidolite asbestos between 1937 and 1966 (*Gibbons, 2000*).

3 RISK ASSESSMENT

3.1 Introduction

3.1.1 What is Risk Assessment

Risk assessments have been defined in many ways but all share the concept of a process for estimating and characterising the potential risks associated with various agents or activities.

The National Research Council (1983) definition is:

Risk assessment is the systematic scientific characterisation of potential adverse health effects resulting from human exposures to hazardous agents or situations.

A risk assessment is a multidisciplinary process that can involve many scientific disciplines. It may be a simple screening exercise or a complex project over many years.

3.1.2 Risk Assessment Approach

The methodology adopted in the conduct of the Human Health Impact Assessment is consistent with that used to evaluate risks to human health associated with a population's exposure to a hazardous agent, in this case asbestos.

The approach to the assessment of risk to human health is based on the protocols/guidelines recommended by the enHealth Council. These are detailed in the document "Environmental Health Risk Assessment" (*enHealth, 2012*).

Identification and assessment of the potential risks to human health within the site have been undertaken by implementing four prime tasks. These tasks are:

1. **Issue Identification** - This involves an evaluation of the available information on the potential occurrence and distribution of asbestos transported by natural processes, such as wind and rain, from the Woodsreef Mine and surrounds as well as asbestos disturbed during recreational activities, to people who may be undertaking recreational activities in the areas surrounding the mine site.

2. **Hazard Assessment** - This task provides a review of the current understanding of the toxicity of asbestos to humans and identifies hazards associated with exposure to airborne asbestos fibres.
3. **Exposure Assessment** - This task draws on the evaluation undertaken as part of the "Issue Identification" stage identifying the groups of people who may be exposed to airborne asbestos released during the recreational activities and by natural processes, such as wind and rain, from the Woodsreef Mine to surrounding communities and quantifying exposure concentrations.
4. **Risk Characterisation** - This task provides the qualitative evaluation of potential risks to human health. The characterisation of risk is based on the review of toxicity of asbestos fibres and the assessment of the magnitude of exposure.

3.2 Objectives

The objective of the Human Health Risk Assessment is to contribute to the analysis of asbestos exposure during recreational activities conducted in areas in the vicinity of the Woodsreef Mine and provide an assessment of the risk to human health associated with the presence of asbestos fibres.

The risk assessment aims to:

- Identify the groups of people who may be exposed to the asbestos during recreational activities near the Woodsreef mine;
- Compare exposure concentrations with contemporary health standards;
- Identify the health risks associated with exposure should it occur; and
- Assess and communicate the identified risks.

Risk assessments of the nature performed here do not provide definitive assessments of the acceptability of risk for specific individuals. Risk assessments should only be applied on a probabilistic basis to a population of exposed persons.

It should be noted that the scope of this Human Health Risk Assessment is limited to asbestos and does not include any other agents of potential concern (if any). Nor does the scope include assessment of asbestos exposures to people trespassing on the mine site to conduct recreational activities.

3.3 Issue Identification

The issues identified in this report relate to the potential for asbestos exposure to people undertaking recreational activities in the areas surrounding the Woodsreef Mine. This exposure is likely to come from two sources. The first potential exposure source being the general background airborne asbestos fibres in the area possible generated from natural processes on the mine site. The second potential exposure source is asbestos fibres made airborne during the recreational activities

3.3.1 Recreational Activities Undertaken Near Woodsreef Mine

There is a "community" of transient observers and recreational users who use the area near the mine. Some of these people will be local residents and some will be residents from outside the local area, visiting the area for sightseeing or recreational purposes. Recreational activities in the vicinity of the mine cover a range of activities. The activities can be either passive or active in nature. For the

purpose of this study, passive activities are taken to include activities that do not involve much movement around site with little potential to disturb soil or vegetation. Examples of passive activities include observing the mine from the road side, or picnicking near the mine. Active activities are taken to include activities that involve greater movement around the site with increased potential to disturb soil or vegetation.

Passive activities tend to occur around the northern fringe of the mine site, along the Bundarra – Barraba Road.

The following activities have been listed as examples of the main passive activities conducted in the vicinity of the mine.

1. Viewing the mine site - There are a few areas where tourists can park their cars on the road side and walk a short distance to the mine fence for views over the mine site.
2. Picnicking - Areas where tourists can picnic close to the mine are located to the northwest of the mine where the Bundarra - Barraba Road runs near Ironbark Creek.
3. Attending services at the St John's Woodsreef Church - A small church with services scheduled the second Sunday of each month.

Active activities tend to occur mostly on lands outside the mine site area, around the northern half of the mine, including both the western and eastern sides of the mine perimeter. It should be noted that some activities occur approximately 4km to the south of the mine, at a camping site off the Pera - Linton Road near where Ironbark Creek enters Split Rock Reservoir.

The following activities have been listed as examples of the main active activities conducted in the vicinity of the mine.

1. Camping along Ironbark Creek in the area to the northwest to north of the mine, within 100 metres to 2 km from the mine site.
2. Camping along Ironbark Creek in the area to the south of the mine, at a camping site off the Pera - Linton Road near where Ironbark Creek enters Split Rock Reservoir. Approximately 4 km south of the mine site.
4. Fossicking for gold and minerals in the area to the north of the mine, within 2 km of the mine site.
3. Bird Watching in the area to the north of the mine, within 100 metres to 2 km from the mine site.
5. Walking along the Flora Trail in the area to the east of the mine, within 50 metres to 500 metres from the mine site.
6. Fishing along the Ironbark River, near the mine site.
7. Use of off road vehicles including cars and motorbikes, in the areas around the mine.

3.3.2 Special Populations

Special populations are sub groups within the community who may be at greater risk of adverse health effects. The increased risk may be due to factors such as age, ill health or close proximity to an identified hazard, in this case the Woodsreef Mine.

Children or teenagers under eighteen years of age are considered at higher risk than older members of the population. In this age group humans are considered to have not reached maturity. Therefore their bodies may respond differently to adults when exposed to a toxic or carcinogenic threat. In many cases they will be at higher risk from the exposure compared to adults.

3.3.3 Key Points - Community & Recreation

- The largest community in proximity to the mine is the town of Barraba with approximately 1,150 people usually residing in town which is located approximately 15 km to the west of the mine. Closer to the mine is the state suburb area of Woodsreef with population of approximately 134 people.
- The lands adjacent to the mine and between the mine site and the town of Barraba are rural in nature and only lightly populated.
- Recreational activities, both passive and active are undertaken in areas ranging from adjacent to the mine to areas up to 4 km from the mine.
- Recreational activities, both passive and active are undertaken by local residents and tourists to the area.

3.3.4 Conceptual Site Model

To help understand how people undertaking recreational activities may be exposed to asbestos a Conceptual Site Model (CSM) has been developed.

Conceptual Site Model (CSM) uses the concept of the links between source – pathway – receptor to assess risk. This can include the source of Contaminants of Potential Concern (COPC), in this case asbestos, which may impact on the communities in question and transport mechanisms whereby asbestos can be moved to exposure points (human receptors). If any of these links are missing then an exposure pathway is incomplete and human exposure will not occur. If the exposure pathway is potentially complete then likely impact on the receptor may need to be assessed.

The CSM development indicated that following factors:

- The presence of asbestos fibres
- The release mechanism whereby the asbestos fibres may be released into the environment
- The transport pathways moving the asbestos fibres through the environment
- Exposure pathways
- Exposure Route being inhalation whereby the a person takes in the asbestos fibres
- Location of potential receptors

- Significant pathways by which exposure may occur
- Minimal exposure pathways, considered as less likely to led to human exposure
- Primary exposure pathways considered to be the pathway by which the largest quantities of emissions of asbestos fibres move
- Secondary exposure pathways considered to be the pathway by which lessor quantities (compared to the Primary exposure pathway) of the emissions of asbestos fibres move

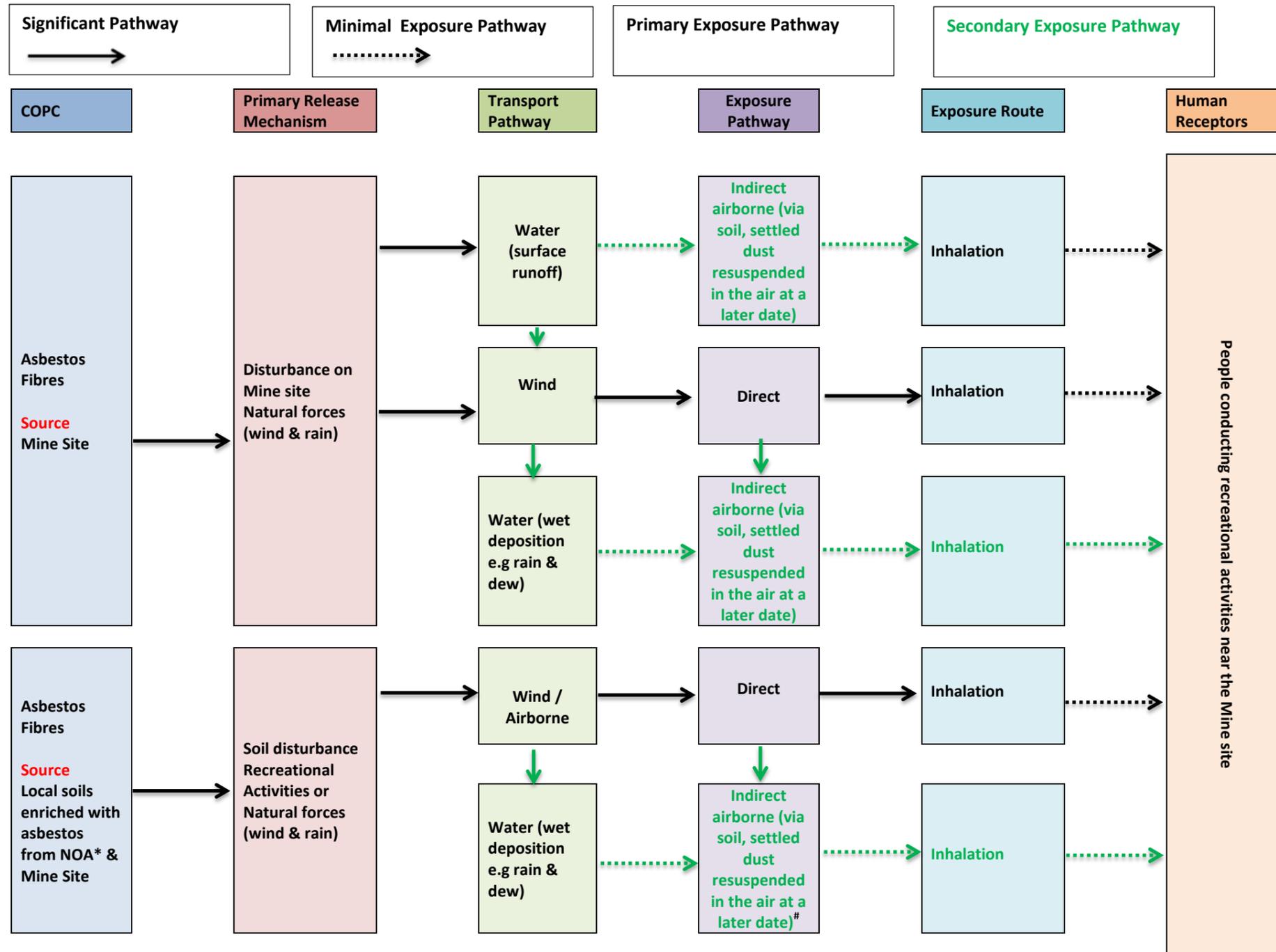
The Primary exposure pathway relating to recreational activities were determined to be via the airborne pathway. The Secondary exposure pathway was considered to be the indirect pathway in which asbestos fibres were transported off site through environmental forces such as wind or water, the asbestos fibres then settle into dusts or soils and at a later date subsequently resuspended in the air when the soil or dusts are disturbed, at which point human exposure may take place.

The Primary exposure pathway can be relatively easily quantified through the airborne asbestos fibre monitoring undertaken during the recreation of recreational activities. Thus any increase in risk associated with recreational activities may be quantified.

The Secondary exposure pathways, where asbestos fibres that have settled out then are resuspended in the air during the remediation works either on the mine site or by natural forces off the mine site, will form a component of the airborne asbestos fibre concentrations measured during the monitoring program undertaken during the remediation.

The Conceptual Site Model showing the proposed links between source of asbestos fibres and pathway to human exposure has been set out in **Figure 4**.

Figure 4 Conceptual Site Model for Potential Asbestos Fibre Exposure to People Conducting Recreational Activities Near the Woodsreef Mine.



* NOA = naturally occurring asbestos;

[#] = May occur at the site of recreation or a different site for example cleaning items such as clothing on return home from conducting recreation

3.3.5 Naturally Occurring Asbestos

As would be expected from a mining operation, the Woodsreef Mine is situated in an area where naturally occurring asbestos (NOA) is found in significant concentrations over a broad area. Areas of naturally occurring asbestos are subject to the usual weathering of the parent material potentially leading to the enrichment of local soils with asbestos fibres. Therefore the presence of asbestos fibres, released by natural forces, in local soils is to be expected. However the extent of natural release of asbestos into soils is unclear. There is a paucity of data on natural background concentrations of asbestos fibres in soils adjacent to asbestos ore bodies. Furthermore localised asbestos concentrations in soils will be very much dependent on site specific factors relating to natural weathering forces, for example local topography, vegetation cover, whether the area is used for farming or pristine wilderness, rainfall patterns etc.

With regards to the area surrounding the Woodsreef deposit the background soil concentrations of naturally occurring asbestos are unclear. However at least in the area of the Woodsreef mine and immediate surrounds the contribution of asbestos released into soils by natural processes weathering naturally occurring asbestos is likely to be dwarfed by the contribution of asbestos released into the environment by mining processes.

3.3.6 Woodsreef Mine

The mine site is approximately 290 hectares in size and is reported to contain a 75 million tonne waste rock dump and 25 million tonne tailings dump and four open pits (*Parsons Brinckerhoff, 2012 & NSW Department of Primary Industries Soil Conservation Service, 2013*). The mine has been derelict since 1983.

The mine site can be functionally divided into the following areas: Open Pits (four on site), Mill Building Area, Waste Dump (three sites, south, west and northeast), and a Tailings Dump. The Mine Road winds along the eastern perimeter of the mine except for a section of road that runs in-between the South Waste Dump and the Tailings Dump (See **Figure 3** above).

The Waste Dumps consist of processed rocks and overburden. The Tailings have been reported as partially processed ore, understood to be predominately asbestos, stockpiled for later reprocessing that never occurred (*NSW Department of Primary Industries Soil Conservation Service, 2013*).

Water drainage studies of the mine site shows on-site drainage flows, that is, back on to the mine site, and off-site drainage flow from the mine site. A siltation / drainage system is in place, partially left over from the mine operations and partially enhanced and expanded by the Soil Conservation Service. These changes were designed to improve drainage and minimise asbestos containing sediments being transported off site with water flows (*NSW Department of Primary Industries Soil Conservation Service, 2013*).

The potential for natural processes, such as rain and wind, to transport materials from the mine site to areas outside the mine boundary will be a major factor in determining the likelihood of the general public being exposed to asbestos from the mine. Wind erosion and transport of asbestos is less significant than waterborne migration in terms of the mass of material that can migrate, although windborne asbestos can be more significant in terms of health risks (*Department of Industry and Resources & Department of Local Government and Regional Development, 2006*).

The ability of the mine site materials and soils to resist these forces of erosion will vary over time. The characteristics of the parent material to form a stable crust will reduce the potential for off-site migration caused by both wind and rain. If the materials do start to migrate under the influence of natural forces such as rain and water movement, then the direction of water drainage from the source materials will determine if the materials leave the mine site. Therefore the ability of a surface to form a

stable crust and the probable water drainage flows from the area of the mine, are primary factors when determining the likely hazard from off-site migration of mine materials.

Ultimately natural forces will be responsible for transporting some materials and soils both off the mine site and within the mine site. However any potential asbestos hazard coupled with the transport of materials will be dependent on three main factors. This includes the asbestos present in the material, how much asbestos is present in the material and in the form of the asbestos.

The first and second factors (the presence or not of asbestos in material and how much asbestos is present) are both of obvious importance. The third factor, the form of the asbestos in the materials, is extremely important for any hazard assessment. The simple underlying principle being within some limits, the smaller the asbestos fibres present the greater the asbestos hazard.

If the asbestos is present as a natural band, encased in rock, with little chance of releasing asbestos fibres, the hazard is negligible. In contrast, asbestos will pose the greatest hazard to humans when present in the form of small fibres or loose bundle of asbestos.

The asbestos hazard to humans occurs via the respiratory route, the breathing in of asbestos fibres. Asbestos can be present in a material but not in a respirable form. Accordingly the hazard posed by mine site materials and soils will be dependent on the ability of the material to release respirable asbestos fibres.

The definition of respirable asbestos fibres is those fibres less than 3µm in width, and greater than 5µm in length and with a width length to width ratio of greater than 3:1 (*AS 4964-2004*). The presence or absence of respirable asbestos fibres is determined during laboratory analysis, using Trace Asbestos Analysis, if Trace Asbestos is reported it indicates the presence of respirable asbestos fibres (*AS 4964-2004*).

Therefore materials that pose the highest potential hazard to exposed humans will be materials with relatively high asbestos content and with the asbestos fibres present in the respirable size range.

3.3.7 Key Points - Woodsreef Mine & Surrounds

- The mine is situated in an area of naturally occurring asbestos
- With regards to the area surrounding the Woodsreef deposit the background soil concentrations of naturally occurring asbestos are unclear.
- In the area of the mine and immediate surrounds the contribution of asbestos released into soils by natural processes weathering naturally occurring asbestos is likely to be dwarfed by the contribution of asbestos released into the environment by mining processes.
- The potential for natural processes, such as rain and wind, to transport materials from the mine site to areas outside the mine boundary is a major factor in determining the likelihood of the general public being exposed to asbestos from the mine.
- Potential asbestos hazards coupled with the transport of materials will be dependent on three main factors. This includes whether asbestos present in the material, how much asbestos is present in the material and in what form is the asbestos.

- Materials that pose the highest potential hazard to exposed humans will be materials with relatively high asbestos content and with the asbestos fibres present in the respirable size range.

3.3.8 Asbestos & Land

As would be expected with a derelict asbestos mine, the presence of asbestos is widespread on the mine site. Furthermore asbestos present on the site and adjacent to the mine site is in the form of both natural occurring asbestos and processed or partially processed asbestos.

Naturally occurring asbestos in the mine site has been reported as averaging 4% of the parent material (*Dames & Moore, 1997*). The naturally occurring asbestos will be largely bound in the rock formation. Therefore the contribution of undisturbed naturally occurring asbestos to the overall release of asbestos from the mine site to the surrounding environment should be minimal.

In the broader regional area surrounding the Great Serpentine Belt the presence of naturally occurring asbestos is likely to have led to areas where weathering processes have released asbestos fibres from the rock into the local soils. Any local enrichment of asbestos in soils from natural processes is likely to be patchy in distribution and very much subject to site specific conditions. Furthermore there is little information available on the likely localised asbestos concentrations in soils as a result of weathering of naturally occurring asbestos in the region. Therefore the extent of natural asbestos enrichment of local soils is unclear.

The largest source of asbestos in a form that may be easily transported off the mine site into the surrounding environment by natural forces such as wind and water will be the processed and partially processed material on the mine site. As previously stated the mine site is reported to contain a 75 million tonne waste rock dump and 25 million tonne tailings dump. The Waste Dumps consist of processed rocks and overburden. The Tailings have been reported as partially processed ore, understood to be predominately asbestos, stockpiled for later reprocessing that never occurred (*NSW Department of Primary Industries Soil Conservation Service (NSW SCS), 2013*).

SLR Consulting conducted a Hazard Assessment of the mine site and adjacent lands in 2013 (*SLR, 2013a*). This study included a site walk over inspection of the mine site with observations made on the site conditions, including crusting and evidence of ground surface migration noted.

Evidence of current erosion and migration of materials within the mine site and off the mine site were readily apparent in many areas of the mine. It appeared that migration of materials is likely to be intermittent in nature and linked to significant events such as heavy rain or the localised catastrophic collapse of sections of the material such as occurs when water causes erosion to undermine areas leading to collapse of previously stable crusts or materials (*SLR, 2013a*).

As part of the SLR (2013a) study, representative soil samples were collected at locations across the area and analysed for asbestos content. This included forty six locations, representative of the broad areas within the mine site and outside the mine boundary. The areas outside the mine boundary included:

- Ironbark Creek, adjacent to pumping station; to tyre mount; and floodplain;
- Ironbark Creek, east flood plain, midway;
- Ironbark Creek, start of walking track north east;
- North of mine central waypoint, north side of Bundarra - Barraba Road;
- Entrance to mine, east of building;
- South end tailings, east road culvert, adjacent to private land;
- Flora Trail adjacent to pit 1, west;

- West of waste dump near pump station; and
- Northwest of overburden.

Critically, respirable asbestos fibres were present at the majority of locations sampled. Asbestos fibres in this size range pose a significant hazard to human health if they are inhaled.

3.3.9 Key Points - Asbestos & Land

The conclusions that can be drawn in relation to asbestos on the mine site and adjacent lands are the following:

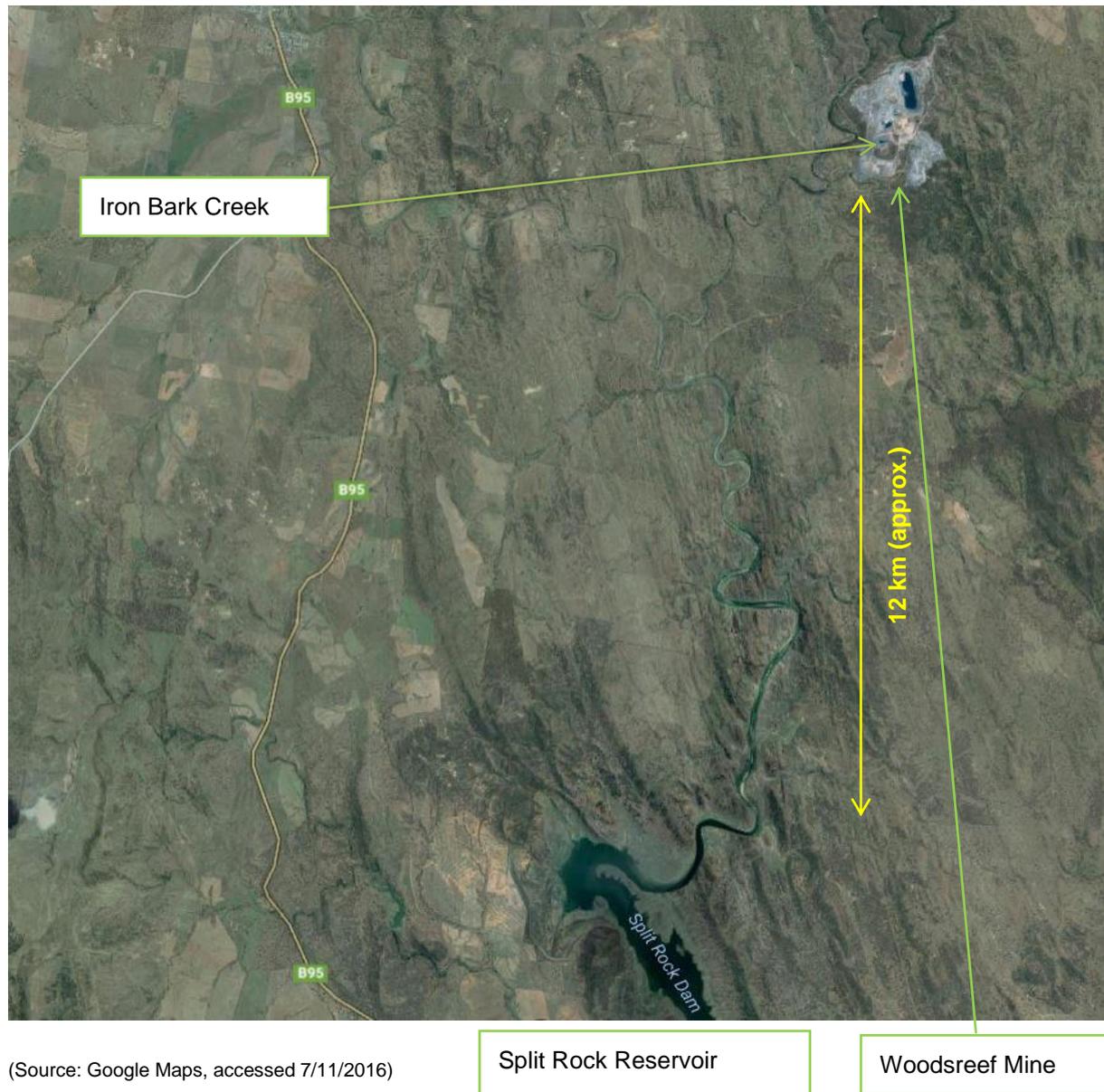
- In the broader regional area surrounding the Great Serpentine Belt the presence of naturally occurring asbestos is likely to have led to areas where weathering processes have released asbestos fibres from the rock into the local soils
- Any local enrichment of asbestos in soils from natural processes is likely to be patchy in distribution and very much subject to site specific conditions. Furthermore there is little information available on the likely localised asbestos concentrations in soils as a result of weathering of naturally occurring asbestos in the region. Therefore the extent of natural asbestos enrichment of local soils is unclear.
- There is evidence of historic and current erosion and migration of materials within the mine site and off the mine site in many areas of the mine.
- The migration of materials is likely to be intermittent in nature and linked to significant events such as heavy rain or the localised catastrophic collapse of previously stable surface crusts or materials.
- There is evidence of various degrees of asbestos contamination across adjacent lands to the mine.
- Respirable asbestos fibres were present in soils across most of the mine site.
- Respirable asbestos fibres were also present in land adjacent to the mine.

3.3.10 Asbestos & Water

Water movement associated with the mine site is important as water has the potential to transport significant amounts of bulk material from the mine site to the surrounding environment and therefore closer to people.

The major waterway transporting surface water away from the areas near the mine is Ironbark Creek which is located on the western side of the mine area. Ironbark Creek flows in a southerly direction eventually entering the Spilt Rock Reservoir. There are smaller ephemeral creeks and drainage around the eastern and southern sides of the mine area. The location of Ironbark Creek and Split Rock Reservoir in relation to Woodsreef Mine has been set out below in **Figure 5**.

Figure 5 Location of Ironbark Creek and Split Rock Dam in relation to Woodsreef Mine



(Source: Google Maps, accessed 7/11/2016)

Water drainage assessments on the mine site shows drainage flows both back on to the mine site and flows off the mine site. It has been estimated that for approximately 65% of the mine site area water drainage is retained on the mine site itself. Therefore approximately 35% of the mine site area drains water off site. Of this approximately 12% of the mine area drains uncontrolled off the mine site and 23% of the mine area drains through some form of sediment control.

There is a paucity of information on the amount of asbestos transported off the mine site into the local creeks and Ironbark Creek or the more distant Split Rock Reservoir. The evidence that is available consists mostly of anecdotal, visual evidence of fibrous material or silt observed at drainage points near the mine site. Dames & Moore (1997) quoted a 1978 report (*Toyer & Main, 1978*) in which erosion and movement of mine tailings into Ironbark Creek was observed. The Toyer & Main report also commented on preliminary sampling of asbestos concentration in water in Ironbark Creek and

“pits” which ranged from 80,000 to 250,000 asbestos fibres per mL of water. However it should be noted that in 1978 the mine was in operation and at that time there was little if any sediment control to capture drainage off the mine site. There is currently a siltation / drainage system in place to capture or impede the movement of materials from the mine site into the surrounding waterways.

Dames & Moore (1997) conducted limited sediment sampling to “update and confirm the results obtained by Toyer & Main (1978)”. The nine sampling sites in streams and creeks replicated sites utilised by Toyer & Main (1978). Asbestos in the form of chrysotile was found in Nangahrah Creek (which flows into Ironbark Creek north of the mine) and Ironbark Creek, both of which receive drainage from the mine site. Chrysotile was also found in sediment of water drainage systems that drain off the Tailings Dump and South Waste Dump into Ironbark Creek. In contrast chrysotile was not detected in samples taken from the sediments of the Manilla River, the river which Ironbark Creek flows into approximately 6 km southwest of the mine.

It should be noted that asbestos from weathering of naturally occurring asbestos away from the mine area is likely to be entering the local streams. The contribution of this source of asbestos to local waterways is unclear. However in the immediate vicinity of the mine the natural contribution of background asbestos is likely to be dwarfed by the transport of asbestos from the mine site into the waterways.

The conclusions that may be drawn from the available observations of others and the authors own observations is that asbestos containing material has been transported from the mine site into Ironbark Creek over the years. Once in the Ironbark Creek system the asbestos would behave in a similar manner to other sediments entering the creek. That is settling out in areas of low flow, being buried over time in the creek bed by incoming sediments, occasionally resuspended and transported with the general sediments during periods of sediment disturbances such as during flooding events. If asbestos containing sediments have been transported along Ironbark Creek and entered the Split Rock Reservoir it would be expected that the asbestos material would settle out into the reservoir sediments and ultimately be buried over time by natural sedimentation processes. Once buried the asbestos should have little or no impact on the environment or end-users of the reservoir water.

3.3.11 Key Points - Asbestos & Water

- Asbestos containing materials have been transported from the mine site into Ironbark Creek over many years.
- The amount of asbestos transported from the mine site into Ironbark Creek is unclear.
- The amount of asbestos from weathering of naturally occurring asbestos transported into Ironbark Creek is unclear.
- Asbestos in the Ironbark Creek system would settle out in areas of low flow, becoming buried over time by incoming sediments.
- Asbestos in Ironbark Creek sediment will occasionally be resuspended and transported with the general sediments during periods of sediment disturbances such as during flooding events.
- If asbestos has been transported into Split Rock Reservoir it would be expected to settle out into the reservoir sediments and be buried over time by natural sedimentation processes. Once buried the asbestos should have little or no impact on the environment or end-users of the reservoir water.

3.3.12 Asbestos & Air Quality

The Australian Occupational Exposure Standard for airborne asbestos was used to assess results of current and historic airborne asbestos concentrations. The use of this standard was chosen by the Woodsreef Taskforce. The basis being that sampling methodology was standardized and allowed comparisons to a significant body of historic Woodsreef air monitoring data collected over at least 25 years.

At the time of writing, the Safe Work Australia eight-hour Time Weighted Average (TWA) for asbestos exposure is 0.1 fibres/mL. An eight-hour TWA is translated as the average airborne concentration of asbestos over a normal eight-hour working day, for a five-day working week. This Safe Work Australia exposure standard is not however, a discriminative dividing line between safe and dangerous concentrations of airborne asbestos fibres but is to be used by appropriately qualified and experienced persons to interpret risk in relation to exposure circumstances.

The methodology used by Safe Work Australia for reviewing and updating the national exposure standards involves the use and acceptance of overseas standards from governmental and non-governmental sources. Sources are selected after an assessment against several factors including quality and availability of supporting documentation, integrity of the development process and consistency with the Safe Work Australia philosophies. Sources include the United Kingdom Health and Safety Executive HSE "Occupational Exposure Limits" and the American Conference of Governmental Industrial Hygienists (ACGIH) "Threshold Limit Values".

3.3.13 Historic Airborne Asbestos Fibre Monitoring

A review of available data indicated that airborne asbestos fibre monitoring had been undertaken a number of times between 1992 and 2012. Monitoring occurred either off mine site as background monitoring or on the mine site as part of monitoring during site works either during remediation works.

The majority of the monitoring between 1992 to 2012 indicated that airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air. That is concentrations were below the detection limit of the methodology. As previously stated the likely concentrations of airborne asbestos during the monitoring period were at least ten times lower than the current occupational exposure limit.

The exceptions occurred during three periods, each time during remediation works on the mine site and at monitoring locations on the mine site only. In these cases the airborne asbestos fibre concentrations were in the range of 0.04 to 0.06 fibres per mL of air. The indicative approximation of samples above the detection limit was 1 sample above the detection limit per 140 samples taken on the mine site.

3.3.14 Contemporary Airborne Asbestos Fibre Monitoring 2013 to 2016

Two air monitoring activities were conducted by SLR from 2013 to 2016. These were classed as Background Monitoring and Activity Based Monitoring. A third round of monitoring was conducted during remediation works on the mine site from 2014 - 2015. Monitoring methodology was as per NOHSC:3003(2005) Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres 2nd edition.

Background Airborne Asbestos Fibre Monitoring

Background airborne asbestos fibre monitoring was conducted during three periods between 2013 and 2016. The first two periods of background monitoring included six rounds of monitoring were conducted by SLR from 14 November 2013 to 14 December 2013.

The second round of monitoring took place during the remediation works including the demolition of buildings undertaken from October 2014 to May 2015. Airborne asbestos fibre monitoring included 1,636 air samples comprising of on mine site monitoring (248 rounds of daily sampling, 1,545 samples) and off site monitoring in the vicinity of the mine, in Barraba and at a control site at Tamworth (12 rounds of daily sampling by SLR, 91 samples).

The most recent round of background air monitoring by SLR took place from 22 April 2016 to 27 June 2016 with twelve rounds of monitoring comprising of 84 samples.

Background airborne asbestos fibre monitoring locations used by SLR between 2013 and 2016 included areas where recreation activities take place. These locations set out in **Table 2** below

Table 2 SLR Air Monitoring Locations – Background Monitoring

Air Monitoring Location		
1	-	Control - Residence in Tamworth
2	-	Barraba Primary School, Mower (Cricket Nets)
3	R9	Glenn Riddle Reserve (2013 only)
4	R19	Boxpark Station
5	R16	Wynaroy
6	R14	Camping - F&F Trail
7	R15	Woodsreef Township (Church)
8	R11	Picnic Site
9	R17	Mr Burgess Property

Results of the Background Air Monitoring at all locations over each round of monitoring by SLR indicated that airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air. That is to say the airborne asbestos fibre concentrations were less than the detection limit of the approved method (*NOHSC:3003(2005)*)

Details of the airborne asbestos fibre monitoring undertaken between 1992 and 2016 at locations on or near the mine site have been summarized in **Appendix C**.

3.3.15 Activity Based Monitoring

Photo 1 Walking along Trail



Activity Based Monitoring was conducted over two rounds in 2013 and 2016. Round 1 was conducted at locations near the mine site from 9 December 2013 to 12 December 2013. In this monitoring SLR Consultants conducted a range of activities whilst wearing personal monitors. The activities were chosen to represent typical recreational pastimes conducted near the mine site. These activities included the following:

- Fossicking
- Camping (two locations) – included activities around camp site
- Bird Watching
- Walking the Flora Trail (near The Mine Road)
- Viewing the mine from various observation points off the Bundarra - Barraba Road
- Walking along the Bundarra - Barraba Road.

Round 2 Activity Based Monitoring was conducted at locations near the mine site from 30 May 2016 to 1 June 2016. In this round SLR Consultants conducted repeat monitoring of selected activities which included:

- Fossicking

- Camping (two locations) – included activities around camp site and simulation of sleeping in tents
- Bird Watching
- Walking along the Bundarra - Barraba Road.

Results of the Activity Based Monitoring for each activity conducted by SLR indicated that airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air. That is to say the airborne asbestos fibre concentrations were less than the detection limit of the approved method (*NOHSC:3003(2005)*).

The airborne asbestos fibre concentrations for the activity based monitoring conducted by SLR in December 2013 and May 2016 have been set out below in **Table 3**. The SLR air monitoring reports have been set out in **Appendix B**.

Table 3 Activity Based Airborne Asbestos Fibre Monitoring Rounds 1 & 2*

Activity	Round 1				Round 2				Rounds 1 & 2
	Date	Temperature (°C)	Rainfall# (24 hour mm)	Number of Samples	Date	Temperature	Rainfall# (24 hour mm)	Number of Samples	Summary Airborne Fibre Concentrations (fibres/mL)
Fossicking	9/12/13	12.0 - 31.0	0	3	9/5/16	16.0 – 25.1	0	3	All <0.01
Camping - Iron Bark Camping Area, near Pumping Station	11/12/13	12.0 - 30.5	0.6	3	10/5/16	13.0 – 22.1	1.6	4	All <0.01
Camping - Iron Bark Camping Area, north of Bundarra - Barrabra Rd, 1km north of mine	10/12/13	20.0 - 33.0	1	3	11/5/16	8.9 – 20.1	0	4	All <0.01
Bird Watching	9/12/13	12.0 - 31.0	0	3	9/5/16	16.0 – 25.1	0	2	All <0.01
Walking the Flora Trail	11/12/13	12.0 - 30.5	0.6	2	-			-	All <0.01
Viewing the mine from various observation points off the Bundarra - Barraba Road	12/12/13	11.2 - 31.6	0	3	-			-	All <0.01
Walking along the Bundarra - Barraba Road, near the mine	10/12/13	20.0 - 33.0	1	3	-			-	All <0.01

Note

* = Temperature and rainfall data from nearest met station, Barraba - Source: Australian Government Bureau of Meteorology, www.bom.gov.au/climate/data/, accessed 27/4/2017). Weather patterns appeared normal based on historic data.

= Rainfall at mostly night or after monitoring had ceased for the day

For all air monitoring including Background, Activity Based monitoring and Remediation monitoring all airborne asbestos fibre concentrations were below the detection limit of the methodology. To put this concentration in context, at the time of writing the Safe Work Australia Exposure Standard for asbestos is 0.1 fibres per mL of air. Therefore the likely concentrations of airborne asbestos during the monitoring period were at least ten times lower than the current occupational exposure limit.

Further Details of the monitoring activities including photographs can be found in **Appendix A**.

3.3.16 Key Points - Asbestos & Air Quality

- Activity Based Monitoring conducted at locations near the mine site in December 2013 and selected activities repeated in May 2016. The activities were chosen to represent typical recreational pastimes conducted near the mine site. These activities included the following: Fossicking, Camping (two locations), Bird Watching, Walking the Flora Trail, Viewing the mine from various observation points off the Bundarra - Barraba Road, Walking along the Bundarra - Barraba Road.
- Activity Based Monitoring near the mine site included 34 samples with recorded airborne asbestos fibre concentrations during all activities of less than 0.01 fibres per mL air. That is below the detection limit of the method.

3.4 Issue Identification Summary

The main issues identified relating to asbestos and the local populations are the following:

- The lands adjacent to the mine and between the mine site and the town of Barraba are rural in nature and only lightly populated.
- Recreational activities, both passive and active are undertaken in areas ranging from adjacent to the mine to areas up to 4 km from the mine.
- Recreational activities, both passive and active are undertaken by local residents and tourists to the area.
- Airborne asbestos fibres are only occasionally becoming airborne at detectable concentrations when there is a physical disturbance on the mine site itself.
- Furthermore detectable concentrations of airborne asbestos fibres have not been recorded outside the mine site in the surrounding communities and locations.
- Activity Based Monitoring conducted at locations near the mine site in December 2013 and May 2016 included 34 samples all of which recorded airborne asbestos fibre concentrations that were less than 0.01 fibres per mL air during all activities tested.

3.5 Toxicity & Carcinogenicity Assessment

Airborne asbestos fibre concentrations are important because asbestos primarily affects the respiratory system. There is no clear evidence of asbestos causing disease through ingestion such as may occur through eating or drinking asbestos contaminated foodstuff or water.

All types of asbestos are carcinogenic, and it is acknowledged that there is some debate that amphibole type asbestos is more potent in causing mesotheliomas than the serpentine type (chrysotile). However, both types can cause mesotheliomas and are believed to be equally potent in causing lung cancer (*ATSDR, 2001*).

All asbestos-related diseases are dose-related: the higher the concentration and duration of exposure, the higher the prevalence of the disease and mortality. Disease can occur as a result of either high exposure to airborne asbestos fibres for a short time or lower exposure over longer periods of time.

The asbestos related diseases, Asbestosis, Lung Cancer and Mesothelioma have been reviewed extensively and a brief summary has been provided in **Appendix F**.

3.6 Exposure Assessment

In general, an exposure assessment aims to provide the magnitude, frequency, extent, character and duration of exposures to a chemical or material of concern, in this case asbestos. An exposure assessment also aims to identify human populations or groups who may be exposed and potential exposure pathways, which in this case is inhalation.

3.6.1 Exposure Pathways and Receptors

An exposure pathway describes the mechanism by which personnel may be exposed to asbestos fibres originating from the Woodsreef Mine. Each exposure pathway must include a source of fibres, mechanism for release of the fibres and a mechanism for fibres to enter the breathing zone. The exposure pathway is incomplete if any of these factors are not present, and therefore no additional risks are associated with that activity.

Receptors

Receptors are similar groups of people from the defined communities. In this assessment, receptors are considered to be individuals who usually undertake recreational activities in close proximity to the mine.

For the purposes of this report, members of the communities have been classified into two (2) exposure categories as set out in **Table 6**.

Table 4 Community Exposure Groupings - Receptors

Exposure Group	
Exposure Group 1- Passive Recreation conducted in proximity to the Mine	Transient observers (general public and visitors) undertaking passive recreational activities (i.e. little or no disturbance of soil and vegetation) in close proximity to the mine
Exposure Group 2 - Active Recreation conducted in proximity to the Mine	Transient observers (general public and visitors) undertaking active recreational activities (i.e. potential for some disturbance of soil and vegetation) in close proximity to the mine

The exposure route for these exposure groups will be inhalation of asbestos fibres. The exposure pathways from which the exposure groups are potentially exposed will be via two pathways. The first exposure pathway being from background airborne asbestos fibre concentrations. The second pathway being through localised airborne asbestos fibres made airborne by the person's activities disturbing asbestos containing soils or asbestos fibres settled on surfaces. Thus the source of asbestos may vary. These issues will be discussed in more detail below.

Source of Asbestos Fibres

The original source of asbestos fibres in the current study is the processed materials on the mine site. However there are also sources of asbestos that have been transported by the forces of nature from the mine site to areas adjacent to the mine site. It is acknowledged that naturally occurring sources of asbestos are also present in the general area however it is probable that the main bioavailable source of asbestos is overwhelmingly from the mine site.

Notional Mechanism for Release of Fibres

The mechanisms responsible for the release of fibres are many and varied but can be defined in two broad groupings. The first being the release of fibres through natural forces, such as wind, rain, erosion etc, and the second grouping being the release of fibres through man made forces, such as when persons disturb the soil/ground.

There is evidence of current erosion and migration of materials within the mine site and off the mine site. The migration of materials and subsequent release of asbestos fibres is likely to be intermittent in nature and linked to significant events such as heavy rain or the localised catastrophic collapse of sections of the material such as occurs when water causes erosion to undermine areas leading to collapse of previously stable crusts or materials (SLR, 2103a).

Release of the asbestos fibres through man made forces is in general not currently occurring on the mine site. The exception to this was during the remediation works are undertaken or historically when trespassers enter the mine site. However man made forces may be disturbing soil containing asbestos fibres in areas where the asbestos fibres have initially been transported off site by natural forces and deposited on lands adjacent to the mine. Examples of soil disturbance off the mine site range from small scale such as a recreational camper or a vehicle disturbing the soil to large scale such as digging up areas for roads works or removal of drainage sediments.

Mechanism for Fibres to Enter the Breathing Zone

Once asbestos fibres have been released then air movement is required for asbestos fibres to enter the breathing zone of a person. This will entail two broad scenarios:

- Air movement will transport airborne fibres over significant distances ranging from hundreds of metres to kilometres (Scenario 1).
- Air movement transporting fibres over limited distances such as metres (Scenario 2).

In Scenario 1, the receptors may be at a distance from the mine and disturbed fibres have to be carried by winds for significant distances. During this distribution the concentrations of airborne asbestos fibres will be diluted from the original fibre suspension from the soil as the winds take the fibres away from the mine site. It is conceivable under the right atmospheric conditions that airborne asbestos fibres may reach receptors at distance from the mine. However the concentration of fibres the receptor may receive in their breathing zone should be significantly diluted compared to the initial airborne fibre concentrations near the mine.

An alternative Scenario 1 example may be a receptor closer to the asbestos source and hence potentially exposed to the higher initial concentrations of airborne fibres before being diluted in the general air movement. Exposure Group 1 "Passive Recreation" near the mine is an example where people viewing the mine from the mine boundary or picnicking in close proximity to the mine, are potentially exposed to the higher airborne fibres concentrations associated with the initial disturbance.

In Scenario 2, the receptors are very close to the original source of the asbestos when fibres become airborne. The distance from the source of airborne fibres may be less than one metre. The mechanism for the release of fibres may also be due to the activities of the receptor disturbing the asbestos source. These receptors are likely to be potentially exposed to higher concentrations than those in the Scenario 1 due to their proximity to the asbestos source. However, the exposure may be of a shorter time period as the airborne fibres disperse into the surrounding air.

Exposure Group 2 "Active Recreation" may be exposed to asbestos fibres entering their breathing zone in this manner.

The exposure scenarios discussed above would largely relate to direct exposure where the asbestos fibres are directly inhaled. This is likely to be the dominant exposure pathway. Secondary exposure through indirect pathways is also possible. Indirect pathways would involve two or more steps, the first step being asbestos fibres contaminating items such as clothes, vehicles, recreational accessories (e.g. tents, tarps, metal detectors, shovels, etc.). Then after this initial contamination, the asbestos fibres would be made airborne through actions such as cleaning of contaminated objects, shaking clothing, etc. This may lead to asbestos fibres being inhaled during the cleaning, etc. This could occur on site or at a different location such as when the persons arrive home.

The above information has been previously summarised in the Conceptual Site Model set out in **Figure 4**.

3.6.2 Assessment of Exposure Concentrations

The exposure concentrations for the current study were based on results of historic air monitoring at the mine site and recent monitoring by SLR as set out above in **Section 3.3.13 to 15**.

It appears that for all Exposure Groups the airborne asbestos fibre concentrations during the recreational activities and the general background levels they may be routinely exposed to is likely to be less than 0.01 fibres per mL of air. This was based on the review of all available airborne asbestos fibre monitoring from 1992 to 2016 and related information such as air quality modelling. All monitoring data from locations off the mine site have recorded airborne asbestos fibre concentrations of less than 0.01 fibres per mL of air.

Airborne asbestos fibre concentrations above 0.01 fibres per mL of air have only been recorded at sampling locations on the mine site itself and only occasionally when remediation activities have been occurring on the mine site. This data fits the assumption that asbestos fibres mainly become airborne during intermittent physical disturbance to the asbestos containing source material. Examples of physical disturbance may be caused by natural forces of erosion or manmade disturbance through remediation works, driving along the now closed section of The Mine Road or recreational activities that disturb the ground structure.

In 1992 monitoring of personnel conducting rehabilitation works using heavy equipment on the Woodsreef tailings dump recorded airborne asbestos fibre concentrations in the range of 0.01 to 0.04 fibres per mL of air (*Dames & Moore, 1997*). The tailings can be considered an area of high asbestos content with a high percentage of respirable size asbestos fibres present in the material, based on current and historic studies as set out in **Section 3.3.8**. Therefore the tailings are in an area where physical disturbance can relatively easily create airborne asbestos fibres. For the purposes of estimating receptor exposure airborne fibre concentrations, the concentration of 0.04 fibres per mL of

air recorded during the tailings rehabilitation works may be used to represent airborne concentrations generated by short term physical disturbance on the mine site.

It appears likely that a large percentage of airborne fibres initially generated from the mine, settled back to ground within a few kilometres of the mine site. However the actual distance airborne asbestos fibres generated on the mine site travel before deposition has to date not been verified by field measurements of airborne asbestos fibres. As stated above, all monitoring data from locations off the mine site have recorded airborne asbestos fibre concentrations of less than 0.01 fibres per mL of air.

Therefore the estimated exposure concentrations, during recreational activities and the long term background concentrations associated with the mine site are likely to be less than 0.01 fibres per mL of air which is not distinguishable from the background at the control site of Tamworth. The estimated background exposure concentrations have been set out in **Table 5**.

Table 5 Recreational Groupings - Background Exposure Concentrations (no disturbance on mine)

Exposure Group	Exposure Concentrations – Background (asbestos fibres/mL air)
Exposure Group 1 - Passive Recreation conducted in proximity to the Mine	< 0.01
Exposure Group 2 - Active Recreation conducted in proximity to the Mine	< 0.01

It should be prudent to consider that Exposure Group 2 (Active Recreation) may be potentially exposed to localised elevated airborne asbestos concentrations over short time periods, generated by their activities which cause physical disturbance to asbestos containing soils, for example trail bike riding around Iron Bark Creek.

Persons in close proximity to the mine site, undertaking recreation activities near the mine (Exposure Groups 1 & 2) may be in close proximity to the asbestos source during the initial disturbance. Asbestos fibre concentrations that persons may be intermittently exposed to are difficult to estimate; however those in closer proximity to a disturbance are more likely to have greater exposure. The current study attempted to simulate Active Recreation exposure, finding airborne fibre concentrations of less than 0.01 fibres per mL. However this result does not preclude the possibility of exposure to higher airborne asbestos concentrations during active recreational activities or during certain climatic conditions such as periods of strong winds.

3.7 Exposure Assessment Summary

- Persons conducting recreational are potentially exposed via two pathways. The first exposure pathway being from background airborne asbestos fibre concentrations. The second pathway being through localised airborne asbestos fibres made airborne by the person's activities disturbing asbestos containing soils or asbestos fibres settled on surfaces.

- Mechanisms for asbestos fibre release were determined to be two broad groupings. The first mechanism being the release of fibres by natural forces of erosion. The second mechanism being the release of fibres by activities of man, for example, recreational activities disturbing the soil outside the mine site.
- Mechanism for asbestos fibres entering the breathing zone of receptors were determined to be two broad groupings. The first mechanism being local winds carrying the fibres longer distances. The second mechanism being the release of fibres by disturbing the soil by individuals and their subsequent exposure
- The estimated exposure concentrations received by recreational users were determined from available air monitoring data, both historic and current and which allowed for estimating an annual background exposure level.
- The exposure assessment indicated that the general background for all recreational users was expected to remain below 0.01 fibres/mL. Based on the results of 2,278 air monitoring samples.
- The exposure assessment indicated that during a disturbance within or near the mine site, persons in close proximity to disturbance, such as persons undertaking recreation activities near the mine may have greater exposure than other groups. This determination was based on prudent observations rather than air monitoring data due to the intermittent nature of site disturbances, the likelihood or not of air monitoring capturing this data and the limitations of the air monitoring methodology such as the uncertainty associated with measurements and limits of detection.
- Recreational activity re-enactment data (34 samples over 7 activities) did not indicate levels above 0.01 fibres/mL, however it is not possible to exclude recreational users being exposed to levels greater than 0.01 fibres/mL.

4 RISK CHARACTERISATION

Risk characterisation involves the incorporation of the exposure assessment and the hazard assessment to provide an overall evaluation and assessment of risk. Risk assessment is used extensively in Australia and overseas to assist decision making on project acceptability and chemical use. Risk is the probability of an unwanted event happening and is often expressed as a multiple of its consequences and frequency. Risks can be defined to be acceptable or tolerable if the population will bear them without undue concern. Regulatory limits are set at points deemed “acceptable” by the regulator, taking into account objective evidence of harm and the general views of society. Risks are unacceptable if they exceed a regulatory limit, or cannot be accepted.

As with any risk assessment there is always a degree of uncertainty associated with the assessment. The factors involved in this uncertainty and the implications are discussed in **Appendix G**.

Negligible risks are those so small that there is no cause for concern, or so unlikely that there is no valid reason to take action to reduce them. Humans continually expose themselves to, or have imposed upon them, the risk of injury or fatality. Self-imposed risk is known as voluntary risk and includes everyday events such as smoking, swimming and driving. Each has an associated risk that people voluntarily accept when weighed against the perceived benefits.

Asbestos fibres are ubiquitous in the environment and essentially the entire population do inhale fibres throughout their life. The receptor groups identified in the current study in general may not be exposed to airborne asbestos concentrations that vary from background ambient outdoor air levels unless significant disturbance of asbestos sources, either on the mine site or off the mine site occurs. Therefore it is useful to consider the significance of the current incidence rates and the estimated background rate.

It is suggested that the background incidence rate of mesothelioma (for those not exposed to asbestos fibres occupationally) is estimated to be less than 1 case per million population per year. Because of the high fatality rate and relatively short survival after diagnosis, incidence and mortality rates are similar (AIHW, 2004). However, it is debated whether this background incidence rate is either due to non-asbestos factors or background exposure to asbestos fibres.

For all exposure scenarios including high level historic occupational exposures, the current incidence of mesothelioma in Australia, as reported by Tossavainen (2004), is 35 cases per million population per year (approximately 490 cases per year) for the population over 15 years of age. This incidence rate reflects the high level occupational exposures occurring between 15 and 40 years ago. A vast majority of people being diagnosed with asbestos-related diseases such as mesothelioma are the workers who worked in the Australian asbestos mines, manufactured asbestos products, unloaded the shiploads of asbestos, worked on construction sites where asbestos was sprayed on the beams and where asbestos products were disrupted aggressively for long periods of time.

With regards to current potential community exposures, if airborne asbestos fibres were at measurable concentrations the exposure risks may be calculated using the US EPA inhalation unit risk factor (US EPA, 2005). Alternately a combined semi quantitative and qualitative based risk assessment including the application of the Safe Work Australia Exposure Standards for airborne asbestos may be used to estimate risk associated with short-term community or worker exposure, such as short term recreational activities, such as less than a day in duration or when work-related activities are undertaken in the area surrounding the mine.

A simple comparison of an air measurement and a health benchmark can be thought of as a "screening" exercise, that is, the risk assessor is screening for possible problems. If the majority of samples are much less than the benchmark, then in a majority of cases it would be appropriate to conclude that a health impact is unlikely.

The principal benchmark used in this assessment was the Safe Work Australia eight-hour TWA value of 0.1 fibres/mL for asbestos exposure.

As stated above, to classify potential public health risk into groups, a combined semi quantitative and qualitative method was used based on the factors considered to influence the likelihood of asbestos exposure to persons and communities. These factors were broadly divided into primary risk factors and secondary risk factors.

Primary Risk Factors

Primary risk factors were defined as risk factors where information was easily measured or well known. Such as the data from historic and current airborne asbestos fibre monitoring, how close to the mine or naturally occurring asbestos (NOA) the activity is conducted and if the recreational activity disturbs the soil.

Primary risk factors were considered to be the following:

- Airborne asbestos fibre concentrations recorded at locations near Exposure Groups from historic records and monitoring data collected during the remediation works.
- Proximity of Exposure Groups to the mine.
- Proximity of Exposure Groups to naturally occurring asbestos (NOA).
- Conducting recreational activities that disturb the soil.

Secondary Risk Factors

Secondary risk factors were defined as risk factors where less information was available or more assumptions needed to be made about a particular risk factor. Such as the possibility of elevated airborne asbestos concentrations occurring near people, the likelihood of people being near the mine or creating localized disturbances of asbestos contaminated soils, estimating frequency of visits to the area or estimating time spent near the mine.

Secondary risk factors were considered to be the following:

- Possibility for airborne asbestos fibre concentrations exceeding 0.01 fibres/mL air during short term disturbances (due to either natural or man-made forces) of asbestos contaminated soils at locations near Exposure Groups.
- Likelihood of Exposure Group being near mine site during short term disturbances of potentially asbestos contaminated soils by forces of nature.
- Likelihood of Exposure Group creating short term disturbances of potentially asbestos contaminated soils near the mine.
- Frequency of visits to mine site vicinity.
- Time spent near mine vicinity during each visit.

Table 6 below provides definitions for each Risk Level, based on the factors listed above.

Table 6 Definitions of Risk Ratings

Risk Level	Definition
Negligible	Health risk is unlikely given the combination of all known primary and secondary risk factors listed above being unlikely to lead to exposure to airborne asbestos fibres concentrations above normal background concentrations, thereby indicating no increased health risk.
Low	Health risk is low , but clearly possible given the potential combination of risk factors described above, leading to increased exposure to airborne asbestos fibres
Medium	Health risk is possible given the potential combination of risk factors described above, leading to increased exposure to airborne asbestos fibres
High	Health risk is likely given the potential combination of risk factors described above, leading to increased exposure to airborne asbestos fibres

In the current study, both historic and monitoring data collected at locations both close to the mine and at distance from the mine indicated airborne asbestos fibre concentrations below the detection limit of the monitoring systems of less than 0.01 fibres/mL air.

Therefore the degrees of risk posed by exposure during as background exposure have been assessed as negligible when there is no major disturbance to the mine or surrounds.

However the above exposure assessment indicated that during a disturbance within or near the mine site, persons in close proximity to disturbance, such as persons undertaking recreation activities near the mine (Exposure Groups 1 & 2) may have greater short term exposures than other groups. This determination was based on prudent observations rather than air monitoring data due to the intermittent nature of site disturbances, the likelihood or not of air monitoring capturing this data, and the limitations of the air monitoring methodology such as the uncertainty associated with measurements and limits of detection.

Assessing the risk of short term exposures depends on the frequency of exposure, length of individual exposures and the exposure concentration. An isolated exposure to asbestos fibres of a short duration is extremely unlikely to result in the development of an asbestos - related disease, as fibre concentrations are likely to be insufficient to increase cumulative lifetime exposure (*enHealth, 2005*). At the other extreme, a short term exposure to high concentrations of asbestos or repeated short term exposures may be sufficient to increase cumulative lifetime exposure and hence increase the risk to an individual.

As previously stated persons in close proximity to disturbance on the mine site or in the surrounding area may be exposed to localised, short term increases in airborne asbestos fibre concentrations. The frequency and magnitude of these short term exposures is unclear. Even though the general background risk from asbestos fibres, maybe considered negligible, based on available current and historic airborne asbestos fibre concentrations. For persons in close proximity during disturbances of the soil on the mine site or disturbances of the soil in areas surrounding the mine site, such as persons undertaking recreation activities near the mine (Exposure Groups 1 & 2) there is currently unquantified potential for short term exposure. Therefore the current report has classified the risk to these persons as negligible to low.

4.1 Risk Characterisation Summary

It appears that for all recreational users the background airborne asbestos fibre concentrations they may be routinely exposed is less than 0.01 fibres per mL of air, that is, below the minimum detection limit of the measurement technique. However for recreational users in close proximity to the mine and naturally occurring asbestos it would be prudent to assume these groups may additionally be potentially exposed to localised higher airborne asbestos concentrations possibly produced over short time periods, generated by their activities or events causing physical disturbance to asbestos containing soils. The current site containment activities and restrictions to access to the mine site and The Mine Road are designed to minimise these potential disturbance activities.

The estimated exposure risks of each group have been set out below in **Table 7**.

Table 7 Community Exposure Groupings - Receptors and Estimated Exposure Risks

Exposure Group	Estimated Background Exposure Risk from Background Airborne Asbestos Fibres
Exposure Group 1 - Passive Recreation conducted in proximity to the Mine	Negligible to Low
Exposure Group 2 - Active Recreation conducted in proximity to the Mine	Negligible to Low

5 CONCLUSIONS

Persons conducting recreational activities are potentially exposed via two pathways. The first exposure pathway being from background airborne asbestos fibre concentrations. The second pathway being through localised airborne asbestos fibres made airborne by the person's activities disturbing asbestos containing soils or asbestos fibres settled on surfaces.

Regarding the background airborne asbestos fibre concentrations, results of monitoring from 1992 to 2016 all indicate that it is likely asbestos fibres are only becoming airborne at detectable concentrations when there is a physical disturbance on the mine site itself.

Airborne asbestos fibre concentrations above 0.01 fibres per mL air, that is the detection limit of the method, have only been recorded during three periods, 1992 (0.04 fibres per mL, sample numbers unknown), 2006 (1 sample, 0.06 fibres per mL) and 2012 (1 sample, 0.04 fibres per mL). These occurred when remediation activities have been occurring on the mine site and only at sampling locations on the mine site itself. The indicative approximation of samples above the detection limit is 1 sample above the detection limit per 1,825 samples taken on the mine site.

Furthermore detectable concentrations of airborne asbestos fibres have not been recorded outside the mine site in the surrounding communities and locations.

Therefore for all recreational users the background airborne asbestos fibre concentrations they may be routinely exposed is likely to be less than 0.01 fibres per mL of air.

Activity based monitoring, both passive and active recreation, conducted as part of the current report found recorded airborne asbestos fibre concentrations of less than 0.01 fibres per mL of air.

However for recreational users in close proximity to the mine and naturally occurring asbestos it would be prudent to assume these groups may additionally be potentially exposed to localised higher airborne asbestos concentrations possibly produced over short time periods, generated by their activities or events causing physical disturbance to asbestos containing soils.

Based on the above findings, the estimated exposure risks from airborne asbestos fibres to recreational users of the areas surrounding the Woodsreef Mine is considered to be Negligible to Low.

6 REFERENCES

- AECOM, 2009 *Asbestos Air Monitoring Reports N2283801: 1-3, 4-7 (7 October); 8-9, 10-14 (& October); 15-21 (8 October); 22-26 (9 October); 27-31 (12 October); 32-41 (13 October); 42-46 (14 October); 47-51 (15 October)*.
- ATSDR 2000 *Case Studies in Environmental Medicine (CSEM) Asbestos Toxicity*. Agency for Toxic Substances and Disease Registry United States Department of Health and Human Services, Public Health Service, Atlanta, GA.
- ATSDR 2001 *Toxicological profile for asbestos*, Agency for Toxic Substances and Disease Registry United States Department of Health and Human Services, Public Health Service, Atlanta, GA.
- Australian Bureau of Statistics (2012) *2011 Census of Population and Housing, Basic Community Profile*.
- Australian Bureau of Statistics (2013) *Technical Paper Socio-Economic Indexes for Areas (SEIFA) 2011*.
- AIHW, 2004 *Cancer in Australia 2001*. Australian Institute of Health and Welfare Canberra. AIHW Cat. No. CAN 23.
- Australian Government Bureau of Meteorology, www.bom.gov.au/climate/data/, accessed 19/3/2014.
- Australian Standard 4964:2004 *Method for the qualitative identification of asbestos in bulk samples*. Standards Australia Ltd.
- Barraba, 2014. Barraba Visitors Centre Website <http://www.barraba.com.au/>, accessed 19/3/2014.
- Brown, R.E., Brownlow, J.W. & Kryen, J.P. (1992) *Metallogenic Study and Mineral Deposit Data Sheets - Manilla - Narrabri, 1:250,000 SH/569-12*.
- Dames & Moore, 1997. *Woodsreef Mine, Hazard and Risk Assessment, Barraba, NSW. Ref 29139-005-070*.
- Department of Industry and Resources & Department of Local Government and Regional Development, 2006. *Management of Asbestos Contamination in Wittenoom, Non Technical Summary November 2006*. Western Australia Government.
- enHealth, 2001. *Health Impact Assessment Guidelines. September, 2001*.
- enHealth, 2012. *Environmental Health Risk Assessment. Guidelines for assessing human health risks from environmental hazards. June, 2012*.
- enHealth, 2005. *Management of Asbestos in the Non-Occupational Environment. Commonwealth of Australia, Canberra*.
- Environment Australia, 1999. *Proposed replacement nuclear research reactor at Lucas Heights: environment assessment report*. Department of the Environment and Heritage, Feb 1999.
- Gibbons, W. 2000. *Amphibole asbestos in Africa and Australia: geology, health hazard and mining legacy*. J Geol Soc 157:851-858
- HAZMAT Services 2011. *Air Monitoring Reports HAZS53302/1-5 (dated 15/09/2011) & HAZS53302/6-9 (dated 25/11/2011)*
- HAZMAT Services 2012a. *Air Monitoring Report HAZS674/1-5 (dated 22/06/2012)*
- HAZMAT Services 2012b. *Air Monitoring Reports HAZS674/6-7 (22/06/2012), HAZS674/10-11 (22/06/2012), HAZS674/14-15 (22/06/2012)*.
- HAZMAT Services 2012c. *Air Monitoring Report HAZS674/8-9 (22/06/2012), HAZS674/12-13 (22/06/2012), HAZS674/16-18 (22/06/2014), HAZS674/19-20 (22/06/2014)*.
- HAZMAT Services 2012d. *Air Monitoring Report HAZS67402/1-1 (11/09/2012), HAZS67402/2-5 (11/09/2012), HAZS67402/6-11 (12/09/2012), HAZS67402/12-13 (12/09/2012), HAZS67402/14-15 (13/09/2012), HAZS67402/16-17 (13/09/2012)*.
- Hendrickx M., 2009. *Naturally occurring asbestos in eastern Australia: a review of geological occurrence, disturbance and mesothelioma risk*. Environ Geol, 57:909-926.
- Hillerdal G, 1999. *Mesothelioma: case associated with non-occupational and low dose exposure*. Occupational and Environmental Medicine, 56:505-513.

HLA, 2000 *Air Monitoring Reports N2075501: 1-5 (20 October); 6-14, 15-21 (21 October); 22-28, 29-35 (22 October); 36-41, 42-49, 50-56 (23 October); 57-63 (25 October); 64-68, 69-75 (26 October); 76-82, 83-87 (27 October); 88-97 (28 October); 98-103, 104-109 (29 October); 110-114, 115-119 (1 November); 120-123, 124, 125 (2 November); 126-127 (3 November); 128-130 (4 November).*

International Agency for Research on Cancer (IARC) (1987). *Overall evaluations of carcinogenicity. An updating of IARC monographs 1 to 42. Supplement 7. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans.* IARC, Lyon.

Leigh J, Driscoll T, 2003. *Malignant Mesothelioma in Australia, 1945-2002.* Int J Occup Environ Health; 9:206-217

National Occupational Health and Safety Commission (NOHSC), 2002. *The incidence of mesothelioma in Australia 1997 to 1999. Australian Mesothelioma Register Report 2002.* Commonwealth of Australia, Canberra.

National Occupational Health and Safety Commission (NOHSC), 2005. *Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres [NOHSC:3003].* 2nd Edition. April 2005.

National Research Council, 1983. *Committee on the Institutional Means for Assessment of Risks to Public Health,* Division on Earth and Life Studies.

NHPA, 2014, National Health Performance Authority, My Hospitals website, <http://www.myhospitals.gov.au/hospital/barraba-multi-purpose-service>, accessed 19/3/2014.

Niklinski J et al, 2004. *The epidemiology of asbestos-related disease.* Lung Cancer, 455, 57–S15.

NSW Department of Primary Industries Soil Conservation Service, 2013 (NSW SCS) *Woodsreef Derelict Asbestos Mine - Sediment Movement Assessment* April 2013.

Parsons Brinckerhoff, 2012 *Geotechnical Assessment for a Capping Layer - Woodsreef Mine Remediation Project*, for NSW Department of Public Works April 2012.

Safe Work Australia, 2010, *Asbestos-Related Disease Indicators*, Commonwealth of Australia, Canberra.

SLR, 2013a. *Hazard Assessment Report Woodsreef Mine Major Rehabilitation Project NSW Trade and Investment Division of Resources & Energy Report Number 610.10893.0030.* SLR Consulting Australia Pty Ltd 6/5/ 2014.

SLR, 2013b. *Woodsreef Mine Major Rehabilitation Project - Air Monitoring Health Risk Assessment, Summary of Monitoring Location Sensitivity Modelling.* SLR Consulting Australia Pty Ltd, 22/8/2013.

SLR, 2015. *Woodsreef Mine Major Rehabilitation Project - Health Impact Assessment 1 Pre-Remediation.* SLR Consulting Australia Pty Ltd, (report not released at time of writing).

SLR, 2016. *Woodsreef Mine Major Rehabilitation Project - Health Impact Assessment 2 During-Remediation.* SLR Consulting Australia Pty Ltd, (report not released at time of writing).

Stewart, P.S.B., 1985. *Woodsreef Mined Ltd - Woodsreef Asbestos Tailings Retreatment by Wet processing, IES.*

Tossavainen A, 2004. *Global use of asbestos and the incidence of mesothelioma.* Int J Occup Environ Health; 10:22-25.

Toyer G.S. and Main, S., 1978, Some Environmental Investigations at the Woodsreef Asbestos Mine. *Geological Survey of New South Wales.* Department of Mineral Resources and Development. Survey Report 1978/382.

United States Environmental Protection Agency (US EPA), 2005. *Asbestos (CASRN 1332-21-4). Toxicological Review Integrated Risk Information System (IRIS).* Online <http://www.epa.gov/iris>.

US EPA, 2001. *Libby Asbestos Site Phase 2 Study* as cited by US EPA 2001 Weis memo. Online <http://www.epa.gov>.

US EPA, 2005 (Risk Estimates) EPA/630/P-03/001F 2005 *Guidelines for Carcinogen Risk Assessment*, Washington, DC.

US EPA, 2008 *Clear Creek Management Area, Asbestos Exposure And Human Health Risk Assessment* U.S. Environmental Protection Agency, Region 9, , San Francisco, California 94105.

Virta, R.,L. 2006 *Worldwide asbestos supply and consumption trends from 1900 through 2003.* US Geological Survey Circular 1298, p34.

World Health Authority (WHO), 1998. *Chrysotile asbestos: Environmental health criteria.* Geneva: Switzerland: World Health Organization.

ACTIVITY BASED MONITORING METHODOLOGY**Summary of Methodology for Activity Based Monitoring****Walking Activities Details**

Three walking based activities were undertaken:

- Walking along Bundarra – Barraba Road adjacent to the northern boundary of the site,
- Walking along and stopping on the Flora and Fauna Track,
- Spending time in 3 locations close to the mine boundary where views of the mine are best and may be used to view the extent of the mine by tourists.

The walking pace and distance walked was dependent on weather conditions on the day of monitoring. Furthermore some activities required stopping for periods of time, for example to make note of birds and flora or view the mine.

Each walking activity was undertaken twice, giving six rounds of monitoring. The duration of each walking activity ranged from two to three hours.

Localised dust generation during the walking would have occurred mainly though the act of walking.

Specific information on PPE was provided in the JSAs. In Round 1 (December 2013) PPE for walking activities will included full Tyvex coveralls and P2 respirators. In Round 2 (May 2016) PPE for walking activities was P2 respirators only, based on the onsite assessment of the risks and review of air monitoring data from 1992 to 2016 including Round 1 activity based monitoring. .

An example of walking activity can be seen in **Photograph 2** below.

ACTIVITY BASED MONITORING METHODOLOGY**Photo 2 Walking along Trail****Camping and Picnicking Activity Details**

Camping and picnicking were undertaken at two locations, each on a different day. The locations were Iron Bark Camping Area, near Pumping Station and Iron Bark Camping Area, north of Bundarra - Barrabra Rd, 1km north of mine.

The aim of the camping and picnicking activity was to capture representative activities conducted during camping and picnicking. It was not to camp out overnight or over a number of days.

To recreate camping activities, SLR purchased tents, picnic table and chairs, and fishing gear. The activity included driving to a suitable site, leaving the car to choose a suitable tent site, general tidying up of the area to prepare a camp site, setting up a campsite including pitching the tent, setting up picnic table and chairs, building a fire place, collecting wood, breaking wood up to pieces suitable for a fire (please note a fire was not be started due to safety concerns) and general campsite activities such as relaxing in the camp site, going for short walks near the camp site and fishing. During Round 1 monitoring time will be spent inside the tent as well as entering and exiting the tent multiple times during the activity. During Round 2 monitoring a monitor was left running inside the tent to simulate a person sleeping inside the test.

Each camping activity was undertaken twice, giving four rounds of monitoring. The duration of each camping activity ranged from approximately two and a half hours to seven and quarter hours.

Localised dust generation during the camping would have occurred mainly through various activities conducted around the camp as set out above. .

ACTIVITY BASED MONITORING METHODOLOGY

Specific information on PPE is provided in the JSAs. In Round 1 monitoring, PPE for camping and picnicking activities included full tyvex coveralls, P2 respirators for any observers and for those conducting the activity a PAPR with P3 filters. In Round 2 monitoring, PPE for camping and picnicking activities include full tyvex coveralls, half face respirators with P3 filters .The final decisions on PPE to be used was based on the onsite assessment of the risks and review of the JSA on the day of monitoring.

Example of camping activity can be seen in **Photographs 3 and 4** below.

ACTIVITY BASED MONITORING METHODOLOGY

Photo 3 Relaxing around the camp site



Photo 4 Fishing in Iron Bark Creek



ACTIVITY BASED MONITORING METHODOLOGY**Fossicking Activity Details**

SLR was advised and had observed fossickers working two type or areas near the mine. Fossickers either fossick along the creek or away from the creek in areas considered by fossickers to be ancient river beds. In both cases fossickers walk along scanning the ground using a metal detector. When the detector alarm is triggered the fossicker digs down using a trowel and sieved the collected soil through a sieve (mesh size = 1/8" or 1/4" inch) into a bucket. Once a significant quantity of sieved soil has been collected, the fossicker goes to the creek and uses a pan to wash out the sieved soil and hopefully collect metals such as gold.

Accordingly SLR fossicked in both areas, including in a creek (off site) that is affected by runoff derived from the mine site, using a metal detector, sieve (mesh size = 1/8 or 1/4 inch), hand trowels, bucket and pan.

Fossicking was undertaken twice, giving two rounds of monitoring. The duration of each fossicking activity was approximately three hours.

Localised dust generation during the fossicking occurred through various activities. Walking around during fossicking generated some dust. However the activity that generated the largest amount of airborne dust occurred during the digging and dry sieving of soils.

Dry sieving occurred frequently during the fossicking, at times only minutes apart. Moreover the dry sieving was conducted within an arms length of the fossickers breathing zone. Therefore fossicking generated significant amounts of airborne dust in the breathing zone of the fossicker and their assistant. .

Specific information on PPE is provided in the JSAs. In Round 1 monitoring, PPE for fossicking activities included full tyvex coveralls, P2 respirators for any observers and for those conducting the activity a PAPR with P3 filters. In Round 2 monitoring, PPE for camping and picnicking activities include full tyvex coveralls, half face respirators with P3 filters.

Examples of fossicking activity can be seen in **Photographs 5 and 6** below.

ACTIVITY BASED MONITORING METHODOLOGY

Photo 5 Fossicking along a dry creekbed



Photo 6 Fossicking – washing of sieved soil to reveal gold



ACTIVITY BASED MONITORING METHODOLOGY**Recreational Activities Not Monitored**

Trail bike riding is an occasional recreational activity conducted in the vicinity of the mine. This activity will disturb soil and thus has the potential to create airborne asbestos fibres. This has been clearly demonstrated in studies of other locations with naturally occurring asbestos, for example Clear Creek Management Area (*US EPA, 2008*).

Trail bike riding was not able to be re-enacted in the current study due to health, safety, emergency and regulatory limitations.

SLR ACTIVITY BASED AIR MONITORING REPORTS

SLR airborne asbestos fibre monitoring reports for activity based monitoring conducted between December 2013 and May 2016 as listed below.

Airborne Asbestos Fibre Monitoring

Table 8 List of SLR Activity Based Airborne Asbestos Fibre Monitoring Reports

Report Reference	Monitoring Date	Recreational Activity
610.10893.00210-FTW-1	9/12/2013	Bird Watching
610.10893.00210-FTW-2	9/12/2013	Fossicking
610.10893.00210-FTW-3	10/12/2013	Walking Bundarra - Barraba Rd
610.10893.00210-FTW-4	10/12/2013	Camping Site 1 – Iron Bark Creek Camping Area, near Pumping Station
610.10893.00210-FTW-5	11/12/2013	Camping Site 2 – Iron Bark Creek Camping Area, North of Bundarra - Barraba Rd, approximately 1 km from mine
610.10893.00210-FTW-6	11/12/2013	Walking on Flora and Fauna Track
610.10893.00210-FTW-7	12/12/2013	Tourist views, three locations on mine boundary with views of the mine
610.10893.00210-FTW-8	30/5/2016	Walking on Flora and Fauna Track
610.10893.00210-FTW-10	30/5/2016	Fossicking
610.10893.00210-FTW-11	31/5/2016	Camping Site 2 – Iron Bark Creek Camping Area, North of Bundarra - Barraba Rd, approximately 1 km from mine
610.10893.00210-FTW-12	1/6/2016	Camping Site 1 – Iron Bark Creek Camping Area, near Pumping Station
610.10893.00210-FTW-13	2/6/2016	Walking Bundarra - Barraba Rd

Airborne Asbestos Monitoring Report

PRIVILEGED AND CONFIDENTIAL

Test method in accordance with NOHSC:3003(2005) & AP-01

Reference: 610.10893.00210-FTW-1

Date: Friday, 10 January 2014

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon	Loc'n	Airflow (L/min)			TIME			Factor	Count		CONC'N (fibres/mL)	REM
					ON	OFF	AVGE	ON	OFF	TOTAL(min)		Fields	Fibres		
9/12/2013	Blank			0				N/A	N/A		100	0	N/A		
9/12/2013	FTW-1	8		1	2.08	2.08	2.08	08:57	12:15	198	481	100	0	<0.01	
9/12/2013	FTW-2	8		2	2.08	2.08	2.08	08:59	12:17	198	481	100	0	<0.01	
9/12/2013	FTW-3	8		3	2.08	2.08	2.08	09:04	12:20	196	481	100	0	<0.01	

Monitoring Locations :

- 0 Blank
- 1 Bird Watching Trail - Kate (Observer)
- 2 Bird Watching Trail - Nathan
- 3 Bird Watching Trail - Craig

Sample Types:

8 Personal

Remarks:

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.

Approved Counter:

Approved Fibre Counter: Dr Craig Simpson

Approved Signatory:

Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

PRIVILEGED AND CONFIDENTIAL

Test method in accordance with NOHSC:3003(2005) & AP-01

Reference: 610.10893.00210-FTW-2

Date: Friday, 10 January 2014

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon	Loc'n	Airflow (L/min)			TIME			Factor	Count		CONC'N (fibres/mL)	REM
					ON	OFF	AVGE	ON	OFF	TOTAL(min)		Fields	Fibres		
9/12/2013	Blank			0				N/A	N/A			100	0	N/A	
9/12/2013	FTW-4	8		4	2.08	2.08	2.08	15:13	18:17	184	481	100	0.5	<0.01	
9/12/2013	FTW-5	8		5	2.08	2.08	2.08	15:16	18:18	182	481	100	0	<0.01	
9/12/2013	FTW-6	8		6	3.03	3.03	3.03	15:19	18:20	181	481	100	1	<0.01	

Monitoring Locations :

- 0 Blank
- 4 Fossicking - Kate (Observer)
- 5 Fossicking - Nathan
- 6 Fossicking - Craig

Sample Types: Remarks:

8 Personal

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

PRIVILEGED AND CONFIDENTIAL

Test method in accordance with NOHSC:3003(2005) & AP-01

Reference: 610.10893.00210-FTW-3

Date: Friday, 10 January 2014

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon	Loc'n	Airflow (L/min)			TIME			Factor	Count		CONC'N	REM
					ON	OFF	AVGE	ON	OFF	TOTAL(min)		Fields	Fibres		
10/12/2013	Blank		0					N/A	N/A		100	0	N/A		
10/12/2013	FTW-7	8	7		3.03	3.03	3.03	09:17	11:30	133	481	100	0	<0.01	
10/12/2013	FTW-8	8	8		3.03	3.03	3.03	09:20	11:32	132	481	100	0	<0.01	
10/12/2013	FTW-9	8	9		3.03	3.03	3.03	09:23	11:34	131	481	100	1	<0.01	

Monitoring Locations :

- 0 Blank
- 7 Walking Bundarra - Barraba Rd - Kate
- 8 Walking Bundarra - Barraba Rd - Nathan
- 9 Walking Bundarra - Barraba Rd - Craig

Sample Types:

8 Personal

Remarks:

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



NATA ACCREDITED LABORATORY NUMBER:3130

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

PRIVILEGED AND CONFIDENTIAL

Test method in accordance with NOHSC:3003(2005) & AP-01

Reference: 610.10893.00210-FTW-4

Date: Friday, 10 January 2014

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon	Loc'n	Airflow (L/min)			TIME			Factor	Count	CONC'N	REM	
					ON	OFF	AVGE	ON	OFF	TOTAL(min)					Fields
10/12/2013	Blank			0				N/A	N/A		100	0	N/A		
10/12/2013	FTW-10	8		10	2.00	2.00	2.00	14:05	17:09	184	481	100	0	<0.01	
10/12/2013	FTW-11	8		11	2.00	2.00	2.00	14:07	17:11	184	481	100	0.5	<0.01	
10/12/2013	FTW-12	8		12	2.00	2.00	2.00	14:09	17:12	183	481	100	0	<0.01	

Monitoring Locations :

- 0 Blank
- 10 Camping Site 1- Iron Bark Creek Camping Area, Near Pumping Station - Kate (Observer)
- 11 Camping Site 1- Iron Bark Creek Camping Area, Near Pumping Station - Nathan
- 12 Camping Site 1- Iron Bark Creek Camping Area, Near Pumping Station - Craig

Sample Types:

8 Personal

Remarks:

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

PRIVILEGED AND CONFIDENTIAL

Test method in accordance with NOHSC:3003(2005) & AP-01

Reference: 610.10893.00210-FTW-5

Date: Friday, 10 January 2014

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon	Loc'n	Airflow (L/min)			TIME			Factor	Count		CONC'N (fibres/mL)	REM
					ON	OFF	AVGE	ON	OFF	TOTAL(min)		Fields	Fibres		
11/12/2013	Blank			0				N/A	N/A			100	0	N/A	
11/12/2013	FTW-13	8		13	2.00	2.00	2.00	07:55	12:15	260	481	100	0	<0.01	
11/12/2013	FTW-14	8		14	2.00	2.00	2.00	07:57	12:20	263	481	100	0	<0.01	
11/12/2013	FTW-15	8		15	2.00	2.00	2.00	07:58	12:25	267	481	100	1	<0.01	

Monitoring Locations :

- 0 Blank
- 13 Camping Site 2 - Iron Bark Creek Camping Area, North of Bundarra ? Barrabra Rd, approx. 1km north of Woodsreef Mine - Kate (Observer)
- 14 Camping Site 2 - Iron Bark Creek Camping Area, North of Bundarra ? Barrabra Rd, approx. 1km north of Woodsreef Mine - Nathan
- 15 Camping Site 2 - Iron Bark Creek Camping Area, North of Bundarra ? Barrabra Rd, approx. 1km north of Woodsreef Mine - Craig

Sample Types:

8 Personal

Remarks:

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

PRIVILEGED AND CONFIDENTIAL

Test method in accordance with NOHSC:3003(2005) & AP-01

Reference: 610.10893.00210-FTW-6

Date: Friday, 10 January 2014

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon	Loc'n	Airflow (L/min)			TIME			Factor	Count		CONC'N (fibres/mL)	REM
					ON	OFF	AVGE	ON	OFF	TOTAL(min)		Fields	Fibres		
11/12/2013	Blank			0				N/A	N/A		100	0	N/A		
11/12/2013	FTW-16	8		16	3.00	3.00	3.00	14:20	16:20	120	481	100	0	<0.01	
11/12/2013	FTW-17	8		17	3.00	3.00	3.00	14:21	16:21	120	481	100	0	<0.01	

Monitoring Locations :

- 0 Blank
- 16 Walking on Flora and Fauna Track - Nathan
- 17 Walking on Flora and Fauna Track - Craig

Sample Types: Remarks:

8 Personal

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

PRIVILEGED AND CONFIDENTIAL

Test method in accordance with NOHSC:3003(2005) & AP-01

Reference: 610.10893.00210-FTW-7

Date: Friday, 10 January 2014

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon	Loc'n	Airflow (L/min)			TIME			Factor	Count	CONC'N	REM	
					ON	OFF	AVGE	ON	OFF	TOTAL(min)					Fields
12/12/2013	Blank			0				N/A	N/A		100	0	N/A		
12/12/2013	FTW-18	8		18	3.00	3.00	3.00	09:08	11:18	130	481	100	0	<0.01	
12/12/2013	FTW-19	8		19	3.00	3.00	3.00	09:10	11:20	130	481	100	0	<0.01	
12/12/2013	FTW-20	8		20	3.00	3.00	3.00	09:12	11:22	130	481	100	0.5	<0.01	

Monitoring Locations :

- 0 Blank
- 18 Tourist Views ? Three Locations on Mine Boundary with Views of Mine - Kate
- 19 Tourist Views ? Three Locations on Mine Boundary with Views of Mine - Nathan
- 20 Tourist Views ? Three Locations on Mine Boundary with Views of Mine - Craig

Sample Types:

8 Personal

Remarks:

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

Test method in accordance with NOHSC:3003(2005) AP-01.03, AP-02.01, 02.03, 02.04 & AP-03

Reference: 610.10893.00210-FTW-8

Date: Friday, 28 April 2017

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon Loc'n	Airflow (L/min)			TIME			Count		CONC'N (fibres/mL)	REM
				ON	OFF	AVGE	ON	OFF	TOTAL(min)	Fields	Fibres		
30/05/2016	Blank		0				N/A	N/A		100	0	N/A	
30/05/2016	FTW-21	11	16	3.00	3.00	3.00	08:45	11:47	182	100	0	<0.01	
30/05/2016	FTW-22	11	17	3.00	3.00	3.00	08:46	11:47	181	100	0	<0.01	

Monitoring Locations :

- 0 Blank
- 16 Walking on Flora and Fauna Track - Nathan
- 17 Walking on Flora and Fauna Track - Craig

Sample Types: Remarks:

11 Exposure

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

Test method in accordance with NOHSC:3003(2005) AP-01.03, AP-02.01, 02.03, 02.04 & AP-03

Reference: 610.10893.00210-FTW-10

Date: Friday, 28 April 2017

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon Loc'n	Airflow (L/min)			TIME			Count		CONC'N (fibres/mL)	REM
				ON	OFF	AVGE	ON	OFF	TOTAL(min)	Fields	Fibres		
30/05/2016	Blank		0				N/A	N/A		100	0	N/A	
30/05/2016	FTW-23	11	4	3.00	3.00	3.00	13:50	16:45	175	100	0	<0.01	
30/05/2016	FTW-24	11	5	3.00	3.00	3.00	14:00	16:40	160	100	0	<0.01	
30/05/2016	FTW-25	11	6	3.00	3.00	3.00	14:05	16:42	157	100	0.5	<0.01	

Monitoring Locations :

- 0 Blank
- 4 Fossicking - Kate (Observer)
- 5 Fossicking - Nathan
- 6 Fossicking - Craig

Sample Types: Remarks:

11 Exposure

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or
measurements included in this document are traceable
to Australian/national standards.

Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

Test method in accordance with NOHSC:3003(2005) AP-01.03, AP-02.01, 02.03, 02.04 & AP-03

Reference: 610.10893.00210-FTW-11

Date: Friday, 28 April 2017

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon Loc'n	Airflow (L/min)			TIME			Count		CONC'N (fibres/mL)	REM
				ON	OFF	AVGE	ON	OFF	TOTAL(min)	Fields	Fibres		
31/05/2016	Blank		0				N/A	N/A		100	0	N/A	
31/05/2016	FTW-26	11	13	2.00	2.00	2.00	08:55	15:10	375	100	1	<0.01	
31/05/2016	FTW-27	11	15	2.00	2.00	2.00	08:56	15:10	374	100	1.5	<0.01	
31/05/2016	FTW-28	11	14	2.00	2.00	2.00	08:57	15:12	375	100	0	<0.01	
31/05/2016	FTW-29	11	21	1.50	1.50	1.50	09:10	16:10	420	100	1	<0.01	

Monitoring Locations :

- 0 Blank
- 13 Camping Site 2 - Iron Bark Creek Camping Area, North of Bundarra - Barrabra Rd, approx. 1km north of Woodsreef Mine - Kate (Observer)
- 14 Camping Site 2 - Iron Bark Creek Camping Area, North of Bundarra - Barrabra Rd, approx. 1km north of Woodsreef Mine - Nathan
- 15 Camping Site 2 - Iron Bark Creek Camping Area, North of Bundarra - Barrabra Rd, approx. 1km north of Woodsreef Mine - Craig
- 21 Camping Site 2 - Iron Bark Creek Camping Area, North of Bundarra - Barrabra Rd, approx. 1km north of Woodsreef Mine - Inside Tent

Sample Types: Remarks:

11 Exposure

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

Test method in accordance with NOHSC:3003(2005) AP-01.03, AP-02.01, 02.03, 02.04 & AP-03

Reference: 610.10893.00210-FTW-12

Date: Friday, 28 April 2017

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon Loc'n	Airflow (L/min)			TIME			Count		CONC'N (fibres/mL)	REM
				ON	OFF	AVGE	ON	OFF	TOTAL(min)	Fields	Fibres		
1/06/2016	Blank		0				N/A	N/A		100	0	N/A	
1/06/2016	FTW-30	11	10	2.00	2.00	2.00	08:40	14:41	361	100	0	<0.01	
1/06/2016	FTW-31	11	11	2.00	2.00	2.00	08:45	14:42	357	100	0	<0.01	
1/06/2016	FTW-32	11	12	2.00	2.00	2.00	08:47	14:45	358	100	0	<0.01	
1/06/2016	FTW-33	11	22	1.50	1.50	1.50	11:34	15:35	241	100	0	<0.01	

Monitoring Locations :

- 0 Blank
- 10 Camping Site 1- Iron Bark Creek Camping Area, Near Pumping Station - Kate (Observer)
- 11 Camping Site 1- Iron Bark Creek Camping Area, Near Pumping Station - Nathan
- 12 Camping Site 1- Iron Bark Creek Camping Area, Near Pumping Station - Craig
- 22 Camping Site 1- Iron Bark Creek Camping Area, Near Pumping Station - Inside Tent

Sample Types: Remarks:

11 Exposure

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

Airborne Asbestos Monitoring Report

Test method in accordance with NOHSC:3003(2005) AP-01.03, AP-02.01, 02.03, 02.04 & AP-03

Reference: 610.10893.00210-FTW-13

Date: Friday, 28 April 2017

Removal Contractor: Not Applicable

Job Location: Woodsreef, Barraba, Tamworth, See Monitoring Locations Below, NSW

Client: NSW Trade and Investment

516 High Street

Maitland

NSW 2320

Date of Test	Sample Code	Type	Mon Loc'n	Airflow (L/min)			TIME			Count		CONC'N (fibres/mL)	REM
				ON	OFF	AVGE	ON	OFF	TOTAL(min)	Fields	Fibres		
2/06/2016	Blank		0				N/A	N/A		100	0	N/A	
2/06/2016	FTW-34	11	7	2.90	2.90	2.90	13:05	15:05	120	100	0	<0.01	
2/06/2016	FTW-35	11	8	2.90	2.90	2.90	13:10	15:05	115	100	1	<0.01	
2/06/2016	FTW-36	11	9	2.90	2.90	2.90	13:05	15:12	127	100	1.5	<0.01	

Monitoring Locations :

- 0 Blank
- 7 Walking Bundarra - Barraba Rd - Kate
- 8 Walking Bundarra - Barraba Rd - Nathan
- 9 Walking Bundarra - Barraba Rd - Craig

Sample Types: Remarks:

11 Exposure

Notes On Sampling:

The above results only relate to the samples tested. This report confirms preliminary report _N/A



**NATA ACCREDITED LABORATORY
NUMBER:3130**

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or
measurements included in this document are traceable
to Australian/national standards.

Approved Fibre Counter: Dr Craig Simpson



Approved Fibre Signatory: Dr Craig Simpson

EXPLANATION OF REPORT

Date:	Date monitoring carried out.
Sample Code:	Internal SLR Consulting Australia Pty Ltd code number to identify each test.
Type:	Indicates type or reason for monitoring, eg. background air monitoring before removal starts.
Personal:	Air monitor worn by person.
Static:	Air monitor placed in a stationary location.
Monitor Location:	Where each monitor is positioned.
Air Flow:	The air flow through the pump is recorded at the start and at the finish of each run, and the average flow calculated.
Time:	The time (24 hour clock) when monitor is started, when finished, and the total time in minutes.
Factor:	A factor related to the particular microscope and filters employed, the factor forms part of the calculation.
Fields:	The total number of standard unit areas examined across the filter sample.
Fibres:	The total number of asbestos <i>conforming</i> fibres counted.
Concentration:	The time weighted average number of <i>conforming</i> asbestos fibres present for the millilitres of air sampled. If the number is less than 0.01 fibres/mL it is recorded as <0.01 as this is the level of sensitivity of the method.

The current exposure standard for any mixture of asbestos fibres (crocidolite, amosite and chrysotile) is 0.1 fibres/mL.

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES**The Mine**

The mine site footprint is approximately 290 hectares in size and is reported to contain a 75 million tonne waste rock dump and 25 million tonne tailings dump. The site also contained two derelict buildings (prior to demolition) and four open pits (*Parsons Brinckerhoff, 2012 & NSW Department of Primary Industries Soil Conservation Service, 2013*).

The mine site can be functionally divided into the following areas: Open Pits (four on site), Mill Building Area, Waste Dump (three sites, south, west and northeast), and a Tailings Dump. The Mine Road winds along the eastern perimeter of the mine except for a section of road that runs in-between the South Waste Dump and the Tailings Dump (See **Figure 3** above).

The Mill Building was demolished during remediation works between October 2014 to June 2015. During these works a Containment Cell was dug to the west of the Mill Building. Then the building was demolished and buried in the Containment Cell.

The Waste Dumps consist of processed rocks and overburden. The Tailings have been reported as partially processed ore, understood to be predominately asbestos, stockpiled for later reprocessing that never occurred (*NSW Department of Primary Industries Soil Conservation Service, 2013*).

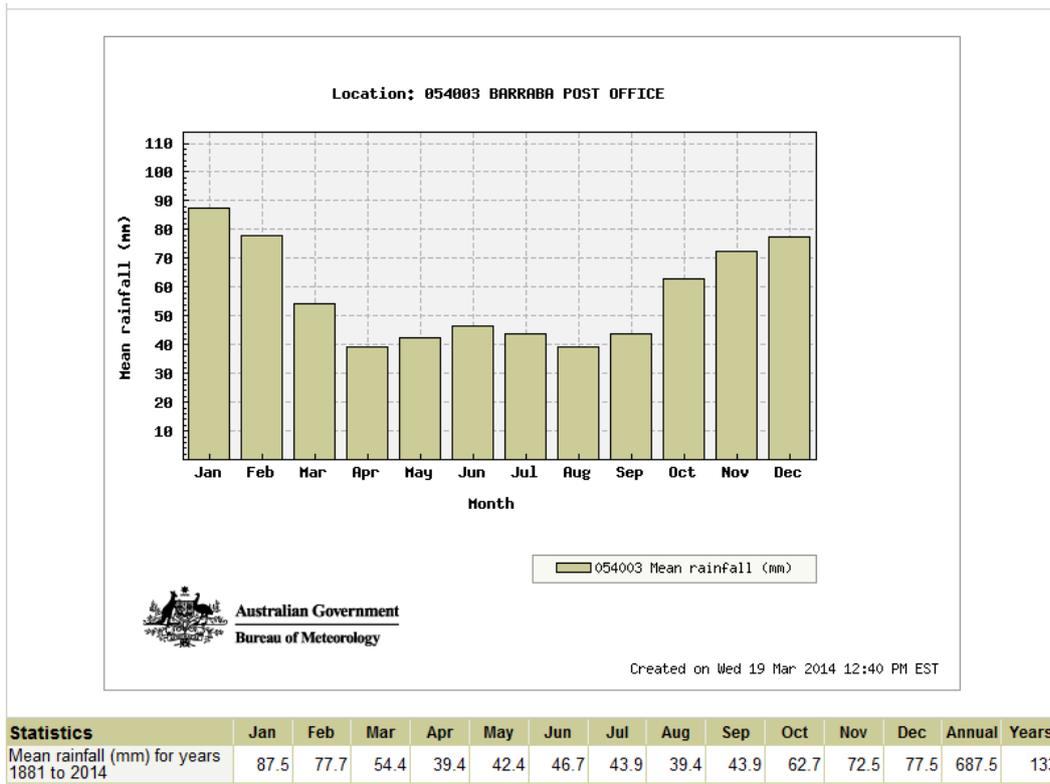
Site Climate

The climatic conditions at Barraba will be broadly similar to the climate at Woodsreef mine. Furthermore of the Bureau of Meteorology weather stations operating in the region near Woodsreef Mine, the weather station with the most extensive climate data is the Barraba Post Office (Weather Station Number: 054003 Opened: 1881 Status: Open Latitude 30.38°S, Longitude 150.61°E Elevation: 500m).

Records of rainfall at Barraba indicated the mean annual rainfall to be 687.5 mm, with the heaviest rainfall usually occurred in October to March. Monthly mean rainfall has been set out below in **Figure 6**. Monthly mean maximum and minimum temperatures have been set out below in **Figure 7** and **Figure 8**.

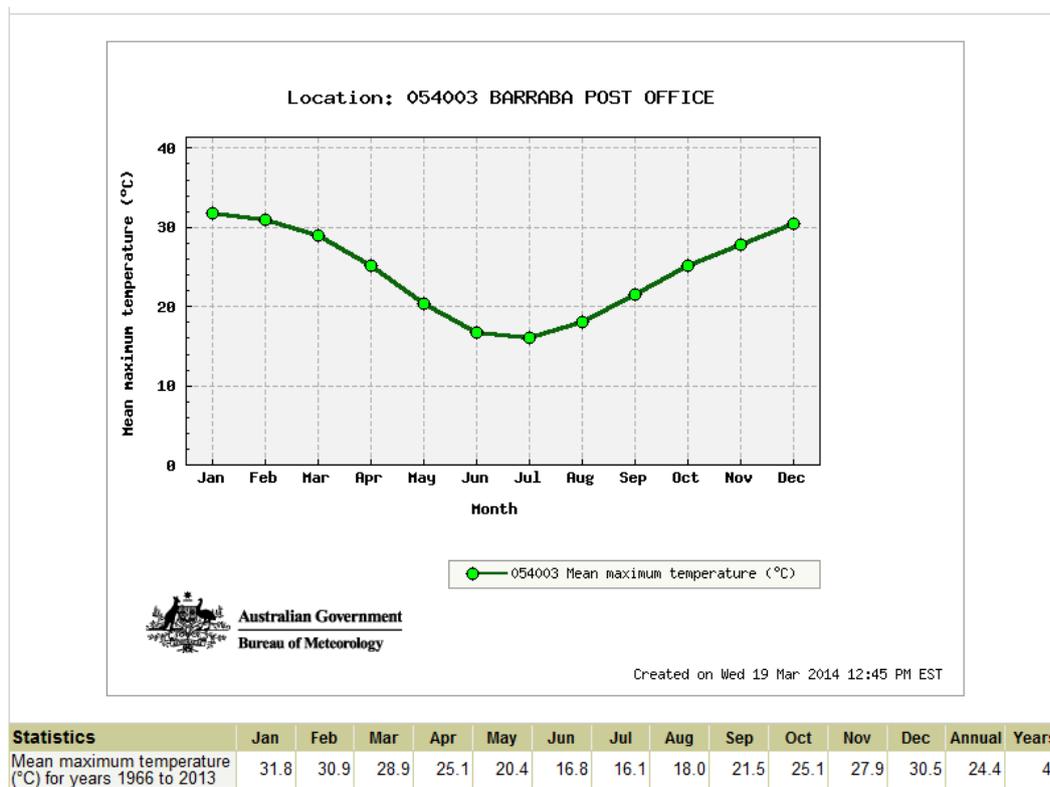
GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Figure 6 Barraba Mean Monthly Rainfall 1881-2014



(Source: Australian Government Bureau of Meteorology, www.bom.gov.au/climate/data/, accessed 19/3/2014)

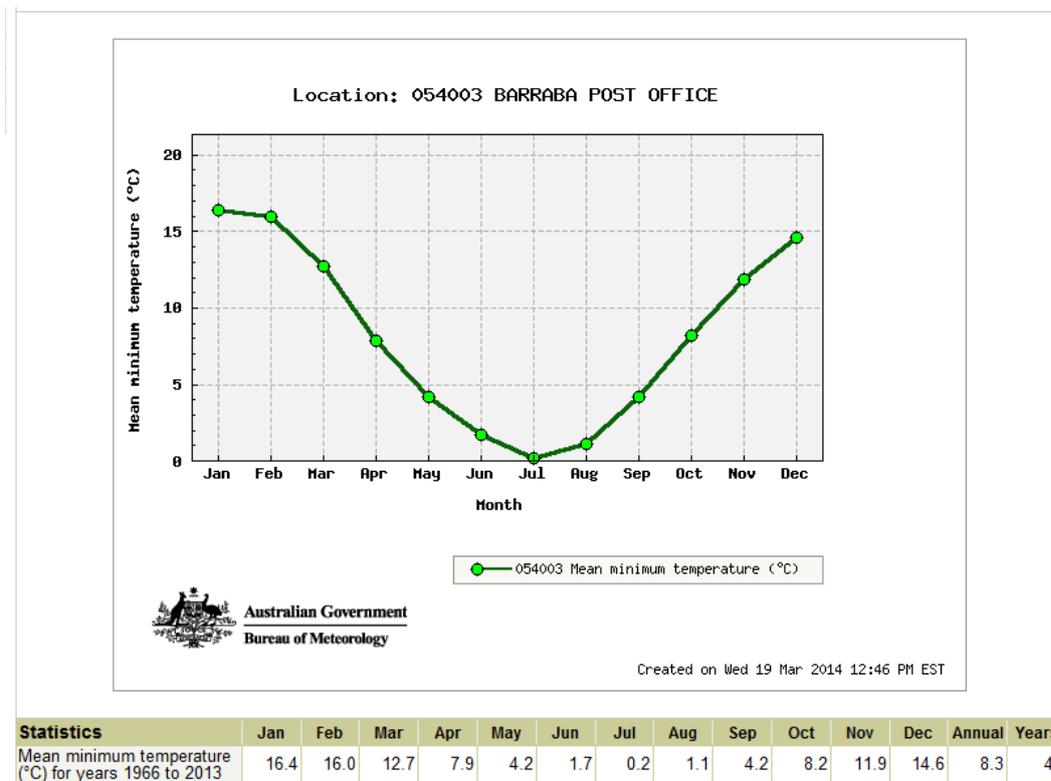
Figure 7 Barraba Monthly Mean Maximum Temperatures 1966-2013



(Source: Australian Government Bureau of Meteorology, www.bom.gov.au/climate/data/, accessed 19/3/2014)

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Figure 8 Barraba Monthly Mean Minimum Temperatures 1966-2013



(Source: Australian Government Bureau of Meteorology, www.bom.gov.au/climate/data/, accessed 19/3/2014)

Geology of the Area Surrounding Woodsreef

The Woodsreef Asbestos mine lies on the Great Serpentine Belt formed by the Peel Fault Line which borders the New England Region and extends from Warialda through Nundle and across to Taree.

The NSW Department of Primary Industries Soil Conservation Service, (2013) describes the geology of the region as the following:

"The rock is ultramafic and hence is low in silica but high in magnesium and iron minerals (mafic).

At the site, the host rock of the asbestos fibres is from the serpentinite which lies between sandstone and argillite and is often overlain by deep alluvial gravels. All the fibre at the site was chrysotile asbestos of the 'cross fibre' variety and is similar chemically to the host rock. Fibre lengths vary up to 15 mm but are mostly around 4 mm. Percentage in the rock ranges up to a maximum of 10% but averaged around 4%."

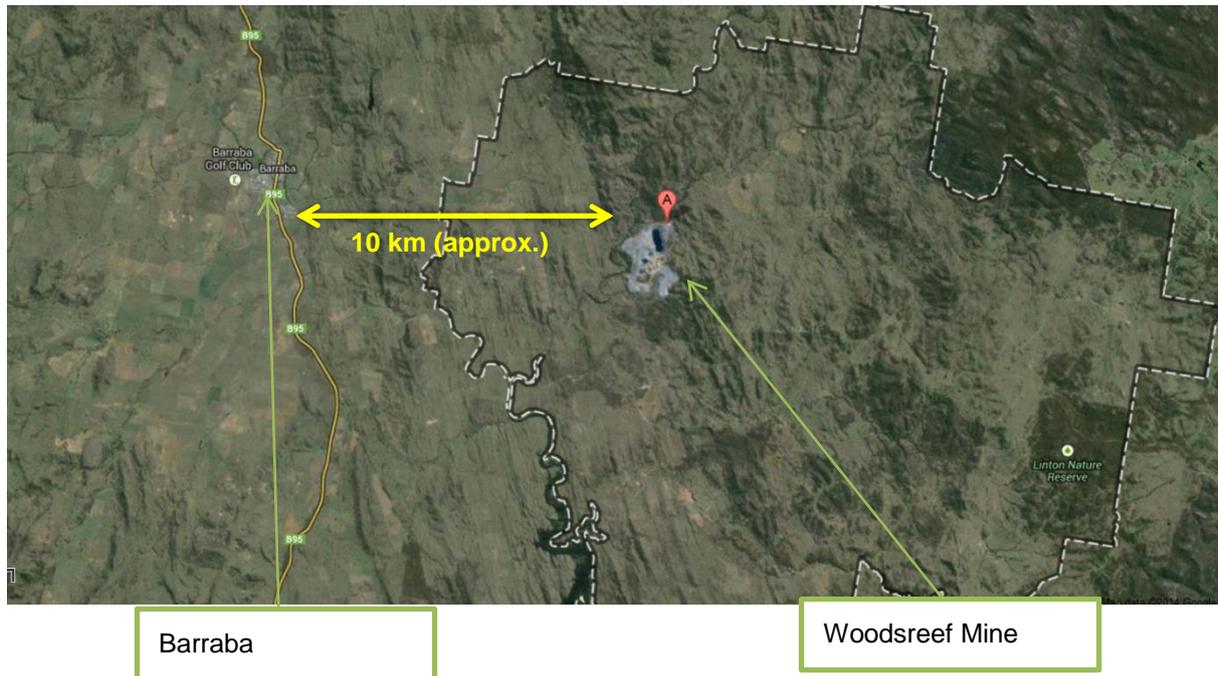
Natural Topography of the Area Surrounding Woodsreef

The Woodsreef topography reflects that formed by the Peel Fault Line. The ridges and valleys generally run in a north south direction. Terrain to the east of the Peel Fault Line is generally higher and steeper, which contrasts with terrain to the west of the Peel Fault Line which is generally lower, "gently undulating valley foothills" (NSW Department of Primary Industries Soil Conservation Service, 2013). The town of Barraba lies to the west of the Peel Fault Line.

The natural topography of the area surrounding Woodsreef can be clearly seen in the aerial view shown below in **Figure 9**.

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Figure 9 Natural Topography of Area Surrounding Woodsreef Asbestos Mine



(Source: Google Maps, accessed 18/3/2014)

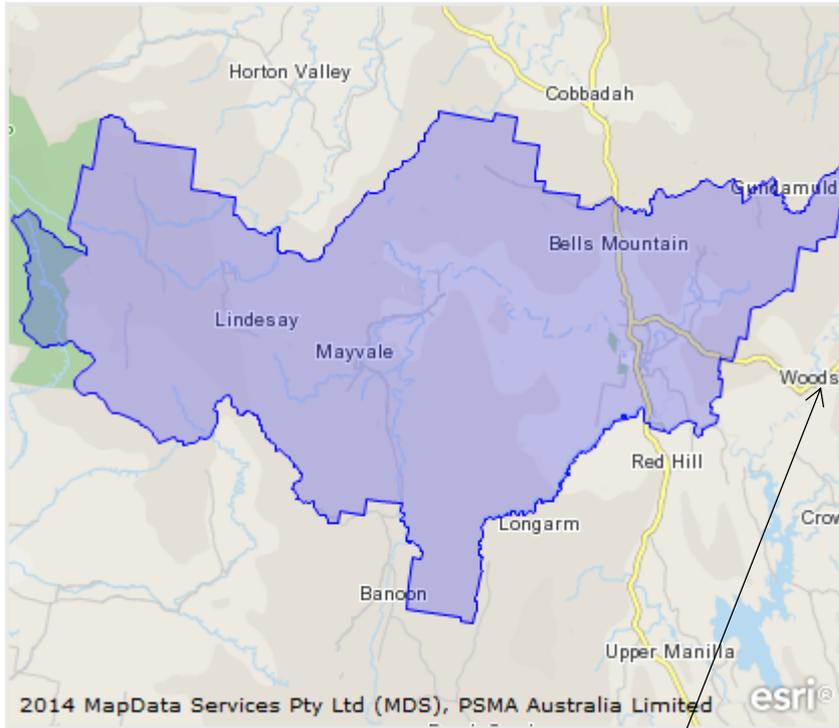
Details of Local Communities

The local communities in closest proximity to the Woodsreef mine live in the two state suburb areas of Barraba (SSC 10122) and Woodsreef (SSC 12553). From the 2011 Census, the usual population size for the Barraba state suburb area was 1,539 of which 1,150 people were listed as usually residing in the Barraba urban area. The population of state suburb area of Woodsreef during the 2011 Census was 134. The area in the immediate vicinity of the Woodsreef mine is rural in nature with scattered houses generally on farmland. From these areas, the main population centre nearest the mine is the township of Barraba.

The locations of Barraba and Woodsreef state suburb areas and their proximity to Woodsreef Mine has been set out below in **Figure 10** and **Figure 11**.

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Figure 10 Barraba Suburb Area and Location of Woodsreef Asbestos Mine

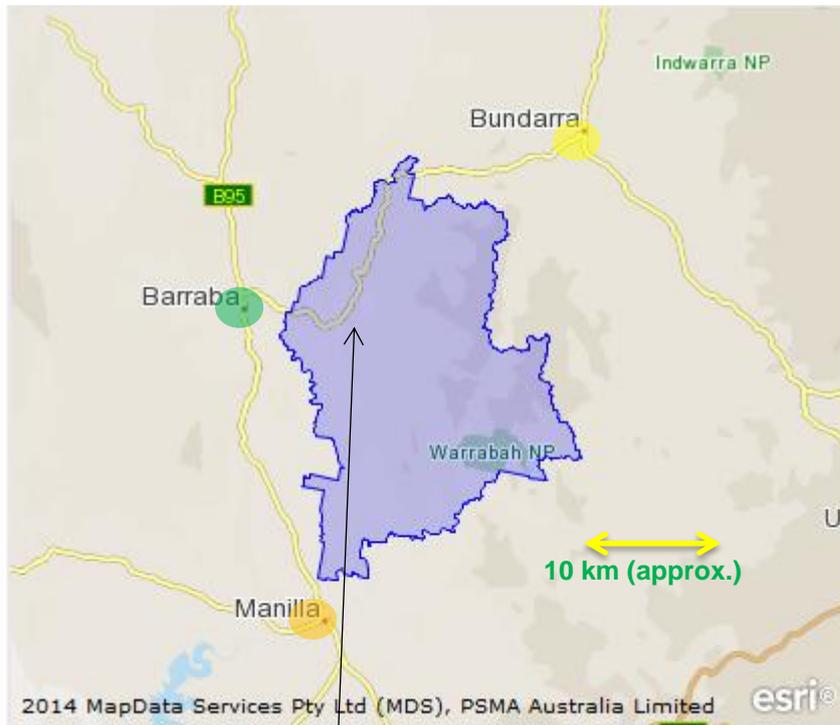


(Source Australian Bureau of Statistics, Census 2011)

Woodsreef Mine

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Figure 11 Woodsreef Suburb Area and Location of Woodsreef Asbestos Mine



Woodsreef Mine

Key	Population Centre	Urban Population
	Barraba	1,150
	Bundarra	381
	Manilla	2,046

(Source Australian Bureau of Statistics, Census 2011)

Transport Routes near Woodsreef Mine

The only transport route in current use near the Woodsreef mine is the Bundarra – Barraba Road. This road skirts the northern edge of the mine site for approximately 1.4 kilometres. There is no data available on current vehicle movements on the Bundarra – Barraba Road. However from observations by the authors when conducting field work near the mine site, the traffic on this road is infrequent and probably around 50 vehicle movements in a 24 hour period.

Historically The Mine Road ran along the eastern edge of the mine site to join up with the Bundarra – Barraba Road. However The Mine Road was closed in early 2014 and is no longer considered a transport route near the mine.

Asbestos & Land

All documents reviewed provided historic evidence of significant and ongoing erosion. Dames & Moore (1997) reported that tailings dump erosion and slumping was progressive and ongoing with visible cracking and subsidence around the top of embankments and channel erosion on steeper slopes. This description continues to be valid in 2017.

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Control of the ongoing erosion across the mine site appears unlikely in the foreseeable future. The Woodsreef Derelict Asbestos Mine - Drainage Assessment Report (NSW SCS, 2013) states that “Erosion control is the lowest priority due to the large area to be addressed and the cost to immediately provide stability.”

The hazard assessment identified that sources of asbestos were present throughout almost all sampling sites. The only exceptions were two sites, Ironbark Creek, start of walking track NE and one sample from Siltation Systems Sediments.

The approximate quantity of asbestos present in the soil particle fraction size less than 2 mm in diameter of the collected samples was estimated as part of the analysis by SLR (2013a). The results indicated estimated asbestos concentrations on a percentage volume to volume ratio ranged from less than 0.1% to 95%. These concentrations clearly indicate the potential scale of the asbestos contamination on the mine site and adjacent lands.

As would be expected in a site such as this, asbestos concentrations varied greatly across the site and also within common functional locations (e.g. Tailings, Road Cuttings, etc) on the site. The broad groupings of sample locations and the estimated asbestos content on the smallest particle size fraction measured (<2 mm) have been set out in **Table 8**.

Table 9 Estimated Ranges of Asbestos Concentrations in <2 mm Particle Size Fraction of Samples (% vol/vol)

Location	Estimated Range of Concentrations of Asbestos in <2 mm Particle Size Fraction of Samples (% vol/vol)
Waste/overburden	<0.1 to 90%
Tailings	<0.1 to 90%
Road cuttings	<0.1 to 70%
Siltation systems sediments	No asbestos detected to 40%
Mill Building vicinity	<0.1 to 95%
Proposed containment cell vicinity	25 to 70%
Ironbark Creek – land in vicinity of creek	No asbestos detected to 90%
Single Location Samples	
North of mine central waypoint, north side of Bundarra – Barraba Road	2%*
Entrance to mine, east of building	<0.1%*
South end tailings, east road culvert, adjacent to private land	5%*
Flora Trail adjacent to pit 1, west	40%*
West of waste dump near pump station	< 0.1%*
North west of overburden	< 0.1%*

Note * = Locations with one sample only

- There is significant asbestos contamination across most if not all of the mine site.
- The concentrations of asbestos in the particle size fraction less than 2 mm in diameter of material across the site varied greatly from less than 0.1% to 95% (vol/vol).

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES**Airborne Asbestos Fibre Monitoring**

A review of available data indicated that airborne asbestos fibre monitoring had been undertaken a number of times between 1992 and 2012. Monitoring occurred either off mine site as background monitoring or on the mine site as part of monitoring during site works either during remediation works.

The majority of the monitoring between 1992 to 2012 indicated that airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air. That is concentrations were below the detection limit of the methodology. As previously stated the likely concentrations of airborne asbestos during the monitoring period were at least ten times lower than the current occupational exposure limit.

The exceptions occurred during three periods, each time during remediation works on the mine site and at monitoring locations on the mine site only. In these cases the airborne asbestos fibre concentrations were in the range of 0.04 to 0.06 fibres per mL of air. The indicative approximation of samples above the detection limit was 1 sample above the detection limit per 140 samples taken on the mine site.

Dames & Moore (1997) reported that in 1992 monitoring conducted by the NSW Department of Mineral Resources for personnel conducting rehabilitation works on the Woodsreef tailings dump recorded airborne asbestos fibre concentrations in the range of 0.01 to 0.04 fibres per mL air. The second instance occurred during the 2009 remediation of the Mill Building, where monitoring on one day (12 October 2009) at one monitoring location on the mine site recorded airborne fibre concentrations of 0.06 fibres per mL of air. However this elevated reading can be explained by the monitor location and activity at the time. The monitor was located at the “clean end of decontamination unit” and the report authors commented that the elevated concentration was due to a clothes drier being operated in the vicinity of the monitor.

In the third instance during the 2012 building of the Bat Habitat, monitoring on one day (13 September 2012) at one monitoring location on the mine site recorded airborne fibre concentrations of 0.04 fibres per mL of air. This elevated reading can be explained by the monitor location and activity at the time. The monitor was located on the “Exterior of Mini Excavator” and presumably the Mini Excavator was used to dig trenches for placement of large pipes used for the Bat Habitat.

During the remediation works, from October 2014 to May 2015, SLR conducted monitoring at locations off the mine site. At the same time, the Hygienists engaged by the demolition contractor, Parsons Brinckerhoff (PB) conducted monitoring on the mine site and occasionally at off site locations.

SLR undertook monitoring of airborne asbestos fibre at seven locations previously monitored in 2013 Background Monitoring (SLR, 2016). Thirteen rounds of monitoring were conducted during the remediation works.

The demolition contractor’s Hygienist, undertook monitoring of airborne asbestos fibres at up to fifteen locations, mostly on the mine site with limited off site monitoring, over two hundred and forty eight rounds of monitoring.

During the remediation works the results of the Air Monitoring at all locations, both on site and off site, over each round of monitoring by both SLR and PB indicated that airborne asbestos fibre concentrations were at levels less than 0.01 fibres per mL of air. That is to say the airborne asbestos fibre concentrations were less than the detection limit of the approved method (NOHSC:3003(2005)).

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Table 10 Woodsreef Airborne Asbestos Fibre Monitoring 1992 to 2016

Date	Activity	Number of Samples	Concentrations	Source	
1992	Dates not provided	Monitoring of personnel during remediation works on the tailings dump using heavy machinery	Not Provided	0.01 - 0.04 fibres / ml	Dames & Moore, 1997
2000	26 May - 22 June	Monitoring a combination of properties adjacent to the mine and locations on the mine site			
		Monitoring of properties adjacent to the mine, Wynaroy, Anglesey, Connors Creek	24	All <0.01 fibres/ml	HLA, 2000
		Monitoring locations on the mine site	61	All <0.01 fibres/ml	HLA, 2000
2004	20 October - 4 November	Monitoring of remediation works on mine site	130	All <0.01 fibres/ml	HLA, 2004
2009	6 October - 15 October	Monitoring of remediation works on mine site	51	Majority samples <0.01 fibres/ml One sample 0.06 fibres/ml	AECOM, 2009
2011	14 September & 24 November	Monitoring during geotechnical survey of mine site	9	All <0.01 fibres/ml	HAZMAT Service, 2011
2012	19 June	Background monitoring of mine site, included Woodsreef Church, Wynaroy, Mine Gate, 2 km South of mine gate & Fossicking area north west of mine	5	All <0.01 fibres/ml	HAZMAT Service, 2012a
2012	20 June - 21 June	Occupational monitoring on mine site during drainage assessment works	6	All <0.01 fibres/ml	HAZMAT Service, 2012b
2012	20 June - 21 June	Monitoring of mine site, near mine boundary during drainage assessment works	9	All <0.01 fibres/ml	HAZMAT Service, 2012c
2012	20 June - 21 June	Monitoring of mine site, near mine boundary and equipment used during building of bat habitat works	17	Majority samples <0.01 fibres/ml One sample 0.04 fibres/ml	HAZMAT Service, 2012d
2013	14 November - 14 December	Background monitoring of locations off the mine site including Barraba and Tamworth control site	48	All <0.01 fibres/ml	SLR, 2013
2013	9 December - 12 December	Activity Based Personal monitoring in the vicinity of the mine including : Fossicking, Camping (two locations), Picnicking, Bird Watching, walking along the Bundarra – Barraba Road	20	All <0.01 fibres/ml	Current report

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

Date	Activity	Number of Samples	Concentrations	Source	
2014-2015	20 October 2014 to 12 May 2015	Remediation monitoring of locations off the mine site including Barraba and Tamworth control site	91	All <0.01 fibres/ml	SLR, 2016
2014-2015	10 September 2014 to 28 May 2015	Remediation monitoring of locations on the mine site and occasionally off site	1,793	All <0.01 fibres/ml	SLR, 2016, PB
2016	9 May 2016 to 11 May 2016	Activity Based Personal monitoring in the vicinity of the mine including : Fossicking, Camping (two locations), Picnicking, Bird Watching, Walking the Flora Trail, viewing the mine from various observation points off the Bundarra – Barraba Road, walking along the Bundarra – Barraba Road	14	All <0.01 fibres/ml	Current report,

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES**Key Points - Asbestos & Air Quality**

- There is historic and contemporary air monitoring data available of airborne asbestos fibre concentration in areas surrounding the mine, from 1992 to 2016.
- Settled dust sampling in 1974 found chrysotile deposited at distances up to 8.5 km from the mine. The authors considered the chrysotile was from the mill operations and not the Tailings dump.
- Air modelling was used to guide the selection of locations for airborne asbestos fibre monitoring in contemporary air monitoring.
- Historic air monitoring data is available from 1992 to 2012. The number of samples collected in 1992 is unclear. Dames & Moore (1997) stated that during the 1992 remediation works on the Tailings Dump, personal air monitors recorded concentrations in the range of less than 0.01 fibres per mL air to 0.04 fibres per mL air. Air monitoring from 2000 to 2012 included 312 samples of which the overwhelming majority of samples, that is 310 samples, recorded airborne asbestos fibre concentrations of less than 0.01 fibres per mL air. The exceptions were two samples taken on the mine site during onsite works. The first exception occurred in 2009 with one sample recording an onsite airborne asbestos fibre concentration of 0.06 fibres per mL air. The second exception occurred in 2012 with one sample recording an onsite airborne asbestos fibre concentration of 0.04 fibres per mL.
- Background airborne asbestos monitoring in 2013 recorded airborne asbestos fibre concentrations at all locations as less than 0.01 fibres per mL air. Repeat monitoring at the same locations in 2014 – 2015 when remediation works were being conducted on the mine site also recorded airborne asbestos fibre concentrations at all locations as less than 0.01 fibres per mL air (91 samples). Monitoring locations were situated within the area with the predicted highest potential for exposure at distances ranging from 100 metres to 5 km approximately from the mine, at Barraba Township and a control location at Tamworth.
- During remediation works in 2014 – 2015 monitoring conducted on the mine site also recorded airborne asbestos fibre concentrations at all locations as less than 0.01 fibres per mL air (1,548 samples).
- Airborne asbestos fibres are only occasionally becoming airborne at detectable concentrations when there is a physical disturbance on the mine site itself.
- Furthermore detectable concentrations of airborne asbestos fibres have not been recorded outside the mine site in the surrounding communities and locations.
- Airborne asbestos fibre concentrations above 0.01 fibres per mL air, that is the detection limit of the method, have only been recorded during three periods, 1992 (0.04 fibres per mL, sample numbers unknown), 2006 (1 sample, 0.06 fibres per mL) and 2012 (1 sample, 0.04 fibres per mL). These occurred when remediation activities have been occurring on the mine site and only at sampling locations on the mine site itself.

Issue Identification Summary

The main issues identified relating to asbestos and the local populations are the following:

- Water drainage on the mine site shows drainage flows both back on to the mine site and flows off the mine site.
- The potential for natural processes, such as rain and wind, to transport materials from the mine site to areas outside the mine boundary will be a major factor in determining the likelihood of the general public being exposed to asbestos from the mine.
- Potential asbestos hazards coupled with the transport of materials will be dependent on three main factors. This includes whether asbestos present in the material, how much asbestos is present in the material and in what form is the asbestos.

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

- Materials that pose the highest potential hazard to exposed humans will be materials with relatively high asbestos content and with the asbestos fibres present in the respirable size range.
- There is evidence of historic and current erosion and migration of materials within the mine site and off the mine site in many areas of the mine.
- The migration of materials is likely to be intermittent in nature and linked to significant events such as heavy rain or the localised catastrophic collapse of previously stable surface crusts or materials
- There is significant asbestos contamination across most if not all of the mine site and adjacent lands.
- The concentrations of asbestos in the particle size fraction less than 2 mm in diameter of material across the site varied greatly from less than 0.1% to 95% (vol/vol).
- Respirable asbestos fibres were present in soils across most of the mine site and adjacent lands.
- Asbestos containing material has been transported from the mine site into Ironbark Creek over the years.
- The amount of asbestos transported from the mine site into Ironbark Creek is unclear.
- Asbestos in the Ironbark Creek system would settle out in areas of low flow, becoming buried over time by incoming sediments
- Asbestos in Ironbark Creek sediment will occasionally be resuspended and transported with the general sediments during periods of sediment disturbances such as during flooding events.
- If asbestos has been transported into Split Rock Reservoir it would be expected to settle out into the reservoir sediments and be buried over time by natural sedimentation processes. Once buried the asbestos should have little or no impact on the environment or end-users of the reservoir water.
- There is data available of airborne asbestos fibre concentrations in areas surrounding the mine.
- Settled dust sampling in 1974 found chrysotile deposited at distances up to 8.5 km from the mine. The authors considered the chrysotile was from the mill operations and not the Tailings dump.
- Historic air monitoring data is available from 1992 to 2012. The number of samples collected in 1992 is unclear. Dames & Moore (1997) stated that during the 1992 remediation works on the Tailings Dump, personal air monitors recorded concentrations in the range of less than 0.01 fibres per mL air to 0.04 fibres per mL air. Air monitoring from 2000 to 2012 included 312 samples of which the overwhelming majority of samples, that is 310 samples, recorded airborne asbestos fibre concentrations of less than 0.01 fibres per mL air. The exceptions were two samples taken on the mine site during onsite works. The first exception occurred in 2009 with one sample recording an onsite airborne asbestos fibre concentration of 0.06 fibres per mL air. The second exception occurred in 2012 with one sample recording an onsite airborne asbestos fibre concentration of 0.04 fibres per mL.
- Background airborne asbestos monitoring in 2013 included 48 samples all of which recorded airborne asbestos fibre concentrations at all locations as less than 0.01 fibres per mL air. Repeat monitoring at the same locations in 2014 – 2015 when remediation works were being conducted on the mine site also recorded airborne asbestos fibre concentrations at all locations as less than 0.01 fibres per mL air (91 samples). Monitoring locations were situated within the area with the predicted highest potential for exposure at distances ranging from 100 metres to 5 km approximately from the mine, at Barraba Township and a control location at Tamworth.
- During remediation works in 2014 – 2015 monitoring conducted on the mine site also recorded airborne asbestos fibre concentrations at all locations as less than 0.01 fibres per mL air (1,548 samples).

GENERAL INFORMATION ON WOODSREEF MINE AND SURROUNDING COMMUNITIES

- Airborne asbestos fibre concentrations above 0.01 fibres per mL air, that is the detection limit of the method, have only been recorded during three periods, 1992 (0.04 fibres per mL, sample numbers unknown), 2006 (1 sample, 0.06 fibres per mL) and 2012 (1 sample, 0.04 fibres per mL). These occurred when remediation activities have been occurring on the mine site and only at sampling locations on the mine site itself.

SCOPE OF A HEALTH RISK ASSESSMENT

A Health Risk Assessment has been defined as “*the process of estimating the potential impact of a chemical, biological, physical or social agent on a specified human population system under a specific set of conditions and for a certain time frame*” (enHealth, 2001). As such a Health Risk Assessment takes into account both positive and negative impacts on the population highlighted in the assessment.

The general framework for Health Risk Assessments (include:

- Screening - Should a Health Risk Assessment be conducted?
- Scooping - Identify issue to be addressed and level of appraisal.
- Profiling - Who is affected and what is their current health status.
- Risk Assessment - What are the hazards? What is the likelihood of harm occurring? Who might be exposed?
- Monitoring and evaluations
- Risk Management - Prevention or minimisation of risk of harm. Managing of consequences and specific risk communications.

SCOPE OF A HEALTH RISK ASSESSMENT**Asbestos & Air Quality**

There is limited data available on the effects of the mine site on local air quality. The air monitoring for asbestos that had previously taken place was often related to works being conducted on the mine site. Dames & Moore (1997) conducted air dispersion modelling to assess the potential airborne asbestos concentrations “downwind of the tailings dump”. The modelling procedure assumed baseline asbestos concentrations at the tailings of 0.01 to 0.04 fibres/mL air which was based on concentrations recorded during remediation works in 1992. The Dames & Moore (1997) modelling indicated that during high wind velocities (up to 10 m/s) downwind asbestos concentrations would likely decline by 70% within 5 km of the tailings dump and by 90% beyond 15 km from the tailings dump.

For the studies associated with the current Woodsreef Mine Major Rehabilitation Project, of which the current study is a part, a programme of monitoring of airborne asbestos was conducted with the aim of obtaining up to date information on the potential exposures of local communities to airborne asbestos from the mine site in its current state.

Air Dispersion Modelling was used to identify locations that subsequently were used when monitoring airborne asbestos fibres. Data from these two procedures was then used in the estimation of the area likely to be affected, the intensity and duration of the effect and the level of health impact (actual health effects) on the risk population (*SLR, 2013b*).

Air Dispersion Modelling

Provided is a brief summary of the modelling assessment conducted to assist with the identification of key monitoring locations that were subsequently utilised in the human health risk assessment. Details of the methodology can be found in *SLR (2015)*.

The objective of this modelling exercise was to identify which of the identified potential monitoring locations were likely to be exposed to lower or greater levels of exposure as compared to other locations, and whether the corresponding relative exposure varies according to changes in seasonal weather conditions. This was performed to ensure that the locations that were predicted to potentially experience elevated likelihood of exposure were incorporated within the monitoring program, and that the program accounted for seasonal variations in dispersion conditions.

Please note that the results presented in this summary do not represent exposure rates, nor do they represent an assessment of environmental harm or health risk. The results are presented as a comparison of predicted impacts at selected locations relative to the maximum off-site impact that is predicted to occur under a range of meteorological conditions covering a 12 year period.

For clarification, the locations predicted to experience higher exposure potentials should not be interpreted as being ‘at risk’ or associated with environmental harm.

In order to differentiate the comparative exposure potential the following terminology was used:

- **Category A Potential** - locations predicted to have a rate of exposure greater than or equal to the maximum rate of exposure predicted at the identified receptor locations.
- **Category B Potential** - locations predicted to have a rate of exposure greater than or equal to 50% of the maximum rate of exposure predicted at the identified receptor locations.
- **Category C Potential** - locations predicted to have a rate of exposure greater than or equal to 20% of the maximum rate of exposure predicted at the identified receptor locations.
- **Category D Potential** - locations predicted to have a rate of exposure greater than or equal to 10% of the maximum rate of exposure predicted at the identified receptor locations.
- **Category E Potential** - locations predicted to have a rate of exposure less than 10% of the maximum rate of exposure predicted at the identified receptor locations.

SCOPE OF A HEALTH RISK ASSESSMENT

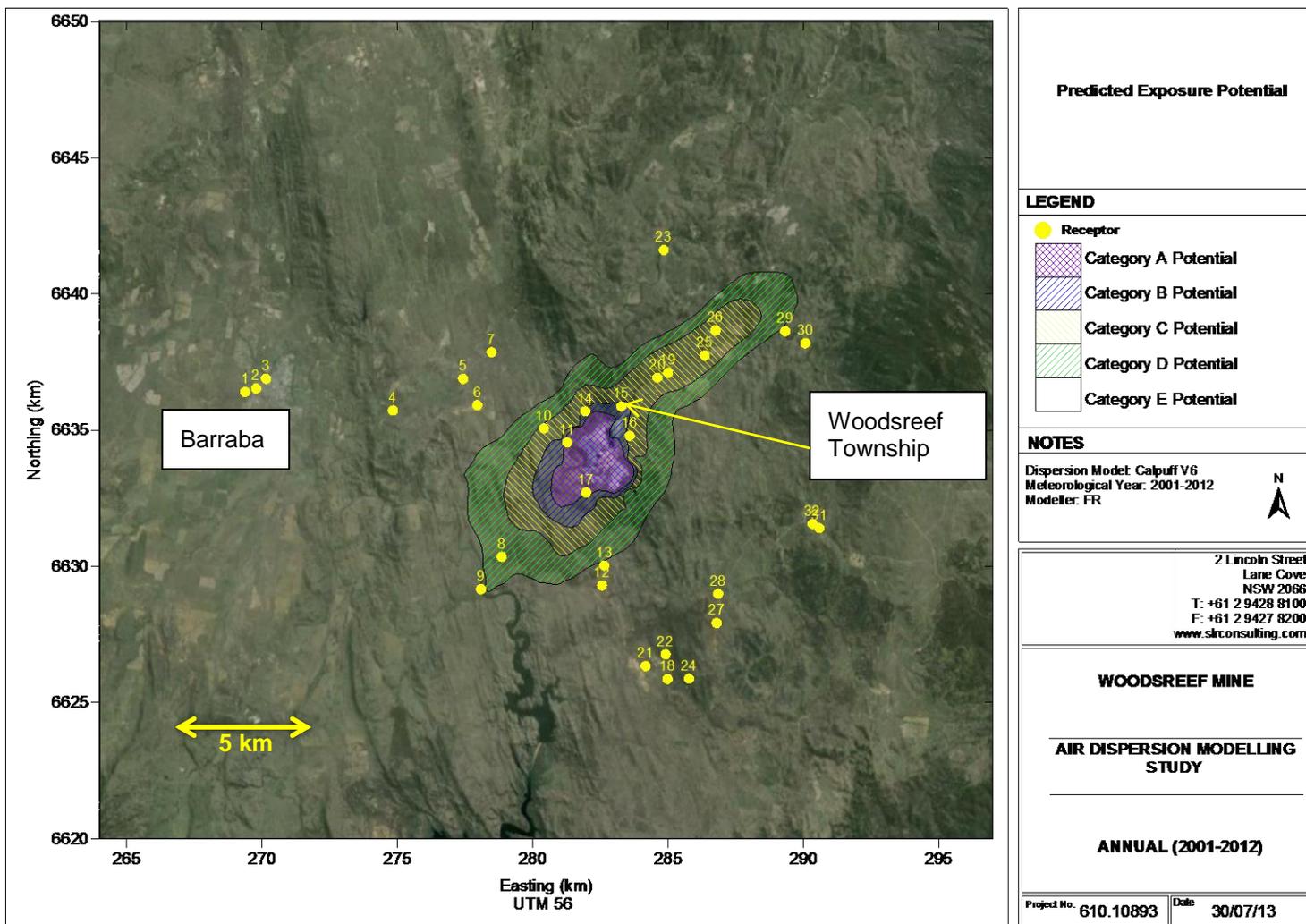
Recreational activities tend to be conducted in areas classified in the modelling as Category A, B, and C areas. That is in areas predicted to have a rate of exposure greater than or equal to 20% of the maximum rate of predicted exposures.

The annual average and seasonal predictions over the years 2001 to 2012 are presented in the following figures:

- Figure 12 Predicted Exposure Potential - Annual Average 2001 to 2012
- Figure 13 Predicted Exposure Potential - Spring 2001 to 2012
- Figure 14 Predicted Exposure Potential - Summer 2001 to 2012
- Figure 15 Predicted Exposure Potential - Autumn 2001 to 2012
- Figure 16 Predicted Exposure Potential - Winter 2001 to 2012

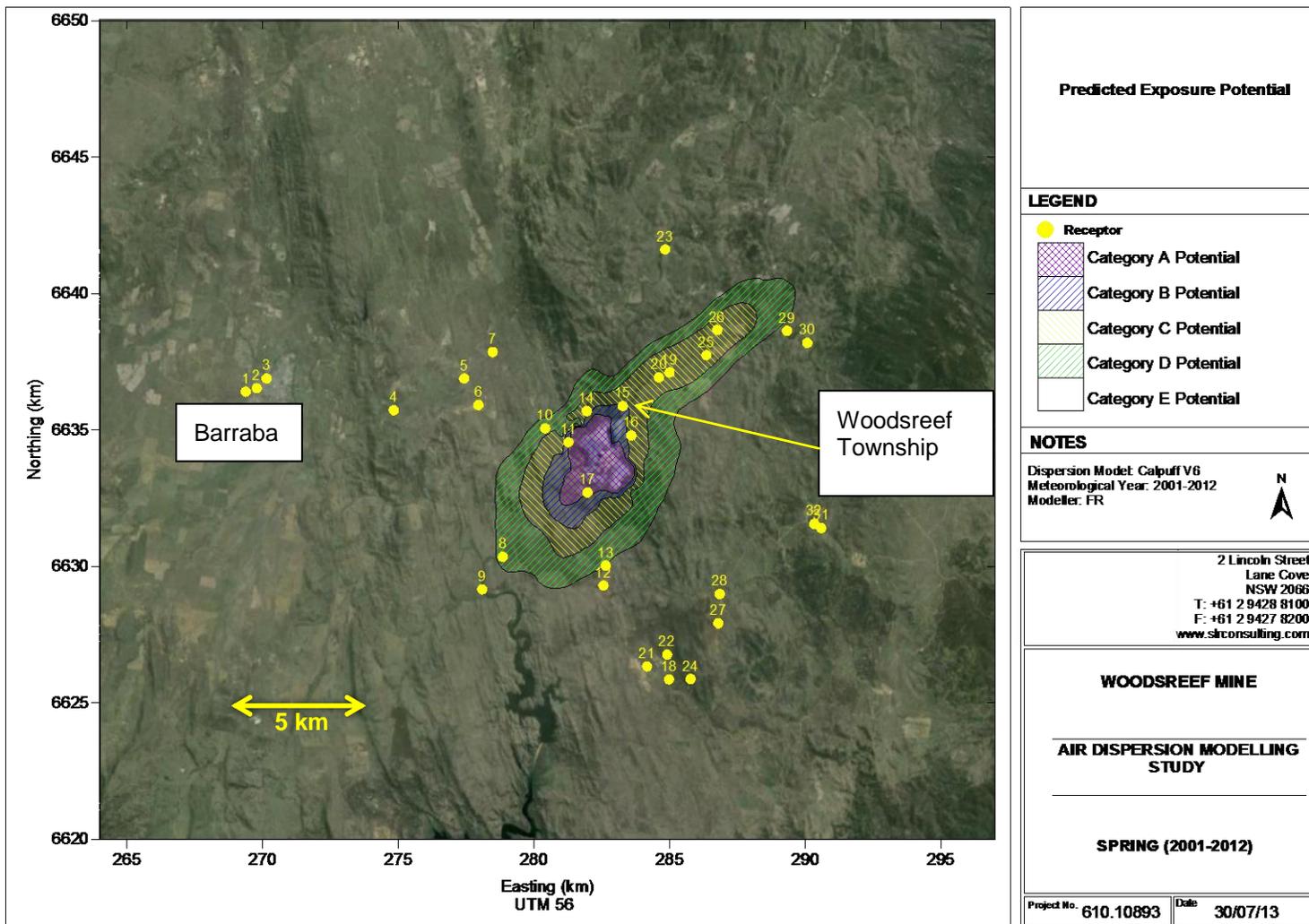
SCOPE OF A HEALTH RISK ASSESSMENT

Figure 12 Predicted Exposure Potential - Annual Average 2001 to 2012



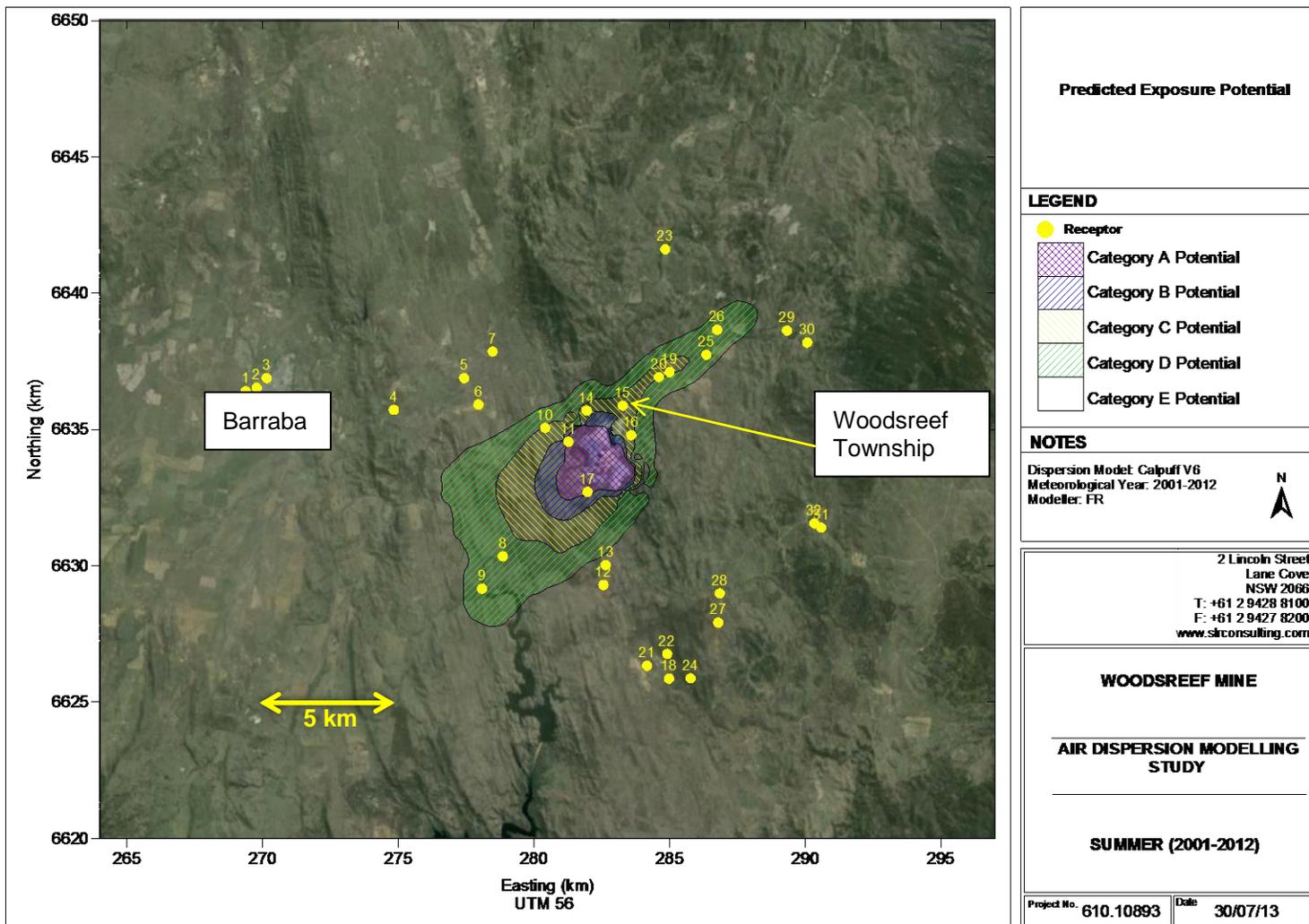
SCOPE OF A HEALTH RISK ASSESSMENT

Figure 13 Predicted Exposure Potential - Spring 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)



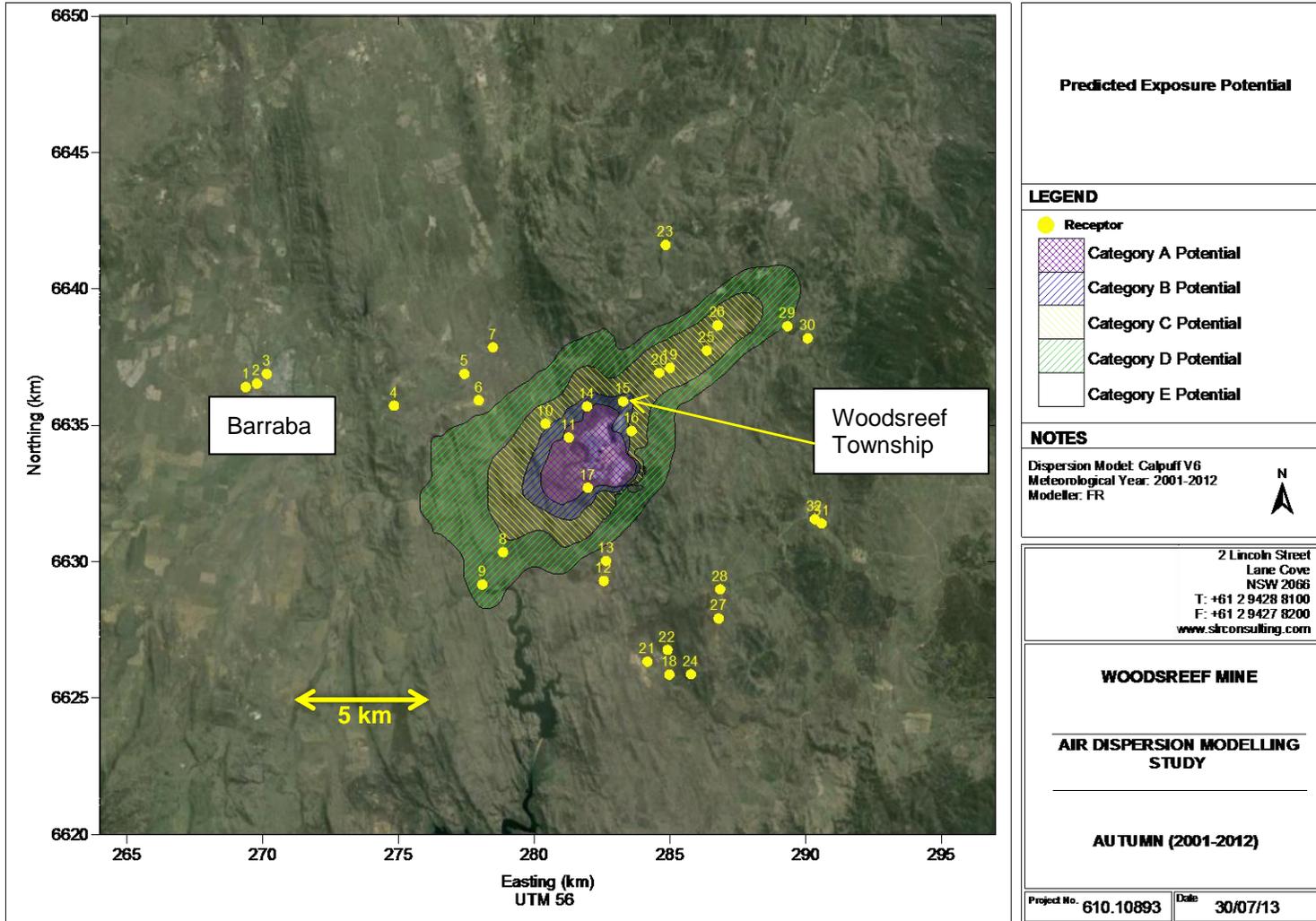
SCOPE OF A HEALTH RISK ASSESSMENT

Figure 14 Predicted Exposure Potential - Summer 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)



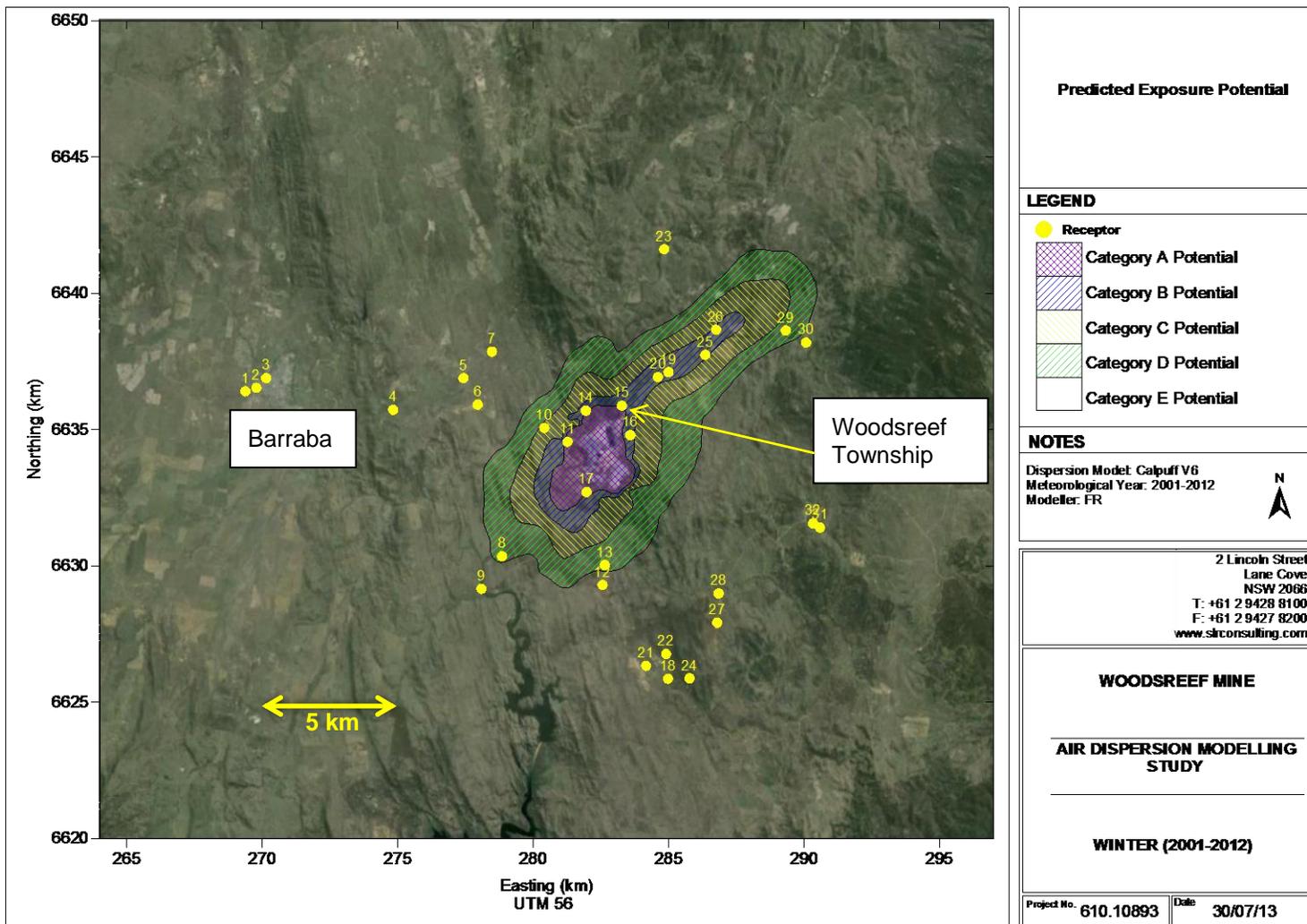
SCOPE OF A HEALTH RISK ASSESSMENT

Figure 15 Predicted Exposure Potential - Autumn 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)



SCOPE OF A HEALTH RISK ASSESSMENT

Figure 16 Predicted Exposure Potential - Winter 2001 to 2012 (Refer to 3.3.12 for category A-E definitions)



SCOPE OF A HEALTH RISK ASSESSMENT

In 1974 “dust sampling” was undertaken at properties in the vicinity of the mine. This sampling appears to be of settled dust. Therefore the results were used in a general way to infer airborne transport of asbestos onto the properties with the underlying assumptions that the source of asbestos was the active processes occurring at the mine. Furthermore the available sources quoting the original works only give qualitative estimations of the amounts of asbestos dust observed. Therefore this information may be useful in providing some evidence of how airborne asbestos may have been transported in terms of direction and distance during previous mine operations. This information is of limited value to the current study due to the asbestos source being active mining processes rather than the effects of natural forces on the derelict mine. However the information has been included below as part of the historic record.

Dames & Moore (1997) quoted from Stewart (1985) that *“Settled dust containing chrysotile was found in very low levels as far as “Black Mountain” (8.5 km) to the southeast of the Mill. Relatively high levels were found at “Fernview” (4 km) to the south and moderate levels at “Box Park” (4 km) to the northeast. Low levels were found at the township of Woodsreef (2 km) to the northeast. The 1974 sampling came only two years after the mine began operation and therefore asbestos levels in neighbouring properties would most likely be attributed to the dispersion of chrysotile fibres from the dryer stack on the Mill only, rather than the tailings dump.”*

ASBESTOS TOXICITY, DISEASE AND HISTORIC OCCUPATIONAL EXPOSURES**Summary of Diseases**

Asbestos related disease can occur as a result of either high exposure to airborne asbestos fibres for a short time or lower exposure over longer periods of time.

There are three primary disease associated with the inhalation of asbestos fibres. These are:

- Asbestosis
- Lung Cancer
- Mesothelioma

Asbestosis and lung cancer are associated primarily with high level occupational exposures.

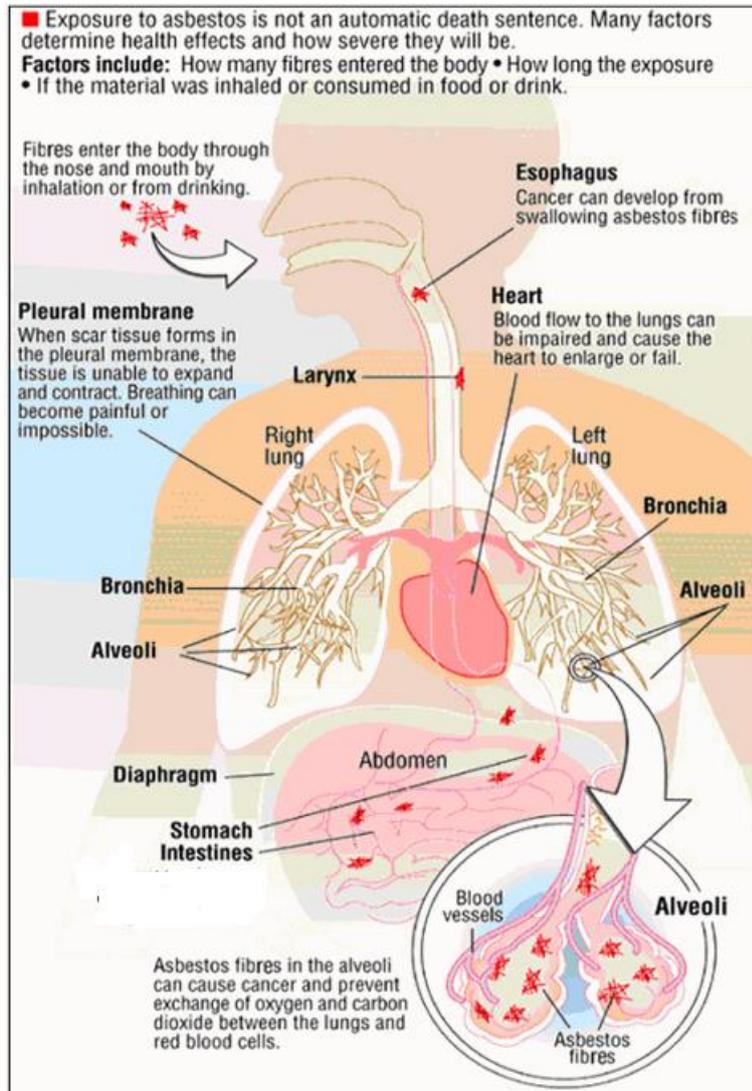
Mesothelioma has been associated with exposures below those causing asbestosis and increased risk of lung cancer. Mesothelioma is considered to be the critical effect endpoint for inhalation exposure to asbestos fibres for the purpose of this study. (Safe Work Australia, 2010)

All asbestos-related diseases are dose-related: the higher the concentration and duration of exposure, the higher the prevalence of the disease and mortality. However, the form of the dose-response curve at low doses, typical for the exposure of general population, is not known. There are contradictory opinions as to whether the dose-response relationship in the region of low doses is linear or not. It is difficult to measure the effects at such low doses either epidemiologically or experimentally.

ASBESTOS TOXICITY, DISEASE AND HISTORIC OCCUPATIONAL EXPOSURES

The asbestos exposure routes and sites of impact in the human body can be seen below in **Figure 17**.

Figure 17 Asbestos Exposure Routes and Impact Sites in the Human Body
(modified from Worksafe NZ, 2015)



Asbestosis and Pleural Disease

Asbestosis and asbestos pleural disease are non-malignant asbestos diseases that are slowly progressive. Asbestosis is a slowly progressive, fibrotic (scarring) lung disease caused by a cascade of responses to inhaled asbestos fibres. The development of asbestosis is directly associated with both multitude and duration of asbestos exposure. The onset of visible fibrosis rarely occurs earlier than 15–20 years from first exposure. Not all individuals exposed to high levels of asbestos fibre develop asbestosis (*enHealth, 2005*).

ASBESTOS TOXICITY, DISEASE AND HISTORIC OCCUPATIONAL EXPOSURES

Asbestos pleural disease is a non-malignant disease caused by inhalation of asbestos fibres that scar the pleura. The pleura is the thin membrane lining the lung and chest cavity. If the scarring is diffuse and extends along the chest wall, it is called pleural thickening. If the scarring is more focused and well-defined, it is called pleural plaques. Asbestos pleural disease results in a similar scarring process as the one that occurs inside the lung with asbestosis; however, it occurs in the lining of the lungs rather than in the lungs (ATSDR, 2001).

Asbestosis occurs in individuals exposed to large quantities of asbestos fibres over long periods of time and is recognised to result from exposure to all forms of asbestos (i.e. chrysotile and amphiboles). There is evidence to suggest a threshold effect associated with asbestosis with a threshold fibre dosage, that is the dose or exposure below which an adverse effect is not expected, of between 25 to 100 F/mL/year (F/mL/year is also referred to as fibre years and is used to describe the cumulative exposure to asbestos fibres). However, this is an area of some debate (ATSDR, 2001). In a review of the epidemiologic evidence for an asbestosis exposure response relationship, the World Health Organization Task Group on Environmental Criteria for Chrysotile Asbestos (WHO, 1998) concluded that “the risk at lower exposure levels is not known.”

There is evidence of an increased incidence of asbestosis in smokers which may be due to a number of issues such as smoking effects on lung function and defence mechanisms, however, no specific ‘dose’ of tobacco that caused this enhanced incidence could be determined (ATSDR, 2001). Lung fibre retention is expected to play a role in the development of asbestosis with trapped asbestos fibres having a prolonged lung residence time. Therefore, the progression of asbestosis may continue for many years after exposure (ATSDR, 2001).

In regards to pleural plaques enHealth (2005) provides the following:

The relationship between dose and response for pleural plaques is much weaker than for asbestosis. A good correlation has been shown between pleural plaques and asbestos fibres in the lungs; however, there is large variation.

Lung Cancer

National and international health agencies have classified asbestos as a known human carcinogen. There is a long latency period of up to 40 years between the initial exposure to asbestos fibres and the development of lung cancer. The combination of tobacco smoking and asbestos exposure synergistically increases the risk of developing cancer (enHealth, 2005; ATSDR, 2001).

There is general agreement that a dose response relationship exists, that is, higher risks occur with higher exposure to asbestos fibres. It is, however, unclear whether a threshold asbestos dose exists for lung cancer. This depends not only on cumulative asbestos exposure, but also on other underlying lung cancer risks (ATSDR, 2000). The incidence of lung cancer from all causes is high in the general population, so asbestos as a causative factor is difficult to prove in an individual patient (ATSDR, 2000).

Mesothelioma

enHealth (2005) provides the following description:

Mesothelioma is a cancer of the lining of the chest cavity (the pleura) or, less commonly, the lining of the abdominal cavity (the peritoneum). It is generally, but not always, associated with continued occupational or other high exposure to respirable asbestos. Fairly consistent and strong epidemiological evidence indicates that approximately 70% to 90% of mesothelioma cases can be related to asbestos exposure and hence it is accepted that asbestos exposure is the cause.

ASBESTOS TOXICITY, DISEASE AND HISTORIC OCCUPATIONAL EXPOSURES

The ability to link asbestos exposure to the development of mesothelioma is subject to sufficient time elapsing since the exposure occurred, to permit the disease to have initiated and developed. Mesothelioma generally does not occur until 20–50 years after exposure. Mesothelioma has been associated with all types of asbestos. However, the evidence for causality is strongest for amphiboles. Mesothelioma occurrence does not appear to be affected by smoking history.

The following is taken from ATSDR (2000):

Mesothelioma can occur with low asbestos exposure; however, very low background environmental exposures carry only an extremely low risk. The dose necessary for effect appears to be lower for asbestos-induced mesothelioma than for pulmonary asbestosis or lung cancer.

A characteristic of mesothelioma is that there is a long latency period (20–30 years) before the signs and symptoms of the disease become apparent. In addition, diagnosis of the disease can be difficult. Mortality from malignant pleural mesothelioma is a function of past exposure to asbestos.

The incidence rates of malignant mesothelioma have been increasing in Australia since 1965 and it is suggested that these rates of mesothelioma are related to the use and production of asbestos in Australia in previous decades. There is no indication of when the incidence rates of mesothelioma will start to decline. Mesothelioma incidence rates are higher in males than females, possibly because of a higher exposure in male-dominated industries that produced or used asbestos (e.g. construction and manufacturing) (NOHSC, 2002).

The Australian mesothelioma register data ranked the risks of mesothelioma according to the following groups listed from highest to lowest (Leigh and Driscoll 2003). It should be noted that the risks presented in **Table D1** reflect high historical exposures and do not represent the level of risk associated with current exposure.

Table D1 Mesothelioma Risks in Occupational Groups in Australia

Occupation	Lifetime Risk (%)
Power station worker	11.8
Railway labourer	6.4
Navy/merchant navy	5.1
Carpenter/joiner	2.4
Waterside worker	2.1
Plasterer	2.0
Boilermaker/welder	1.9
Bricklayer	1.8
Plumber	1.7
Painter/Decorator	1.2
Electrical fitter/mechanic/electrician	0.7
Vehicle mechanic	0.7
All Australian men	0.39
All Australian women	0.05

Extrapolation from epidemiological studies provides an estimated background incidence of non-occupational mesothelioma of one to two per million per year (Hillerdal, 1999). Case data suggest a dose response relationship with risk increasing with increasing dose; however, a threshold concentration below which mesothelioma will not occur has not been demonstrated (ATSDR, 2000; Hillerdal, 1999).

ASBESTOS TOXICITY, DISEASE AND HISTORIC OCCUPATIONAL EXPOSURES**Historic Exposures to Asbestos**

In most evaluations asbestos-related disease rates are predicted to peak sometime during the next few decades. This can be attributed to long latency periods of asbestos-related disease and high historic exposures. Exposure to asbestos has been found in many occupations, the major contributions coming from the primary asbestos production or manufacture industries, from the building industry generally and from shipping-related activities. Numerous other occupations may also involve asbestos exposure, albeit to a lesser degree. Such occupations include the staff of coal powered power stations, mechanics repairing motor vehicles (brakes, clutch), carpenters and woodworkers, electricians, welders, etc (*Hillerdal, 1999; Niklinski, 2004*)

With few exceptions little or no sampling was conducted prior to the 1950s when exposure concentrations were thought generally to be higher than those monitored more recently, due to lack of use of dust control equipment at the time and procedures to reduce dust levels that were introduced only later. However, airborne fibre concentrations within workplaces in the 1950's were estimated and recreated to be within tens to thousands of fibres/mL. Measurements from workplaces in the 1960s often showed peak doses of 20 fibres/mL and much less in more recent years. Due to long latency periods, current mesothelioma rates are likely due to these 'high' historical occupational exposures.

UNCERTAINTIES AND LIMITATIONS

Uncertainties are present in all risk assessments and this reinforces the need for a systematic and rigorous approach. While the enHealth human health risk assessment process attempts to estimate risk as accurately as possible, there are various sources of uncertainty in the process that should be examined. Understanding these uncertainties places the risk estimates in a proper perspective allowing them to be applied in practice with an appropriate level of confidence.

In general, the uncertainties and limitations of human health risk assessment can be classified into the following categories:

- Personnel exposure assessment.
- Toxicological assessment.
- Risk characterisation.

Various sources of uncertainty are briefly discussed below.

Uncertainty related to Exposure Assessment

The uncertainties that may exist in exposure assessment include the estimation of concentrations in the air and the use of PCM analytical techniques:

- Uncertainties relating to air modelling.
- Uncertainties relating to the use of historic data.
- Random error in sample analysis may produce erroneous data.
- PCM cannot distinguish between asbestos and non-asbestos conforming fibres, which causes uncertainty about the actual asbestos fibre concentration for a given area and artificially boost the asbestos fibre counts.

Uncertainty related to Asbestos Content of soils

There is a general lack of information on asbestos content of soils in areas where recreational activities may be occurring. Accordingly estimating potential exposure through indirect pathways such as surface contamination from contact with asbestos containing soils is unclear.

Uncertainty related to Toxicity Assessment

In general, the available scientific literature is insufficient to provide a thorough understanding of all of the potential toxic properties of chemicals or materials to which humans may be exposed. It is necessary therefore, to extrapolate these properties from data obtained under other conditions of exposure and involving experimental laboratory animals. This may introduce two types of uncertainties into the risk assessment, as follows:

- Those related to extrapolation from one species to another.
- Those related to extrapolating from high exposure doses, usually in experimental animal studies, to the lower doses usually estimated for human exposure situations.

For asbestos, epidemiology studies used to derive toxicity information often involve high exposure concentrations in an occupational setting.

Safety factors are introduced to compensate for these uncertainties. The use of safety factors and extrapolating from high exposure concentrations typically leads to a conservative over-estimation of dose response relationships.

UNCERTAINTIES AND LIMITATIONS**Uncertainty in Risk Characterisation**

The methods available for the estimation of cancer risk do not account for the increased lifetime risk of lung cancer due to prior lung disease. Cancer risks could therefore be underestimated for susceptible subpopulations with prior lung disease.

There is a degree of uncertainty in estimating the risk of contracting cancer (lung cancer or mesothelioma) at low doses. As exposure response data are derived mainly from high occupational exposures scenarios, there is difficulty in estimating risk for short-term exposure at low levels over long periods of time. Additionally, no risk estimates are calculated for non-cancer risks due to the unavailability of any method.

In this study, measured asbestos fibre concentrations were used to estimate risks from exposure and this approach may conservatively over-estimate the risks involved.

Uncertainty related to the use of Australian Occupational Exposure Standards

There is uncertainty associated with using occupational standards for assessing exposure in the non-occupational environment. Occupational standards are determined for work place exposures over the working life of an adult, for example 40 hours per week over a working life of 30 to 40 years. Accordingly these standards allow higher exposures than would normally be allowed or expected in the non-occupational environment. Nor do occupational standards consider more sensitive subsets of a population such as children.

However an acceptable level for asbestos exposure has not been determined in the non-occupation environment.

As such the use of an occupational standard, while imperfect, at least provided the basis for standardized sampling methodology and allowed comparisons to a significant body of historic Woodsreef air monitoring data collected over at least 25 years.

Moreover occupational exposure standards are based on the best available information from industrial experience, human exposure data and animal studies.

Uncertainty related to Frequency of Site Visits for Recreational Purposes

There is uncertainty associated with the frequency at which persons will repeatedly visit the area to conduct recreational activities. In many cases the cases it is likely recreational users will only visit the area once or few times. Local residents of Barraba, Woodsreef and surrounds may conduct repeated recreational activities more often than visitors. However there is no information currently available on the frequency of repeat visits to the area.

In the current report, assumption were made that recreational users will only visit the area for short periods, such as a day or two on a weekend, once to a few times per year.

If a person is conducting recreational activities repeatedly over many days during each year, then their exposure risk may be greater than Negligible to Low.

Uncertainties Conclusion

While a number of parameters used within the risk assessment have a moderate degree of uncertainty associated with them, values used to define these parameters have been selected to be conservative. This has resulted in estimates of risk which tend towards a conservative overestimation.