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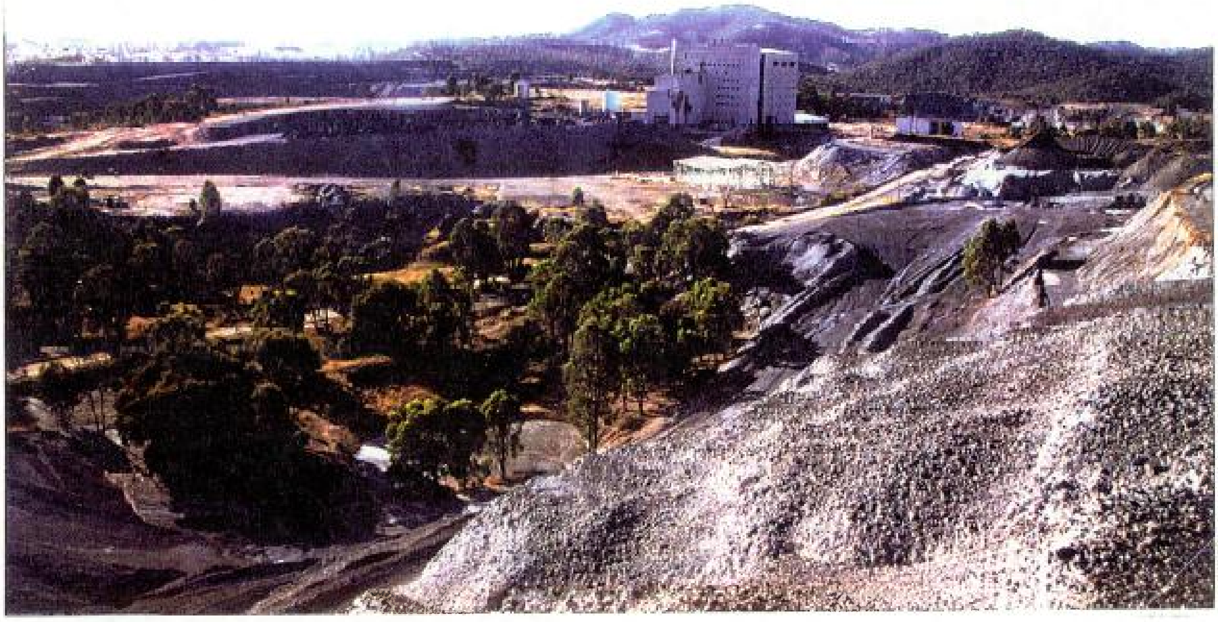
Woodsreef Asbestos Mine, Barraba : synopsis for risk assessment

NSW Environmental Protection Authority

CONFIDENTIAL

Woodsreef Asbestos Mine, Barraba.

Synopsis for Risk Assesment



September, 1996

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EXECUTIVE SUMMARY

PART ONE : GENERAL

INTRODUCTION

Woodsreef Asbestos Mine Barraba poses many risks to the surrounding environment due to the lack of rehabilitation after mine closure. Hazards at the mine must, therefore, be prioritised in terms of associated risk, in order to effectively allocate limited funding.

ENVIRONMENT

The Barraba region has a temperate climate with moist summers and relatively dry winters, averaging 80 mm and 43 mm respectively. Winds are predominantly from the north west and from south west.

The mine is located within a large pod of the great serpentinite belt, which is associated with the Peel Fault subduction system. The major host rocks of chrysotile are serpentinized harzurgite and massive serpentinite, which contain a cross fibre arrangement with fibre lengths normally less than 6 mm. The deposit was discovered in the early 1880s, with mining occurring sporadically since that time. The most recent mine closed in 1983. Since then interest has been shown in using wet processing to remill the tailings and possibly reopen the North Pit for mining.

PART TWO : HAZARD & RISK IDENTIFICATION

SEDIMENT & SITE STABILITY

Lack of vegetation cover and the slope of the dump batters, ranging between 30° and 40°, has increased the risk of erosion and sedimentation of Ironbark and Nangahrah Creeks, as well as settling dams and other drainage lines. Waste rock and tailings dumps are the two major sources of the mine-derived sediment. The forms of erosion mobilising this sediment include:

- rill and sheet erosion;
- occasional mass movement of the batters, including breaches in the waste rock dump head bunds and the slumping of the southern batter of the tailings dump;
- dump weakening and possibly tunnel erosion due to lateral and vertical infiltration, indicated by tension cracks and location of the tailings dump location over several small intermittent streams; and
- dust emissions.

The resulting sedimentation contaminates waterways by affecting their hydrological, biological, physical and chemical attributes. It also decreases the effectiveness of settling dams if they are not readily maintained. Data are not available to quantify the impact of these factors.

Potential seismic activity within the Peel Fault could potentially act as a catalyst for weakening site features such as the waste rock and tailings dump.

ASBESTOS

Chrysotile asbestos is considered the major hazard associated with the site, as perceived by the general public. This concern is overstated, however, and stems from general concern and health risks associated with asbestos derived from amphibole. Chrysotile is the sole member of the serpentinite asbestos group which has a wavy and flexible morphology and is relatively susceptible to chemical breakdown. Fibres can be either carried by water, commonly with sediment, or become airborne.

Waterborne chrysotile presents no significant health risk to humans. However, its impact on aquatic ecosystems has not being investigated at the site.

Airborne chrysotile asbestos presents a far greater hazard, with health risks dependent upon the ambient concentration of fibres, fibre morphology (in terms of length and width), and exposure period. Chrysotile asbestos has been associated with asbestosis, lung cancer and mesotheliomas. However, the ambient fibre levels at Woodsreef site are well below the recommended 0.5 f/ml risk threshold, according to 1984 data. This, however, requires confirmation given the time lapse since the measurements were taken and the current derelict status of the mine.

CHEMICAL WATER QUALITY

The chemical impact of runoff and leachate from the waste rock and tailings dumps on the natural drainage system, is not currently a major hazard associated with the mine. Leachate from dumps does not reduce the useability of water within Ironbark Creek, because the assessed chemical parameters still meet the current criteria for Australian Drinking Water Guidelines (1994). Significant rises in magnesium, alkalinity and electrical conductivity occur with each inflow of mine drainage into Ironbark Creek. Chemical water quality, however, must be re-assessed, given the current derelict status of the mine.

RELATED ANTHROPOCENTRIC CONCERNS

Woodsreef mine is generally considered visually unattractive, and requests for rehabilitation often allude to this concern. With limited revegetation, the stark grey-white colouring of the old mine site is in total contrast to the surrounding agricultural and bushland environments. In addition the large seven-storey mill building and associated structures, are starting to fall into disrepair and are surrounded by scattered refuse.

Trespassing by the public within the Woodsreef Mine site is another concern associated with the derelict mine. Whilst no instances of injuries have being reported to date, the risk of future injuries still remains, given the various hazards pertaining to the mine site.

PART THREE : EXISTING & PROPOSED WORK

EXISTING REMEDIATION WORKS

Revegetation

Although revegetation of the site is considered a major step in the rehabilitation process, studies indicate that the waste rock and tailings substrates provide arduous growing conditions, due to factors such as an adverse calcium/magnesium ratio and low nutrient status. However, limited natural colonisation by grasses and some shrubs has occurred. Several trial plots have been established in the past and include:

- trial rehabilitation plots established by the Corporation, on the top of the tailings dump and north of the wet processing mill, which used imported soil planted with a range of herb, grass and tree species; and
- a trial plot established by the Department of Mineral Resources on the western waste rock dump, which used mine waste as a substrate and planted with of *Asteraceae* and *Acacia* species.

These trials demonstrated that the addition of a soil substrate leads to healthier plant establishment and growth.

Sedimentation & Erosion Control

The major sedimentation erosion control measures include:

- settling ponds and limited internal drainage bunds, which were installed by the company during mine operation or shortly after; and
- the three dam water diversion system and improved internal drainage systems, which was constructed in 1992 by the Soil Conservation Service.

There are three settling ponds, of varying capacity, aimed at reducing the inflow of sediments into Ironbark Creek by collecting runoff from the southern drainage channels of the mine. The three dam diversion system is designed to prevent drainage from catchments east of the tailings dump from infiltrating the dump and causing tunnel erosion and destabilisation.

PROPOSED WORKS

Rehabilitation Strategies

Rehabilitation strategies have been proposed by the Corporation and the Soil Conservation Service with the Dept of Mineral Resources also contributing to the development of such plans. The main focus of these plans were:

- to reduce batter slopes to acceptable and stable angles;
- to isolate the tailings dump, either by encapsulation or returning the material to the pits; and
- to reduce the erosion potential and improve the visual amenity by revegetating the site.

The large cost associated with these rehabilitation strategies, has prevented their implementation at the mine.

Wet Tailings Processing

The remilling of tailings dump for chrysotile and possibly the remaining ore within the North Pit, has being proposed and investigated several times. The remilling process could recover in excess of 300,000 tonnes of fibre using a wet processing plant, as opposed to conventional dry processing techniques. Trials and feasibility studies have being conducted by the Corporation in 1985 and a Mineral Commodities/Black Hill Minerals consortium, Marrall Pty Ltd. Concerns over the hazards associated with the use of chrysotile and an uncertain market has prevented the project from being developed.

Landfill Development

The mine pits have been proposed as possible landfill sites, for either general asbestos waste or future landfill developments by Barraba Shire Council.

PART FOUR : RECOMMENDATIONS & CONCLUSIONS

INFORMATION NEEDS

The available data on the hazards, risks and impacts associated with Woodsreef Asbestos Mine is far from comprehensive. Thus various data need to collected and includes:

- a rapid bio-assessment to determine the impact on the aquatic environment of different types of pollution emanating from the mine;
- a comprehensive analysis of chemical water quality, which may provide a current comparison to historic data;
- data on sediment, such as:
  - ~ the distribution of finer sediment emanating from the mine, including impact on settling ponds;
  - ~ determination of erosion potential from the various substrates throughout the site;

~ determination of batter stability and likely impacts associate with further movement; and

- present ambient dust levels need to be determined in order to provide an accurate indication of current risk. Preferably under varying wind speeds and direction

PRELIMINARY PRIORITISATION OF HAZARDS

❶ Sediment derived from slumping and erosion of the southern batter of the tailings dump.

❷ Sediment derived from regular sheet and rill erosion of waste rock and tailings dumps.

❸ Sediment derived from breaching of diversion bunds at the head of the waste rock dump.

❹ Poor chemical water quality in Ironbark and Nangahrah Creek resulting from leachate and contaminated surface runoff from the waste rock and tailings dump, particularly if Dam A fails, and/or leachate production is increased.

❺ Health concerns due to airborne dust and/or asbestos, particularly from the tailings dump.

❻ Injury to the public who visit the site, either legally or illegally.

❼ Metal mobilisation leading to bio-accumulation in plants and higher members of the food chain.

❽ Adverse chemical water quality in Ironbark Creek and shallow fractured rock aquifers as a result of increases in pit water levels.

❾ Dump destabilisation due to seismic activity in the Peel Fault System.

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PART ONE

GENERAL

Figure 1.1: *Woodsreef Asbestos Mine, site features.*

1 INTRODUCTION

Woodsreef Asbestos Mine is located 15 km east of the township of Barraba, in the south western region of the New England Tablelands. The mine extracted the mineral chrysotile, white asbestos, from a deposit associated with the Great Serpentinite Belt. One hundred million tonnes of material was extracted, of which only 550,000 tonne was reported as chrysotile (Stewart, 1995). The large volume of remaining waste was deposited in either the waste rock or tailing dumps, creating one of the largest non-coal pits in New South Wales (Figure 1.1).

The mine has had a long but sporadic working history, dating back to 1918. Financial difficulties throughout the last period of operation (1970 to 1980) resulted in mine closure. Consequently the operating company, Chrysotile Corporation of Australia Pty Ltd herein called the Corporation, failed to carry out significant site rehabilitation work. Since closure, inadequate defaulted securities and the proposed reopening of the mine, have prevented the implementation of suggested rehabilitation strategies. The lack of rehabilitation has been a source of public and environmental concern.

Hazards associated with Woodsreef mine need to be prioritised according to their risk. Hazards are defined as the intrinsic potential of something to cause harm and risk is the likelihood that the hazard will occur. Prioritising will enable the efficient allocation of available funds to the remediation of hazards presenting significant risk.

1.1 OBJECTIVE & SCOPE

The objective of this report is to supply a comprehensive document that will provide a platform for the development of a risk assessment at the Woodsreef Asbestos Mine. The synopsis will review all current information and issues associated with the mine that are relevant, given its present condition. It will also provide a bibliography of available data and literature on the mine. The report will also outline any gaps in the current data base and will preliminarily prioritise the hazards for their apparent risk and impact.

2 ENVIRONMENT

Woodsreef Mine is located 15 km east of Barraba (Figure 2.1). The mine is bounded to the north by Nangahrah Creek and to the west by Ironbark Creek. These creeks drain the site, with Nangahrah Creek converging into Ironbark Creek, 2 km north west of the mine. The southern area of the mine is drained by various intermittent streams which flow into Ironbark Creek. The eastern margin of the mine is bounded by hilly terrain that drains east under the tailings dump.

Original vegetation surrounding the mine has being cleared or at least significantly altered, due to pastoral activities. Soils are generally poor and support natural stands of *Eucalyptus albens*. Alluvial soils associated with the water courses are dominated by stands of *Casuarina cunninghamiana*.

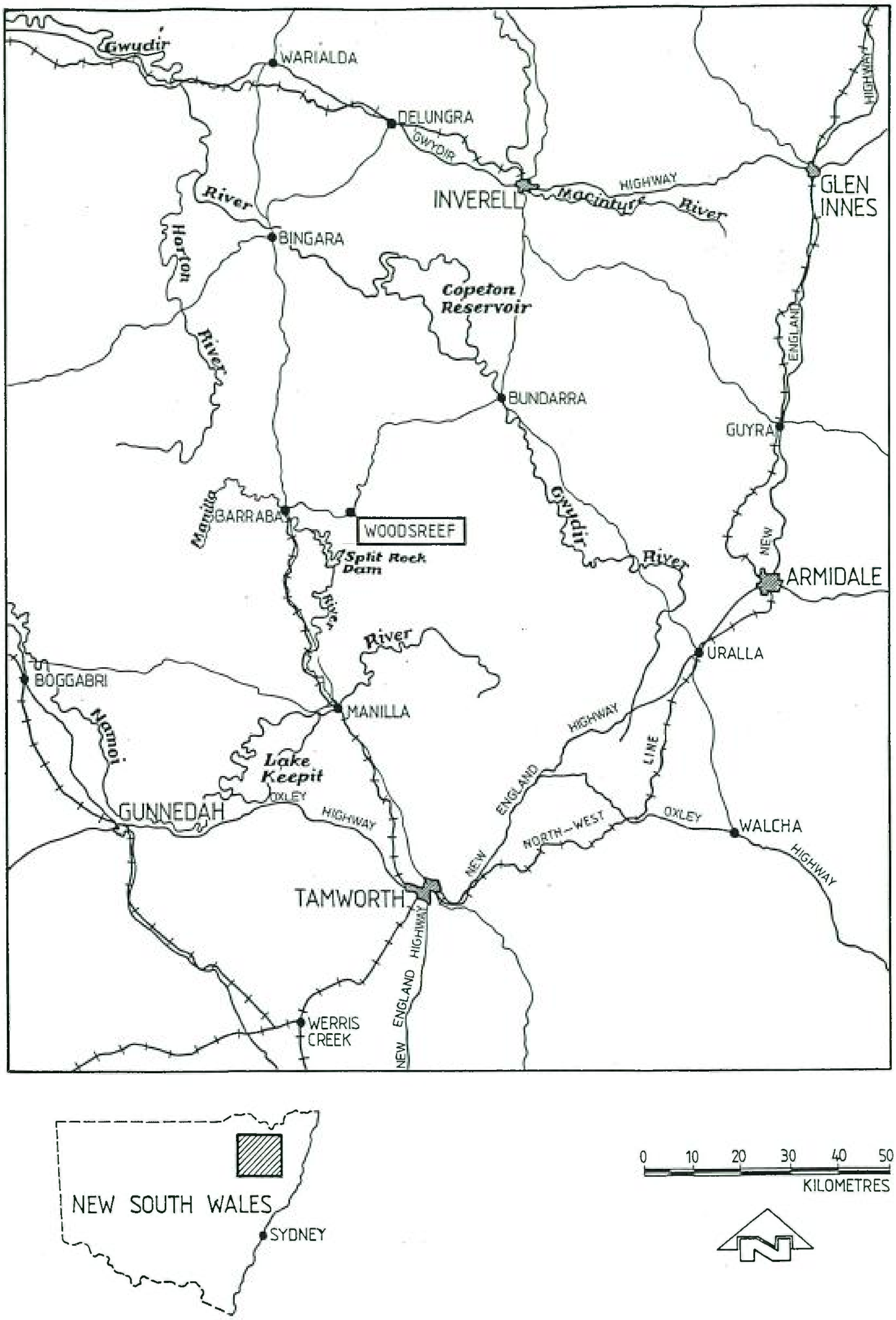

Figure 2.1: *Location of Woodsreef Asbestos Mine, Barraba.*

Comprehensive evaluations of aspects of the regions' environment are given in Stewart (1985), Hoskings & James (1995) and other documents listed in APPENDIX I.

2.1 CLIMATE

The Barraba region has a temperate climate, with moist summers and dry winters. Average summer temperatures range between a maximum of 31°C and minimum of 14°C, with temperatures of up to 40°C recorded. Average winter temperatures range from 17°C to -1°C, with lows of -5°C recorded. Barraba records an average 81 frosts per annum, with a similar number expected at Woodsreef. These climatic parameters are discussed further within Stewart (1985). Wind and rainfall variables are intrinsically linked to the hazards of the mine and are considered below.

2.1.1 Wind

Seasonal wind direction, speed and frequency, for the Barraba region, are given in the wind roses in Figure 2.2. The dominant winds are from the north west, south west, south and west respectively, representing 60-65% of the total wind direction. Winds from of south east, east and north east represent less then 7% of the total wind direction and rarely exceed 40 km per hour. Diurnal variation also occurs, with north west winds dominating of a morning and south, south west and north west winds of an afternoon.

Morning and afternoon wind speed (m/s) and direction (°), is available on disk from the EPA. The data are located within the file BARA2.LST, which is in ASCII format (PC compatible).

2.1.2 Rainfall

Barraba receives a yearly average of 684.5 mm from an average of 77 days. January is the wettest month of the year with an average rainfall of 88.5 mm over 7.9 days (Figure 2.3). April is the driest month, with an average rainfall of 39.25 mm occurring over 4.7 days. Although April is the driest month winter is, on average, drier than autumn. Winter rainfall is also the least variable, with summer rainfall having three times the variability. Reliable rainfall data for Woodsreef ranges from 1973-1983 and indicates that the annual rainfall is generally 28 mm less than that recorded at Barraba. The Woodsreef rainfall data are given in APPENDIX II, whilst daily rainfall data in mm from March 1881 to August 1996, is available on disk from the EPA. The data are located within the file BARA1.LST, which is in ASCII format (PC compatible).

A cumulative frequency distribution of daily rainfall at Barraba, from March 1881 to August 1996 is shown in Figure 2.4. The graph indicates that 99 % of all daily rainfall events are less than 56 mm, 50 % are less than 4.5 mm. The highest daily rainfall event recorded was 194.3 mm on the 25th of February, 1955. High rainfall events were also recorded on 15th January, 1910 and 10th November, 1976 as 162.6 mm and 145.0 mm respectively.

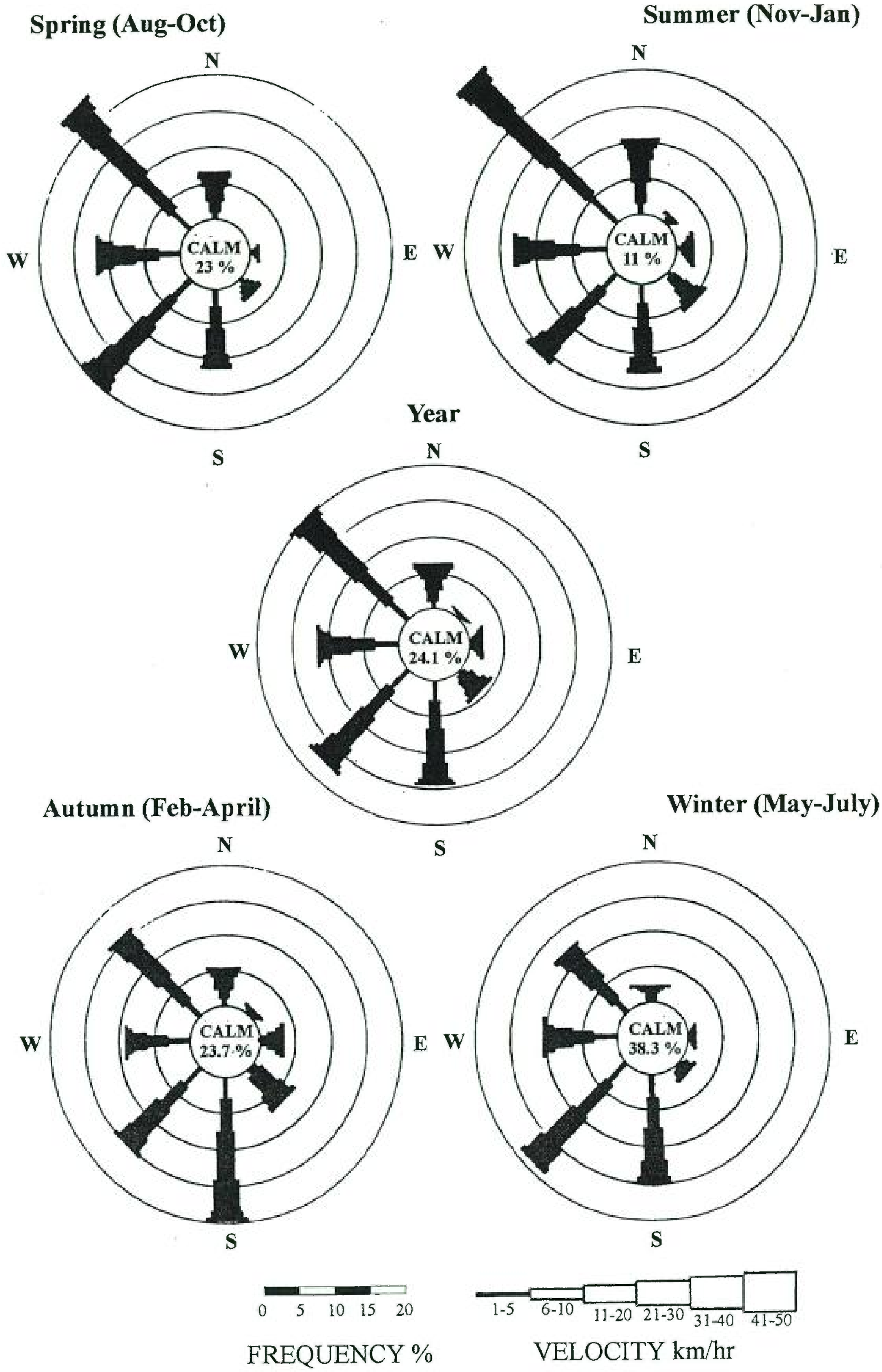

Figure 2.2: *Seasonal and annual wind roses for the Barraba region (Stewart, 1985).*

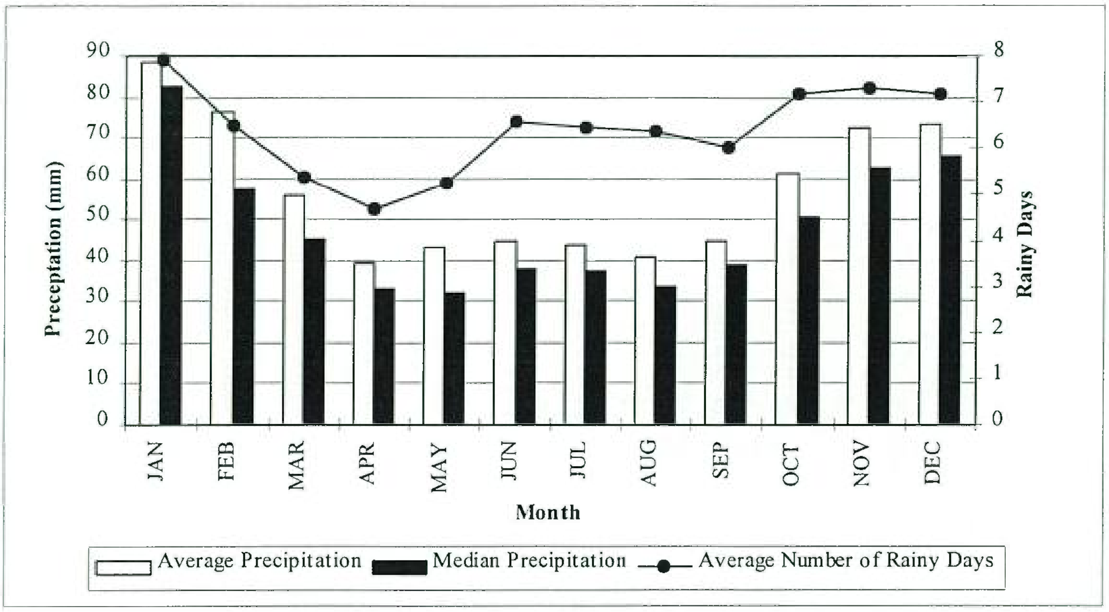

Figure 2.3: *Average and median monthly rainfall for the Barraba area, including the average number of rainy days per month.*

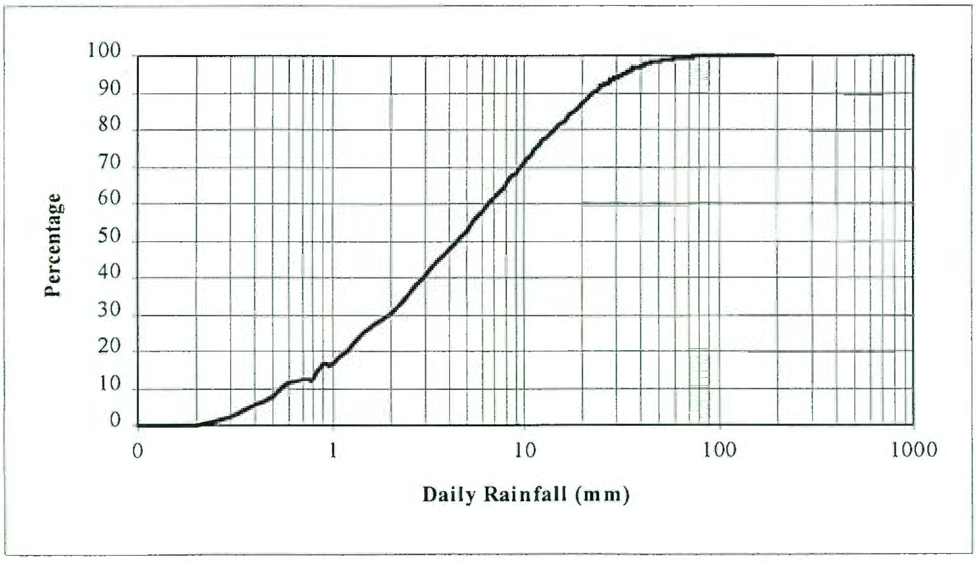

Figure 2.4: *Cumulative frequency distribution of daily rainfall for the Barraba area. Daily rainfall events occur on average 21.01% of the year.*

2.2 GEOLOGY

Mine geology is intricately related to the hazards a mine presents to the environment. An understanding of mine geology is, therefore, essential in determing hazards and the risks they present.

2.2.1 Peel Thrust Fault & Great Serpentine Belt

The Peel Thrust Fault is a subduction system that separates the Tamworth Belt to the west from the Tableland Complex to the east (O'Hanley & Offler, 1992). The fault is 400 km long and runs from Warialda to Nundle before heading east toward Laurieton. The fault is traced by discontinuous and irregular deposits of schistose, massive serpentinite and ophiolitic ultramafic and mafic rocks, known as the Great Serpentinite Belt (Brown et al, 1990).

2.2.2 Mine Site Geology

The Woodsreef ultramafic pod represents the most concentrated deposit of chrysotile fibres in the Great Serpentinite Belt. The 8 km long and 2 km wide pod (Toyer & Main, 1978) contains massive serpentinite, schistose serpentinite and partly serpentinized harzurgite, with cenozoic gravels partially overlaying, (Figure 2.5). Serpentinized harzurgite and massive serpentinite are the major host rocks of the chrysotile mineral, which occurs in a cross fibre arrangement. The fibre is normally less then 6 mm in length and is chemically identical to the host rock (Brown et al, 1990; O'Hanley & Offler, 1992). The host rocks are also rich in magnesium and iron, and contain nickel (2,000 ppm), cobalt (79 ppm) and chromium (3,125 ppm).

2.2.3 Fault Activity

The Peel Thrust Fault is considered geologically active, although no current data conclusively indicate fault movement (Kevin M^{c}Cue, pers. comm. 13/8/1996). Determination of seismic recurrence intervals associated with the fault are, therefore, difficult. Minor earthquakes have been recorded in the region, although these have not been attributed to the fault. The last earthquake occurred on the 14th November 1990 with its epicentre located south of Bundarra. It registered 5 on the Richter Scale and led to the development of small fluvial fans in hilly terrain near the epicenter (Dr Peter Flood, pers. comm. 27/5/1996).

3 HISTORY OF MINING

The chrysotile deposit at Woodsreef was discovered in the early 1880s (Brown et al, 1990). It was first mined by the Asbestos Mining Company of Australia Ltd, from 1918 to 1923. Mining from two separate quarries, the company produced 2,500 tonnes of fibre, at an average length of 12 mm (Toyer & Main, 1978). James Hardie Pty Ltd investigated the potential of the site in 1949, with Marcal Asbestos Pty Ltd extracting 14 tonnes of fibre ten years later. White Asbestos Mining Pty Ltd purchased the mining leases in 1964, and began site investigations as the Chrysotile Corporation of

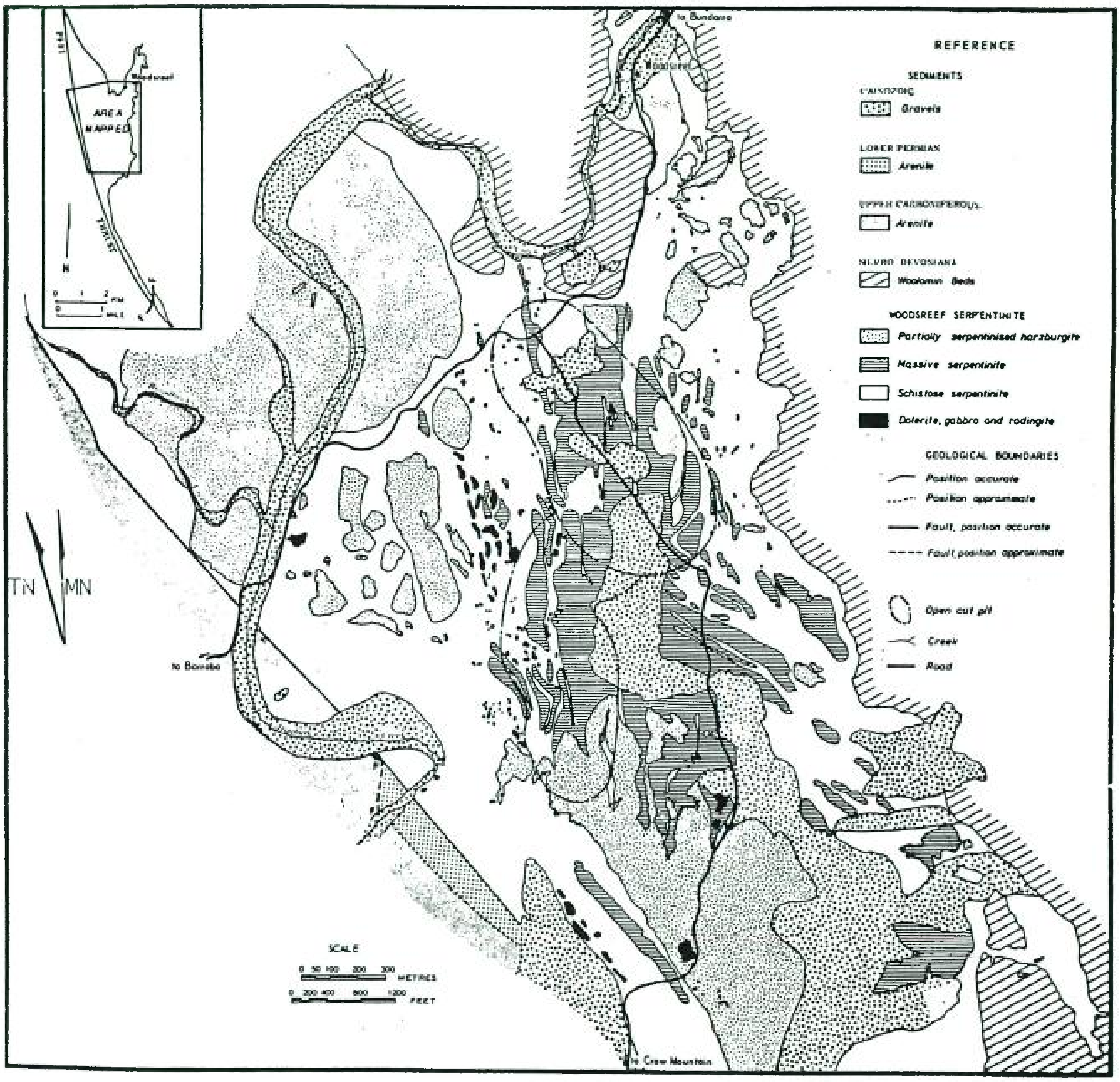

Figure 2.5: *Woodsreef Asbestos Mine site geology.*

Australia. Open pit operations began in the South Pit in 1971 (Stewart, 1985). Developing a dry processing operation in 1972, the mining focus shifted to better ores within the North Pit in 1975. Despite extracting approximately 70,000 tonnes of chrysotile fibres from 13,000,000 tonnes of serpentinite country rock per annum (Toyer, 1981), the mining operations ceased in 1983.

Interest has since been shown in the use of wet processing to re-mill the tailings and possibly recommence mining within the North Pit. The Corporation submitted an Environmental Impact Statement for consideration in 1985, after Kilborn Ltd investigated the feasibility of developing a wet processing plant at Woodsreef. In 1991, Marrall Pty Ltd completed a second feasibility study and consequently holds EL No. 4445, which embraces the tailings dump.

The mine is currently classified derelict, with the majority of the land under crown control. The parcel of land upon which the mill building, offices and trial wet processing plant are situated is privately owned. Further details on the leases associated with the mine are given in APPENDIX III.

PART TWO

HAZARD & RISK IDENTIFICATION

4 SEDIMENTATION & SITE STABILITY

Sediment derived from unstable site features is one of the major hazards associated with the Woodsreef mine site. The lack of vegetation cover and the slopes of the dump batters, (ranging between 30° and 40°), has increased the risk of erosion and sedimentation. As Split Rock Dam is located only 10 km downstream of the mine, sedimentation of Ironbark and Nangahrah Creeks is of major concern. Dust emissions are of concerns, as are water movement through dumps and fault activity.

The two major sources of the mine derived sediments are the waste rock and tailing dumps. Both these structures suffer from rill and sheet erosion, occasional mass movement of the batters and internal dump weakening, indicated by external tension cracks.

4.1 TAILINGS & WASTE ROCK DUMPS

4.1.1 Tailings Dump

The tailings dump covers approximately 43 ha and has an average height of 45 m, reaching a maximum height of 70 m. The dump contains 24 million tonnes of fine material, varying in size throughout the dump as indicated by the wide size grading envelope (Figure 4.1). A light protective crust has formed on the surface of the tailings, offering limited resistance to erosion processes (Figure 4.2).

4.1.2 Waste Rock Dumps

The two waste rock dumps cover an area of 117 ha and consist of barren serpentine country rock, soil overburden, gravel and ore rock (Toyer & Main, 1978). The size fraction within the dumps varies from boulders a few meters across to fines. This variation in size has led to the eluviation of fines deeper into the profile, resulting in the relatively stable coarse surface crust (Figure 4.3).

4.1.3 Hazards

The protective crust of both the tailings and waste rock dumps has reduce the potential of waste material becoming mobilised, particularly by wind. This crusting of the surface material, however, may reduce infiltration into the dumps, thus increasing runoff. Runoff does not present a major hazard on the relatively flat top of the dumps. However, movement of this water over the dump batters and sloping areas has led to the extensive rill and sheet erosion (Figures 4.4 and 4.5). This erosion has caused sedimentation of Ironbark and Nangahrah Creeks, as well as settling dams and other drainage lines (Figure 4.6).

The southern batter of the tailings dump is at risk of collapse, as indicated by slumping along the batter head. Steel gauge posts were used to monitored batter movement between 1989 and 1990, (Figure 4.7). This investigation indicated that batter movement was strongly correlated with moisture

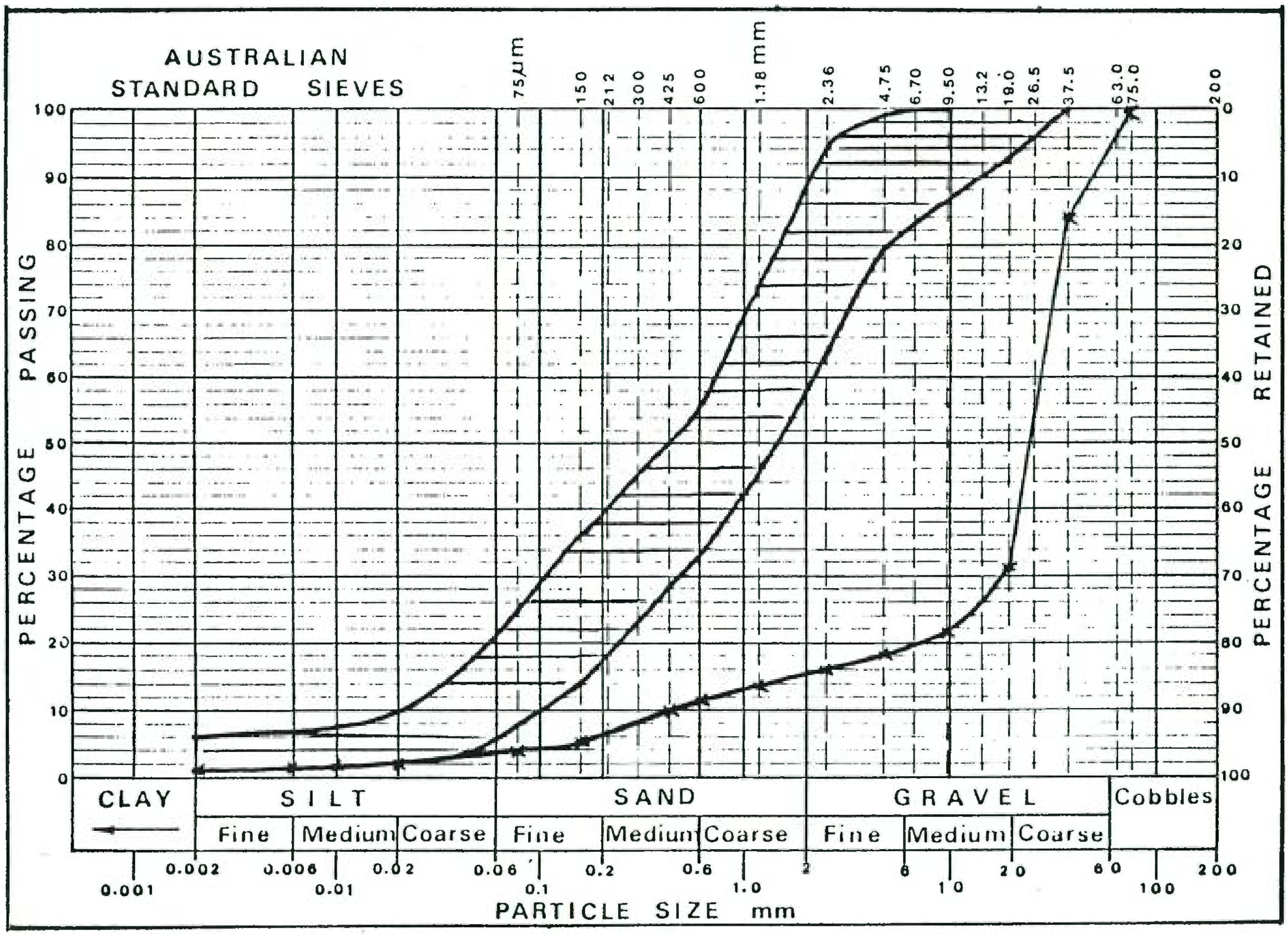

Figure 4.1: *Grading envelope of mill tailings. Single curve indicates non representative sample 9753.*

(Tadanier & Cantwell, 1986)

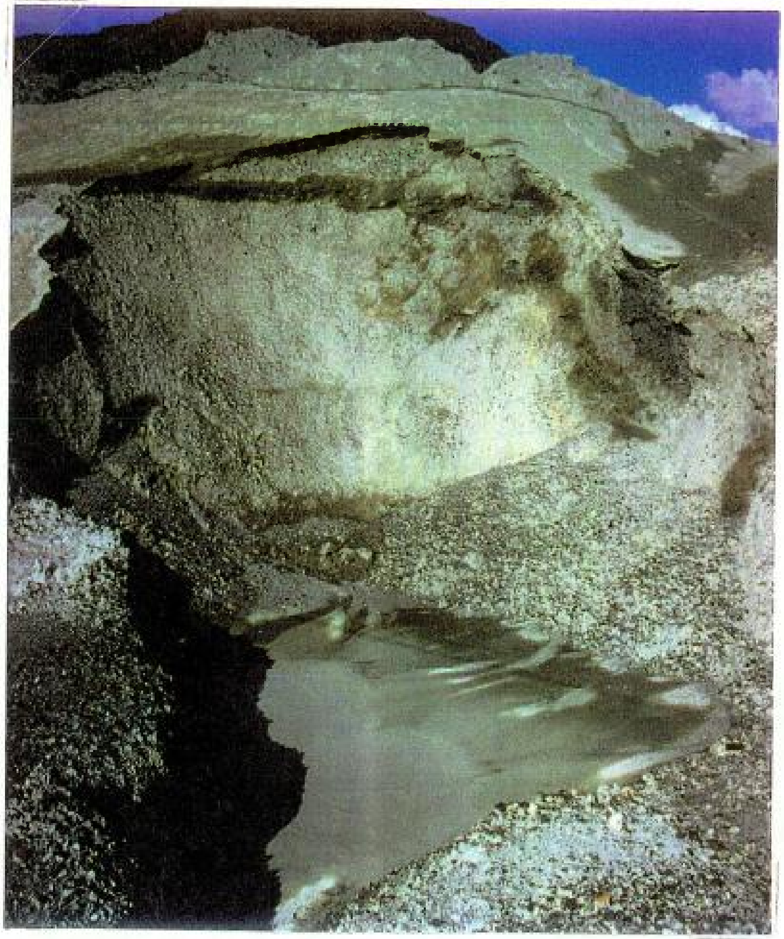

Figure 4.2: *Surface crusting on the tailings dump.*

Figure 4.3: *Eluviation of fines deeper into the profile of the southern waste rock dump, leading to a stable surface.*

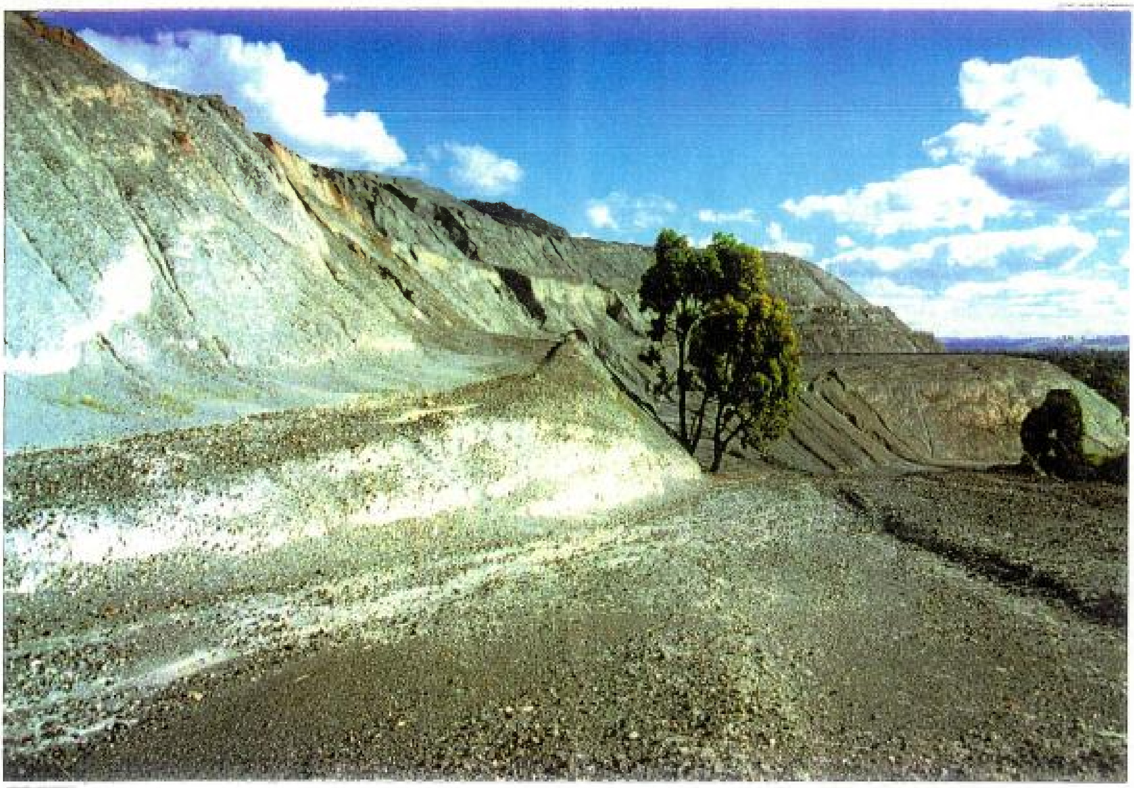

Figure 4.4: *Rill erosion along the western batters of the tailings dump.*

Figure 4.5: *Erosion of the access track and conveyer belt run, at the north west end of the tailings dump.*

content within the tailings dump. Compounded by its 30° to 40° slope, the batter requires re-grading to a suitable angle, otherwise collapse is inevitable. Batter collapse may only result at the toe of the dump and is likely to be contained by the settling ponds. As collapse is more likely to occur during a high intensity rainfall event, settling ponds would quickly exceed capacity and tailings would be transported into Ironbark Creek. Such a sedimentation event would significantly affect water quality, hydrology and aquatic environments down stream of the mine (Quinn et al, 1992 a & b).

The southern waste rock dump batter was also monitored using steel gauge posts. No significant movement recorded between 1989 and 1990. These batters are not stable as a number of breaches in the head bunds are evident, as well as severe rill erosion down the slope. These breaches probably occurred as a result of water ponding behind the coarse grained head bunds, with the resulting pressure causing failure. The two largest breaches occur on the southern side of the southern waste rock dump batter. The eastern most breach formed in January 1989 while the other is much older (Figure 4.8). Material scoured from current and future breaches poses a significant sedimentation hazard to Ironbark Creek and the settling dams below the waste rock dump, (Figure 4.9).

Concern exists over possible destabilisation of the tailings dump due to the lateral infiltration of drainage from the upper eastern catchments. Infiltration may cause the illuviation of fines from water-tailings interface areas creating tunnel erosion and internal destabilisation of the tailings dump. The Soil Conservation Service constructed three interception dams in 1992 in order to reduce the potential of this occurring. All dams were designed for a one in five year rainfall event. Dam A intercepts drainage from the eastern catchments and via an automated pumping system, transports water into Dam B. Dam B then overflows into Dam C from where the water is safely discharged into Ironbark Creek via natural drainage lines. The scheme has being successful in diverting drainage although it is only a temporary measure. Long term stability will require the implementation of other abatement strategies. This scheme is discussed further in Section 8.2 and APPENDIX IV, whilst dam locations are shown on the attached map.

4.2.2 Uncertainty

Risks associated with erosion of tailings and waste rock dumps have been reduced by the creation of settling ponds, diversion dams and interior drainage bunds. Effects of these risk reduction measures have not been quantified, therefore, uncertainty currently exists in relation to the impacts and rates of sedimentation that are likely to occur. Potential collapse of the southern batter of the tailings dump compounds the uncertainty associated with sedimentation. This lack of quantitative data relating to both the erosion and sedimentation hazards presented by the mine requires investigation before undertaking a risk assessment.

4.3 SOUTH AND NORTH PITS

The South and north pits are highly unstable, with the old benches susceptible to erosion and mass movement. Coffey & Partners Pty Ltd (1982a) investigated the stability of the north pit and determined that the benches were unstable particularly along the eastern wall, where tension cracks and scarps had developed. The western wall of the north pit also is unstable as indicated by bench deterioration and a large failure along the western rim of the pit. Three major factors contribute to the unstable nature of the pits:

- low sheared strength serpentinite zones within the massive serpentinite and harzburgite;
- orientation of the S1 schistosity; and
- orientation of the main joint sets that dip at 60-70°.

Before the Coffey & Partners Pty Ltd (1982a) investigation, Golder & Associates Pty Ltd monitored the development of tension cracks within the pits. Monitoring of pit stability was abandoned after mine closure as the pits did not present a hazard to the external environment.

4.4 PEEL THRUST FAULT

As mentioned in Section 2.2.3, seismic activity associated with the Peel Thrust Fault may have implications for site stability at the Woodsreef Asbestos Mine. Whilst the risk of significant seismic activity is not known, it should not be discounted. If a seismic event was to occur, the severity of subsequent impacts would be dependent upon its magnitude, epicentre location, climatic conditions and moisture content of the dumps at the time of the activity. Potential hazards associated with such an event could include mass movement, dump destabilisation and groundwater contamination. Any seismic event having these effects would lead to massive increases in background levels indicators like chrysotile, magnesium and sediments.

Seismic activity could potentially lead to the collapse of the pit benches, waste rock dumps or tailings dump, particularly the later. If the dumps collapse during dry conditions then the impacts are likely to be localised. Material is likely to be deposited at the toe of the dump, with short term increases in ambient chrysotile fibre levels. If the seismic activity were to occur under wet conditions then subsequent batter collapse would result in massive sediment movement in a similar scenario to that discussed in Section 4.1.3.

The disturbance of the consolidating material within the dumps, due to seismic activity, could potentially weaken any internal and/or external structure of the dumps. Cracking and slumping could make the dumps more susceptible to accelerated erosion in future rainfall and wind events.

Activity within the fault zone could also affect the stability of the pits through the development of cracks. The development of significant fissures could cause the pits to drain. The impact this would have upon the fractured ground water aquifers is uncertain, although it is likely to be minimal due to the current drainage of groundwater into the pits.

Figure 4.6: *Accumulation of mine derived sediment in the southern drainage channel. The grey sediment has formed a boggy substrate up to one meter deep.*

Figure 4.7: *Steel gauge posts on the southern batters of the tailings dump.*

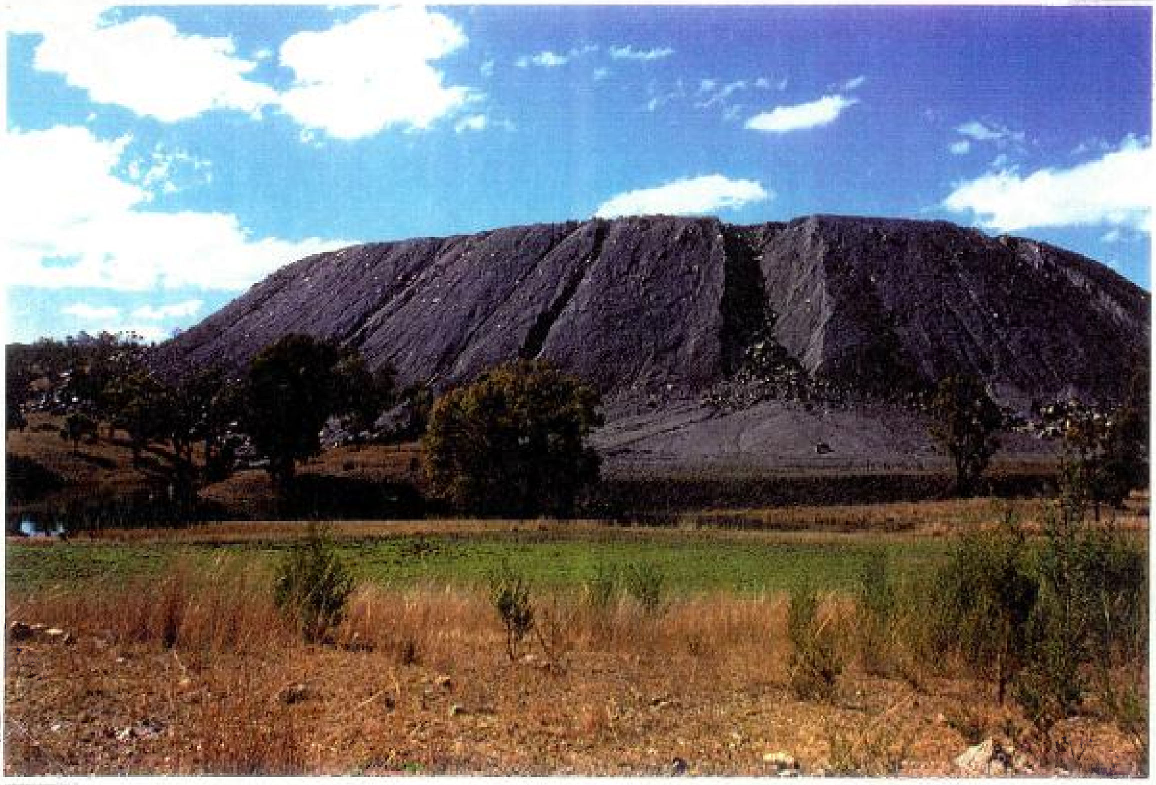

Figure 4.8: *A large breach in the south western batter of the southern waste rock dump.*

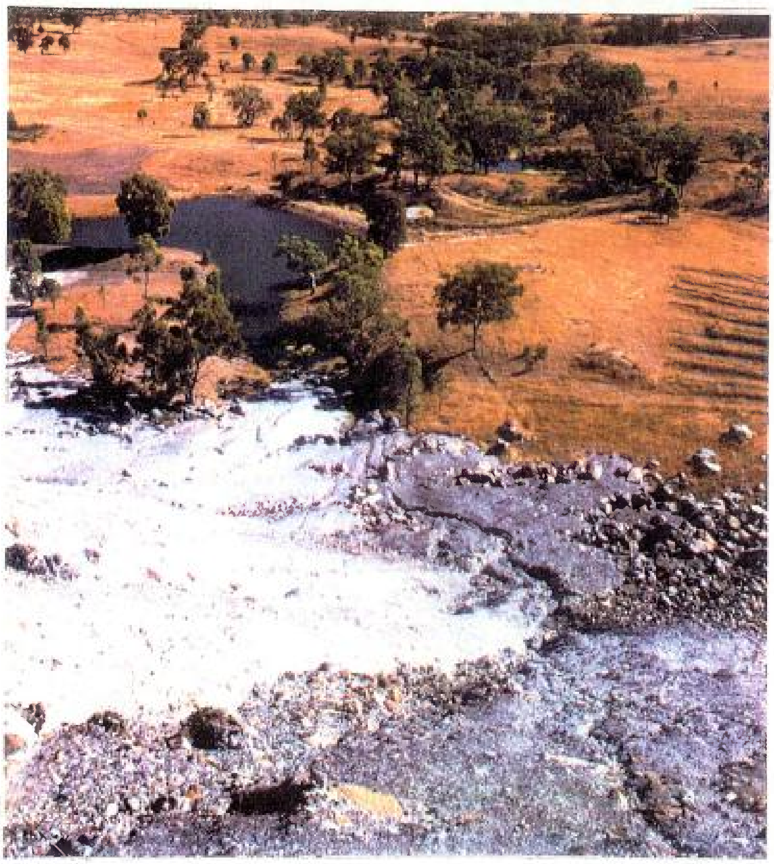

Figure 4.9: *Sedimentation of dam by material derived from the southern waste rock dump. (View from head of southern waste rock dump looking south)*

5 ASBESTOS

Asbestos is a common name applied to a group of hydrated silicate minerals that have a fibrous nature. There are two generic types of asbestos, those found within serpentine and those within amphibole deposits (MOD, 1993; MacNevin, 1970). The serpentine form was mined at the Woodsreef Asbestos Mine and is commonly called white or chrysotile asbestos. Whilst chrysotile is the only form of asbestos within the Woodsreef deposit, O'Hanley (1991) stated that tremolite asbestos was once a major constituent of the formation. Until it was replaced by lizardite±brucite mesh-rim textures, during the first period of serpentinization (O'Hanley & Offler, 1992).

5.1 TYPES OF ASBESTOS

There are two basic groups of asbestos, those with amphibole mineralogy and those with serpentine mineralogy. Chrysotile asbestos is the only member of the serpentine group and is a hydrated magnesium silicate. The amphibole asbestos group are also magnesium silicates, but contain high levels of iron and various amounts of calcium, sodium and fluorine (MOD, 1993). Compared to chrysotile, amphiboles have a rigid and brittle nature, forming sharp pointed needle - like fibres. Crocidolite (blue asbestos) and amosite (grey or brown asbestos) are the most common amphiboles. Others such as tremolite, actinolite and anthophyllite also have fibrous forms.

Table 5.1: *Chemical composition of asbestos minerals and non-asbestos forms (MOD, 1993).*

Asbestiform Variety	Chemical Composition	Non-Asbestiform Variety
Serpentine Group		
chrysotile	$Mg_3(Si_2O_5)(OH)_4$	antigorite, lizardite
Amphibole Group		
crocidolite	$Na_2Fe_3Fe_2(SI_8O_{22})(OH,F)_2$	riebeckite
amosite (grunerite)	$(Mg,Fe)_7(Si_8O_{22})(OH)_2$	cummingtonite-grunerite
anthophyllite	$(Mg,Fe)_7(Si_8O_{22})(OH,F)_2$	anthophyllite
tremolite	$Ca_2Mg_5(Si_8O_{22})(OH,F_2)$	tremolite
actinolite	$Ca_2(Mg,Fe)_5(Si_8O_{22})(OH,F)_2$	actinolite

Chrysotile asbestos has a monoclinic crystal structure which occurs in fractures, as stockwork veins or in pyroxene cleavage in serpentinite (MacNevin, 1970). Ranging from apple to dark green in colour, the mineral turns white when fibreised, taking on a soft wavy flexible fibre morphology as (Figure 5.1). This wavy and flexible morphology is influenced by the concentrations of iron and water within the fibre, with relatively high iron and low water concentrations lead to harsher mineral fibres (MacNevin, 1970). Woodsreef chrysotile has an iron content of 4.56% and water content of 15.42% (Raggatt, 1924). This composition has created a slightly harsher fibre compared with chrysotile mined at Theford, Canada (Becker

& Haag, 1928), and Barberton, South Africa (Hall, 1930). Another important morphological feature of chrysotile is its susceptibility to decomposition by acids and seawater. Consequently, is not as chemically or physically durable as the amphibole asbestos.

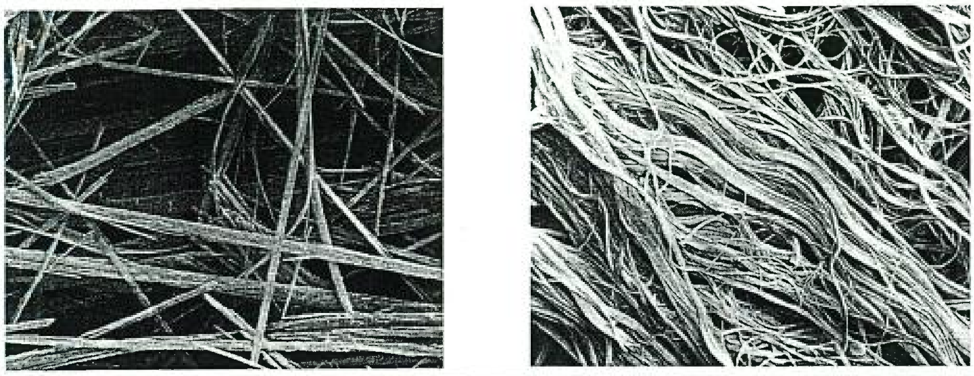

Figure 5.1: *Photomicrographs comparing crocidolite and chrysotile fibre morphology (MOD, 1993).*

5.2 ASBESTOS SCARE AND PUBLIC CONCERN

Using the term asbestos to define both the amphibole and serpentinite fibrous minerals, has led to a great deal of confusion and misinformation about chrysotile within the community. Confusion arises in situations where specific studies on amphiboles, such as crocidolite, continually refer to the study fibre as asbestos. It is common to have such findings, through misinterpretation and ignorance, relayed throughout the community as facts relevant to all types of asbestos. This action fosters anxiety which is the foundation of the so called *asbestos scare*.

These perceptions are difficult to overcome once established within society, due to continued ignorance or deliberate scare tactics (Brookins, 1990). Generally the media, government departments and lobby groups compound the problem. A recent example of such actions occurred after a Worksafe organised symposium on asbestos in the workplace where it was reported in the media that Australia had the highest rate of asbestos related mesothelioma in the world. Whilst this may be true, no indication was given as to the type of asbestos involved and the workers' exposure history.

Whilst lobby groups, such as the European based *Ban Asbestos*, continually advocate a total band of asbestos and asbestos products, the U.S. Fifth Circuit Court of Appeals ruled against a proposed ban in the United States of America. The American Federal EPA proposed to ban all types of asbestos, declaring them dangerous materials under the US Toxic Substances Control Act. However, Justice Drost's ruling concluded that while all asbestos fibres are hazardous the risks associated with chrysotile are significantly less then the amphiboles (Warren, 1994). Drost stated that a blanket ban was inappropriate and that "*... the agency, inadvertently, may actually increase the risk of injury Americans face ...*" Justice Drost's findings indicate that the risks associated with chrysotile asbestos are not as severe as public opinion suggests (Warren, 1994).

The Barraba community is no exception, as concerns have been raised on several occasions relating to the hazards presented by the Woodsreef Asbestos Mine. Several letters received by Barraba Shire Council express concern over the levels of airborne chrysotile within the town and the potential health risks associated with the fibres.

5.3 ASBESTOS PATHWAYS

At Woodsreef Asbestos Mine chrysotile exposure to humans can occur through two basic pathways, waterborne and airborne (Figure 5.2). Whilst both these pathways exist naturally, a considerable increase in levels is expected because of the mine.

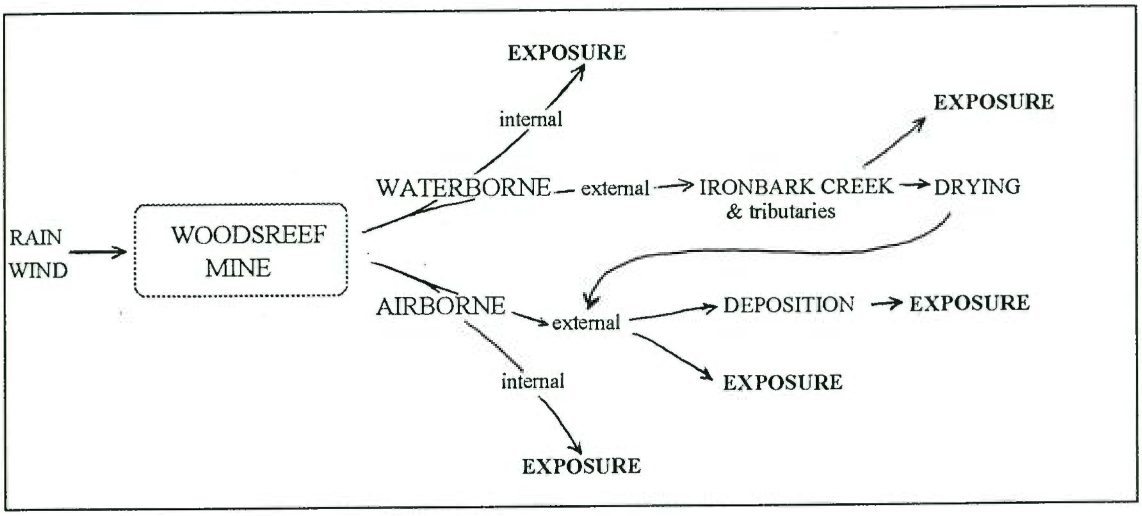

Figure 5.2: *Schematic diagram of the potential asbestos pathways.*

5.3.1 Waterborne

The chrysotile fibre load of external mine waters is likely to have decreased since mine closure, due to improvements in internal drainage systems, development of settling ponds and water diversion dams. These structures reduce the quantity of water entering Ironbark Creek, particularly along the southern boundary of the mine. However, seepage from the northern and western boundaries has not been significantly altered by these structures. It is unlikely that this water collects significant amounts of sediment as the seepage process is likely to have a filtering affect.

Internal drainage waters are likely to still carry a high chrysotile fibre loading. When considering the water is regularly consumed by the site caretaker, internal drainage water posses the biggest potential health hazard if current opinion on ingested fibres changes.

5.3.1.1 Hazards

Hazards associated with water borne asbestos are considered relatively minor, provided the chrysotile fibres remain within the water column or at least sufficiently moist so as to prevent the fibres becoming airborne.

Toyer (1981) stated that questions concerning hazards associated with the ingestion of chrysotile remain unresolved due to the time interval between exposure and illness. Whilst this uncertainty remains, there is no consistent evidence that ingested asbestos is hazardous to health (WHO, 1986 & 1993, Anon, 1991). Separate investigations by Polissar et al. (1982) and MacRae (1988) into the affect ingested chrysotile fibres found no significant increases in the incidence of gastrointestinal tumours, or any other pathological problems. Chrysotiles' susceptibility to chemical and acid breakdown is the likely reason ingested fibres do not lead to health problems (MacNevin, 1970).

Environmental hazards arising from waterborne chrysotile relate to its flocculating nature that may have implications for the substrate, filter feeding organisms and watercourse vegetation as shown in Figure 5.3. These hazards have not been investigated at Woodsreef nor are they reported in the literature or. It should be noted that background fibre levels naturally exist, the hazard lies with increased fibre levels due to the existence of the derelict mine.

Toyer and Main (1978) undertook preliminary studies in waterborne fibre levels in both Ironbark Creek and the south pit. Unfortunately, the methods adopted for the study used an optical microscope which excluded fibres below 5μm in length. This led to counts that were not representative of the fibreload and thus invalid. American studies indicate that at least 50% of fibres are below 5μm in length. However, this percentage is site specific as each chrysotile deposit has fibres of various lengths depending on vein structure.

5.3.1.2 Risk

Current literature indicates the ingestion of chrysotile bearing waters is not likely to impact upon the health of the consuming organism. While this implies an extremely low risk at various levels of exposure, both the background and mine derived chrysotile levels within the water column need to be determined. This will assist in quantifying other environmental hazards. Background levels of asbestos within the water column can reach levels of 10^6 fibres per litre, whereas milling and mining practices can produce levels up to 10^{12} fibres per litre (Toyer, 1991).

5.3.2 Airborne

Chrysotile asbestos is most hazardous to human health when it becomes airborne and is inhaled. The health risks associated with inhaling chrysotile fibres depend upon the exposure period, ambient concentration of fibres and fibre morphology. Since mining operations have ceased at Woodsreef the levels of airborne chrysotile fibres are likely to have dropped significantly, and thus so have the risks associated with the airborne fibres.

5.3.2.1 Hazard

The basic hazard associated with the inhalation of chrysotile fibres is the potential for respiratory tract disease. These diseases are common to both amphibole and chrysotile asbestos, and include asbestosis, lung cancer and mesotheliomas. As previously stated, the inherent potential of chrysotile to induce the development of these diseases is considerably less than amphibole asbestos (McConnel et al., 1994; Churg & Vedal, 1994).

Chrysotile retention in the lung, compared with other amphibole fibres, is relatively short, particularly where exposure is low and no other substances such as tobacco smoke influence retention (Albin et al., 1994; Browne, 1994; Churg & Vedal, 1994). This short retention time is due to the susceptibility of fibres to chemical breakdown, with rapid dissolution occurring in the lungs and pleural mesothelial cells. Chrysotile, having generally shorter fibres, tends not to generate the quantity of active oxygen species, which are linked to cell damage by alveolar macrophages (Hansen & Mossman, 1987).

A great deal of concern has been expressed within the Woodsreef and Barraba region in relation to the potential of airborne chrysotile fibres diminishing air quality and causing health problems. Ambient chrysotile asbestos levels have not being assessed within the Barraba township. They are most likely low, however, due to the direction of prevailing winds (Figure 5.5). Mortality studies within towns situated close to working chrysotile mines in Eastern Canada indicate no significant increases in mortality or in the incidence of either lung cancer, mesothelioma or other asbestos-related respiratory diseases (Churg, 1986; McDonald, 1985; Pampalon et al, 1982), despite pulmonary concentrations 5 to 10 times higher than those in residents from non contaminated regions.

The environmental hazards associated with airborne chrysotile fibres include the potential smothering of vegetation and modification of the soil nutrient composition. In proportion to other airborne dust from the site, chrysotile fibres only play a minor role in these processes.

5.3.1.2 Risk

The current airborne chrysotile exposure standard recommended by the National Occupational Health and Safety Commission is 0.5 f/ml, where fibre diameter is less than 3 μm and longer than 5 μm. The threshold is a cautious estimate of risk and is currently under review (Warrick Tiers, pers. comm. 15/6/1996). Current studies suggest a higher threshold would not increase the risk of respiratory tract disease (Browne, 1994).

Studies indicate no significant increase in mortality after 15 fibre years (Weill, 1979) and 10-25 fibre years (Ohlson & Hogsted, 1985). Doll and Peto (1985) suggest an exposure threshold for asbestosis of 25 fibre-years (1 f/ml for 25 years), would not increase the risk of asbestosis development. Varying exposure thresholds have being suggested for lung cancer of 3 f/ml indefinitely (Browne, 1994) or 30 fibre-years (Anon, 1994). A much lower risk threshold of around 5 fibre-years (1 f/ml for 5 years) is suggested for mesotheliomas (Browne, 1994).

These thresholds do not take into account compounding factors that increase risk by attenuating the lungs' defence mechanisms. The presence of substances such as tobacco smoke and dust can cause longer retention of chrysotile fibres in the lungs and thus increase the risk of disease. Increased risk of lung cancer is also recognised as being related, not to levels of inhaled chrysotile, but to the development of asbestosis (Browne, 1994). This is related to the fact that mineral fibres act as promoters but not initiators of cancer. Groups of workers who have been exposed to levels of 1 to 45 f/ml exhibit no significant increase in lung cancer (Churg, 1993; McDonald et al., 1993).

Although the chrysotile risk threshold of 0.5 f/ml has been established, no current data exists to quantify the onsite and offsite risks associated with airborne asbestos from Woodsreef Mine. Previous monitoring was undertaken during mine operation in 1981-82, site investigations in 1984 and erosion stabilisation work in 1992.

During mine operation, between 1981 and 1982, no recorded ambient fibre concentration was greater than 10 f/ml, about 72% of samples were below the then accepted threshold of 2 f/ml. With the exception of 1984, ambient concentrations of chrysotile fibres were appreciably higher due to disturbance and thus not applicable to current conditions. The 1984 data indicates that current ambient levels of chrysotile are likely to be below recommended threshold level of 0.5 f/ml, as background counts were 0.02 f/ml.

5.4 ASBESTOS SOURCES WITHIN WOODSREEF MINE

5.4.1 Tailings Dump

The tailings dump contains approximately 24 million tonnes of fine material, 600,000 tonnes (2.5%) of which is refuse chrysotile fibres. As previously stated, the dump exhibits surface crusting, below which the tailings remain relatively moist (Terry, 1995). The risk of airborne chrysotile from the tailings dump is unlikely, with ambient levels of ≤ 0.2f/ml recorded in 1984.

5.4.2 Waste Rock Dumps

The waste rock dumps are potentially a major source of chrysotile fibres, as a large amount of ore is held within them. Illuviation of the fines into the profile has reduced the risk of movement by erosion either by wind or water. Fibre levels of these dumps is considered to be significantly less than the tailings dump.

5.4.3 Ore Stockpiles

Two small ore stockpiles are located within the mine and they contain high amounts of chrysotile. The chrysotile contained within the stockpiles is not fibreised and in many cases is still bound within the serpentinite ore rock. However, exposed ore rocks on the surface of the stockpiles have undergone significant weathering and crumble when disturbed, exposing the hardier veins of chrysotile.

5.4.4 Pits

South and north pits contain 5.4 and 12.1 million tonnes of chrysotile ore respectively. The walls of these pits are highly unstable under wet conditions, with the benches susceptible to erosion and mass movement (Figure 5.4). Such events are unlikely to influence ambient fibre levels because low levels of dust occur under wet conditions when events are likely to occur.

6 CHEMICAL WATER QUALITY

Contaminated waters emanating from the Woodsreef Asbestos Mine have the potential to reduce water quality within Ironbark Creek. Concern exists over the chemical characteristics of the leachate and runoff water emanating from the tailings and waste rock dumps, particularly as Split Rock Dam is located 10 km downstream of the mine. Of most concern is the possible mobilisation of metal ions particularly magnesium and potential alkaline leachate from the ultra-basic serpentinite ore.

Two separate studies have been undertaken to asses water quality hazards associated with drainage waters. The first was a comprehensive water quality assessment undertaken by Toyer and Main in 1978. Samples were collected in October 1977, March 1978 and August 1978 from 16 monitoring sites, shown in APPENDIX IV. The second sampling study was a monitoring program, initiated by Woodsreef Mines (Stewart, 1985). Samples were collected from October 1979 to October 1980 and again between March and June 1984, at the two sites shown in APPENDIX IV.

6.1 SUMMARY OF RESULTS

The investigation by Toyer & Main (1978) showed that leachate from the dumps did not impair the useability of the water within Ironbark Creek. All the assessed chemical parameters were below the criteria outlined in the current Australian Drinking Water Guidelines (1994). Significant increases in magnesium, alkalinity and electrical conductivity occurred in Ironbark Creek. These higher levels were caused by the inflow of mine drainage and steadily increased downstream due to further confluence of mine drainage, (Figure 6.1). Samples from the Manilla River (site WR-1) indicate that these high levels do not persist in Manilla River or Split Rock Dam principally due to dilution effects. This is supported by the Department of Land and Water Conservation, who undertake routine water sampling at site WR-1 as well as within Split Rock Dam and have recorded no adverse levels of these parameters have been recorded (Peter Huhta, pers. comm. 27/3/96).

The Woodsreef Mine survey indicated that the influence the mine drainage on Ironbark Creek was amplified during periods of low flow (Toyer & Main, 1978). This is due to the capacity of the tailings and waste rock dump to hold and retain water, leading to the attenuation in drainage flow.

Figure 5.3: *Chrysotile forming mats on couch grass along drainage lines.*

Figure 5.4: *Mass movement within the North Pit*

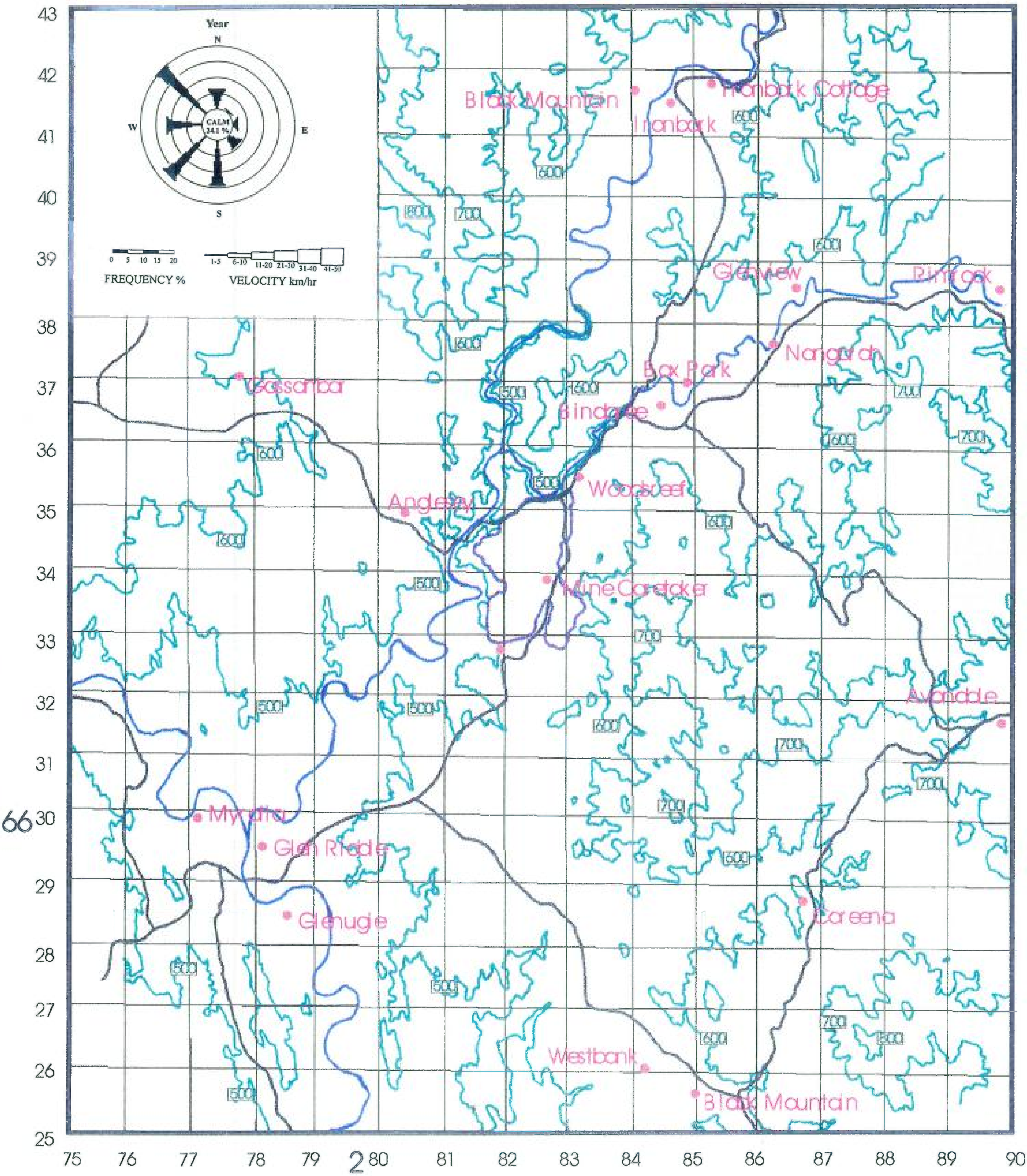

Figure 5.5: *Occupied dwellings surrounding Woodsreef Asbestos Mine, with annual wind rose.*

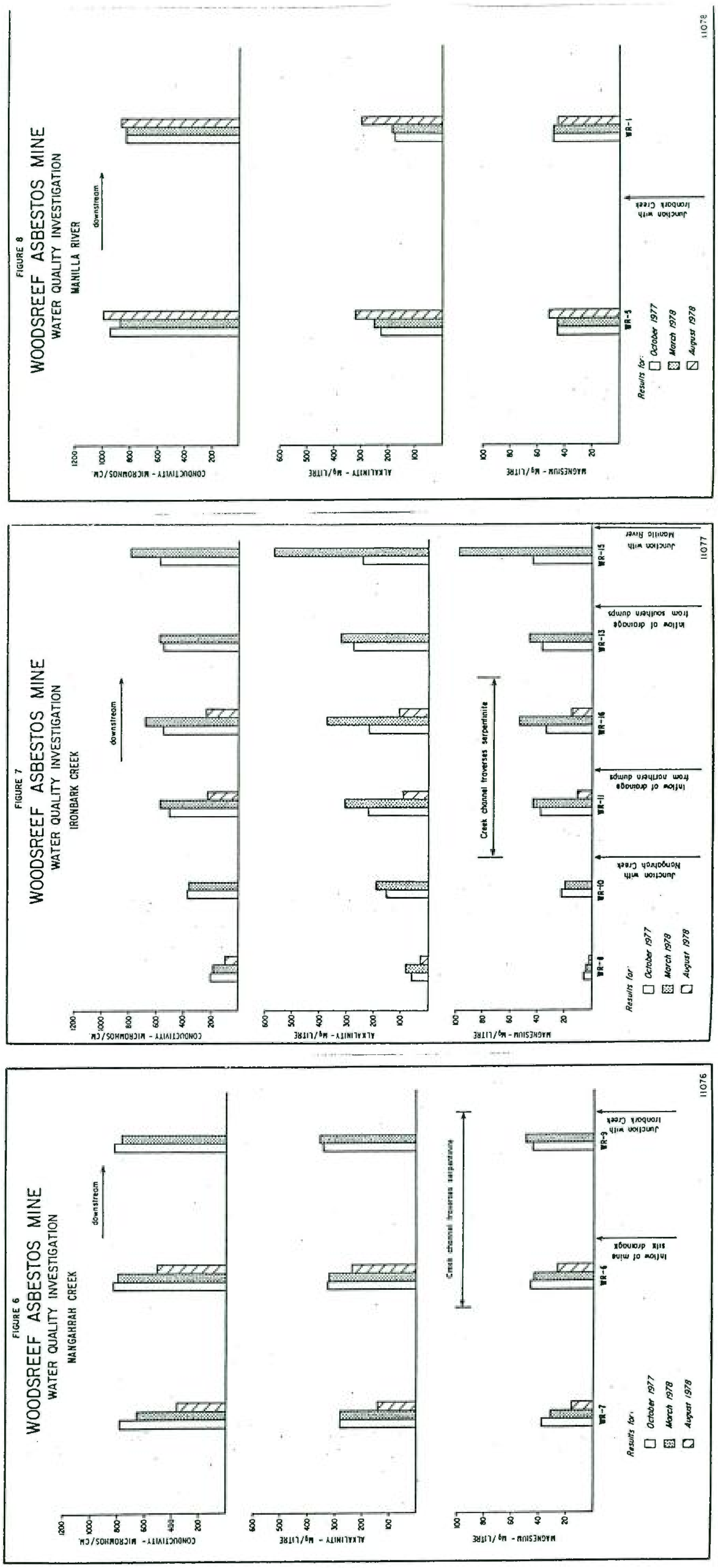

Figure 6.1: *Increases in the chemical parameters magnesium, alkalinity and electrical conductivity, at sites along Ironbark Creek (Toyer & Main, 1978).*

7 RELATED ANTHROPOCENTRIC CONCERNS

7.1 VISUAL IMPACT

Woodsreef mine is generally considered an eyesore, and calls for rehabilitation often allude to this concern. This mine site can be recognised from as far away as Mt Kaputar, (a major vista point for the south western slopes). However, at this range it is not offensive. The mine is first noticeable on the Barraba approach from 7.3 km away (Stewart, 1985).

With limited revegetation, the mines stark grey-white colouring is in total contrast to the surrounding agricultural and bushland environments. This is compounded by the large seven-storey mill building and associated structures, most of which are in disrepair and are surrounded by scattered refuse. This is particular noticeable along the Crow Mountain Road, (Figure 7.1).

7.2 SITE SAFETY

The general public have being observed trespassing within the Woodsreef Mine site on several occasions, mainly above the North Pit and on the tailings dump. Whilst no instances of injury have been reported, the risk posed by the various hazards of the mine site are high.

A standard star post and plain wire perimeter fence extends around the mining area, with an additional section of man-proof chain mesh fence around the mill. Several warning signs have also been posted on the perimeter fence indicating the hazards of the mine. In many instances these exclusionary precautions are inadequate to prevent trespass. For example, sections of the fence around the tailings dump have being completely buried by tailings sediment, through the processes of runoff and deposition. In respect to the pit, the perimeter fence is an inadequate deterrent as shown in Figure 7.2. This area is the most common site of trespass.

Figure 7.1: *Refuse within the mine site (view from Crow Mountain Rd)*

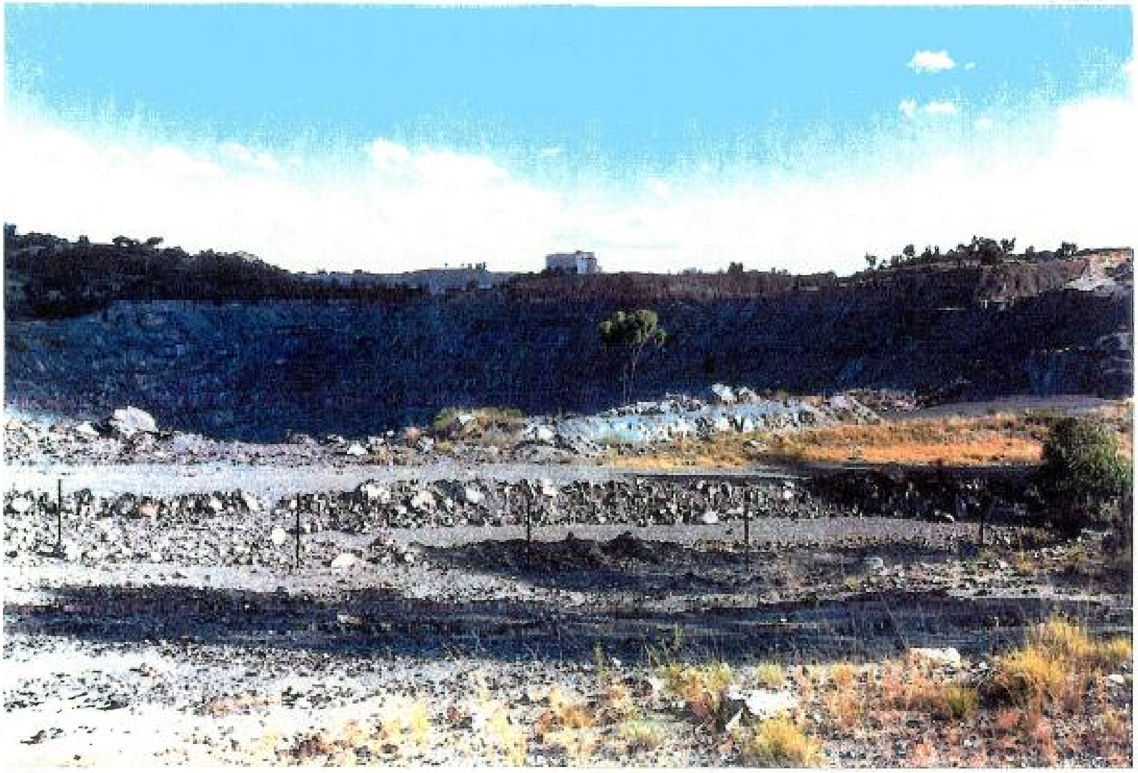

Figure 7.2: *Plain wire perimeter fencing above the North Pit*

PART THREE

EXISTING & PROPOSED WORK

8 EXISTING REMEDIATION WORKS

Revegetation trials and sedimentation and erosion control structures are the extent of remediation work carried out at the derelict Woodsreef Asbestos Mine. These measures were intended as preludes to site rehabilitation, however, limited funding and uncertainty over the mine's future has prevented the implementation of rehabilitation plans.

8.1 REVEGETATION

Revegetation is considered a major step in the rehabilitation of the mine, as it improves dump stability and visual amenity. Analysis indicates, however, that the waste rock and tailings substrates are unsuitable for plant establishment, due to an adverse calcium/magnesium ratio, low nutrient status and high levels of nickel and chromium. Consequently eleven revegetation trials have been undertaken (Figure 8.1) to determine suitable substrate and planting mixtures.

8.1.1 Corporation Trial Plots

Nine trial revegetation plots were established by the Corporation, eight prior to mine closure and one after the wet processing trials in 1984. Plots incorporating a topsoil treatment exhibited superior plant establishment and continued growth, compared to other trialed substrates. Plot 1 (Figure 8.1 & 8.2) is the most successful of the top soil trials, supporting healthy specimens of planted *Eucalyptus sideroxylon, E. cladocalyx*, *Acacia cynaophilla*, *Casuarina cunninghamiana*, couch and native grass species. Native grasses were also used to vegetate other topsoil trials, plots 3, 5 and 6 (Figure 8.3).

The revegetated wet process tailings dump, plot 9 (Figure 8.1), is located directly north of the trial wet processing plant. Capped with waste rock and ridge gravel the dump was partially overlaid with top soil. Locally sourced and imported seedlings were planted in the prepared substrate, with good establishment and continued growth exhibited.

8.1.2 Mineral Resources Trials (waste rock)

The Department of Mineral Resources are currently trialing direct sowing techniques for the establishment of vegetation on the western waste rock dump. Using *Asteraceae* and *Acacia* species, limited germinated has occurred although it should be noted that the plants vigour and general health are poor due to the harsh substrate.

8.1.3 Native Colonisation

Despite the arduous growing conditions of the tailings and waste rock dumps, limited vegetative colonisation has occurred. Native grasses have established within trial rehabilitation plots (Figure 8.3) and in the depressions of the waste rock dumps, where fines appear at the surface.

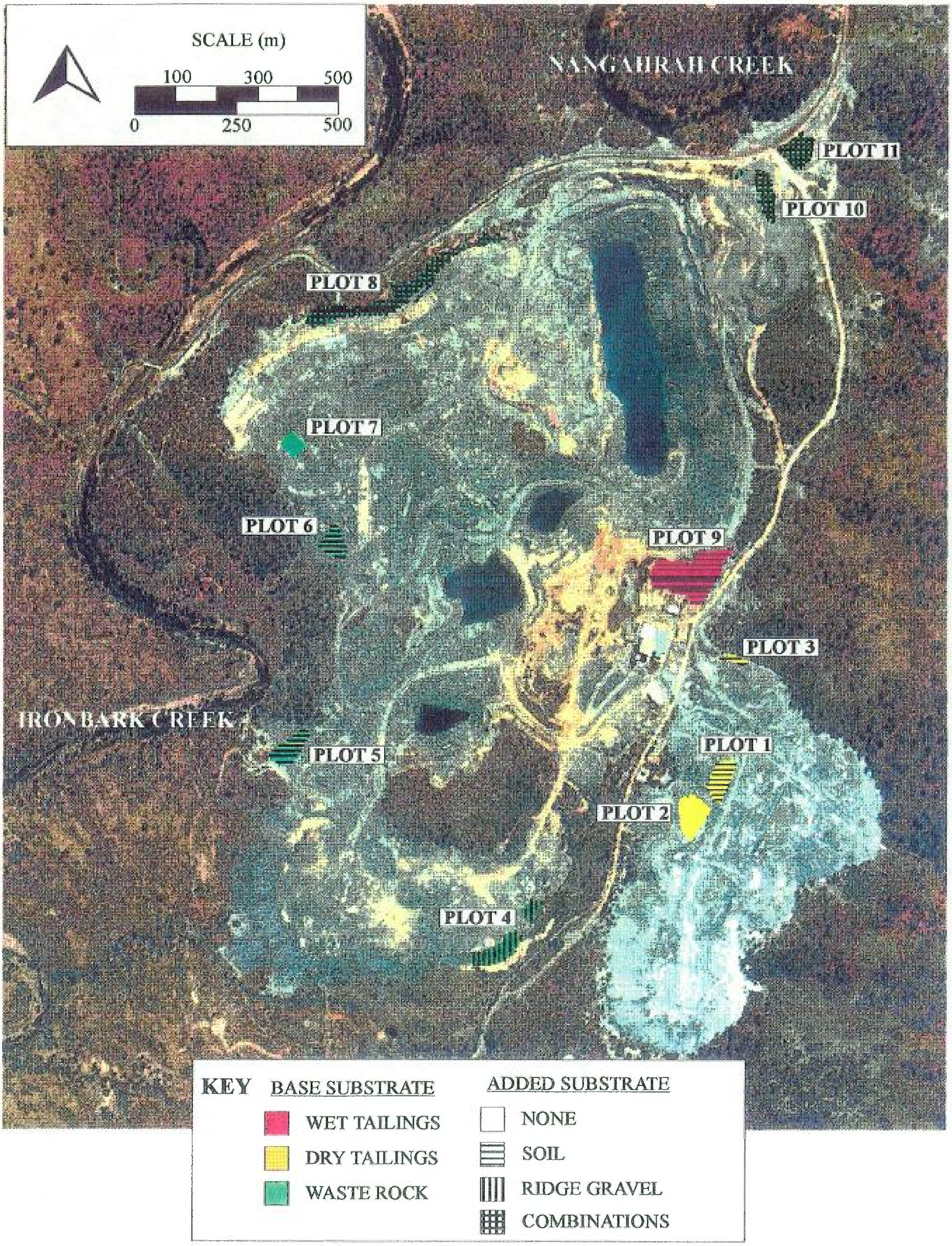

Figure 8.1: *Revegetation trials undertaken at Woodsreef Asbestos Mine, site location map.*

Figure 8.2: *Successful trial revegetation plot on the tailings dump, using a soil substrate (plot 1).*

Figure 8.3: *Dumped soil supporting natural herbaceous growth, on the south western batter of the western waste rock dump (plot 6).*

8.2 SEDIMENTATION & EROSION CONTROL

Sedimentation of local waterways is a major hazard associated with the derelict Woodsreef Asbestos Mine. In 1992, the Soil Conservation Service established sediment control structures, to reduce the hazards presented by mine derived-sediment. Three divergence dams were constructed, aimed at preventing runoff from eastern catchments influencing the stability of the tailings dump. The first dam (DAM A, Figure 8.4), is designed for a 1 in 5 year storm event within its 100 ha catchment. With a capacity of 19,500 m^3 stored water is evacuated from DAM A into DAM B (Figure 8.4), through an automated pontoon pumping system. Dam B holds 30,000 m^3 which is collected from its 10 ha catchment and water pumped from DAM A. DAM B overflows into DAM C, which has a capacity of 19,000 m^3. In addition to this DAM D (Figure 8.4) was constructed and internal drainage systems were improved. A breakdown of associated costs is given in APPENDIX V.

Prior to mine closure the Corporation constructed settling ponds, shown in Figure 8.4, in accordance with recommendations made by Toyer and Main (1978). These ponds, however, are only considered to be short term solutions, as the company was looking to re-mill the tailings using wet processing around 1977.

9 PROPOSED WORKS

A variety of work has being proposed for the Woodsreef mine site, however, has failed to come to fruition due to a variety of reasons. These proposals are outlined below.

9.1 REHABILITATION STRATEGIES

Various rehabilitation strategies have being proposed for the Woodsreef mine, however, none have been implemented due to financial restrictions and site uncertainty. Strategies were developed by the Corporation and the Soil Conservation Service, with the Department of Mineral Resources and CSIRO contributing.

In 1980 the Soil Conservation Service suggested the tailings batters be reshaped to a maximum slope of 10°. Followed by tailings encapsulation with 30-40 cm of waste rock then top dressing. Revegetation trials incorporating plant species such as *Medicargo sativa* and Lap Lap purpureus under various fertiliser and gypsum rates. Other native species, such as *Eucalyptus crebra, E. punctata,* and *Acacia hakeoides* were also suggested for possible trial plots. These were later reaffirmed by recommendations for rehabilitation trials offered by Soil Conservation Service in 1982, as shown in APPENDIX IV.

The Soil Conservation Service also recommended four substrate/revegetation trials to be carried out in plot 8 (Figure 8.1) on the waste rock dumps. However, inadequate rain and followed by mine closure prevented these trials from developing further then ground preparation. The treatments were;

❶ Top soil, gypsum, phosphate and seeding

KEY MITIGATION STRUCTURES

- INTERCEPTION DAMS (1992)
- SETTLING PONDS (< 1983)
- DRAINAGE BUNDS

DRAINAGE

- INTERNAL
- EXTERNAL (FREE)
- EXTERNAL (MITIGATED)

Figure 8.4: *Sedimentation and erosion control structures, site location map.*

❷ As above but using an environmat covering

❸ Hydromulching, containing seeds at a cost of $5000/ha (1982 quote)

❹ Bitumen emulsion, containing seeds at a cost of $5000/ha (1982 quote)

Other recommendations on revegetation are summarised in APPENDIX V.

9.1.1 Barraba Mine Rehabilitation Feasibility Study

In October 1986 a confidential report entitled Barraba Mine Rehabilitation Feasibility Study was finalised. An interdepartmental project the report proposed two rehabilitation strategies, the removal of tailings (A) and the encapsulation of tailings (B). In addition, revegetation plans were developed which aimed to increase the visual amenity of the derelict mine. Neither A, B or the revegetation strategies were adopted, however, due to funding limitations and concern from the mining sector pertaining to the sterilisation of the refuse and ore chrysotile.

9.1.1.1 Strategy A : Removal of Tailings

Strategy A (Figure 9.1) has three main components, the initial removal and deposition of tailings into the north pit, re-grading of the batters on the waste rock dumps and revegetation of tailings dump area.

9.1.1.2 Strategy B : Encapsulation of Tailings

Strategy B (Figure 9.2), detailed three viable methods of encapsulation using, vegetation and soil, waste rock only and, vegetation and soil combined with waste rock. These methods all required the re-grading of the tailings batters to a slope of 1.5:1, as outlined by the slope stability report within APPENDIX V.

9.2 WET TAILINGS PROCESSING

The mining sector has continued to show a great deal of interest in the Woodsreef site, in particular the refuse chrysotile held within the tailings dump and the remaining ore within the North Pit. Expressions of interest have been shown by Chrysotile Corporation of Australia in 1985 and a Mineral Commodities/Black Hill Minerals consortium, Marrall Pty Ltd in 1991.

The interest was in developing a wet processing mill at Woodsreef to re-mill the tailings and potentially the north pit. The feasibility of the operation was proven by an on site pilot mill, however, concern over the hazards associated with the use of chrysotile and an uncertain market led to the project not being developed.

Mineral Commodities postulated that the cost of a wet processing mill, with a two million t/a capacity, would be approximately $15 million. With an estimated production of 600,000 tons of chrysotile the operation would generate $300 million in revenue. From this the government would receive 4% due to royalties, approximately $12 million. The Department of Mineral Resources

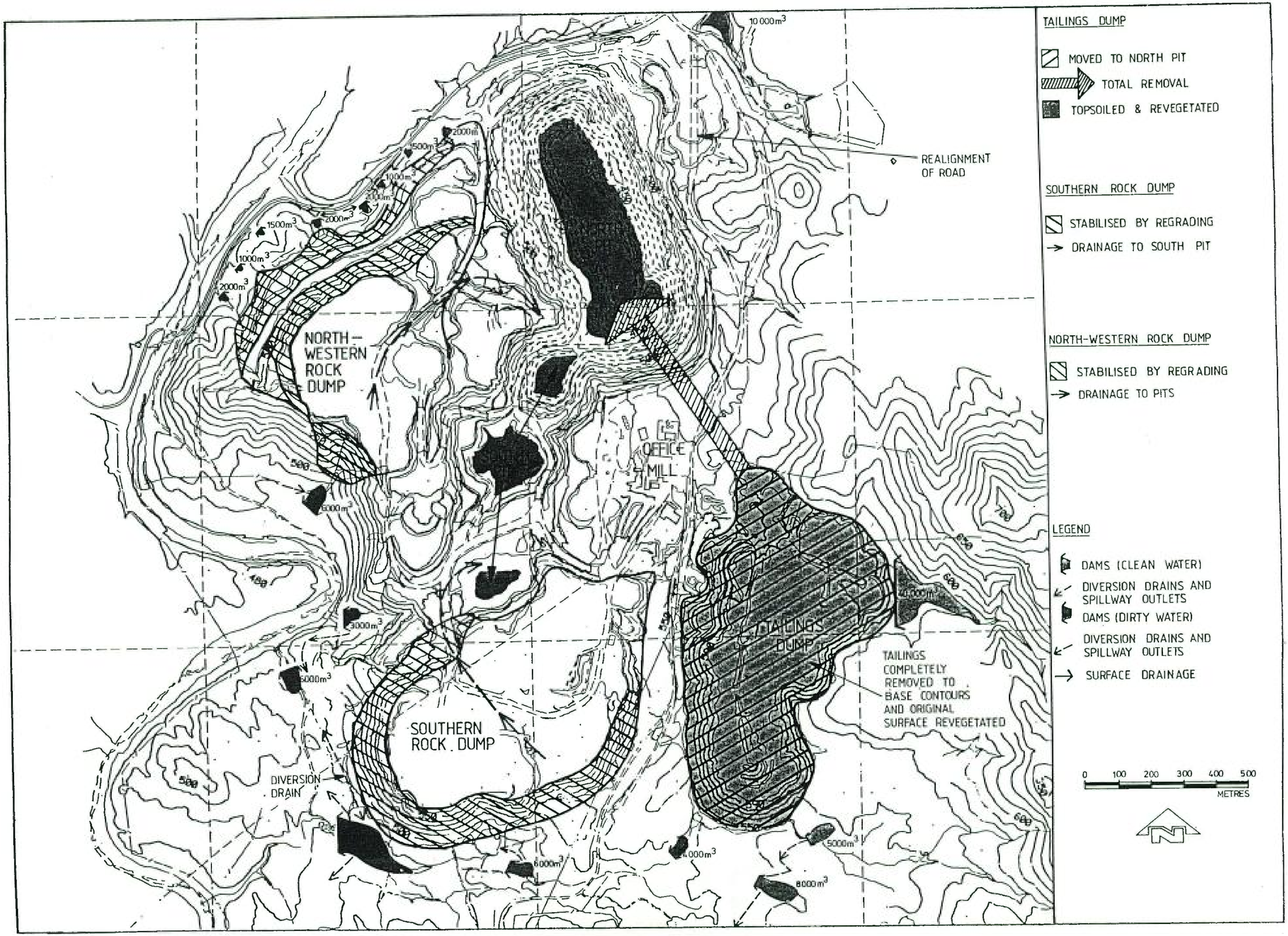

Figure 9.1 : *Strategy A : Removal of Tailings schematic summary.*

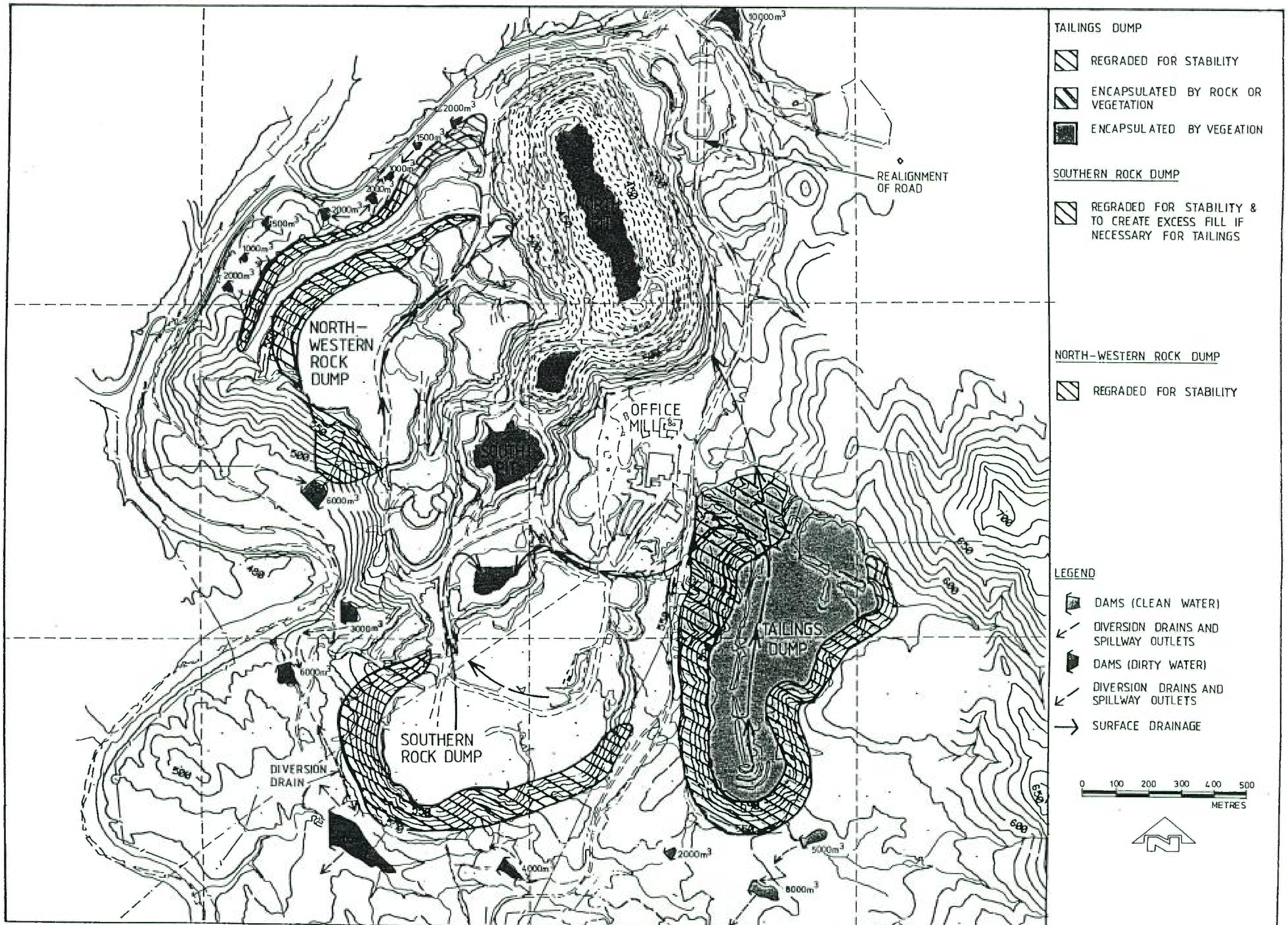

Figure 9.2 : *Strategy B : Encapsulation of Tailings schematic summary.*

TABLE 6A

ECONOMIC COMPARISON OF STRATEGY A - TAILINGS REMOVAL

	Options Involved	Cut to Fill (m^3)	Rate ($/$m^3$)	Cost ($)	Cut, Haul, Fill (m^3)	Rate ($/$m^3$)	Cost ($)	Revegetation (m^2)	Rate ($/$m^2$)	Cost ($)	Other Items ($)	TOTAL COST
STRATEGY A.1 (Hydraulically)												
Tailings Dump	T1	-			14,650,000	5.20	76,180,000	470,000	2.30	1,081,000		
Southern Waste Rock Dump	S1	310,000	1.25	387,500	-			-			as below	
North-Western Waste Rock Dump	N1	200,000	1.25	250,000	-			-				
TOTAL		510,000		637,500	14,650,000		76,180,000	470,000		1,081,000	2,805,000	$80,703,500
STRATEGY A.2 (Conveyor)												
Tailings Dump	T2	-			14,650,000	5.00	73,250,000	470,000	2.30			
Southern Waste Rock Dump	S1	310,000	1.25	as above	-			-	2.30	as above	as below	
North-Western Waste Rock Dump	N1	200,000	1.25		-			-	2.30			
TOTAL		510,000		637,500	14,650,000		73,250,000			1,081,000	2,805,000	$77,773,500
STRATEGY A.3 (Truck & Loader)												
Tailings Dump	T3	-			14,650,000	3.00	43,950,000	470,000	2.30			
Southern Waste Rock Dump	S1	310,000	1.25	as above	-			-	2.30	as above	as below	
North-Western Waste Rock Dump	N1	200,000	1.25		-			-	2.30			
TOTAL		510,000		637,500	14,650,000		43,950,000			1,081,000	2,805,000	$48,473,500

Other Items:

Erosion control & drainage	455,000
Topsoil carting road	31,000
Mill building demolition	30,000
Crow Mt. Road re-alignment	36,000
Other Costs	1,750,000
Maintenance (present worth)	503,000
	$2,805,000

TABLE 6B

ECONOMIC COMPARISON OF STRATEGY B - TAILINGS ENCAPSULATION

	Options Involved	Cut to Fill (m^3)	Rate ($/$m^3$)	Cost ($)	Cut, Haul, Fill (m^3)	Rate ($/$m^3$)	Cost ($)	Revegetation (m^2)	Rate ($/$m^2$)	Cost ($)	Other Items ($)	TOTAL COST
STRATEGY B.1												
Tailings Dump	T4	1,600,000	1.15	1,840,000				560,000	2.40	1,344,000		
Southern Waste Rock Dump	S1	310,000	1.25	387,500				-			as below	
North-Western Waste Rock Dump	N1	200,000	1.25	250,000				-				
TOTAL		2,110,000		2,477,500				560,000		1,344,000	2,884,000	$6,705,500
STRATEGY B.2		NOT RECOMMENDED BY SCS										
STRATEGY B.3												
Tailings Dump	T6	560,000	1.15	644,000	-			370,000	2.30	851,000		
Southern Waste Rock Dump	S2	290,000	1.25	362,500	570,000	4.10	2,337,000	-			as below	
North-Western Waste Rock Dump	N1	200,000	1.25	250,000	-			-				
TOTAL		1,050,000		1,256,500	570,000		2,337,000	370,000		851,000	2,827,000	$7,271,500
STRATEGY B.4												
Tailings Dump	T7	590,000	1.15	678,500	-			390,000	2.30	897,000		
Southern Waste Rock Dump	S3	300,000	1.25	375,000	450,000	4.10	1,845,000	-			as below	
North-Western Waste Rock Dump	N1	200,000	1.25	250,000	-			-				
TOTAL		1,090,000		1,303,500	450,000		1,845,000	390,000		897,000	2,827,000	$6,872,500

Other Items:

Erosion control & drainage	405,000
Topsoil carting road	31,000
Mill building demolition	30,000
Crow Mt. Road re-alignment	36,000
Other Costs	1,750,000
Maintenance (present worth)	632,000/ 575,000
	$2,884,000/$2,827,000

Figure 9.3: *Cost summary comparing Strategies A & B.*

suggested, however, that only 300,000-350,000 tonnes of fibres would be recovered. This recovery rate would significantly lower the economic value of the project, generating only $33.75-$39.4 million dollars.

The tailings were also investigated to determine whether the extraction of nickel, chromium and magnetite was economically feasible. It was determined that whilst this process was technically possible it was uneconomical given current technology.

9.3 LANDFILL DEVELOPMENT

The pits at the Woodsreef mine have been suggested for potential landfill developments. Initially it was proposed that general asbestos waste be dumped within the pits, however, concern was raised over the possibility of non chrysotile asbestos or mixed asbestos products been dumped. Barraba Shire Council have also expressed limited interest in the site as a future landfill development.

PART FOUR

RECOMMENDATIONS & CONCLUSIONS

10 REQUIRED INFORMATION

The available data set on the hazards, risks and impacts associated with Woodsreef Asbestos Mine, is incomplete. This is due to two main reasons, firstly some hazards have not been fully investigated or identified and thus data does not exist. Secondly, data may have been collected during or shortly after the mines operation, thus is not relevant given the mines derelict status. This section aims to outline what data is needed prior to commencement of a risk assessment.

10.1 WATER QUALITY & SEDIMENTATION

Apart from the routine monitoring of basic water quality parameters at site WR-1 and within Split Rock Dam, no quantitative water monitoring has occurred since mine closure. It is therefore imperative to quantify the impact Woodsreef is having upon the surrounding drainage channels, in particular Ironbark and Nangahrah Creeks. This requires the determination of comprehensive data sets that could be achieved through investigations into, stream macro-invertebrate communities, chemical water quality and sediment characteristics.

10.1.1 Rapid Bio-Assessment

Rapid bio-assessment is a recognised technique for evaluating the general health of waterbody, by assigning abundance and signal values to certain families of macro-invertebrate. The signal values indicate a particular family's tolerance to general pollutants such as, sedimentation, alkalinity, magnesium and electrical conductivity. It is recommended that a sub set of the sites used by Toyer and Main (1978) be used in the assessment, sampling riffle, edge and pool habitats. The data gained from such an assessment should provide a true indication of the impact the mine drainage is having upon the biological attributes of Ironbark and Nangahrah Creeks.

Such an assessment will be carried out during August 1996 and completed by November.

10.1.2 Chemical Water Quality

Previous analysis of various chemical and physical water quality parameters occurred during mining operations and thus repeat sampling is required. It is recommended that comprehensive samples be undertaken in conjunction with the rapid bio-assessment, enabling historical comparison with the data that was collected by Toyer & Main (1978). Other sites such as the pits and settling dams should also be investigated. This will provide data on the hazards associated with mine leachate and contaminated surface runoff.

A comprehensive water quality analysis will be undertaken in conjunction with the rapid bio-assessment and will be available in November.

10.1.3 Sediment Characteristics

As previously stated sedimentation of drainage lines and water ways is one of the major hazards associated with Woodsreef Mine and very little quantitative data exists. Three avenues of investigation are required to quantify the hazard and risk presented by sedimentation:

- the determination of the erosion potential of the dumps;
- the potential impact of batter movement; and
- the current distribution of sediment emanating from the mine.

The determination of sediment distribution should take into account, the current sedimentation status of the settling dams, and thus the life expectancy of these dams given their derelict status.

10.2 DUST MONITORING

Ambient chrysotile fibre levels at Woodsreef Asbestos Mine have being investigated in 1981-82, 1984 and again in 1992. This information indicates that current ambient fibre levels are most likely to be below the recommended risk threshold of 0.5 f/ml this assumption, however, requires confirmation. Ambient fibre levels should be undertaken at various locations through out the mine and within the surrounding area, using a membrane filter. Repeat sampling at the sites given various wind speeds would enable the determination of the wind speed/ambient fibre level relationship.

11 PRELIMINARY PRIORITISATION OF HAZARDS

The hazards associated with Woodsreef Asbestos Mine have not had a major impact upon the surrounding environment since mine closure. In terms of the potential risk and impact, however, these hazards need to be prioritised in order to achieve appropriate funding allocations. This is the basis of the risk assessment, and a preliminary review of available data suggests that the hazards that present the highest risk of adverse impact, are in the order outlined below.

❶ Sediment derived from slumping and erosion of the southern batter of the tailings dump.

❷ Sediment derived from regular sheet and rill erosion of waste rock and tailings dumps.

❸ Sediment derived from breaching of diversion bunds at the head of the waste rock dump.

❹ Poor chemical water quality in Ironbark and Nangahrah Creek resulting from leachate and contaminated surface runoff from the waste rock and tailings dump, particularly if Dam A fails, and/or leachate production is increased.

❺ Health concerns due to airborne dust and/or asbestos, particularly from the tailings dump.

❻ Injury to the public who visit the site, either legally or illegally.

❼ Metal mobilisation leading to bio-accumulation in plants and higher members of the food chain.

❽ Adverse chemical water quality in Ironbark Creek and shallow fractured rock aquifers as a result of increases in pit water levels.

❾ Dump destabilisation due to seismic activity in the Peel Fault System.

PART FIVE

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PART SIX

APPENDICES

APPENDIX I

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APPENDIX II

RAINFALL DATA FOR WOODSREEF

Chrysotile Corporation of Australia Pty Ltd

Rainfall at Woodsreef

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1973	156.5	90.0	18.8	34.5	23.0	37.0	59.8	42.5	50.5	150.8	80.5	79.8	**823.7**
1974	185.5	15.3	30.0	61.5	66.3	8.8	33.3	44.4	14.0	56.5	105.3	5.0	**625.9**
1975	66.0	170.5	77.0	20.5	4.0	45.0	26.0	28.0	36.0	103.0	90.5	67.0	**733.5**
1976	156.3	187.5	62.5	6.0	27.0	54.8	54.5	11.8	40.3	66.5	110.3	32.0	**809.5**
1977	78.5	110.8	93.5	36.8	139.5	53.0	4.3	17.5	31.5	41.8	40.0	27.0	**674.2**
1978	183.3	76.5	78.5	14.0	94.0	103.5	56.0	30.0	85.5	34.0	123.2	117.3	**995.8**
1979	76.3	24.3	93.3	24.3	95.5	54.8	9.5	16.0	57.0	56.8	54.5	10.3	**572.6**
1980	32.0	15.8	26.5	3.5	81.0	21.8	37.9	13.3	2.5	56.0	17.8	94.6	**402.7**
1981	2.5	81.3	0.5	23.8	83.0	52.8	63.3	12.0	28.5	78.5	75.0	63.5	**564.7**
1982	69.3	21.5	142.5	13.0	46.5	7.3	14.5	12.0	24.8	38.3	11.5	126.5	**527.7**
1983	85.5	60.3	59.5	98.0	168.8	43.0	46.0	51.8	68.7	105.9	65.5	87.7	**940.7**
1984	207.0	119.8	38.5	45.0	7.0	25.0	144.7						

Reccurence intervals for the Woodsreef area, calculated by the Soil Conservation Service in 1991.

EVENT	INTENSITY (mm/hr)
2 yr, 1 hr	30.05
2 yr, 12 hr	5.30
2 yr, 72 hr	1.38
50 yr, 1 hr	60.50
50 yr, 12 hr	9.50
50 yr, 72 hr	2.50

APPENDIX III

MINING & ASSOCIATED LEASES

Woodsreef Asbestos Mine is classified derelict, with all mining leases terminated. Leases were held by Chrysotile Corporation of Australia Pty Ltd or subsidiary companies. The exception is El 4445 which was held by Marrall Pty Ltd and embodied several leases pertaining to the tailings dump.

Special Lease (1906 Act)

LEASE	INITIATED	EXPIRED	SECURITY	DESCRIPTION
454	15/11/68	15/11/94	$5000	84.7 ha (ML 36)
456	10/12/68	10/12/94	$5000	12.67 ha (ML33)
464	16/12/68	16/12/94	$5000	37.74 ha (ML 34)
515	12/2/70	12/2/90	$1000	(ML 32)
603	9/6/72	9/6/92	$1000	135.97 ha (ML 3)

Mineral Lease (1906 Act)

LEASE	INITIATED	EXPIRED	SECURITY	DESCRIPTION
5825	22/3/63	22/3/83	$100	24.68 ha (ML:26)
5826	23/4/63	23/4/83	$100	25.46 ha (ML 27)
5827	22/4/63	23/4/83	$50	13.3 ha (ML 28)
5866	8/6/64	8/6/84	$200	4.86 ha (ML 22)
5867	8/6/64	8/6/84	$200	11.33 ha (ML 23)
5868	8/6/64	8/6/84	$200	1.21 ha (ML 24)
5879	8/6/64	8/6/84	$200	3.23 ha (ML 30)
5918	23/10/64	23/10/84	$50	4.05 ha (ML 29)
5928	17/12/64	17/12/84	$100	4.0 ha (ML 31)
6151	10/12/68	10/12/88	$200	(ML 35)
6212	28/4/70	28/4/90	$200	(ML 25)
6253	9/10/70	9/10/90	$500	29.95 ha (ML 38)
6254	9/10/70	9/10/90	$500	31.57 ha (ML 37)
6344	14/9/72	14/9/92	$200	(ML 41)
6345	14/9/72	14/9/92	$200	29.54 ha (ML 40)

Speacial Private Lands Lease (1963 Act)

LEASE	INITIATED	EXPIRED	SECURITY	DESCRIPTION
63	2/1/69	2/1/87	$200	32.78 ha (PML 14)
113	22/7/70	22/7/90	$200	(PML 13)
154	17/8/72	17/8/92	$0	(PML 18)
164	10/11/72	10/11/92	$200	(PML 21)
183	13/7/73	13/7/93	$200	2.357 ha (PML 16)
197	27/9/73	28/9/93	$200	40.47 ha (PML 17)

Private Lands Lease (1906 Act, *1924 Act*)

LEASE	INITIATED	EXPIRED	SECURITY	DESCRIPTION
3685	21/2/68	21/2/88	$200	29.14 ha (PML 10)
3689	21/2/68	21/2/88	$200	21 ha (PML 6)
1307	*16/10/72*	*16/10/92*	*$500*	*(PML 12)*
1400	*5/5/71*	*5/5/91*	*$200*	*(PML 15)*

Exploration Lease (

LEASE	INITIATED	EXPIRED	SECURITY	DESCRIPTION
919	13/9/76	13/9/78		155.525 km^2
933	26/10/76	26/10/76		83.64 km^2
4445		95		

Mining Lease (1906 Act)

LEASE		EXPIRED	SECURITY	DESCRIPTION
405	9/3/77	9/3/98	$0	14.16 ha (18,19,31,50,51,52)
476	3/8/77	3/8/98	$10,000	7 ha

Dredging Lease (1973 Act)

LEASE	INITIATED	EXPIRED	SECURITY	DESCRIPTION
1260	27/11/70	27/2/97	$4,000	GL 49 & 59

APPENDIX IV

WATER QUALITY DATA

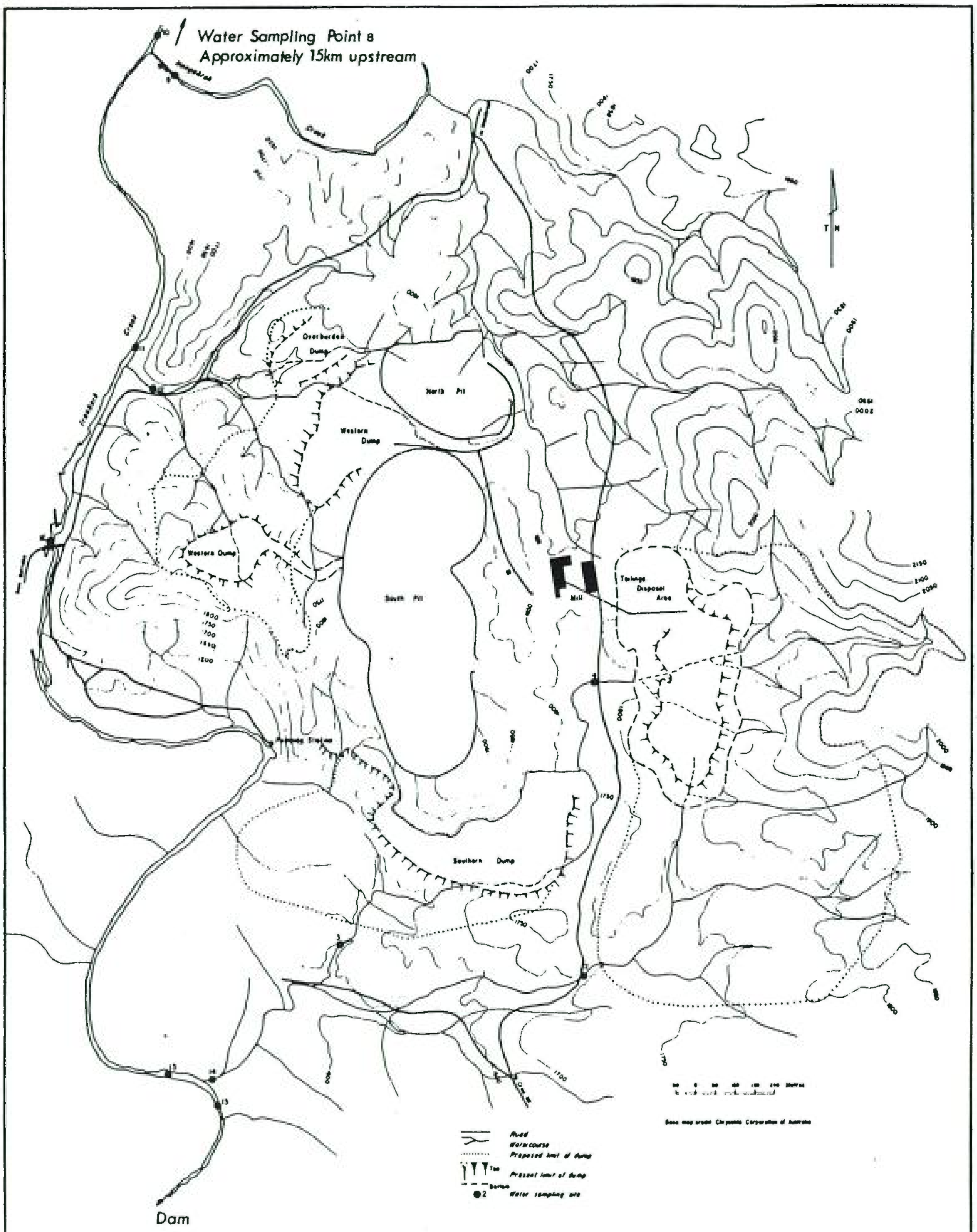


Figure 1

WOODSREEF ASBESTOS MINE

Water and Stream Sediment Sample Localities

13008

Sampling Locations (Toyer & Main, 1978)

SITE	LOCATION	INFLUENCES
	Creeks draining mine site	
WR-12	Small creek draining western WRD just before junction with IC	Drainage form western WRD Creek channel traverses serpentinite
WR-4	Outflow immediately below the TD	Drainage from the TD Creek channel traverses serpentinite
WR-3	Downstream from WR-4	Drainage from southern WRD and TD
WR-2	Small creek to the south of the TD	Runoff from the TD Creek channel traverses serpentinite
WR-14	Small creek draining the southern WRD and TD, just upstream from junction with IC	Total southern mine drainage
	Nangahrah Creek	
WR-7	7km upstream from junction with IC	Background
WR-6	2km upstream from junction with IC	Runoff from the TD Creek channel traverses serpentinite
WR-9	Just upstream from junction with IC	Drainage from mine site Creek channel traverses serpentinite
	Ironbark Creek	
WR-8	15km upstream from junction with NC	Background
WR-10	Just upstream from junction with NC	Background
WR-11	Just upstream from junction with main creek draining western WRD	NC inflow, runoff from mine site. Creek channel traverses serpentinite
WR-16	Between the inflow of the northern and southern drainage systems of the mine site	Drainage from western WRD Creek channel traverses serpentinite
WR-13	Just before junction with creek draining southern WRD and TD	Drainage from mine site
WR-15	Downstream from inflow of southern drainage system of mine site	Total drainage from mine site
	Manilla River	
WR-5	10km upstream from junction with IC	Barraba, and particularly the sewage treatment works
WR-1	1km downstream from junction with IC	Outflow from mine site down IC

Where ; NC : Nangahrah Creek
IC : Ironbark Creek
WRD : waste rock dump
TD : tailings dump

Company Sampling Locations (Stewart, 1985)

SITE	LOCATION	INFLUENCES
1	IC homestead, 7km upstream of mine	Background
2	Pumps on IC	Drainage from the western and northern WRD. Creek channel traverses serpentinite

APPENDIX V

REVEGETATION

(RECEIVER APPOINTED)

BCB/ST

23rd September, 1976.

Mr. D.R. Meyer,
CSIRO,
P.O. Box 1600,
CANBERRA CITY. 2601.

Dear Mr. Meyer,

Mr. McMahon has passed me your letter of 10th September, 1976 as I am conducting a trail planting on the tailings dump of our asbestos mining operation at Woodsreef, N.S.W.

The tailings as they now stand comprise 100% serpentinite rock with a size range of 5 cms rock to fine sand. There is no soil or humus of any kind. Any analysis of actual chrysotile fibre is attached for your information. As chrysotile has the same chemical composition as the enclosing rock, the same analysis should apply to tailings (except for some water).

The tailings also contain the following element proportions:

Copper	200 ppm
Nickel	1850 "
Cobalt	14 "
Lead	60 "
Zinc	6400 "
Manganese	1250 "
Chromium	3400 "

According to the paper reprint you kindly sent us the tailings are exceptionally toxic.

The trail rehabilitation programme under way involves laying about 30 cms of soil over the tailings and planting grass (Kikuyu) and vine type plants and vegetables - pumkin, watermelon etc. The idea is when the plants die in winter, to force humus into the tailings.

... 2/

Trees, planted in pockets of soil comprise mainly the She Oak, Wild Fig and Willows. We hope the roots will eventually penetrate the tailings for moisture (the tailings retain a high percentage of water) and at some time rejuvinate the tailings so as to support future growth. We have also applied super-phosphate, lime and nitrogen. Any recommendations as to other tree varieties would be appreciated.

As you recommended I have forwarded via Comet, two bags of tailings which we would appreciate if you would analyse or donduct experimental plantings on.

Yours faithfully,
CHRYSOTILE CORPORATION OF
AUSTRALIA PTY. LIMITED
(Receiver Appointed)

B.C. Butt,
EXPLORATION MANAGER.

CSIRO

DIVISION OF PLANT INDUSTRY

P.O. BOX 1600, CANBERRA CITY, A.C.T. 2601 TELEPHONE 46 4911 TELEGRAMS PLANTINDUSTRY CANBERRA TELEX 62351

DRM:BAW
Ref:

15th July 1977

Mr B.C. Butt,
Exploration Manager,
Chrysotile Corporation
of Australia Pty. Ltd.,
P.O. Box 120,
BARRABA N.S.W. 2347

Dear Mr Butt,

I am enclosing a set of photographs of a pot trial using the tailings and sown with barley (var. "Weeah"). All pots have had a basal application of potassium, boron, molybdenum and calcium nitrate. Photographs 1, 2 and 3 show the effect of three levels of superphosphate - 0, 2.5 tonnes per hectare (1 ton/acre) and 5 tonnes/hectare (2 tons/acre) respectively; each level with and without two levels of gypsum and two levels of lime. All treatments were mixed through the soil in each pot. The other photographs (with the exception of number 9) show various comparisons of the treatments mentioned above.

I propose to take soil pH measurements and to analyse the soil solution of the various treatments but as this will take a little time I decided to show you some observable results.

As anticipated pH has a major effect and the results shown in photograph 1 are of particular interest. The addition of the lower level of gypsum has undoubtedly lowered the pH slightly and apparently permitted some ion to come into solution causing a depression in growth. The higher level of gypsum has lowered the pH even further, tied up the offending ion, and in addition released some soil phosphorus. The response to superphosphate shown in photograph 2 is probably a combined effect of phosphorus and pH and at this level of phosphorus the addition of the lower level of gypsum is sufficient to reduce the pH to a point approximately equal to that of the high level of gypsum shown in photograph 1. Analysis of the soil solution should make this clearer and if the analysis supports what I have suggested then the possibility exists of using a high level of gypsum with a very low level of superphosphate, possibly 4 or 5 cwt/ac of sulphur fortified super.

The photographs do not clearly show the differences in color; however with the one exception already mentioned the gypsum treatments are all greener and healthier than any of the other treatments.

The only observable effect of lime is a slight reduction in growth. Photographs 7 and 8 show the comparisons.

The plants are less than 3 weeks old so that differences would be greater as they mature, however at this stage the best plants in the high superphosphate treatment have a 20% higher yield than any in the

low super treatment and a 50% higher yield than in the nil superphosphate treatments.

In addition to the foregoing I have been testing a number of elements on the tailings material to determine whether there is a requirement or otherwise when the major limiting factors for normal plant growth have been overcome. At this stage, it appears that only potassium is in short supply. Photograph 9 shows plants grown with the high level of superphosphate and gypsum without and with potassium sulphate.

If I were to make a recommendation on the basis of the evidence so far, for a fertiliser treatment for testing on the dumps, I think I would suggest the higher levels of superphosphate and gypsum, but I would also suggest a treatment using the high level if gypsum together with a low level of sulphur fortified superphosphate. In any case if it is convenient the fertiliser could be applied only to the planting sites, that is, mixed through the volume of tailings contained within an area of approximately 6 inches in diameter by 6 inches deep, into which one or more plants can be established. The following levels would be appropriate for the volume of soil mentioned-

Gypsum	@ 16 t/ha = (approx)	43g	(1½ oz)
Superphosphate	@ 5 t/ha = "	14g	(½ oz)
Sulphur fertilised super (alternative treatment)	@ 400 kg/ha = "	1g	
Potassium sulphate	@ 400 kg/ha = "	1g	
Calcium nitrate	@ 200 kg/ha = "	½g	

Calcium nitrate would need to be applied periodically to the surface either as a dry salt or in solution.

It is difficult from this distance to assess the physical problems associated with the revegetation of the dumps however I can appreciate that there are many.

The results presented here are from plants grown in undrained pots with the water maintained at "field capacity" by weighing the pots each day, thus eliminating water stress. If water is a limiting factor on the dumps then plant species become much more important. Dr John Leigh of our Ecology Section has indicated that he could perhaps give advice in this area but would be reluctant to do so without seeing the site. One further point; in a previous test the overburden responded extremely well to the low levels of both gypsum and super so it seems unlikely that if you continue to use the overburden and you use gypsum super-phosphate potassium sulphate and nitrogen that you would have too many problems with this treatment.

I hope this has been of some help and I will let you know the results of further tests.

Yours sincerely,

(D.R. Meyer)

10th May, 77

The District Inspector of Mines,
Armidale.

xxxxxx(065)451344.

EX-1

The Manager,
Chrysotile Corporation of Australia Pty. Ltd.,
P.O. Box 120,
BARRABA, N.S.W. 2347.

Dear Sir,

Following a recent inspection of the tailings disposal area and revegetation trials at Woods Reef, I would like to offer some suggestions concerning both tailings disposal and future revegetation trials.

1. Tailings Disposal.

From discussions held with Mr. Butt, it is understood that your Company is close to completing long term plans for disposal and eventual rehabilitation of mill tailings. It appears that these plans will be similar to proposals upon which the Soil Conservation Service has been working. I would be pleased to review and comment upon your plans when they have been completed. However I feel that several aspects of your proposals, as briefly outlined by Mr. Butt, should be reconsidered.

a) It is understood that the proposed dump will be constructed in a series of "terraces", commencing at ground level along its eastern extremities and progressively increasing in height towards the west. Apart from reducing the volume of tailings which could be stored within the area, it is considered that this scheme could eventually lead to problems of erosion and runoff disposal along the eastern flanks of the dump. As the dump increases in size, there will be a tendency for runoff from the top surface and eastern slopes of the dump to collect and flow along the eastern toe of the dump. Runoff from the natural land surface further east will also be concentrated along the eastern toe of the dump. Disposal of this runoff in a safe manner, without causing erosion of the tailings, could pose serious problems.

As an alternative, it is suggested that the direction of dump construction be reversed. The size and form of the existing tailings dump should be roughly preserved and terracing should be conducted towards the east and south. The height and distance apart of each terrace should be adjusted so that the depth of material remains roughly constant as the land surface rises towards the ridge line. This method would allow a considerably greater volume of tailings to be stores within a given area or, conversely, the surface area occupied by the dump could be reduced. In addition it would greatly simplify the final disposal of runoff from the dump itself and from the surrounding land surface.

b) I understand that the Department of Mines has recommended that the outer faces of the dump be re-graded to a maximum slope of 18°.

While this would no doubt increase the stability of the dump, it is considered that in this particular case, there may be disadvantages in reducing slopes to this extent. As dump batters are reduced, both the surface area and length of slope of the faces are increased, with a corresponding increase in erosion potential. The surface area to be covered with topsoil is also increased. Under normal circumstances, this would not present serious problems. However, it seems unlikely that the bare tailings material at Woods Reef will ever support a worthwhile stand of vegetation. Topsoil available within the lease area is extremely scarce and of poor quality.

Thus, before a decision is made on final dump batters, it is suggested that the following experiment be conducted.

A section of the present dump face approximately 150-200 metres long should be re-graded to a slope of 26°. Berms 4-5 metres wide should be constructed at 6-10 metre vertical intervals along the face and they should be back-sloped approximately 0.5 metre towards the dump.

The dump face and berms should then be covered with waste rock to a minimum thickness of 30cm, using material ranging in size from coarse gravel up to 30-40cm in diameter. The material should be placed by dumping over the face, commencing at the first berm and progressively working up the face.

Topsoil should be spread along the berms to a depth of 10-15cm, allowing some material to spill over the dump face. This should then be sown to vegetation, watering as necessary to promote good growth.

It is considered that this method, if successful, would achieve the following benefits.

- It would considerably reduce the amount of earthmoving needed to re-shape the dump faces.
- The tailings material would be adequately protected from wind and water erosion, regardless of whether satisfactory revegetation can be achieved or not.
- The amount of topsoil needed to treat the dump faces would be appreciably reduced.

c) Due to its extremely adverse calcium/magnesium ratio and possibly nickel and aluminium toxicity, it is doubtful that the tailings will ever support a useful stand of vegetation. The prospect of satisfactory long-term revegetation, even with the use of topsoil, is not good. Until sufficient trial work has been conducted to demonstrate that long term revegetation can be achieved, consideration should be given to covering both the faces and top surface of the dump with waste rock. Covering the entire dump with 30-40cm of waste rock would protect it from wind and water erosion and also provide an additional means of disposal of the rock. Should later trial work show revegetation to be feasible, then the rock layer could be topdressed with soil. In this connection, it is important that all available topsoil within the dump site be progressively stripped and stockpiled as the dump expands.

2. Revegetation Trials.

The trials which have been commenced by Mr. Butt are very encouraging and have achieved better results than would have been predicted from trial work carried out at Scone Research

With a view to continuing and expanding these trials, I would suggest that the following plant species and fertilizers be tested.

a) Warm-season pasture plants. (Sow in late September/early October and repeat in late January/early February).

Lucerne (Medicago sativa).

Dolichos lab lab (Lab Lab purpureus).

Rhodes grass (Chloris gayana).

Buffel grass (Cenchrus ciliaris).

b) Cool-season species. (Sow in mid-April).

Rye corn (Secale cereale).

Lucerne (Medicago sativa).

Wimmera rye grass (Lolium rigidum).

Jemalong medic (Medicago truncalvla).

Your present method of applying topsoil to the tailings should be repeated on a new area and each species should be sown individually into a plot measuring 2 metres by 5 metres. The rye corn should be sown both on its own and in combination with wimmera rye grass and Jemalong medic. Should you wish to proceed with this trial, I may be able to supply you with sufficient seed of each species for several small plots. Double superphosphate at the rate of 300kg/ha, together with 200kg/ha of ammonium sulphate, should be applied at sowing time and again six months later. Because of the low calcium availability in the tailings, I would suggest that all plots be given a basal dressing of gypsum at the rate of 2 tonnes per hectare. Since the pH of the material is already high, all calcium applications should be made in the form of gypsum and not as lime.

To determine calcium requirements, I feel that a separate small trial would be worthwhile. Six 2 metre by 5 metre plots should be topsoiled in the normal way and prior to sowing the following gypsum applications should be made:-

1st two plots - 2 tonnes/ha gypsum.

2nd two plots - 10 tonnes/ha gypsum.

3rd two plots - 20 tonnes/ha gypsum.

The gypsum should be mixed well with the topsoil by rotary hoe or hand fork. Each plot should then be sown with the following mixture:-

Lucerne @ 15kg/ha.

Kikuyu @ 30kg/ha.

Double superphosphate @ 300kg/ha.

Ammonium sulphate @ 200kg/ha.

Sowing should be carried out in late September or early October. All plots should be watered as necessary to maintain soil moisture.

The re-shaped dump faces, in the experiment outlined earlier, should be sown to a mixture of rye corn at 40kg/ha, Wimmera rye grass at 15kg/ha and Jemalong medic at 15kg/ha, together with fertilizers at the rates suggested above. If the re-shaping work can be completed in time, this sowing could be conducted in late June. However if seasonal conditions are unfavourable, it may be necessary to re-sow the faces in mid-April, 1978.

The following tree species may be worthwhile testing on the tailings dump:-

Narrow-leaved Ironbark (Eucalyptus crebra).

Grey gum (E. punctata).

Belah (Casuarina cristata).

Black wattle (Acacia hakeoides).

Silky Oak (Grevillia robusta).

Bracelet honey-myrtle (Melaleuca armillaris).

Tree planting is best carried out in the following manner:-

Holes 30cm in diameter at 1 metre deep should be dug in the tailings and filled to within about 20cm of the surface with good quality alluvial loam.

Two or three slow release fertilizer pellets (Kokei balls) should be placed on the loam around the sides of the hole. The seedling is placed in position and the hole completely filled with soil and tamped lightly. The seedlings should be thoroughly watered immediately and given a good watering about once a week for the first six months.

I wish you success with the trials and will follow the results with interest. On receipt of your tailings disposal plans, I will be able to provide more detailed advice on runoff and erosion control measures for the tailings area.

Yours faithfully,

J.C. Hannan,
Soil Conservationist
Extractive Industries

JCH:KJC

Mr. L. M. Stevens,
District Inspector of Mines,
Dept. of Industrial Relations & Mineral Resources,
P. O. Box 341,
INVERELL. N.S.W. 2360.

Our reference: B/341.
Your reference:

Telephone: (067) 82 1292.

10th August, 1982.

Dear Mark,

Re your request for recommendations for a revegetation programme on the rock dumps of the Barraba Asbestos Mine. In response to your questions:-

1. Recommended grass species are:-

SPRING SOWING.

Rhodes grass	at 15 kg/ha.
Couch	" 10 kg/ha
Buffel	" 10 kg/ha

AUTUMN SOWING.

Wimmera Ryegrass	at 10 kg/ha.
Northam Sub Clover	at 10 kg/ha.
Nungarin Sub Clover	at 10 kg/ha.
Hiafa White Clover	at 5 kg/ha.

FERTILISER.

Starter 12	at 400 kg/ha.
Six monthly topdressing of Ammonium Sulphate at	100 kg/ha.
Gypsum	at 2 tonnes/ha.

Tree plantings have previously been tried and the successful species should be planted on the benches above these revegetation trials.

2. Applications.

Where topsoil and/or topdressing material has been spread on the more gradual slopes these areas can be established by sowing grass species by conventional mechanical means. Such an area is adjacent to the Mine turn off from the Barraba/Bundarra Road. (See attached map point A).

Here a shotgum mixture is recommended.

Couch
Rhodes
Buffel
Wimmera Ryegrass
Northam Sub Clover

at the rates suggested in recommendation 1.

Starter 12 at 400 kg/ha should also be used.

Species that do well here can act as a guide for further trials.

On the steeper benched areas alternative measures of vegetation establishment will have to be trialed. (See B on map).

/ Some

Some alternative methods of revegetation are -

(a) Spreading a protective layer of "Environmat" over the slopes after broadcasting a seed-fertiliser mixture on to introduced top soil.

(b) Hydro-mulching:- the spraying of an adhesive mixture of fertiliser and seed onto the previously top soiled slope.

(c) Bitumen emulsion:- spraying a protective layer of bitumen onto a prepared and sown seed bed.

3. Location.

(See Section B on attached map). This area is on the side slope of the second terrace layer, on the right hand side of the main road from Barraba. The first slope has a lot of protruding trees and has only a shallow covering of overburden and as such would not be representative of most of the slopes.

Three different experimental plots are suggested using the previously described establishment methods.

Each should be about 20-40 metres wide, split into halves, one half of each plot incorporating the suggested rate of gypsum. See attached diagram for layout.

The shotgum mixture of seed and fertiliser recommended in reply to question 1 should be used throughout the 3 plots.

Method:-

(I) Gypsum should be spread at the recommended rate on the relevant section of each plot.

(II) Topsoil should be spread over the entire surface of the experimental area. The existing layer of ridge gravel has rilled badly since being spread and is a poor substitute for topsoil. Once spread the topsoil should be worked horizontally to create a surface of low, contour ridges and depressions. This ridged surface will assist in seed and moisture retention.

The contour working can be done by dragging a heavy chain across the slope of the trial blocks after the topsoil has been spread. Commercial hydroseeding firms should have a machine designed for this purpose.

(III) The seed and fertiliser mix should now be broadcast evenly over Plot A and C; and the environmat pegged down onto Plot A. A thin layer of hay should be spread over Plot C and tacked down with a bitumen emulsion. Plot B can now have the hydroseeder apply the seed-fertiliser-adhesive mix.

4. Time.

These trials should be carried out during early spring as the summer grass species are the most useful in resisting erosion, particularly caused by the summer storms. Hopefully the seasonal climatic conditions are suitable. Without the optimum moisture conditions I would still recommend sowing and manual watering at appropriate times. These plots are only small and the experiment is to determine the best establishment technique, i.e. how pasture species can be grown on the slopes of waste rock material, and what pasture species are best for this purpose. Not which species will survive the current Woodsreef climate.

Tree plantings could be carried out at the same time.

Some terms used and areas inspected during my last visit to the Mine require elaboration.

Top Soil and Top Dressing Material.

By definition top dressing material is soil that has been used instead of topsoil, had it been available. This material is usually derived from the soil below the A horizon due to perhaps the absence of, or the existence of a very thin layer of topsoil. As such this material varies from topsoil in physical make up and may be unsuitable for successful revegetation.

The ridge gravel that has already been spread over some of the batters on the waste dump can be classified as topdressing material. This material is considered a poor substitute for other areas of locally available topsoil due to its clayey,dispersible and hard setting nature.

Topsoil can be stripped from the natural land surface directly below the southern wall of the waste dump (See C on map) and any other areas that are likely to be sterilized by future dumping. This top soil should be spread over the batters and worked as previously described.

The timing of the stripping and respreading of this topsoil is critical for successful revegetation. If this process of removal and respreading is done within a short period of time, with favourable moisture conditions, a large percentage of native grasses, seeds and biotic life will remain viable. Consequently revegetation should be accelerated.

Methods of stripping the top soil and subsequent protective measures for the exposed subsoil can be outlined on site when required.

For your information please find attached a photocopy of the abstract from "Some Environmental Investigations at the Woodsreef Asbestos Mine". G.S. Toyer & S. Main, December, 1978.

Yours faithfully,

Doug Stewart

Doug. Stewart.
District Soil Conservationist.
Barraba.

New South Wales Government

Soil Conservation Service

22 Pitt Street, Sydney 2000
P.O. Box R201
Royal Exchange
Sydney 2000

Phone: (02) 27 7235 or 27 9551
Telex: AA 23477
DX 22 Sydney

Mr N. Himsley,
Project Manager,
Barrabo Mine Site Steering Committee,
C/- Dams Safety Committee,
State Office Block,
Phillip Street,
SYDNEY 2000 00

Contact:

Our reference: R1259/2

Your reference:

REPORT ON TOPSOILING RECOMMENDATIONS FOR FINE TAILINGS DUMPS AT BARRABA MINE

Background

The following information and recommendations are presented following the request to this Service to undertake field inspections, sampling and chemical/mechanical analyses of alternative sources of topsoil and provide recommendations for consideration by the Steering Committee.

Recommendation

For the topsoiling and revegetation of tailings at this site, it is recommended that the structural alluvial loam materials which occupy the lower terraces bordering the Manilla River and Ironbark Creek, at 'Glen Riddle' be utilized. This soil type is also distributed in similar situations further down the catchment, below topwater level of Split Rock Dam. Locations of soils evaluated and detailed test results are presented in the accompanying maps and table.

'Glen Riddle' (Area B)

The structural alluvial loam at 'Glen Riddle' (Site 2, Area B, refer Map 2, appears to exhibit no major physical or chemical constraints which may cause establishment problems of recommended species. Moderate clay dispersion which is a feature, particularly of the surface 50 cm, can be rectified by the application of gypsum. This will assist in binding fine particles into stable aggregates and thereby reducing the probability of serious rilling on steep batters.

Adjoining areas of hardsetting red brown earth (occupying slightly higher terraces, e.g. Site 1, Area B) are generally not recommended due to high clay dispersibility and poor fertility, however, with suitable amendments, the topsoil (0-30 cm) only, would be satisfactory.

Because of the reasonably high fine sand and silt combinations of recommended materials from borrow Areas B, rilling on steep batters will create problems. Grades no greater than 15% would normally be the recommendation. If grades by necessity, are to be steeper, it is essential that a hydramulching technique be used to apply seed and fertilizer. This will aid stability to exposed surface soil during the establishment phase.

Estimate of Available Soil Quantity

	Area (ha)	Average Depth (cm)	Volume (m³)
Structural Alluvial Loams	* 24	2m	480 000

* These are soils resulting from alluvial deltas which align the Manilla River and Ironbark Creek.

Area adjacent to Fine Tailings Dump (Area A)

For soil materials on barrow Area A, the following points should be considered.

The sandy podzolic soil (see Map 2) is not suitable. Infertile both physically and chemically. Very erodible.

The black earth and red earth soils have some serious constraints. Having developed on serpentine parent materials these soils are very high in magnesium and very low in calcium. This can be seen from the result sheet which also shows low levels of K and P. The imbalance of Mg to Ca is critical to uptake of nutrients and suppressed levels of Ca can be determined to establishment and growth of legumes. Stunted and sparse natural vegetation is proof of low inherent infertility, e.g. the characteristic Xanthorreha australia (Blackboy) community.

The surface sealing characteristics of the black earth would also make it particularly vulnerable to rilling. Although considered inferior to the materials of site 2, borrow area B, if used, ameliorants would be required. Consideration would also have to be given to rehabilitation of the borrow area particularly as the red earth occurs as a soil veneer (one metre deep) on undulating terrain.

Estimate of Available Soil Quantities

	Area (ha)	Average Depth (cm)	Volume (m³)
1. Black Earth (Sites 4, 7, 8, 10-14)	9	90	81,000
2. Red Earth/Euchrazem (Sites 1, 2, 3, 9)	* 12.5	80	100,000

* Not definitive of real extent of this soil. It also occurs on adjoining higher landscapes albeit in a shallower form. Note that slope and topography will be major considerations in rehabilitation of borrow area.

Recommended Procedure of Topsoiling Tailings

1. Topdress shaped batters with no less than 15 cm of soil
2. Spread gypsum where required (dump gypsum satisfactory)
3. To key in soil and allow for absorption of runoff, rip on contour (rippers reversed to avoid inversion).
4. Hydromulch seed and fertilizer.

Recommended Seed Mix and Fertilizers

Recommendations for revegetation are provisional at this stage. Previous reports by the Service on this mine site have recommended the need for trial assessment of species.

Should topsoiling/revegetating be considered as a viable option, it is recommended that trials be undertaken to ascertain species effectiveness in stabilising this site.

1. Topsoiled Fine Tailings Dump Species

Species

Sub-clover Seaton Park, *Trifolium subteraneum*	6 kg/ha
Barrel Medic. Jemalong *Medicago truncatula*	6 kg/ha
Wimmera Ryegrass *Lolium nigidum*	8 kg/ha
Demeter Fescue *Festuca arundinacea*	5 kg/ha
Rose Clover *Trifolium hirtum*	5 kg/ha
Harden Bergia Native wisteria	1 kg/ha
Rhodes Grass *Chloris gayana* (stolaniferous)	15 kg/ha
Couch *Cynodon dactylon* (hulled)	8 kg/ha
Fertilisers : Starter 15	300 kg/ha
Gypsum	2.5 tonnes/ha

2. Rehabilitation of Borrow Areas

Species

Sub-clover Seaton Park *Trifolium subterraneum*	4 kg/ha
Barrel Medic, Jemalong *Medicago truncatula*	4 kg/ha
Wimmera Ryegrass *Lolium nigidum*	5 kg/ha
Demeter Fescue *Festuca arundinacea*	3 kg/ha
Rose clover *Trifolium hirtum*	3 kg/ha
Rhodes Grass *Chloris gayana*	5 kg/ha
Fertiliser : Starter 15	125 kg/ha

Consideration of Ridge Material for use as Subsoil on Level Topsoiled Areas

Examination of previous analyses of ridge material located within the mine site revealed the following considerations.

- poor Ca/Mg ratio
- nickel, bordering on toxic levels
- poor available water capacity
- inclined to be dispersible

Pot trials from Scone indicated growth of Rhynchelytrum repens (natal red top) and Galenia secunda while Gymbopogon reractus died. This indicates limited ability to support sown exotics. However, a field trial at Woodsreef where ridge material had been spread on a 3:1 batter shows a good establishment of Chloris gayana (rhodes grass).

Recommendation

Given the above constraints and mainly because of the reasonably successful establishment of rhodes grass on site, it is recommended that no more than 7 cm of ridge material be used with 2.5 t/ha gypsum overlain by 8 cm of recommended topsoil.

Should this option be adopted then an additional fertilizer requirement of 100 kg/ha Starter 15 would be necessitated due to the poorer nutrient status of the ridge material. Total fertilizer requirement for areas topsoiled using 7 cm ridge material underlying 8 cm of structured alluvial soil would be 400 kg/ha Starter 15 (or equivalent).

C A Booth

C. A. BOOTH
For R. S. JUNOR
Acting Commissioner

27.8.86

APPENDIX VI

STABILITY CONCERNS

PART A : SOIL CONSERVATION WORKS

PART B : LMK STABILITY ANALYSIS

PART C : OTHER

PART A : SOIL CONSERVATION WORKS

DEPARTMENT of CONSERVATION AND LAND MANAGEMENT

Incorporating SOIL CONSERVATION SERVICE of NSW

WOODSREEF ASBESTOS MINE

CONSULTANCY BRIEF

Offering services to:
DEPARTMENT of MINERAL RESOURCES

BACKGROUND

At the request of Mr. Bruce Kremer I have prepared design and cost estimates for works up to the value of $107,000 necessary for the short term stabilisation, as outlined in the Barraba Mine Rehabilitation Feasibility Study (oct 86), of the tailings and waste rock dumps.

These works are grouped under two stages.

AIM

The aim of these works is to reduce the amount of runoff water getting under the tailings dump. This will be achieved by the construction of three dams and associated diversion banks.

SCOPE of DEPARTMENTS COMMISSION

Stage I.
The Department will construct three dams and diversion banks.
Dam A is the first of three dams required to divert runoff water around the tailings dump. Due to site restrictions the wall of this dam is proposed to be constructed against the tailings batter. Consequently this will necessitate the incorporation of a plastic liner to ensure structural soundness. The capacity of this dam will be 19,500m^3 providing storage capable of holding a 1 in 5 year storm from its 100ha catchment. As a plastic liner is used in this dam it will be essential to fence the No.2 batter off from livestock.

Dam B catchment area is approximately 30 ha, of which 20 ha is proposed to be diverted directly to Dam C. This will reduce the runoff into Dam B enabling it to handle water pumped from Dam A and reduce the burden on the dams outlet.

The storage capacity of Dam B is 30,000m^3 and will store water from a 10ha catchment and water pumped from Dam A. It is then diverted to Dam C.

Dam C catchment area is approximately 45ha. This is the last of the diversion dams having a capacity of 19,000m^3. The outlet from this dam will provide final diversion around the tailings dumps.

Dam B and Dam C will require the use of a water cart and a sheeps foot roller to ensure that the aggregated clays are dispersed enough to provide an effective seal.

STAGE II: PUMPING SYSTEM

Dam A will hold a 1 in 5 year storm and has no outlet, due to site restrictions. A storm of a larger magnitude will flood the dam, the pump and motor. This will most likely cause damage to the dam wall and most certainly the pump motor. For this reason a submersible pump has been chosen.

Power extension will be carried out by a private firm located at Scone chosen in preference by lowest qote. The local electricity council is in full concurrence with their employment as there unions will not allow them to work in or adjacent to asbestos material.

The pumping system will have a discharge rate of 40l/s using a discharge pipe of 125mmØ UPVC pipe.

Based on the design of Dam A it will take approximately 2.5 days to pump the equivalent of a 1 in 1 year storm at 40 l/s.

OCCUPATIONAL HEALTH & SAFETY

Safety with the handling of asbestos contaminated material is of major concern to our staff. We have investigated this matter and will incorporate all recommended safety procedures, the costs have been shown accordingly.

Please accept this brief for your perusal. If there are any further enquiries please do not hesitate to contact us.

FEE 20/10/92

The total fee for this consultancy is $107,000 made up of the following components;

STAGE 1		
Works		Cost
Dam A		$ 10,000
Dam B		$ 16,000
Dam C		$ 13,000
Diversion Banks		$ 2,000
	Sub Total	$ 41,000
STAGE II		
Pumping System		
40 l/s pump & pipes & fittings		$ 25,000
Installation of system		$ 10,000
Power extension		$ 21,000
	Sub Total	$ 56,000
OCCUPATIONAL HEALTH & SAFETY		
Supply of equipment for staff		$ 10,000
	TOTAL	$107,000

Contact Officers:

District: Mr. Jack Chubb
District Manager
MANILLA (067) 851203

Region: Mr. Tony Page
Manager, Business Operations
TAMWORTH (067) 678426

Head Office: Mr. John Allen
Executive Manager, Business Operations
SYDNEY (02) 2286111

Acceptance.

Department of Conservation and Land Management (incorporating the Soil Conservation Service of N.S.W.) agrees to provide the extent of services outlined in this brief for the fee of $107,000. This offer holds for a period of 3 (three) months from the date of my signature.

The provision of the services shall commence from the date of receipt of this signed brief acceptance with a local order for the same.

Acceptance of these services as outlined in the brief is indicated by the signatures below.

OFFER	ACCEPTANCE
Signed: [signature]	Signed: [signature]
Name: Tony Platts	Name: G. Terrey
Position: Manager Business Operations	Position: C/M
Date: 22.10.92	Date: 17 Nov 92

For:
The Department of Conservation and Land Management.

For:
The Department of Mineral Resources.

DEPARTMENT of CONSERVATION AND LAND MANAGEMENT

Incorporating SOIL CONSERVATION SERVICE of NSW

WOODSREEF ASBESTOS MINE

CONSULTANCY BRIEF

Offering services to:
DEPARTMENT of MINERAL RESOURCES

1.0 INTRODUCTION

At the request of Mr. Bruce Kremer I have prepared design and cost estimates for stages III & IV at Woodsreef asbestos mine, necesssary for the short term stabilisation, as outlined in the Barraba Mine Rehabilitation Feasibility Study (oct 86), of the waste rock dumps.

1.0 STAGE III

This stage provides for drainage of water from the southern waste rock dump into the south pit and the north western waste rock dump into the north pit.

Works include the construction of two silt traps and an evaporation pond plus channels to drain the water on top of the waste rock dump back into the pit.

2.0 STAGE IV
See attachment 2 for location

These works include the construction of two silt trap dams and evaporation pond.

3.0 SAFETY

Safety with the handling of asbestos contaminated material is of major concern to our staff. We have investigated this matter and will incorporate all safety procedures the costs have been shown in 4.0.

4.0 COST DETAILS

Works	Cost
STAGE III	
Drainage of northern waste rock dump into north pit.	$20,000
Drainage of southern waste rock dump into south pit.	$20,000
Total	$40,000
STAGE IV	
Construction of silt traps below waste rock dumps.	$ 3,500
Construction of evaporation pond	$ 750
Total	$ 4,250
Occupational Health & Safety	$10,000
Grand Total	$54,250

C.J.CHUBB
DISTRICT SOIL CONSERVATIONIST
MANILLA
15th December 1992

Attachment 1.

Department of Conservation and Land Management agrees to provide the extent of services outlined in this brief for the fees stated. This offer holds for a period of 3 (three) months from the date of my signature.

The provision of the services shall commence from the date of receipt of this signed brief acceptance with a local order for the same.

Acceptance of these services as outlined in the brief is indicated by the signatures below.

OFFER	ACCEPTANCE
Signed:....................	Signed:....................
Name:......................	Name:......................
Position:..................	Position:..................
Date:......................	Date:......................
For The Department of Conservation and Land Management.	For The Department of Mineral Resources.

PART B : LMK STABILITY ANALYSIS

Stability Analysis

The geotechnical analysis of dump stability required consideration of the dump geometry, material strength parameters and the water table level within the dumps. No external forces such as earthquake loading have been included.

The tailings dump and waste rock dumps both have similar batter angles on their leading edges and values in the range of 37 to 38 degrees (measured from the horizontal) were recorded on site for both dumps. The laboratory testing of the tailings provided drained strength parameters of a similar value. Friction angles (being the slope of the strength envelope) in the range of 39 to 40 degrees, with some cohesion, were recorded in the laboratory. The close correlation between the dump batter angles and the laboratory testing was expected given the method of dump placement. The similar batter angles of the tailing dump and the waste rock dump faces implies that the strength of the finer material governs the stability of the batters for the waste rock dumps.

As tension cracks were observed on both the tailings and waste rock dumps, it has been concluded that the dumps have previously, at least once, been at a failure condition (limiting stability). In addition to the tension cracks along the crest of the tailings dump, a landslip was also observed. The trigger for these failures is believed to be a rise in pore pressure, or more simply, a rise in water level (phreatic surface) within the dumps.

The rationale of the stability analyses was therefore to derive a mathematical model of the dumps at a state of limiting stability by adjustment of the phreatic surface. This model was then modified by regrading of the surface and the improvement in factor of safety (against instability) was calculated.

In this case, back-analysis was used to confirm the choice of material properties and critical phreatic surface. Given this, and the acceptance by the MRD of the risk of instability, a target improvement in the factor of safety of about 20% has been adopted for this Study, representing a factor of safety of about 1.2.

The material properties used in the analyses presented in Table E1. The design shear strength parameters are considered representative of the materials in the field at shallow depth and the analysis has conservatively neglected the expected increase in shear strength of the tailings with burial depth.

The stability analyses have been performed for a 60 metre high dump. The long term stability has been calculated using the computer programme STABL which uses Carter's method (1971) of slope stability analysis. This method exhibits a similar economy to that of the simplified Bishop procedure but is able to accommodate general non-circular surfaces. The results of the stability analyses follow.

The result of the analyses are also presented in Table E2. By reference to the table, it is seen that the improvement in factor of safety for a 1.5:1 batter angle is about 17% which is marginally less than the target value of 20%. Given the other proposed works to improve surface drainage on the dumps, this batter angle was accepted by the Steering committee for the design of rock fill and rock encapsulated slopes. The batter slopes for Tailings Treatment T4 (topsoil and re-vegetation) were selected on the basis of stability of the skin of topsoil upon the surface of the slopes. It eventuates the over-all stability is much less critical in this instance and the stability results show a greater improvement in factor of safety than targeted.

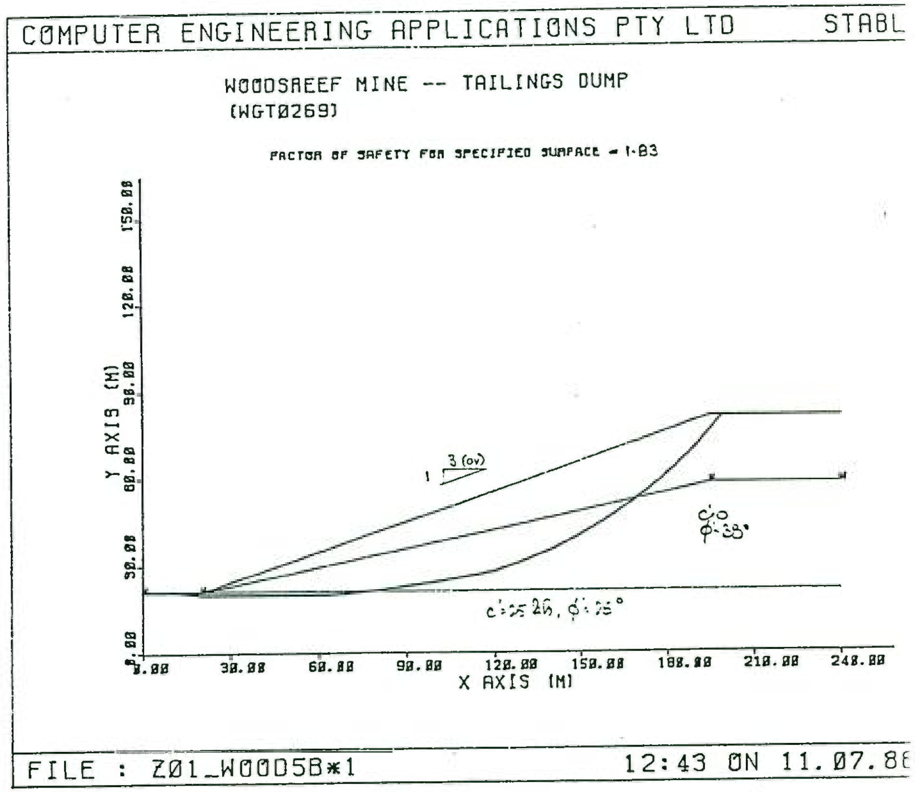
TABLE E1 MATERIAL PROPERTIES

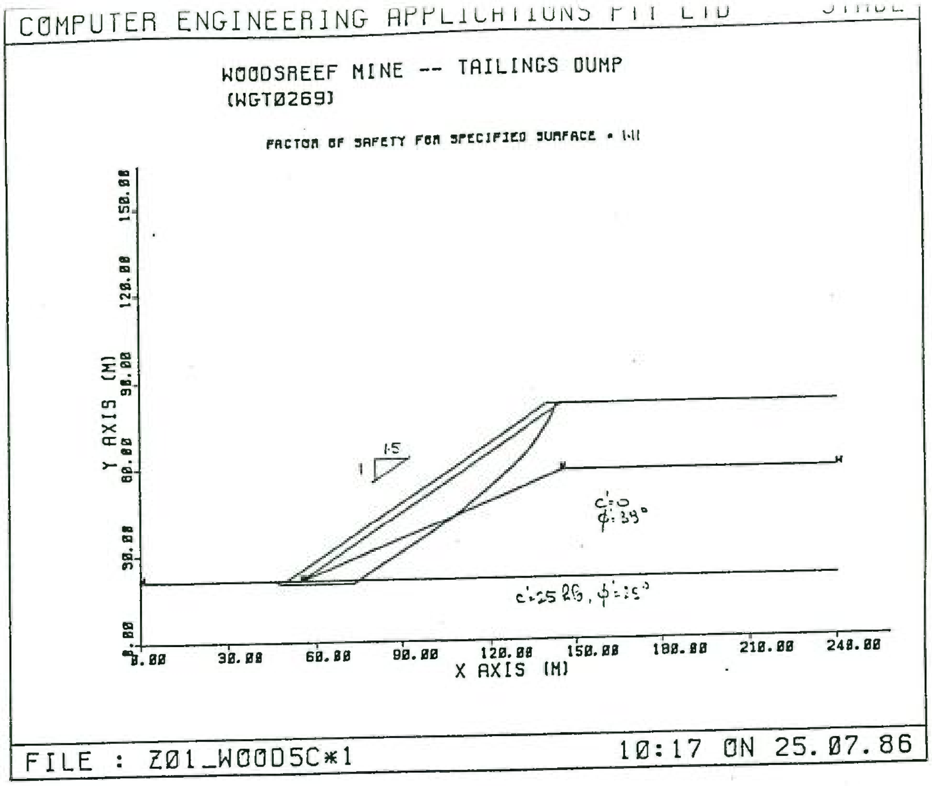
Material	Long Term Strength Parameters*	
	c' (kPa)	ø' (degrees)
Foundation Clay	25	25
Dump Material	0	38

* c' = effective cohesion intercept of strength envelope
ø' = effective angle of internal friction (slope of strength envelope).

TABLE E2 RESULTS OF STABILITY ANALYSES

Model	Calculated Factor of Safety	Improvement in Factor of Safety over Base Model
BASE MODEL	0.95	-
30° LEADING EDGE	1.20	26%
1.5:1 LEADING EDGE (Approx 34°)	1.11	17%
3:1 LEADING EDGE (Approx 18°)	1.83	93%




COMPUTER ENGINEERING APPLICATIONS PTY LTD
WOODSREEF MINE -- TAILINGS DUMP
(WGT0269)
FACTOR OF SAFETY FOR SPECIFIED SURFACE = 1.11
Y AXIS (M)
X AXIS (M)
FILE : Z01_WOODSC*1
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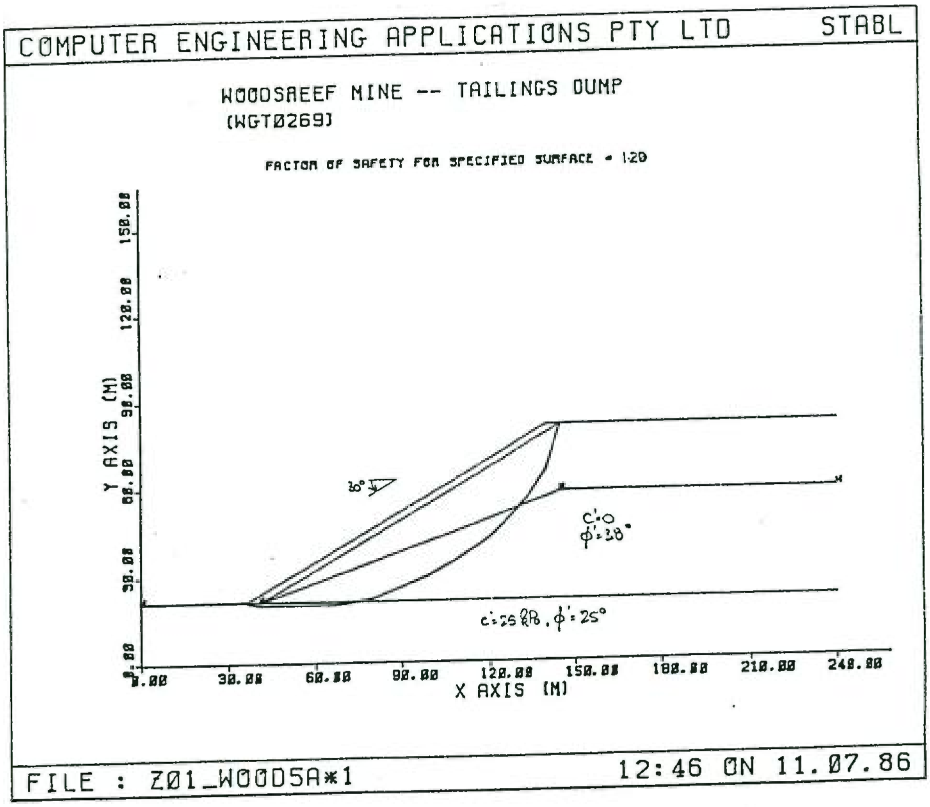
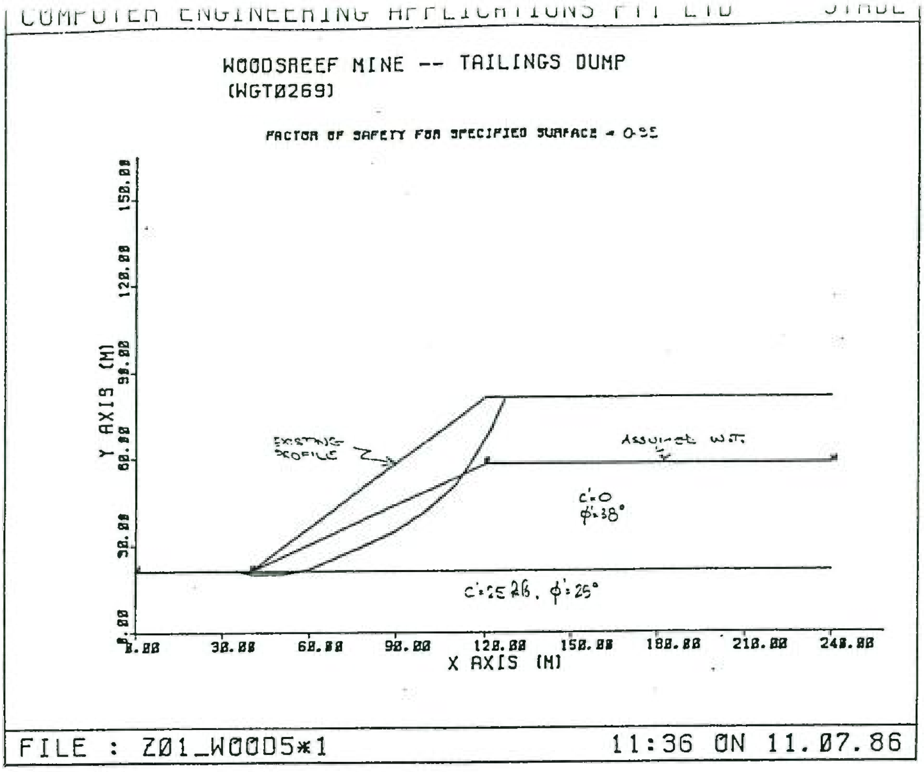

COMPUTER ENGINEERING APPLICATIONS PTY LTD
STABL
WOODSREEF MINE -- TAILINGS DUMP
(WGT0269)
FACTOR OF SAFETY FOR SPECIFIED SURFACE = 1.20
Y AXIS (M)
X AXIS (M)
FILE : Z01_WOODSA*1
12:46 ON 11.07.86



WOODSREEF MINE -- TAILINGS DUMP
(WGT0269)
FACTOR OF SAFETY FOR SPECIFIED SURFACE = 0.95
Y AXIS (M)
0.00
30.00
60.00
90.00
120.00
150.00
EXISTING PROFILE
ASSUMED W.T.
c'=0
φ'=38°
c'=25 26, φ'=25°
X AXIS (M)
0.00
30.00
60.00
90.00
120.00
150.00
180.00
210.00
240.00
FILE : Z01_WOOD5*1
11:36 ON 11.07.86

PART C : OTHER

OF N.S.W.

29th August, 1977

P.O. Box 130, Scone, N.S.W. 2337
Telephone: XXXXXX (065) 451344.

In reply quote EX-1
and address "District Soil Conservationist"

The Operations Manager,
Chrysotile Corporation of Australia Pty. Ltd.,
P.O. Box 120,
BARRABA, N.S.W. 2347.

Dear Sir,

I wish to acknowledge receipt of your letter of 15th July and of plans for the proposed tailings disposal area. The plans have since been reviewed and, in general, are similar in concept to those which the Soil Conservation Service had prepared for the area. There are however, several aspects of the plans which either have not been explained in detail, or which the Service feels should be reconsidered. These are as follows:-

1. Although a slope angle of 35° on the dump faces has been shown in practise to be stable, it is considered that this is a maximum value which leaves no margin of safety. Undercutting of the batters by as little as 10cm during berm-shaping operations could lead to instability which would eventually cause berms to be buried beneath 30-40cm of tailings.

   It is therefore recommended that the proposed width of berms and vertical interval between berms be retained, but that batter angles be reduced to 26°. This would result in an overall face angle (including benching) of 21.5° or 2.5:1. If the outer toe of the dump is retained in the position indicated on your plan, this would result in a reduction in the total volume of the dump of approximately 3%. In view of the fact that the proposed dump volume exceeds the requirements of the present mining operation, this reduction in volume should not be significant.

2. The location of the diversion channel around the south-eastern corner of the dump should be altered for the following reasons. (See attached plan).

- The proposed line of the channel would require excavation of a trench, in excess of 8 metres deep, between grid lines 6N and 7N.

  This excavation would be needed to maintain the required channel gradient where the channel passes through the crest of a ridge. To achieve stable batter slopes, this trench would need to be up to 50m wide at ground level and would extend beneath the proposed toe of the dump on the lower side.

  As an alternative, it is suggested that the channel be located as shown on the attached plan, to discharge directly into the head of the natural watercourse. This would require trenching to a depth of only approximately 4.5 metres, for a considerably shorter distance.

- The watercourse, into which it is proposed to discharge the diversion channel, will itself be buried beneath the tailings dump between grid lines 25E and 29E. It is therefore recommended that an additional diversion channel be constructed, as indicated on the plan, to prevent runoff flowing against the toe of the dump.

3. Between the approximate grid positions of 13N/33E and 19N/31E, the surface of the tailings dump will be at ground level along the 610-metre contour. While this "feathering out" of the dump will effectively blend it with the surrounding terrain, it will also create problems of runoff from the surrounding catchment flowing across the tailings surface. Since the dump surface will slope at 1.5° towards the west, any runoff flowing across the surface would eventually be discharged over the western face of the dump, where erosion problems could arise.

   To minimise erosion risk, it is recommended that contour banks be constructed on the tailings surface, roughly parallel to the 610-metre contour, as indicated on the plan. Between the approximate grid positions of 19N/31E and 19N/30E, a natural pond will be formed above the dump. It is recommended that this be retained as a dam, with its spillway discharging into a natural watercourse near the north-western corner of the dump.

4. No mention was made in your letter of the source of topsoil or ridge gravel for topdressing the dump. It is strongly recommended that all available soil material within the dump area be stripped and stockpiled at suitable locations for later re-spreading. Topsoil should be stripped progressively, as the dump expands and should be stockpiled in locations where it will not become mixed with, or contaminated by, tailings material.

5. Because of the steep angle of the dump faces, the only means of placing soil on the inter-berm slopes would be by dumping over the berms. This would be extremely wasteful of soil and it is doubtful if the soil could be retained on the slopes. It is thus suggested that top-soiling be confined to the berms only and that the inter-berm slopes be covered with waste rock. This would minimise erosion risk and prevent dust being blown from the dump faces. As the dumping programme permits, the berms should be progressively planted to trees and shrubs. Species should be selected which will grow to a height of at least 10 metres, so that eventually the inter-berm slopes will be concealed. Species selection will depend upon the results of trial work, but any of the species mentioned in my letter of 10th May, 1977 should be suitable.

6. To enable rehabilitation work to be progressive, it is recommended that dump construction be divided into sections. It is suggested that the area north of the 11N grid line be completed first, followed by the area east and south of the 29E and 11N grid lines and finally by the area south and west of these lines. Such a division would also minimise the area to be rehabilitated, should mining operations cease for any reason before the deposit has been fully exploited.

Yours faithfully,

TAMWORTH, 3rd July, 1981.

T/3644

Woodsreef Asbestos Mine, Barraba

Situation Report as at 30/6/81.

An inspection of Woodsreef Asbestos Mine, Barraba was carried out by W. Ford, A/Assistant Area Director, Tamworth and D. Stewart, District Soil Conservationist, Barraba on Wednesday 1st July, 1981. The aim of this inspection was to determine the present and potential erosion and subsequent siltation risk present at the mine.

1. THE PROBLEM

The erosion risk results directly from the stock-piled overburden and mill tailings dumps surrounding the proximity of the open cut mine and refining mill. These dumps are completely exposed to the elements. Some water and wind erosion has and is occurring. However, the actual erosion potential is massive as these dumps cover an area of approximately 60 hectares.

Water courses from the mine drain directly into Ironbark Creek a distance of 0.5 - 2.5 km from the various dumps. This creek then joins the Manilla River approximately 6km to the southwest. The wall of the proposed Split Rock Dam is approximately 30km downstream (by watercourse) from the mine, but the proposed top water level (TWL) comes back to the Racecourse Creek/Ironbark Creek junction. This is only 2.5km downstream from the mine (see diagram1).

Irrespective of what is stated in the abstract of the report "Some Environmental Investigations at the Woodsreef Asbestos Mine", G.S. Toyer and S. Main, December, 1978, (copy attached) the risk of major siltation into the proposed Dam is very high. This risk increases significantly in the summer montha when it can be expected that high intensity storms and occassionally the remnants of cyclonic rains from Queensland normally occur. It should be noted here that these type of rainfall events have not occurred in the laat 3 year's summers.

2. MINE AREA DESCRIPTION

Woodsreef Asbestos Mine is located 18km east of Barraba. The mine is located directly south-west of the Bundarra/Crow Mountain road junction.

Rock and overburden dumps are located on the northern and south-western perimeters of the mine pit. Mill tailings are conveyed over the Crow Mountain road to the east and south-east. The approximate areas covered by (1) the rock and overburden dump, and (2) the mill tailings dumps would be 20 hectares and 24 hectares respectively.

Water drainage from the area can be seen on diagram 1. Distances shown are from respective dump locations to Ironbark Creek. Diagram 2 delineates the area covered by the mill tailings dump.

Large scale open cut mining operationa began in 1971 although some mining activity began aa far back aa 1918.

It is not proposed to discuss climatic, geologic, soil and vegetation characteristics in this report. These have adequately been described in previous correspondence and also in the Mines Department Report prepared by Toyer and Main in 1978.

3. COMPANY HISTORY

In 1971 mining was commenced by Woodsreef Mines Ltd under its operating subsidiary Chrysotile Corporation of Australia Pty. Ltd. Financial problemd saw the appointment of receiver-managers in 1973. Further financial problems have plagued the mine until this year when it actually began closure. Funds were raised overseas and full closure was prevented. However, two thirds of the workforce were put off and only one shift is currently being worked.

Historically the Company has not carried out any significant rehabilitation works on the tailings dumps (H.O. letter to Dept. of Mineral Resources 73/1743 dated 9/10/80). Small trial areas of works have been done but these have not led to stabilization of the area as a whole. The Company's addendum to the Toyer/Main Report (1978) states certain works would be carried out in 1980. These works are not evident.

Mining has been carried by the dry extraction process. However, Mr. Jim Brooks (Mines Inspector, Armidale) advised the D.S.C., Barraba last week during a telephone conversation that the Company intended to introduce a wet milling process. Existing mill tailings are to be re-processed. The life expectancy of this operation would be 10-12 years.

As the Company's past history shows, this plan should only be noted at this stage. Local reports indicate that as yet this process has not been fully developed on a commercial scale. If this milling process is implemented then the current mill tailings dump would be altered considerably. No location for waste from this process has been identified. Appropriate stabilization and rehabilitation recommendations would therefore have to be developed prior to the introduction of this reprocessing operation.

4. EROSION RISKS

Current erosion and erosion risk problems arise from a number of factors present at the mine. These have been described previously (the most recent H.O. 73/1743 dated 9/10/80) and therfore are summarised as follows.

(a) Dump batters, particularly those of the mill tailings dump, have gradients which vary between 30° - 40° with the majority being 33° and over. As a result batters are highly unstable and evidence of slips and slumpage is quite visible. (See photographsA).

(b) Dry material from the mill tailings is subject to wind erosion. The area surrounding the tailings dump is covered with a layer of tailings material at an average of 60mm deep 100 metres from the dump (See photograph thereby adding to the area contributing to siltation (approximately 15 hectares). Contrary to the addenum of the Toyer/Main Report some material is windborne. One complaint re dust has been received from a property 8km south-east of the mine when winds prevail from the north-west (J. Noon, "Yarramarra", Barraba).

(c) Lack of compaction in the mill tailings dump aggrevate problems (a) and (b) above.

(d) Overburden and mill tailings dumps are highly erodible when subjected to rain. The material is easily transported in water as is evidenced by the amount of siltation in the drainage lines adjoining the dumps (See photographsC). The Company itself admits rain breaks down the surface crust formed on the mill tailings.

(e) There has been little or no topsoiling carried out over the dumps. In fact much of this is buried underneath the tailings dump.

(f) There is a complete lack of vegetation on most of the dumps. This is because of the lack of topsoil and toxicity of much of the material (calcium/magnesium ratio) present in the dumps.

(g) The risk of high intensity storms and/or prolonged rains would lead to severe erosion of the dumps.

(h) There have been little to no erosion control measures in the form of earthworks undertaken by the Company. As a result drainage lines have been exposed to direct siltation from the dumps (See photgraphsC).

(i) Erosion control recommendations re use of waste rock on the tailings dump have not been carried out by the Company.

As a result of the above factor, the overburden and mill tailings dumps are extremely prone to the forces of soil erosion. There is a genral unstability within the dumps. This would be greatly aggrevated if storms of 1 in 10 years (55mm/1 hour)) or greater, and/or prolonged heavy rains were experienced at the mine. Substantial erosion of the dumps would occur in these events.

5. <u>SILTATION RISKS</u>

Two major siltation risks currently exist as a direct result of the unstable dump batters at the mine. These are:

(i) <u>Siltation of Ironbark Creek</u> - Some siltation of this creek is already occurring. (See photograph D). As described in 4. above major siltation of this creek is possible should serious erosion of the mine's dumps occur. Once this siltation has started, continuous problems would be experienced every rainfall unless erosion control measures were implemented.

The major concern arising from the siltation of Ironbark Creek is subsequent siltation of the proposed Split Rock Dam. Although no definitd date for commencement of construction for this Dam has been set, there is no shadow of doubt that it will go ahead.

Therefore siltation of Ironbark Creek will result in siltation of Split Rock Dam. Further, pollution of the dam's waters from this siltation could result (asbeatos fibres, toxic minerals, etc.) but this factor would have to be determined by the Mines Department.

(ii) <u>Siltation of Crow Mountain Road</u> - This road is currently experiencing siltation problems from the western face of the mill tailings dump (see photograph E). It is quite evident from this photograph that silt is being graded off the road's surface.

Further, if recommendations made previously were carried out (that is gradients of the dumps batters were reduced to 21.5°) this road would be completely engulfed. Relocation of the road near the mines mill area would therefore be necessary.

6. <u>EROSION CONTROL MEASURES</u>

Many of these measures have been recommended previously. These are summarised as follows:

(a) Dump batters should be reduced and benches installed so that the overall gradient angle does not exceed 21.5°.

(b) Surface treatment of batters and berms should include topsoiling of the berms, the covering of inter-berm slopes with waste rock, and the revegetation of the berms with trees, scrubs, etc.

(c) The dumping of further mill tailings at the northern end to bring the surface of this dump up to the 610 metre contour.

(d) Provision of drainage to the south of mill tailings dump.

(e) Topdressing with waste rock of a small area of the mill tailings dump (30-40cm covering) so that the effects of this treatment on wind and water erosion can be studied.

(f) The installation of a diversion channel around the south-eastern corner of the mill tailings dump.

The Mining Company has not carried out these measures in full. As a result it is considered that <u>additional</u> erosion control measures are required to ensure siltation into Ironbark Creek is prevented. These measures should include:

(i) The inatallation of silt trap structures in the drainage lines east of the Crow Mountain road (see diagram 1.).

(ii) The installation of a major silt dam on the western side of the Crow Mountain road (downstream). This structure should have a pipe fitted and be in the vicinity of 10,000 to 15,000 cubic metres in capacity. Engineering advice re design would be necessary (see photograph F).

(iii) The installation of diversion banks and drains immediately above the existing perimeter of the mill tailings dump. The run-off from the catchment above this dump (nearly 200 hectares) should be diverted prior to hitting the tailings dump(see diagram 1).

(iv) Further diversionary works should be designed above those described in (iii) so that if tailings cover these works before reaching the 610 metre contour level similar diversionary precautions can be undertaken.

7. <u>CONCLUSION</u>

An extremely high erosion risk exists on the batters of the Woodsreef Asbestos Mine's overburden and tailings dumps. These batters are unstable and they are completely exposed to the forces of erosion.

It is considered that extremely severe erosion would result at the mine should a severe storm or heavy prolonged rain occur.

The mining Company has not undertaken any significant rehabilitation or erosion control works to prevent possible siltation into Ironbark Creek which runs along the western boundary of the mine.

S.O. 1063 D. West, Government Printer

Should erosion of the mine's dump occur, large scale siltation of Ironbark Creek will result. In the long term this siltation will affect the projected Split Rock Dam.

Access on the Crow Mountain road near the mine is being endangered by siltation from the mill tailings dump. This situation is aggrevated by the fact that batters from the tailings dump almost encroach on the road.

Immediate action is required to remedy the erosion situation at the mine. Stabilization of the various dumps batters is needed to reduce erosion risk and hazard. Additionally more silt traps, diversion banks and drains are required to minimise siltation risks. A major silt trap should be constructed below the main potential siltation source prior to run-off entering Ironbark Creek.

8. RECOMMENDATIONS

It is recommended that:

- the Department of Mineral Resources and Development be immediately advised as to the potential erosion and siltation risk currently existing at the Woodsreef Asbestos Mine.

- complete planning of the additional erosion control measures be undertaken by the Service and the Mines Department be advised accordingly.

- measures such as the relocation of the Crow Mountain road near the mine, planning of waste disposal from the wet milling process if introduced, and further revegetation trials and research be included in the overall mine rehabilitation and stabilization programme submitted by this Service to the Department of Mineral Resources and Development.

Warwick Ford

W.A. Ford,
for W.J. Rhodes,
Area Director,
TAMWORTH.

8 JUL 1981

THE COMMISSIONER.

Attention: Deputy Chief Soil Conservationist (Works and Land Management).

Photographs removed. 27/7/81.

W. A. FORD, EXT. 330. MI 1572

TAMWORTH, 11th Sept., 1981.
T/3644.

Woodsreef Asbestos Mine, Barraba.

Head Office 72/1743.

Further to my report dated 3rd July, 1981, an inspection of part of the mine area was held on Wednesday, 2nd September, 1981. This inspection was held at the request of Mr. Jim Brooks, Mines Inspector, Armidale. Those present at the inspection included Mr. Brooks, Doug Stewart, District Soil Conservationist, Barraba, and myself as the Acting Assistant Area Director.

The following is a report on this inspection:

1. THE PROBLEMS.

Mr. Brooks was concerned with two problems at the mine. These are:

(a) The encrouchment of stock-piled overburden on the western side of the mine into Ironbark Creek. Photographs A and B (particularly B) show the problems. Batter gradients of these dumps are in excess of 35°.

(b) The siltation and erosion being caused near the eastern side of the mine pit adjacent to the Barraba/Bundarra road. This problem is being caused by water which is pumped from the mine pit and is then being allowed to flow down overburden dumps before flowing into Ironbark Creek (see photographs C to F).

2. DISCUSSION.

Batter gradients of the overburden dumps mentioned in Problem 1 (a) are well in excess of the recommended 21.5° (see report dated 3/7/81). Benches need to be installed so that stability is increased.

A silt retention structure could be built in the water disposal area below the dump in photograph A. This would retain silt currently present in the run-off prior to these flows entering Ironbark Creek. This proposed structure would be situated on the flood plain of Ironbark Creek.

The installation of benches on the dump shown in photograph B will, in the opinion of myself and Mr. Brooks, present major problems. Batter gradients could not be reduced to the desired incline because the toe of this dump would then encrouch into and across Ironbark Creek just below where the mine is currently obtaining its water supply. An increased batter gradient would have to be accepted in this instance. However, it is still considered that benching would be desirable.

The siltation which is resulting from the operation described Problem 1 (b) is significant because it is continuous. It could be overcome by constructing a significant silt dentention structure (2000 m^3 or larger) in place of the one shown in photograph D. All pumping could then be directed through this

structure rather than through the two points (photographs D and E).

Siltation from these currently used pumping operations enters Ironbark Creek at location 9 diagram A of my previous report.

3. OTHER DISCUSSION.

(a) With Mr. Brooks - During our inspection Mr. Brooks made mention of the fact that the mining leases held by Woodsreef are currently being renewed. Mr. Brooks has recommended to his superiors in the Mines Department that Woodsreef surety be increased from $10,000 to $2M.

(b) General Inspection - After Mr. Brooks left to attend to other work the District Soil Conservationist and myself drove down Crow Mountain road to have a general look at the stability of the mill tailings dump batters and other overburden dump batters.

Since our June inspection it is quite apparent that significant erosion has occurred. Photographs G, H and I are of the mill tailings dumps at location 10 of my previous report. Photograph J is of the overburden dump near location 1. As can be seen by comparison increased erosion of both dumps' batters has occurred.

Rainfall at the Barraba Soil Conservatin Service office since my previous report has been as follows:

JULY, 1981 - 8 wet days. 73 mm. Two falls one of 25 mm and then 2 days later the other of 28 mm were of significance. The District Soil Conservationist reported that these were of a low to moderate rainfall intensity.

AUGUST, 1981 - 5 wet days. 11 mm. There were no significant rainfall events during this month.

This erosion compared with the rainfall events confirms statements I made previously. That is that, significant erosion will occur at Woodsreef Mine should high intensity or prolonged rains occur at the mine site.

4. CONCLUSION.

The placement of overburden on the western side of the mine site near Ironbark Creek has already and will continue to provide a source of direct siltation into the creek.

The dump site situated just below the mine's water supply source on Ironbark Creek will ultimately encroach onto the creek if dumping is continued. As it is if the dump batter gradients were reduced to 21.5°, the dump would encroach into the creek.

The erosion being caused by pumping water from the mine pit is providing a continuous source of siltation into Ironbark Creek. This silt load could be reduced significantly by the construction of an adequate silt trap before run-off crosses under the Barraba/Bundarra road.

Since my last inspection on 1st July, 1981, significant erosion has occurred on the batters of the mill tailings dump even though only low to moderate rainfall intensities have been recorded since that date.

5. RECOMMENDATIONS.

It is recommended that:

- the Department of Mineral Resources and Development be advised of this recent inspection and that Mr. Brooks, the District Soil Conservationist, Barraba, and myself consider that continued dumping of material on the dumps shown in photographs A and B will greatly increase the siltation risk into Ironbark Creek.

- an additional silt dentention structure be incorporated into the second recommendation of my previous report to handle flows from pumping operations within the mine pit.

Warwick Ford

W. A. FORD.
for W. J. RHODES.
AREA DIRECTOR, TAMWORTH.

THE COMMISSIONER.

ATTENTION: STATE CO-ORDINATOR,
LAND RESOURCES.

Further modification of recommendation should be left in abeyance until the outcome of approach to Dept. Min Res. is known. [illegible] 18-9-81

Mr Roberts

.P

Public Works Department

CIVIL ENGINEERING DIVISION

BARRABA MINE SITE REHABILITATION:

GEOTECHNICAL INVESTIGATION.

LOCAL OFFICE FILE NUMER: 1192.

M 6112/85

REPORT No. 86077.

R. TADANIER
SUPERVISING ENGINEER
GEOMECHANICS LABORATORY

B. L. CANTWELL
PRINCIPAL ENGINEER
DESIGN

TABLE OF CONTENTS

LIST OF APPENDICES

1. INTRODUCTION

At the request of the Dams Section, Design Branch, the Geotechnical Centre has undertaken a geotechnical investigation of the tailings dump at the Woodsreef Mine Site, near Barraba.

This report presents the data from the field and laboratory investigations. The investigation was carried out in accordance with the scope of work outlined in the discussions held between Messrs. C. Karwaj and N. Himsley and a subsequent minute M6112/B5 dated May 21st, 1986.

Samples 976D and 9765 were tested by Coffey and Partners and Longworth and McKenzie Pty Ltd, respectively. The remaining samples were tested by the Geotechnical Centre. All test results are appended.

2. INVESTIGATION

2.1 Fieldwork

Fieldwork was undertaken on May 15th, 1986 and comprised the excavation of five pits to depths ranging from 1.5m to 2.5m.

Three (3) pits were excavated at the top of the tailings dump and two (2) at the base. Bulk disturbed samples and thin walled undisturbed (50mm and 100mm diameter) samples were taken. In addition, three (3) density in place determinations, using sand replacement method, were carried out.

All field work was supervised throughout by a Technical Officer who logged the pits and carried out the on site testing and sampling.

2.2 LABORATORY TESTING

The following tests were performed on selected soil samples:

* Dry Density and Moisture Content
* Grading Analysis
* Atterberg Limits
* Dispersion Analysis
* Constant Head Permeability test in triaxial cell
* Consolidated Undrained (CU) triaxial test

3. BORELOGS DISCUSSION

In pits P1 and P3, excavated at the top of the tailings dump, the profiles basically consisted of gravelly silty sand underlaid by gravel with some sand and interbedded layers of gravel and sand. The tailings were generally of loose consistency.

In pits P4 and P5, excavated at the base of the tailings dump, the profiles were variable.

In pit P4, tailings were encountered to a depth of 1m followed by 1m thick layer of medium dense gravelly silty sand. Below, to termination depth at 2.5m, soft, sandy silty clay with rounded cobbles up to 150mm in diameter was encountered.

In pit P5, the profile consisted of tailings to a depth of 1m followed by 0.3m thick horizon of clayey sandy silt and then 0.7m thick layer of stiff, gravelly sandy clay. Below, to pit termination depth at 2.3m, moderately to highly weathered serpentinite was encountered.

4. TEST RESULTS

4.1 In situ Density and Moisture Contents

Table 1 summarizes the in situ dry density determinations by sand replacement method and density/moisture content determinations from the undisturbed samples extracted in the laboratory.

Table 1 : Summary of Densities and Moisture Content Data

PIT	DEPTH (m)	METHOD	WET DENSITY (t/m^3)	DRY DENSITY (t/m^3)	MC (%)
1	0.1 - 0.4	U100 *	1.98	1.85	7.1
1	0.1	DIP **	1.98	1.85	6.9
1	1.5	DIP	1.82	1.77	3.1
2	1	DIP	1.66	1.57	5.5
2	1 - 1.3	U100	1.73	1.69	2.4
3	0.1 - 0.35	U50 ***	1.99	1.84	7.9
3	0.5 - 0.8	U50	1.87	1.76	6.3
3	1 - 1.3	U100	2.00	1.90	5.5
4	0.1 - 0.4	U100	1.80	1.55	16.4
4	1 - 1.35	U100	2.05	1.89	8.3
5	1.6 - 1.8	U100	1.96	1.57	24.9

* Thin walled undisturbed sample 100mm diameter

** Density in Place - sand replacement method.

*** Thin walled undisturbed sample 50mm diamter.

4.2 Grading Analysis

The grading envelopes of tailings is presented as Figure 1. Majority of the tested samples were predominantly gravelly sands with some silt and traces of material in the clay size fraction classifying as SM or SW/SM.

Variation to the above was encountered for sample 9753 (Pit 1 - 1.5m) where the material was a gravel with some sand and cobbles classifying as GP.

All tailings samples contained some asbestos. In order to examine its behaviour two of the samples were subjected to dispersion analysis. The dispersal index for samples 9752 and 9756 was 27.1 and 18.2 respectively. The DI is a ratio of chemically dispersed (ie. with deflocculant) corrected 7 hour reading to mechanically dispersed (ie. no deflocculant) corrected 7 hour reading.

Plate 1 shows the behaviour of sample 9756 after a settling time of 24 hours. With no deflocculant, majority of the asbestos fibre has settled out, however, with deflocculant most of the asbestos remained in the suspension.

4.3 Permeability

The permeability, determined by a constant head method in the triaxial cell, varied from 10^{-4} cm/sec to 6×10^{-5} cm/sec.

4.4 Shear Strength Test Data

Table 2 summarizes the results of Consolidated Undrained Triaxial Tests carried out on selected samples.

Table 2 : Shear Strength Test Data

SAMPLE	PIT	DEPTH (m)	PLACEMENT CONDITIONS		EFFECTIVE STRESS PARAMETERS	
			DRY DENSITY (t/m^3)	MC (%)	APPARENT COHESION C' (kPa)	ANGLE OF FRICTION ϕ' (deg)
9750	1	0.1-0.4	1.85	7.1	9	38
9756	2	1 - 1.3	1.69	2.4	7	37
9760	3	1 - 1.3	1.90	5.5	0	38.5
9761	4	0.1-0.4	1.55	16.4	11	40
9762	4	1 - 1.35	1.89	8.3	12	35
9765	5	1.6-1.8	1.57	24.9	25	25.5

If there are any enquiries regarding these results please contact R. Tadanier, Inspecting Engineer, Geomechanics Laboratory on Tel: [02] 516 0277.

B.L. Cantwell,
Principal Engineer,
Design

per 17/7/86
for: R. Tadanier,
Inspecting Engineer,
Geomechanics Laboratory.

Inspecting Engineer,
Dams.
(Attn: Mr. N. Himsley).

MINUTE PAPER

PAPERS:–

SUBJECT:– Inspection of Woodsreef Asbestos Mine by Engineering Branch, August, 1987.

Introduction

An extensive surface inspection of the Woodsreef asbestos mine tailings and waste-rock dumps were undertaken by the Chief Mining Engineer (minerals) and the Regional Mining Engineer (North East) on August 14th, 1987. The aim of the inspection was to determine whether there was any pollution of watercourses occurring from the tailings and waste rock dumps.

Discussion

There had been 11mm of rain in the area in the 24 hours prior to the inspection, however the site was devoid of rainfall from August 3rd, when 18mm of rain fell.

Run-off from the spoil dumps (tailings and waste-rock) flows in a westerly direction into the Southerly flowing Ironbark Creek. The watercourses that were most likely to carry eroded spoil material were traced to determine the extent, if any, of sedimentation.

Fifteen sites were examined in all (see attached sheet).

Conclusion

It was found that under the weather conditons that have prevailed since the mine closed in 1983, the site is in a maintenance-free condition with little remedial work required, apart from the cleaning out of culverts and repair of a small retention dam. The retention dams that have been constructed are working satisfactory.

Tailings are not being transported downstream further than a retention dam approximately 100m from the South west toe of the tailings dam. The freeboard of the dam needs to be increased by 0.5m.

A letter will be written to the company directing them to carry out the required works.

per D.C. Laurence
Regional Mining Engineer
ARMIDALE
20-8-87

Chief Mining Engineer

Attach:

ANNEXURE A

SITE	COMMENT
1	South west toe of tailings dump. No seepage.
2	Small retention dam. 150m from toe of tailings dam on westerly flowing watercourse. Dam is full of tails, needs increase in freeboard. Photograph 1.
3	Small dam on watercourse, 100m from retention dam. No flow, dirty waterbut no tailings present.
4	Watercourse crosses Crow Mountain road. No flow, no evidence of tailings.
5.	Small dam, 500m south of tailings dam. Small flow of clean water. Photo 2.
6	South of the southeastern toe of the Southern Rock Dump. Waste material has wasted down the face and some has been deposited in the creek. A small flow of approximately 0.5 litres/sec of very clear water. Bed of creek is obviously waste material but no suspended matter.
7	South west corner of Southern Rock Dump. Similar situation to 6, but more material wasted from face of dump into the watercourse. Clear water.
8	Confluence of two watercourses, and site of small dam. Algal growth but clear water. Some waste material evident.
9	Confluence of watercourse and Ironbark Creek. Clear water approximately 10 litres/sec. Water sample taken. Photograph 3. No evidence of waste.
10	Westerly flowline off Southern Rock Dump. Site of silt retention structure made of truck tyres. Stucture is working to satisfactorily in retaining much of the waste material from the dump. No seepage or water flow.
11	Site of proposed 6000m³ dam on South West side of North Western Rock Dump. No flow or maintenance problems.
12	Westerly side of North Western dump. The red clay that was dumped over the face is badly eroding into a culvert which is now blocked.

13	Another culvert where fine red clay has filled a culvert. Clay has spread over the creek flats but not into creek itself.
14	Site of previous spillage on North Western dump. Retention bank has been constructed and is working satisfactorily.
15	Main Barraba road crosses Iron-bark Creek. No suspended matter in creek.

APPENDIX VII

PROPOSED REHABILITATION STRATEGIES

COSTING

6.0 ESTIMATION OF COSTS

The basis of all costs is mid-1986 prices.

6.1 Earthworks

Unit costs were derived for a variety of suitable methods of work for batter regrading and dump removal. Cost data were obtained from the LMK in-house database and from general discussions with earthmoving contractors. A summary of hourly equipment hire rates and resultant costs per cubic metre for each operation are shown in Appendix H.

The unit costs for each option were selected on the basis of suitability of method and cost effectiveness, and are a general indication only. We believe that costing relativity has been maintained in the analyses, but more detailed assessments would be required to identify actual cost levels. Allowances have been made for operator accommodation and for contractor set-up costs. For Strategy A the operations consist of either 2 shift or continuous operations on a 5 day per week basis. For Strategy B a single shift of 8 hours daily (with no weekend working) has been assumed.

The details of the development of the unit rates are presented in Appendix H. In extract, the principal rates are:

Operation		Work Method	$/m^3$
Tailings Dump Removal	-	Hydraulic Monitors	$5.20
	-	Conveyor	$5.00
	-	Loaders/Trucks	$3.00
Tailing Dump Batter Regrading	-	Dozers	$1.15
Waste Rock Removal to Tailings Dump	-	Loaders/Trucks	$4.10
Waste Dump Batter Regrading	-	Dozers	$1.25

6.2 Erosion Control and Drainage

The treatment recommended by SCS to control erosion is based on a network of dams, diversion drains and outlet spillways. It varies in detail depending on the particular option examined, but the following provides a broad estimate of the budget allowance which should be made for these works.

An estimate of the costs for the different erosion control measures, have been formulated by LMK based on pro-rata costs provided by SCS. (See Appendix I). The costs include allowance for the construction of various settlement dams, water diversion works and boundary fencing. The details of the costing are presented in Appendix H, though in summary they are as follows:

Strategy A	$455,000
Strategy B	$405,000

These figures are the same for each option within the different Strategies and indicate that there are less costs in drainage and erosion control associated with regrading of the tailings than in the removal of the dump.

6.3 Revegetation

The rate for revegetation is based on a number of component rates supplied by SCS. In order to provide a reasonable estimate which will be within the same order of accuracy as the other rates provided in this study, some of the rates for the tailings dump have been applied to other works on the site.

The details of the costs are presented in Appendix H. The derived rates are as follows:

General revegetation rate	$2.31/m^2$
Revegetation rate for Tailings Treatment T4	$2.40/m^2$
Construction of topsoil haul road	$31,000.00

6.4 Demolition and Burial of Mill Buildings

It is possible that the Mill Buildings could be sold for scrap. Nevertheless, a nominal cost for demolition and revegetation of the site has been made assuming sale is not realised.

Nominal cost	$30,000.00

6.5 Road Re-alignment Adjacent to North Pit

The re-establishment of Crow Mountain Road to its Road Reserve is part of the rehabilitation work. The cost of an unsealed country road has been calculated from LMK & PWD in-house data-bases, and has been estimated at $40,000/km. The cost of the re-alignment is thus :

0.9 km @ $40,000	$ 36,000.00

6.6 Other Costs

Other costs which will be associated with the rehabilitation of the site include professional services for the following :

* the resolution of environmental matters;
* the performance of revegetation trials;
* the detailed survey, investigation and civil and landscape design of the site;
* the preparation of contract drawings and documents;
* the supervision of the works for the construction period;
* the supervision of maintenance of drainage lines and dams, fences, vegetation and weed control programmes; and
* an allowance for contingencies.

These costs have been estimated for both Strategies as:

Pre-rehabilitation work		$ 250,000
Professional fees		$ 500,000
Supervision of construction		$ 600,000
Contingencies		$ 400,000
	Total	$ 1,750,000

6.7 Maintenance

The costs of maintenance over a period of 5 years following successful completion of the rehabilitation have been estimated by the SCS. The maintenance costs include:

* repairs to erosion control works;
* re-seeding vegetation areas;
* replacing topsoil from eroded areas;
* noxious weed and animal control;
* de-silting of dams;
* topdressing with fertilizers; and
* de-silting of berms and waterways.

The costs were estimated using mid-1986 prices and are presented in Appendix I. The maintenance for each option within the Strategy was costed and the present worth was established using the assumption of 8% inflation. The present worth of the maintenance costs are:

Strategies A.1, A.2 and A.3	$503,000
Strategy B.1	$632,000
Strategies B.3 and B.4	$575,000
Strategy A.3V	$516,000
Strategy B.1V	$645,000
Strategies B.3V and B.4V	$588,000

6.8 Costs

The principal directive from the MRD is to provide the most cost effective rehabilitation measures for the mine site, commensurate with the development of environmental safeguards and engineering stability. To this end, the costs of the Strategies have been determined by extension of the unit rates. This economic comparison of the Strategies is presented on Tables 6A, 6B and 6C.

TABLE 6C

ECONOMIC COMPARISON OF STRATEGIES WITH VISUAL OPTIONS

	Options Involved	Cut to Fill (m^3)	Rate ($/$m^3$)	Cost ($)	Cut, Haul, Fill (m^3)	Rate ($/$m^3$)	Cost ($)	Revegetation (m^2)	Rate ($/$m^2$)	Cost ($)	Other Items ($)	TOTAL COST
STRATEGY A.3V												
Tailings Dump	T3	-			14,650,000	3.00	43,950,000	470,000	2.30	1,081,000		
Southern Waste Rock Dump	S4	400,000	1.25	500,000	-			140,000	2.30	322,000	as below	
North-Western Waste Rock Dump	N2	410,000	1.25	512,500	-			260,000	2.30	598,000		
TOTAL		810,000		1,012,500	14,560,000		43,950,000	870,000		2,001,000	2,818,000	$49,781,500
STRATEGY B.1V												
Tailings Dump	T4	1,600,000	1.15	1,840,000				560,000	2.40	1,344,000		
Southern Waste Rock Dump	S4	400,000	1.25	500,000				140,000	2.30	322,000	as below	
North-Western Waste Rock Dump	N2	410,000	1.25	512,500				260,000	2.30	598,000		
TOTAL		2,310,00		2,852,500				960,000		2,264,000	2,897,000	$8,013,500
STRATEGY B.3V												
Tailings Dump	T6	560,000	1.15	644,000	-			370,000	2.30	851,000		
Southern Waste Rock Dump	S5	300,000	1.25	375,000	570,000	4.10	2,337,000	140,000	2.30	322,000	as below	
North-Western Waste Rock Dump	N2	410,000	1.25	512,500	-			260,000	2.30	598,000		
TOTAL		1,270,000		1,531,500	570,000		2,337,000	770,000		1,771,000	2,840,000	$8,479,500
STRATEGY B.4V												
Tailings Dump	T7	590,000	1.15	678,500	-			390,000	2.30	897,000		
Southern Waste Rock Dump	S6	300,000	1.25	375,000	450,000	4.10	1,845,000	140,000	2.30	322,000	as below	
North-Western Waste Rock Dump	N2	410,000	1.25	512,500	-			260,000	2.30	598,000		
TOTAL		1,300,000		1,566,000	450,000		1,845,000	790,000		1,817,000	2,840,000	$8,068,000

Other Items: Strategy A.

Erosion control & drainage	455,000
Topsoil carting road	31,000
Mill building demolition	30,000
Crow Mt. Road re-alignment	36,000
Other Costs	1,750,000
Maintenance(present worth)	516,000
	$2,818,000

Other Items: Strategy B.

Erosion control & drainge	405,000
Topsoil carting road	31,000
Mill building demolition	30,000
Crow Mt. Road re-alignment	36,000
Other Costs	1,750,000
Maintenance (present worth)	645,000/ 588,000
	$2,897,000/$2,840,000