

EIS 1343 Vol 2

AB020024

Cadia Gold Mine : environmental impact statement : volume 2.

Appendices

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NEWCREST MINING LIMITED

CADIA GOLD MINE



Environmental Impact Statement

Volume 2
APPENDICES

Woodward-Clyde

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CADIA GOLD MINE

Environmental Impact Statement

Volume 2

APPENDICES

INTRODUCTION TO VOLUME 2

The Cadia Gold Mine Environmental Impact Statement (EIS) is presented in three volumes. Volume 1 contains the Executive Summary and Main Text of the EIS. The remaining two volumes contain the Appendices to Volume 1 and present the complete technical reports and figures supporting the EIS. The following summary outlines the contents of each volume.

VOLUME 1 - TEXT

Volume 1 contains the Executive Summary, Table of Contents, Main Text and Attachments. The Main Text is divided into the following sections:

Section 1 Introduction;
Section 2 Project Description;
Section 3 Description of the Environment;
Section 4 Potential Impacts and Mitigation Measures;
Section 5 Rehabilitation;
Section 6 Environmental Management and Monitoring Programmes;
Section 7 References;
Section 8 Abbreviations and Acronyms; and
Section 9 Glossary of Terms.

The Attachments to the Main Text are listed below:

Attachment 1 Requirements of Director, Department of Planning;
Attachment 2 Comments arising from the Planning Focus Meeting;
Attachment 3 Land Ownership Table; and
Attachment 4 Properties of Process Chemicals.

VOLUME 2 - APPENDICES A - H

Volume 2 contains the following technical reports:

Appendix A Climate and Meteorology
Prepared by AGC Woodward-Clyde (1995).

Appendix B Air Quality
Prepared by P. Zib & Associates Pty Ltd (August, 1995).

Appendix C Acoustics
(Noise, Transportation and Blasting Impact Assessment)
Prepared by Richard Heggie Associates Pty Ltd (October, 1995).

Appendix D Flora
Prepared by C.C. Bower and R.W. Medd (1995).

Appendix E Fauna
Prepared by A.M. Fisher and D.L. Goldney (October, 1995).

Appendix F Fish Fauna
(Fish Fauna and Stream condition of the Upper Flyers and Cadiangullong Creeks, Central Tablelands, N.S.W.)
Prepared by J.J. Bauer (February, 1995).

Appendix G Freshwater Macroinvertebrate Survey
Prepared by A.F. Gibbs (March, 1995).

Appendix H Assessment of Impacts of the Cadia Water Supply Scheme on Riparian and Instream Integrity.
Prepared by D.L. Goldney (June, 1995).

VOLUME 3 - APPENDICES I - U

Volume 3 contains the following technical reports:

Appendix I Water Quality and Water Management
Prepared by AGC Woodward-Clyde (1995).

Appendix J Visual Impact
Prepared by Loder and Bailey Group and AGC Woodward-Clyde (1995).

Appendix K Transport
Prepared by AGC Woodward-Clyde (1995).

Appendix L Land Valuation
Prepared by Hopcraft Aylward (May 1995).

Appendix M Assessment of Potential Social Impact
Prepared by AGC Woodward-Clyde (1995).

Appendix N Aboriginal Heritage
(Archaeological Study of Proposed Mine)
Prepared by Dr. J. Kohen (March, 1995).

Appendix O European and Natural Heritage
Prepared by Godden Mackay (January, 1995).

Appendix P Soils and Land Unit Mapping
Prepared by Department of Conservation and Land Management (June, 1994).

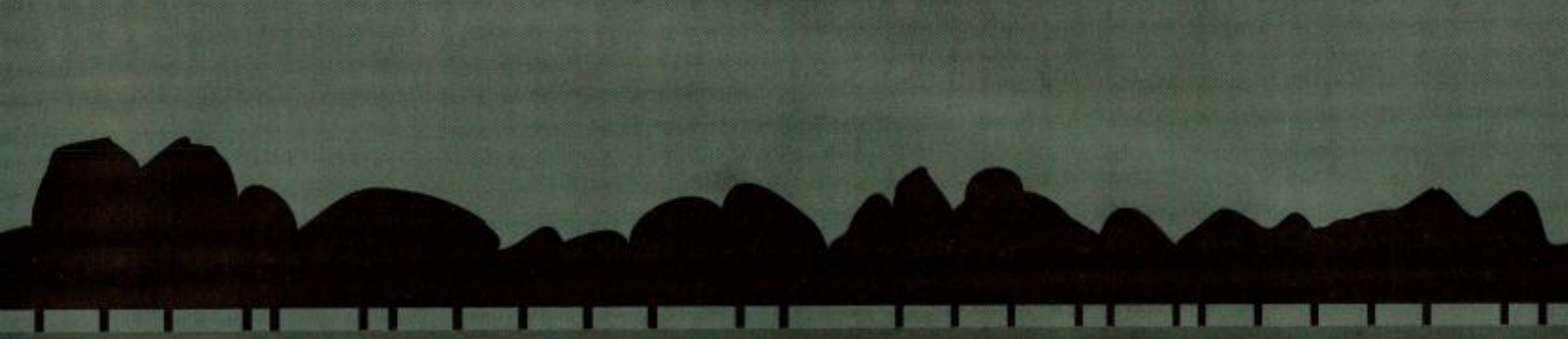
Appendix Q Waste Characterisation and Management
Prepared by AGC Woodward-Clyde (1995).

Appendix R Baseline Soil Geochemistry
Prepared by AGC Woodward-Clyde (1995).

Appendix S Land Management Plan
Prepared by B.J. Baldwin (June, 1995).

Appendix T Proposed Rehabilitation Programme
Prepared by AGC Woodward Clyde (1995).

Appendix U Risk Assessment
Prepared by Australian Centre of Advanced Risk and Reliability Engineering Ltd (October, 1995).



APPENDIX A

Climate and Meteorology

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1.0 INTRODUCTION

The Cadia region is characterised by a warm temperate climate influenced predominantly by geographical factors such as elevation, distance from the coast and the proximity of Mt Canobolas to the north.

The following section provides a description of the climate and meteorology of the Cadia region. Data for the description has been provided from long-term Bureau of Meteorology station records including Cadia (Station No. 063189), Orange Post Office (Station No. 063065), Canobolas State Forest (Station No. 063018), Canobolas Public School (Station No. 063017), Orange Airport (Station No. 063231) and Orange Agricultural Research Station (Station No. 063254). This data is supplemented with an ongoing meteorological monitoring programme which commenced in April 1994. Figure A-1 shows the locations of ongoing monitoring sites.

The equipment used for the on-site monitoring programme consists of five pluviometers, one wind station (installed January 1995), and an automatic weather station which records data electronically. The following parameters are recorded:

- rainfall (five pluviometer sites (Figure A-1), recording daily totals and time of 0.5 mm bucket tip event);
- wind speed and wind direction at 10 m above ground level (hourly averages and standard deviations, daily average wind speed) at two locations (Figure A-1);
- evaporation (hourly totals, calculated using Penman Monteith formula);
- solar radiation (hourly and daily totals);
- air temperature at 2 m and 10 m above ground level (hourly and daily mean maxima and minima);
- humidity at 10 m above ground level (hourly and daily mean, maxima and minima); and
- barometric pressure at 2 m above ground level (daily and hourly average maximum and minimum).

2.0 REVIEW OF CLIMATIC ELEMENTS

The following sections review the climatic data collected for the Cadia region.

2.1 RAINFALL

Rainfall within the area is affected by its geographical location within New South Wales and the varying altitude and topography of the area. Generally, rainfall is associated with the following events.

(i) The movement of cold fronts across New South Wales, predominantly during the winter months.

(ii) The movement inland of tropical cyclones or low pressure cells which have been located over the Pacific Ocean. These mostly occur during summer and autumn.

Long-term rainfall data from the Bureau of Meteorology is presented in Table A-1. The data indicate that the Cadia area generally receives rain in most months of the year. The total annual rainfall varies across the study area from 818 mm at Cadia Station to 1099 mm at Canobolas State Forest.

Regional data indicates that while rainfall is significant in all months, a slight seasonality in distribution occurs with a concentration in winter and spring. Highest variability in monthly rainfall generally occurs in February, March, April, November and May.

As part of the ongoing climatic monitoring programme a total of four pluviometers were installed in March 1994 to measure local rainfall. A fifth pluviometer was installed in September 1994. Figure A-2 presents total monthly rainfall measured by the pluviometers. Monthly data for PV1 was incomplete for April, May and October 1994 and January to April 1995. Data was also incomplete in September 1994 for PV4.

Historical data indicate fewer heavy rainfall events occurring in April-May and August-September. The trend is confirmed by rainfall data from the pluviometers. Low rainfall was registered in August and September 1994 (5 - 40 mm) at pluviometer sites 1, 2, and 3. Rainfall during the remainder of the year is variable with troughs occurring during May and December 1994 and peaks occurring in June and November 1994 and January 1995. Rainfall at the Cadia site increased during spring and summer with January being the wettest month to date with 180 - 220 mm (depending on specific pluviometer location).

TABLE A-1
BUREAU OF METEOROLOGY DATA FOR RAINFALL IN THE CADIA AREA

	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual rainfall
CADIA (1882 - 1928)													
Mean Rainfall (mm)	69.0	42.0	58.0	56.0	62.0	102.	83.0	80.0	74.0	71.0	55.0	66.0	818
Median Rainfall (mm)	55.3	26.9	49.9	46.7	55.7	96.3	74.9	74.1	67.7	65.4	39.0	55.0	802.5
Mean No. of Raindays	6	5	5	5	8	11	11	10	9	7	6	6	89
ORANGE POST OFFICE (1870 - 1968)													
Mean Rainfall (mm)	69.7	59.2	62.5	58.6	73.6	97.8	83.9	85.3	70.2	80.9	68.1	68.6	878.4
Median Rainfall (mm)	62.2	43.4	47.5	49.6	65.2	85.5	77.2	77.8	66.6	63.6	58.1	61.8	811.3
Mean No. of Raindays	6	6	6	6	9	11	11	11	9	9	7	7	98
ORANGE AIRPORT (1968 - 1993)													
Mean Rainfall (mm)	96.1	80.7	54.0	63.6	68.8	59.0	90.7	99.5	82.9	83.9	70.2	70.0	919.4
Median Rainfall (mm)	72.2	73.0	46.3	43.2	68.3	53.0	91.2	100.	81.4	87.1	69.9	61.4	847
Mean No. of Raindays	9	8	7	8	11	12	14	15	12	11	10	9	126
CANOBOLAS STATE FOREST (1949 - 1992)													
Mean Rainfall (mm)	95.0	77.3	68.4	75.2	94.5	86.8	118.	122.	97.6	109.	82.6	73.2	1100.5
Median Rainfall (mm)	78.6	56.5	59.2	61.9	87.6	73.6	115.	121.	93.5	91.5	72.2	72.8	984.2
Mean No. of Raindays	7	6	6	6	10	10	11	13	10	10	8	7	104
CANOBOLAS PUBLIC SCHOOL (1905 - 1992)													
Mean Rainfall (mm)	79.2	67.1	61.2	63.3	79.1	95.3	99.6	98.8	76.2	91.3	73.7	71.8	956.6
Median Rainfall (mm)	69.6	46.0	47.9	52.9	74.8	82.7	88.0	93.5	69.6	79.7	63.0	62.0	829.7
Mean No. of Raindays	6	6	6	6	8	10	11	11	9	10	7	7	97

Variation between the different pluviometers is generally minor. No recognisable trends related to pluviometer location can be identified at this stage.

2.2 EVAPORATION

Hourly total evaporation measurements have been recorded at the Cadia weather station beginning April 1994. The weather station logs potential evaporation as calculated by the Penman Monteith equation. Long-term regional Class "A" pan evaporation data from the Orange Agricultural Research Station is measured using a standard "evaporation pan". The Cadia Meteorological Station uses the combination radiation/aerodynamic Penman Monteith formula. This formula uses data on temperature, solar radiation, wind and humidity. Consequently, evaporation results from a Class "A" Pan and the Penman Monteith formula are not directly comparable.

The mean annual evaporation for the Bureau of Meteorology, Orange Agricultural Research Station is 1491.8 mm (Class 'A' Pan). Monthly trends in evaporation show December and January having higher rates whilst June and July record the lowest. When comparing mean annual evaporation and average annual rainfall, a moisture deficit (net difference between evaporation and rainfall) is evident for an average year and the ground is dry. This moisture deficit is most pronounced during summer months.

2.3 TEMPERATURE

Long-term regional temperature data indicate that January is the hottest month and July the coldest. The mean daily maxima range from 8.9°C in July to 25.6°C in January at the Orange Airport; from 10.6°C in July to 28.1°C in January at the Orange Post Office; and from 8°C in July to 26°C in January and February at the Canobolas State Forest Station. Mean daily minima range from 0.4°C in July to 12.1°C in February at the Orange Airport; from 0.4°C in July to 12.4°C in January and February at the Orange Post Office; and from 1°C in July to 13°C in January and February at Canobolas State Forest. Table A-2 shows Bureau of Meteorology temperature data for the Cadia area.

A feature of the monthly temperature variations is the sharp decline in temperatures from March to April. The sudden onset of winter and the gradual establishment of summer is a feature of the district.

TABLE A-2
BUREAU OF METEOROLOGY DATA FOR TEMPERATURE IN THE CADIA AREA

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ORANGE AIRPORT (1968 - 1992)												
Mean Daily Maximum Temperature	25.6	25.1	22.3	17.8	13.5	10.1	8.9	10.2	13	16.9	19.9	23.7
Mean Daily Minimum Temperature	11.8	12.1	9.6	6.2	3.7	1.3	0.4	1.3	3	5.5	7.3	9.7
ORANGE POST OFFICE (1870 - 1968)												
Mean Daily Maximum Temperature	28.1	27.4	24.8	19.9	15.1	11.6	10.6	12.3	16.2	19.8	23.5	26.6
Mean Daily Minimum Temperature	12.4	12.4	10.1	6.2	3.1	1.5	0.4	1.0	2.9	5.5	8.3	10.9
CANOBOLAS STATE FOREST (1949 - 1956, 1965 - 1969)												
Mean Daily Maximum Temperature	25.5	26.2	22.6	18.9	13.5	10.2	8	9.9	12.8	17.1	20.3	22.9
Mean Daily Minimum Temperature	13	13.3	11	7.4	4	2.6	0.9	2.2	3.7	7.3	8.9	11.3

Weather station records from the Project site indicate the highest mean daily maximum occurred in December 1994, the lowest mean daily maximum in August 1994 (at 2 m). Weather station mean daily maxima at 10 m elevation are generally slightly cooler than those at 2 m, due to temperature lapse rate factors. Weather station mean daily minima at 10 m elevation are generally warmer than those at 2 m due to the fact that minimum temperatures occur just prior to or at sunrise. At this time, convection processes occur where warmed air is forced to rise and cold air sinks to lower levels to replace it.

Light frosts occur in early April and extend to the end of October. Frost data, measured by temperatures of 0°C or lower, are available for the Orange Post Office and Orange Airport stations. The average number of frost days per year at these stations is 43 and 51 respectively. The frequency of frosts at both stations peak in July.

Temperature at the Cadia site is monitored as part of an ongoing programme using data collected from the meteorological site installed in March 1994. Temperature is measured at 10 m and at the standard Bureau of Meteorology, Stevenson screen height of approximately 1.5 m (Table A-3). The data show a summer daily average maximum during December 1994 of 29.2°C and a winter daily average minimum during August of 1.6°C (Figure A-3).

2.4 SNOW

No documented data for snowfalls is available for Cadia. However, SMEC (1971) states that snowfalls occur in most years in the Cadiangullong Creek catchment above 910 m while at the Cadia mine site, only the occasional falls can be expected. Snow fell at the Project site in July 1994 and April 1995.

Orange Airport and Orange Post Office average six and five snow days per year respectively with average snow day frequencies peaking in July and August.

The occurrence of snow days are directly related to the progress of cold fronts eastward across New South Wales during winter. Effects of altitude and cold temperatures associated with these fronts trigger snowfall events. This is reflected in the number of days with a maximum of zero degrees celsius or lower. These tend to peak in June, July and August.

2.5 WIND

Bureau of Meteorology 9.00 am and 3.00 pm wind records are available for the Orange Airport. The wind roses illustrating this data are presented in Appendix B. These records extend from 1968 to 1992.

Orange Airport

Orange Airport 9.00 am wind roses for summer show predominant winds blowing from the north-east. Wind speeds range from 11 km/hr to 30 km/hr.

Summer 3.00 pm wind roses show a distinct wind shift from the mostly north-easterly component to a predominant south-west to westerly direction at generally the same speeds as the morning (11 to 30 km/h).

TABLE A-3
CADIA METEOROLOGY STATION DATA

Month	Relative Humidity Average Daily		2m Air Temperature Average Daily		10m Air Temperature Average Daily		Solar Radiation Monthly Total MJ/m²
	Max %	Min %	Max °C	Min °C	Max °C	Min °C	
Apr-94	84	48	19.6	8.8	18.7	9.4	436.53
May-94	84	51	14.9	5.9	14.3	6.9	329.66
Jun-94	92	61	9.9	3.8	9.6	4.2	104.06
Jul-94	91	60	11.1	2.3	10.6	3.4	295.77
Aug-94	84	51	11.0	1.6	10.4	2.7	374.12
Sep-94	78	40	14.9	4.1	14.2	5.0	514.89
Oct-94	78	36	19.3	7.8	18.5	8.6	483.16
Nov-94	87	43	22.1	10.7	21.3	11.2	588.11
Dec-94	73	32	29.2	16.3	28.1	16.8	583.16
Jan-95	86	48	25.1	14.6	24.3	14.7	604.37
Feb-95	82	41	25.8	13.9	24.9	14.2	253.39
Mar-95	80	38	23.6	10.7	22.6	11.7	623.15
Apr-95	87	47	16.3	5.9	15.5	6.5	378.87

Autumn 9.00 am wind roses display mainly north-easterly winds in early autumn, which shift to predominatly south-westerly winds in late autumn. Wind speeds are generally 6 km/hr to 20 km/hr.

Autumn 3.00 pm wind roses show a predominantly north-west to south-westerly component with speeds generally 6 km/hr to 20 km/hr.

Winter morning winds have a distinct south-west to westerly direction at speeds from 11 km/hr to 30 km/hr. The afternoon winds maintain the south-westerly component with a north-westerly influence co-dominating at speeds generally from 6 km/hr to 30 km/hr.

Winds during spring have a definite south-west component but with a north-west to north east influence which becomes more pronounced in late spring. Wind speeds during spring are generally 11 km/hr to 30 km/hr. Spring afternoon winds blow mainly from north-west to south-westerly directions at speeds ranging from 11 km/hr to 30 km/hr.

Project Meteorology Station

Wind directions and speeds have been recorded from the Cadia site meteorological station (Figure A-1) since April 1994. Wind roses for these data have been compiled and are presented in Appendix B.

Annual wind roses display diurnal variations in wind direction. Wind direction was found to be predominantly from the north-east during most hours of the day except for the afternoons when west to south-westerly winds predominate. Wind speeds during the morning are generally higher than the rest of the day, ranging from <7 km/hr to 30 km/hr.

Site summer winds are predominantly from the north-east at speeds from <7 km/hr to 30 km/hr. There is a slight south-westerly component which blows during the afternoon at speeds between 7 km/hr to 17 km/hr.

Early autumn winds have a strong south-easterly component, shifting to the north-east through the later part of autumn. Wind speeds are generally from 7 km/hr to 30 km/hr throughout this season.

Winds at the site during winter are dominated by two directions. During the afternoon hours they are predominatly south-westerlies, however, for the remainder of the day they are from the north-east. Wind speeds in winter are generally lighter during the night (<7 km/hr) with speeds ranging from <7 km/hr to 17 km/hr during the day.

Early spring winds show a distinct westerly component at speeds generally from <7 km/hr to 30 km/hr. This shifts to a distinct north to north-easterly component during the remainder of spring at speeds of <7 km/hr to 17 km/hr.

2.6 HUMIDITY

Humidity data has been recorded for the Cadia area at the site meteorological station (Figure A-1). The mean

daily maximum relative humidity ranges from 92% in June to 78% in September - October. Mean daily minimum relative humidity ranges from 61% in June to 32% in December.

Regional humidity data from both Orange Airport (1968 - 1988) and Orange Post Office (1968 - 1988) are shown in Table A-4. This data shows a seasonal increase in both 9.00 am and 3.00 pm humidity levels during winter, with the highest readings occurring in June and July (9.00 am - 87% and 86% at Orange Airport and 85% and 84% at Orange Post Office and 3.00 pm - 70% and 67% at Orange Airport and 59% and 60% at the Orange Post Office). The peak humidity recordings coincide with the seasonal concentration of rain in winter and spring.

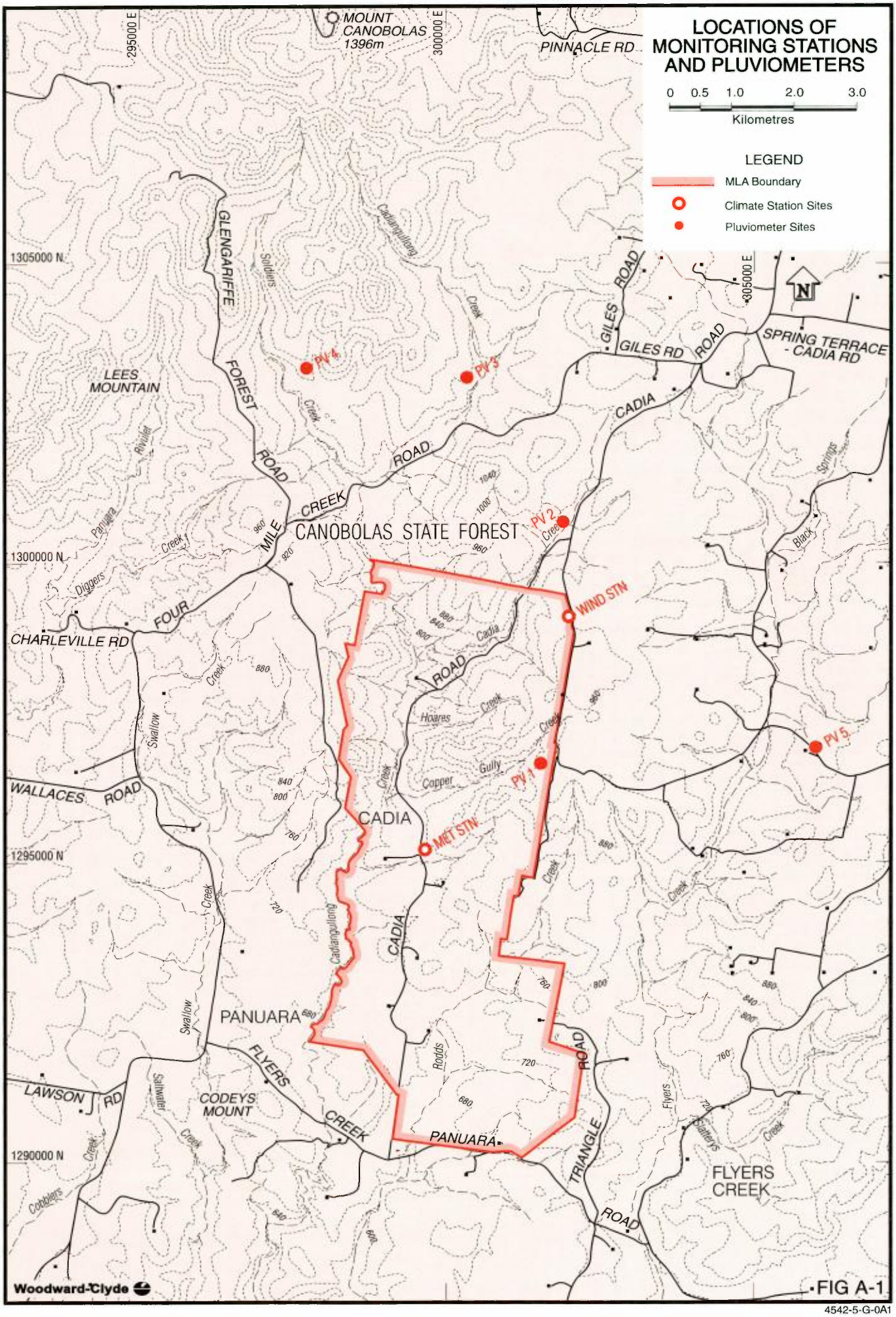
TABLE A-4
BUREAU OF METEOROLOGY DATA
FOR HUMIDITY IN THE CADIA AREA

Month	Orange Airport		Orange Post Office	
	9.00am	3.00pm	9.00am	3.00pm
January	65	43	56	35
February	70	47	60	36
March	70	49	64	40
April	73	56	70	43
May	82	65	80	54
June	87	70	85	59
July	86	67	84	60
August	80	63	80	54
September	73	61	67	47
October	68	55	60	44
November	67	51	52	34
December	62	43	54	36

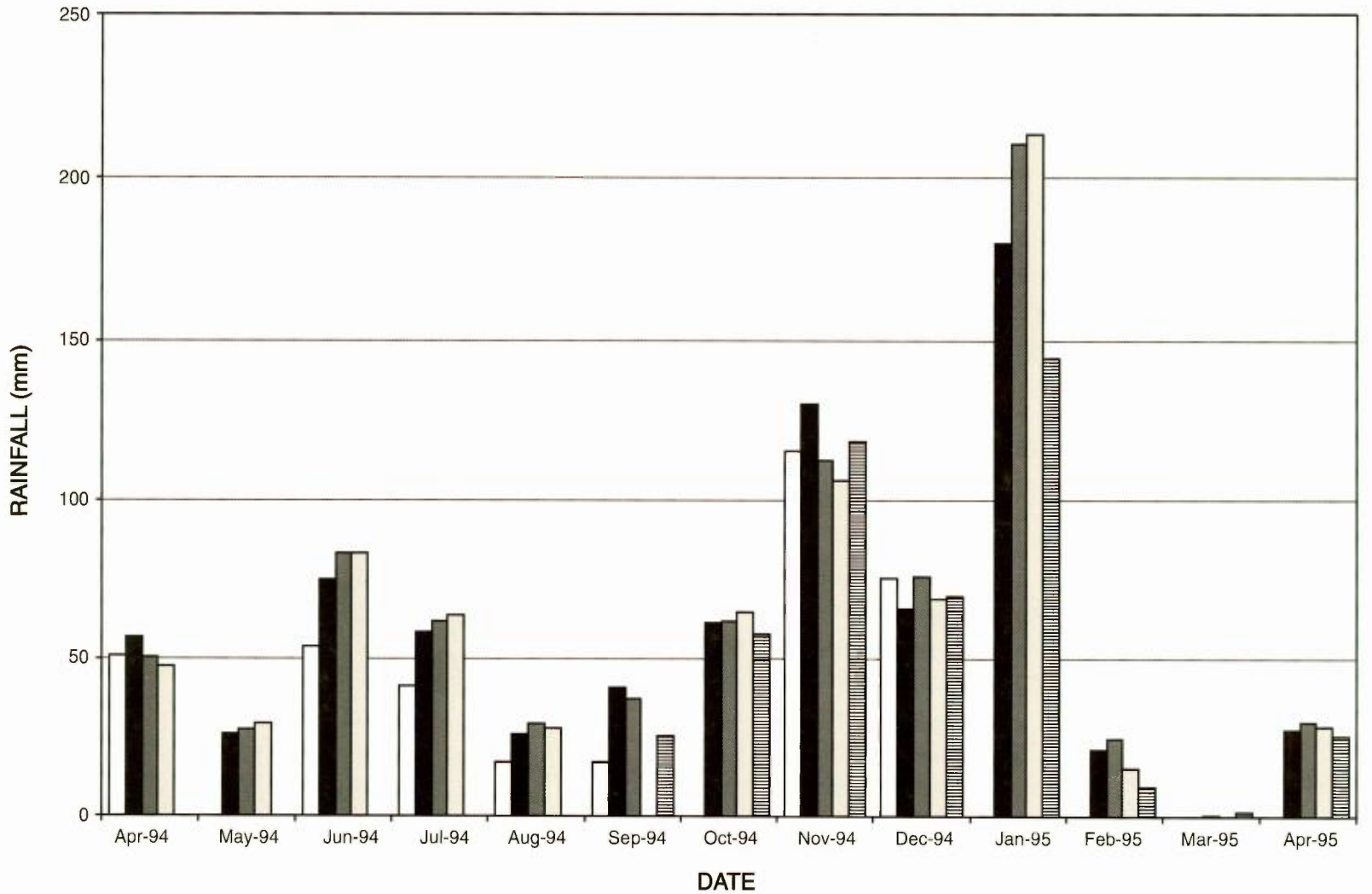
3.0 REFERENCES

1. Snowy Mountains Engineering Corporation (SMEC) (1971) *Cadia Project: Report on Investigations for Water Supply, Flood Diversion, Tailings and Waste Disposal, Mill Foundations, Haul Roads.* Prepared for Pacific Copper Explorations Limited.

2. Bureau of Meteorology (1975): *Manual of Meteorology Part 1*, General Meteorology.


LOCATIONS OF MONITORING STATIONS AND PLUVIOMETERS
0 0.5 1.0 2.0 3.0
Kilometres
LEGEND
MLA Boundary
Climate Station Sites
Pluviometer Sites
MOUNT CANOBOLAS 1396m
PINNACLE RD
295000 E
300000 E
305000 E
1305000 N
1300000 N
1295000 N
1290000 N
GLENGARIFFE FOREST ROAD
LEES MOUNTAIN
GILES ROAD
GILES RD ROAD
SPRING TERRACE - CADIA RD
CADIA ROAD
MILE CREEK
CANOBOLAS STATE FOREST
PV 1
PV 2
PV 3
PV 4
PV 5
WIND STN
MET STN
CADIA
CHARLEVILLE RD
FOUR
WALLACES ROAD
PANUARA
FLYERS CREEK ROAD
LAWSON RD
CODEYS MOUNT
TRIANGLE ROAD
FLYERS CREEK
Woodward-Clyde
FIG A-1

4542-5-G-0A1



*NB PV5 installed in September 1995.
Data record incomplete for PV1 (April,May and Oct 1994, Jan to Apr 1995) and PV4 (Sept 1994)

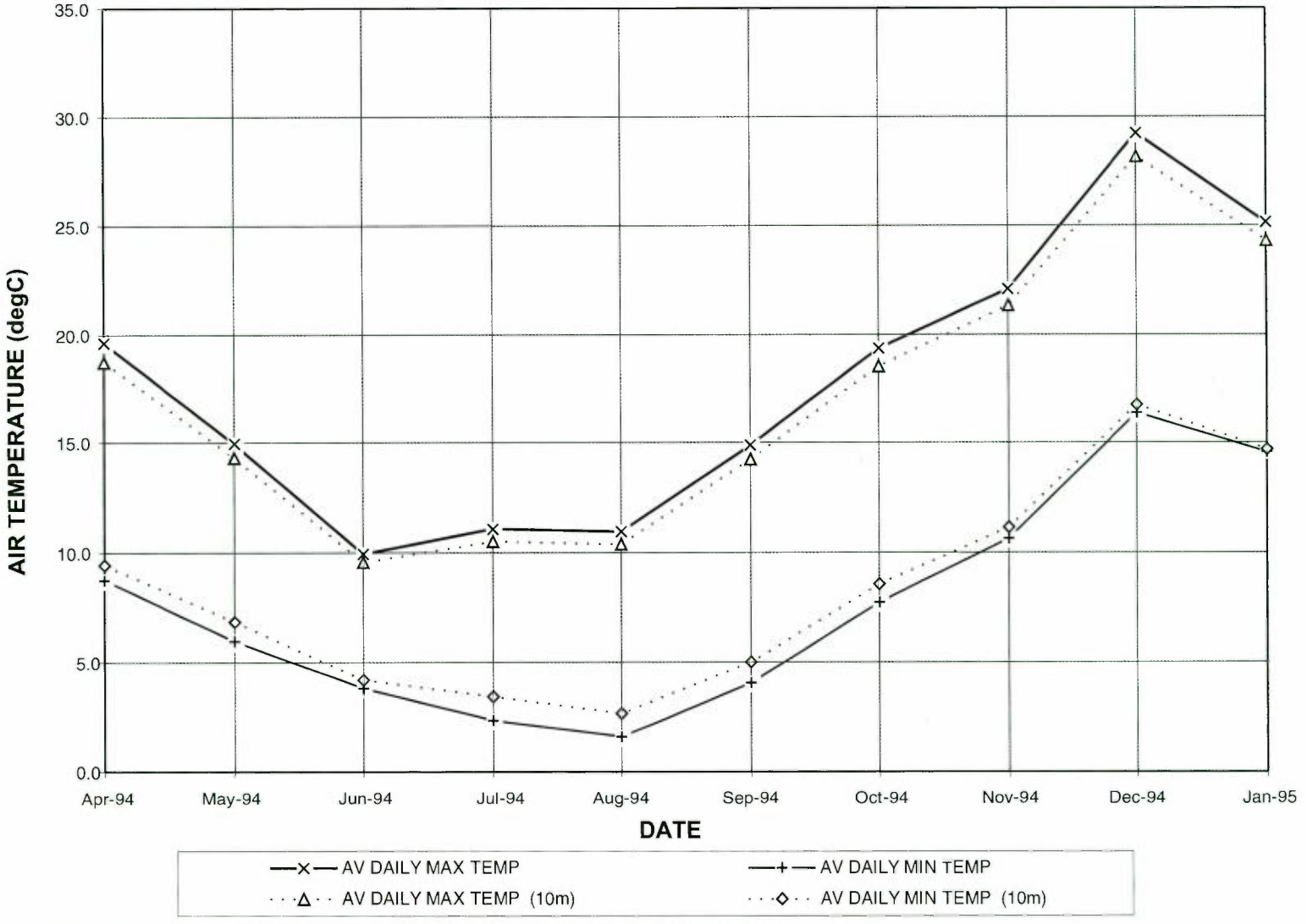
SOURCE:\A32\4541-2.1\PLLUVIO\PVALL.XLS

CADIA PLUVIOMETERS
TOTAL MONTHLY RAINFALL

FIG A-2

Woodward-Clyde

4542-5-G-0A2



*NB DATA RECORD NOT COMPLETE FOR MONTHS OF JUNE, OCTOBER AND DECEMBER

SOURCE:\A32\4542-2.3\METDATA\SUMMARY.XLS

MONTHLY AVERAGE DAILY AIR TEMPERATURE

FIG A-3

CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT

Woodward-Clyde

4542-5-G-0A3

APPENDIX B

Air Quality

NEWCREST MINING LIMITED

ASSESSMENT OF AIR QUALITY RESULTING FROM THE PROPOSED GOLD/COPPER PROJECT AT CADIA, NEW SOUTH WALES

Revision 2.0
August 1995

P. ZIB & ASSOCIATES PTY. LTD.
Consultants
Air Quality and Pollution Control

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1.0 INTRODUCTION

This report provides the basis for assessment of the effects of the proposed open cut gold mine and processing plant at Cadia on air quality. A study of the generation and dispersion of atmospheric dust emissions has been requested by AGC Woodward-Clyde for inclusion in the Environmental Impact Statement (EIS) for the development.

Existing air quality in the project area is discussed in Section 2. A brief description of the proposal is given in Section 3. The description includes the main aspects of mining by conventional open cut methods and outlines the techniques to be used for ore handling and processing prior to gold recovery.

The potential for generation of atmospheric dust and the proposed air quality safeguards are outlined in Section 4. Details of the dust emission factors used in the compilation of dust emission inventories are given together with information concerning particle size distributions.

The methodology of dust dispersion modelling is introduced in Section 5. Criteria for the selection of representative years for inclusion in the modelling are given and inventories of dust emissions for the selected years are presented. The meteorological data used in the model are introduced next. An outline of the dust dispersion model completes the presentation in Section 5.

The results of dispersion modelling are presented in Section 6. Long-term rates of dust deposition predicted to result from the operation are given first and related to amenity- based criteria which were specified by the EPA. The predictions are shown in a series of isopleths superimposed on the project site and the impact is assessed for a variety of receptors and land uses including nearby residences.

Predictions of long-term concentrations of total suspended particulates in the ambient air, relevant air quality guidelines and the impact assessment of long-term concentrations are presented in the second part of Section 6.

The last part of Section 6 contains special topics of the assessment including the effect of construction activities prior to the commencement of mining and estimates of the peak levels of atmospheric dust during short-term episodic events.

The main findings of the study are summarised and the conclusions are presented in Section 7. A list of references, attachments and a glossary of terms complete the report.

2.0 EXISTING AIR QUALITY

Air quality in the region containing the project area at Cadia is determined by atmospheric emissions from farming activities, road and rail traffic, as well as commercial and residential activities. There are no significant industrial installations near Cadia which would emit large amounts of waste gases into the air. The general level of typical industrial pollutants such as the oxides of sulphur and nitrogen, ozone and carbon monoxide is therefore expected to be low. The main component of foreign material in the ambient air is particulate matter (atmospheric dust).

DUST DEPOSITION

A monitoring programme of dust deposition rates was established at the project site in March 1994. The purpose of the monitoring was to characterise the existing air quality in terms of atmospheric dust. Atmospheric dust is generated by a range of activities which take place in the Cadia area including agriculture, road construction and vehicular traffic on paved and unpaved roads. The action of strong winds on dry, barren areas may also result in the generation of airborne dust. Domestic burning contributes to the amount of particulate matter in the air during certain parts of the year.

An initial network of 11 dust deposition gauges was established to determine monthly rates of dustfall at locations surrounding the project site. Following a review of the monitoring network during a site inspection in May 1994, a further 2 sampling sites were added giving a total of 13 dust deposition gauges. The locations of the individual sampling sites is shown in Figure B-1.

Regular sampling commenced in March 1994. Deposit gauges were maintained over a period of approximately 30 days, collected and sent to the laboratory for analysis. The mass of dried insoluble solids and combustible matter were determined for each sample.

The mean deposition rates of atmospheric particulates at each of the 13 sampling sites are summarised in Table B-1. Standard deviations from the mean rate are also shown together with the mean ash fraction remaining in the sample after combustion and the number of valid measurements at each site.

TABLE B-1
MEAN DUST DEPOSITION RATES (g/m²/MONTH) RECORDED IN THE CADIA AREA SINCE MARCH 1994

Site	Deposition Rate (g/m²/month)			No. of Measurements
	Water Insoluble		Ash Fraction	
	Mean	Std. Dev.	Mean	
1	1.99	(2.27)	74%	10
2	1.84	(1.98)	73%	11
3	2.05	(1.94)	70%	11
4	2.93	(2.65)	64%	8
5	1.95	(1.38)	62%	11
6	1.49	(0.80)	62%	9
7	1.49	(1.67)	73%	11
8	1.40	(1.73)	66%	10
9	2.15	(2.95)	73%	11
10	2.87	(3.31)	70%	10
11	1.86	(2.15)	72%	11
12	2.38	(2.83)	76%	8
13	2.14	(2.29)	65%	6

The mean deposition rates ranged from 1.40 g/m²/month recorded at site No.8 to 2.93 g/m²/month at site No. 4. The standard deviations from the mean were generally high exceeding 100 percent of the mean value at most sites.

The mean fractions of ash remaining in the samples after organic material was removed by combustion varied between 62 and 76 percent. These results confirmed that organic material of mainly plant and insect origin was an essential part of the total atmospheric fallout.

The mean deposition rate averaged across the entire monitoring network of 13 sampling sites was 2.04 g/m²/month.

Large variations were recorded in the mean deposition rates during individual months of the year. Table B-2 shows the mean values together with standard deviations and ash fractions which were recorded across the monitoring network during the indicated intervals of about one month each.

A dramatic increase in dust deposition across the monitoring network was recorded during October and especially in November. The mean dust deposition rate rose from about 1.0 g/m²/month for March to September to 3.75 g/m²/month in October and reached a very high 7.92 g/m²/month during November. Strengthening winds and a prolonged period of drought resulted in a number of dust storms which maintained the presence of particulate matter in the air at a very high level. The inorganic fraction also increased markedly during this period confirming a presence of particles of mostly mineral origin in the air. Whilst still remaining above the levels which were recorded prior to October, the mean dust deposition was reduced to about 2.0 g/m²/month in December, January and February. Only in March did the mean recorded value drop again to less than 1.0 g/m²/month.

TABLE B-2
MEAN DUST DEPOSITION RATES (g/m²/MONTH) RECORDED DURING INDIVIDUAL MONTHLY INTERVALS

Interval	Deposition Rate (g/m²/month)			No. of Measure-ments
	Water insoluble		Ash Fraction	
	Mean	Std. Dev.	Mean	
20/03/94 - 20/04/94	1.00	(0.36)	67%	10
20/04/94 - 18/05/94	1.08	(0.58)	54%	11
18/05/94 - 22/06/94	0.94	(0.36)	62%	11
22/06/94 - 26/07/94	0.61	(0.40)	54%	11
26/07/94 - 23/08/94	1.02	(0.40)	50%	13
23/08/94 - 27/09/94	1.23	(0.35)	55%	12
27/09/94 - 28/10/94	3.75	(1.11)	79%	12
28/10/94 - 29/11/94	7.92	(1.92)	84%	11
29/11/94 - 19/01/95	1.82	(0.85)	56%	11
19/01/95 - 20/02/95	2.32	(0.78)	58%	13
20/02/95 - 21/03/95	0.69	(0.61)	52%	12

CONCENTRATIONS OF TOTAL SUSPENDED PARTICULATES

The monitoring of total suspended particulates (TSP) in the ambient air commenced in January 1995. The purpose of the monitoring programme which is carried out in accordance with AS 2724.3 - 1984, is to determine premining levels of TSP in the project area.

The number of samples obtained to date is relatively small especially with regard to determining an annual mean. Individual 24-hour concentrations ranged from a low of 17.9 µg/m³ to a high of 103.8 µg/m³ which was recorded on 29th March 1995. The mean concentration over the initial period of sampling was about 50 µg/m³.

3.0 DESCRIPTION OF THE PROPOSAL AND MINING SEQUENCE

Newcrest Mining Limited proposes to develop an open cut mine at Cadia to obtain approximately 200 Mt of gold bearing ore for subsequent recovery by staged flotation. The

annual rates of production will be 17 Mtpa of ore and up to 57.6 Mtpa of waste material and marginal ore.

The mining will be carried out by conventional open cut methods in benches of 15 m. Both ore and waste material will be drilled and blasted. One and, later on, two electric rope shovels will be used to load the material to trucks. Ore will be hauled to a primary crusher located near the perimeter of the pit and then to a ROM stockpile in the processing area. Waste will be placed in a smaller disposal area located to the northeast of the pit and in a larger disposal area in the south.

The projected life of the proposed development is 12 years. Progressive rehabilitation of the project site will commence during this time and be completed at the end of the development.

4.0 GENERATION OF DUST AND AIR QUALITY SAFEGUARDS

Atmospheric dust would be the main component of air emissions from the project. Other possible sources of air emissions would be exhaust fumes from mobile equipment, blasting fumes, and evaporative emissions from the processing area. All these emissions are expected to be minor.

A range of air quality safeguards will be implemented to minimise the generation of atmospheric dust from the open cut operation. These safeguards will be based on current control techniques as recommended for open cut mining in New South Wales by the EPA. The main components of the controls can be summarised as follows.

During the construction period, watering of disturbed surfaces as well as access roads will be used to reduce dust emissions. Restricting the size of the surface area which would be disturbed at any given time is an effective approach to dust control and will be applied as often as possible.

Maintaining the extent of the total area exposed to dust generation by wind erosion small, regular watering of dusty surfaces, and extensive watering and route marking of haul roads will be the main aspects of the air quality safeguards during the operation.

The other aspects of dust control will include collection of fine dust from drilling, prevention of truck overloading and the resulting spillage of waste material and ore during loading and hauling, and regular maintenance of all haul roads. Watering and regular maintenance are expected to result in a control efficiency of at least 50 percent.

The waste emplacement area will be progressively reshaped and revegetated to minimise the potential for wind erosion.

The proposed air quality safeguards at the processing plant are extensive and designed not only to minimise emissions to air but also to retain as much of the valuable gold bearing ore as possible for further processing.

A water spray dust suppression system would be used at the primary crusher bin during truck dumping of raw ore. Crushed material would be discharged while a bag house dust collection system will be installed to control the emission of fine particles from the crusher discharge. All conveyors will incorporate wind covers as necessary.

All material handling transfer points will be fully skirted with dust enclosures to direct dust laden air to the bag house collection system. A water spray will control dust at the top of the coarse ore stockpile. The enclosed spaces subject to dust build up (crusher apron feeder enclosure) will be ventilated with exhaust air passing through a bag house collection system. The lime silos will have integral baghouses to collect dust from pneumatic transfer operations. Reagent mixing tanks will be covered and vented through water scrubbers to control noxious or explosive vapours and dust.

Wet grinding of crushed ore at the processing plant will both minimise and provide efficient control of dust emission. Ample washdown points will be provided to facilitate good housekeeping and minimal dust build up from slurry spills.

5.0 MODELLING APPROACH AND METHODOLOGY

Before an assessment of atmospheric dust which would result from 12 years of operation is made, a variety of input information is required to describe the operation and the generation and dispersion of dust particles.

Dust particles will be generated by a multitude of operating equipment and range in size from minute particles in the submicron range to much heavier particles which settle rapidly not far away from the place of their origin.

The particles remaining in the air are carried by wind and dispersed by the action of the atmosphere. The weight of the particles and the uptake characteristics of the surface cause the particles to deposit on the surface at various distances from the operations under continuously changing atmospheric conditions.

Detailed emission inventories of atmospheric dust were prepared using a range of dust emission factors for individual types of mining and material handling and process-

ing activities. The resulting dust emission rates were divided into three particle size categories corresponding to fine, inhalable and coarse dust.

A computer model of dust dispersion was then invoked to obtain predictions of mean annual dust deposition rates and concentrations of total suspended particulates and to facilitate plotting of dust contours.

5.1. EMISSIONS OF DUST

The rates of dust emissions were determined for individual groups of mining and material handling operations using the projected extent of operations together with emission factors for each unit operation. The dust emission factors for open cut mining were recently reviewed as part of a study directed by the EPA (formerly the SPCC) and NSW Coal Association and funded by the National Energy, Research, Development and Demonstration Council (NERDDC). The study report (SPCC, 1988) listed emission factors which were experimentally determined at surface coal mines in the Hunter Valley of New South Wales. Emission factors for those activities which were not tested in the conditions prevailing in New South Wales, were adapted from the published results of experiments undertaken in the United States (USEPA, 1981, 1988). A list of emission factors and the source of the data is shown in Table B-3.

Four individual years of mining were selected for inclusion in the quantitative assessment of dust emissions. Mining during Year 1 will be associated with waste disposal in an area located to the northeast of the pit. Year 1 was thus selected to assess the combined effect of mining and waste disposal on air quality in the surrounding area.

The volume of waste material is expected to rise in Year 4 of the operation. This year also marks the commencement of the second stage of mine development. Marginal ore will be reclaimed from a stockpile located on the south dump and hauled to the primary crusher for processing.

Year 6 was used as a representative year of full mining during the second stage of the mine development. Mining quantities of 17 Mtpa of ore and 50.6 Mtpa of waste rock are expected and the waste material will be placed in the main disposal area located to the south of the pit.

Finally, Year 9 of the operation was selected to assess the air quality in the latter part of the development with mining of ore continuing at a rate of 17 Mtpa and with most of the waste material having been placed in the disposal areas. The rehabilitation of those areas will be well advanced covering about 75 percent of the main disposal area by the end of Year 9.

TABLE B-3
DUST EMISSION FACTORS USED FOR THE CADIA PROJECT AND THE SOURCE OF DATA.

Operation	Emission Factor	Reference	Control Efficiency Included in the Emission Factor
Open-cut Mining			
Topsoil removal, clearing (dozer)	14.0 kg/hr	SPCC (1983)	
Drilling	0.6 kg/hole	SPCC (1983)	
Blasting (Note 1)	$0.00022\ A^{1.5}$	USEPA (1988)	
Loading - shovel	0.025 kg/t	SPCC et al (1988)	
Ripping, removal - dozer	3.29 kg/hr	USEPA (1988)	Silt = 4%, Moisture = 3%
Graders on roads	0.615 kg/km	USEPA (1988)	
Haulage roads	2.00 kg/VKT (Note 2)	SPCC et al (1988)	Watering = 50%
Truck dumping	0.012 kg/t	SPCC et al (1988)	
Waste spreading - dozer	7.30 kg/hr	USEPA (1988)	Silt = 5%, Moisture = 2%
Ore Handling			
Unloading (to crusher)	0.01 kg/t	USEPA (1988)	Watering = 50%
Primary and secondary crushing and screening	0.002 kg/t	USEPA (1988)	Filtering = 99%
Active storage pile	14.8 kg/ha/day	USEPA (1991)	
Loading to trucks (loader)	0.025 kg/t	SPCC et al (1988)	
Unsealed Roads (not haul roads)	4.00 kg/VKT	SPCC et al (1988)	
Exposed Areas			
Wind erosion of exposed areas	0.40 kg/ha/hr	SPCC (1983)	

Notes: 1. Emission factor in (kg/blast A is the area to be blasted (m^2)
2. VKT = vehicle kilometers travelled.

5.1.1 Emissions in Year 1

The total annual emission of atmospheric dust in Year 1 of the operation was estimated at 5658.3 tonnes. Details of the emission inventory are shown in Table B-1-1 in Attachment B-1.

The open cut operation was estimated to result in an emission of 2408.2 tonnes of atmospheric dust per year. Included in this subtotal was the contribution to the emission of dust from hauling mined ore to the primary crusher and from the activities at the crusher including loading of crushed ore to trucks for transport to the processing plant. In relative terms, the open cut operation was estimated to generate about 43 percent of the total dust generation rate in Year 1.

Haulage of crushed ore to the processing plant and the activities at the processing plant were estimated to generate 233.3 tonnes of atmospheric dust per annum or about 4 percent of the total.

Disposal of waste rock in Year 1 will take place at both the northern dump and the main dump which is located to the south of the pit. The haulage, dumping and spreading of waste were estimated to generate 383.9 tonnes of atmospheric dust per year in the northern part and 1268.1 tonnes per year at the main dump. The combined contribution of waste disposal to the total emission of dust in Year 1 was 29 percent.

Grading of roads and traffic on unsealed roads (other than main haul roads) were estimated to generate 111.1 t/yr of dust or about 2 percent of the total. The remaining contribution of approximately 22 percent was estimated to be from wind erosion of exposed areas including the shallow pit, both dump areas, a prestripped section of the tailings dam and the tailings dam wall as well as the processing plant and the contractor site. The total emission of dust from wind erosion in Year 1 was estimated to reach 1253.7 tonnes per year.

5.1.2 Emissions in Year 4

A marked increase in the total annual dust emission was estimated for Year 4 of the operation. The quantity of waste material will rise to 57.3 Mtpa at the beginning of Stage 2 of the proposed development. Approximately 6 Mtpa of marginal ore will be reclaimed from a stockpile on the south dump.

The total emission rate of atmospheric dust was estimated to reach 7461.9 tonnes per year. The largest increase in dust emission was calculated for the haulage, dumping and spreading of waste. The estimated contribution of waste disposal rose from 29 percent in Year 1 to 34 percent in Year 4. Details of the emission inventory for Year 4 are given in Table B-1-2 in Attachment B-1.

Pit operations including reclamation of marginal ore will remain the strongest source of dust emissions with an estimated 3288.2 t/yr or almost 44 percent of the total. Unlike during the waste disposal, a portion of the dust from the pit operations will be emitted near the floor of the pit and hence within its confines. Some dust particles may thus be retained within the pit and the floor of the pit will not be subject to wind erosion.

Wind erosion of the prestripped section of the pit and, predominantly, of the surface of the waste dump and the dry section of the tailings dam was estimated to result in an emission of 1280.4 tonnes of dust or 17 percent of the total for Year 4.

5.1.3 Emissions in Year 6

The total emission rate of atmospheric dust in Year 6 of the operation was estimated to be 7028.4 tonnes per year. Table B-1-3 in Attachment B-1 contains details of the estimates. The emission in Year 6 will be reduced as a result of a progressive rehabilitation of the main dump and a cessation of the need to supplement the quantity of mined ore by marginal ore reclaimed from the stockpile area on the south dump.

The main sources of atmospheric dust in Year 6 will be the pit with 3042.6 t/yr (approximately 43 percent), wind erosion with 1180.2 t/yr (17 percent) and waste disposal with 2437.0 t/yr (35 percent).

5.1.4 Emissions in Year 9

While the mining of ore will continue at an unchanged rate of 17 Mtpa in Year 9, the mining and disposal of waste and partly also the rehabilitation of the waste dump will be nearing completion. As a result of the progress in mining and waste rehabilitation, the total dust emission in Year 9 was estimated to be reduced to 3139.8 tonnes per year. About 50 percent of the total dust was estimated to be generated by operations taking place in the main pit. Waste disposal and wind erosion will add 10 and 28 percent respectively. The contribution by operations at the processing plant to the total emission will be approximately 8 percent in Year 9.

5.1.5 Summary of Dust Emissions

The result of dust emission estimates for Years 1, 4, 6 and 9 of the operation are summarised in Table B-4. The table also shows the quantities of ore and waste to be mined during the respective years, and the amounts of atmospheric dust thus generated in the process of mining and processing of one tonne of ore (dust to ore ratios) in each of the modelled years.

The calculated dust to ore ratios ranged from 0.18 kg/t in Year 9 to 0.46 kg/t at the beginning of Stage 2 in Year 4. It may be noted that mining operations in modern open

cut coal mines result in dust to coal ratios which usually fall within a range of between about 1.0 and 1.5 kg of atmospheric dust per a tonne of ROM coal. In the presence of similar dust controls and safeguards in both types of operations, the lesser amounts of atmospheric dust which were estimated for the Cadia project reflect the more favourable stripping ratios for the proposed development when compared with a typical open cut coal mine in New South Wales.

TABLE B-4
SUMMARY OF DUST EMISSION ESTIMATES FOR THE PROPOSED OPERATION

Year	Annual Emission of Dust (tonnes/yr)	Mined Quantities (Mtpa)		Dust : Ore Ratio (kg/tonne)
		Ore	Waste	
1	5658.3	16.1	34.9	0.35
4	7442.9	16.3*	57.3	0.46
6	7028.4	17	50.6	0.41
9	3139.8	17	3.6	0.48

* Includes 6 Mtpa from a stockpile of marginal ore.

5.2. PARTICLE SIZE DISTRIBUTIONS

Three particle size classes were used to divide the atmospheric dust into fine, inhalable and coarse fractions corresponding to aerodynamic diameters ranging from 0 to 2.5, 2.5 to 15.0 and 15.0 to 30.0 microns. The mean diameters in each class, for the purpose of modelling, were assigned values of 1.0, 6.1 and 21.1 microns.

In the process of assigning particle size distributions to the individual dust generating activities, the results of a study undertaken at selected Hunter Valley mines in 1986 (Dames & Moore, 1986) were used. Experimental data published by Axetell et al (USEPA, 1981) for a number of surface coal mines in the United States were used to assign particle size distributions to dust emissions from those mining activities which were not studied in the Hunter Valley.

The particle size distributions for atmospheric emissions from ore processing including crushing, screening and conveying and transfer were estimated using the generalised particle size distributions for unprocessed ores published recently by the USEPA (USEPA, 1988).

The applied particle size distributions are shown together with the source of the data in Table B-5.

5.3 METEOROLOGICAL DATA

Dispersion modelling of airborne dust resulting from open cut mining and ore handling requires the knowledge of representative meteorological conditions. The direction and speed of the mean wind combined with atmospheric stability in composite frequency functions are the most commonly used input parameters.

Mean wind direction determines the general direction in which the dust will be transported. Mean wind speed determines the amount of initial dilution of the airborne material and the speed with which the material is moving. Atmospheric stability is often used in dispersion modelling to give a measure of dispersion related to turbulence. The main advantage of using atmospheric stability classification is that it is more readily obtained from meteorological records than are direct turbulence measurements.

A minimum of one year of data is needed to include seasonal variations in the data base. Variations from year to year exist and longer periods of continuous records, if available, improve the usefulness and accuracy of dispersion estimates. Criteria which determine how representative each meteorological data set is of conditions prevailing in the project area include proximity of the meteorological station to the project site, complexity of the terrain in the area, free exposure of the meteorological station to the airflow, and the length of time over which the data was collected.

Continuous measurements of meteorological parameters commenced at the project site in March 1994. The location of the meteorological monitoring station was shown in Figure B-1.

As a result of on-site monitoring, 12 months of records were available for analysis and inclusion in the air quality modelling. The basic recording interval was one hour and mean values of wind speed, wind direction, air temperature and solar radiation were used together with records of sigma theta (standard deviation of horizontal wind direction) to develop joint frequency distributions for application in the model.

Seasonal and annual wind roses for the Cadia site are shown in Attachment B-2.

The most common winds at the project site were from a sector between the north and northeast. These winds were particularly frequent during the summer (October to March) developing at about sunset, strengthening during the night and lasting into the early hours of the following morning. During the daytime, the majority of winds came from the western half and particularly from a sector between the west and southwest. With the exception of ESE winds, afternoon winds from the eastern half were not frequent in summer.

A distinct diurnal pattern in the direction of the prevailing wind was recorded in winter as well. Winds from a sector between the north and northeast developed at sunset. These winds were lighter in winter than in summer and continued as lighter winds throughout the night into

TABLE B-5
PARTICLE SIZE DISTRIBUTIONS USED FOR THE CADIA PROJECT AND THE SOURCE OF DATA

Operation	Particle Size Ranges			Reference
	FP	IP	CP	
	0 - 2.5 µm	2.5 - 15 µm	15 - 30 µm	
Open-cut Mining				
Topsoil removal	19.6	54.0	26.4	USEPA (1981)
Ripping (dozer)	2.6	22.5	74.9	USEPA (1991)
Ore and waste drilling	9.0	62.0	29.0	Dames & Moore (1986)
Ore and waste blasting	5.1	46.0	48.9	USEPA (1981)
Ore and waste loading (shovel, loader)	7.0	50.0	43.0	USEPA (1991)
Grading of roads	5.5	48.0	46.5	USEPA (1981)
Ore and waste haulage	6.0	53.0	41.0	Dames & Moore (1986)
Waste dumping	4.0	44.0	52.0	Dames & Moore (1986)
Waste spreading, shaping (dozer)	19.6	54.0	26.4	USEPA (1981)
Wind erosion	3.5	67.0	29.5	USEPA (1981)
Ore Handling				
Unloading	4.0	44.0	52.0	Dames & Moore (1986)
Crushing and screening	15.0	60.0	25.0	USEPA (1988)
Conveyors, transfer points	15.0	60.0	25.0	USEPA (1988)

the following morning. The majority of winds during the afternoon were from the western half with easterly winds being only very infrequent. The afternoon winds were stronger and showed the largest frequencies of directions from the southwest and a sector between the west and west-northwest.

The annual wind roses reflected a distinct diurnal pattern as well as the seasonal variation in wind speed and direction. North to northeasterly winds were most frequent changing from light flows in the evening to stronger flows at night and even further into the early morning hours before being replaced by mostly westerly flows during the daytime. Winds from a quadrant between the south and east remained infrequent at all times.

The main trends in the wind records which were collected at the project site between April 1994 and March 1995 were in a general agreement with the long term records from Orange airport. Monthly wind roses for Orange airport are shown for times of 9 am and 3 pm in Attachment B-2 together with monthly wind roses for the project site. The latter were based on continuous recording using a basic averaging interval of one hour.

Stability classification was determined for each hour of the data from the on-site records. For daytime conditions (solar radiation of 100 W/m² or greater), hourly values of solar radiation and wind speed were applied in a scheme proposed by Turner (1964) and Pasquill (1961).

A method by Mitchell (1982) was used for night-time conditions (solar radiation less than 100 W/m²) to derive stability classification from records of sigma theta and wind speed. The results of stability determinations are summarised in Table B-6.

TABLE B-6
FREQUENCIES (PERCENT) OF ATMOSPHERIC STABILITY CATEGORIES ESTIMATED FROM METEOROLOGICAL RECORDS COLLECTED AT CADIA IN 1994-95

Season	Atmospheric Stability Category					
	Unstable		Neutral		Stable	
	A	B	C	D	E	F
Summer	9.4	14.5	12.4	35.5	7.8	20.4
Winter	1.9	11.5	12.7	30.6	11.7	31.6
Year	5.7	13.0	12.5	33.1	9.7	26.0

The results were in a general agreement with the distributions of atmospheric stability categories which were Wales on previous occasions and confirmed a seasonal variation in the occurrence of unstable and stable air at the project site. Strongly stable conditions were relatively frequent and were often associated with a northeasterly direction of the air flow.

5.4 DISPERSION MODEL

The estimated rates of dust emissions were applied together with the meteorological data in a computer model of dust dispersion. The model is described in Attachment B-3. A computer plotting routine was used to draw isopleths of predicted dust deposition rates and concentrations of total suspended particulates in the ambient air.

Directional dependence of the wind erosion component of the dust source term was retained in the model by invoking the contribution by wind erosion only when the wind speed exceeded a threshold value of 5.4 m/s in that particular direction. The total frequency in the meteorological data of wind speeds in excess of the threshold value was 9.1 percent.

6.0 MODELLING RESULTS AND IMPACT ASSESSMENT

Atmospheric dust is the only type of air pollutant which will be released from the mining operation in a quantity that is of consequence in air quality considerations. Many dust particles generated from the mining operation tend to be of a rather large size resulting in a rapid settling at relatively short distances from the location of the emission. Depending on the size of the particulate matter, the air quality criteria for particulate matter thus distinguish between dust deposition and concentration of suspended dust particles in the ambient air.

6.1 DUST DEPOSITION

6.1.1 Air Quality Guidelines

Depositing dust (dustfall) if present at sufficiently high levels, can reduce the amenity of an area which is used for living, farming and other activities to such an extent that they cease to be either enjoyable or viable. The specific effects contributing to this degradation of amenity include mainly the presence of visible dust either in the air or on surfaces, and soiling of surfaces and materials.

In New South Wales in the past, the EPA (formerly SPCC) used an annual average of 4.0 g/m^2/month as the level at which amenity was likely to be affected causing complaints of nuisance dust. More recently, the EPA adopted new amenity based criteria for dust deposition. The EPA criteria are summarised in Table B-7.

The maximum acceptable increase in the mean annual dust deposition rate is thus 2 g/m^2/month in those residential areas in which the existing rate of dust deposition does not exceed 2 g/m^2/month. For those areas the criteria seek to limit the total dust deposition rate (the sum of the existing level and the increment due to a new development) to 4 g/m^2/month expressed as an annual mean.

TABLE B-7
NSW EPA CRITERIA FOR DUST FALLOUT

Existing Dust Level (g/m^2/month)	Maximum Acceptable Increase over Existing Dust Level (g/m^2/month)	
	Residential Suburban	Rural, Semi-Rural, Urban, Commercial and Industrial
2	2	2
3	1	2
4	0	1

Note: If the existing dust level in any area is greater than 4 g/m^2/month (i.e. 5 or above) then no increase in dust fallout is acceptable as a result of any proposed dust emitting works.

Similarly, the criteria allow for an increment of up to 2 g/m^2/month in the mean annual dust deposition rate in those rural and semi-rural as well as commercial areas in which the existing dust deposition does not exceed 3 g/m^2/month. For these locations, the maximum acceptable total dust deposition rate is 5 g/m^2/month expressed as an annual mean.

Monitoring results of existing dust deposition rates in the area containing the project site were presented in Section 2. The existing levels fall within the definition of the EPA criteria above. As a result, when applied to the proposed development at Cadia, the criteria specify a mean annual increment of 2.0 g/m^2/month as the maximum acceptable increase over the existing levels for all land located outside the project site.

6.1.2 Predicted Levels

Increases in the mean annual rate of dust deposition during selected years of operation were predicted first. The results of the predictions are presented as a set of isopleths (dust contours) in Figures B-2 to B-5. The shape of the dust deposition contours reflected the direction of the main winds as well as the position and configuration of the main dust generating sources including the pit, waste emplacement areas and the haul roads. The contribution of operations at the processing plant is also discernible from the dust contours.

Inherent in the results presented in Figures B-2 to B-5 was the assumption that the dust emissions would be able to follow a path free of obstructions through the air to the grid points at which the modelling calculations were carried out. Physical obstacles located along the path in the form of trees, other types of vegetation and rising terrain can be expected to interfere with the dispersing cluster of atmospheric particles and so remove a portion of the dust from the air. However, the complexities of describing this removal mechanism in acceptably reliable mathematical terms prevented its inclusion in regulatory dispersion models rendering the results to be conservative in the majority of cases.

Retention of a portion of the atmospheric particulates generated within a deep pit by the pit itself is a well known phenomenon (Cole et al, 1984, SPCC, 1983, SPCC et al, 1988, 1989) which increases with increasing depth of the pit floor in relation to the surrounding terrain. Retention of up to 60 percent and possibly as much as 80 percent of the atmospheric particulates generated within the pit has been quoted.

The depth of the pit at the project site will gradually increase to between 450 m and 600 m at the end of the development. It was assumed for the purpose of modelling that all atmospheric dust would be able to escape from the pit (no retention) in Year 1 of the operation. Retention of 30 percent of the pit emissions was assumed for Years 4 and 6, and 50 percent for Year 9. These assumptions were again conservative and so likely to have resulted in higher predicted levels of dust deposition outside the pit.

Figures B-2 to B-5 thus shows conservatively predicted increases in the mean annual dust deposition rate for 4 selected years of mining which were described in the previous section. Incremental levels corresponding to 0.5, 0.75, 1.0, 2.0, 4.0 and 6.0 g/m^2/month were drawn on figures containing the project site.

Year 1

The predicted increases in the mean annual rate of dust deposition in Year 1 are shown in Figure B-2. The emphasis was placed in Figure B-2 on determining the approximate position of the contour line which corresponds to an incremental value of 2.0 g/m^2/month (annual average). This line was predominantly confined to the project site.

Mean dust deposition in excess of 2.0 g/m^2/month was predicted to occur within the project site at locations close to the pit, waste disposal areas, major haul roads and the processing plant. The mean rate of dust deposition will diminish at locations which are situated further away from the dust generating sources. The reduction in dust deposition at those locations will depend on the separation distance and on the prevailing dispersion conditions.

The mean rate of dust deposition will fall more rapidly in the direction of infrequent winds notably towards the northwest and north. The prevailing northeasterly winds will carry dust particles towards the southwest. The dust contours in Figure B-2 also showed the effect of west to southwesterly winds on dispersion of atmospheric particulates from the proposed operation.

The nearest residences to the path of the prevailing winds coming from the main dust generating sources in Year 1 will be 'Caringle' (approximate coordinates 296 700 E, 1293 500 N) and 'Stratton Vale' (approximate coordinates 298 250 E, 1290 350 N). An increase of 0.95 g/m^2/month in the mean annual deposition rate was predicted for the 'Caringle' which is located about 1.5 km to the southwest of the project site. The residence at 'Stratton Vale' was predicted to receive an increase of 0.60 g/m^2/month.

Even lower increments in mean dust deposition were predicted for the remaining residences in the vicinity of the project site. Residence 'Cornwall' (coordinates 302 300 E, 1298 600 N) near the northeastern corner of the project site was predicted to receive 0.43 g/m^2/month, 'Tunbridge Wells' (coordinates 297 500 E, 1299 600 N) less than 0.10 g/m^2/month. The latter is located near the northwestern corner of the project site and so about 3 km away from the main dust generating sources and also away from the direction of the prevailing winds.

Among the other residences which are located near the boundaries of the project site, residence 'North West' (coordinates 302 900 E, 1291 700 N ISG Zone 55/3) was predicted to receive 0.15 g/m^2/month, residence 'Carinya Park' (coordinates 300 300 E, 1289 800 N) 0.30 g/m^2/month and residence 'Warrengong' (coordinates 304 100 E, 1295 150 N) 0.28 g/m^2/month.

Year 4

All waste disposal in Year 4 will be to the main dump which is located to the south of the pit. The closure of the northern dump will result in a general shift in the dust deposition contours shown in Figure B-3 to the south. The contour line representing an increase in the mean annual dust deposition rate of 2.0 g/m^2/month was again predicted to be predominantly confined to the project site. Excursions beyond the project site were predicted to occur to the west of the waste dump.

Among the residences, the highest increment in the mean annual dust deposition rate of 0.97 g/m^2/month was predicted for 'Caringle'. A rise from 0.60 g/m^2/month in Year 1 to 0.81 g/m^2/month at 'Stratton Vale' reflected the progression of the operation in a southerly direction.

An increment of 0.41 g/m^2/month was predicted for 'Carinya', 0.35 g/m^2/month for 'Warrengong' and 0.22 g/m^2/month for 'North West'.

The predicted increase in dust deposition at 'Cornwall' dropped to 0.32 g/m^2/month in Year 4 as a result of the relocation of waste dumping activities at the project site. The predicted increments in dust deposition continued to be very low to the northwest of the project site.

Year 6

Annual increases in dust deposition rates are predicted in Figure B-4. The contour line which corresponds to a predicted increase of 2.0 g/m^2/month moved further to the west and southwest mainly as a result of dust emissions from the waste disposal. The extent of the area which

was predicted to be included within a contour line of 2.0 g/m²/month outside the western as well as the eastern boundary of the project site remained small.

The highest predicted increments in the mean annual dust deposition in Year 6 were 0.82 g/m²/month at 'Caringle' and 0.80 g/m²/month at 'Carinya'.

The predicted increases in dust deposition dropped at 'Cornwall' to 0.31 g/m²/month but rose at 'North West' to 0.26 g/m²/month. Located to the east of the main waste disposal area, residence 'Warrengong' was predicted to receive an increment of 0.39 g/m²/month.

Year 9

The pit will reach a depth of, at least, 450 m in Year 9 and the removal of waste rock will be almost complete.

Rehabilitation of the waste disposal areas will be well advanced covering about 50 percent of the surface area. The predicted increases in the mean annual dust deposition in Figure B-5 thus showed a marked contraction in the extent of the area covered by the respective contour lines.

This contraction was reflected in the values which were predicted for the individual residences in the vicinity of the project site. The highest increment in dust deposition was predicted at 'Stratton Vale' but its magnitude dropped to 0.35 g/m²/month. The predicted increase in dust deposition at 'Caringle' was 0.28 g/m²/month. There were no other residences at which the predicted increases in the mean annual dust deposition rate would reach at least 0.20 g/m²/month in Year 9.

6.1.3 Impact Assessment

The impact of dust emissions from the proposed development was assessed in terms of the EPA objective for protection of amenity by comparing the predicted mean annual increases in dust deposition with a maximum acceptable value of 2.0 g/m²/month.

The results of dust dispersion modelling showed that with the exception of a small section of unoccupied land located just outside the western boundary of the project site, and a narrow strip of forestry land outside the eastern boundary in Year 6, the EPA objective will be met with respect to all land outside the project site. The amount of dust emissions will vary throughout the period of proposed operation. Notwithstanding the variations, the EPA objective will be met at all non-Company owned residences at all stages of the development.

Because of a variety of dust controls and operational measures to reduce emissions of dust as well as the considerable separation distances which exist between even the nearest non-Company owned residences and the main sources of dust emissions within the project site, the maximum increases in the mean annual dust deposition rates were predicted to remain less than a half of the EPA objective.

A narrow portion of land situated along the western boundary of the project site was identified as land on which the increase in mean annual dust deposition may exceed 2 g/m²/month. This portion of land is located immediately to the west of the processing plant and the main waste disposal area. The length of the potentially affected area was predicted to be up to 3.5 km in the north-to-south direction, and extend to about 500 m to the west of the boundary. The main part of this land has been acquired by the proponent.

The increase in dust deposition on the remaining section was predicted to be limited to between 2 and 4 g/m²/month. The land should therefore remain undeveloped for residential purposes throughout the first half of the operation of the proposed mine.

6.2 CONCENTRATION OF TOTAL SUSPENDED PARTICULATES

6.2.1 Air Quality Guidelines

The health effects of dust are related to the concentration of suspended particles in the air as distinct from dust deposition. The effects of inhaled dust are specifically related to the types of particles inhaled, the particles' sizes, the ability of the respiratory tract to capture and eliminate the particles and the reactivity of the particles with lung tissue (SPCC, 1983).

The National Health and Medical Research Council of Australia (NHMRC, 1985) recommended annual concentration of 90 µg/m³ as the maximum permissible level of total suspended particulates in the air to protect public health in residential environments. Exposure periods shorter than one year are not covered by the NHMRC goals. In the United States, the USEPA used a primary air quality standard of 260 µg/m³ to protect public health. This standard applied to peak concentrations experienced over 24 hours and may not be exceeded more than once a year. A secondary standard of 150 µg/m³ over 24 hours was used by the USEPA to protect public against nuisance dust. The NSW EPA has adopted the primary standard of 260 µg/m³ as its objective but not the secondary standard of 150 µg/m³.

More recently, the USEPA and regulatory authorities in a number of European countries adopted air quality objectives which were specifically designed to address the levels of particles which have aerodynamic diameters of less than 10 microns in size (PM10). By contrast, total suspended particulates which are covered by the objectives listed above range in size to 30 microns and possibly higher.

In recognition of these developments, the NSW EPA has now listed the USEPA ambient air standards for PM10 concentrations among its objectives. These objectives seek to limit the mean annual concentration of PM10 in residential environments to 50 $\mu g/m^3$. Similarly, the maximum concentrations of PM10 over an interval of 24 hours are limited to 150 $\mu g/m^3$.

No air quality guideline values are available either in Australia or overseas which would relate to the concentration of total suspended particulates in the air during brief dust episodes. The episodes are the result of adverse weather conditions, usually strong winds and dry weather, sometimes coinciding with higher than normal emissions of dust. Wind erosion of dusty surfaces is often the main component of the emission which may last for a few hours.

6.2.2 Predicted Levels

The results of modelling predictions of mean annual dust concentrations during four selected years of the proposed development are shown in Figures B-6 to B-9. The contour lines indicate the predicted increases in the mean annual concentrations of total suspended particulates in the ambient air. Contour levels corresponding to increments of 10, 20, 30, 40, 50, 60 and 100 $\mu g/m^3$ were used in the figures.

Year 1

The predicted increases in the mean annual concentration of total suspended particulates (TSP) in the ambient air in Year 1 are presented in Figure B-6.

The main trends in the predicted dust levels which were displayed earlier by the dust deposition contours were repeated in the contour maps of TSP concentrations. The shape of the predicted concentration isopleths reflected the location of main dust sources and the prevailing wind directions.

Mean annual concentrations of TSP at the project site were predicted to increase by about 60 $\mu g/m^3$ or more in the vicinity of the main dust generating sources. Increments of 40 $\mu g/m^3$ will be almost entirely confined to the project site as well. Initial results of high-volume sampling in early 1995 indicated a presence of TSP concentration levels of about 40 to 50 $\mu g/m^3$ in the ambient air near the project site. An increment of at least 40 $\mu g/m^3$ in the mean annual concentration of TSP would thus be needed for the total concentration to equal the NHMRC guideline value of 90 $\mu g/m^3$ for residential environments.

An increase of 40 $\mu g/m^3$ in the mean annual concentration of TSP was predicted for a small area located just outside the western boundary of the project site. The increases which were predicted for all remaining locations outside the project site were less than 40 $\mu g/m^3$.

Among the nearest residences, 'Caringle' was predicted to receive an increase in the mean annual concentration of about 17 $\mu g/m^3$ and 'Stratton Vale' 13 $\mu g/m^3$. Increments of less than 10 $\mu g/m^3$ were predicted for the other non-Company owned residences included in the modelling.

Year 4

A displacement in the TSP concentration contours towards the south was predicted in Figure B-7 as a result of increased utilisation of the main waste disposal area. The highest increases were predicted to occur near the main sources of atmospheric particulates in this year, the pit and the waste dump.

Mean annual increments of about 18 $\mu g/m^3$ were predicted for the nearest residences located to the southwest and south-southwest of the operation. The residences included 'Caringle' and 'Stratton Vale'. An increment of just over 10 $\mu g/m^3$ was predicted for 'Carinya Park'. The predictions for all other residences were less than 10 $\mu g/m^3$.

Year 6

Figure B-8 shows the predicted increases in the mean annual concentrations of TSP in the ambient air in Year 6

Mean annual concentrations of TSP were predicted to reach about 60 $\mu g/m^3$ along the eastern boundary of the project site but drop to about 40 $\mu g/m^3$ at a distance of approximately 500 m further to the east. With the exception of another narrow strip of land immediately to the west of the dumping operations, all other locations outside the project site were predicted to receive contributions of less than 40 $\mu g/m^3$ (annual average).

A mean annual increase of 19 $\mu g/m^3$ was predicted for residence 'Stratton Vale' in Year 6. The residence 'Caringle' was predicted to receive an increase of 16 $\mu g/m^3$. Lower values were obtained for residences 'Panuara', 'Oaky Creek' and 'Carinya Park'. The remaining residences including 'North West' and 'Warrengong' to the east of the project site were predicted to receive less than 10 $\mu g/m^3$.

Year 9

The concentrations of TSP in the ambient air will be much reduced towards the end of the mine development. Contours of incremental TSP concentrations were predicted to contract in a manner shown in Figure B-9.

All of the non-Company residences were predicted to receive increments of less than 10 $\mu g/m^3$ in the mean an-

nual concentrations of TSP in the ambient air. The highest increments of about 7 $\mu g/m^3$ were again predicted for the residences located to the south-southwest of the operation.

6.2.3 Impact Assessment

The mean annual concentrations of TSP at all non-Company owned residences were predicted to increase by less than 20 $\mu g/m^3$ throughout the life of the project. The resulting total concentrations of TSP will thus remain below the NHMRC guideline value of 90 micrograms/m^3.

Particulate matter with diameters of less than 10 microns (PM10) usually constitutes about 50 percent of the total suspended particulates (TSP) in the ambient air. When a ratio of 50 percent is applied to the proposed development, the mean annual concentrations of PM10 at all residences are expected to be less than 35 $\mu g/m^3$. As a result, a mining operation which incorporates the use of standard dust control measures and safeguards as proposed will not adversely affect public health in the surrounding areas.

Short-term dust episodes

Short-term dust episodes relate to temporary increases in the amount of dust raised mainly from disturbed surfaces and other dust containing areas by strong winds in dry weather conditions. As outlined in Section 5.4 earlier, the contribution of erosion of disturbed surface by winds in excess of about 20 kph to the total dust emission was included in the modelling of annual dust deposition rates and TSP concentrations.

The wind records which were collected in the project area in 1994-95 indicated that the potential for the occurrence of frequent dust episodes is not very high at Cadia. Wind speeds of 20 kph and higher were recorded with an annual frequency of only 9.1 percent.

The nature, strength and duration of a dust episode are determined by a variety of factors which are not easily quantified. A number of assumptions must be made regarding the location of earthmoving equipment at the time of the episode, the strength and direction of the wind, and dust generation rate caused by wind erosion, and the duration and severity of the meteorological event which has caused the episode to occur. It is thus evident that realistic predictions of dust concentrations in the air during the episodic event are more difficult to achieve than corresponding predictions of annual dust levels.

As a rule, dust episodes are more frequent and lead to higher short-term concentrations of wind-blown dust in those areas for which the long-term predictions of annual dust levels indicated reduction in amenity. It was shown earlier that the locations at which the amenity criterion of 2.0 g/m^2/month (mean annual increment) will be reached were predicted to be mainly confined to the project site. It is therefore not expected that atmospheric dust would escape during the isolated dust episodes and reach the nearest residences located further downwind in such quantities which would cause temporary dust nuisance in high winds.

6.3 DUST LEVELS DURING CONSTRUCTION

The construction period will extend over 21 months and include site preparation, initial stripping and stockpiling of topsoil, construction of tailings dam wall as well as various roadworks and erection of buildings and processing plant. Watering of dusty areas and restricting the speed of vehicles travelling on unmade surfaces and unsealed roads will be used as the main dust controls during this period.

The main component of the construction, in terms of dust emissions and air quality, will be the site preparation and construction of tailings dam wall (Phase 1 of construction activity). Approximately 4 Mt of rock will be removed from the pit area and hauled along the existing Cadia Road for use in building the tailings dam wall. The wall will be up to 40 m high and require 4 to 6 months of construction time. The duration of Phase 1 of the construction period is expected to be about 8 months.

Another 6 months were earmarked for roadworks including the upgrading of unsealed roads to each of the water dams, the construction and sealing of diverted Cadia Road, the main access road as well as access roads to the contractor's site and the site office. Construction of water dams and weirs, and buildings and plant will complete the initial activity on site.

Roadworks and building construction are expected to result in lower mean dust emissions than the site preparation and tailings dam construction during Phase 1 of the construction period. Dust emission inventories were therefore developed for the activities during Phase 1 and applied in the dispersion model to obtain estimates of mean increments in dust deposition rates and TSP concentrations in a manner similar to the modelling of dust emissions during the operation of the mine in Years 1, 4, 6 and 9.

6.3.1 Emissions of Dust

A dust emission inventory was compiled for Phase 1 of the construction period. Details of the inventory are given in Table B-1-5 in Attachment B-1.

Soil removal and stockpiling, waste rock removal from the pit area and loading to trucks for transport along Cadia Road to the tailings dam area were estimated to generate 111.2 tonnes of dust over a period of 8 months. Haulage

of waste rock along Cadia Road and light vehicle traffic were estimated to add 490.1 tonnes over the same period. The surface of the Cadia Road is made of gravel and regular watering will be applied to control dust.

The activities in the tailings dam area were estimated to contribute a further 61.6 tonnes to the total emission of atmospheric dust during Phase 1 of the construction. Wind erosion of both the pit and tailings dam areas was assumed to take place over the entire surface. Finally, in order to provide a conservative estimate and to account for dust emissions from the waste disposal areas and the plant and contractor's sites, it was assumed that the surfaces of these areas have been fully stripped and would be subject to wind erosion at the same time as the Phase 1 construction activity is taking place.

The total estimated emission of atmospheric dust over a period of 8 months was 1384.0 tonnes.

6.3.2 Predicted Levels

The estimated emissions were again applied in the dispersion model to obtain estimates of increases in the mean dust deposition rate and TSP concentrations in the ambient air. The predicted increases in dust deposition are shown in Figure B-10. Figure B-11 shows predicted increments in TSP concentrations.

Increases corresponding to a mean dust deposition rate of 2.0 g/m^2/month and a mean TSP concentration of 40 $\mu g/m^3$ were predicted to be confined within the project site.

An increment of 0.60 g/m^2/month in the mean dust deposition rate was predicted for the residences 'Carinya Park' and 'Stratton Vale'. 'Oaky Creek' was predicted to receive an increment of 0.42 g/m^2/month over a period of 8 months. The predicted increases for the residences located to the northwest, northeast, east and southeast of the project site were less than 0.10 g/m^2/month.

The increments in TSP concentrations in the ambient air at the residences will be similarly low with values ranging from 17 $\mu g/m^3$ at Carinya Park to less than 5 $\mu g/m^3$ at the majority of residences located generally to the east and north of the project site.

6.3.3 Impact Assessment

Standard dust controls including watering, road marking and restricting the speed of vehicles travelling on unsealed surfaces will also be applied during the construction. The results of dust emission inventories and subsequent dispersion modelling for the most intensive phase of the construction period indicated that the applicable air quality objectives will be met at all locations outside the project site.

6.4 DUST EMISSIONS FROM OPTIONAL ACCESS ROADS

The assessment of dust levels was further extended to include modelling of potential emissions from optional access roads. The positions and lengths of routes 'A' and 'B' are shown in a sketch in Figure B-12. An optional access road would have surface made of formed gravel. No further dust controls were considered for the purpose of this assessment.

6.4.1 Route 'A'

Route A would link the project site with a relocated Cadia Road in the east. It was assumed that the road would carry traffic in both directions. The total traffic movements due to the mine operations were estimated at 240 return trips per day. Light vehicles would account for 226 trips, heavy vehicles (delivery trucks) for 14 trips per day.

Emission factors of 1.5 and 4.0 kg of dust per vehicle kilometre (VKT) were applied to determine annual dust emissions from each 0.5 km section of the road at 75.5 and 10.2 tonnes per year for light and heavy vehicles respectively. Vehicle speed as well as vehicle weight were considered in the emission estimates.

The predicted mean annual rates of dust deposition resulting from the traffic using route A are presented in Figure B-13. The shape of the dust contours reflected the position of the road in the central section of the mining lease area and along its western boundary. Annual increments in dust deposition of 2.0 g/m^2/month would be limited to a close proximity of the access road.

6.4.2 Route 'B'

Predictions of mean annual dust deposition rates for route B are shown in Figure B-14. This route would have its starting and ending points on the existing Cadia Road and would thus provide access from both the north and the south. It was assumed for the purpose of the dust emission inventory that one half of the vehicles would approach the project site from the north and the other half from the south.

A reduced density of traffic in comparison to route A resulted in narrower dust contours as shown in Figure B-14. Annual increments of 2.0 g/m^2/month were predicted to be confined to locations within the mining lease area.

6.4.3 Impact Assessment

A combined impact of the mining and ore processing operations and traffic using an unsealed access road on the levels of atmospheric dust was assessed for Year 4 of the mining operations. It was shown earlier that Year 4 rep-

resented the year of the highest dust emission rate from the proposed development.

Predicted combined increases in the mean annual dust deposition from mining in Year 4 and traffic using access route A are shown in Figure B-15. When compared to the predicted increases in the mean annual dust deposition from mining in Year 4 alone in Figure B-3, Figure B-15 indicated a relatively small extension of the contour line corresponding to 2.0 g/m^2/month outside the western boundary of the project site. Most of the land which falls within this contour line is owned by the Company.

Predicted combined increments in the mean dust deposition from mining in Year 4 and unsealed access road B are shown in Figure B-16. The extension of the contour line corresponding to 2.0 g/m^2/month outside the western boundary is marginally smaller than in Figure B-15. The contour of 2.0 g/m^2/month would also extend outside the boundary in the southwestern corner where the access road B would turn north off Panuara Road.

Because of their position predominantly within the mining lease area, the use of optional unsealed access routes A or B is not expected to alter significantly the predictions of mean annual increments in dust deposition rates and TSP concentrations in the air outside the project site which were presented in Sections 6.1 and 6.2 of the report.

Additional dust control measures such as regular watering in dry weather conditions or sealing of the surface could be adopted selectively on those sections of the access road which may be located near sensitive, non-Company owned land.

7.0 CONCLUSIONS

The generation and dispersion of atmospheric dust from the proposed development at Cadia were examined and quantified. The open cut mine will operate with standard dust controls and be subject to a range of approval and licence conditions by the EPA.

Four years of the proposed operations, Years 1, 4, 6 and 9, were used to develop inventories of dust emissions. A separate dust emission inventory was also developed for the most intensive phase of the construction period. The impact of dust emissions on air quality was assessed using dispersion modelling techniques which included the use of meteorological data collected at the project site. The predicted increases in dust deposition and dust concentration in the ambient air were assessed by reference to the applicable EPA and NHMRC air quality objectives. Results of on-site monitoring of existing levels of atmospheric dust in the area containing the project site were included in the assessment.

Results of dispersion modelling confirmed that the amenity- based criteria will not be exceeded at any of the surrounding residences. All non-Company owned residences were predicted to receive mean annual increments of less than 1.0 g/m^2/month. Residential amenity as well as other land use will not be affected by dust deposition resulting from the proposed operation.

Similarly, the concentrations of TSP and PM10 in the ambient air will remain at levels well below the applicable guideline values. No adverse effects on public health were thus predicted as a result of the proposed and safeguarded operation.

A narrow portion of land situated outside the western boundary of the project site and a strip of forestry land outside the eastern boundary were identified as the only land on which the increase in mean annual dust deposition may exceed 2 g/m^2/month and the mean annual concentration of TSP 90 $\mu g/m^3$ at some stage of the operation especially during the early years of mining.

The increase in dust deposition was predicted to be limited to between 2 and 4 g/m^2/month and the mean annual concentration of TSP to between approximately 80 and 120 $\mu g/m^3$. The land should therefore remain undeveloped for residential purposes during the first half of the proposed operation.

A dust monitoring programme has been implemented at the project site and includes the determination of the concentrations of dust in the air in addition to dust deposition. The monitoring is expected to continue throughout the life of the mine or as required by the NSW EPA. The monitoring results will be able to be used to assess compliance of the operating mine with the air quality objectives and licence conditions as well as for the purpose of environmental management.

The current location of the high volume sampling site is to the southeast of the project area. It is recommended that, in view of the results obtained during this study, another sampling site be found in a southwestern direction from the project site. The proposed location should be near one of the closest residences such as Stratton Vale or Caringle which is located on Company owned land. The existing sampler should be relocated to the new sampling site as soon as possible or a second sampler should be acquired to collect information regarding concentrations of TSP in the ambient air in that area. The monitoring of PM10 particles in the same area should also be considered in consultation with the NSW EPA.

Atmospheric dust will be the main component of emissions to air from the proposed development. Other emissions will include exhaust fumes from mobile equipment, blasting fumes and evaporative emissions from the processing area including odours. All these emissions will remain only minor and will be confined to the project site.

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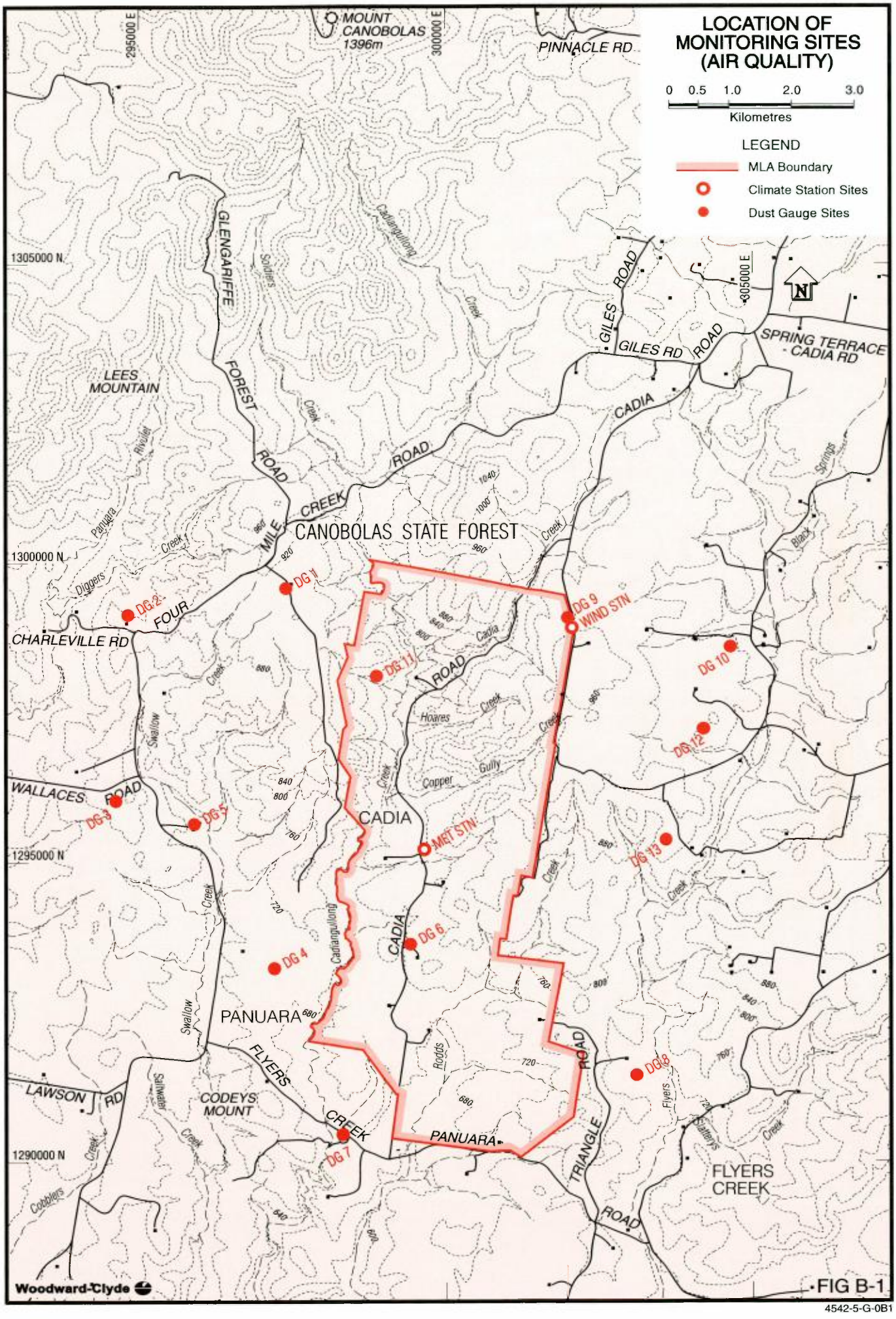
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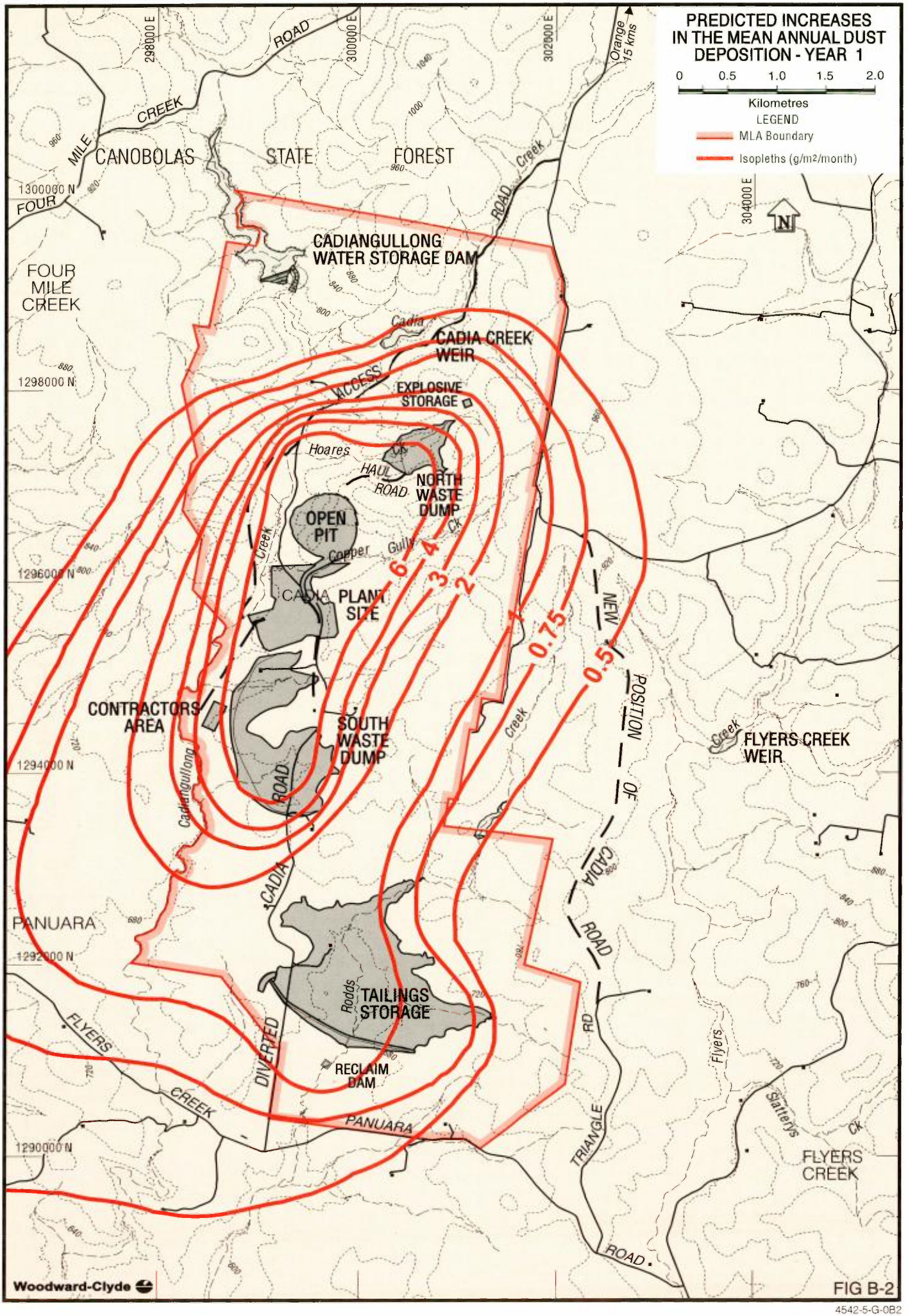
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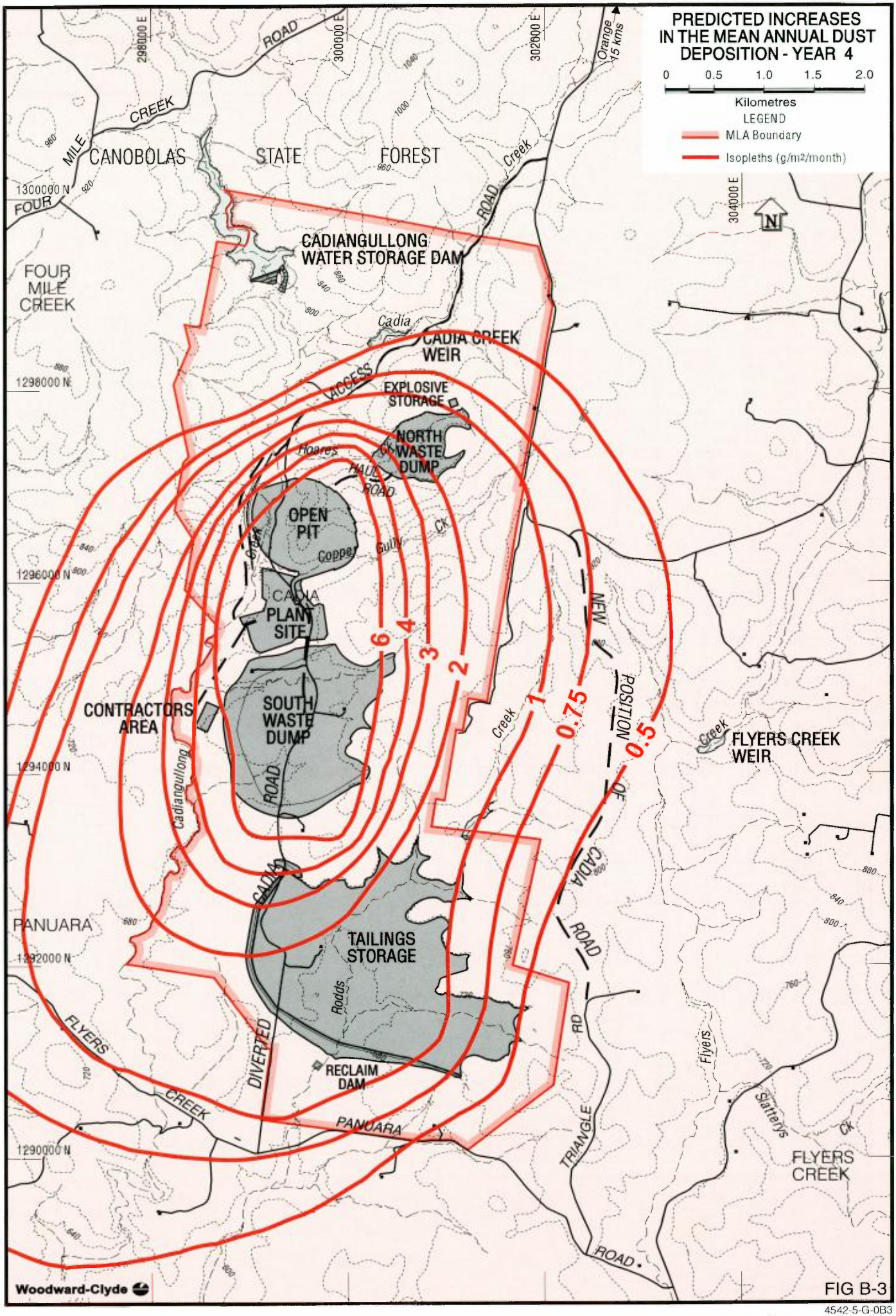
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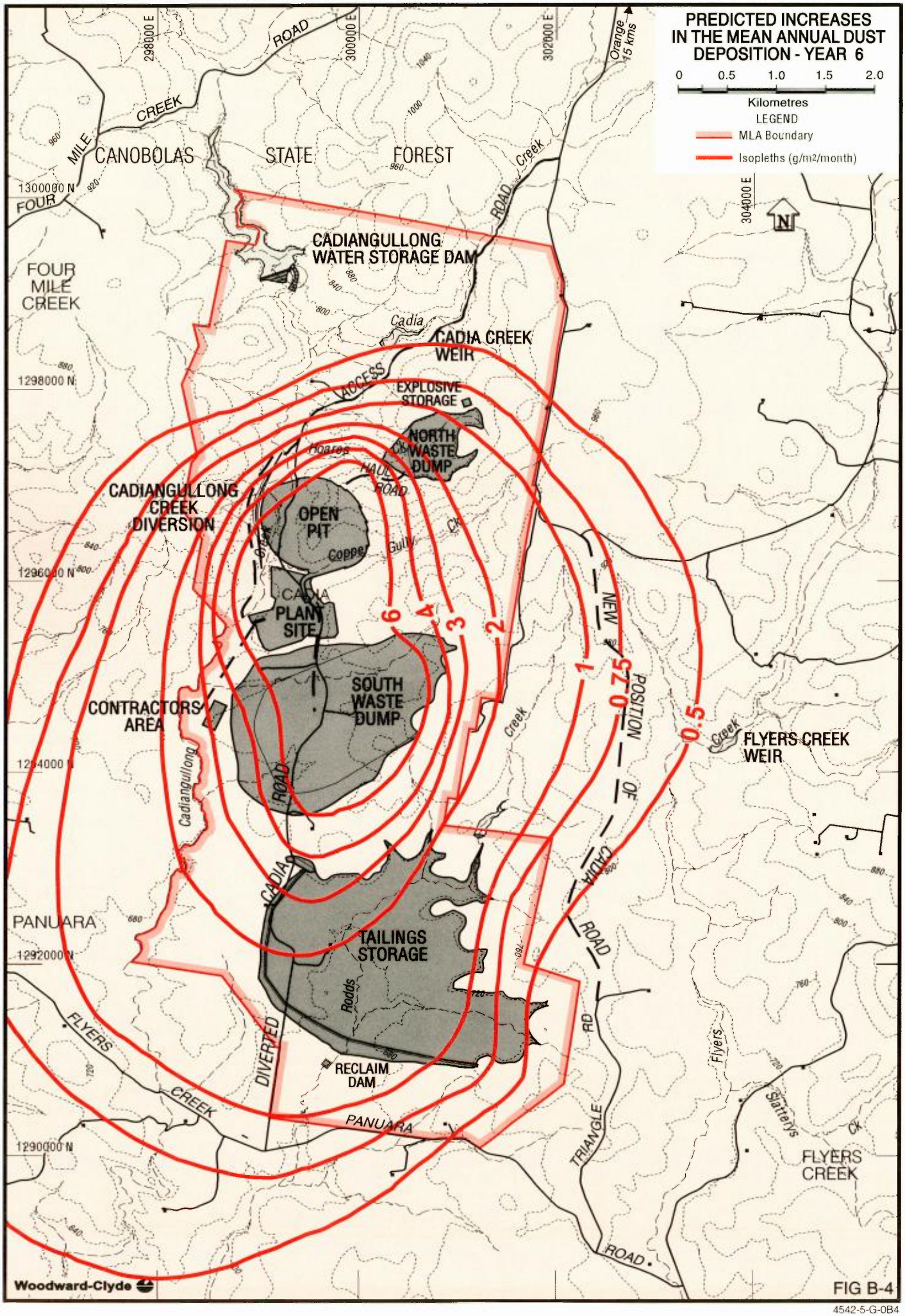

LOCATION OF MONITORING SITES (AIR QUALITY)
0 0.5 1.0 2.0 3.0
Kilometres
LEGEND
MLA Boundary
Climate Station Sites
Dust Gauge Sites
MOUNT CANOBOLAS 1396m
295000 E
300000 E
305000 E
PINNACLE RD
1305000 N
1300000 N
1295000 N
1290000 N
GLENGARIFFE FOREST ROAD
LEES MOUNTAIN
GILES ROAD
GILES RD ROAD
SPRING TERRACE - CADIA RD
CADIA ROAD
MILE CREEK
CANOBOLAS STATE FOREST
FOUR CHARLEVILLE RD
WALLACES ROAD
LAWSON RD
FLYERS CREEK ROAD
TRIANGLE ROAD
CADIA
PANUARA
CODEYS MOUNT
FLYERS CREEK
DG 1
DG 2
DG 3
DG 4
DG 5
DG 6
DG 7
DG 8
DG 9
WIND STN
DG 10
DG 11
DG 12
DG 13
MET STN
Woodward-Clyde
FIG B-1

4542-5-G-0B1

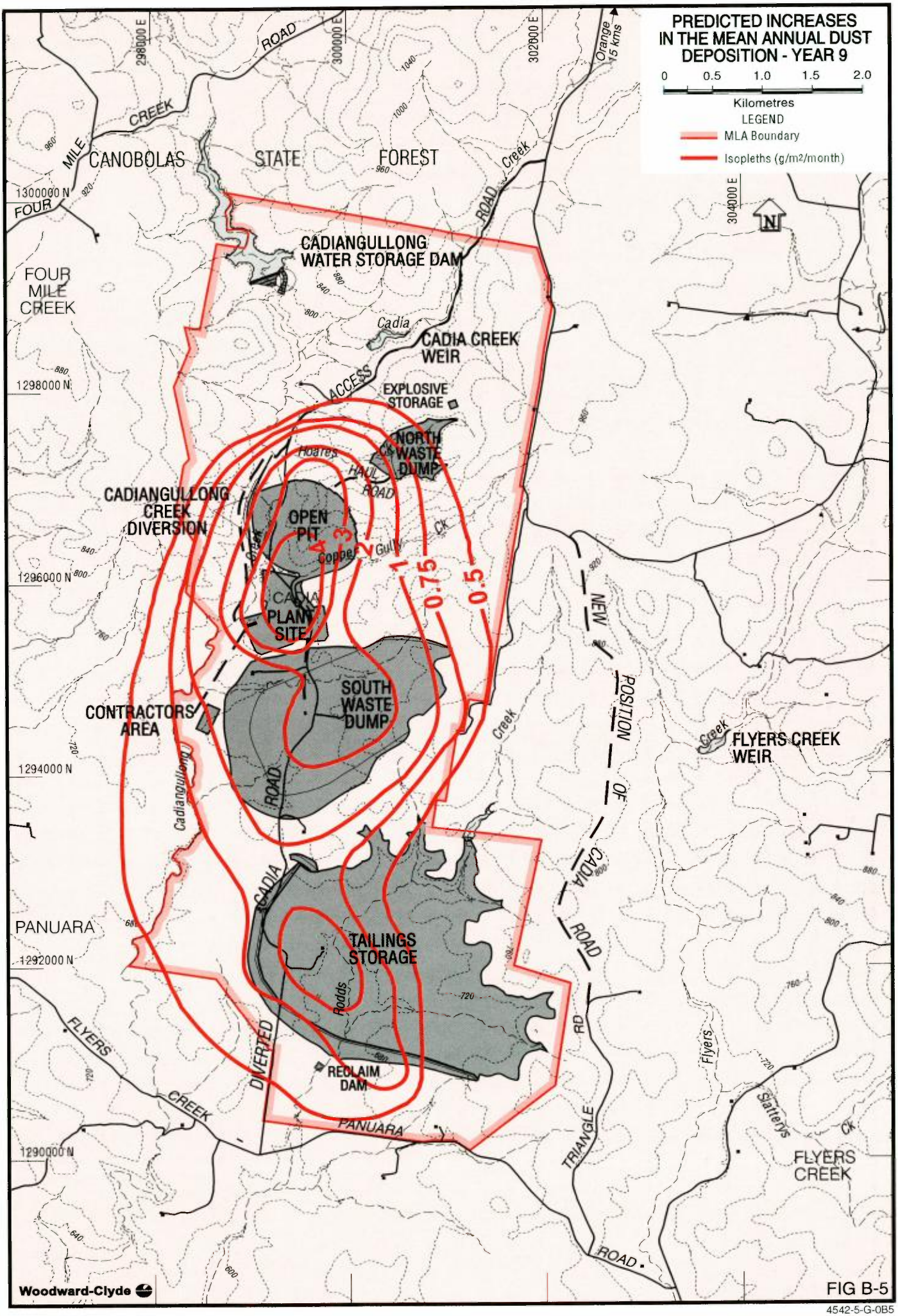

PREDICTED INCREASES IN THE MEAN ANNUAL DUST DEPOSITION - YEAR 1
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (g/m2/month)
CANOBOLAS STATE FOREST
FOUR MILE CREEK
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
ACCESS
HAUL ROAD
NORTH WASTE DUMP
OPEN PIT
Hoares Gully
Copper Gully
CADIA PLANT SITE
CONTRACTORS AREA
SOUTH WASTE DUMP
TAILINGS STORAGE
RECLAIM DAM
DIVERTED
FLYERS CREEK WEIR
FLYERS CREEK
PANUARA
NEW CADIA ROAD POSITION
TRIANGLE RD
6
4
3
2
1
0.75
0.5
1300000 N
1298000 N
1296000 N
1294000 N
1292000 N
1290000 N
298000 E
300000 E
302000 E
304000 E
Orange 15 kms
N
Woodward-Clyde
FIG B-2

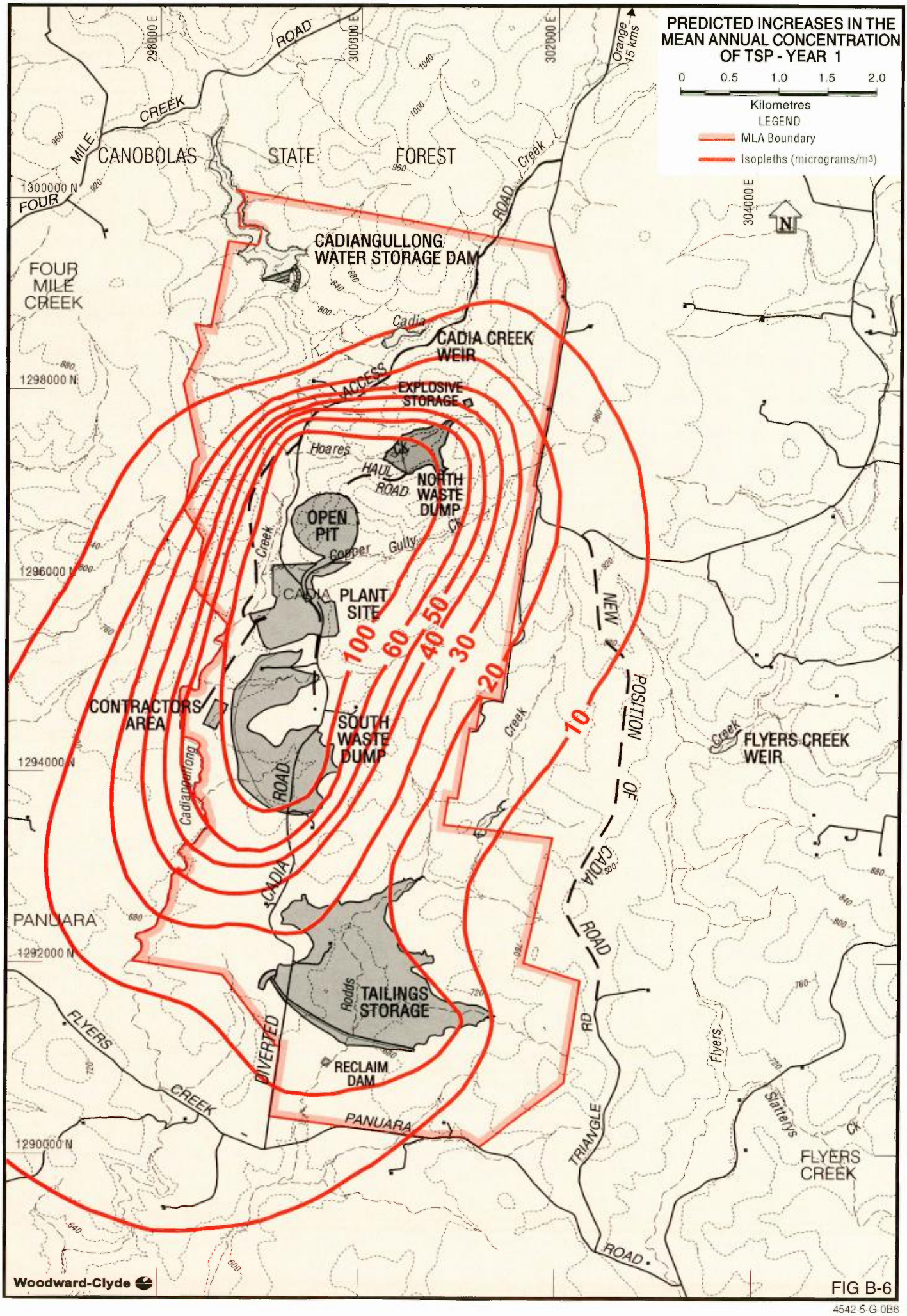
4542-5-G-0B2


PREDICTED INCREASES IN THE MEAN ANNUAL DUST DEPOSITION - YEAR 4
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (g/m2/month)
CANOBOLAS STATE FOREST
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
NORTH WASTE DUMP
OPEN PIT
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
FLYERS CREEK WEIR
FLYERS CREEK
FOUR MILE CREEK
PANUARA
6
4
3
2
1
0.75
0.5
Woodward-Clyde
FIG B-3
4542-5-G-0B3

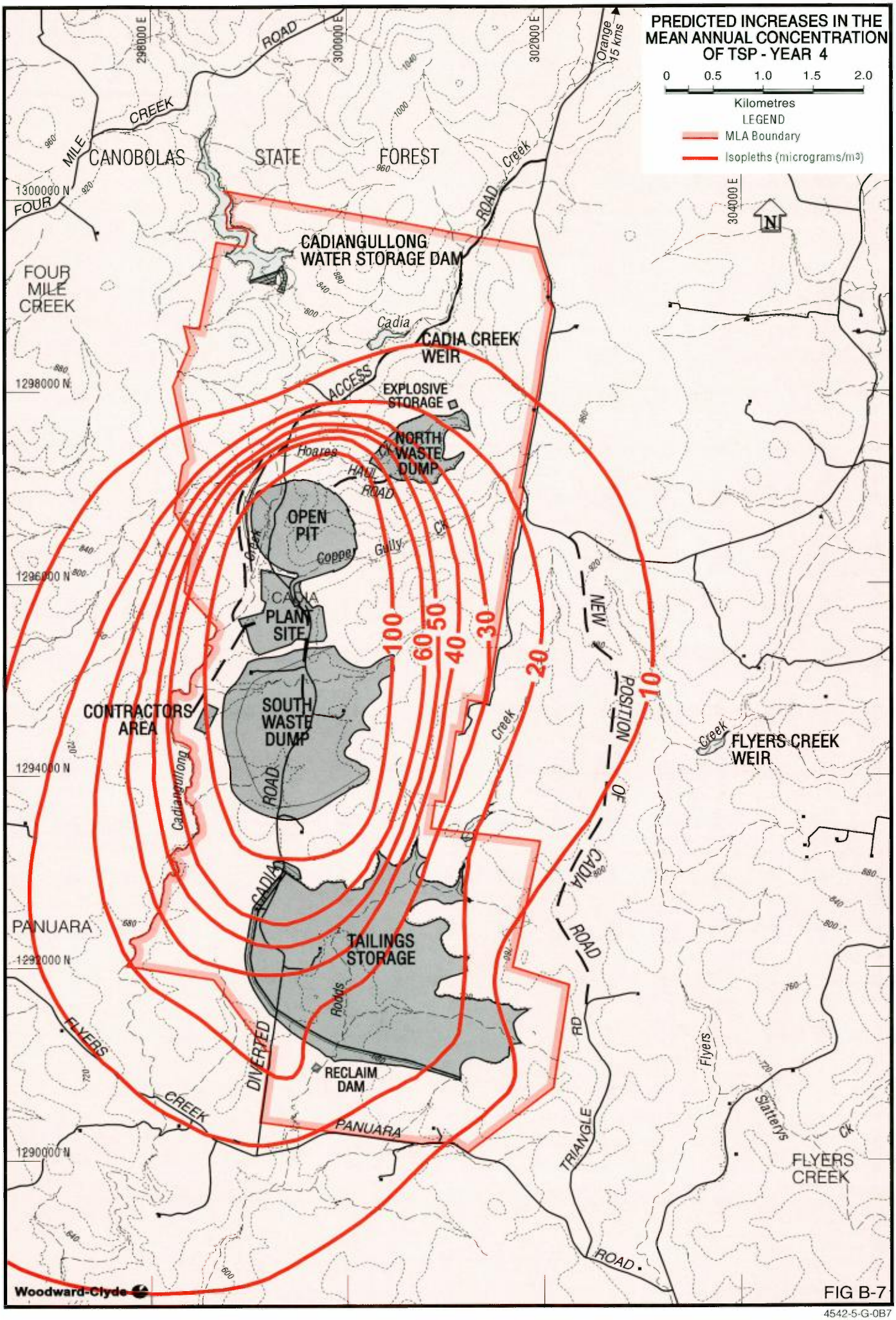

PREDICTED INCREASES IN THE MEAN ANNUAL DUST DEPOSITION - YEAR 6
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (g/m2/month)
CANOBOLAS STATE FOREST
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
NORTH WASTE DUMP
CADIANGULLONG CREEK DIVERSION
OPEN PIT
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
FLYERS CREEK WEIR
FOUR MILE CREEK
PANUARA
FLYERS CREEK
6
4
3
2
1
0.75
0.5
Woodward-Clyde
FIG B-4

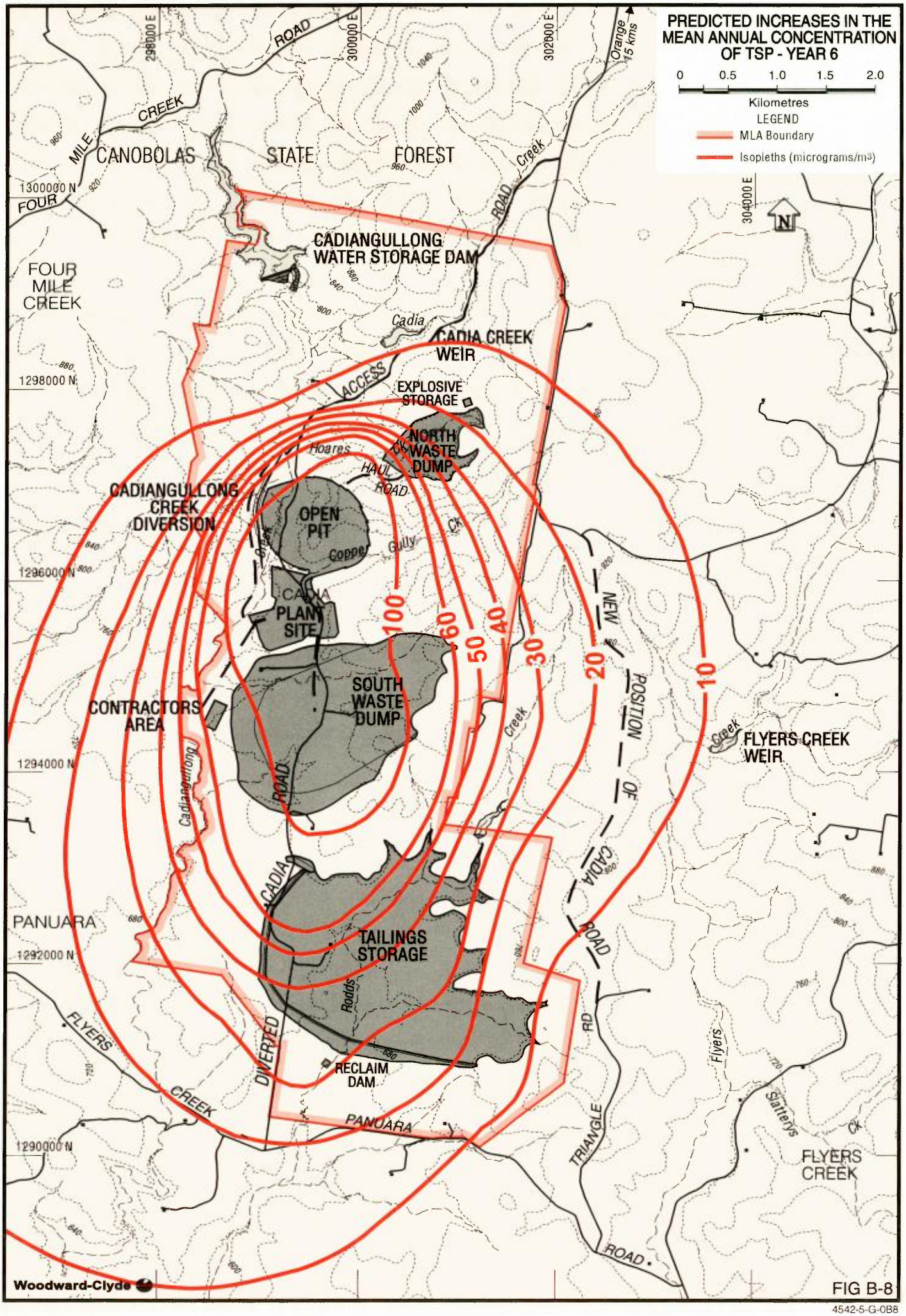
4542-5-G-0B4


PREDICTED INCREASES IN THE MEAN ANNUAL DUST DEPOSITION - YEAR 9
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (g/m²/month)
CANOBOLAS STATE FOREST
FOUR MILE CREEK
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
ACCESS
EXPLOSIVE STORAGE
NORTH WASTE DUMP
HAUL ROAD
CADIANGULLONG CREEK DIVERSION
OPEN PIT
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
DIVERTED
NEW POSITION OF CADIA ROAD
FLYERS CREEK WEIR
FLYERS CREEK
PANUARA
4.3
2
1.1
0.75
0.5
Orange 15 kms
298000 E
300000 E
302000 E
304000 E
1300000 N
1298000 N
1296000 N
1294000 N
1292000 N
1290000 N
N
Woodward-Clyde
FIG B-5
4542-5-G-0B5

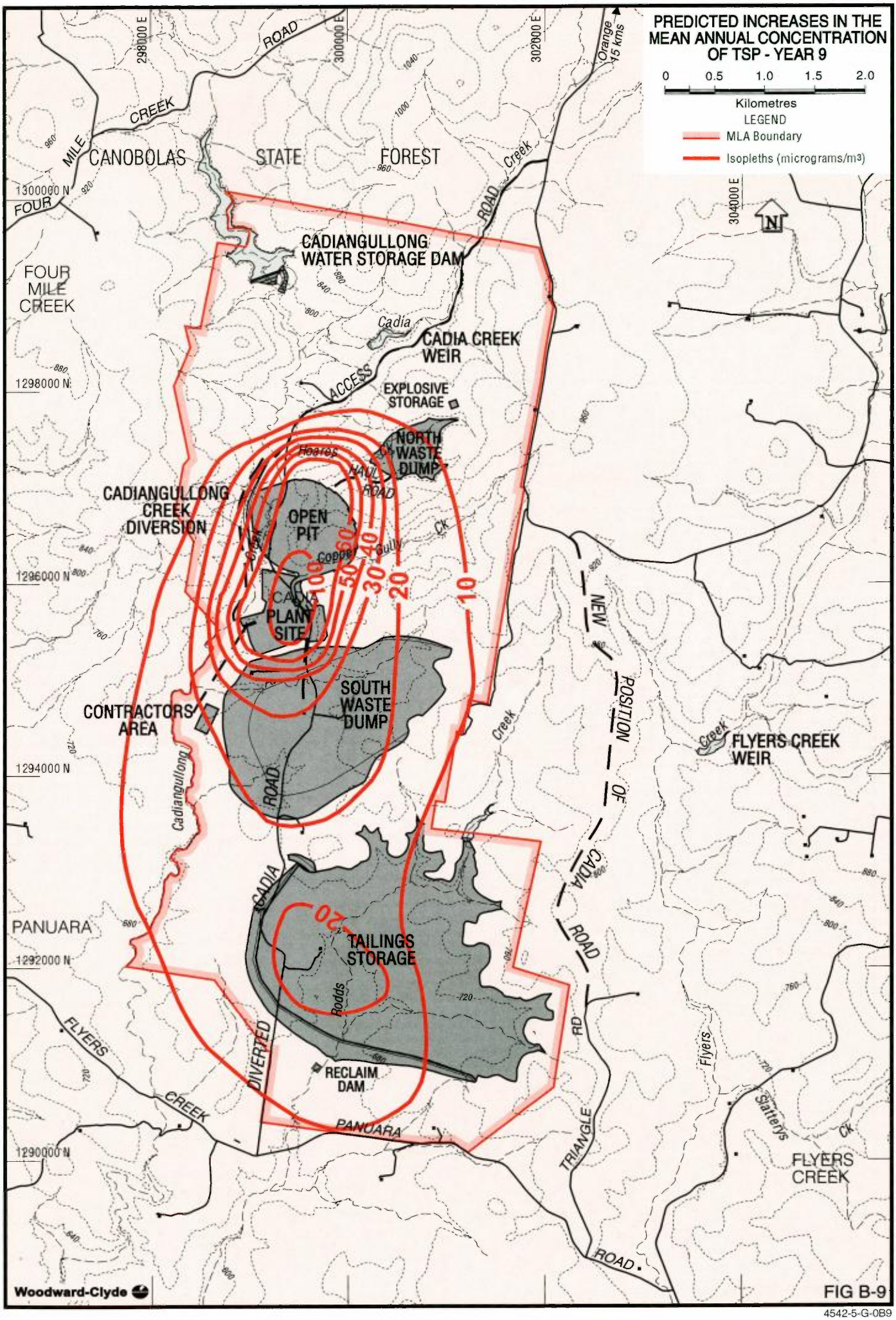

PREDICTED INCREASES IN THE MEAN ANNUAL CONCENTRATION OF TSP - YEAR 1
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (micrograms/m3)
CANOBOLAS STATE FOREST
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
ACCESS
HAUL ROAD
NORTH WASTE DUMP
OPEN PIT
CADIA PLANT SITE
CONTRACTORS AREA
SOUTH WASTE DUMP
TAILINGS STORAGE
RECLAIM DAM
DIVERTED
FLYERS CREEK WEIR
FLYERS CREEK
FOUR MILE CREEK
PANUARA
NEW CADIA ROAD POSITION
100
60
50
40
30
20
10
Woodward-Clyde
FIG B-6

4542-5-G-0B6

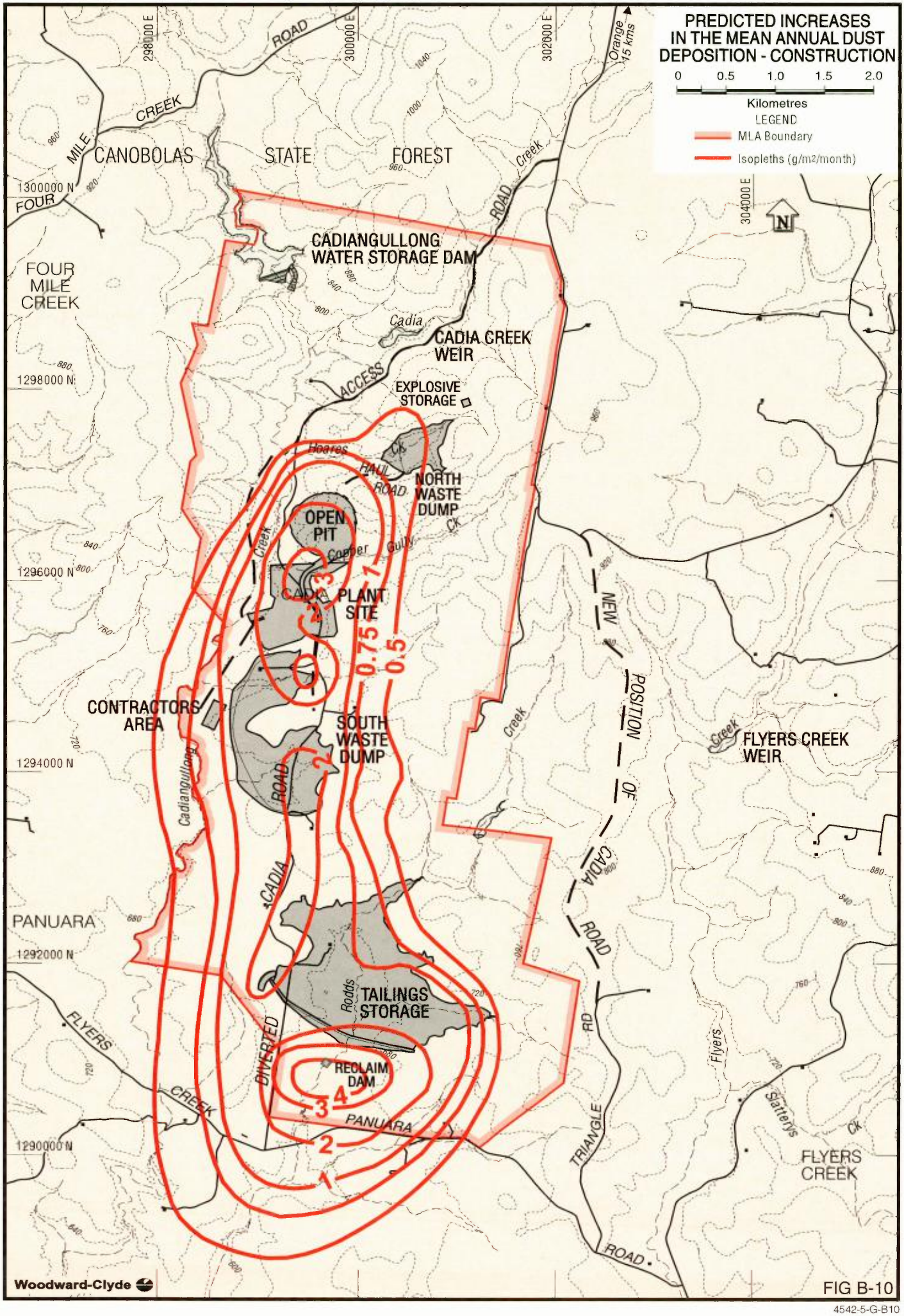

PREDICTED INCREASES IN THE MEAN ANNUAL CONCENTRATION OF TSP - YEAR 4
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (micrograms/m3)
CANOBOLAS STATE FOREST
CADIANGULLONG WATER STORAGE DAM
FOUR MILE CREEK
CADIA CREEK WEIR
EXPLOSIVE STORAGE
NORTH WASTE DUMP
OPEN PIT
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
FLYERS CREEK WEIR
FLYERS CREEK
PANUARA
ACCESS
HAUL ROAD
NEW CADIA ROAD
DIVERTED
TRIANGLE RD
100
60
50
40
30
20
10
Woodward-Clyde
FIG B-7
4542-5-G-0B7


PREDICTED INCREASES IN THE MEAN ANNUAL CONCENTRATION OF TSP - YEAR 6
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (micrograms/m3)
CANOBOLAS STATE FOREST
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
NORTH WASTE DUMP
OPEN PIT
CADIANGULLONG CREEK DIVERSION
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
FLYERS CREEK WEIR
FOUR MILE CREEK
PANUARA
FLYERS CREEK
ACCESS ROAD
HAUL ROAD
CADIA ROAD
NEW POSITION OF CADIA ROAD
DIVERTED
TRIANGLE RD
100
60
50
40
30
20
10
1300000 N
1298000 N
1296000 N
1294000 N
1292000 N
1290000 N
298000 E
300000 E
302000 E
304000 E
Orange 15 kms
N
Woodward-Clyde
FIG B-8

4542-5-G-0B8


PREDICTED INCREASES IN THE MEAN ANNUAL CONCENTRATION OF TSP - YEAR 9
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (micrograms/m3)
CANOBOLAS STATE FOREST
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
NORTH WASTE DUMP
CADIANGULLONG CREEK DIVERSION
OPEN PIT
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
FLYERS CREEK WEIR
FOUR MILE CREEK
PANUARA
FLYERS CREEK
NEW CADIA POSITION
ACCESS ROAD
HAUL ROAD
DIVERTED
TRIANGLE RD
100
50
30
20
10
60
40
20
298000 E
300000 E
302000 E
304000 E
1300000 N
1298000 N
1296000 N
1294000 N
1292000 N
1290000 N
Orange 15 kms
N
Woodward-Clyde
FIG B-9

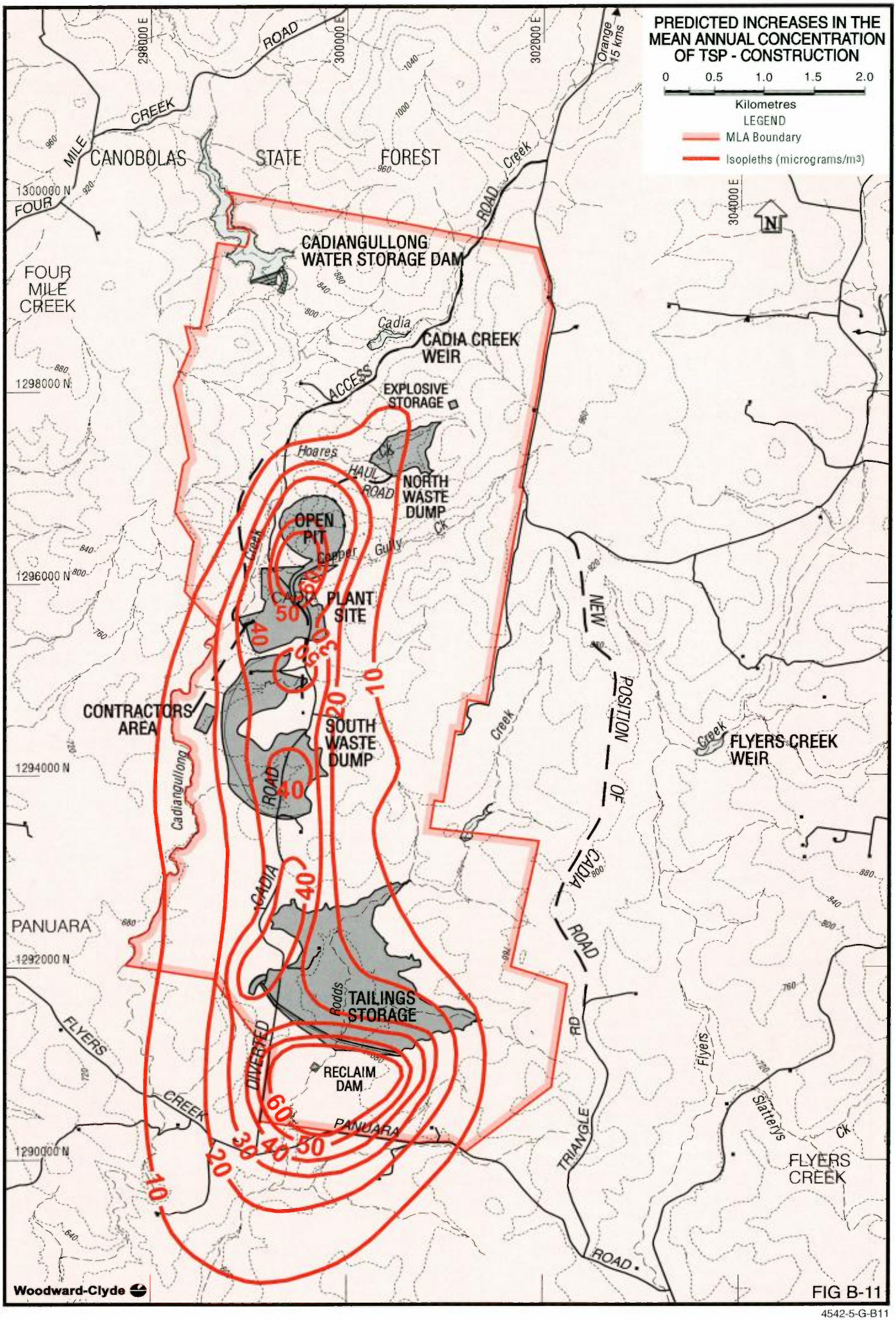
4542-5-G-0B9



Woodward-Clyde

FIG B-10

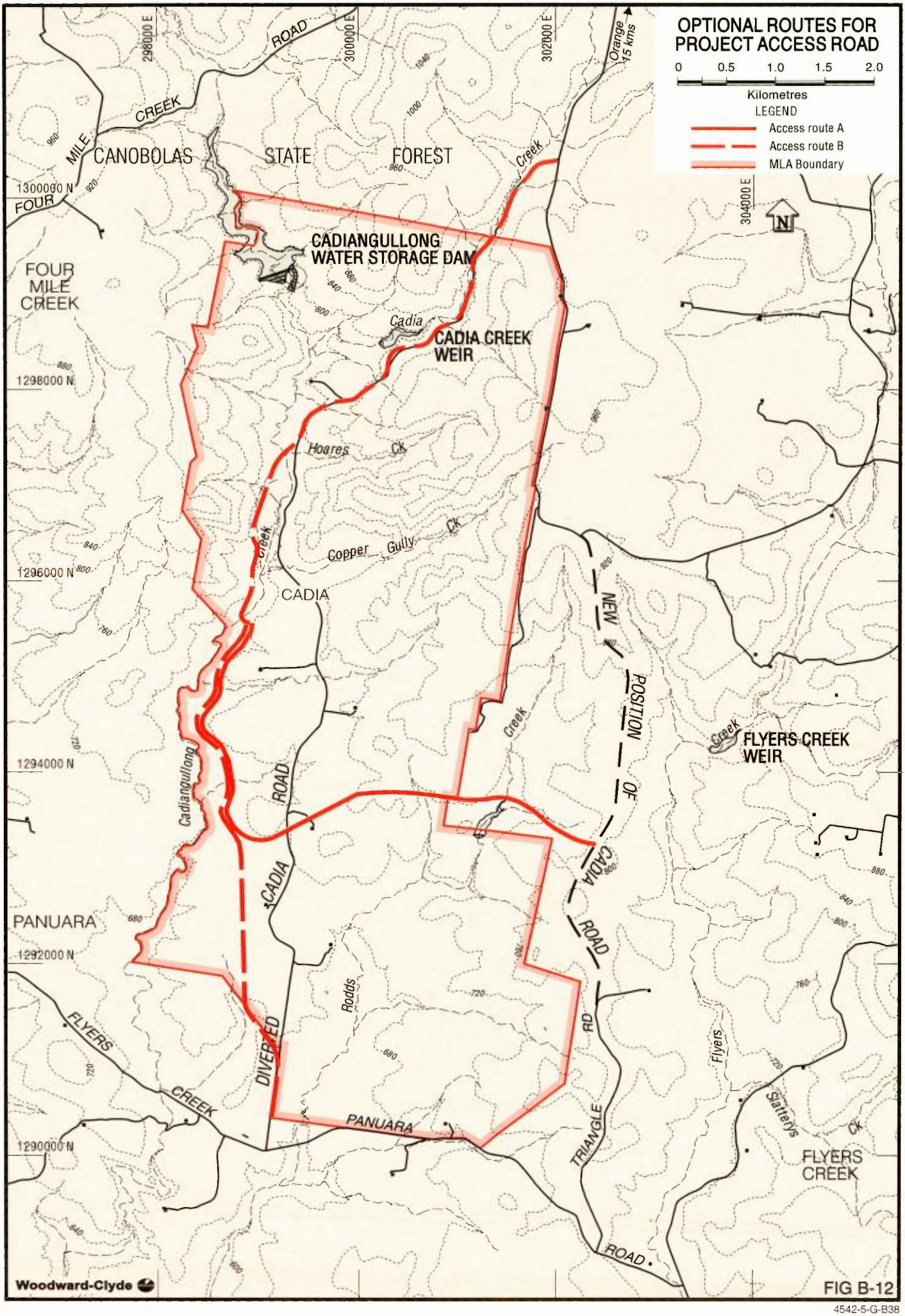
4542-5-G-B10



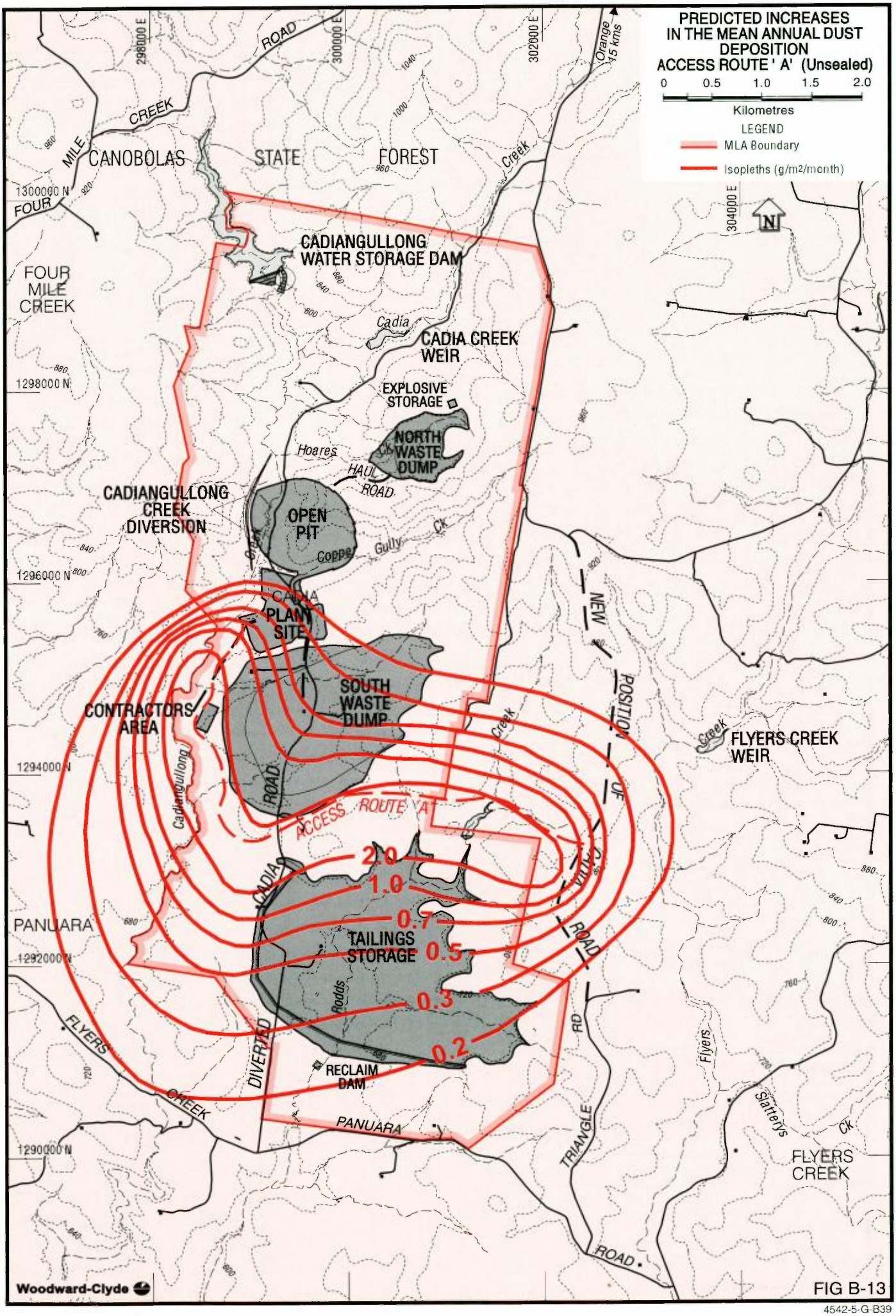
Woodward-Clyde

FIG B-11

4542-5-G-B11


OPTIONAL ROUTES FOR PROJECT ACCESS ROAD
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
Access route A
Access route B
MLA Boundary
CANOBOLAS STATE FOREST
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
FLYERS CREEK WEIR
FOUR MILE CREEK
CADIA
PANUARA
NEW POSITION OF CADIA ROAD
TRIANGLE RD
DIVERTED
Cadiangullong
Copper Gully Ck
Hoares Ck
Rodds
Flyers
Slatterys Ck
FLYERS CREEK
Orange 45 kms
298000 E
300000 E
302000 E
304000 E
1300000 N
1298000 N
1296000 N
1294000 N
1292000 N
1290000 N
Woodward-Clyde
FIG B-12

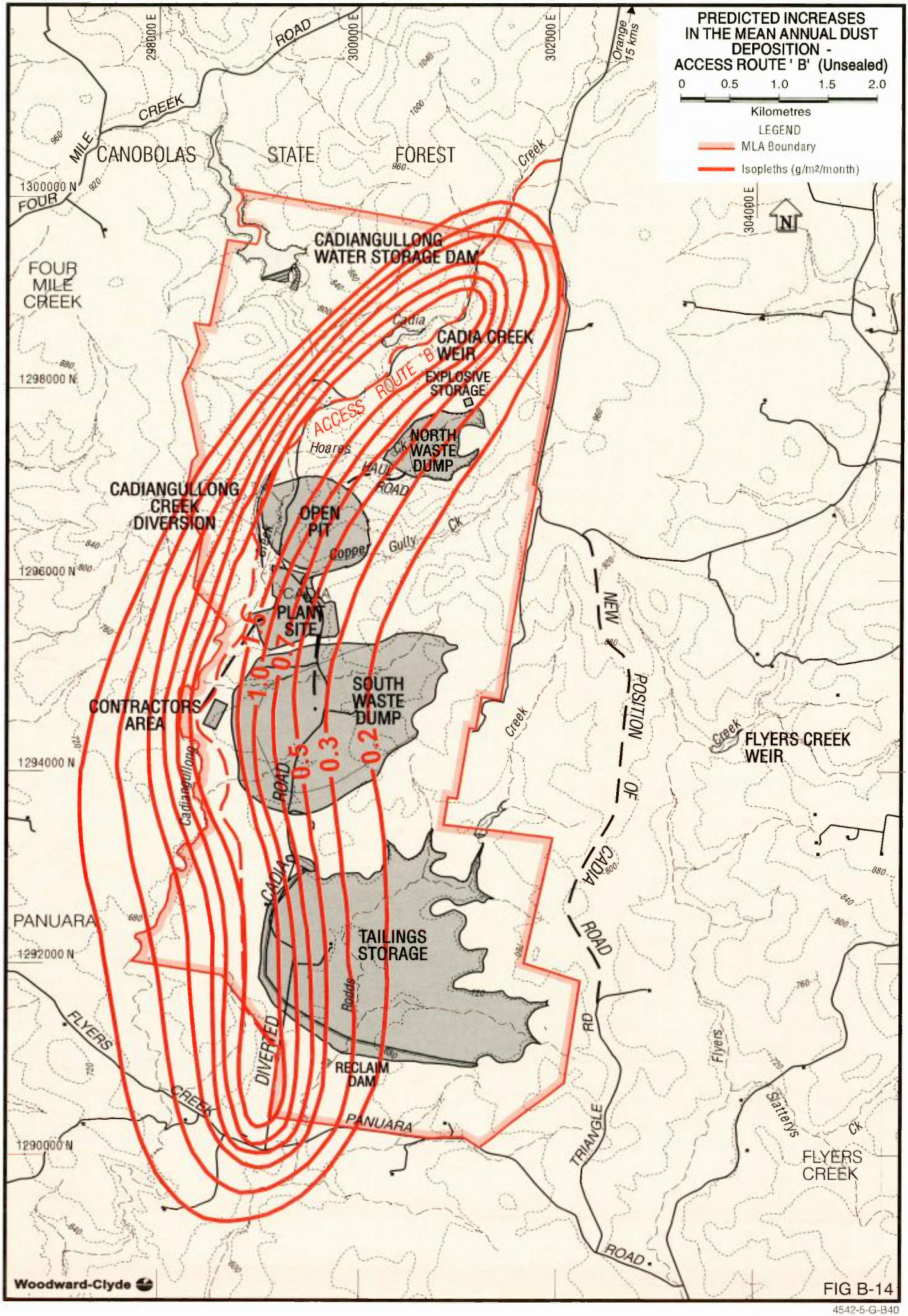
4542-5-G-B38



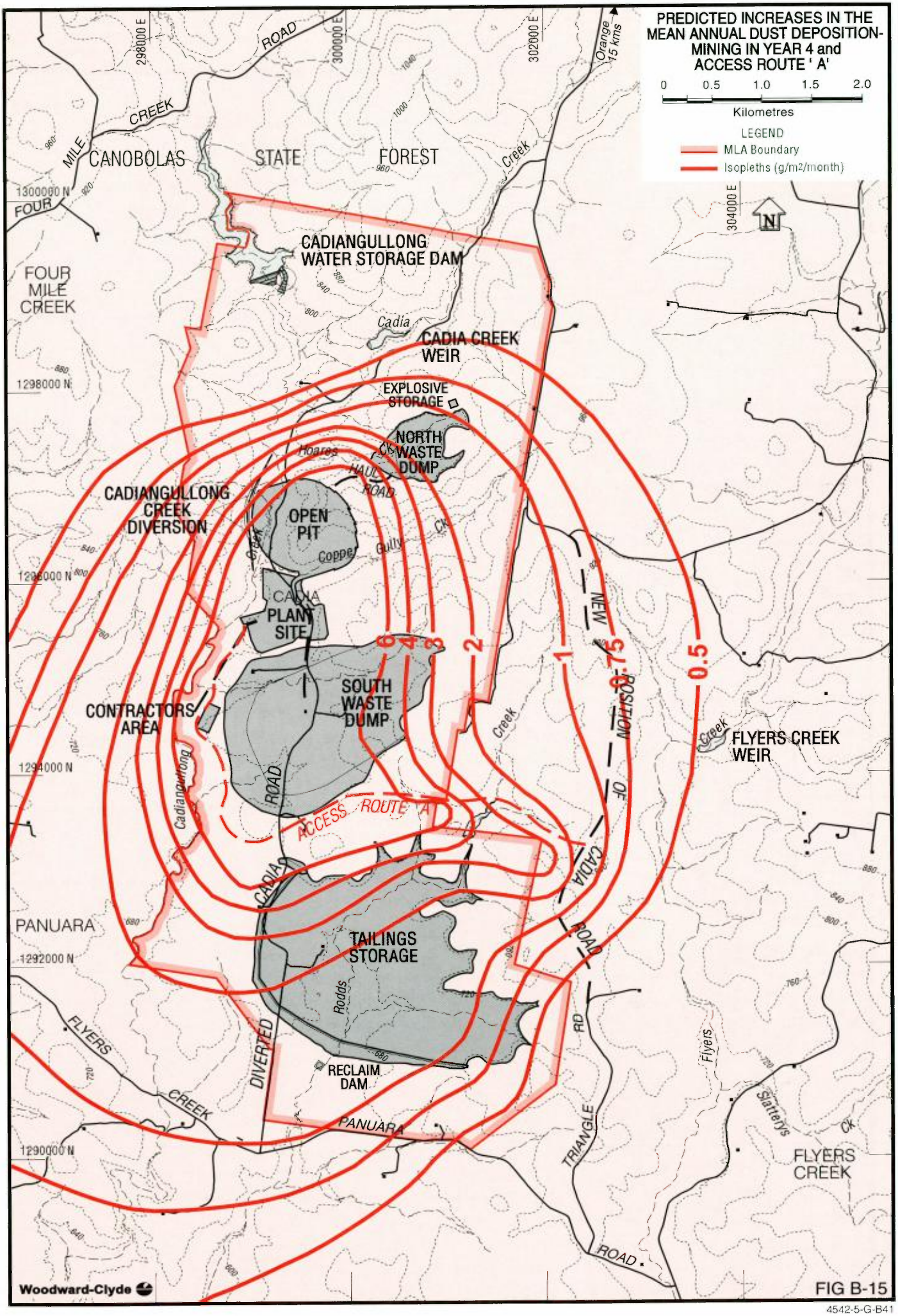
Woodward-Clyde

FIG B-13

4542-5-G-B39


PREDICTED INCREASES IN THE MEAN ANNUAL DUST DEPOSITION - ACCESS ROUTE ' B' (Unsealed)
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (g/m2/month)
CANOBOLAS STATE FOREST
FOUR MILE CREEK
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
ACCESS ROUTE 'B'
NORTH WASTE DUMP
CADIANGULLONG CREEK DIVERSION
OPEN PIT
PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
DIVERTED
FLYERS CREEK WEIR
FLYERS CREEK
PANUARA
NEW CADIA ROAD
POSITION OF
TRIANGLE RD
ROAD
1.0
0.7
0.5
0.3
0.2
1300000 N
1298000 N
1296000 N
1294000 N
1292000 N
1290000 N
298000 E
300000 E
302000 E
304000 E
Woodward-Clyde
FIG B-14

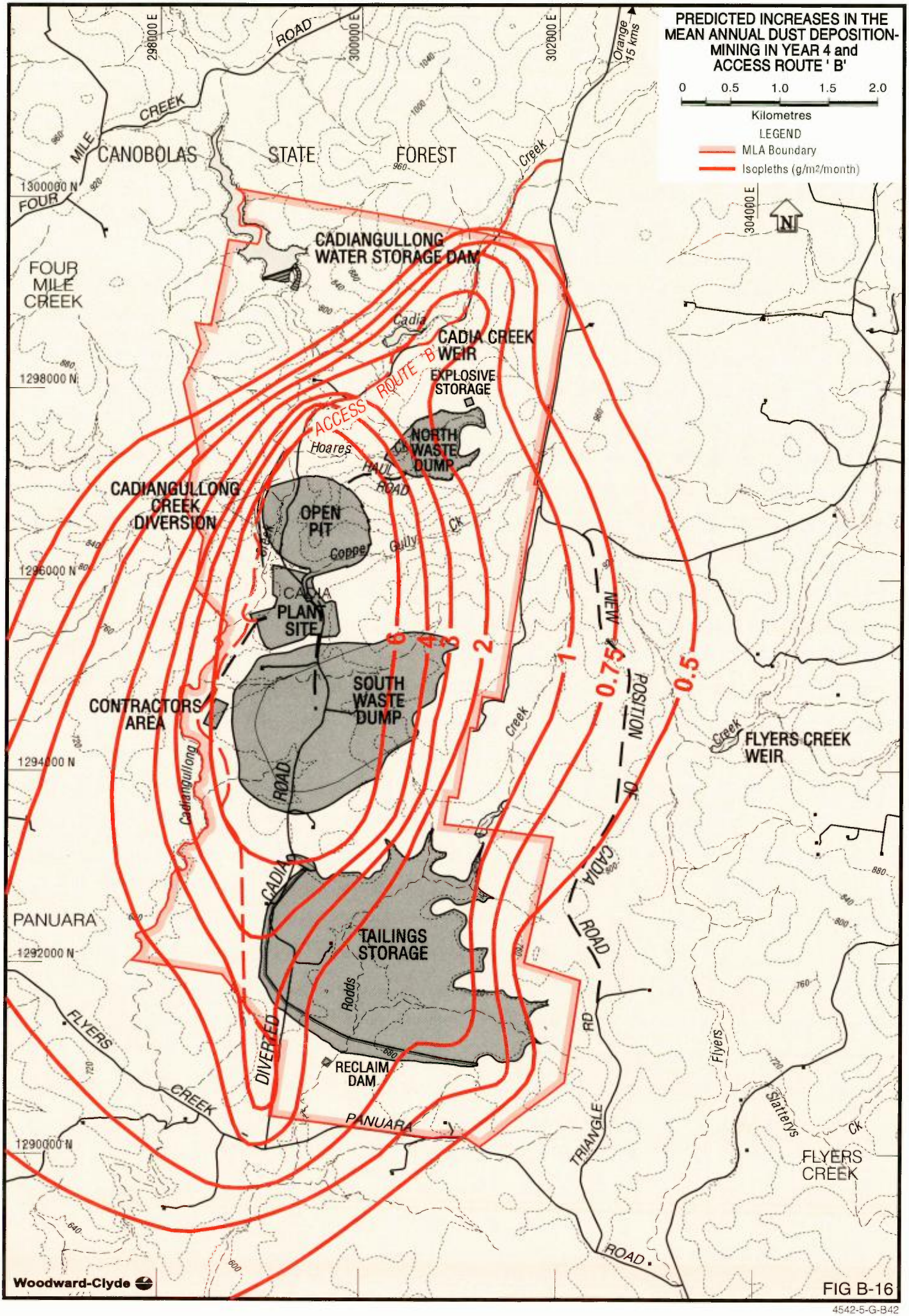
4542-5-G-B40



Woodward-Clyde

FIG B-15

4542-5-G-B41


PREDICTED INCREASES IN THE MEAN ANNUAL DUST DEPOSITION- MINING IN YEAR 4 and ACCESS ROUTE ' B'
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
MLA Boundary
Isopleths (g/m2/month)
298000 E
300000 E
302800 E
304000 E
Orange 15 kms
N
ROAD
CREEK
MILE
CANOBOLAS
STATE
FOREST
Creek
1300000 N
FOUR
FOUR MILE CREEK
CADIANGULLONG WATER STORAGE DAM
Cadia
CADIA CREEK WEIR
EXPLOSIVE STORAGE
ACCESS ROUTE "B"
1298000 N
NORTH WASTE DUMP
Hoares
HAUL ROAD
CADIANGULLONG CREEK DIVERSION
OPEN PIT
Copper
Gully
Ck
1296000 N
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
Cadiangullong
ROAD
1294000 N
8
4
2
1
0.75
0.5
NEW POSITION OF CADIA ROAD
FLYERS CREEK WEIR
PANUARA
1292000 N
TAILINGS STORAGE
Rodds
DIVERTED
RECLAIM DAM
FLYERS CREEK
PANUARA
1290000 N
TRIANGLE RD
Flyers
Slatterys Ck
FLYERS CREEK
ROAD
Woodward-Clyde
FIG B-16

4542-5-G-B42

ATTACHMENT B-1

DUST EMISSION INVENTORIES

TABLE B-1-1
DUST EMISSION INVENTORY FOR YEAR 1 OF THE CADIA PROJECT

	Extent of operation	Annual emission	Comments
Pit operations			
Topsoil removal, clearing	440 hrs/yr	6.2 t/yr	Assume 5% of the time
Dozer	8,320 hrs/yr	27.4 t/yr	Assume 95% of the time
Ore and waste drilling	21,560 holes/yr	12.9 t/yr	Bench height = 15 m, pattern 7.8 m × 7.8 m
Ore and waste blasting	392 blasts/yr	16.6 t/yr	42.3 kg/blast Area of blast = 3333m²
Ore and waste loading (shovel)	51.0 Mtpa	1,275.0 t/yr	
Waste haulage (in pit)	158,630 VKT/yr	317.2 t/yr	Average distance = 500 m (in pit) Load = 220 t/truck
Ore haulage	73,180 VKT/yr	146.4 t/yr	Average distance = 500 m (in pit) Load = 220 t/truck
Ore dumping	16.1 Mtpa	161.0 t/yr	
Primary crushing and screening	16.1 Mtpa	32.2 t/yr	
Active storage pile	16.1 Mtpa	10.8 t/yr	Assume 24 hrs/day, area = 1.0 ha incl. equipment traffic, wind erosion
Loading to trucks	16.1 Mtpa	402.5 t/yr	
Subtotal		2,408.2 t/yr	
Processing plant			
Ore haulage (from primary crusher)	95,135 VKT/yr	190.3 t/yr	Distance = 650 m Load = 220 t/truck
Active stockpile	16.1 Mtpa	10.8 t/yr	Details as at primary crusher
Secondary grinding and milling	16.1 Mtpa	32.2 t/yr	Assume controls and emission equal to primary crusher
Subtotal		233.3 t/yr	
Waste disposal - Northern dump			
Waste haulage (to disposal area)	59,090 VKT/yr	118.2 t/yr	Average distance = 650 m (out of pit) Load = 220 t/truck
Waste haulage (in disposal area)	40,910 VKT/yr	81.8 t/yr	Average distance = 450 m Load = 220 t/truck
Waste dumping	10.0 Mtpa	120.0 t/yr	
Waste spreading, shaping (dozer)	8,760 hrs/yr	63.9 t/yr	1 dozer - 100%
Subtotal		383.9 t/yr	

TABLE B-1-1 (CONTINUED)
DUST EMISSION INVENTORY FOR YEAR 1 OF THE CADIA PROJECT

	Extent of operation	Annual emission	Comments
Waste disposal - Main dump			
Waste haulage (to disposal area)	452,720 VKT/yr	905.4 t/yr	Average distance = 2000 m (out of pit) Load = 220 t/truck
Waste dumping	24.9 Mtpa	298.8 t/yr	
Waste spreading, shaping (dozer)	8,760 hrs/yr	63.9 t/yr	1 dozer - 100%
Subtotal		1,268.1 t/yr	
Remaining sources			
Unsealed roads	24,825 VKT/yr	99.3 t/yr	Assume 3 traffic movements per day to each Cadia Creek, Flyers Creek and Cadiangullong, 6 movements to tailing dam
Grading of roads	19,200 km/yr	11.8 t/yr	
Subtotal		111.1 t/yr	
Wind erosion			
Pit area (total)	48.5 ha	169.9 t/yr	
Waste dump	45.1 ha	158.0 t/yr	Northern
	147.0 ha	515.1 t/yr	Main
Tailings dam (prestrip), wall	95.2 ha	333.6 t/yr	
Processing plant	16.0 ha	56.1 t/yr	
Contractor site	6.0 ha	21.0 t/yr	
Subtotal		1,253.7 t/yr	
TOTAL		5,658.3 t/yr	

TABLE B-1-2
DUST EMISSION INVENTORY FOR YEAR 4 OF THE CADIA PROJECT

	Extent of operation	Annual emission	Comments
Pit operations			
Topsoil removal, clearing	880 hrs/yr	12.4 t/yr	Assume 10% of the time
Dozer	2 × 8320 hrs/yr	54.8 t/yr	2 dozers
Ore and waste drilling	28,600 holes/yr	17.2 t/yr	Bench height = 15 m, pattern 7.8 m × 7.8 m
Ore and waste blasting	362 blasts/yr	26.3 t/yr	72.8 kg/blast Area of blast = 4790m²
Ore and waste loading (shovel)	67.6 Mtpa	1,690.0 t/yr	
Waste haulage (in pit)	260,455 VKT/yr	520.9 t/yr	Average distance = 500 m (in pit) Load = 220 t/truck
Ore haulage (from pit)	46,280 VKT/yr	93.6 t/yr	Average distance = 500 m (in pit) Load = 220 t/truck
Ore loading (from stockpile)	6.0 Mtpa	150.0 t/yr	Reclaimed from stockpile on south dump
Ore haulage (from stockpile)	54,540 VKT/yr	109.1 t/yr	Average distance = 1000 m (in pit) Load = 220 t/truck
Ore dumping	16.3 Mtpa	163.0 t/yr	
Primary crushing and screening	16.3 Mtpa	32.6 t/yr	
Active storage pile	16.3 Mtpa	10.8 t/yr	Assume 24 hrs/day, area = 1.0 ha incl. equipment traffic, wind erosion
Loading to trucks	16.3 Mtpa	407.5 t/yr	
Subtotal		3,288.2 t/yr	
Processing plant			
Ore haulage (from primary crusher)	96,315 VKT/yr	192.6 t/yr	Distance = 650 m Load = 220 t/truck
Active stockpile	16.3 Mtpa	10.8 t/yr	Details as at primary crusher
Secondary grinding and milling	16.3 Mtpa	32.6 t/yr	Assume controls and emission equal to primary crusher
Subtotal		236.0 t/yr	

TABLE B-1-2 (Continued)
DUST EMISSION INVENTORY FOR YEAR 4 OF THE CADIA PROJECT

	Extent of operation	Annual emission	Comments
Waste disposal			
Waste haulage (to disposal area)	651,135 VKT/yr	1,302.3 t/yr	Average distance = 1250 m (out of pit) Load = 220 t/truck
Waste haulage (in disposal area)	208,365 VKT/yr	416.7 t/yr	Average distance = 400 m Load = 220 t/truck
Waste dumping	57.3 Mtpa	687.6 t/yr	
Waste spreading, shaping (dozer)	2 × 8760 hrs/yr	127.8 t/yr	2 Dozers
Subtotal		2,534.4 t/yr	
Remaining sources			
Unsealed roads	24,825 VKT/yr	99.3 t/yr	Assume 3 traffic movements per day to each Cadia Creek, Flyers Creek and Cadiangullong, 6 movements to tailing dam
Grading of roads	2 × 19,200 km/yr	23.6 t/yr	
Subtotal		122.9 t/yr	
Wind erosion			
Pit area (prestrip)	10.0 ha	35.0 t/yr	
Waste dump	232.0 ha	812.9 t/yr	12% rehabilitated
Tailings dam (prestrip), wall	101.4 ha	355.4 t/yr	
Processing plant	16.0 ha	56.1 t/yr	
Contractor site	6.0 ha	21.0 t/yr	
Subtotal		1,280.4 t/yr	
TOTAL		7,461.9 t/yr	

TABLE B-1-3
DUST EMISSION INVENTORY FOR YEAR 6 OF THE CADIA PROJECT

	Extent of operation	Annual emission	Comments
Pit Operations			
Dozer	2 × 8320 hrs/yr	54.8 t/yr	2 dozers
Ore and waste drilling	28,600 holes/yr	17.2 t/yr	Bench height = 15 m, pattern 7.8 m × 7.8 m
Ore and waste blasting	362 blasts/yr	26.3 t/yr	72.8 kg/blast Area of blast = 4790m²
Ore and waste loading (shovel)	67.6 Mtpa	1,690.0 t/yr	
Waste haulage (in pit)	230,000 VKT/yr	460.0 t/yr	Average distance = 500 m (in pit) Load = 220 t/truck
Ore haulage	77,270 VKT/yr	154.5 t/yr	Average distance = 500 m (in pit) Load = 220 t/truck
Ore dumping	17 Mtpa	170.0 t/yr	
Primary crushing and screening	17 Mtpa	34.0 t/yr	
Active storage pile	17 Mtpa	10.8 t/yr	Assume 24 hrs/day, area = 1.0 ha incl. equipment traffic, wind erosion
Loading to trucks	17 Mtpa	425.0 t/yr	
Subtotal		3,042.6 t/yr	
Processing plant			
Ore haulage (from primary crusher)	110,450 VKT/yr	200.9 t/yr	Distance = 650 m Load = 220 t/truck
Active stockpile	17 Mtpa	10.8 t/yr	Details as at primary crusher
Secondary grinding and milling	17 Mtpa	34.0 t/yr	Assume controls and emission equal to primary crusher
Subtotal		245.7 t/yr	

TABLE B-1-3 (Continued)
DUST EMISSION INVENTORY FOR YEAR 6 OF THE CADIA PROJECT

	Extent of operation	Annual emission	Comments
Waste disposal			
Waste haulage (to disposal area)	575,000 VKT/yr	1,150.0 t/yr	Average distance = 1,250 m (out of pit) Load = 220 t/truck
Waste haulage (in disposal area)	276,000 VKT/yr	552.0 t/yr	Average distance = 600 m Load = 220 t/truck
Waste dumping	50.6 Mtpa	607.2 t/yr	
Waste spreading, shaping (dozer)	2 × 8,760 hrs/yr	127.8 t/yr	
Subtotal		2,437.0 t/yr	
Remaining sources			
Unsealed roads	24,825 VKT/yr	99.3 t/yr	Assume 3 traffic movements per day to each Cadia Creek, Flyers Creek and Cadiangullong, 6 movements to tailing dam
Grading of roads	2 × 19,200 km/yr	23.6 t/yr	
Subtotal		122.9 t/yr	
Wind erosion			
Waste dum	226.5 ha	793.7 t/yr	25% rehabilitated
Tailings dam (prestrip), wall	88.3 ha	309.4 t/yr	50% of wall rehabilitated
Processing plant	16.0 ha	56.1 t/yr	
Contractor site	6.0 ha	21.0 t/yr	
Subtotal		1,180.2 t/yr	
TOTAL		7,028.4 t/yr	

TABLE B-1-4
DUST EMISSION INVENTORY FOR YEAR 9 OF THE CADIA PROJECT

	Extent of operation	Annual emission	Comments
Pit operations			
Dozer	8,760 hrs/yr	28.8 t/yr	
Ore and waste drilling	8,690 holes/yr	5.2 t/yr	Bench height = 15 m, pattern 7.8 m × 7.8 m
Ore and waste blasting	110 blasts/yr	8.0 t/yr	72.8 kg/blast Area of blast = 4790m²
Ore and waste loading (shovel)	20.6 Mtpa	515.0 t/yr	
Waste haulage (in pit)	32,730 VKT/yr	65.5 t/yr	Average distance = 1,000m (in pit) Load = 220 t/truck
Ore haulage	154,540 VKT/yr	309.1 t/yr	Average distance = 1,000m (in pit) Load = 220 t/truck
Ore dumping	17 Mtpa	170.0 t/yr	
Primary crushing and screening	17 Mtpa	34.0 t/yr	
Active storage pile	17 Mtpa	10.8 t/yr	Assume 24 hrs/day, area = 1.0 ha incl. equipment traffic, wind erosion
Loading to trucks	17 Mtpa	425.0 t/yr	
Subtotal		1,571.4 t/yr	
Processing plant			
Ore haulage (from primary crusher)	100,450 VKT/yr	200.9 t/yr	Distance = 650 m Load = 220 t/truck
Active stockpile	17 Mtpa	10.8 t/yr	Details as at primary crusher
Secondary grinding and milling	17 Mtpa	34.0 t/yr	Assume controls and emission equal to primary crusher
Subtotal		245.7 t/yr	
Waste disposal			
Waste haulage (to disposal area)	40,910 VKT/yr	81.8 t/yr	Average distance = 1,250 m (out of pit) Load = 220 t/truck
Waste haulage (in disposal area)	26,185 VKT/yr	52.4 t/yr	Average distance = 800 m Load = 220 t/truck
Waste dumping	3.6 Mtpa	43.2 t/yr	
Waste spreading, shaping (dozer)	2 × 8,760 hrs/yr	127.8 t/yr	
Subtotal		305.2 t/yr	

TABLE B-1-4 (Continued)
DUST EMISSION INVENTORY FOR YEAR 9 OF THE CADIA PROJECT

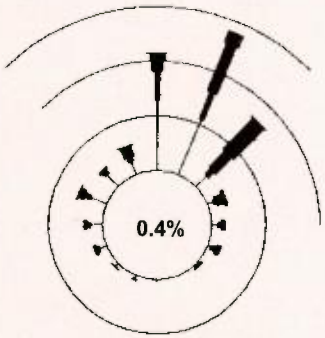
	Extent of operation	Annual emission	Comments
Remaining sources			
Unsealed roads	24,825 VKT/yr	99.3 t/yr	Assume 3 traffic movements per day to each Cadia Creek, Flyers Creek and Cadiangullong, 6 movements to tailing dam
Grading of roads	2 × 19,200 km/yr	23.6 t/yr	
Subtotal		122.9 t/yr	
Wind erosion			
Waste dump	150.0 ha	525.6 t/yr	50% rehabilitated
Tailings dam (prestrip), wall	83.3 ha	291.9 t/yr	75% of dam rehabilitated
Processing plant	16.0 ha	56.1 t/yr	
Contractor site	6.0 ha	21.0 t/yr	
Subtotal		894.6 t/yr	
TOTAL		3,139.8 t/yr	

TABLE B-1-5
DUST EMISSION INVENTORY FOR YEAR 0 (CONSTRUCTION - PHASE 1) OF THE CADIA PROJECT

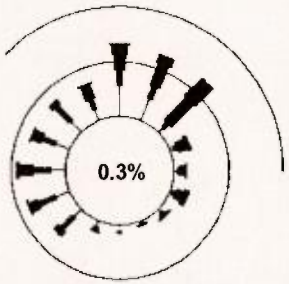
	Extent of operation	Total emission	Comments
Pit area			
Topsoil removal, stockpiling (scraper)	2 × 320 hrs	9.0 t	2 scrapers for 8 hrs a day
Dozer (ripping, pushing)	2 × 320 hrs	2.2 t	2 dozers for 8 hrs a day
Waste loading (excavator)	4.0 Mt	100.0 t	
Subtotal		111.2 t	
Cadia Creek Road			
Waste haulage	200,040 VKT	400.1 t	Average distance = 5,000 m to tailings dam, 1,000 m on wall
Light vehicles	60,000 VKT	90.0 t	Assume 30 light vehicles per day
Subtotal		490.1 t	
Tailings dam area			
Waste dumping	4.0 Mt	48.0 t	
Shaping, pushing			
(scraper)	2 × 320 hrs	9.0 t	2 scrapers for 8 hrs a day
(dozer)	2 × 320 hrs	4.6 t	2 dozers for 8 hrs a day
Subtotal		61.6 t	
Wind erosion			
Pit area	38.5 ha	90.1 t	
Waste dump	12.8 ha	30.0 t	Northern
	33.0 ha	77.2 t	Main
Tailings dam (prestrip), wall	201.9 ha	472.4 t	
Processing plant	16.0 ha	37.4 t	
Contractor site	6.0 ha	14.0 t	
Subtotal		721.1 t	
TOTAL		1384.0 t	

ATTACHMENT B-2

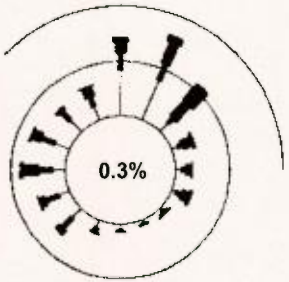
WIND ROSE DIAGRAMS



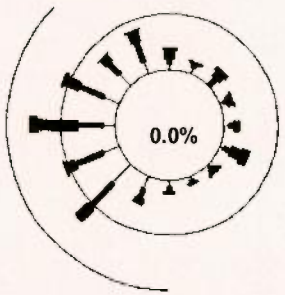
Frequencies for hours 000 - 600



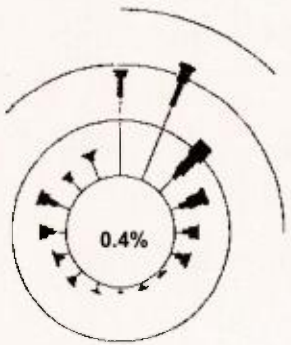
Frequencies for hours 600 - 1200



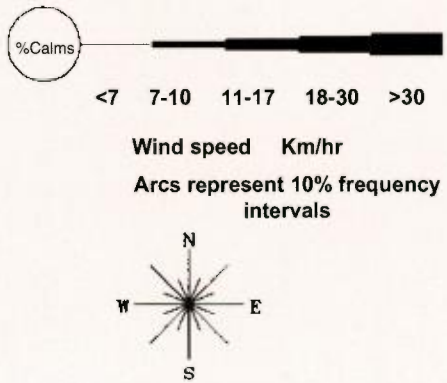
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



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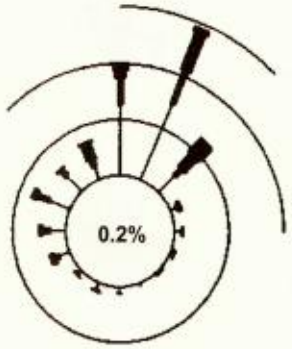
WINDROSES
CADIA ANNUAL 94-95

FIG B-17

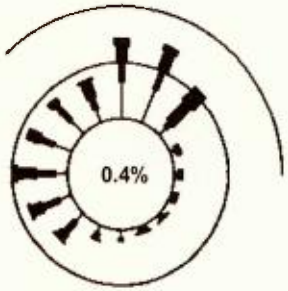
CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT

4542-5-G-B12

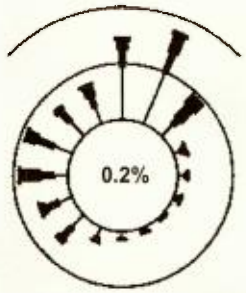
Woodward-Clyde



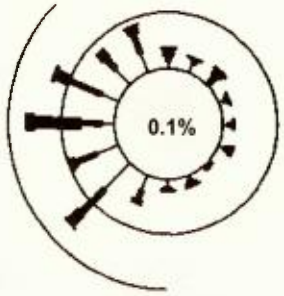
Frequencies for hours 000 - 600



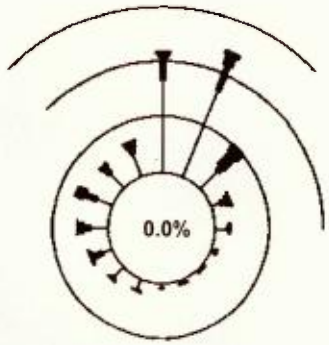
Frequencies for hours 600 - 1200



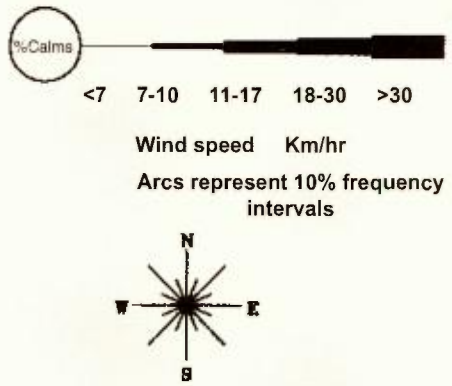
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400

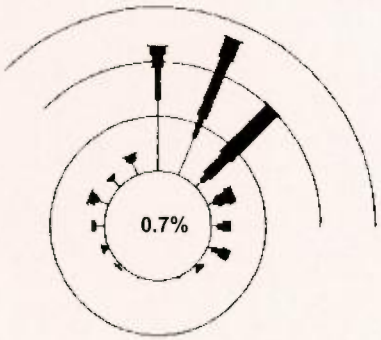


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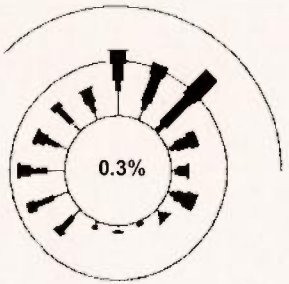
WINDROSES
CADIA WINTER 94

FIG B-18

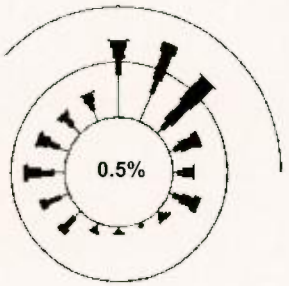
Woodward-Clyde



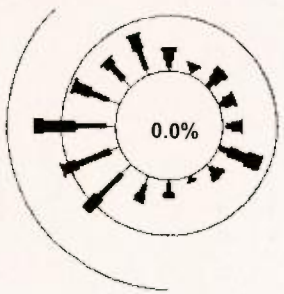
Frequencies for hours 000 - 600



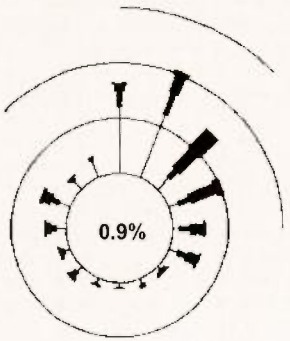
Frequencies for hours 600 - 1200



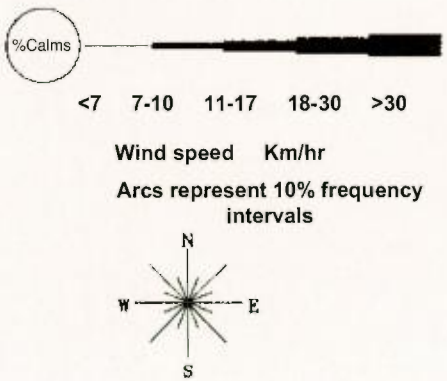
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



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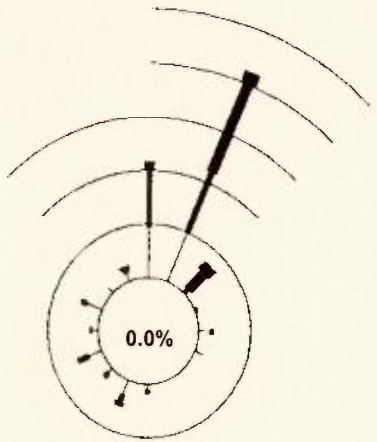
WINDROSES
CADIA SUMMER 94-95

FIG B-19

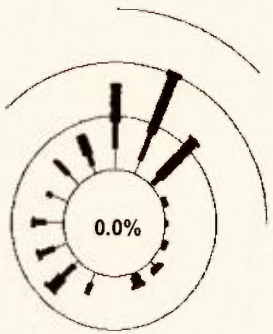
CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT

4542-5-G-B14

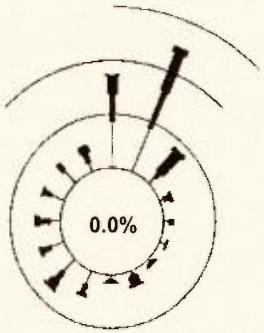
Woodward-Clyde



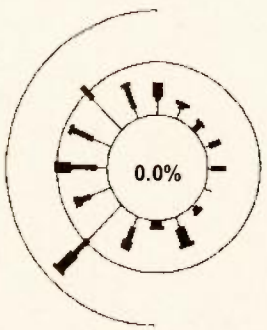
Frequencies for hours 000 - 600



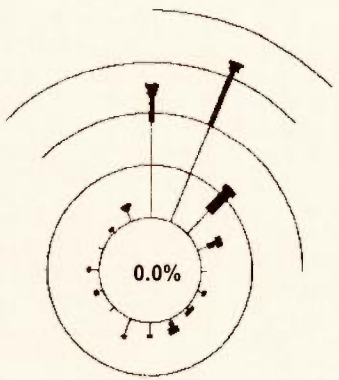
Frequencies for hours 600 - 1200



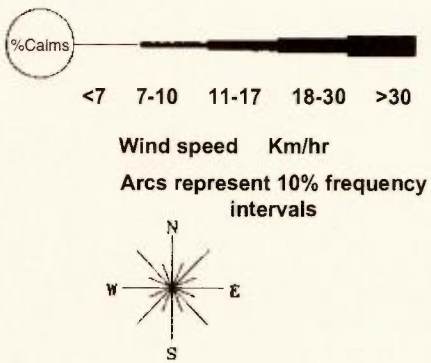
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



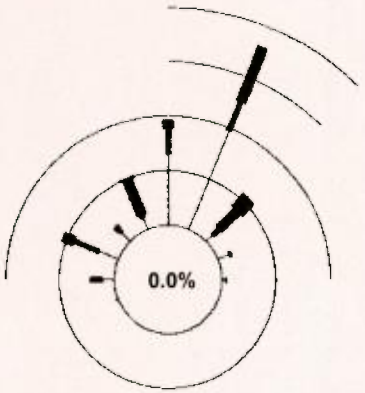
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WINDROSES
CADIA APRIL 94

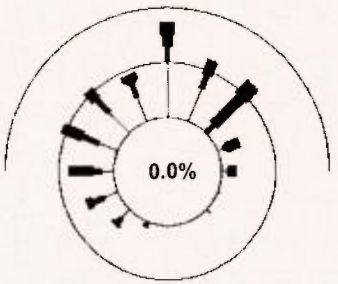
FIG B-20

4542-5-G-B15

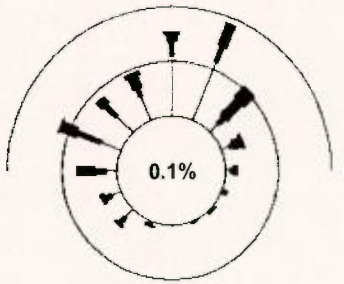
Woodward-Clyde



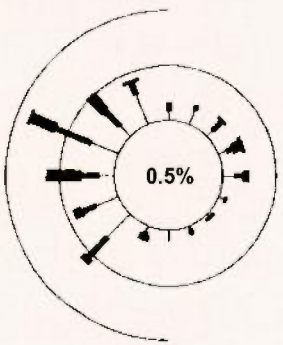
Frequencies for hours 000 - 600



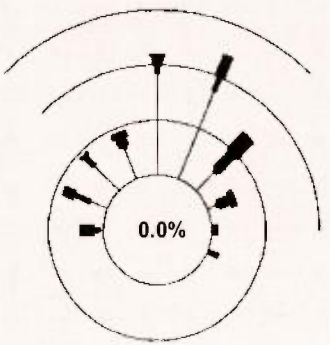
Frequencies for hours 600 - 1200



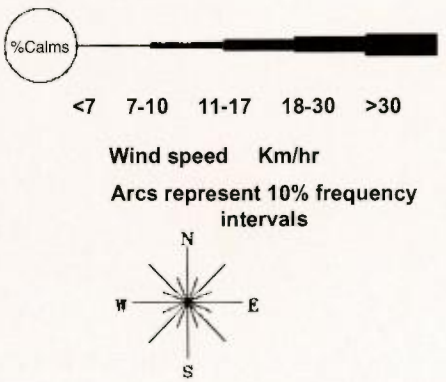
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



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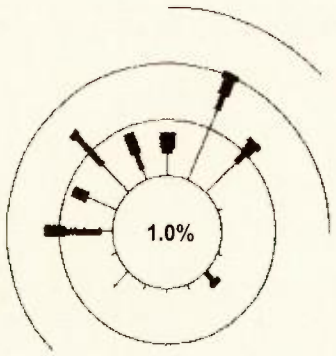
WINDROSES
CADIA MAY 94

FIG B-21

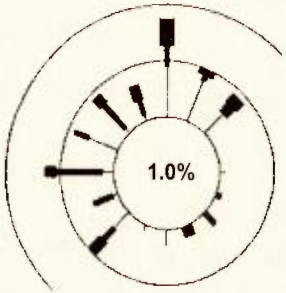
Woodward-Clyde

4542-5-G-B16

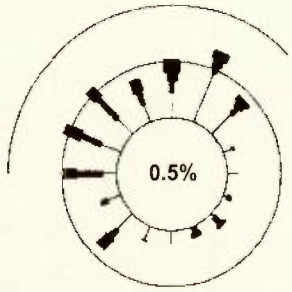
CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



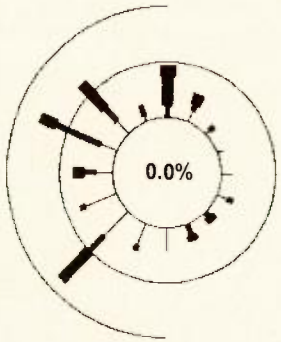
Frequencies for hours 000 - 600



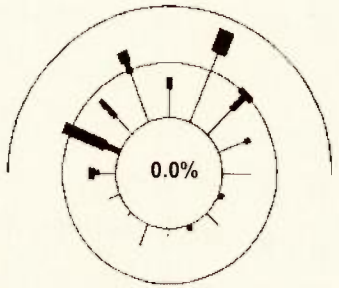
Frequencies for hours 600 - 1200



Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



<7 7-10 11-17 18-30 >30

Wind speed Km/hr

Arcs represent 10% frequency intervals



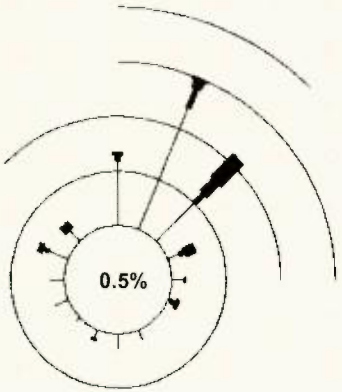
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WINDROSES
CADIA JUNE 94

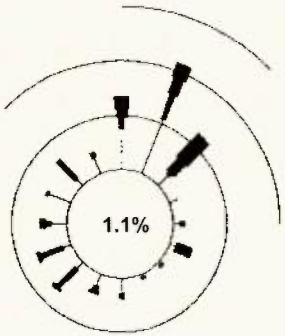
FIG B-22

4542-5-G-B17

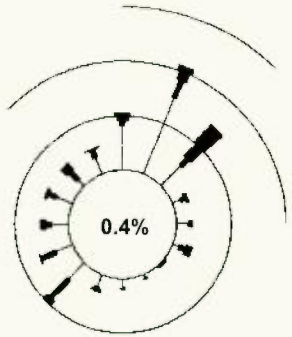
Woodward-Clyde



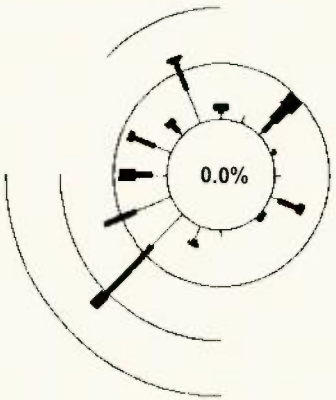
Frequencies for hours 000 - 600



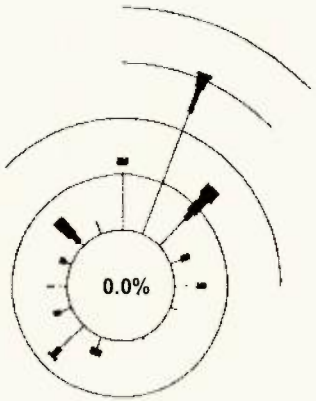
Frequencies for hours 600 - 1200



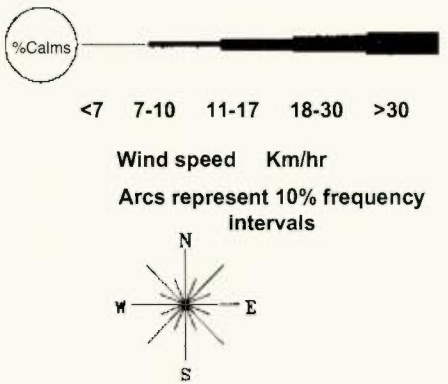
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



P. ZIB & ASSOCIATES PTY LTD

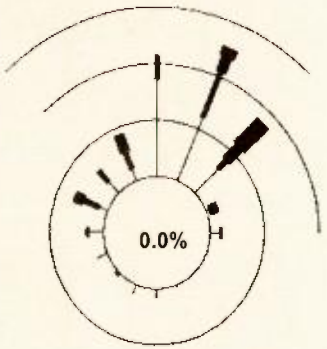
WINDROSES
CADIA JULY 94

FIG B-23

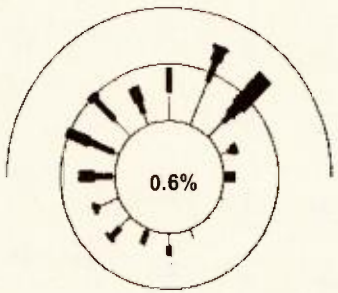
CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT

4542-5-G-B18

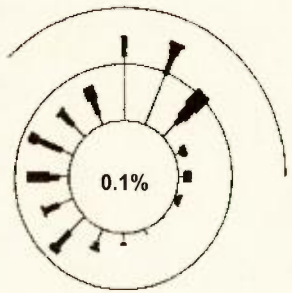
Woodward-Clyde



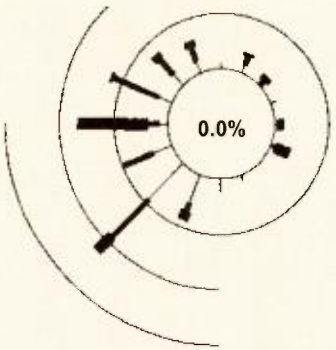
Frequencies for hours 000 - 600



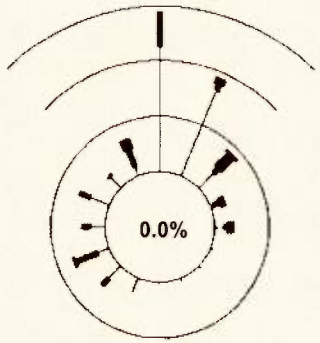
Frequencies for hours 600 - 1200



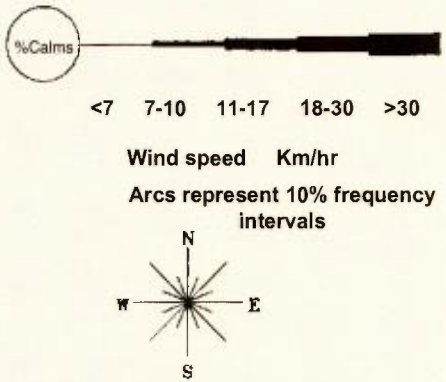
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



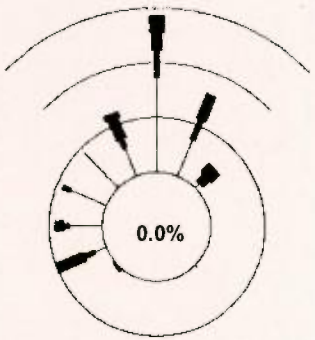
P. ZIB & ASSOCIATES PTY LTD

WINDROSES
CADIA AUG 94

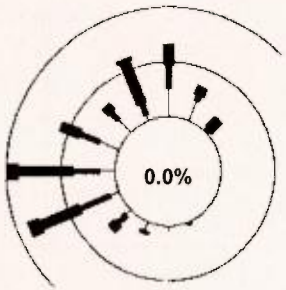
FIG B-24

Woodward-Clyde

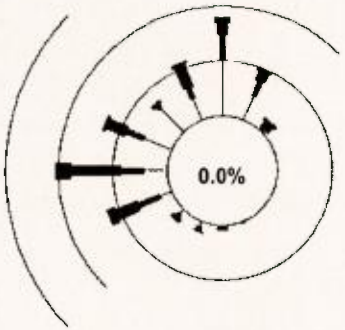
4542-5-G-B19



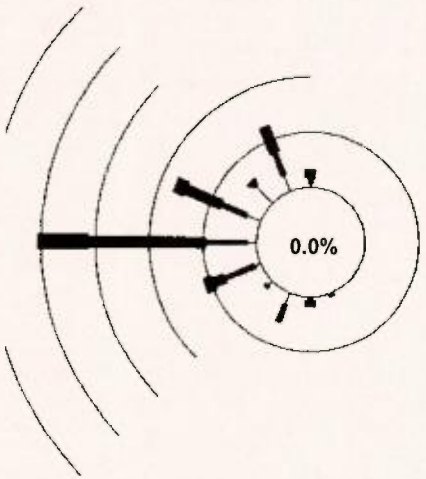
Frequencies for hours 000 - 600



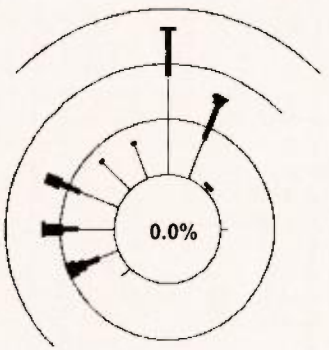
Frequencies for hours 600 - 1200



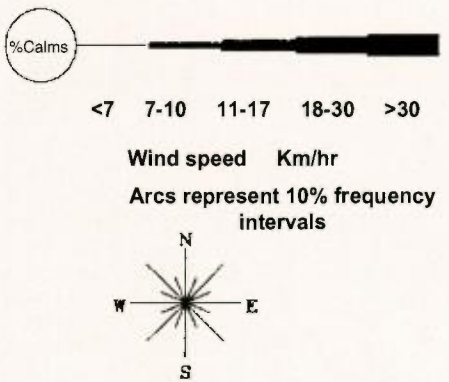
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



P. ZIB & ASSOCIATES PTY LTD

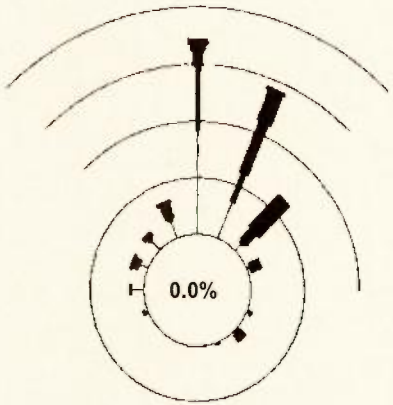
WINDROSES
CADIA SEPT 94

FIG B-25

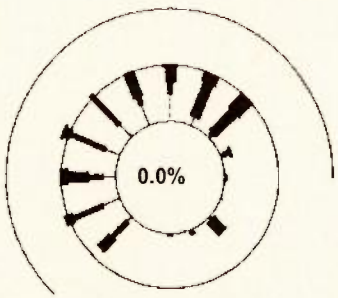
Woodward-Clyde

4542-5-G-B20

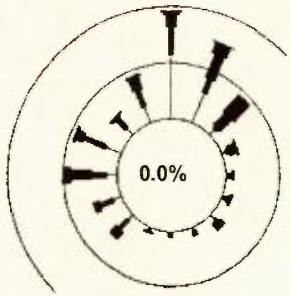
CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



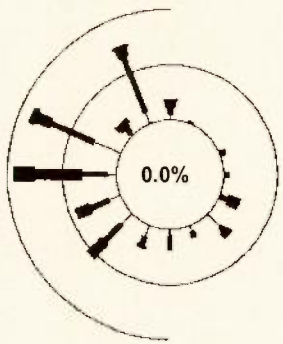
Frequencies for hours 000 - 600



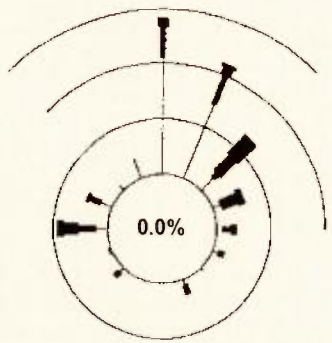
Frequencies for hours 600 - 1200



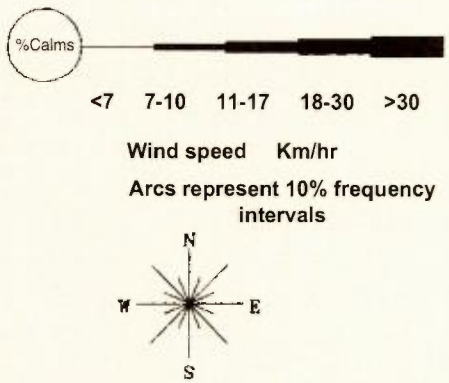
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



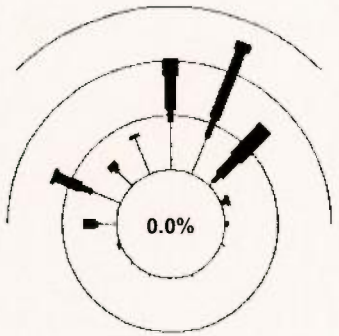
P. ZIB & ASSOCIATES PTY LTD

WINDROSES
CADIA OCT 94

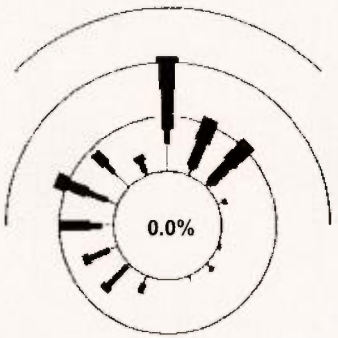
FIG B-26

Woodward-Clyde

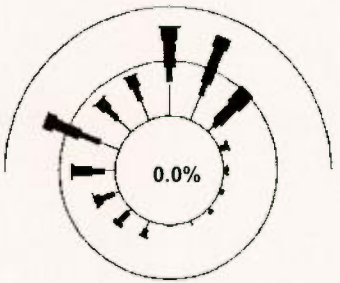
4542-5-G-B21



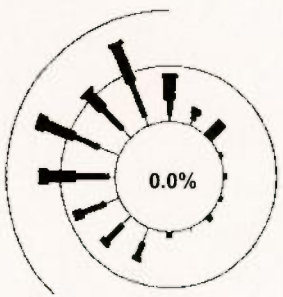
Frequencies for hours 000 - 600



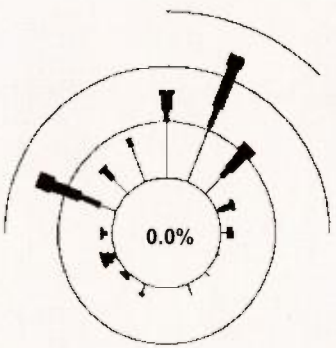
Frequencies for hours 600 - 1200



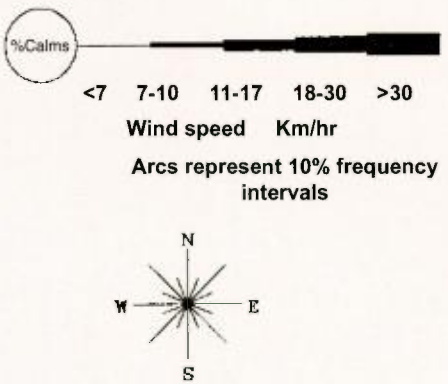
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



P. ZIB & ASSOCIATES PTY LTD

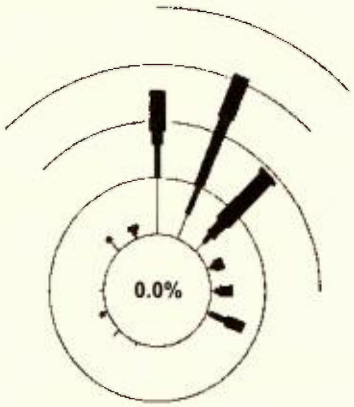
WINDROSES
CADIA NOV 94

FIG B-27

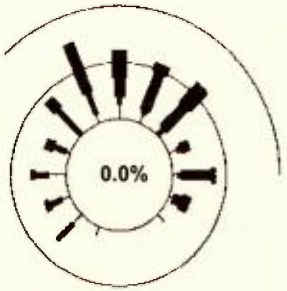
CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT

4542-5-G-B22

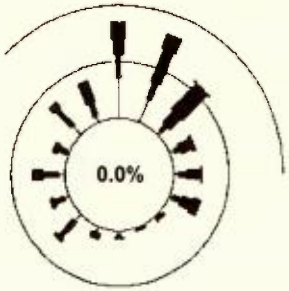
Woodward-Clyde



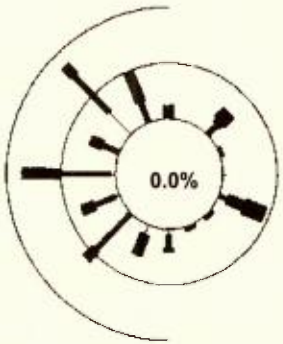
Frequencies for hours 000 - 600



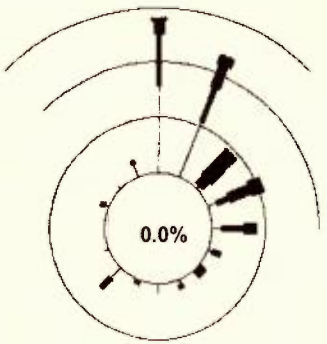
Frequencies for hours 600 - 1200



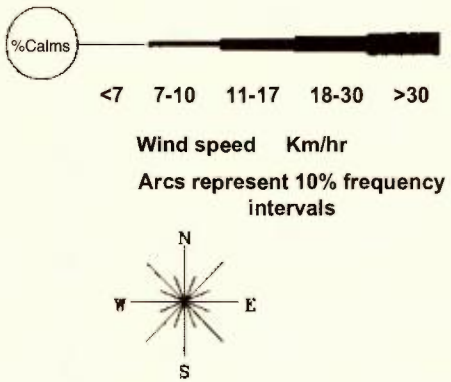
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400

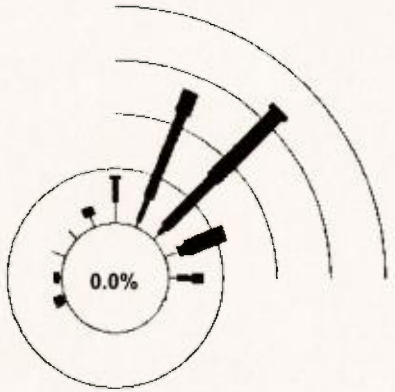


P. ZIB & ASSOCIATES PTY LTD

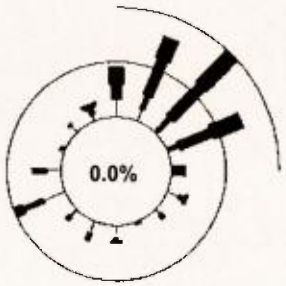
WINDROSES
CADIA DEC 94

FIG B-28

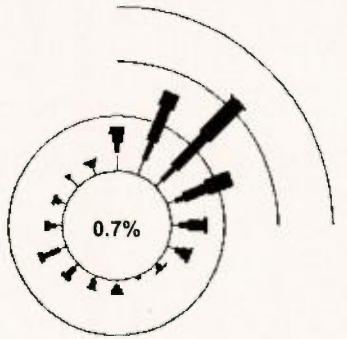
Woodward-Clyde



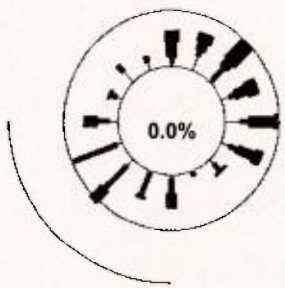
Frequencies for hours 000 - 600



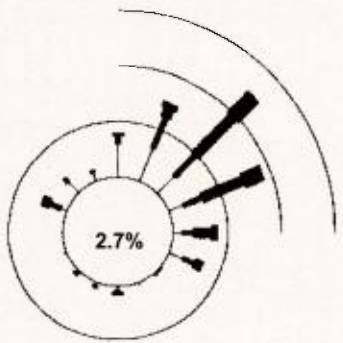
Frequencies for hours 600 - 1200



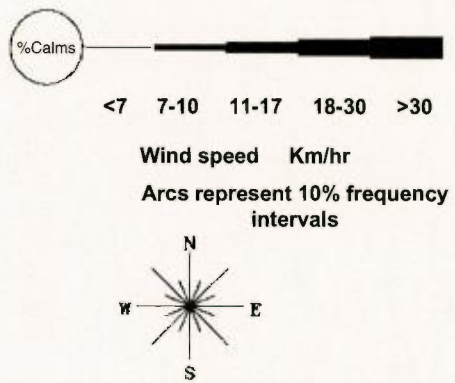
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



P. ZIB & ASSOCIATES PTY LTD

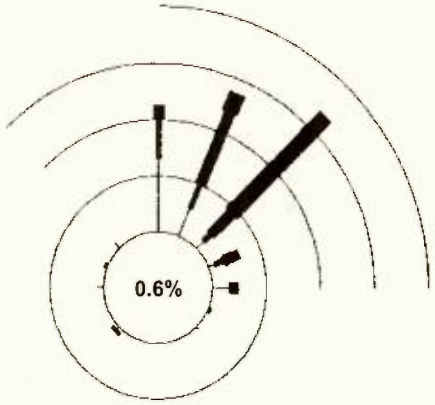
WINDROSES
CADIA JAN 95

FIG B-29

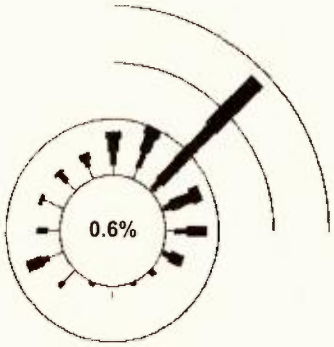
Woodward-Clyde

4542-5-G-B24

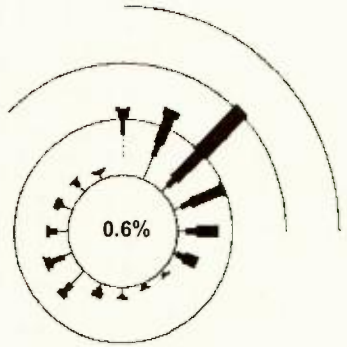
CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



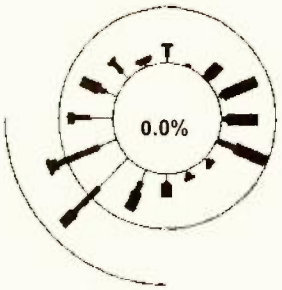
Frequencies for hours 000 - 600



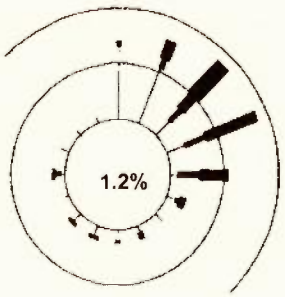
Frequencies for hours 600 - 1200



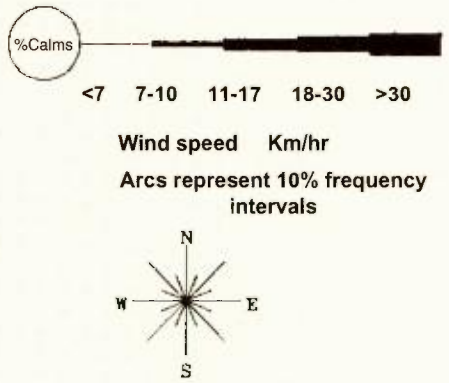
Frequencies for hours 000 - 2400



Frequencies for hours 1200 - 1800



Frequencies for hours 1800 - 2400



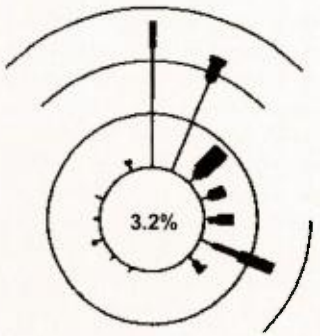
P. ZIB & ASSOCIATES PTY LTD

WINDROSES
CADIA FEB 95

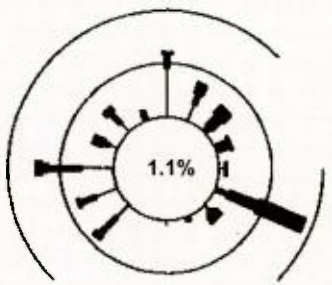
FIG B-30

4542-5-G-B25

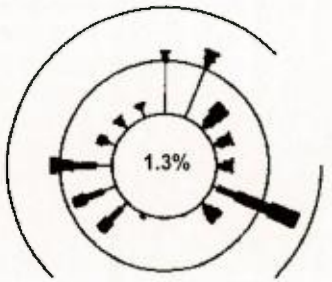
Woodward-Clyde



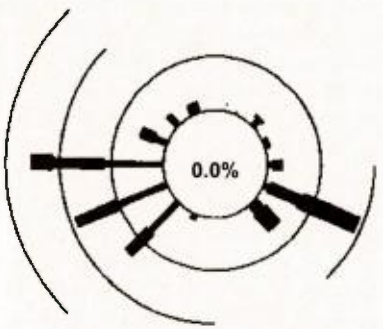
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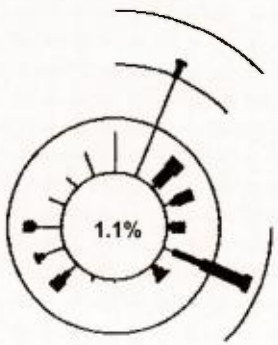
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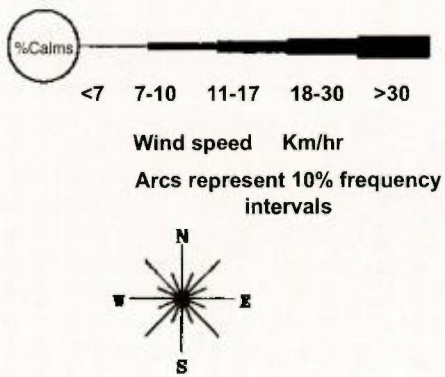
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Frequencies for hours 1800 - 2400



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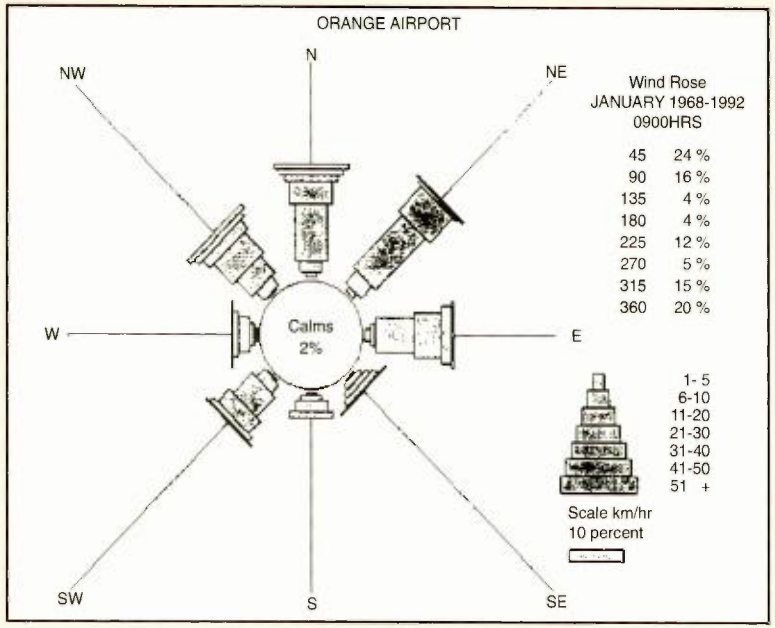
WINDROSES
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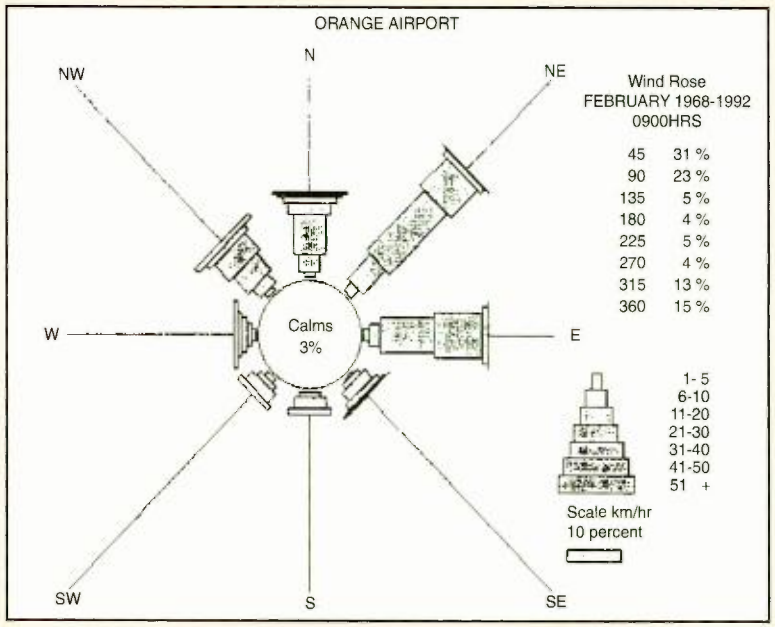
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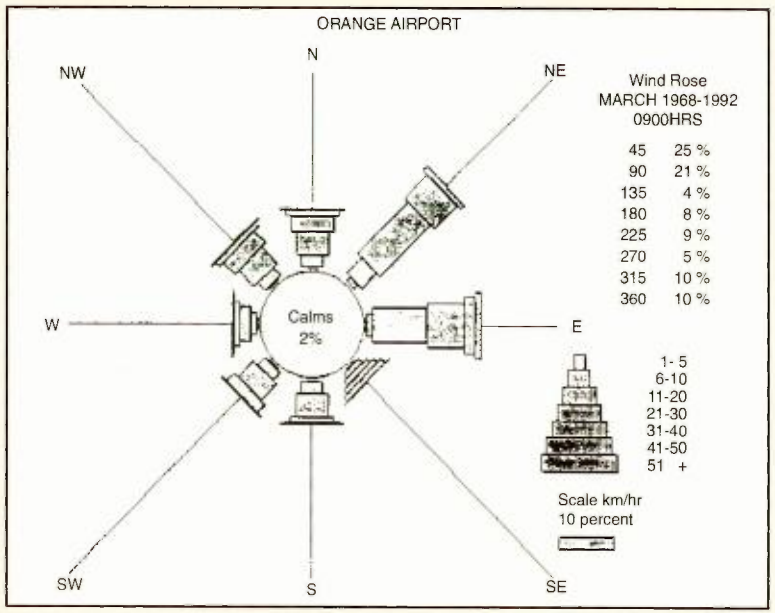
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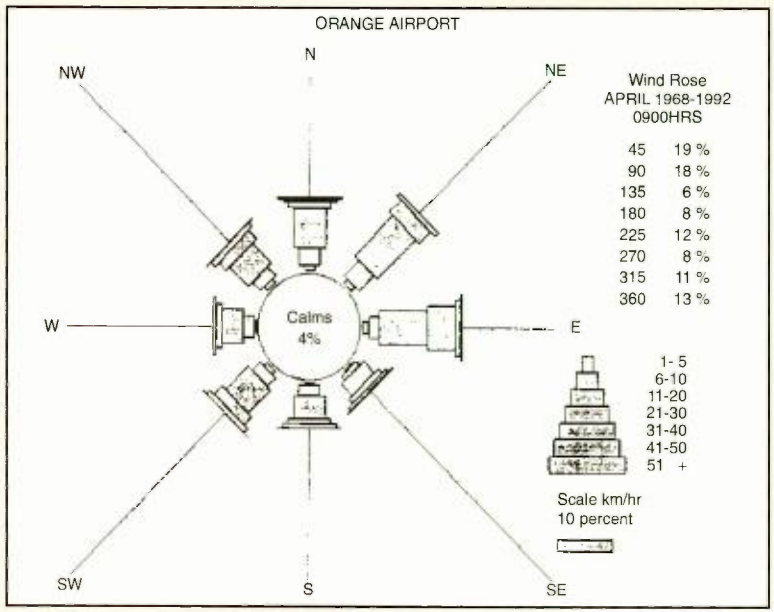
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CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



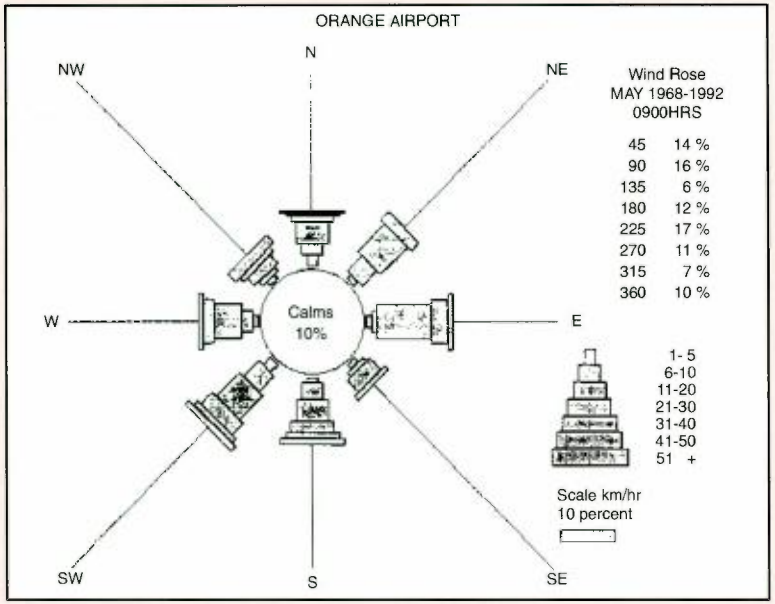


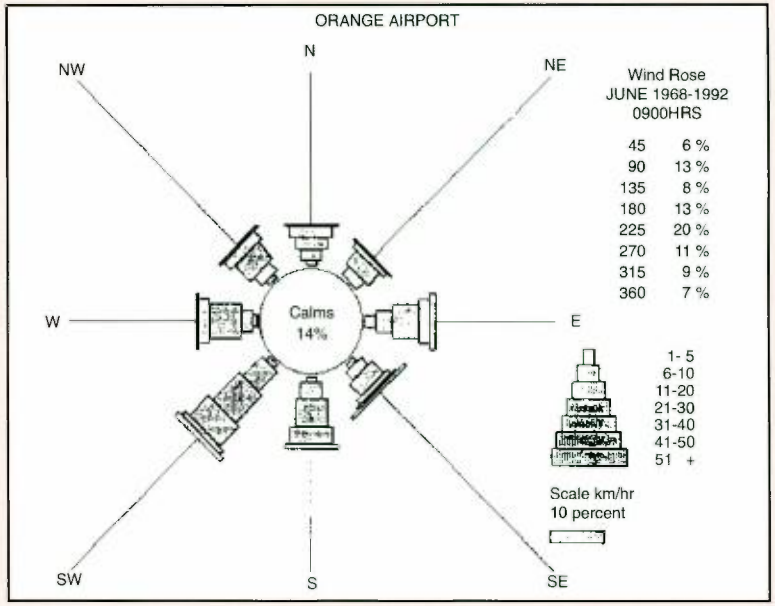


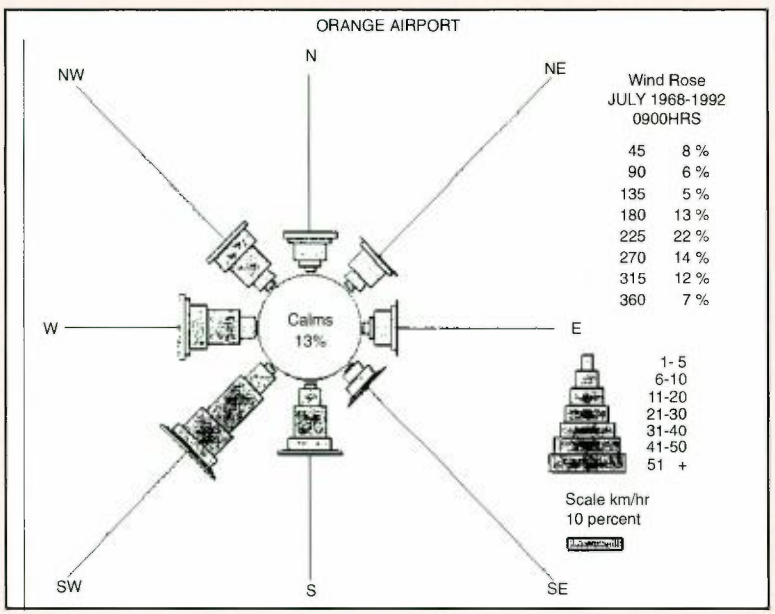


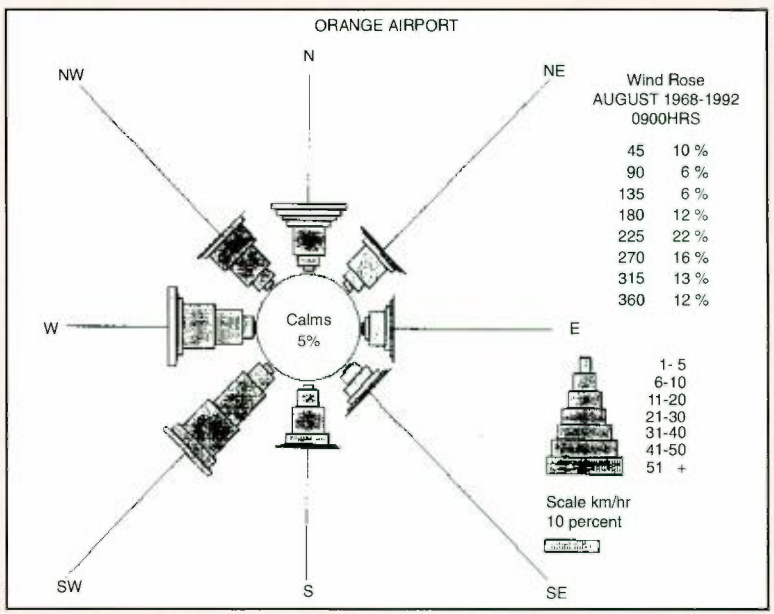
WINDROSES: ORANGE AIRPORT
0900 HRS 1968 -1992
JAN-FEB-MAR-APR

FIG B-32









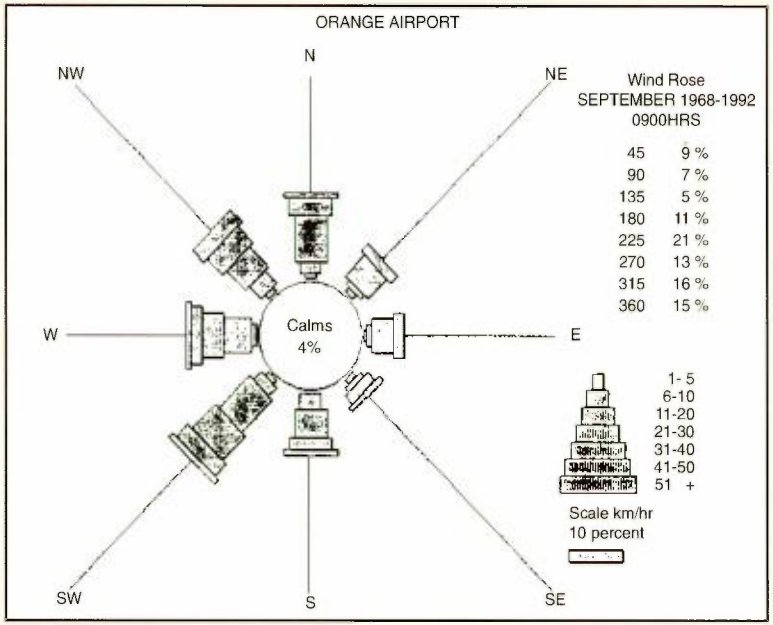
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0900 HRS 1968 -1992
MAY-JUN-JUL-AUG

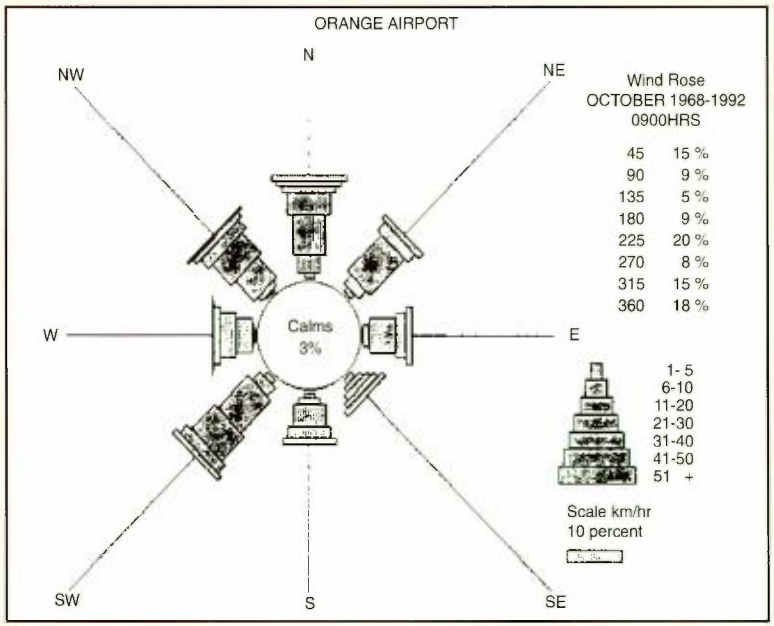
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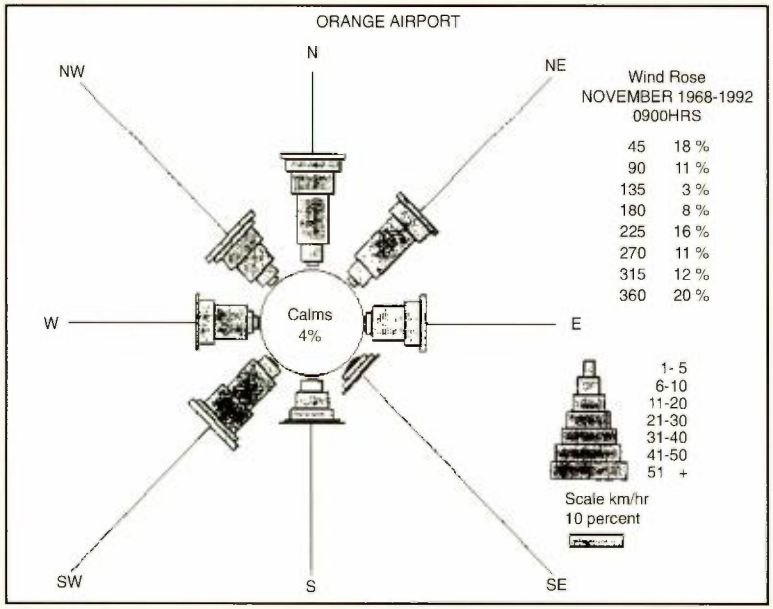
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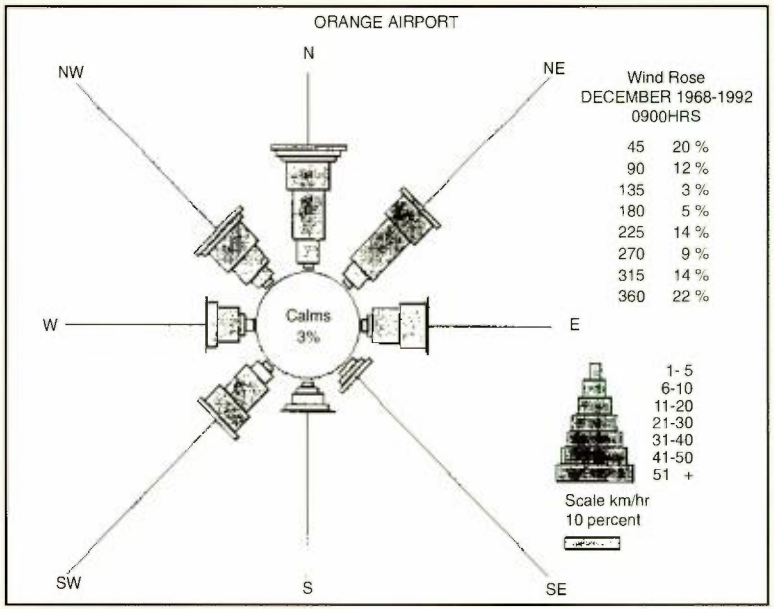
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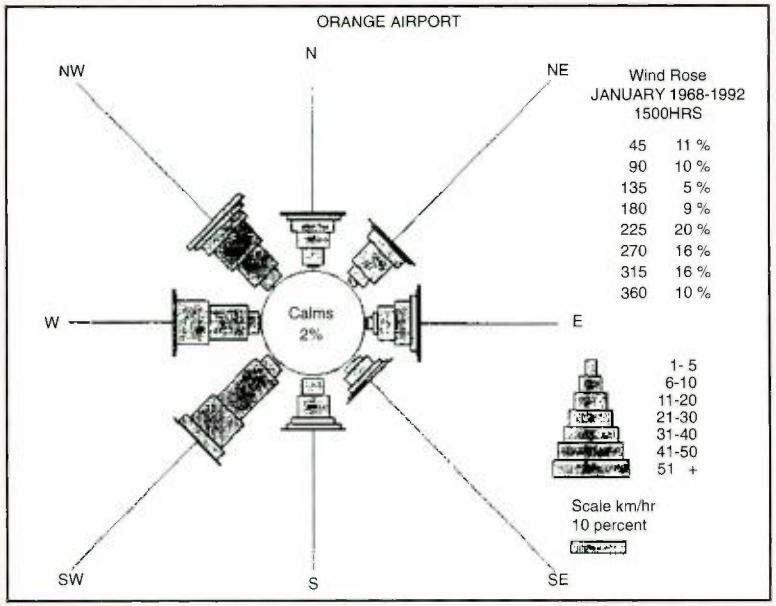


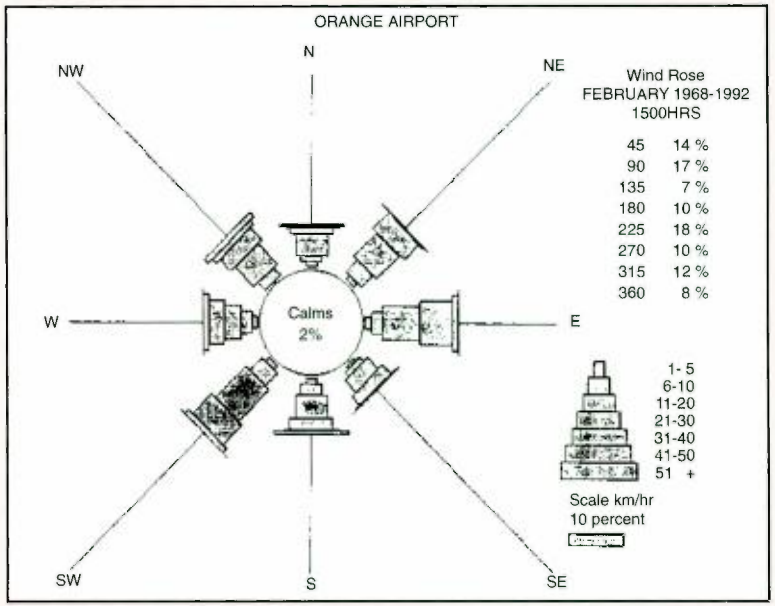


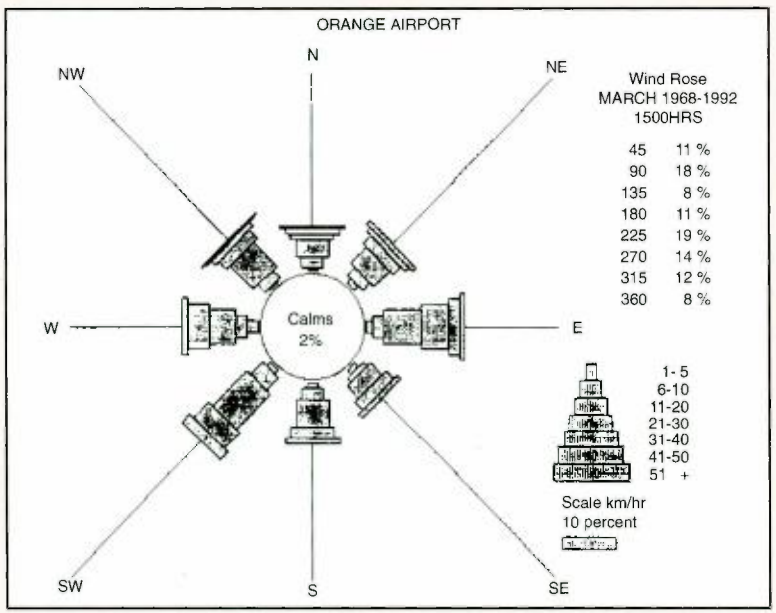


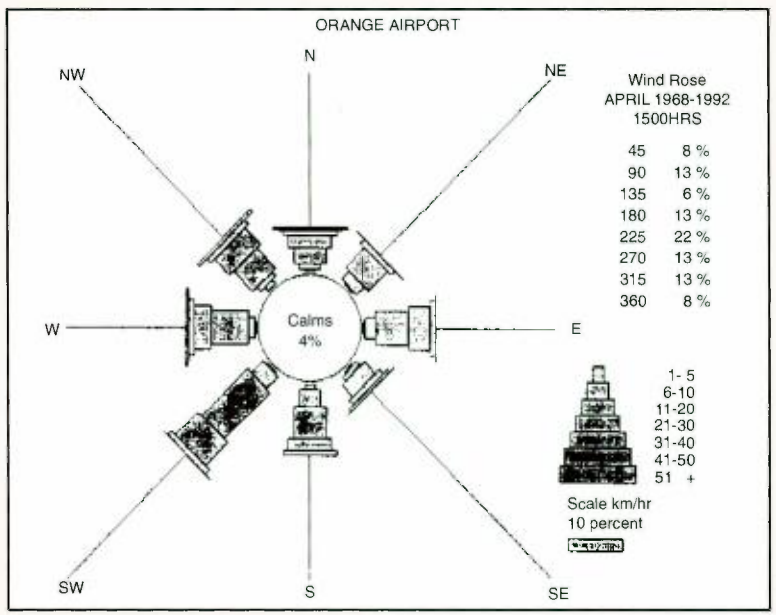
WINDROSES: ORANGE AIRPORT
0900 HRS 1968 -1992
SEP-OCT-NOV-DEC

FIG B-34









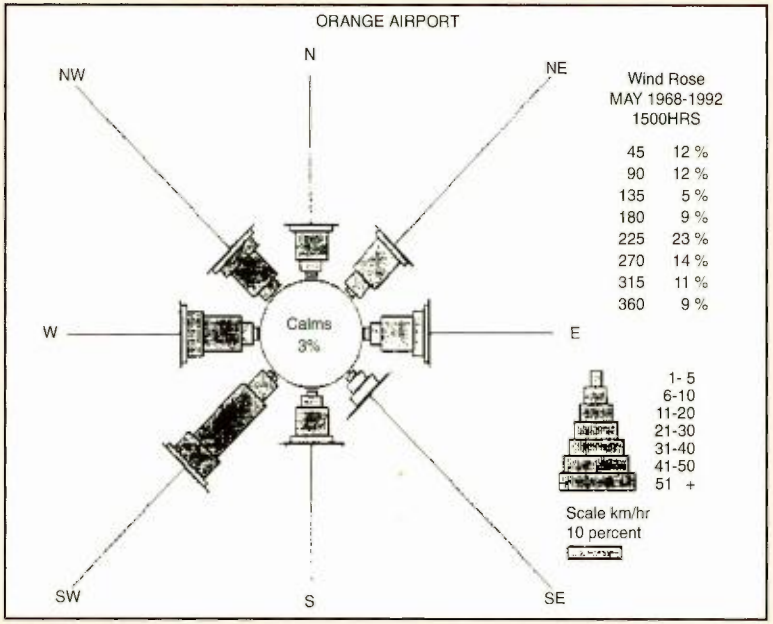
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1500 HRS 1968 -1992
JAN-FEB-MAR-ARP

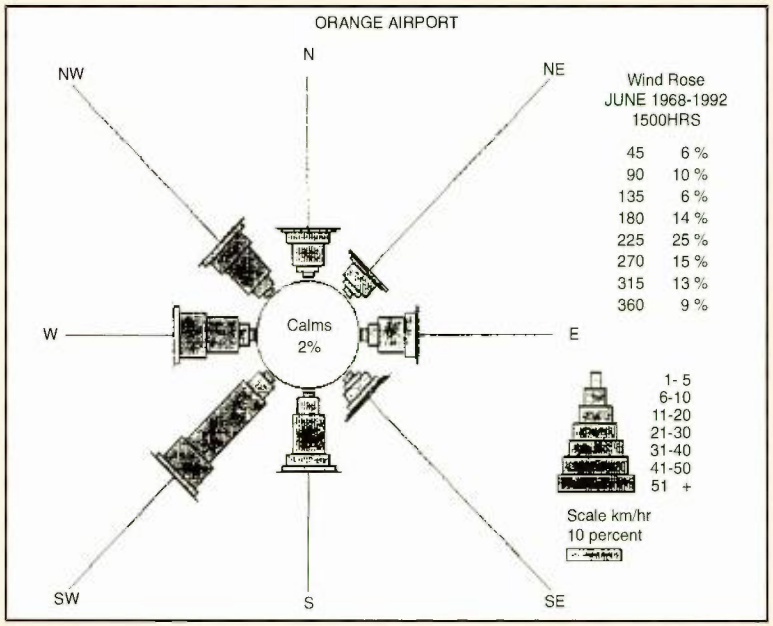
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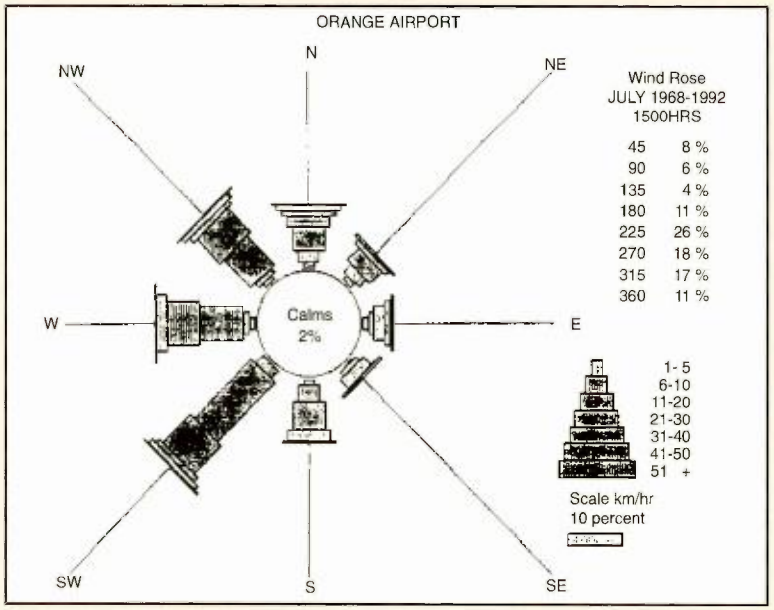
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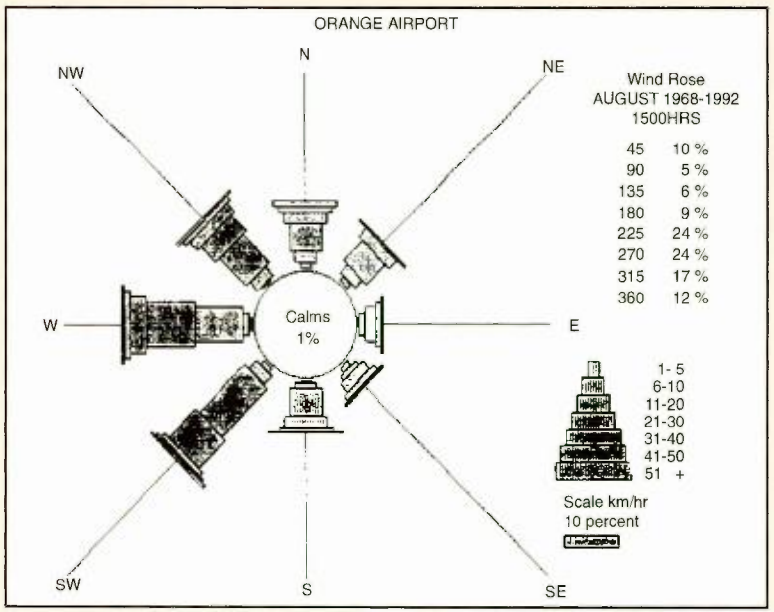
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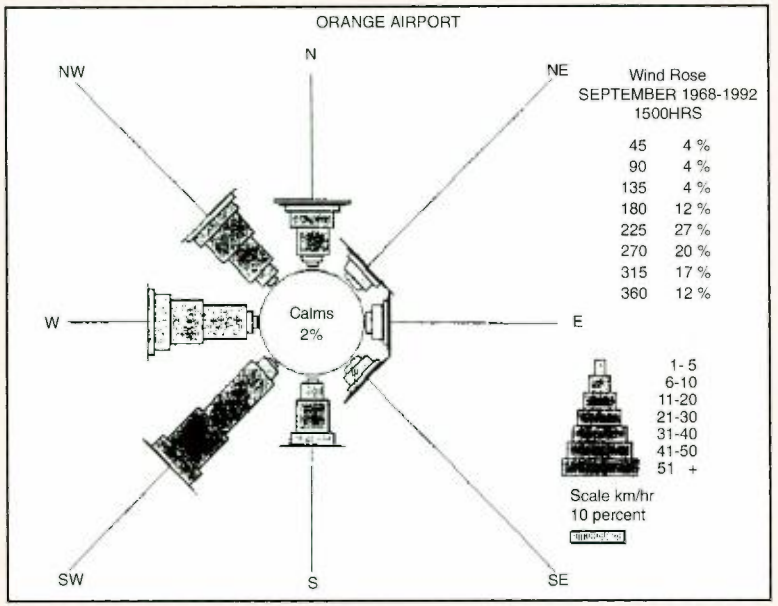


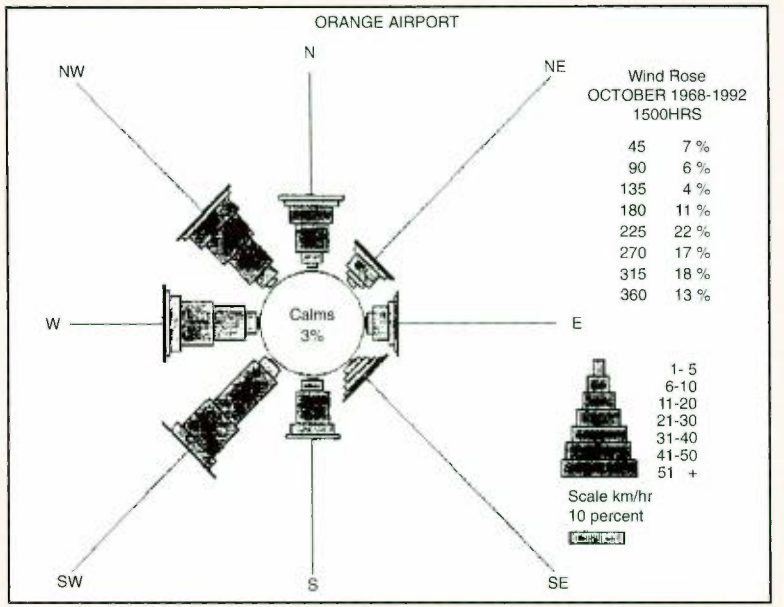


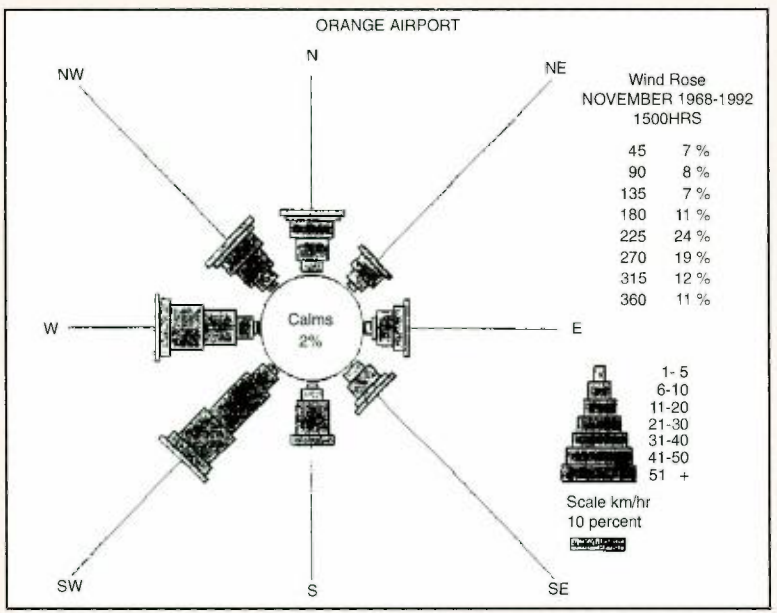
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1500 HRS 1968 -1992
MAY-JUN-JUL-AUG

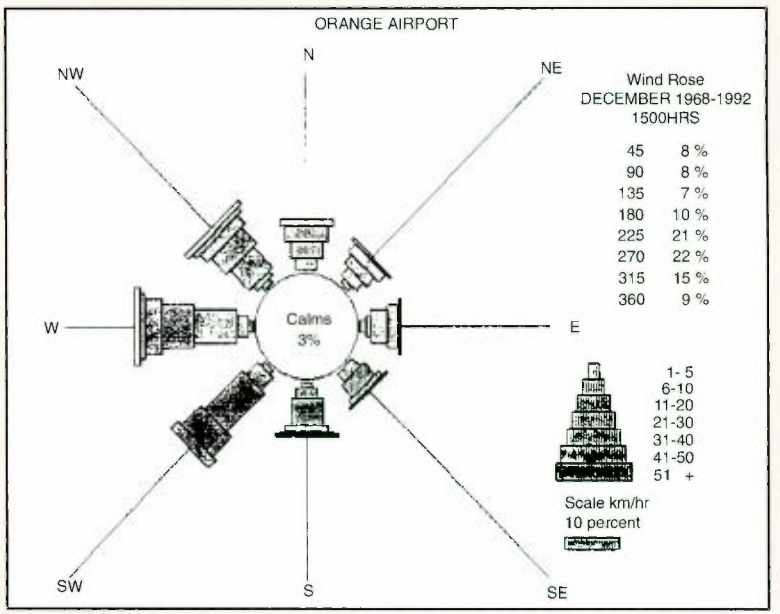
FIG B-36

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WINDROSES: ORANGE AIRPORT
1500 HRS 1968 -1992
SEP-OCT-NOV-DEC

FIG B-37

CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT

4542-5-G-B32

Woodward-Clyde

ATTACHMENT B-3

DISPERSION MODEL FOR DUST EMISSIONS AND GLOSSARY OF TERMS

ATTACHMENT B-3

DISPERSION MODEL FOR DUST EMISSIONS

The dispersion model for emissions of particulate matter was based on the concept of a Gaussian plume represented by the formula

$$C = \frac{2}{\sqrt{2\pi'} \times \Delta\theta'} \sum_{i,j,k} \frac{Q_{i,j,k}\, f_{i,j,k}}{\hat{u}_{i,k}\, \sigma_z} S(\theta) \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

where C = the ground level concentration of particles in the air in the direction è at a distance x from the source, the mass per unit volume.

$\Delta\theta'$ = the sector width in radians.

Q = the pollutant emission rate in mass per unit time.

f = the combined frequency of occurrence of wind speed class i, wind direction section j and atmospheric stability category k.

$\hat{u}$ = the mean wind speed at the plume height H,

σ_z = the standard deviation of the vertical concentration distribution at a distance x.

In the model, which was developed from the ISC computer code, the area surrounding each source of dust was divided into sectors of equal angular width of 22.5 degrees corresponding to one of the 16 sector of annual frequency distributions of wind direction. The emissions from each source were partitioned among the sectors according to the frequencies of wind blowing towards the receptor.

Dust emission rates were calculated for each type of operation. A number of volume sources of variable size, height and initial lateral and vertical dimensions were used to represent the operations in the computer model. Exposed areas and stockpiles were modelled for wind erosion of the surfaces.

Parametric equations were used to fit Pasquill-Gifford curves of dispersion parameters (Turner, 1969). The equations varied with downwind distance and atmospheric stability. Lateral and vertical virtual distances were determined from the initial dimensions of the volume sources and added to the actual downwind distance for calculating the standard deviations.

Dust emissions were divided into 3 particle size categories comprising particles with a diameter below 2.5 microns, particles between 2.5 and 15 microns, and particles larger than 15 microns. In each particle size range the reduction of the dust concentration in the ambient air by deposition to the surface was modelled by reducing the height of the dust plume.

Dry deposition velocities were determined for particles in each particle size category from Sehmel and Hodgson (1974). Land surface of roughness length of 0.10 m and a mean friction velocity of 0.20 m/s were used to represent the average conditions under the travelling plume. Wet deposition through precipitation was not included in the model. The deposition velocities were also used to determine the deposition rate of atmospheric dust to the surface as

D (deposition) = C (concentration) × vd (deposition velocity)

Seasonal and annual dust deposition rates were calculated for each emission source and summed to obtain the predicted value at each point of a grid array. A computer plotting routine was then applied to fit isopleths to the grid calculations.

The dust deposition model was previously validated at the request of the SPCC using the monitoring results collected at an existing coal mine in the Hunter Valley. The validation indicated a systematic agreement between the modelling predictions and monitoring results with a degree of overprediction by the model still in evidence.

GLOSSARY OF TERMS

Air Pollutant
A substance in ambient atmosphere resulting from the activity of man or from natural processes and causing adverse effects to man and the environment.

Air Pollution
Presence of air pollutants.

Air Pollution Emissions Inventory
An information, collection and processing system containing data on emissions of, and sources of, air pollution from both man-made and natural causes.

Ambient Air
Outdoor air to which people, structures, plants and animals are exposed.

Ambient Air Quality
The quality of the ambient air near ground level, expressed as concentrations of deposition rates of air pollutants.

Ambient Air Quality Criteria
Quantitative relationship between a pollutant's dose, concentration, deposition rate or any other air quality - related factors, and the related effects on receptors, e.g. humans, animals, plants, or materials. Air quality criteria serve as the scientific basis for formulating ambient air quality standards or objectives.

Area Source
A group of pollutant-emitting facilities on surfaces which are evenly distributed across a well defined region.

Atmospheric Stability
A measure of turbulence which determines the rate at which the effluent is dispersed as it is transported by the wind.

Background Level
The concentration (deposition) level of a pollutant which must be added to the concentration (deposition) level of the modelled sources in order to obtain a total.

Concentration
The amount of a substance, expressed as mass or volume, in a unit volume of air.

Dispersion/Diffusion
A mixing process in which air motions mix a pollutant plume over an ever increasing volume, thereby diluting the concentration of the pollutant in the ambient air.

Dispersion Model
A set of mathematical equations relating the release of air pollutant to the corresponding concentrations in the ambient atmosphere or deposition on the surface.

Dispersion Parameters
The parameters which describe the growth of the dimensions of a Gaussian plume as a function of travel distance or travel time. The dispersion parameters are classified according to diffusion categories, which describe the influence of different turbulence conditions in the atmospheric boundary layer on the dispersion.

Dust
Particles of mostly mineral origin generated by the mining and handling of materials and erosion of surfaces.

Emission
The release of air pollutants into the atmosphere.

Emission Factor
An expression for the rate at which a pollutant is generated as a result of some activity, divided by the level of that activity.

Fugitive Emissions
Emissions not entering the atmosphere from a stationary vent (stack). Examples of fugitive dust sources include vehicular traffic on unpaved roads, handling of raw materials, wind erosion of dusty surfaces, etc.

Gaussian Plume Model
An approximation of the dispersion of a plume from a continuous point source. The concentration distribution perpendicular to the plume axis is assumed to be Gaussian. The plume travels with a uniform wind velocity downwind from the source. Its dimensions perpendicular to the wind direction are described by dispersion parameters as a function of distance or travel time from the source. The dispersion coefficients depend on diffusion categories and sometimes also on the source height and the surface roughness. The basic assumption underlying the Gaussian plume model is that the dispersion takes place in a stationary and homogenous atmosphere, with a sufficient wind speed (>1 m/s).

Gravitational Fall
The downward settling of particles in the atmosphere due to the effects of gravity. The rate of descent of a particle depends on the balance between the aerodynamic drag and the gravitational acceleration (Stokes law). For particles with approximately the density of water and a diameter of less then 20 microns the fall velocity is small compared with the vertical velocities in the atmosphere, so that these particles can remain aloft.

Ground Level Concentration
Applied to the concentration, calculated or observed, in the neighbourhood of the ground surface.

Line Source
A pollutant producing activity which is uniformly spread out along a narrow band.

Long-Term
A period of time associated with annual air quality standards. Long-term models usually address pollutant concentrations over several seasons to one year.

Meteorological Episode or Event
A short period of time, varying between one hour and a few days, over which a single class of weather conditions is dominant.

Mixing Height
The vertical depth of the atmosphere through which air pollutants can be dispersed.

Neutral Atmosphere
The atmospheric condition for which the vertical temperature profile is equal to the adiabatic lapse rate over the whole boundary layer. Vertical air motions are neither enhanced nor suppressed. The turbulence intensity is moderate.

Particulate Matter
Small solid or liquid particles suspended in or falling through the atmosphere. Sometimes expressed by the terms particulates.

Physical Removal Process
A series of events which lead to the direct depletion of an air pollutant in the ambient atmosphere without chemical transformation. Several physical mechanisms include settling of heavy particles, impaction on vegetation and structures, and rainout.

Plume
The shape of the concentration distribution of the emissions from a point source when transported by the mean wind and dispersed by turbulence.

Point Source
A single activity that causes the release of a pollutant plume from a stationary vent. Large smoke-stack emissions are modelled as a single point source.

Receptor Point
The geographical point where an air pollutant concentration (deposition) is measured or calculated by means of an air pollution dispersion model.

Short-Term
A period of time associated with air quality standards for pollutant exposures ranging between one hour and twenty four hours.

Source
The place where pollutants are emitted into the atmosphere. Sources may be point, area or line sources. Often the term "source" is used for a whole plant or an installation. In air pollution modelling, the terms "continuous source" and "instantaneous source" are used:

- Continuous source: Source which emits pollution continuously over a time period much larger than the travel time to a point where the concentration is considered. Usually it is assumed that during this time period the emission is constant.

- Instantaneous source: Source which emits pollution over a time period much shorter than the travel time of the emission to a point where its concentration is considered.

Stable
Used with respect to the atmospheric boundary layer, when the vertical temperature gradient is greater then the adiabatic lapse rate. Vertical air motions are suppressed. The turbulence intensity is low resulting in poor dispersion conditions.

Temperature Inversion
An increase in air temperature with height.

Turbulence
Any irregular or disturbed flow in the atmosphere that produces gusts and eddies.

Wind Direction
The direction from which the wind, averaged over a certain period of time, is blowing.

APPENDIX C

Acoustics

CADIA HILL PROJECT
NOISE, TRANSPORTATION AND BLASTING IMPACT ASSESSMENT

Revision 2

Prepared for:

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On Behalf of:

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Central Melbourne VIC 3004

October 1995

RICHARD HEGGIE ASSOCIATES PTY LTD

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Note: Due to the large volume of raw data, collected for the noise study, some of the larger attachments to this appendix have not been included (viz. Attachment C-6, C-7 and C-11). The information contained within these attachments is presented in the complete report lodged with DOP Sydney, EPA Bathurst, and Newcrest Mining Limited Cadia.

EXECUTIVE SUMMARY

INTRODUCTION

This report presents the results and findings of a detailed acoustical impact assessment of the proposed development of a gold/copper mine at Cadia Hill, near Orange, NSW by Newcrest Mining Limited.

The project will consist of open cut mining with staged flotation and carbon in pulp (CIP) extraction. It is anticipated that the project will involve the processing of 17 million tonnes per annum (Mtpa) of ore, to derive approximately 90,000 tonnes per annum of concentrate. The gold/copper would then be transported off site for refinement.

To determine the acoustical impact of the project, the major sources of noise and vibration emissions have been grouped into three distinct areas for evaluation and assessment as follows:

MINE NOISE

- Noise emission from mobile plant and equipment during the mine site construction phase.
- Noise emission from mine operations including fixed processing plant and mobile earthmoving equipment.

EMISSIONS FROM BLASTING

- Ground-borne vibration and airblast noise resulting from blasting operations.

TRANSPORTATION NOISE

- Noise emission from traffic on public roads during both construction and operational phases.

OVERVIEW OF ACOUSTICAL TERMINOLOGY AND ASSESSMENT PROCEDURES

Sound or noise may be defined as any pressure variation that the human ear can detect. Sound is transmitted in the air by pressure waves which have two important characteristics: amplitude and frequency. Amplitude and frequency determine the effect that noise has at the receptor.

Amplitude is perceived as loudness and is measured in units of decibels (dB). The sound pressure level (SPL) is the parameter used to describe the relative "strength" of the noise. SPL is expressed in decibels (dB), which relate the amplitude of the sound pressure to a reference sound pressure. This reference corresponds to the threshold of hearing, the minimum audible sound pressure at 1000 Hz: 20 mPa. The decibel scale ranges from the threshold of hearing at 0 dB to above the threshold of pain at about 140 dB.

Frequency is perceived as pitch and is measured in Hertz (Hz) or Kilohertz (kHz - 1,000 Hz). The frequency of the sound produces its distinctive tone.

When measuring noise it is important to understand that the decibel scale is not linear but logarithmic. This scale has been adopted because the range of sound levels detected by the ear is so large. As noise sources increase or decrease in loudness the ear does not perceive the change in dB level as proportional to the loudness. For example a 3 dB increase in noise level, though not very noticeable to the ear, represents a doubling of sound energy, while a 10 dB increase, which is perceived as twice as loud, represents a ten-fold increase in sound energy.

Another consequence of the use of a logarithmic scale for noise measurement is that noise levels cannot be simply added together. Thus, the combined noise level of two different noise sources which separately produce 87 dB and 89 dB, when placed together, will be 91 dB, not 176 dB.

Sound levels can be measured in a variety of ways depending upon the scientific need and instrument used. For assessing environmental noise the weighting, or the frequency response, of the measuring meter is required to conform to a set standard - the "A" weighting. The "A" weighting of the meter's response corresponds approximately to how the human ear perceives sound at low to moderate levels. The corresponding measured value is expressed as dBA.

As suggested above, a change of 1 dBA or 2 dBA change in sound level represents only a marginal difference and is difficult for most people to detect. A 3 dBA to 5 dBA change corresponds to small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. A range of typical noise levels is presented in the Table C-1.

TABLE C-1
RANGE OF TYPICAL NOISE LEVELS

Sound Pressure Level - dBA	Typical Source	Subjective Evaluation
130	Threshold of pain	Extremely noisy Intolerable
120	Jet take-off	
110	Rock concert	
100	Pneumatic hammer	Very noisy
90	Heavy truck	
80	Busy street traffic	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General office	
40	Living room	Quiet to very quiet
30	Bedroom	
20	Unoccupied recording studio	Almost silent
10/0	Threshold of hearing	Silent

The assessment of environmental noise emissions from mining projects involves the establishment of acceptable noise emission limits based on existing background noise levels which are determined prior to the construction of the mine.

In general terms, the noise emission from the project is limited to the level of existing background noise plus an additional 5 dBA.

It is often the case therefore, that noise emissions from established mining projects are audible at some of the nearest residential receivers, particularly at night, whilst remaining within their predetermined noise emission limits.

MINE SITE EXISTING ACOUSTICAL ENVIRONMENT

As shown on the Location Plans in Attachment C-2, seven rural residential properties beyond the mine lease boundary have been selected to represent the noise environment of the potentially affected area and form the basis for assessing noise emissions from the mines development and operation.

In order to characterise and quantify the existing winter and summer season ambient noise environments, unattended continuous noise logging and operator-attended noise surveys were conducted in May/June 1994 and December/January 1994/95 respectively.

The ambient noise measurements quantify the overall noise level at the particular locality, without respect for the individual noise sources which constitute the total noise environment.

Ambient noise levels were determined by measuring statistical noise exceedance levels over a 15 minute sample period. The exceedance levels (LAN) are the levels exceeded for N% of the sample interval. The LA90 represents the level exceeded for 90% at the interval period and is referred to as the average minimum or background noise level. The LA10 is the level exceeded for 10% of the time and is usually referred to as the average maximum noise level.

The accumulated daytime, evening and night-time LA90 background noise levels for both winter and summer seasons are presented in Table C-2.

The measured LA90 background noise levels are typical of a quiet and undeveloped rural environment, with noise levels falling below 30 dBA at most localities throughout the day during both winter and summer seasons.

CONSTRUCTION AND MINE NOISE EMISSION DESIGN LIMITS

On the basis of the LA90 background noise levels presented above and the EPA's Noise Control Manual, the calculated and recommended composite LA10 contributed noise emission limits for construction and mine operations respectively are presented in Table C-3 for the purpose of noise impact assessment at the seven residential properties surrounding the project area.

EVALUATION OF NOISE EMISSION

In order to determine the acoustical impact from mining operations, a computer model was developed incorporating the significant proposed mining noise sources, the surrounding terrain and nearby potentially affected rural residential properties.

For the purpose of predicting the noise emission levels during the mines construction and operational phases of development, the following operating scenarios were assessed:

TABLE C-2
ACCUMULATED DAYTIME, EVENING AND LA90 BACKGROUND NOISE LEVELS

Location Number	Property Name	Winter Season LA90			Summer Season LA90		
		Daytime 0700 hrs to 1800 hrs	Evening 1800 hrs to 2200 hrs	Night-time 2200 hrs to 0700 hrs	Daytime 0600 hrs to 1800 hrs	Evening 1800 hrs to 2200 hrs	Night-time 2200 hrs to 0600 hrs
DG1	Tunbridge Wells	30 dBA	22 dBA	21 dBA	32 dBA	32 dBA	30 dBA
DG4	Caringle	32 dBA	29 dBA	28 dBA	37 dBA	37 dBA	32 dBA
DG5	Bundella	30 dBA	30 dBA	30 dBA	28 dBA	29 dBA	23 dBA
DG7	Stratton Vale	30 dBA	29 dBA	29 dBA	31 dBA	31 dBA	25 dBA
DG8	Northwest	26 dBA	24 dBA	24 dBA	28 dBA	27 dBA	23 dBA
DG9	Willunga (Cornwall)	30 dBA	30 dBA	30 dBA	32 dBA	32 dBA	27 dBA
DG12	Lagoon Farm	30 dBA	30 dBA	30 dBA	29 dBA	31 dBA	29 dBA

Note:
1. All LA90 noise levels less than 30 dBA may have been influenced by the loggers electronic noise floor.
2. The winter season LA90 background noise levels at DG9, DG5 and DG12 have been assumed as 30 dBA.
3. If the measured LA90 background noise level is below 30 dBA, then 30 dBA shall be the assumed noise level in accordance with EPA procedures.

TABLE C-3
L_{A10} NOISE LIMITS FOR CONSTRUCTION AND MINE OPERATIONS

Location Number	Property Name	Preferred Construction Hours 0600 hrs to 2200 hrs			Mine Operations (24 hours Monday to Sunday)		
		Up to 4 wks	4 to 26 wks	Greater than 26 wks	Daytime 0700 hrs to 1800 hrs	Evening 1800 hrs to 2200 hrs	Night-time 2200 hrs to 0700 hrs
DG1	Tunbridge Wells	50 dBA	40 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG4	Caringle	50 dBA	40 dBA	35 dBA	37 dBA	35 dBA	32 dBA
DG5	Bundella	50 dBA	40 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	50 dBA	40 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG8	Northwest	50 dBA	40 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG9	Cornwall	50 dBA	40 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	50 dBA	40 dBA	35 dBA	35 dBA	35 dBA	33 dBA

- Construction Phase - Weir and plant site earthworks (anticipated duration greater than 26 weeks).
- Construction Phase - Tailings dam earthworks (anticipated duration 26 weeks).
- Mine Operations Stage I - Year 1 (northern and southern waste dump operation).
- Mine Operations Stage II - Year 4 (southern waste dump operation).
- Mine Operations Stage II - Year 6 (southern waste dump operation).

The predicted overall contributed L_{A10} noise emission levels for the two mine operating stages to the seven nearest potentially affected residential properties have been calculated under the following atmospheric conditions:

- Firstly, for "neutral" atmospheric conditions (i.e. 20°C air temperature, 70% relative humidity, 0°C/100 m temperature gradient and 0 m/s wind velocity) as advocated by the EPA.

- Secondly, for an adverse wind condition (i.e. 6°C air temperature, 85% relative humidity, 0°C/100 m temperature gradient and 1.5 m/s wind velocity 11.25° east of north).

  As shown by the wind roses in Attachment C-9, this wind condition occurs between 0000 hours and 0600 hours on approximately 25% of nights throughout the year.

- Thirdly, for an adverse temperature inversion (i.e. 6°C air temperature, 85% relative humidity, 3°C/100 m temperature gradient and 0 m/s wind velocity).

  A 3°C/100 m vertical temperature gradient would generally be considered as a strong inversion. In the absence of site specific temperature gradient data, it is assumed that temperature inversions up to 3°C/100 m gradient may occur on approximately 25% of nights throughout the year.

MINE SITE CONSTRUCTION PHASE

The following assessments are derived from the predicted noise levels presented in Table 8-2-1 and the calculated construction emission limits presented in Table 6-2-2:

a. The contributed L_{A10} noise levels from the weirs and plant site construction phase, during both neutral and adverse wind conditions comply with the most stringent noise emission limit of 35 dBA at all residential properties.

b. The contributed L_{A10} noise levels from the tailings dam construction phase, during both neutral and adverse wind conditions, comply with the most stringent noise emission limit of 35 dBA at all residential properties with the exception being at Stratton Vale (DG7).

   It is anticipated however that construction of the tailings dam will be restricted to within a 6 month period. The Stratton Vale (DG7) residence therefore, because of its locality with respect to the tailings dam, would attract a noise emission limit of 40 dBA. The predicted L_{A10} noise emission level of 42 dBA therefore marginally (2 dBA) exceeds this limit, which is only likely to occur under an adverse wind condition on approximately 25% of evenings throughout the year.

It is therefore recommended that noise levels are routinely monitored at the Stratton Vale (DG7) residence during the construction of the tailings dam to ensure that noise emissions do not significantly exceed the noise emission limits.

MINING AND PROCESSING OPERATIONS - STAGE I

The predicted overall contributed L_{A10} noise emission levels for Stage I mine operations to the seven nearest potentially affected residential properties are presented in Table C-4 together with the corresponding noise emission limits.

It is concluded that the predicted LA10 noise levels may appreciably exceed the night-time criterion by up to 8 dBA at Caringle (DG4) during adverse meteorological conditions, from Year 1 mining operations.

Similarly, the predicted LA10 noise levels may appreciably exceed the night-time criterion by up to 5 dBA at Stratton Vale (DG7) during strong temperature inversion conditions, from Year 1 mining operations.

The predicted LA10 noise levels comply with the recommended daytime, evening and night-time criteria at all residential properties, with marginal (2 dBA) and moderate (4 dBA) exceedances of the night-time criteria at Bundella (DG5) and Tunbridge Wells (DG1) respectively during strong temperature inversion conditions.

It is anticipated that the noise emission levels predicted for Year 1 mining operations would generally be maintained throughout Year 2, with noise emissions reducing at Tunbridge Wells (DG1) in Year 3 as the northern waste dump will no longer be active.

It is therefore recommended that noise levels are routinely monitored throughout Stage I mining operations to ensure that noise emissions do not significantly exceed the recommended noise limits.

MINING AND PROCESSING OPERATIONS - STAGE II

The predicted overall contributed LA10 noise emission levels for Stage II mine operations to the seven nearest potentially affected residential properties are presented in Tables C-5 and C-6 together with the corresponding noise design limits.

It is concluded that the predicted LA10 noise levels may appreciably exceed the night-time criterion by up to 10 dBA at Caringle (DG4) during both neutral and adverse meteorological conditions throughout Stage II mining operations.

The predicted LA10 noise levels may appreciably exceed the night-time criterion by up to 6 dBA at Stratton Vale (DG7) during adverse wind conditions throughout Stage II mining operations.

Similarly, the predicted LA10 noise levels may appreciably exceed the night-time criterion by 5 dBA at Bundella

TABLE C-4
PREDICTED LA10 CONTRIBUTED NOISE EMISSION LEVELS - YEAR 1 MINE OPERATIONS

Location Number	Property Name	Mine Emission Overall LA10			Recommended LA10 Noise Limit		
		Stage I - Year 1			Daytime	Evening	Night-time
		Neutral	Wind	Inversion	0700 hrs to 1800 hrs	1800 hrs to 2200 hrs	2200 hrs to 0700 hrs
DG1	Tunbridge Wells	27 dBA	25 dBA	37 dBA	35 dBA	35 dBA	33 dBA
DG4	Caringle	30 dBA	40 dBA	39 dBA	37 dBA	35 dBA	32 dBA
DG5	Bundella	20 dBA	31 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	20 dBA	38 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG8	Northwest	16 dBA	30 dBA	27 dBA	35 dBA	35 dBA	33 dBA
DG9	Cornwall	23 dBA	23 dBA	29 dBA	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	16 dBA	16 dBA	27 dBA	35 dBA	35 dBA	33 dBA

TABLE C-5
PREDICTED LA10 CONTRIBUTED NOISE EMISSION LEVELS - YEAR 4 MINE OPERATIONS

Location Number	Property Name	Mine Emission Overall LA10			Recommended LA10 Noise Limit		
		Stage II - Year 4			Daytime	Evening	Night-time
		Neutral	Wind	Inversion	0700 hrs to 1800 hrs	1800 hrs to 2200 hrs	2200 hrs to 0700 hrs
DG1	Tunbridge Wells	22 dBA	17 dBA	34 dBA	35 dBA	35 dBA	33 dBA
DG4	Caringle	36 dBA	42 dBA	42 dBA	37 dBA	35 dBA	32 dBA
DG5	Bundella	29 dBA	29 dBA	38 dBA	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	26 dBA	39 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG8	Northwest	21 dBA	34 dBA	34 dBA	35 dBA	35 dBA	33 dBA
DG9	Cornwall	20 dBA	18 dBA	27 dBA	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	15 dBA	14 dBA	31 dBA	35 dBA	35 dBA	33 dBA

TABLE C-6
PREDICTED L_{A10} CONTRIBUTED NOISE EMISSION LEVELS - YEAR 6 MINE OPERATIONS

Location Number	Property Name	Mine Emission Overall L_{A10}			Recommended L_{A10} Noise Limit		
		Stage II - Year 6			Daytime	Evening	Night-time
		Neutral	Wind	Inversion	0700 hrs to 1800 hrs	1800 hrs to 2200 hrs	2200 hrs to 0700 hrs
DG1	Tunbridge Wells	23 dBA	20 dBA	34 dBA	35 dBA	35 dBA	33 dBA
DG4	Caringle	28 dBA	42 dBA	41 dBA	37 dBA	35 dBA	32 dBA
DG5	Bundella	28 dBA	31 dBA	38 dBA	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	25 dBA	35 dBA	30 dBA	35 dBA	35 dBA	33 dBA
DG8	Northwest	22 dBA	33 dBA	32 dBA	35 dBA	35 dBA	33 dBA
DG9	Cornwall	20 dBA	18 dBA	27 dBA	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	16 dBA	15 dBA	32 dBA	35 dBA	35 dBA	33 dBA

(DG5) during strong temperature inversion conditions throughout Stage II mining operations.

The predicted L_{A10} noise levels comply with the recommended daytime, evening and night-time criteria at all other residential properties, with marginal (1 dBA) exceedances of the night-time criterion at Northwest (DG8) and Tunbridge Wells (DG1) during adverse meteorological conditions.

It is anticipated that the noise emission levels beyond Year 9 mining operations may commence to diminish as overall extraction rate significantly reduces and haul truck movements are confined to the marginal ore stockpiles on the northeast area of the southern waste dump.

It is therefore recommended that noise levels be routinely monitored throughout Stage II mining operations to ensure that noise emissions do not significantly exceed the recommended noise limits.

MINING AND PROCESSING OPERATIONS NOISE CONTOUR DIAGRAMS

The predicted L_{A10} contributed noise level contour diagrams for Stage II Year 4 mining operations are given in Attachment C-10.

BLAST EMISSIONS IMPACT ASSESSMENT

In order to determine the levels of blast emission at the nearby heritage chimney and surrounding residential properties from the proposed production blasting, the measured blast emission data, as determined by the JKMRC in their investigation of trial blast emissions in July 1994, was used to develop blast emission site laws.

The following assessments are derived from the predicted levels of blast emissions given in Table 9-2-2 and the recommended structural damage and human comfort criterion presented in Section 6.4.

a. The predicted levels of ground vibration and airblast of 2.5 mm/s and 121 dBLinear at the nearby heritage chimney comply with the recommended damage criteria of 3 mm/s and 132 dBLinear respectively.

b. The predicted levels of ground vibration at all residential properties comply with the structural damage criterion of 5 mm/s recommended for low-rise residential buildings in AS 2187.2-1993.

c. The predicted levels of ground vibration at all residential properties comply with the most stringent human comfort criterion of 1 mm/s, for Sundays and Public Holidays, recommended by the EPA.

d. The predicted levels of peak airblast at all residential properties are well below the US Bureau of Mines' structural damage limit of 132 dBLinear.

e. The predicted levels of peak airblast (5% exceedance) at all residential properties comply with the general human comfort criterion of 115 dBLinear for daytime blasting, Monday to Saturday 0900 hours to 1500 hours, recommended by the EPA.

   There may, however, be a marginal (1 dB to 2 dB) exceedance of the Monday to Saturday early morning (0600 hours to 0900 hours) and evening (1500 hours and 2000 hours) airblast criteria of 105 dBLinear at Cornwall (DG9), Tunbridge Wells (DG1) and Bundella (DG5) residences.

   Moreover, for blasting conducted on Sundays and Public Holidays, the predicted peak airblast levels may exceed the nominated human comfort criterion of 95 dBLinear by 4 dB to 12 dB at the surrounding residential properties.

In view of the proximity of the engine house and chimney to the proposed extraction site, it is important that vibration monitoring be performed during early stages of the project to quantify the induced vibration at particu-

lar locations within potentially affected structure. If necessary, blasting techniques can then be modified accordingly to ensure that any exceedances of the "structurally safe" limits in Table 6-4-2 are minimised.

It is also recommended that blasting on Sundays and Public Holidays is only conducted where compliance with the relevant EPA human comfort blast emission criteria can be demonstrated via a thorough blast emission monitoring program implemented at the commencement of the mine operations. Consideration should be given to an application to the EPA to vary the current "standard" limits applying to blasting in extended hours and weekends, as the limits are overly restrictive (see Section 6.4.4).

ROAD TRAFFIC NOISE IMPACT ASSESSMENT

In order to determine the acoustical impact from traffic movements associated with the projects development, existing and predicted traffic flows have been sourced from the TRAFFIX (Traffic Engineering Services, March 1995 and July 1995) assessment of transport options and supplementary traffic information.

The anticipated daily and peak hourly vehicle movements associated with both construction and mine operations are presented in the table below together with the estimated existing traffic flow for the corresponding period.

TABLE C-7
DAILY AND PEAK HOURLY VEHICLE MOVEMENTS

Phase/ Location	Period	Peak Hourly Vehicle Movements		Average Daily Vehicle Movements	
		Light	Heavy	Light	Heavy
Construction	0530 hrs to 0630 hrs	100	3	240	30
Mine Operations	0530 hrs to 0630 hrs	75	5	200	50
	1730 hrs to 1830 hrs				
Existing Traffic Cadia Rd Site 2	0530 hrs to 0630 hrs	13	1	515	29
	1730 hrs to 1830 hrs	40	1		
Existing Traffic Cadia Rd Site 3	0530 hrs to 0630 hrs	13	1	315	34
	1730 hrs to 1830 hrs	28	2		

The following impact assessment is derived from the results presented in Table 10-1-1 and Table 10-4-1 and the EPA's recommended $L_{Aeq(1hour)}$ road traffic noise criteria of 50 dBA daytime and 45 dBA night-time as presented in Section 6.5.

a. It is predicted that nine residences at or within 30 m of the roadway receive noise levels marginally (1 dBA to 2 dBA) in excess of the 45 dBA limit for night-time.

   Similarly, it is predicted that six residences at or within 20 m of the roadway receive noise levels marginally (1 dBA to 2 dBA) in excess of 50 dBA limit for day-time.

b. The predicted peak hourly traffic noise levels associated with both construction and mining vehicle movements are generally within 1 dBA and can therefore be considered as audibly equivalent.

c. It is predicted that the 13 residences within 40 m of Cadia Road may receive noise levels in excess of 50 dBA $L_{Aeq(1hour)}$ during the peak daytime mining traffic flows between 1730 hours and 1830 hours.

d. Similarly, the 17 residences within 100 m of Cadia Road may receive traffic noise levels in excess of 45 dBA $L_{Aeq(1hour)}$ during the peak night-time construction and mining traffic flows between 0530 hours and 0630 hours.

It is concluded that 13 residences may receive traffic noise levels ranging from 1 dBA to 8 dBA in excess of 50 dBA $L_{Aeq(1hour)}$ during the peak mining daytime period between 1730 hours and 1830 hours.

Similarly, an additional 4 residences may receive traffic noise levels which are 1 dBA to 14 dBA in excess of 45 dBA $L_{Aeq(1hour)}$ during the period of peak night-time construction and mining traffic between 0530 hours and 0630 hours.

It is therefore recommended that consideration be given to providing acoustic mitigation measures to the nearest potentially affected properties (in the other of six) along Cadia Road. These may include individual building treatments, acoustic barriers or noise bund walls, and should be developed in consultation with the respective occupants or property owners.

CONCLUSION

In view of the foregoing and in order to limit potential adverse acoustical impacts associated with the project, it is strongly recommended that a Noise and Blasting Management Plan be designed and implemented, defining the noise and blasting monitoring procedures and the approaches to mitigating impacts to be implemented throughout the development and operation of the mine.

1.0 INTRODUCTION

Richard Heggie Associates was commissioned by Woodward-Clyde Pty Ltd on behalf of Newcrest Mining Limited to assess potential impacts of construction and operational noise, transportation noise and blast emissions from a proposed gold/copper mine development at Cadia Hill, near Orange, NSW.

The project will consist of open cut mining with staged flotation and carbon in pulp (CIP) extraction. It is anticipated that the project would involve the processing of 17 million tonnes per annum (Mtpa) of ore over a 12 year period, to derive approximately 90,000 tonnes per annum of concentrate. The gold/copper concentrate would then be transported off site for refinement.

The sources of noise generation at the mine include crushing and processing plant, drills, trucks and mobile earthmoving equipment. The deposit will be blasted, resulting in the generation of airblast noise and groundborne vibration.

Attachment C-1 is a Glossary of Acoustical Terms used throughout this report. For words used within this report without a corresponding definition, refer to Australian Standard 1633-1985 "Acoustics - Glossary of Terms and Related Symbols".

2.0 SITE DETAILS

The Cadia Hill Project area is located 25 km southwest of Orange in the Central Tablelands of New South Wales as shown on the Locations Plans in Attachment C-2. The project area covers approximately 700 ha along the Cadiangullong Creek valley. The general landscape is undulating, cleared and well grassed, gradually changing to steeper and less cleared terrain rising toward Mount Canobolas.

As part of the Cadia Hill development it is planned that there be a buffer zone of approximately 3100 ha of land around the mine site and its associated works to minimise the impact of mining activities on adjoining land holders. Most of the land in the proposed Mine Buffer Zone (MBZ) is currently used for improved pasture grazing.

Newcrest either owns or has options to buy the majority of the properties within the MLA area. The properties which it does not have an option over are all the Crown Reserves, Crown roads and public roads within the MLA area, and includes a portion of the property on the southern boundary of the MLA owned by Sally Jane Gordon. Adjacent lands are owned by Newcrest, private land holders, the NSW Forestry Commission, Crown Land Reserves and Local Government Councils. In 1989 a Permanent Conservation Order (PCO), issued under the NSW Heritage Act, 1977, was placed over a restored Cornish Engine House and Chimney built in the 1860's.

Attachment C-3 is the General Arrangement Plans of the mine's development for Stage I Years 1 and 3 and Stage II Years 4, 6, 9 and 12. The seven nearest potentially affected rural residential properties beyond the MLA boundary (selected as Key Noise Monitoring Locations) and the chimney heritage site are presented in Table 2-1 together with the minimum distance from each dwelling to the near point of the resource, waste dump and plant site areas.

TABLE 2-1
DISTANCE TO NEAREST POTENTIALLY AFFECTED RESIDENTIAL PROPERTIES AND CHIMNEY

Location Number	Property Description	Open Pit		South Waste Dump		North Waste Dump		Plant Site
		Year 1	Year 12	Year 1	Year 12	Year 1	Year 2	Fixed
DG1	Tunbridge Wells	3,450 m	3,150 m	4,700 m	4,700 m	3,700 m	3,700 m	3,900 m
DG4	Caringle	3,800 m	3,800 m	2,150 m	2,150 m	5,150 m	5,150 m	2,950 m
DG5	Bundella	3,400 m	3,100 m	2,800 m	2,800 m	4,450 m	4,450 m	2,850 m
DG7	Stratton Vale	5,800 m	5,800 m	3,300 m	3,300 m	7,000 m	7,000 m	4,950 m
DG8	Northwest	5,500 m	5,350 m	3,850 m	3,600 m	5,800 m	5,700 m	4,900 m
DG9	Cornwall	3,050 m	2,950 m	4,450 m	3,550 m	1,700 m	1,550 m	3,800 m
DG12	Lagoon Farm	4,300m	4,250 m	5,350 m	3,950 m	3,200 m	3,000 m	4,850 m
-	Chimney	1,100 m	800 m	2,250 m	2,250 m	1,750 m	1,750 m	1,450 m

3.0 PROJECT OVERVIEW

3.1 MINE SITE CONSTRUCTION PHASE

The overall construction phase of the mine will be of 24 months duration, involving an average of some 400 staff working a single shift, with peak level of 600 during critical short periods. The 400 staff level is considered appropriate for design purposes, although it is acknowledged that construction worker levels can be expected to vary during the particular construction tasks under operation.

Site access will involve the relocation of Cadia Road from the western side of the site to the eastern side, to align with Triangle Road in the vicinity of Wire Gully Diggings. The relocated Cadia Road enables the construction of a site access loop road which will ensure that the mine operates relatively independently of the local road network (Cadia Road).

3.2 MINING OPERATIONS

The geometry and low metal grades of Cadia Hill's mineralisation mean that it would be necessary to design a project that achieves economies of scale using large tonnage, low cost bulk mining methods.

The mining method proposed for Cadia Hill Project is conventional open pit operation. It is anticipated that ore production will be 17 Mtpa, with waste rock generation in excess of 55 Mtpa. Gold production will average 300,000 ounces per year.

The pit will be developed over two stages, with Stage I developing the upper topographical areas from RL 775 down to 505. Stage II will cut back the pit into the ridge to the north and develop the pit across Cadiangullong Creek in Year 4.

Waste rock and ore removal will be by conventional drill, blast, load and haul operation using electronic shovels and large rear dump trucks.

3.3 PROCESSING OPERATIONS

The mineralisation in the Cadia Hill Project ore body is predominantly pyrite, with lesser amounts of chalcopyrite and minor amounts of bornite, digenite and chalcocite.

Initially the Run-of-Mine (ROM) ore will be trucked to a primary crusher outside the pit and the crushed product trucked to a conveyor at the mill for storage as coarse ROM stockpile. The coarse ore will then be transferred to the grinding and gravity-flotation circuit where the majority of gold concentrate can be recovered. Standard flotation reagents will be used as part of the concentrating process.

Copper concentrate will gravitate to separate high rate thickeners where flocculant will be added to enhance settling rate and improve thickener overflow clarity. The final product will consist of copper concentrate containing gold credits. Tailings from each flotation section will be thickened and then pumped to the tailings disposal facility.

3.4 FILTER STATION AND RAIL SIDING OPERATIONS

The transportation of gold/copper concentrate will involve a slurry pipeline to the existing (FCL) container terminal at Blayney. The slurry concentrate would be delivered to the filter station in Blayney via a pipeline from Cadia Hill along current road easements and dewatered using filter press equipment.

The dried concentrate material is then stockpiled (1,000t maximum) before loading into 20t containers ready for transport from Blayney to Newcastle on cargo trains. The facility will be fully enclosed with a large single shed abutting a rail-head site of the existing rail line through Blayney. The concentrate will then be hauled via the Main Western Railway.

The FCL container terminal at Blayney operates under existing licence conditions. An assessment of its noise impact potential is therefore beyond the scope of this study.

4.0 HOURS OF OPERATION

4.1 MINE SITE CONSTRUCTION PHASE

The preferred periods for construction activity are as follows:

Monday to Saturday	0600 hrs to 2200 hrs (regular)
Sunday	0600 hrs to 2200 hrs (occasional)

4.2 MINING AND PROCESSING OPERATIONS

Mining and processing operations would be conducted over two 12 hour shifts, seven days per week throughout the year, with changeovers at 0600 hours and 1800 hours.

4.3 BLASTING OPERATIONS

Ore and waste blasting will be restricted to the following times:

Monday to Sunday	0600 hrs to 2000 hrs

5.0 MINE SITE EXISTING ACOUSTICAL ENVIRONMENT

5.1 OVERVIEW OF METHODOLOGY

Ambient noise surveys to characterise and quantify the existing winter season acoustical environment in the area surrounding the proposed mine were conducted by Woodward-Clyde in May and June 1994. Additional summer season ambient noise surveys were conducted by Woodward-Clyde in accordance with the methodology and procedures detailed in RHA Project Quality Plan 4288-Q1 in December 1994 and January 1995.

The background noise monitoring programme was implemented in accordance with AS 1055-1989, "Acoustics - Description and Measurement of Environmental Noise" and the EPA's Environmental Noise Control Manual. Unattended environmental noise loggers were positioned at five and seven key monitoring locations as shown in Table 2-1 for the winter and summer measurement surveys respectively.

In order to supplement the unattended noise logger measurements and to assist in identifying the character and duration of ambient noise sources, operator-attended surveys were also conducted at all monitoring locations at various intervals throughout the survey periods.

It should be noted that the background noise measurements conducted at the Willunga (DG9) residence have been used for assessment purposes at the Cornwall property, as Willunga was incorporated into the MLA boundary subsequent to the background noise monitoring program.

The Willunga residence is located approximately 500 m from the Cornwall residence and is representative of the background noise environment for this area including the Cornwall property.

5.2 INSTRUMENTATION AND MEASUREMENT PARAMETERS

5.2.1 Unattended Monitoring and Operator-Attended Surveys

All acoustic instrumentation employed throughout the background noise monitoring programme has been designed to comply with the requirements of AS 1259.2-1990, "Sound Level Meters" and carries current NATA or manufacturer calibration certificates.

A description of instrumentation, designated type and serial numbers is shown in Table 5-2-1.

TABLE 5-2-1
ACOUSTIC INSTRUMENTATION SCHEDULE

Location Number	Instrument Description	Designated Type	Serial Number	
			Winter	Summer
DG1	ARL EL015 Noise Logger	Type 2	192442	192424
DG4	ARL EL015 Noise Logger	Type 2	192419	192443
DG5	ARL EL015 Noise Logger	Type 2	-	192442
DG7	ARL EL015 Noise Logger	Type 2	192435	192441
DG8	ARL EL015 Noise Logger	Type 2	192412	192440
DG9	ARL EL015 Noise Logger	Type 2	192422	192405
DG12	ARL EL015 Noise Logger	Type 2	-	193444
Operator Attended	Brüel & Kjær 2231 Precision Integrating SLM	Type 1	1470014	
Calibration	Brüel & Kjær 4230 Acoustic Calibrator	Type 1	1103316	
Operator Attended	Rion NA-29 Sound Level Meter	Type 1	01280406	
Calibration	Quest Electronics QC-20 Calibrator	Type 1	QF2080018	

All instrumentation was programmed to record continuously the noise exceedance levels in 15 minute intervals including the L_{Amax}, L_{A1}, L_{A5}, L_{A10}, L_{A50}, L_{A90}, L_{A95}, L_{A99}, L_{Amin} and the L_{Aeq}.

Instrument calibration was conducted before and after each measurement survey, with the variation in calibrated levels not exceeding ±0.5 dBA.

5.2.2 Weather Monitoring Station

Meteorological data was obtained from the base automatic weather monitoring station currently located at the centre of the project site. The weather data gathered from this location was considered representative of weather conditions for the area, throughout the noise monitoring program.

The automatic weather station was programmed to continuously record the meteorological parameters as shown in Table 5-2-2.

TABLE 5-2-2
METEOROLOGICAL
MEASUREMENT PARAMETERS

Measured Parameter	Unit	Sample Interval
Mean wind speed	km/h	60 minutes
Mean wind direction	Degrees	60 minutes
Aggregate rainfall	mm	60 minutes
Mean air temperature	°C	60 minutes
Relative humidity	%	60 minutes

5.3 UNATTENDED NOISE MONITORING RESULTS

The unattended noise logger data from each Key Monitoring Location, together with the measured weather conditions from the Base Meteorological Station were processed on a daily basis.

Prior to further analysis, the ambient noise level data from each location which correlated with periods of unstable weather (e.g. rainfall greater than 0.5 mm or wind speed greater than 18 km/h) were discarded. Similarly, noise level measurements which were potentially affected by occasional drilling operations were also rejected. The acceptable ambient noise level data from each location was then processed using RTA Technology's technique of statistical noise level accumulation. The method of statistical accumulation produces an estimate of the true noise exceedance level (LAN) over the sample period.

The statistical noise exceedance levels (LAN) are the levels exceeded for N% of the interval period. The LA90 represents the level exceeded for 90% of the interval period and is referred to as the average minimum or background noise level. The LA10 is the level exceeded for 10% of the time and is usually referred to as the average maximum noise level. The LAeq is the equivalent continuous sound pressure level and represents the steady sound level which is equal in energy to the fluctuating level over the interval period.

The acceptable background noise level data were longitudinally accumulated from Monday to Sunday to produce a 24 hour statistical accumulation of the primary noise parameters (LA1, LA10, LAeq and LA90), in 15 minute intervals. The accumulated background noise level data for each Key Monitoring Location is presented for winter and summer surveys in Attachment C-4 and Attachment C-5 respectively.

In order to derive the overall winter background noise levels for various daily time periods, the data was then laterally accumulated for the period 0700 hours to 1800 hours (daytime), 1800 hours to 2200 hours (evening) and 2200 hours to 0700 hours (night-time). The accumulated winter season background noise levels for each Key Monitoring Location are presented in Table 5-3-1.

Winter season background noise measurements were not conducted at Bundella (DG5) and Lagoon Farm (DG12) and therefore 30 dBA has been presented in Table 5-3-1 as the assumed LA90 background noise level for daytime, evening and night-time.

In addition, due to the relatively small sample of winter season data at Location DG9, it is reasonable to assume that the LA90 background noise levels would be less than 30 dBA and therefore 30 dBA will be used in the evaluation of appropriate mine noise emission limits.

Similarly, to derive the overall summer background noise levels the data were laterally accumulated for the period 0600 hours to 1800 hours (daytime), 1800 hours to 2200 hours (evening) and 2200 hours to 0600 hours (night-time). The accumulated summer season background noise levels for each Key Monitoring Location are presented in Table 5-3-2.

TABLE 5-3-1
ACCUMULATED WINTER SEASON LA90 BACKGROUND NOISE LEVELS

Location Number	Property Name	Daytime - (dBA)				Evening - (dBA)				Night-time - (dBA)			
		LA1	LA10	LAeq	LA90	LA1	LA10	LAeq	LA90	LA1	LA10	LAeq	LA90
DG1	Tunbridge Wells	58	50	50	30	57	48	46	22*	60	51	49	21*
DG4	Caringle	56	50	47	32	49	42	39	29*	55	48	44	28*
DG5	Bundella	-	-	-	30	-	-	-	30	-	-	-	30
DG7	Stratton Vale	57	49	48	30	54	44	42	29*	52	46	42	29*
DG8	Northwest	55	47	45	26*	48	40	39	24*	48	40	37	24*
DG9	Willunga (Cornwall)	69	62	58	35	66	60	56	34	65	60	56	33
DG12	Lagoon Farm	-	-	-	30	-	-	-	30	-	-	-	30

Note: All LA90 noise levels less than 30 dBA may have been influenced by the loggers electronic noise floor.

TABLE 5-3-2
ACCUMULATED SUMMER SEASON L_{A90} BACKGROUND NOISE LEVELS

Location Number	Property Name	Daytime - (dBA)				Evening - (dBA)				Night-time - (dBA)			
		L_{A1}	L_{A10}	L_{Aeq}	L_{A90}	L_{A1}	L_{A10}	L_{Aeq}	L_{A90}	L_{A1}	L_{A10}	L_{Aeq}	L_{A90}
DG1	Tunbridge Wells	60	51	56	32	68	50	54	32	51	41	43	30
DG4	Caringle	58	52	53	37	56	50	50	37	56	48	46	32
DG5	Bundella	63	52	54	28*	54	47	47	29*	55	46	48	23*
DG7	Stratton Vale	62	54	52	31	57	49	48	31	57	47	46	25*
DG8	Northwest	57	47	53	28*	54	47	57	27*	52	45	47	23*
DG9	Willunga (Cornwall)	63	54	55	32	63	52	55	32	58	50	50	27
DG12	Lagoon Farm	56	48	50	29*	52	47	54	31	48	43	45	29*

Note: All L_{A90} noise levels less than 30 dBA may have been influenced by the loggers electronic noise floor.

In accordance with Chapter 20 of the EPA's Environmental Noise Control Manual, if the existing background noise level is below 30 dBA, then 30 dBA shall be assumed to be the background noise level. This assumption therefore applies to the accumulated L_{A90} background noise levels as indicated by the asterisks in Table 5-3-1 and Table 5-3-2.

5.4 OPERATOR-ATTENDED NOISE SURVEYS

At each Key Monitoring Location operator-attended noise surveys of 15 minutes duration were conducted on at least once throughout the summer season program during the periods shown in Table 5-4-1.

TABLE 5-4-1
SUMMER SEASON ATTENDED NOISE SURVEY PERIODS

Time (hours)	Period
0600 - 1000	Daytime
1000 - 1400	Daytime
1400 - 1800	Daytime
1800 - 2200	Evening
2200 - 0200	Night-time
0200 - 0600	Night-time

The attended noise measurements were conducted with a precision integrating sound level meter in order to qualify the results obtained with the unattended noise loggers. During attended noise surveys, the operator identified the character and duration of acoustically significant ambient noise sources. Wherever possible the operator quantified local traffic flow and made a quantitative assessment of the prevailing weather conditions.

5.5 OPERATOR-ATTENDED NOISE SURVEY RESULTS

The winter season operator-attended noise survey results are given in Attachment C-6. The survey results include the following information:

- A description of the measurement location and reference co-ordinates.
- The range and maximum overall A-weighted noise levels.
- The range and maximum 1/1 octave band (31.5 Hz to 8 kHz) A-weighted noise levels.

The summer season operator-attended noise survey results are given in Attachment C-7. The survey results include the following information:

- Key Monitoring Location.
- Date and time of the noise survey.
- Measured level of the primary noise parameters including the L_{Aeq}, L_{A1}, L_{A5}, L_{A10}, L_{A50}, L_{A90}, L_{A95} and L_{A99} in the 15 minute interval.
- A description of audible noise sources identified during the survey period.

6.0 IMPACT ASSESSMENT PROCEDURES

6.1 AIRBORNE NOISE EMISSION - GENERAL OBJECTIVES

Responsibility for the control of noise emission from premises scheduled under the NSW Noise Control Act and the NSW Pollution Control Act is vested in the Environment Protection Authority (EPA). In implementing its environmental noise control policy, the EPA has two broad objectives:

a. That the noise from any single source does not intrude greatly above the prevailing background noise level.

b. That the background noise level does not exceed the level appropriate for the particular locality and land use.

6.2 MINE SITE CONSTRUCTION NOISE EMISSION DESIGN LIMITS

In order to limit the potential offensiveness of noise from a specific source, any exceedance of the background noise level should generally not be more than 5 dBA. The increase is determined by comparing the L_{A10} (or average maximum) noise level contributed at the receptor from the potentially intrusive noise occurring with the L_{A90} (or average minimum) value determined in its absence.

When dealing with construction noise and the like, the Authority recognises that a higher level of noise is likely to be tolerated by receptors in view of the relatively short duration of the noise exposure. As a result, the EPA has published guidelines in its Environmental Noise Control Manual (Chapter 171-1) for the control of construction site noise.

In summary, the Authority's preferred approach to the control of construction noise involves the following:

a. Level Restrictions
b. Time Restrictions
c. Silencing

a. Level Restrictions

For a cumulative construction noise exposure period of up to 4 weeks duration, the L_{A10} when measured over a period of not less than 15 minutes when the construction site is in operation should not exceed the background level by more than 20 dBA. For a cumulative noise exposure period of between 4 and 26 weeks, the L_{A10} noise level should not exceed the L_{A90} level by more than 10 dBA. For a cumulative noise exposure period greater than 26 weeks, the L_{A10} noise level should not exceed the L_{A90} level by more than 5 dBA.

b. Time Restrictions

Monday to Friday	0700 hrs to 1800 hrs
Saturday	0700 hrs to 1300 hrs (if inaudible at residential premises), or 0800 hrs to 1300 hrs (audible at residential premises)

No work on Sundays or public holidays.

c. Silencing

All practical measures should be used to silence construction equipment, particularly in instances where extended hours of operation are required.

The results of the background noise measurements and statistical accumulations for the seven Key Monitoring Locations surrounding the project area are presented in Table 5-3-1 and Table 5-3-2. The accumulated L_{A90} background noise levels for the proponent's preferred hours of construction activity are presented in Table 6-2-1.

On the basis of the proponent's preferred hours of construction activity presented in Section 4.1 and the foregoing EPA construction guidelines the calculated L_{A10} contributed noise emission limits are presented in Table 6-2-2 for Monday to Sunday construction activity throughout the year.

6.3 MINING AND PROCESSING NOISE EMISSION DESIGN LIMITS

In order to limit the potential offensiveness of noise from a specific source, the difference between the L_{A10} noise level contributed at the receptor (from the potentially intrusive noise) and the L_{A90} (average minimum) background sound level in its absence, should generally not exceed 5 dBA.

TABLE 6-2-1
ACCUMULATED L_{A90} BACKGROUND NOISE LEVELS FOR PREFERRED CONSTRUCTION HOURS

Location Number	Property Name	Winter Season			Summer Season
		0600 hrs to0700 hrs	0700 hrs to 1800 hrs	1800 hrs to2200 hrs	0600 hrs to 2200 hrs
DG1	Tunbridge Wells	23 dBA	30 dBA	22 dBA	32 dBA
DG4	Caringle	28 dBA	32 dBA	29 dBA	37 dBA
DG5	Bundella	30 dBA	30 dBA	30 dBA	29 dBA
DG7	Stratton Vale	29 dBA	30 dBA	29 dBA	31 dBA
DG8	Northwest	25 dBA	26 dBA	24 dBA	27 dBA
DG9	Willunga (Cornwall)	30 dBA	30 dBA	30 dBA	32 dBA
DG12	Lagoon Farm	30 dBA	30 dBA	30 dBA	30 dBA

Note: 1. All L_{A90} noise levels less than 30 dBA may have been influenced by the loggers' electronic noise floor.
2. The winter season L_{A90} background noise levels at DG9, DG5 and DG12 have been assumed as 30 dBA.
3. If the measured L_{A90} background noise level is below 30 dBA, then 30 dBA shall be the assumed noise level.

TABLE 6-2-2
CALCULATED L_{A10} CONTRIBUTED NOISE EMISSION LIMITS - CONSTRUCTION PHASE

Location Number	Property Name	Preferred Construction Hours 0600 hrs to 2200 hrs		
		Up to 4 wk	4 to 26 wk	Greater than 26 wk
DG1	Tunbridge Wells	50 dBA	40 dBA	35 dBA
DG4	Caringle	50 dBA	40 dBA	35 dBA
DG5	Bundella	50 dBA	40 dBA	35 dBA
DG7	Stratton Vale	50 dBA	40 dBA	35 dBA
DG8	Northwest	50 dBA	40 dBA	35 dBA
DG9	Cornwall	50 dBA	40 dBA	35 dBA
DG12	Lagoon Farm	50 dBA	40 dBA	35 dBA

To assist in balancing possibly adverse effects on individuals and potential benefits to the broader community arising from infrastructure development and resource use (especially in the light of its social worth or as a result of government decisions), the EPA has drafted a schedule of recommended L_{A90} background noise levels for various land-use categories. An extract from the schedule relating to the three most stringent classifications is presented in Table 6-3-1.

TABLE 6-3-1
EPA RECOMMENDED OUTDOOR L_{A90} BACKGROUND NOISE LIMITS

Zoning Description	Time Period	Recommended L_{A90} Limits	
		Acceptable	Extreme
Residences in Rural Areas	Day	45 dBA	50 dBA
	Night	35 dBA	40 dBA
Residences in Residential Areas	Day	45 dBA	50 dBA
	Night	35 dBA	40 dBA
Residences Near Industrial Areas or on Busy Roads	Day	50 dBA	55 dBA
	Night	40 dBA	45 dBA

Notes
1. For Monday to Saturday, "day" is defined at 0700 hours to 2200 hours
2. On Sundays and Public Holidays, "day" is defined as 0800 hours to 2200 hours

The EPA's objective is for the L_{A90} background noise levels not to exceed the specified "acceptable" limit. Where the recommended "acceptable" level is not achievable (for technical or economic reasons), then the lowest achievable may be permitted, provided the resultant noise levels at the receptors do not exceed the relevant "extreme" limit.

In localities where there is likely to be on-going industrial or infrastructure development, consideration needs to be given to the cumulative effects of noise from successive development in order to avoid what is known as a "creeping background noise" effect. In view of the potential resource development in the Cadia area it is appropriate that some consideration be given to this effect occurring in the vicinity of the project site.

The results of the background noise measurements and statistical accumulations for the six Key Monitoring Locations surrounding the project area are presented in Table 5-3-1 and Table 5-3-2. On the basis of the L_{A90} background noise levels and Table 20-1 from the EPA's Noise Control Manual, the daytime, evening and night-time acceptable L_{A10} contributed noise emission limits for winter and summer seasons are presented in Table 6-3-2 and Table 6-3-3 respectively, for Monday to Sunday mining and processing operations.

TABLE 6-3-2
EPA ACCEPTABLE L_{A10} CONTRIBUTED NOISE EMISSION LIMITS - WINTER SEASON

Location Number	Property Name	Daytime 0700 hrs to 1800 hrs	Evening 1800 hrs to 2200 hrs	Night-time 2200 hrs to 0700 hrs
DG1	Tunbridge Wells	35 dBA*	35 dBA*	33 dBA*
DG4	Caringle	37 dBA*	35 dBA*	33 dBA*
DG5	Bundella	35 dBA*	35 dBA*	33 dBA*
DG7	Stratton Vale	35 dBA*	35 dBA*	33 dBA*
DG8	Northwest	35 dBA*	35 dBA*	33 dBA*
DG9	Cornwall	35 dBA*	35 dBA*	33 dBA*
DG12	Lagoon Farm	35 dBA*	35 dBA*	33 dBA*

TABLE 6-3-3
EPA ACCEPTABLE L_{A10} CONTRIBUTED NOISE EMISSION LIMITS - SUMMER SEASON

Location Number	Property Name	Daytime 0700 hrs to 1800 hrs	Evening 1800 hrs to 2200 hrs	Night-time 2200 hrs to 0700 hrs
DG1	Tunbridge Wells	37 dBA	37 dBA	33 dBA*
DG4	Caringle	42 dBA	42 dBA	32 dBA*
DG5	Bundella	35 dBA*	35 dBA*	33 dBA*
DG7	Stratton Vale	36 dBA	36 dBA	33 dBA*
DG8	Northwest	35 dBA*	35 dBA*	33 dBA*
DG9	Cornwall	37 dBA	37 dBA	33 dBA*
DG12	Lagoon Farm	35 dBA*	36 dBA	33 dBA*

In view of the foregoing discussion, it is recommended that the L_{A10} contributed noise emission limits for summer and winter be rationalised. A composite set of limits, as indicated by the asterisks in Tables 6-3-2 and 6-3-3, should therefore be adopted for the purpose of noise impact assessment at the seven residential properties surrounding the project area during the proposed hours of operation Monday to Sunday.

The composite L_{A10} contributed noise emission limits are presented in Table 6-3-4 for Monday to Sunday mining and processing operations.

TABLE 6-3-4
RECOMMENDED L_{A10} CONTRIBUTED NOISE EMISSION LIMITS - MONDAY TO SUNDAY

Location Number	Property Name	Daytime 0700 hrs to 1800 hrs	Evening 1800 hrs to 2200 hrs	Night-time 2200 hrs to 0700 hrs
DG1	Tunbridge Wells	35 dBA	35 dBA	33 dBA
DG4	Caringle	37 dBA	35 dBA	32 dBA
DG5	Bundella	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	35 dBA	35 dBA	33 dBA
DG8	Northwest	35 dBA	35 dBA	33 dBA
DG9	Cornwall	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	35 dBA	35 dBA	33 dBA

6.4 BLAST EMISSIONS DESIGN LIMITS

6.4.1 Ground Vibration - Structural Damage AS 2187.2-1993

The vibration velocity "damage" criteria recommended in the Standards Association's Explosives Code, AS 2187.2-1993, vary according to the type of building and are defined in terms of peak particle velocity (PPV), as shown in Table 6-4-1.

TABLE 6-4-1
RECOMMENDED PEAK PARTICLE VELOCITY - AS 2187.2

Type of Building or Structure	Particle Velocity (Vp)
Houses and low-rise residential buildings; commercial buildings not included below	10 mm/s
Commercial and industrial buildings or structures of reinforced concrete or steel construction	25 mm/s

Notes:
1. This table does not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations which may necessitate taking additional measurements on the structure itself, to detect any magnification of ground vibrations which might occur within the structure. Particular attention should be given to the response of suspended floors.
2. In a specific instance, where substantiated by careful investigation, a value of peak particle velocity other than that recommended in the Table may be used.
3. The peak particle velocities in the Table have been selected taking into consideration both human discomfort and structural integrity together with the effect on sensitive equipment located within buildings.

The standard goes on to say that "The likelihood of damage in residential areas starts to increase at ground vibration levels above 10 mm/s (peak particle velocity). Structures which may be particularly susceptible to ground vibration should be examined on an individual basis. Peak particle velocity may not be the appropriate criterion for determination of damage. In the absence of a particular site-specific study which may determine the appropriate damage criterion, then peak particle velocity is suggested as the damage criterion and a maximum level of 5 mm/s is recommended for blast design purposes, as experience has shown that damage is unlikely to occur at ground vibration levels below this level".

The majority of buildings in the area surrounding the project site are low-rise residential buildings and therefore attract the ground vibration damage criterion of 5 mm/s peak vector sum (PVS).

6.4.2 Ground Vibration - Structural Damage DIN 4150-Part 3:1986

As stated in AS 2187.2, structures which may be particularly susceptible to ground vibration, which would include the historic Cornish Engine House and Chimney, should be examined on an individual basis. German Standard DIN 4150 - Part 3:1986 provides guideline levels of vibration velocity for evaluating the effects of short term vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The relationship between levels of structural vibration inducted by ground vibration and the probability of damage to structures is extremely complex. This is due to the very great variations between structures in regard to design, dimensions, materials, methods and quality of construction, type and condition of foundation, and pre-stress effects. The intensity, duration, frequency content and number of occurrences of the vibration, all play an important role in the strains induced in the structure and the extent of any possible damage.

Even with a reasonable knowledge of all these factors for a particular class of structure, it may still be difficult to assess the risk of vibration damage to a specific building because of great uncertainties regarding the extent of static pre-stress within the structural and surface elements, and any secondary stress effects caused by differential settlements, wind, and dampness and temperature variations.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised and presented in Table 6-4-2.

The minimum "safe limit" of peak vibration velocity at low frequencies for commercial building and buildings of similar design is 20 mm/s (Group 1). For dwellings and buildings of similar design and/or use it is 5 mm/s (Group 2) and for structures which may be particularly sensitive to ground vibration, such as historic buildings with preservation orders (Group 3), it is 3 mm/s. This latter criterion could also be applied to buried archaeological artefacts.

TABLE 6-4-2
DIN 4150 - STRUCTURAL DAMAGE - SAFE LIMITS FOR BUILDING VIBRATION

Group	Type of Structure	Vibration Velocity in mm/s			
		Frequency at Foundation			Plane of Floor of Uppermost Storey
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures with particular sensitivity to vibration, not corresponding to those listed in Groups 1 or 2, and that have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used

It should be noted from Table 6-4-2 that levels higher than these minimum figures for low frequencies may be quite "safe", for high frequencies.

It should also be noted that these levels are "safe limits", up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Should such damage be observed without vibration levels exceeding the "safe limits" then it should be attributed to other causes. DIN 4150 also states that when vibration levels higher than the "safe limits" are present, it does not necessarily follow that damage will occur.

6.4.3 Airblast - Structural Damage

Based largely on work carried out by the US Bureau of Mines, the US Office of Surface Mining has presented the following regulatory limits for airblast from blasting (depending on the low frequency limit of the measuring system):

Low Frequency Limit	Peak Airblast Level Limit
2 Hz or lower	132 dB (Linear)
6 Hz or lower	130 dB (Linear)

These levels are generally consistent with the level of 133 dB(Linear) nominated in AS 2187.2-1993.

The US criteria are structural damage limits based on relationships between level of airblast and probability of window breakage, and include a significant safety margin. It has been well documented that windows are the elements of residential buildings most at risk to damage from airblast from blasting.

While cracked plaster is the type of damage most frequently monitored in airblast complaints, research has shown that window panes fail before any other structural damage occurs (USBM, RI 8485-1980). The probabilities of damage to windows exposed to a single airblast event are as shown in Table 6-4-3.

TABLE 6-4-3
PROBABILITY OF WINDOW DAMAGE FROM AIRBLAST

Overpressure dBLinear	Level kPa	Probability of Damage	Effects and Comments
140	0.2	0.01%	"No damage" - windows rattle
150	0.6	0.5%	Very occasional failure
160	2.0	20%	Substantial failures
180	20.0	95%	Almost all fail

6.4.4 Human Comfort and Disturbance Considerations

The ground vibration and airblast levels which cause concern or discomfort to residents are significantly lower than the damage limits.

The recommended criteria for blasting in NSW based on human discomfort are contained in the EPA's Noise Control Manual (Chapter 154). The limiting criteria for the control of blasting impact at residences is reproduced in Table 6-4-4.

Overpressure exceedance is to be limited to 120 dB (Linear) for not more than 5% of the total number of blasts.

Ground vibration exceedance is to be limited to 10 mm/s (ppv) for not more than 5% of the total number of blasts.

TABLE 6-4-4
LIMITING CRITERIA FOR THE CONTROL OF BLASTING IMPACT AT RESIDENCES

Time of Blasting		Blast Overpressure Level (dBLinear)	Ground Vibration, Peak Particle Velocity (mm/sec)
Monday - Saturday	0900 hrs to 1500 hrs	115	5
Monday - Saturday	0600 hrs to 0900 hrs	105	2
	1500 hrs to 2000 hrs		
Sunday and Public Holidays	0600 hrs to 2000 hrs	95	1
	2000 hrs to 0600 hrs		

Note: The 95 dB to 105 dB airblast levels set down by the EPA for extended hours or weekends are considered overly restrictive, and are lower than the thresholds at which building occupants would perceive any appreciable effect of the blast event. Should blasting be anticipated to occur during periods when these limits would apply, then application should be made to the EPA (with supporting technical data), for a variation in the limits.

The Australian Standard 2187.2-1993 does not give human comfort criteria for ground vibration from blasting. It does however make mention of human comfort level for airblast in saying that "A limit of 120 dB for human comfort is commonly used".

6.5 ROAD TRAFFIC NOISE DESIGN LIMITS

Whilst operating on privately owned property, the noise assessment procedure for road traffic noise is as previously outlined in Section 6.3. That is, the predicted L_{A10} noise contributions are added to the predicted L_{A10} noise level of the items mobile equipment and processing plant. On public roads, different noise assessment criteria apply.

In some instances, an intermediate approach between the "private" and "public" roadway assessment approaches may be appropriate. This could, for example, apply to an isolated private road, well away from the mining or processing operations, where the vehicle noise would be clearly perceived as "traffic" noise, rather than as part of the operations.

The EPA's criteria for traffic noise on public roads having volume flows of less than about 1000 vehicles per day are described under the section "Intermittent or Low Traffic Flow" in the Environmental Noise Control Manual and employ an $L_{Aeq,T}$ description. The time interval (T) generally used is 60 minutes.

For rural situations, the EPA recommends that residences should have an $L_{Aeq,T}$ of not more than 50 dBA for new developments and 55 dBA for existing situations during daytime hours. An $L_{Aeq,T}$ 5 dBA below these levels is generally acknowledged as applicable to night-time hours (2200 hours to 0700 hours), although some consideration of sleep arousal effects is also required.

The EPA's preferred hours of operation for truck movements are presented in Table 6-5-1.

TABLE 6-5-1
EPA'S PREFERRED HOURS FOR TRUCK MOVEMENTS

Frequency of Vehicle Movement	Preferred Hours of Operation	
	Monday to Saturday	Sunday and Public Holidays
Normal frequency	0700 hrs to 1800 hrs	Minmal movement, subject to individual assessment
At substantially reduced frequency	0600 hrs to 0700 hrs 1800 hrs to 2200 hrs	0800 hrs to 1800 hrs
Minimal or isolated occurrence	2200 hrs to 0600 hrs	1800 hrs to 0800 hrs

Based upon the foregoing, the design limits for road traffic noise at residences along Cadia Road are an $L_{Aeq,T}$ level of 50 dBA for daytime (0700 hours to 2200 hours) vehicle movements with an $L_{Aeq,T}$ level of 45 dBA recommended for any night-time (2200 hours to 0700 hours) vehicle movements.

7.0 MAJOR SOURCES OF EMISSION

The major sources of noise and vibration emissions may be grouped into three distinct areas for the purpose of impact assessment and are as follows:

Mine Noise

- Noise emission from mobile plant and equipment during the mine site construction phase.
- Noise emission from mine operations including fixed processing plant and mobile earthmoving equipment.

Emissions from Blasting

- Ground-borne vibration and airblast noise resulting from blasting operations.

Transportation Noise

- Noise emission from traffic on public roads during both construction and operational phases.

These are assessed in the following sections of this report.

8.0 MINE NOISE IMPACT ASSESSMENT

8.1 EVALUATION OF NOISE EMISSION LEVELS - GENERAL DISCUSSION

In order to determine the acoustical impact from mining, a computer model was developed incorporating the significant proposed noise sources, the surrounding terrain and nearby potentially affected rural residential properties.

The Cadia Hill Project computer model was prepared using RTA Software's Environmental Noise Model (ENM for Windows, Version 3.04), a commercial software system developed in conjunction with the NSW Environment Protection Authority. Although the present state of knowledge in respect to atmospheric propagation and ground effects is incomplete, the acoustical algorithms utilised by this software have been endorsed by the Australian and New Zealand Environment Council and all State Environmental Authorities throughout Australia as being the most appropriate currently available.

For the purpose of predicting the noise emission levels during the mine's construction and operational phases of development, the following operating scenarios were assessed:

- Construction Phase - Weir and plant site earthworks (anticipated duration greater than 26 weeks).
- Construction Phase - Tailings dam earthworks (anticipated duration 26 weeks).
- Mine Operations Stage I - Year 1 (northern and southern waste dump operation).
- Mine Operations Stage II - Year 4 (southern waste dump operation).
- Mine Operations Stage II - Year 6 (southern waste dump operation).

The ENM noise model sound power levels (SWL) were derived from file data of similar items of mobile equipment and fixed plant. If necessary the SWL's were adjusted to suit the overall mechanical or electrical power rating of the equipment to be used for this project.

Attachment C-8 is the ENM noise model data sheet which provides the following information:

- A description of the modelling scenarios
- The total number of each type of plant or equipment
- A description of the mobile equipment or fixed plant
- The source of the SWL data and the condition of operation
- The maximum overall A-weighted SWL for each item
- The maximum linear octave band SWL for each item
- The acoustical source height above ground level for each item
- The local co-ordinates (X, Y, Z) for each item during each modelling scenario.

The SWL data were incorporated into the model to predict the maximum contributed noise emission levels in octave bands from each source to the receiver localities. The overall maximum contributed noise emission level at the receiver is calculated from concurrent operation of all items of equipment located in "typical" operating positions for each scenario assessed.

Based on field measurements of noise emissions from large mining projects, the difference between the overall maximum and L_{A10} noise levels can be up to 7 dBA. A common reduction of 5 dBA has therefore been applied to convert the overall maximum noise levels to L_{A10} noise levels in accordance with EPA assessment requirements.

It should be noted that the maximum sound power levels given for each item of mobile equipment do not include noise emissions which emanate from reversing alarms. In general terms, the intermittent activation and character of reversing alarms when in operation at significant distances from a receiver, result in a negligible contribution to the L_{A10} noise emission from the overall mining operation.

In the event that reversing alarm noise is considered to be a source of annoyance, the alarm noise level should be checked against the appropriate Department of Mineral Resource requirements and the necessary mitigating action taken to achieve an acceptable noise reduction without compromising safety standards.

8.2 MINE SITE CONSTRUCTION PHASE

Predicted Noise Emissions Levels

The predicted overall contributed L_{A10} noise emission levels for the construction phase at the seven nearest potentially affected residential properties have been calculated under the following meteorological conditions:

- Firstly, for "neutral" atmospheric conditions (i.e. 20°C air temperature, 70% relative humidity, 0°C /100 m temperature gradient and 0 m/s wind speed) as advocated by the EPA, which would generally apply to daytime operations.

- Secondly, for adverse weather conditions (i.e. 12°C air temperature, 65% relative humidity, 0°C /100 m temperature gradient and 1.5 m/s wind velocity 11.25° east of north).

  As shown by the wind roses attached as Attachment C-9, this wind condition occurs between 1800 hours and 2200 hours on approximately 25% of evenings throughout the year.

The predicted overall contributed L_{A10} noise emission levels for the two construction phases to the seven nearest potentially affected residential properties are given in Table 8-2-1 together with the corresponding L_{A10} contributed noise emission limits as presented in Table 6-2-2.

TABLE 8-2-1
PREDICTED LA10 CONTRIBUTED NOISE EMISSION LEVELS - CONSTRUCTION PHASE

Location Number	Property Name	Construction Emission Overall L_{A10}				Calculated L_{A10} Noise Limits		
		Weirs and Plant Site		Tailings Dam		< 4 Wk	4 to 26 Wk	>26 Wk
		Neutral	Wind	Neutral	Wind			
DG1	Tunbridge Wells	23 dBA	20 dBA	13 dBA	10 dBA	50 dBA	40 dBA	35 dBA
DG4	Caringle	11 dBA	27 dBA	22 dBA	20 dBA	50 dBA	40 dBA	35 dBA
DG5	Bundella	9 dBA	27 dBA	22 dBA	18 dBA	50 dBA	40 dBA	35 dBA
DG7	Stratton Vale	7 dBA	21 dBA	30 dBA	42 dBA	50 dBA	40 dBA	35 dBA
DG8	Northwest	22 dBA	34 dBA	24 dBA	22 dBA	50 dBA	40 dBA	35 dBA
DG9	Cornwall	25 dBA	20 dBA	13 dBA	8 dBA	50 dBA	40 dBA	35 dBA
DG12	Lagoon Farm	9 dBA	10 dBA	9 dBA	4 dBA	50 dBA	40 dBA	35 dBA

Impact Assessment

The following assessments are derived from the predicted noise levels presented in Table 8-2-1 and the calculated construction noise emission limits presented in Table 6-2-2:

a. The contributed L_{A10} noise levels from the weirs and plant site construction phase, during both neutral and adverse wind conditions comply with the most stringent noise emission limit of 35 dBA at all residential properties.

b. The contributed L_{A10} noise levels from the tailings dam construction phase, during both neutral and adverse wind conditions, comply with the most stringent noise emission limit of 35 dBA at all residential properties with an exception being at Stratton Vale (DG7).

   It is anticipated however that construction of the tailings dam will be restricted to within a 6 month period. The Stratton Vale (DG7) residence therefore, because of its locality with respect to the tailings dam, would attract a noise emission limit of 40 dBA. The predicted L_{A10} noise emission level of 42 dBA therefore marginally (2 dBA) exceeds this limit, which is only likely to occur under an adverse wind condition on approximately 25% of evenings throughout the year.

It is therefore recommended that noise levels be routinely monitored at the Stratton Vale (DG7) residence during the construction of the tailings dam, and the works be modified if necessary to ensure that noise emissions do not significantly exceed the noise emission limits.

8.3 MINING AND PROCESSING OPERATIONS - STAGE I

Predicted Noise Emission Levels

The predicted overall contributed L_{A10} noise emission levels for the two mine operating stages to the seven nearest potentially affected residential properties have been calculated under the following meteorological conditions:

- Firstly, for "neutral" atmospheric conditions (i.e. 20°C air temperature, 70% relative humidity, 0°C/100 m temperature gradient and 0 m/s wind velocity) as advocated by the EPA, and would generally apply to daytime operations.

- Secondly, for an adverse wind condition (i.e. 6°C air temperature, 85% relative humidity, 0°C/100 m temperature gradient and 1.5 m/s wind velocity 11.25° east of north).

  As shown by the wind roses attached as Attachment C-9, this wind condition occurs between 2200 hours and 0600 hours on approximately 25% of nights throughout the year.

- Thirdly, for an adverse temperature inversion (i.e. 6°C air temperature, 85% relative humidity, 3°C/100 m temperature gradient and 0 m/s wind velocity).

  A 3°C/100 m vertical temperature gradient would generally be considered as a strong inversion. In the absence of site specific temperature gradient data, it is assumed that a temperature inversion up to 3°C/100 m gradient may occur on approximately 25% of nights throughout the year.

The predicted overall contributed L_{A10} noise emission levels for Stage I mine operations at the seven nearest potentially affected residential properties are presented in Table 8-3-1 together with the corresponding noise emission limits as presented in Table 6-3-4.

Impact Assessment

The following assessments are derived from the predicted noise levels presented in Table 8-3-1 and the recommended mine operation emission limits presented in Table 6-3-4.

a. The contributed L_{A10} noise levels from Year 1 mining operations during neutral meteorological conditions

TABLE 8-3-1
PREDICTED L_{A10} CONTRIBUTED NOISE EMISSION LEVELS - YEAR 1 MINE OPERATIONS

Location Number	Property Name	Mining Emission Overall L_{A10}			Recommended L_{A10} Noise Limits		
		Stage I - Year 1			Daytime	Evening	Night-time
		Neutral	Wind	Inversion	0700 hrs to 1800 hrs	1800 hrs to 2200 hrs	2200 hrs to 0700 hrs
DG1	Tunbridge Wells	27 dBA	25 dBA	37 dBA	35 dBA	35 dBA	33 dBA
DG4	Caringle	30 dBA	40 dBA	39 dBA	37 dBA	35 dBA	32 dBA
DG5	Bundella	20 dBA	31 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	20 dBA	38 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG8	Northwest	16 dBA	30 dBA	27 dBA	35 dBA	35 dBA	33 dBA
DG9	Cornwall	23 dBA	23 dBA	29 dBA	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	16 dBA	16 dBA	27 dBA	35 dBA	35 dBA	33 dBA

comply with the most restrictive night-time noise criteria and are therefore well below the daytime and evening emission limits at all residential properties.

b. The contributed L_{A10} noise levels during adverse wind comply with the night-time criteria at all residential properties, except Caringle (DG4) and Stratton Vale (DG7).

   The contributed L_{A10} noise level of 40 dBA at Caringle (DG4) and 38 dBA at Stratton Vale (DG7) during adverse wind may appreciably exceed the night-time criterion by 8 dBA and 5 dBA respectively.

c. The contributed L_{A10} noise levels during a strong temperature inversion may marginally exceed the night-time criterion by 2 dBA at both Bundella (DG5) and Stratton Vale (DG7).

   Similarly, the contributed L_{A10} noise level during a strong temperature inversion may moderately exceed the night-time criterion by 4 dBA at Tunbridge Wells (DG1).

   Moreover the contribution L_{A10} noise levels of 39 dBA at Caringle (DG4) during a strong temperature inversion may appreciably exceed the night-time criterion by 7 dBA.

It is concluded that the predicted L_{A10} noise levels may appreciably exceed the night-time criterion by up to 8 dBA at Caringle (DG4) during adverse meteorological conditions, from Year 1 mining operations.

Similarly the predicted L_{A10} noise levels may appreciably exceed the night-time criterion by up to 5 dBA at Stratton Vale (DG7), during adverse meteorological conditions, from Year 1 mining operations.

The predicted L_{A10} noise levels comply with the recommended daytime, evening and night-time criteria at all residential properties, with marginal (2 dBA) and moderate (4 dBA) exceedances of the night-time criteria at Bundella (DG5) and Tunbridge Wells (DG1) respectively during strong temperature inversion conditions.

It is anticipated that the noise emission levels predicted for Year 1 mining operations would generally be maintained throughout Year 2, with noise emissions reducing at Tunbridge Wells (DG1) in Year 3 as the northern waste dump will no longer be active.

It is therefore recommended that noise levels be routinely monitored throughout Stage I, and that mining operations be modified where practical to ensure that noise emissions do not significantly exceed the recommended noise limits.

8.4 MINING AND PROCESSING OPERATIONS - STAGE II

Predicted Noise Emission Levels

The predicted overall contributed L_{A10} noise emission levels for Stage II mine operations to the seven nearest potentially affected residential properties are presented in Table 8-4-1 and Table 8-4-2 together with the corresponding noise design limits as presented in Table 6-3-4.

Impact Assessment

The following assessments are derived from the predicted noise levels presented in Table 8-4-1 and Table 8-4-2 and the recommended mine operation noise emission limits presented in Table 6-3-4:

a. The contributed L_{A10} noise levels from Stage II mining operations during neutral atmospheric conditions comply with the most restrictive night-time noise criteria and are therefore well below the daytime and evening emission limits at all residential properties.

   The exception being at Caringle (DG4), where the contributed L_{A10} noise level of 36 dBA may moderately

TABLE 8-4-1
PREDICTED L_{A10} CONTRIBUTED NOISE EMISSION LEVELS - YEAR 4 MINE OPERATIONS

Location Number	Property Name	Mine Emission Overall L_{A10}			Recommended L_{A10} Noise Limits		
		Stage II - Year 4			Daytime	Evening	Night-time
		Neutral	Wind	Inversion	0700 hrs to 1800 hrs	1800 hrs to 2200 hrs	2200 hrs to 0700 hrs
DG1	Tunbridge Wells	22 dBA	17 dBA	34 dBA	35 dBA	35 dBA	33 dBA
DG4	Caringle	36 dBA	42 dBA	42 dBA	37 dBA	35 dBA	32 dBA
DG5	Bundella	29 dBA	29 dBA	38 dBA	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	26 dBA	39 dBA	35 dBA	35 dBA	35 dBA	33 dBA
DG8	Northwest	21 dBA	34 dBA	34 dBA	35 dBA	35 dBA	33 dBA
DG9	Cornwall	20 dBA	18 dBA	27 dBA	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	15 dBA	14 dBA	31 dBA	35 dBA	35 dBA	33 dBA

(4 dBA) exceed the night-time criterion, whilst remaining below the daytime criterion of 37 dBA which would generally apply to neutral atmospheric conditions.

b. The contributed L_{A10} noise levels from Year 4 mining operations during adverse wind may marginally exceed the night-time criterion by 1 dBA at Northwest (DG8).

   Moreover, the contributed L_{A10} noise level of 42 dBA at Caringle (DG4) and 39 dBA at Stratton Vale (DG7) during adverse wind may appreciably exceed the night-time criterion by 10 dBA and 6 dBA respectively.

c. The contributed L_{A10} noise levels from Year 4 mining operations during a strong temperature inversion may marginally exceed the night-time criterion by 1 dBA, 2 dBA and 1 dBA at Tunbridge Wells (DG1), Stratton Vale (DG7) and Northwest (DG8) respectively.

   Moreover, the contributed L_{A10} noise levels of 42 dBA at Caringle (DG4) and 38 dBA at Bundella (DG5) during a strong temperature inversion may appreciably exceed the night-time criterion by 10 dBA and 5 dBA respectively.

d. The contributed L_{A10} noise levels from Year 6 mining operations during an adverse wind may marginally exceed the night-time criteria by 2 dBA at Stratton Vale (DG7).

   Moreover the contributed L_{A10} noise levels of 42 dBA at Caringle (DG4) during an adverse wind, may appreciably exceed the night-time criterion by 10 dBA.

e. The contributed L_{A10} noise level from Year 6 mining operations during a strong temperature inversion may marginally exceed the night-time criterion by 1 dBA at Tunbridge Wells (DG1).

   Moreover, the contributed L_{A10} noise levels of 41 dBA at Caringle (DG4) and 38 dBA at Bundella (DG5) during a strong temperature inversion may appreciably exceed the night-time criterion by 9 dBA and 5 dBA respectively.

It is concluded that the predicted L_{A10} noise levels may appreciably exceed the night-time criterion by up to 10 dBA at Caringle (DG4) during both neutral and adverse wind conditions throughout Stage II mining operations.

TABLE 8-4-2
PREDICTED L_{A10} CONTRIBUTED NOISE EMISSION LEVELS - YEAR 6 MINE OPERATIONS

Location Number	Property Name	Mine Emission Overall L_{A10}			Recommended L_{A10} Noise Limits		
		Stage II - Year 6			Daytime	Evening	Night-time
		Neutral	Wind	Inversion	0700 hrs to 1800 hrs	1800 hrs to 2200 hrs	2200 hrs to 0700 hrs
DG1	Tunbridge Wells	23 dBA	20 dBA	34 dBA	35 dBA	35 dBA	33 dBA
DG4	Caringle	28 dBA	42 dBA	41 dBA	37 dBA	35 dBA	32 dBA
DG5	Bundella	28 dBA	31 dBA	38 dBA	35 dBA	35 dBA	33 dBA
DG7	Stratton Vale	25 dBA	35 dBA	30 dBA	35 dBA	35 dBA	33 dBA
DG8	Northwest	22 dBA	33 dBA	32 dBA	35 dBA	35 dBA	33 dBA
DG9	Cornwall	20 dBA	18 dBA	27 dBA	35 dBA	35 dBA	33 dBA
DG12	Lagoon Farm	16 dBA	15 dBA	32 dBA	35 dBA	35 dBA	33 dBA

The predicted LA10 noise levels may appreciably exceed the night-time criterion by up to 6 dBA at Stratton Vale (DG7) during adverse wind conditions throughout Stage II mining operations.

Similarly, the predicted LA10 noise levels may appreciably exceed the night-time criteria by 5 dBA at Bundella (DG5) during strong temperature inversion conditions throughout Stage II mining operations.

The predicted LA10 noise levels comply with the recommended daytime, evening and night-time criteria at all other residential properties, with marginal (1 dBA) exceedances of the night-time criterion at Northwest (DG8) and Tunbridge Wells (DG1) during adverse meteorological conditions.

It is anticipated that the noise emission levels beyond Year 9 mining operations may commence to diminish as overall extraction rate significantly reduces and haul truck movements are confined to the marginal ore stockpiles on the northeast area of the southern waste dump.

It is therefore recommended that noise levels are routinely monitored throughout Stage II, and mining operations to ensure that noise emissions do not significantly exceed the recommended noise limits.

8.5 MINING AND PROCESSING OPERATIONS NOISE CONTOUR DIAGRAMS

The contributed LA10 noise level contour diagrams are presented in Attachment C-10 for Stage II Year 4 mining operations and meteorological conditions as shown in Table 8-5-1.

TABLE 8-5-1
PREDICTED LA10 CONTRIBUTED NOISE LEVEL CONTOUR DIAGRAMS

Attachment	Mine Operating Scenario	Meteorological Conditions
C-10	Stage II - Year 4	Neutral (ie 20°C, 70%, 0°C/100 m, 0 m/s)
C-10	Stage II - Year 4	Wind (ie 6°C, 85%, 0°C/100 m, 1.5 m/s NNNE)
C-10	Stage II - Year 4	Inversion (ie 6°C, 85%, 3°C/100 m, 0 m/s N)

9.0 BLAST EMISSIONS IMPACT ASSESSMENT

9.1 PROPOSED BLASTING PRACTICES

The proposed method of material extraction (ore and waste) is by drill and blasting techniques as described in Section 3.0. A summary of the proposed blast design details are presented in Table 9-1-1.

The maximum production rate will be 17 million tonnes per annum (tpa) of ore in Years 6 to 9 with a maximum of 57.8 Mt of waste being produced in Year 6. The detailed blast designs presented in Attachment C-11 are based on the information provided in the reports by JKMRC (July, 1994) and ICI Explosives (February, 1995) in relation to the Cadia Mine Project and have been developed to meet the proposed rates of production.

The blast patterns, consisting of seven rows of 17 and 20 holes, have been designed to fragment approximately 300,000 tonnes of ore and waste respectively and allow one blasthole per delay producing a maximum instantaneous charge (MIC) of 743 kg for ore and 649 kg for waste, assuming all wet blastholes.

9.2 BLAST EMISSION LEVELS

Prediction of Blasting Emission Levels

In order to determine the levels of blast emissions at the nearby heritage chimney and surrounding residences from the proposed blasting, the measured ground vibration and airblast levels from the JKMRC report were used to develop blast emission site laws.

TABLE 9-1-1
PROPOSED BLAST DESIGN DETAILS - ORE AND WASTE

Blast Design Parameter	Typical Dimension
Number of holes	119
Number of rows	7
Hole diameter	251 mm
Hole inclination (to vertical)	0°
Bench height	15 m
Burden	6.7 m
Spacing	9 m
Subdrill	2.2 m
Stemming depth	5.1 m
Delay timing	Exel (non-electric)
Column explosive	Powergel 2560 (wet), Energan 2640 (Dry)
Powder factor	0.82 kg/m3 (ore), 0.72 kg/m³ (waste)
Maximum Instantaneous Charge (MIC)	743 kg (ore), 648 kg (waste)

The measured data, given in Table 9-2-1 was generated by single hole blasts fired within the area of the proposed open pit.

It was concluded from the trial blasting that the blast-induced ground vibrations were generally characterised by very low maximum values and a relatively low dominant

frequency. The maximum peak vector sum (PVS) velocity recorded at the location closest to the blasting sites was 0.8 mm/s. At the site of the heritage chimney, the maximum recorded ground vibration was 0.3 mm/s. Ground vibrations adjacent to the chimney were characterised by a dominant frequency of about 11 Hz associated with the surface wave component of the ground vibrations.

The measured blast emission data has been used to develop the blast emission site laws for ground vibration and airblast which are presented graphically in Attachment C-12 .

For each site law plot, the lower of each pair of lines (labelled 50%) is based on the median of the measured data. However, the ground vibration and airblast criteria advocated by the EPA (refer Section 7.5.4), cater for the inherent variation in emission levels from a given blast design by allowing a five percent exceedance of a general criterion up to a (never to be exceeded) maximum. Correspondingly, the "5% exceedance" lines have also been included in the blast emission site laws.

The 5% site laws for ground vibration and airblast are:

Ground Vibration

$$PVS\ (5\%) = 10^{1.33}(SD_1)^{-0.84}$$

Airblast

$$SPL(5\%) = 162.0 - 24.4 \log (SD_2)$$

where PVS (5%) and SPL (5%) are the levels of ground vibration (Peak Vector Sum - mm/s) and airblast (dBLinear) respectively, above which 5% of the total population (of data points) will lie, assuming that the population has the same statistical distribution as the underlying measured sample.

SD_1 and SD_2 are the ground vibration and airblast scaled distances, where:

$$SD_1 = \frac{\text{Distance}}{\sqrt{\text{MIC}}} \quad (m.kg^{-0.5})$$

$$SD_2 = \frac{\text{Distance}}{\sqrt[3]{\text{MIC}}} \quad (m.kg^{-0.33})$$

Based on the findings of the JKMRC report, even after optimisation of the delay combination, the predicted single hole blast emission levels are likely to be amplified by a factor of 2 when firing multiple delayed blastholes. Consequently, the site law formulae were adjusted for amplification prior to being used to plot prediction charts of airblast versus distance from the proposed production blasting. The adjusted prediction charts developed from the measured trial blasting ground vibration and airblast emissions are shown in Figures C-1 and C-2 respectively, for an MIC of 743 kg.

TABLE 9-2-1
TRIAL BLAST MONITORING AND EMISSION RESULTS - MAY/JUNE 1994

ANFO Equivalent Weight (kg)	PVS Ground Vibration Velocity (mm/s)	Distance (m)	Peak Airblast (dBLinear)	Distance (m)
100	0.16	1455	97.9	1385
123	0.30	1510	97.4	1470
189	0.16		93.2	
162	0.18		94.2	
152	0.18		91.9	
181	0.16	1575	92.8	1540
189	0.16		95.8	
288	0.16		90.4	
160	0.14	1890	92.8	1735
172	0.12		90.9	
268	0.10		90.9	
251	0.09		95.0	
100	0.33	660	110.3	622
123	0.80	705	109.7	680
189	0.40		101.7	
162	0.55		104.2	
152	0.30		99.2	
181	0.18	795	102.7	791
189	0.24		102.7	
288	0.22		97.1	
160	0.14	1075	99.9	945
172	0.19		97.6	
268	0.22		98.4	
251	0.20		100.2	
160	-	-	97.9	1440
172	-		98.4	
268	-		98.4	
251	-		99.3	

Note: Caution should be used when applying the prediction charts to determine emission levels from blasts that have designed parameters (charge weights and blast to receiver distances) that are significantly different from those presented in Table 9-2-1. For the Cadia Hill site, because of the intervening topography and distance between the blast site and surrounding receivers and as the blast face deepens into the pit, the blast emission prediction charts are more likely to over estimate the level of blast emissions (particularly airblast) at the nearest potentially affected residences.

In view of foregoing, the (conservative) blast emissions prediction charts were used to predict the levels of ground vibration and airblast at the nearby heritage chimney and seven nearest potentially affected residential dwellings from blasting at the near point of the proposed pit as presented in Table 9-2-2.

TABLE 9-2-2
PREDICTED 5% EXCEEDANCE
BLAST EMISSIONS (MIC 743 KG)

Location Number	Property Description	Distance From Blast to Residence	Predicted Blast Emission Level	
			PVS Ground Vibration Velocity	Peak Linear Airblast Level
DG1	Tunbridge Wells	3,150 m	0.8 mm/s	106 dB
DG4	Caringle	3,800 m	0.7 mm/s	104 dB
DG5	Bundella	3,100 m	0.8 mm/s	106 dB
DG7	Stratton Vale	5,800 m	0.5 mm/s	100 dB
DG8	Northwest	5,350 m	0.5 mm/s	100 dB
DG9	Cornwall	2,950 m	0.8 mm/s	107 dB
DG12	Lagoon Farm	4,250 m	0.6 mm/s	103 dB
-	Chimney	800 m	2.5 mm/s	121 dB

Impact Assessment

The following assessments are derived from the predicted levels of blast emissions given in Table 9-2-2 and the recommended structural damage and human comfort criterion presented in Section 6.4.

a. The predicted levels of ground vibration and airblast of 2.5 mm/s and 121 dBLinear at the nearby heritage chimney comply with the recommended damage criteria of 3 mm/s and 132 dBLinear respectively.

b. The predicted levels of ground vibration at all residential properties comply with the structural damage criterion of 5 mm/s recommended for low-rise residential buildings in AS 2187.2-1993.

c. The predicted levels of ground vibration at all residential properties comply with the most stringent human comfort criterion of 1 mm/s, for Sundays and Public Holidays, recommended by the EPA.

d. The predicted levels of peak airblast at all residential properties are well below the US Bureau of Mines' structural damage limit of 132 dBLinear.

e. The predicted levels of peak airblast (5% exceedance) at all residential properties comply with the general human comfort criterion of 115 dBLinear for daytime blasting, Monday to Saturday 0900 hours to 1500 hours, recommended by the EPA.

   There may, however, be a marginal (1 dB to 2 dB) exceedance of the Monday to Saturday early morning (0600 hours to 0900 hours) and evening (1500 hours and 2000 hours) airblast criteria of 105 dBLinear at Cornwall (DG9), Tunbridge Wells (DG1) and Bundella (DG5) residences.

   Moreover, for blasting conducted on Sundays and Public Holidays, the predicted peak airblast levels may exceed the nominated human comfort criterion of 95 dBLinear by 4 dB to 12 dB at the surrounding residential properties.

In view of the proximity of the engine house and chimney to the proposed extraction site, it is important that vibration monitoring be performed during early stages of the project to quantify the induced vibration at particular locations within potentially affected structure. If necessary, blasting techniques can then be modified accordingly to ensure that any exceedances of the "structurally safe" limits in Table 6-4-2 are minimised.

It is also recommended that blasting on Sundays and Public Holidays only be conducted where compliance with the relevant EPA human comfort blast emission criteria can be demonstrated via a thorough blast emission monitoring program implemented at the commencement of the mine operations. Consideration should also be given to an application to the EPA to vary the current 'standard' limits applying to blasting in extended hours and weekends, as the limits are overly restrictive (see section 6.4.4 of this report).

10.0 ROAD TRAFFIC NOISE IMPACT ASSESSMENT

10.1 EVALUATION OF TRAFFIC NOISE - GENERAL DISCUSSION

In order to determine the acoustical impact from traffic movements associated with the projects existing and predicted traffic flows have been sourced from the TRAFFIX (Traffic Engineering Services - March 1995 and July 1995) assessment of transport options and supplementary traffic information.

A visual inspection to identify the rural residential properties located adjacent to Cadia Road was conducted in December 1994. Based on the assumption that the majority of employees would commute from Orange to the mine site, the estimated residence offset distances from Cadia Road are presented in Table 10-1-1 together with the property name, if identified.

10.2 EXISTING TRAFFIC FLOW DATA

Existing traffic flow measurements were conducted by TRAFFIX (July 1995) over one week's duration commencing on 27 June 1995. Traffic volume data was collected at four sites in the vicinity of the proposed mine, focusing particularly on the route to Orange. The sites are described below and are shown on the Traffic Locations Diagram in Attachment C-13.

Site 1 - Forest Road, south of Sharpes Road
Site 2 - Cadia Road, south of Forest Road
Site 3 - Cadia Road, south of Cadia to Spring Terrace Road
Site 4 - Cadia to Spring Terrace Road, East of Cadia.

Of the survey results, the data from Site 2 is applicable to the traffic flows on Cadia Road adjacent to Residences 1 to 17 in Table 10-1-1. Similarly, the survey results from Site 3 would represent traffic traversing Cadia Road adjacent to Residences 18 to 25.

TABLE 10-1-1
ESTIMATED RESIDENCE OFFSET DISTANCE FROM CADIA ROAD

Number and Property Name	Offset Distance
1. Allambie	150 m
2. -	150 m
3. -	120 m
4. Roseville	120 m
5. -	10 m
6. -	30 m
7. Bayood	150 m
8. -	10 m
9. Karlisle	20 m
10. Tathra	40 m
11. -	40 m
12. -	20 m
13. -	60 m

Number and Property Name	Offset Distance
14. Sheewah	40 m
15. Springdale	20 m
16. Fairview	70 m
17. -	40 m
18. Kamilario	200 m
19. -	100 m
20. Willowdale	60 m
21. Mayfield	30 m
22. Feon Hills	10 m
23. Endsleigh Park	200 m
24. Coorabun	30 m
25. Cornwall	200 m

A complete list of the survey results at all four sites are presented in Appendix 1 of TRAFFIX (July 1995) report. It should be noted that the traffic flows may include existing mine-related vehicle movements, details of which were not available.

The existing traffic flow results have been summarised and presented in Table 10-2-1 and Table 10-2-2 for Site 2 and Site 3 respectively.

TABLE 10-2-1
EXISTING CADIA ROAD TRAFFIC FLOW - SITE 2

Period (Hours)	Measured Seven Day Mean Vehicle Movements	
	Light	Heavy
0500 to 0600	6	Nil
0600 to 0700	20	1
1700 to 1800	47	2
1800 to 1900	34	1
Total Daily	515	29

TABLE 10-2-2
EXISTING CADIA ROAD TRAFFIC FLOW - SITE 3

Period (Hours)	Measured Seven Day Mean Vehicle Movements	
	Light	Heavy
0500 to 0600	5	Nil
0600 to 0700	21	2
1700 to 1800	36	2
1800 to 1900	20	1
Total Daily	315	34

10.3 MINE CONSTRUCTION AND OPERATIONS-TRAFFIC GENERATION

The construction phase of the mine will involve an average of some 400 staff working a single shift, with a maximum of 600 employees during critical short periods.

On the assumption that all employees travel by private car, and that an average car occupancy of 3 is applicable, then these employees will generate some 270 car trips per day (135 in - morning; 135 out - afternoon). It can be reasonably expected that there will be some staggering of start and finish times in view of the large range of employee classifications, so that peak hourly flows of about 110 vehicles are predicted.

While the majority of these workers are expected to commute from Orange, there will be some travel between other townships in the region, including Blayney, Millthorpe, Carcoar, Cargo and Cudal, as presently occurs with other major employment generators in the region.

It can be reasonably assumed that the major flow of employees will occur along the Cadia Road - Forest Road corridor to/from Orange, with some 240 vehicles per day (120 in; 120 out) expected (90% of total trips). This translates to peak hourly flows of some 100 vehicles (i.e. 100 in - morning; 100 out - afternoon), when account is taken of the staggering of start and finish times.

Similarly, normal mine operations are based upon 300 employees operating in two 12 hour shifts commencing at 0600 hours and 1800 hours. Heavy vehicles will be used to deliver fuel, lime, flocculants and steel balls for ore crushing. Additional light vehicle movements will be generated by visitors and general deliveries to the mine site.

The anticipated daily and peak hourly vehicle movements associated with both construction and mine operations are presented in Table 10-3-1 together with the estimated existing traffic flow for the corresponding period and section of Cadia Road.

TABLE 10-3-1
MINE-GENERATED AND EXISTING VEHICLE MOVEMENTS ON CADIA ROAD

Phase/ Location	Period	Peak Hourly Vehicle Movements		Average Daily Vehicle Movements	
		Light	Heavy	Light	Heavy
Construction	0530 hrs to 0630 hrs	100	3	240	30
Mine Operations	0530 hrs to 0630 hrs	75	5	200	50
	1730 hrs to 1830 hrs				
Existing Traffic Cadia Rd Site 2	0530 hrs to 0630 hrs	13	1	515	29
	1730 hrs to 1830 hrs	40	1		
Existing Traffic Cadia Rd Site 3	0530 hrs to 0630 hrs	13	1	315	34
	1730 hrs to 1830 hrs	28	2		

It is assumed that the peak hourly vehicle movements associated with construction operations would occur between 0530 hours and 0630 hours (i.e. night-time) as employees commence work between 0600 hours and 0700 hours, however it is anticipated employee departures will be generally staggered.

Similarly, it is assumed that the peak hourly vehicle movements associated with mine operations would occur between 0530 hours and 0630 hours (i.e. night-time) as well as between 1730 hours and 1830 hours (i.e. daytime) correlating with each change of shift.

10.4 PREDICTION OF ROAD TRAFFIC NOISE

The predictions of road traffic noise were carried out using UK Department of Transport's (Welsh Office) Calculations of Road Traffic Noise (CORTN) method to predict the peak $L_{Aeq(1hour)}$ level. This method takes into account vehicle volume, vehicle speed, vehicle type, road configuration, intervening topography and receiver location, and includes adjustments for Australian conditions and the effective source heights of various components of vehicle noise (tyre/ pavement interface, engines, exhausts, etc.).

The calculated peak hour $L_{Aeq(1hour)}$ noise levels for the existing and mine-generated vehicle movements along the Cadia Road corridor are presented in Table 10-4-1, based on the peak hourly movements given in Table 10-3-1.

10.5 TRAFFIC NOISE IMPACT ASSESSMENT

The following impact assessment is derived from the results presented in Table 10-1-1 and Table 10-4-1 and the EPA's recommended $L_{Aeq(1hour)}$ road traffic noise criteria of 50 dBA daytime and 45 dBA night-time as presented in Section 6.5.

a. It is predicted that nine residences at or within 30 m of the roadway currently receive noise levels marginally (1 dBA to 2 dBA) in excess of the 45 dBA limit for night-time.

   Similarly, it is predicted that six residences at or within 20 m of the roadway receive noise levels marginally (1 dBA to 2 dBA) in excess of 50 dBA limit for daytime.

TABLE 10-4-1
PREDICTED PEAK $L_{Aeq(1HOUR)}$ TRAFFIC NOISE LEVELS

Receiver		Existing Traffic - $L_{Aeq(1hour)}$				Mine Generated Traffic	
Distance	No	Site 2		Site 3		Construction Phase $L_{Aeq(1hour)}$	Mine Operations $L_{Aeq(1hour)}$
		0530 hrs to 0630 hrs	1730 hrs to 1830 hrs	0530 hrs to 0630 hrs	1730 hrs to 1830 hrs		
10 m	3	47	52	47	51	59	58
20 m	3	46	51	46	50	55	55
30 m	3	46	49	46	49	53	53
40 m	4	44	48	44	47	52	51
60 m	2	42	45	42	45	49	49
70 m	1	41	44	41	44	48	48
100 m	1	38	42	38	42	46	46
120 m	2	37	41	37	41	45	45
150 m	3	36	40	36	39	44	43
200 m	3	34	38	34	37	42	42

b. The predicted peak hour traffic noise levels associated with both construction and mining vehicle movements are generally within 1 dBA and can therefore be considered as audibly equivalent.

c. It is predicted that the 13 residences within 40 m of Cadia Road may receive noise levels in excess of 50 dBA $L_{Aeq(1hour)}$ during the peak daytime mining traffic flows between 1730 hours and 1830 hours..

d. Similarly, the 17 residences within 100 m of Cadia Road may receive traffic noise levels in excess of 45 dBA $L_{Aeq(1hour)}$ during the peak night-time construction and mining traffic flows between 0530 hours and 0630 hours.

It is concluded that 13 residences may receive traffic noise levels (1 dBA to 8 dBA) in excess of 50 dBA $L_{Aeq(1hour)}$ during the peak mining daytime period between 1730 hours and 1830 hours.

Similarly, an additional 4 residences may receive traffic noise levels (1 dBA to 14 dBA) in excess of 45 dBA $L_{Aeq(1hour)}$ during the period of peak night-time construction and mining traffic between 0530 hours and 0630 hours.

It is therefore recommended that consideration be given to providing acoustic mitigation measures to the nearest potentially affected properties (in the order of six) along Cadia Road. These may include individual building treatments, acoustic barriers or noise bund walls, and should be developed in consultation with the respective occupants or property owners.

Further, a modified access route to the project area is presently under consideration. This route, being a public road and mine access, would follow an alignment to the west of Cadia Road. In terms of traffic noise-affected residences, should this become the preferred route, all the residences in Table 10-1-1 would still be adjacent to the access road, with the exception of the Cornwall residence (No 25).

11.0 EFFECTS OF METEOROLOGY ON NOISE LEVELS

11.1 WIND EFFECTS

As discussed in the Mine Noise Impact Assessment (Section 8.0), the most common prevailing wind condition at the site is from the north to northeast, with wind speeds of 1.5 m/s occurring on approximately 25% of evenings and nights throughout the year.

In general, a steady, gentle breeze of less than about 1.5 m/s can enhance noise levels without increasing background noise levels, whereas winds of higher velocity tend to increase background levels and obscure other noise sources. Downwind, winds of velocities up to about 1.5 m/s can enhance noise levels in the order of 5 dBA relative to still conditions, assuming flat topography between source and receiver. Conversely, noise levels up wind may be reduced by a similar amount. Strong winds tend to increase local ambient noise, due to turbulence or movement of trees and shrubs, which can mask noise from more distant sources.

As presented in the noise predictions in Tables 8-2-1, 8-3-1, 8-3-2 and 8-4-2, the overall mine noise emission levels are significantly increased at the downwind receiver locations which include Bundella (DG5), Caringle (DG4), Stratton Vale (DG7) and Northwest (DG8).

Steady light to moderate winds produce higher noise levels downwind, and lower noise levels upwind from a given source than in still air due to three factors. The first effect at a source directly downwind or upwind is that the attenuation at a given receptor is equivalent to that in still air at a distance determined by the difference between the sonic velocity and the wind velocity. As sonic velocity is 344 m/s, the velocity difference and this effect are relatively small.

The second effect, caused by the wind velocity profile in a vertical plane, has a greater effect, and causes refraction of sound radiated at small angles above the horizontal. Some of the upward-directed sound returns to ground level at some distance away, thereby focusing and increasing the sound intensity at that location.

The third, and most significant factor for the Cadia Project, is due to the interaction of the second effect with the intervening ground topography. Under still conditions the natural topography and the developed land profile (i.e. waste dump and pit) may provide significant barrier attenuation to mining noise emissions. However, as the wind velocity profile in the vertical plane increases, the sound rays become curved downwards, and effects of these barriers are diminished and noise enhancement can be in excess of 10 dBA at particular locations.

Airblast is similarly affected by an increase in wind velocity with altitude. The rate of change of sound speed with altitude modifies the wave front as it propagates from the blast and creates the path that the wave front will follow.

A difference of 5 dB may occur within a 180 degree range in location to the wind direction at the same distance to the blast site.

11.2 VERTICAL TEMPERATURE GRADIENTS

Air temperature normally decreases with altitude, a condition known as temperature lapse. Conversely, a temperature inversion occurs when a layer of air has a temperature increasing with altitude, or at the boundary between a lower cool layer and a higher warm layer.

Four types of inversion are commonly described: radiation, subsidence, turbulence, and frontal.

Radiation inversions result from cooling of the ground on a clear night, with associated radiant cooling of a layer of air near the ground.

Subsidence inversions result from descent of air over a large area such that the upper layers descend further than, and therefore are heated more than, the lower descending layers. This implies an anticyclone, with the inversion above divergent flow at low levels.

Turbulence inversions result from mixing of a layer of stable air near the ground, due to wind flow around rough terrain. The inversion is formed at the interface between the layers.

Frontal inversions are part of either a cold front, as cold air wedges under a warm air mass, or a warm front, as warm air overrides a cooler air mass.

Radiation inversions are normally surface inversions, while the other types are usually upper inversions. It is possible to have simultaneous inversions at different levels.

The acoustical effect of temperature inversions is due to the increase of sonic velocity with increased air temperature. In a temperature lapse condition, sound rays will be refracted upwards, and there will be a decrease in received sound intensity at a distant location on the ground.

Under temperature inversion conditions, air temperature increases with altitude, and sound rays are diffracted downwards. This causes focussing of sound intensity at some radius from the source, and an increase in received sound levels.

Radiation inversions are broken by thermal instability in the inversion layer, due to solar heating of the ground. As the inversion breaks, warmer air from above is mixed down into the inversion layer. In winter, inversions commonly break by mid to late morning but can last all day if the upper atmosphere becomes overcast. The break-up is commonly experienced as a very cold morning which becomes quite mild in mid-morning. It can be seen in winter when the brown haze trapped in a distinct layer rapidly spreads to higher levels at some time in the morning. In summer, radiation inversions normally break up within 2 hours to 3 hours after sunrise.

In winter, radiation inversions are normally associated with drainage flows. The drainage flow is modified by topography and the extent of this effect would depend on the depth of the inversion layer.

Wind and temperature inversion effects generally apply to all noises, except that inversions appear to affect low frequency sound more than higher frequency sound, possibly because of the relatively large distances involved, the higher frequency sounds are already attenuated by other effects (e.g. atmospheric adsorption).

In the absence of site specific temperature gradient data, it is assumed that temperature inversions of up to 3°C/100 m gradient may occur on approximately 25% of nights throughout the year, although strong inversions of 3°C/100 m are likely to be more common during winter months coinciding with some air drainage.

In order to demonstrate the dependence of noise propagation on inversion conditions, Table 11-2-1 presents the predicted overall contributed L_{A10} noise emission levels for Stage I Year 1 mine operations to the seven nearest potentially affected residential properties for various vertical temperature gradients.

TABLE 11-2-1
PREDICTED L_{A10} NOISE LEVELS YEAR 1
- VERTICAL TEMPERATURE GRADIENTS

Location Number	Property Name	Vertical Temperature Gradient 3°C/100 m (6°C Air temperature 85% RH, 0 m/s Wind)						Night -time Noise Limit
		-1	0	1	2	3	4	
DG1	Tunbridge Wells	23	28	33	35	37	38	33
DG4	Caringle	29	31	37	39	39	40	32
DG5	Bundella	17	22	31	33	35	37	33
DG7	Stratton Vale	20	22	29	34	35	35	33
DG8	Northwest	14	17	20	23	27	31	33
DG9	Cornwell	23	24	26	26	29	31	33
DG12	Lagoon Farm	17	17	19	22	27	29	33

Airblast levels at certain points can be raised by the focussing effects occurring with a temperature inversion. Alternatively sound shadow zones may occur in warmer conditions (towards the middle of the day), in which the overpressure levels are lower than would be expected.

Under extremely adverse temperature inversion conditions, an increase of between 8 dB and 20 dB may be possible at a radius of 2 km or more from the blast site. Similarly, low cloud cover is sometimes reported to 'reflect' sound waves, thereby increasing their intensity on the ground. This is possibly a result of diffraction (i.e. bending of sound paths) due to the existence of atmospheric temperature gradients which occur in the presence of cloud cover, rather than a true "reflection".

12.0 EFFECTS OF NOISE AND BLASTING ON FARM ANIMALS

One of the earliest studies (Ely and Petersen 1941) directly related to this area of research was a study concerned primarily with the factors involved in the ejection of milk in an effort to learn why cows habitually "let down" or "hold up" their milk. In one phase of their study, these researchers created fright stimuli caused by exploding paper bags every 10 seconds for 2 minutes just prior to attaching the mechanical milker.

Such stimuli resulted in an immediate cessation of milk ejection. Thirty minutes after the fright stimuli, hand milking produced only 70% of the normal amount of milk. Intrajugular injections of adrenalin produced somewhat the same results.

A later study by Parker and Bayley (US Department of Agriculture 1957) was conducted to determine if there was any measurable effect of jet aircraft noise and flyovers on the milk production of dairy herds. Data covering a period of 12 months were obtained on the daily milk deliveries from 182 herds located within three miles of 8 United States Air Force bases using jet aircraft.

An analysis of data from 42 herds did not show any evidence that flyovers or proximity to the ends of the active runways had an effect on the milk production of the herds.

In another study (Casaday and Lehmann 1967) animal installations were selected for observations on animal behaviour under sonic boom conditions. Numbers of animals observed in this study were about 10,000 commercial feedlot beef cattle, 100 horses, 150 sheep and 320 lactating dairy cattle. Booms during the test period were scheduled at varying intervals during the morning hours Monday to Friday of each week.

Observers were stationed to watch specified groups of animals and to note behaviour patterns of the animals just prior to, during and immediately following each boom. They also noted disturbances caused by low flying aircraft used in noise tests.

Results of the study showed that the reactions of the sheep and horses to sonic booms were slight. Dairy cattle were little affected by sonic booms (125 dB to 136 dB). Only 19 of 104 booms produced even a mild reaction, as evidenced by a temporary cessation of eating, raising of heads, or slight startle effects in a few of those being milked. Milk production was not affected during the test period, as evidenced by total and individual milk yield.

The researchers developed a summary by species and farms indicating that the few abnormal behavioural changes observed were well within the range of activity variation within a group of animals. They defined these changes as horses jumping up and galloping around the paddock, bellowing of dairy cattle, and increased activity by beef cattle. These are the kind of insignificant behavioural changes that might be expected by farm animals on adjoining pastoral land to the mine development.

13.0 CONCLUSIONS AND RECOMMENDATIONS

This report presents the results and findings of a detailed acoustical impact assessment of the proposed development of a gold/copper mine at Cadia Hill, near Orange, NSW by Newcrest Mining Limited.

The study nominated seven rural residential properties beyond the Mine Lease Area boundary to be representative of the noise environment of the potentially affected rural area and to form the basis for assessing noise emissions from the mines development and operations.

A background noise monitoring program was implemented in order to characterise and quantify the existing winter and summer season noise environments at seven residential properties surrounding the project site. On the basis of the measured L_{A90} background noise levels, calculated and acceptable contributed noise emission limits were determined in accordance with EPA recommended procedures for both the construction phase and mine operations respectively.

To determine the acoustical impact of the project, the major sources of noise and vibration emissions were grouped into three distinct areas for evaluation and assessment - noise from mine construction and operation, blasting emission and transportation noise.

- The assessment of noise emission from mobile plant and equipment during the construction phase of the mine site has identified that the contributed L_{A10} noise levels at the Stratton Vale (DG7) residence from the construction of the tailings dam may marginally (2 dBA) exceed construction noise limits under an adverse wind condition.

  At all other receiver locations (even under "adverse" weather conditions), predicted noise emission from construction works complies with EPA limits.

  The assessment of noise emissions from mine operations (fixed processing plant and mobile earthmoving equipment) has concluded that the contributed L_{A10} noise levels comply with the recommended daytime (35 dBA), evening (35 dBA) and night-time (33 dBA) criteria at all residential properties during neutral atmospheric conditions throughout the 12 year mine life. The exception being at Caringle (DG4), where noise emissions during neutral atmospheric condi-

tions may moderately (4 dBA) exceed the night-time criterion of 32 dBA whilst remaining below the day-time criterion of 37 dBA at this property.

However, during light wind and strong temperature inversions, the barrier attenuations provided by intervening ground profiles will diminish, and mine noise emission have the potential to increase significantly, particularly during winter nights. It is predicted that the overall LA10 noise emissions may appreciably exceed the recommended night-time criteria by 10 dBA, 6 dBA and 5 dBA at Caringle (DG4), Stratton Vale (DG7) and Bundella (DG5) respectively, at various stages throughout the life of the mine.

- The predicted levels of ground vibration and airblast resulting from blasting operations at the nearby heritage chimney comply with the recommended damage criteria of 3 mm/s and 132 dBLinear respectively.

  The predicted levels of ground vibration and airblast at all residential properties comply with the appropriate damage criteria recommended by the Australian Standard 2187.2-1993 and the US Bureau of Mines respectively.

  The predicted levels of ground vibration at all residential properties comply with the most stringent human comfort criterion of 1 mm/s, recommended by the NSW EPA. For blasting conducted on Sundays and Public Holidays the predicted peak airblast levels may exceed the EPA's nominated human comfort criterion of 95 dBLinear by 4 dB to 12 dB at the surrounding residential properties, however these limits are considered overly restrictive.

- The assessment of road traffic noise, generated by the associated increase in vehicle movements along Cadia Road has identified that 17 residential properties are likely to receive noise levels (1 dBA to 14 dBA) in excess of the EPA's recommended criteria during the anticipated peak hourly daytime (1730 hours to 1830 hours) and night-time (0530 hours to 0630 hours) traffic flows.

  It is therefore recommended that consideration be given to providing acoustic mitigation measures (in consultation with the occupants) to the nearest potentially affected properties (in the order of six) along Cadia Road, which may include individual building treatments, acoustic barriers or bund walls.

In view of the foregoing and in order to limit potential adverse acoustical impacts associated with the project, it is strongly recommended that a Noise and Blasting Management Plan be designed and implemented, defining the noise and blasting monitoring procedures and the approaches to mitigating impacts to be implemented throughout the development and operation of the mine.

14.0 REFERENCES

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PVS GROUND VIBRATION VELOCITY PREDICTION CHART

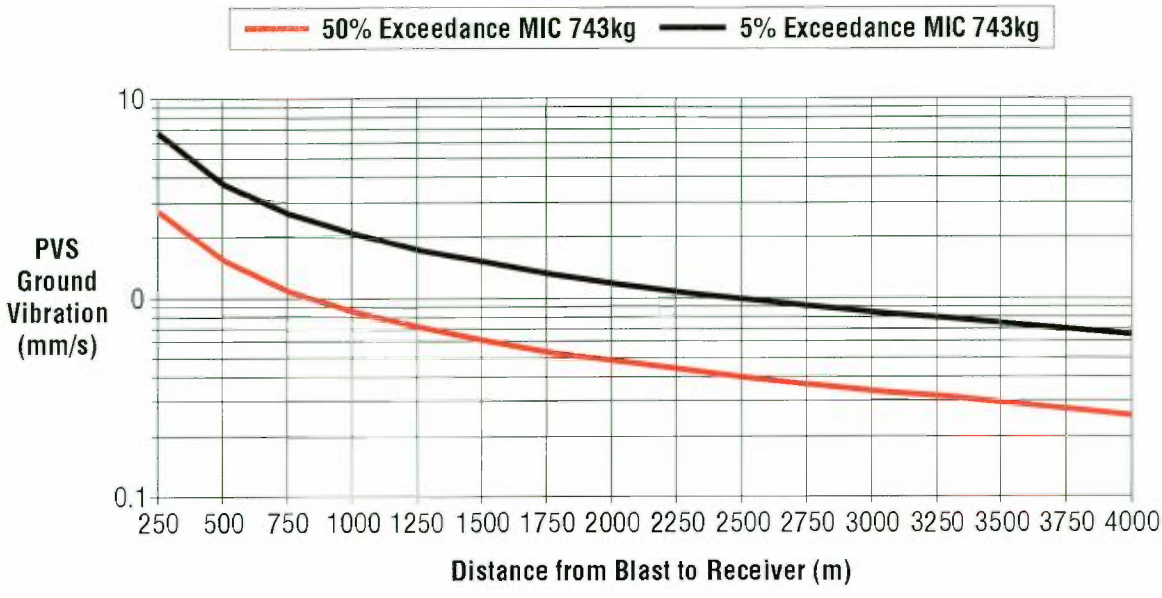
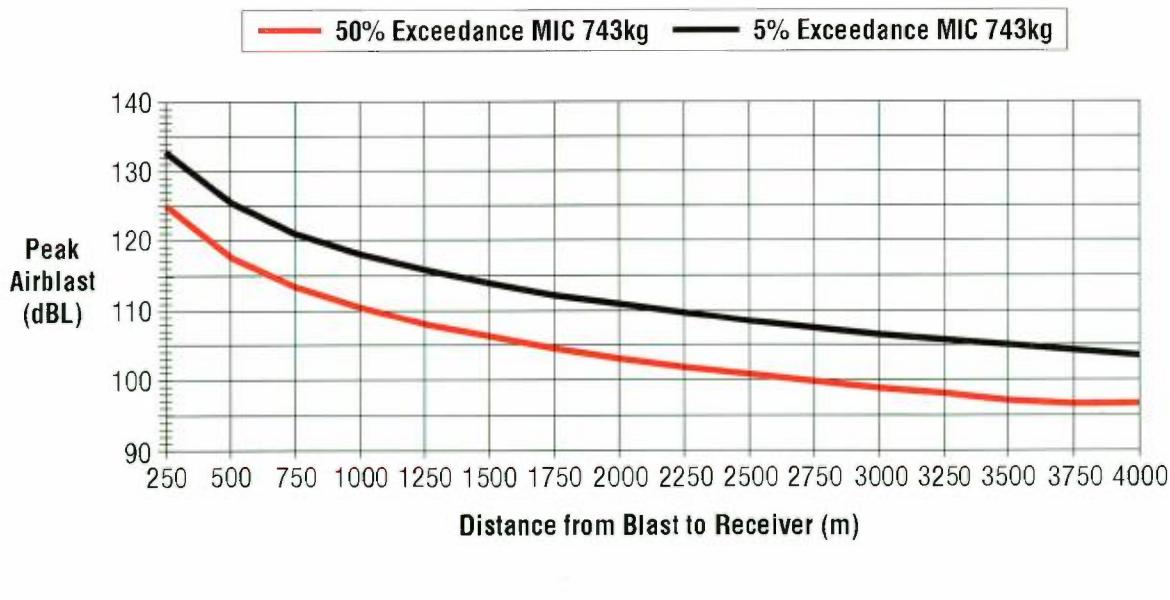


FIG C-1

PEAK AIRBLAST LEVEL PREDICTION CHART



Woodward-Clyde

FIG C-2

ATTACHMENT C-1

GLOSSARY OF ACOUSTICAL TERMS

Acoustic Calibrator
A device for applying a sound pressure of known level to the microphone or sensor of a sound measuring system, for the purpose of calibration.

Air Absorption
The phenomena of attenuation of sound waves with distance propagated in air, due to dissipative interaction within the gas molecules.

Ambient Sound (or noise)
The all-encompassing sound at a point being composite of sounds from near and far.

Background Noise Level
The level of ambient sound indicated on a sound level meter in the absence of the sound under investigation (e.g. sound from a particular noise source or sound generated for test purposes). Refer statistical sound levels.

Centre Frequency
Of a band pass filter: the geometric mean of the nominal limiting frequencies.

Diffraction
Modification of the progressive wave distribution due to the presence of obstacles in the field. Reflection and refraction are special cases of diffraction.

Direction of Propagation
The direction of flow of energy associated with a wave.

Far Field
That part of the field of a source radiating sound in free field conditions, wherein the sound pressure and the particle velocity are substantially in phase or in which particle velocity is inversely proportional to the distance from the source.

Impulse Sound
Sound consisting of a single pressure peak, or the sequence of such peaks, or a single burst with multiple pressure peaks whose amplitude decays with time, or a sequence of such bursts.

Infrasound
Sound oscillation, the frequency of which is less than the nominal lower limit of audibility i.e. less than 16 Hz.

L_{A1}
The noise level exceeded for 1% of the sample period.

L_{A10}
The noise level exceeded for 10% of the sample period. This is commonly referred to as the average maximum noise level.

L_{A90}
The noise level exceeded for 90% of the sample period. This is commonly referred to as the average minimum or background noise level.

L_{Aeq}
The equivalent continuous sound pressure level and represents the steady sound level which is equal in energy to the fluctuating level over the interval period.

Loudness
The attribute of an auditory sensation which describes the listener's ranking of sound in terms of its audibility.

Masking
The raising of a listener's threshold of hearing for a given sound due to the presence of another sound.

Near Field
Of a source: that part of the field of a source radiating sound in free field conditions, wherein the sound pressure and particle philosophy are not in phase.

Noise
A. Sound which a listener does not wish to hear.
B. Sound from sources other than the one emitting the sound it is desired to receive, measure or record.
C. A class of sound of an erratic, intermittent or statistically random nature.

Noise Level
The term used in lieu of sound level when the sound concerned is being measured or ranked for its undesirability in the contextual circumstances.

Refraction
The phenomena occurring when a wave crosses a boundary between two media in which the waves have different phase velocities. This leads to a change of wave length.

Reverberant Sound
The sound in an enclosure excluding that which is received directly form the source.

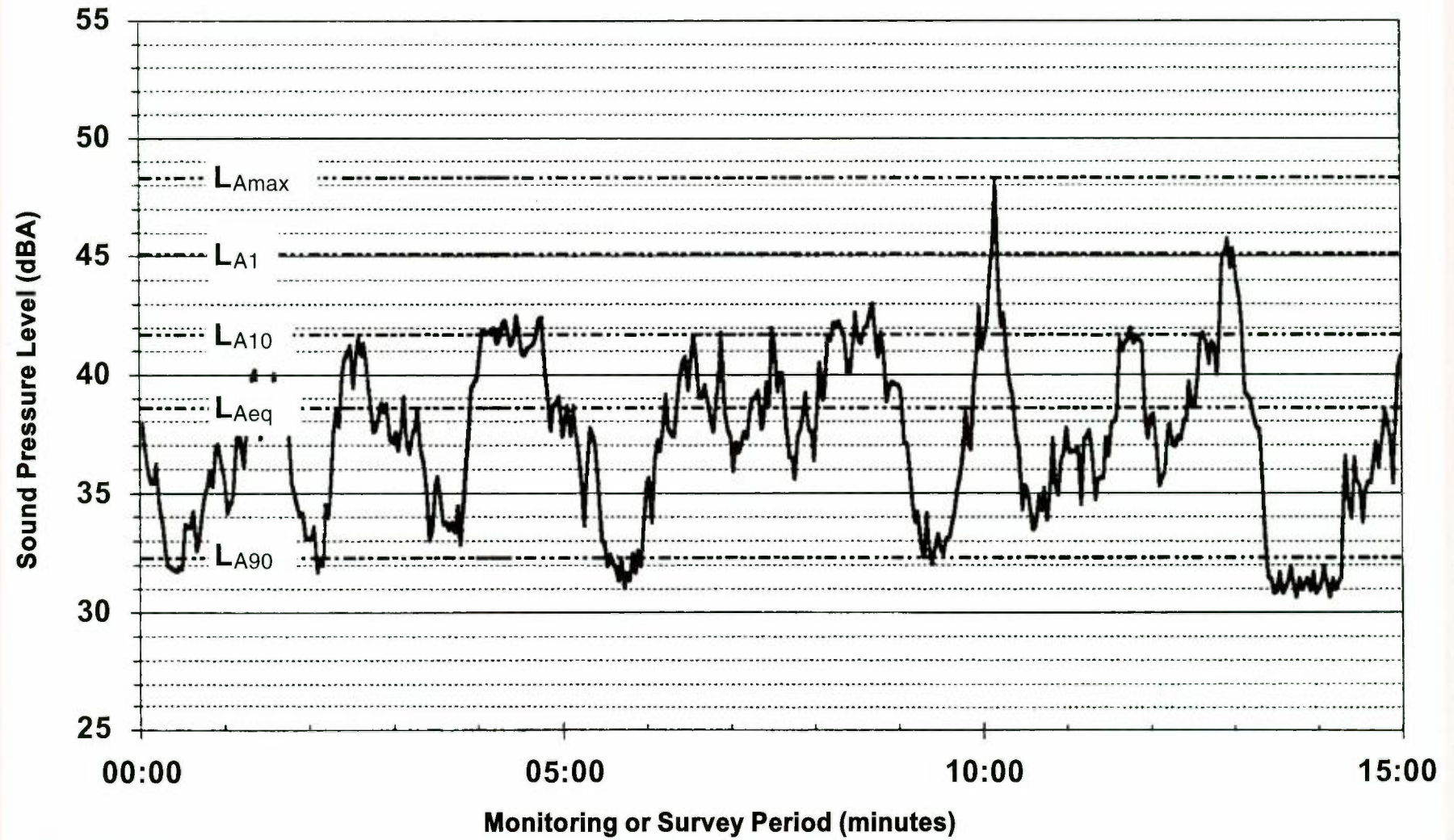
Reverberation
The persistence, after emission of a sound has stopped, of a sound field within an enclosure.

Sound Level
The level of the frequency weighted and time weighted sound pressure as determined by a sound level meter.

Sound Power
Of a source, the total sound energy radiated per unit time.

Sound Pressure Level (SPL)
Of a sound, 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level. International and Australian values for the reference sound pressure level are 20 micropascals in air and 100 millipascals in water.

Statistical Sound Levels
Of a fluctuating sound pressure (usually "A" frequency weighted and fast time response), the level which exceeded for N% of the sample period. The most frequently used are defined and presented graphically in figure C-3.



HYPOTHETICAL NOISE SIGNAL - DISPLAY OF STATISTICAL INDICES

FIG C-3

Woodward-Clyde

ATTACHMENT C-2

LOCATION AND LOCALITY PLANS

(NOT INCLUDED IN THIS APPENDIX, REFER TO FIGURE 1-1 AND 3-1 OF VOLUME 1)

ATTACHMENT C-3

OPERATIONAL MINING LANDFORMS FOR YEARS 1, 3, 4, 6, 9 AND 12.

(NOT INCLUDED IN THIS APPENDIX, REFER TO FIGURE 2-1, 2-2 AND 2-3 OF VOLUME 1)

ATTACHMENT C-4

ACCUMULATED AMBIENT NOISE LEVELS - WINTER SEASON.

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, WILLUNGA (DG9) - 17.5.94 to 19.5.94

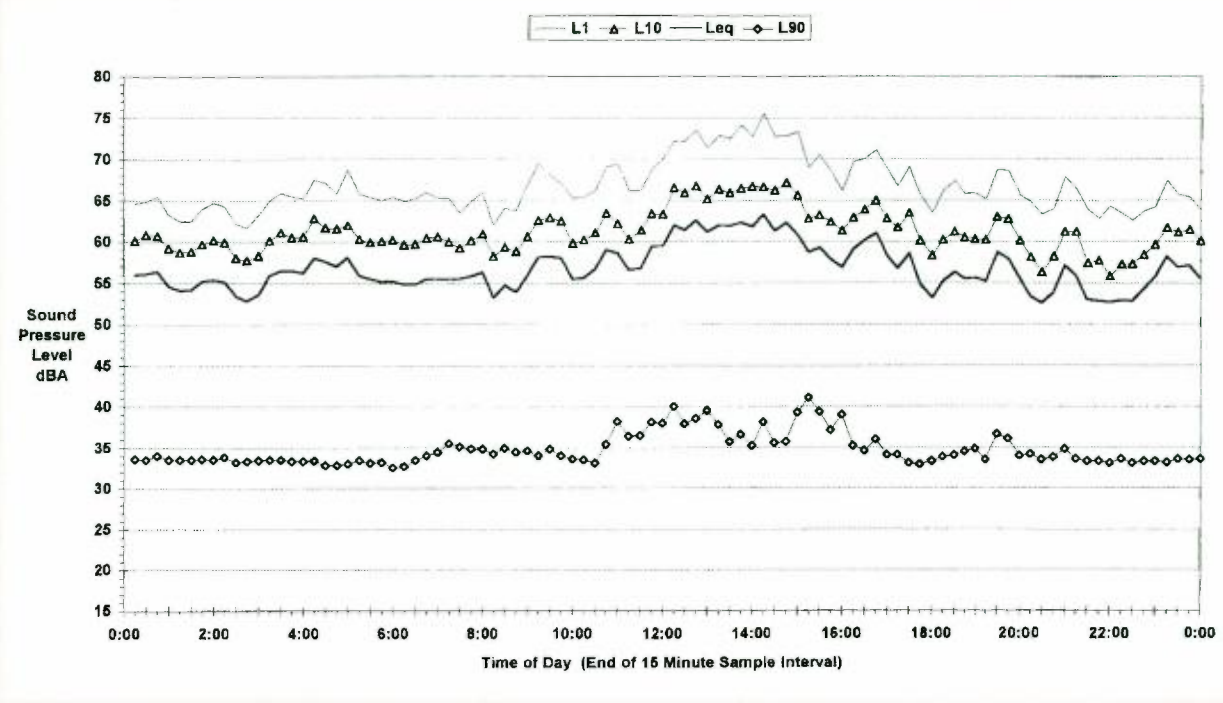
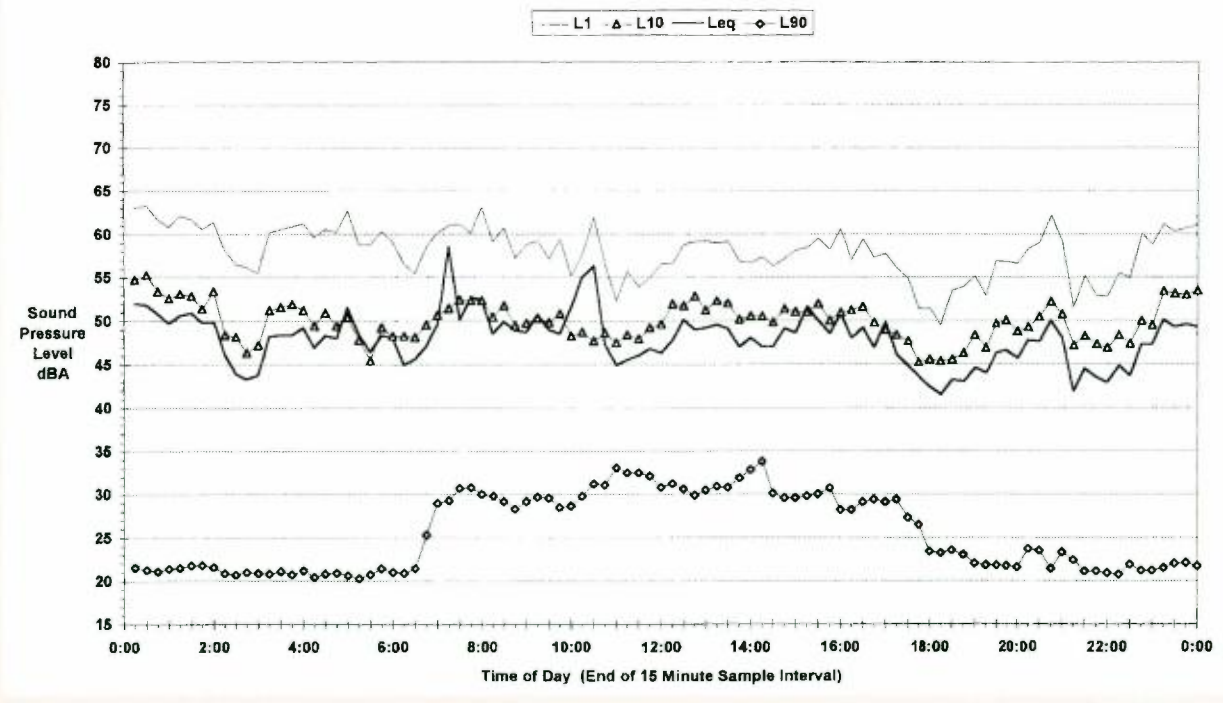


FIG C-4

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, TUNBRIDGE WELLS (DG1) - 17.5.94 to 22.5.94, 10.6.94 to 14.6.94



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FIG C-5

ACCUMULATED AMBIENT NOISE LEVELS LOCATION,CARINGLE (DG4) - 17.5.94 to 19.5.94, 10.6.94 to 14.6.94

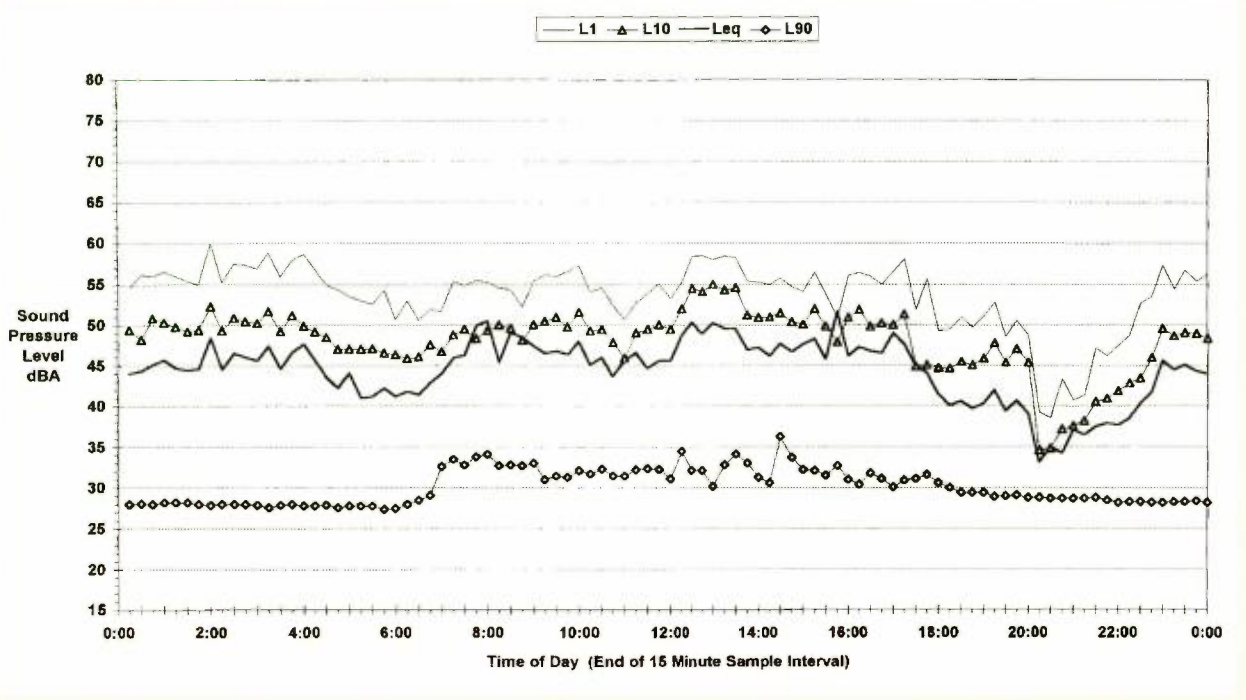
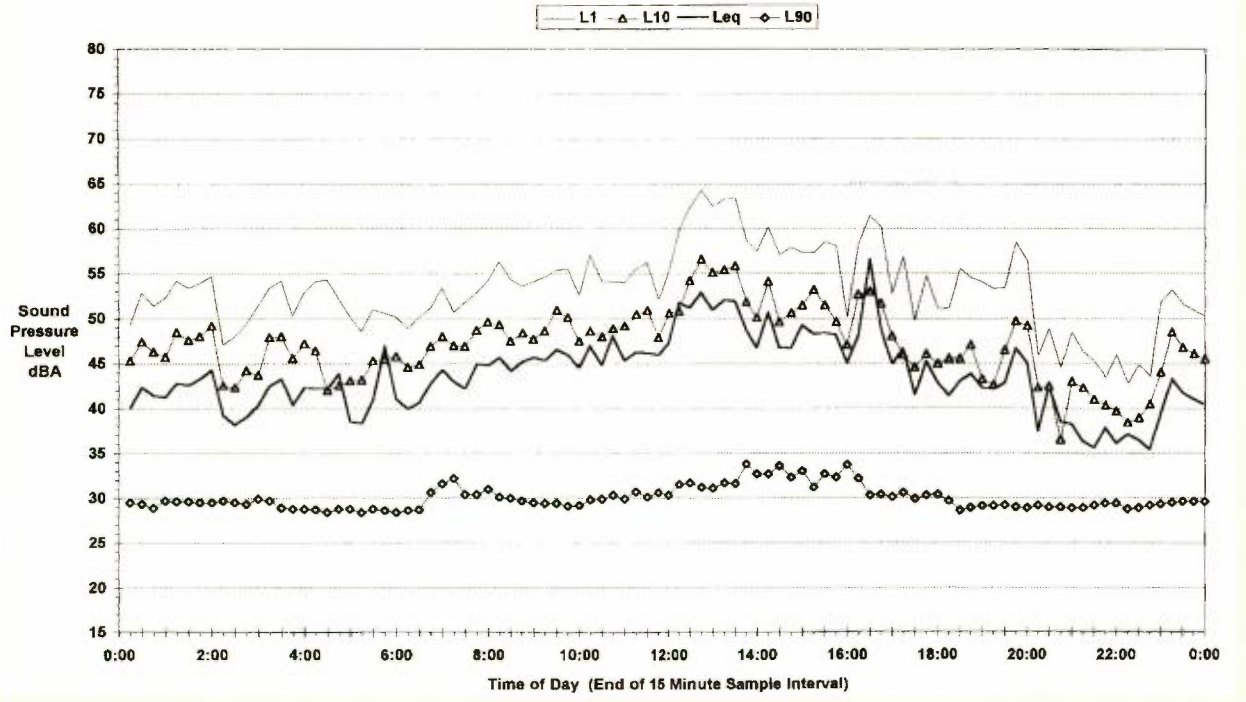


FIG C-6

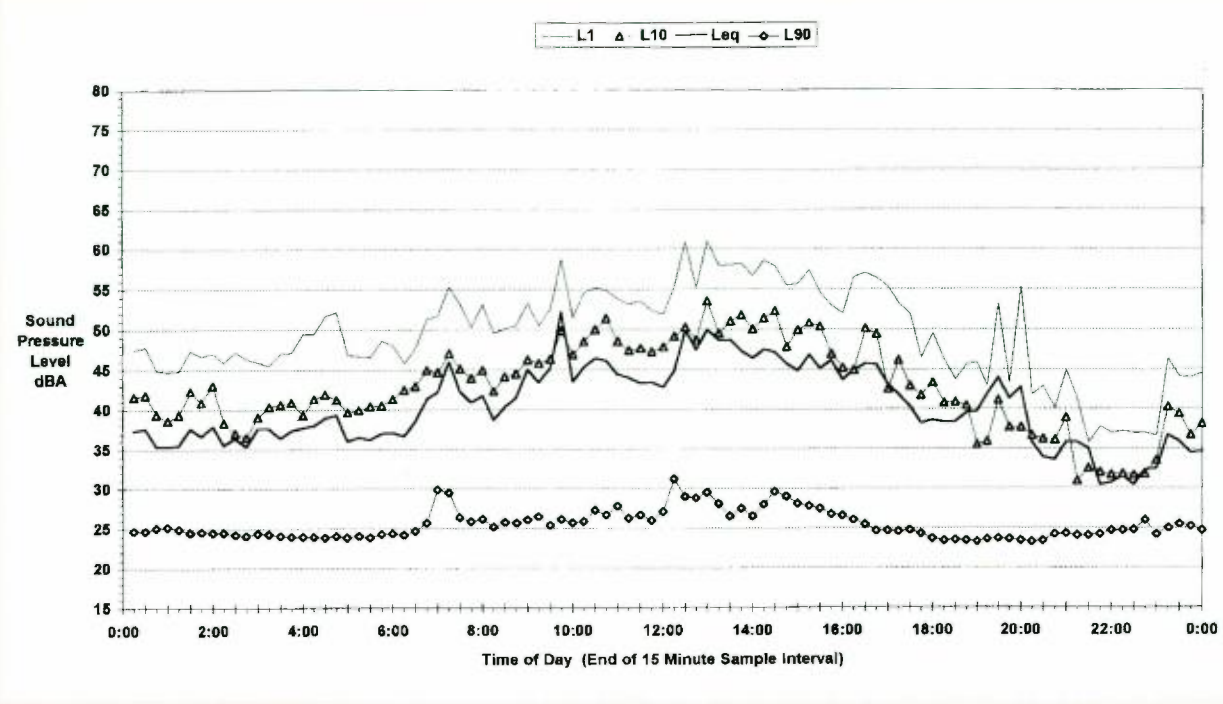
ACCUMULATED AMBIENT NOISE LEVELS LOCATION, STRATTON VALE (DG7) - 17.5.94 to 19.5.94, 10.6.94 to 14.6.94



Woodward-Clyde

FIG C-7

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, NORTHWEST (DG8) - 17.5.94 to 19.5.94, 10.6.94 to 14.6.94



Woodward-Clyde

FIG C-8

ATTACHMENT C-5

ACCUMULATED AMBIENT NOISE LEVELS - SUMMER SEASON.

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, WILLUNGA (DG9) - 7.12.94 to 2.1.94

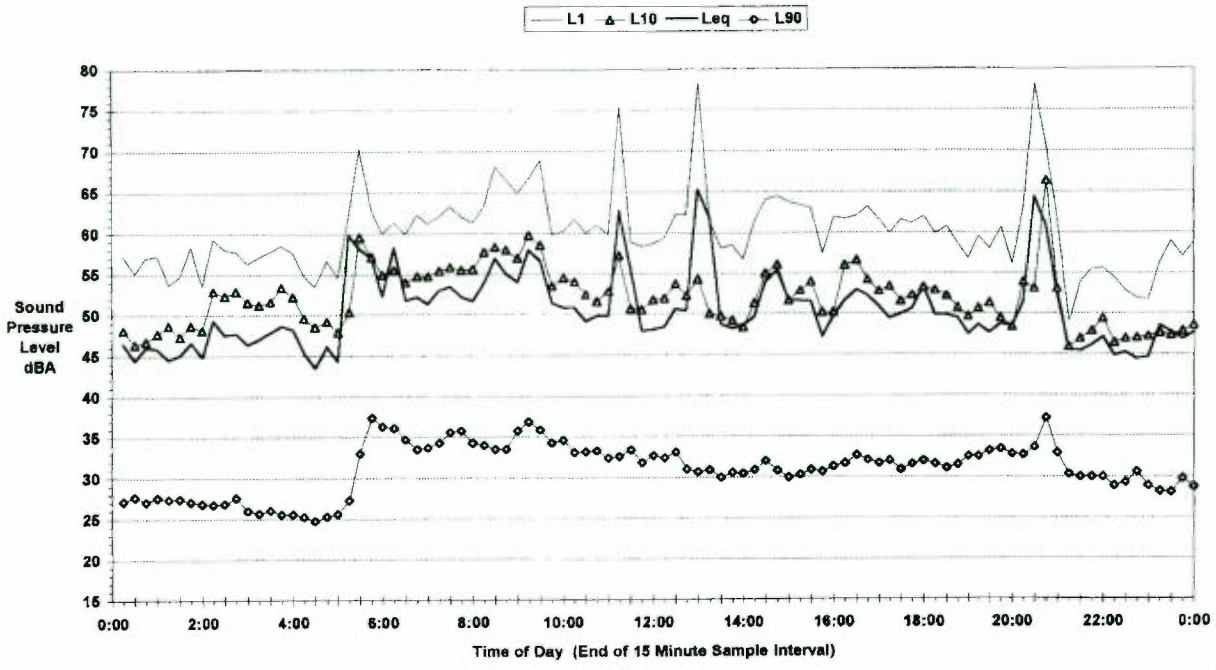
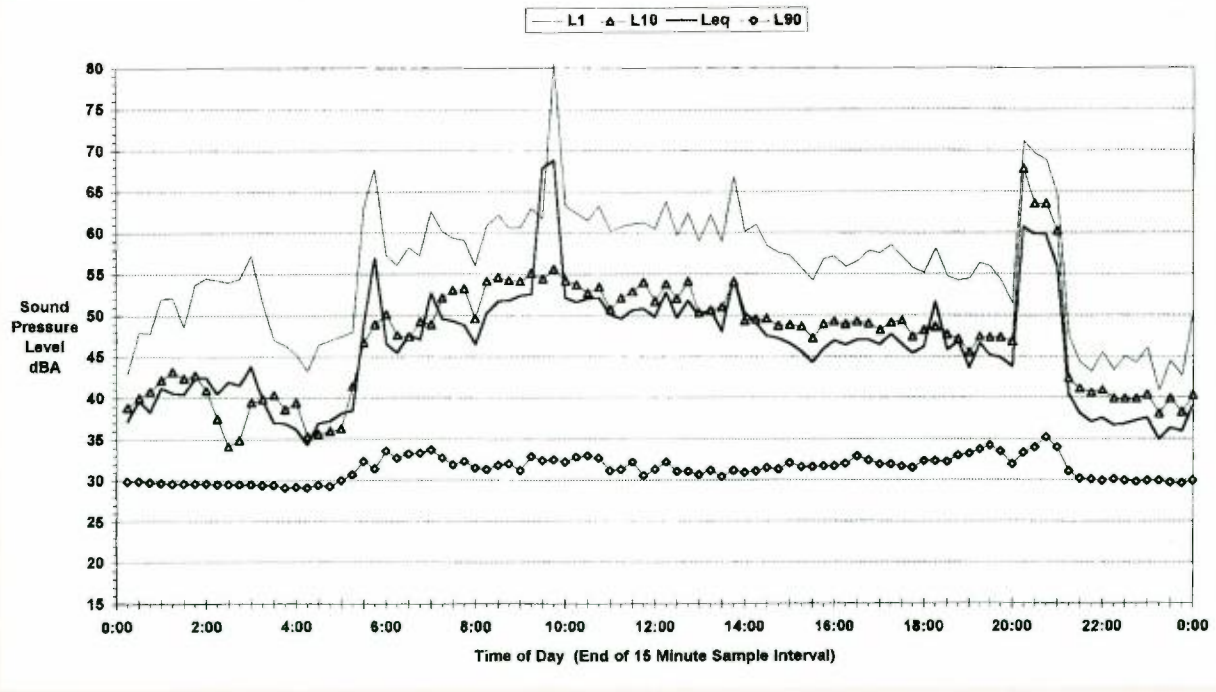


FIG C-9

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, TUNBRIDGE WELLS (DG1) - 16.12.94 to 1.2.95



ACCUMULATED AMBIENT NOISE LEVELS LOCATION, BUNDELLA (DG5) - 7.12.94 to 31.12.94

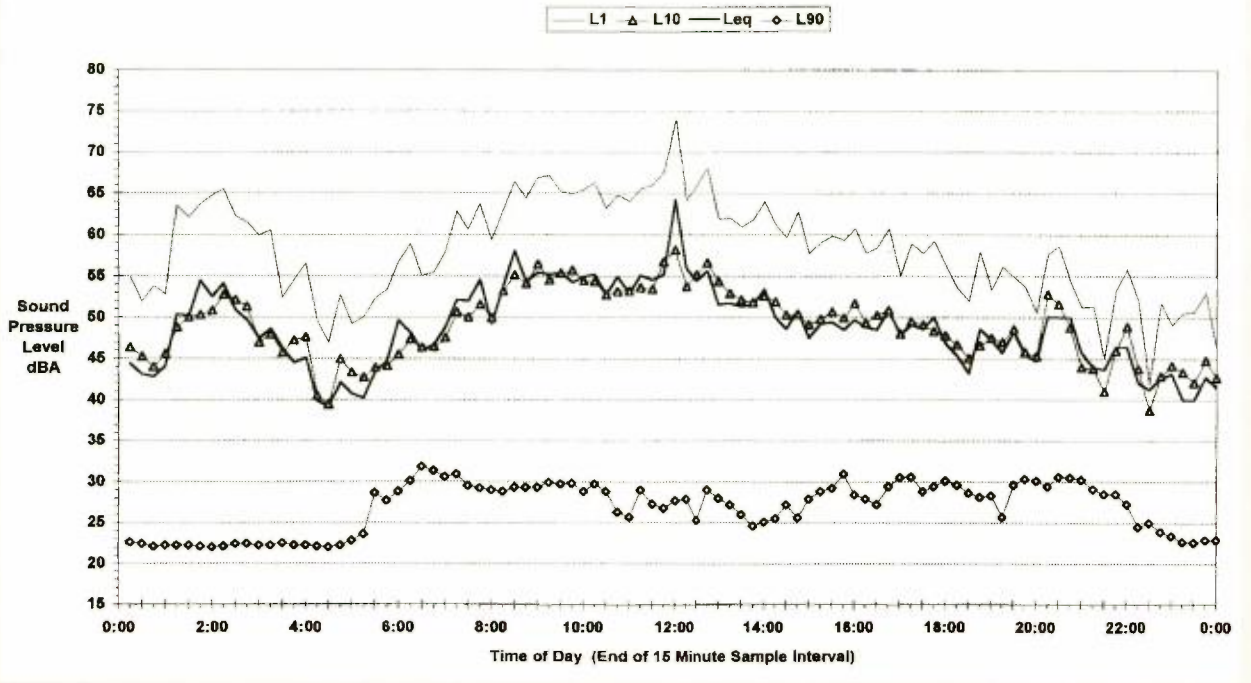
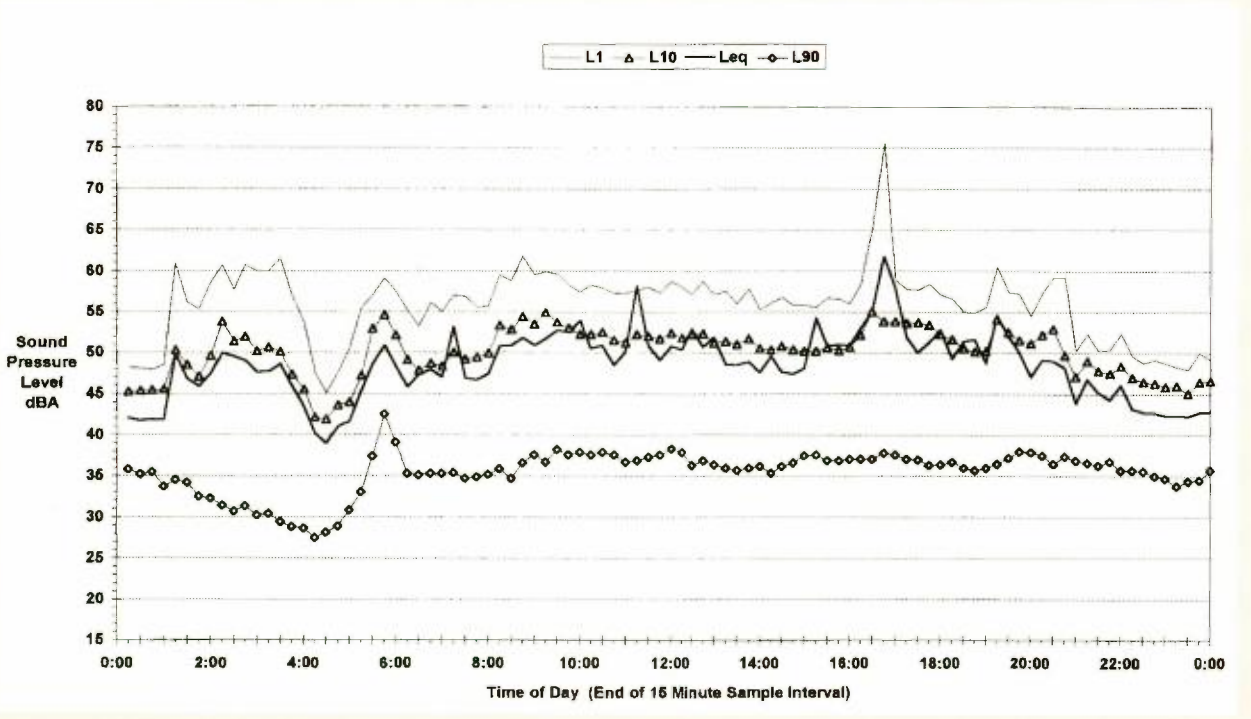


FIG C-11

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, CARINGLE (DG4) - 7.12.94 to 27.12.94



Woodward-Clyde

FIG C-12

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, STRATTON VALE (DG7) - 7.12.94 to 2.1.95

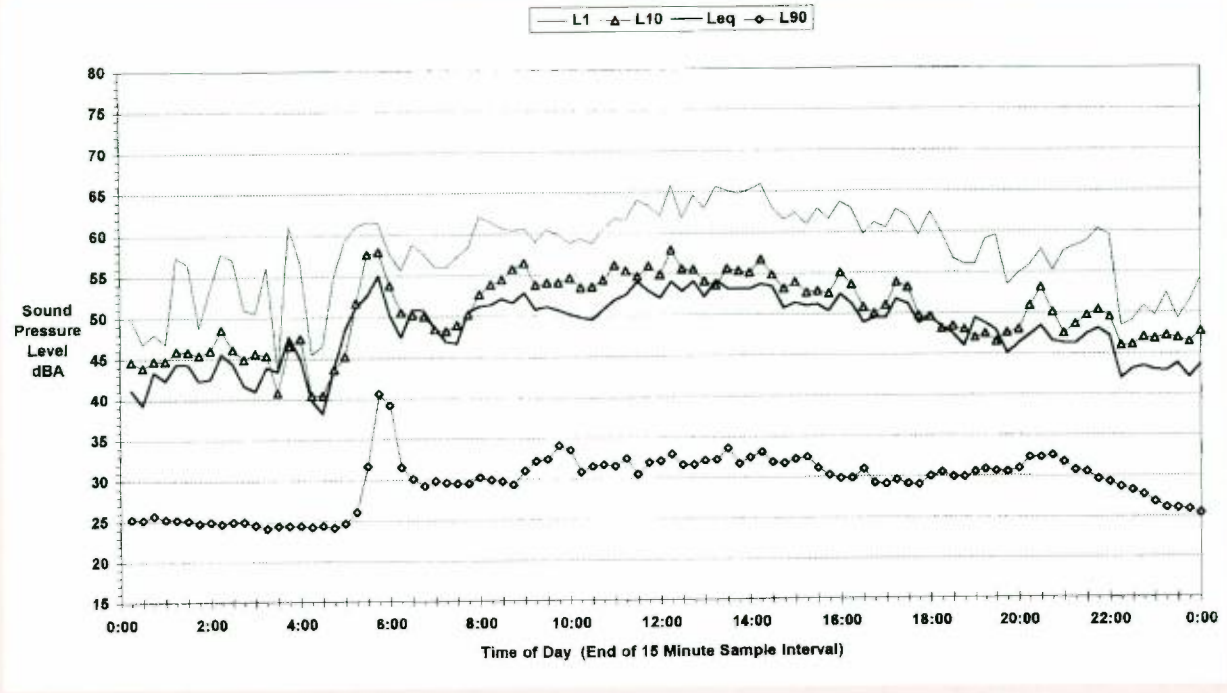
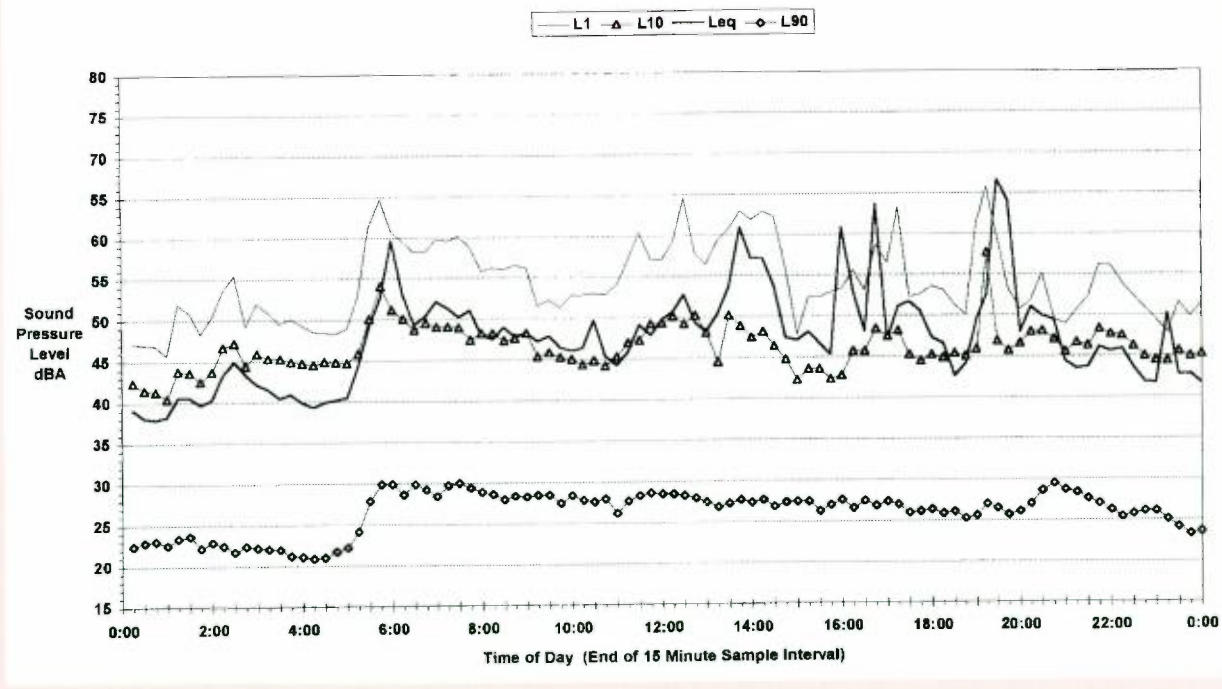
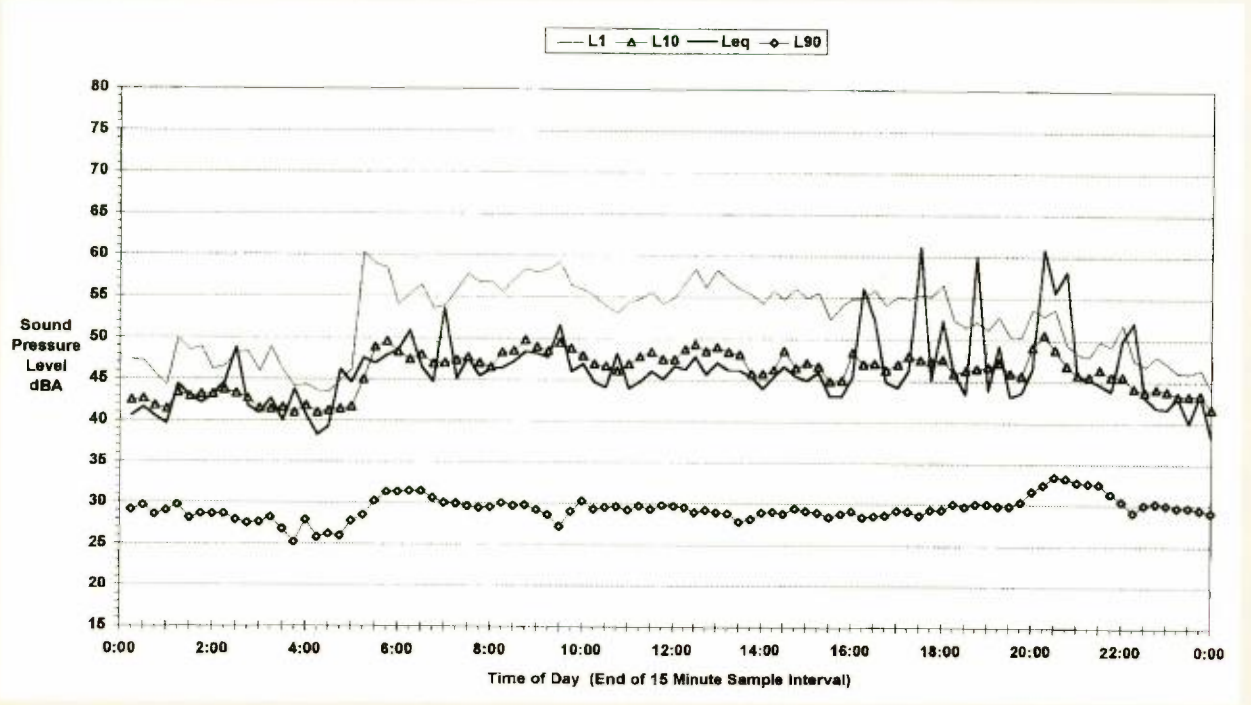


FIG C-13

ACCUMULATED AMBIENT NOISE LEVELS LOCATION, NORTHWEST (DG8) - 7.12.94 to 2.1.95



ACCUMULATED AMBIENT NOISE LEVELS LOCATION, LAGOON FARM (DG12) - 7.12.94 to 1.2.95



Woodward-Clyde

FIG C-15

ATTACHMENT C-6

OPERATOR-ATTENDED NOISE SURVEY RESULTS - WINTER SEASON.

(NOT INCLUDED IN THIS APPENDIX)

ATTACHMENT C-7

OPERATOR-ATTENDED NOISE SURVEY RESULTS - SUMMER SEASON.

(NOT INCLUDED IN THIS APPENDIX)

ATTACHMENT C-8

ENM NOISE MODEL SOUND POWER LEVEL DATA SHEET.

ENM NOISE MODEL SOUND POWER LEVEL DATA SHEET - 28 July 1995

CADIA HILL PROJECT - AGC Woodward Clyde — ENM Coordinate System, ISG minus 290000mE, minus 1280000mN

Stage /Year	No. of Items	Item Description	Condition /Source	Overall SWL dBA	Linear Sound Power Level dB re 10pW 1/1 Octave Band Centre Frequency Hz 31.5	63.0	125.0	250.0	500.0	1k	2k	4k	8k	Acoustic centre above Gr	Item 1 Coordinate E	N	Gr	Item 2 Coordinate E	N	Gr	Item 3 Coordinate E	N	Gr	Item 4 Coordinate E	N	Gr	Item 5 Coordinate E	N	Gr	Item 6 Coordinate E	N	Gr
		Receivers													DG9 - Cornwall			DG1 - Tunbridge Wells			DG5 - Bundella			DG7 - Stratton Vale			DG8 - Northwest			DG12 - Lagoon Far		
n/a	6	Rural Residential Properties												1.5	12240	18570	980	7350	19710	910	5800	15660	720	8080	10380	650	12700	11640	760	13980	17830	910
															208 degrees			146 degrees			95 degrees			26 degrees			329 degrees			233 degrees		
		Construction - Weirs and Processing Plant Site																														
Con.	4	Excavator	Rear excavating - Hitachi UH07 (Q87)	105.0	97.0	112.0	106.0	102.0	102.0	101.0	97.0	87.0	77.0	2.0	9080	19110	790	9080	19110	790	10060	18270	780	13110	14250	770	-	-	-	-	-	-
Con.	2	CAT 16G Grader	Downhill Passby - CAT 16G (L64)	113.6	103.0	104.4	109.9	109.4	108.5	110.4	105.2	101.8	99.0	2.3	9080	19110	790	10060	18270	780	-	-	-	-	-	-	-	-	-	-	-	-
Con.	4	CAT D11N Dozer	Pushing - CAT D11N (L64)	115.5	119.6	121.2	111.7	115.1	114.1	108.6	106.7	104.9	101.1	3.0	9080	19110	790	9080	19110	790	10060	18270	780	13110	14250	770	-	-	-	-	-	-
Con.	4	50t Haul Truck	Uphill Empty - CAT 773B (N14)	116.0	111.1	123.3	117.5	116.4	114.3	108.4	109.2	100.4	93.7	2.9	9080	19110	790	9080	19110	790	9080	19110	770	10060	18270	780	-	-	-	-	-	-
Con.	2	Blast Hole Drill BE 49R2-100	Drilling - BE 45R (L64)	115.6	108.0	109.5	123.5	115.0	110.6	110.9	108.0	101.2	94.7	2.0	9080	19110	790	13110	14250	770	-	-	-	-	-	-	-	-	-	-	-	-
Con.	4	Scraper	Passby - CAT 637E (F93)	111.0	111.0	116.0	115.0	109.0	107.0	106.0	104.0	97.0	92.0	2.9	9080	19110	790	9080	19110	790	9080	19110	790	13110	14250	770	-	-	-	-	-	-
Con.	2	CAT 994 Front-end Loader	Loading - CAT 992 FEL (L64)	119.4	109.2	113.6	128.6	112.0	113.7	115.7	110.7	104.5	96.7	4.5	9080	19110	790	10060	18270	780	-	-	-	-	-	-	-	-	-	-	-	-
Con.	2	CAT 777 Water Cart	Estimate - (L64)	115.3	105.6	110.3	115.0	113.6	113.0	111.3	105.7	100.5	95.9	3.3	9080	19110	790	10060	18270	780	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	Vibrating Roller	Estimate - (J33)	110.0	99.0	104.0	109.0	112.0	107.0	105.0	102.0	96.0	90.0	2.0	9080	19110	790	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	Sheeps Foot Roller	Estimate - (J33)	110.0	99.0	104.0	109.0	112.0	107.0	105.0	102.0	96.0	90.0	2.0	9080	19110	790	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Con.	3	Cement Truck	Estimate - (N14)	108.7	105.3	112.2	106.6	109.4	103.9	104.3	100.9	96.6	88.3	2.5	9105	15520	730	9105	15520	730	9105	15520	730	-	-	-	-	-	-	-	-	-
		Construction - Tailings Dam																														
Con.	2	Excavator	Rear excavating - Hitachi UH07 (Q87)	105.0	97.0	112.0	106.0	102.0	102.0	101.0	97.0	87.0	77.0	2.0	9450	11375	660	9950	11175	660	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	CAT 16G Grader	Downhill Passby - CAT 16G (L64)	113.6	103.0	104.4	109.9	109.4	108.5	110.4	105.2	101.8	99.0	2.3	9450	11375	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	CAT D11N Dozer	Pushing - CAT D11N (L64)	115.5	119.6	121.2	111.7	115.1	114.1	108.6	106.7	104.9	101.1	3.0	9450	11375	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Con.	2	CAT 793B Haul Truck (240T)	Uphill Loaded - Euclid 190T (L64)	119.7	110.4	111.4	116.7	117.0	115.9	115.7	112.4	106.0	103.0	4.3	9450	11375	680	9370	12000	700	-	-	-	-	-	-	-	-	-	-	-	-
Con.	2	CAT 793B Haul Truck (240T)	Downhill Empty - Euclid 190T (L64)	123.4	120.1	119.3	120.2	127.3	123.8	112.6	106.7	100.3	94.1	4.3	9950	11175	660	9370	12000	700	-	-	-	-	-	-	-	-	-	-	-	-
Con.	2	Scraper	Passby - CAT 637E (F93)	111.0	111.0	116.0	115.0	109.0	107.0	106.0	104.0	97.0	92.0	2.9	9450	11375	680	9950	11175	660	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	CAT 994 Front-end Loader	Loading - CAT 992 FEL (L64)	119.4	109.2	113.6	128.6	112.0	113.7	115.7	110.7	104.5	96.7	4.5	9950	11175	660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	CAT 777 Water Cart	Estimate - (L64)	115.3	105.6	110.3	115.0	113.6	113.0	111.3	105.7	100.5	95.9	3.3	9950	11175	660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	Vibrating Roller	Estimate - (J33)	110.0	99.0	104.0	109.0	112.0	107.0	105.0	102.0	96.0	90.0	2.0	9450	11375	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Con.	1	Sheeps Foot Roller	Estimate - (J33)	110.0	99.0	104.0	109.0	112.0	107.0	105.0	102.0	96.0	90.0	2.0	9950	11175	660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Pit Operations																														
I / f	2	P&H 2800 Electric Shovel	Dumping - P&H 2800 (L64)	122.5	118.6	129.1	124.1	116.3	121.5	118.4	112.5	103.0	93.0	6.0	9810	16685	715	9505	16425	715	-	-	-	-	-	-	-	-	-	-	-	-
I / f	4	CAT 793B Haul Truck (240T)	Uphill Loaded - Euclid 190T (L64)	119.7	110.4	111.4	116.7	117.0	115.9	115.7	112.4	106.0	103.0	4.3	9810	16685	715	9315	15875	750	9495	15770	750	9925	17145	805	-	-	-	-	-	-
I / f	4	CAT 793B Haul Truck (240T)	Downhill Empty - Euclid 190T (L64)	123.4	120.1	119.3	120.2	127.3	123.8	112.6	106.7	100.3	94.1	4.3	9505	16425	715	9800	16315	715	10675	17190	869	9170	13870	736	-	-	-	-	-	-
I / f	nil	LeTourmeau L1400 FEL	Loading - CAT 992 FEL (L64)	120.5	110.3	114.7	129.7	113.1	114.8	116.8	111.8	105.6	97.8	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I / f	3	Driltech D90 KS Drill	Drilling - BE 45R / SC 45M (L64)	115.7	108.0	109.5	121.2	115.0	110.7	111.1	108.3	101.4	94.7	2.0	9760	16745	730	9600	16610	730	9440	16470	730	-	-	-	-	-	-	-	-	-
I / f	2	CAT D11N Track Dozer	Pushing - CAT D11N (L64)	115.5	119.6	121.2	111.7	115.1	114.1	108.6	106.7	104.9	101.1	3.0	10675	17190	869	9170	13870	736	-	-	-	-	-	-	-	-	-	-	-	-
I / f	2	CAT 834 Wheel Dozer	Estimate - CAT 834 Wheel Dozer (L64)	113.2	117.3	118.9	109.4	112.8	111.8	106.3	104.4	102.6	98.8	2.7	9810	16685	715	9505	16425	715	-	-	-	-	-	-	-	-	-	-	-	-
I / f	1	CAT 16G Grader	Downhill Passby - CAT 16G (L64)	113.6	103.0	104.4	109.9	109.4	106.5	110.4	105.2	101.8	99.0	2.3	9800	16315	715	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I / f	1	CAT 777 Water Cart	Estimate - (L64)	115.3	105.6	110.3	115.0	113.6	113.0	111.3	105.7	100.5	95.9	3.3	9440	16005	730	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
II / 4	2	P&H 2800 Electric Shovel	Dumping - P&H 2800 (L64)	122.5	118.6	129.1	124.1	116.3	121.5	118.4	112.5	103.0	93.0	6.0	9310	16305	655	9730	16830	655	-	-	-	-	-	-	-	-	-	-	-	-
II / 4	6	CAT 793B Haul Truck (240T)	Uphill Loaded - Euclid 190T (L64)	119.7	110.4	111.4	116.7	117.0	115.9	115.7	112.4	106.0	103.0	4.3	9605	16585	505	9710	16770	640	9310	16305	655	9730	16830	655	9975	16415	655	9435	15955	730
II / 4	6	CAT 793B Haul Truck (240T)	Uphill Loaded - Euclid 190T (L64)	119.7	110.4	111.4	116.7	117.0	115.9	115.7	112.4	106.0	103.0	4.3	9315	15875	750	9495	15770	750	9500	14450	777	10050	14600	777	9800	15200	777		Idle	
II / 4	6	CAT 793B Haul Truck (240T)	Downhill Empty - Euclid 190T (L64)	123.4	120.1	119.3	120.2	127.3	123.8	112.6	106.7	100.3	94.1	4.3	9605	16585	505	9675	16670	535	9310	16305	655	9730	16830	655	9835	16375	655	9590	16095	715
II / 4	5	CAT 793B Haul Truck (240T)	Downhill Empty - Euclid 190T (L64)	123.4	120.1	119.3	120.2	127.3	123.8	112.6	106.7	100.3	94.1	4.3	9360	16035	730	9600	15470	750	9230	13830	777	9500	14450	777		Idle		-	-	-
II / 4	1	LeTourmeau L1400 FEL	Loading - CAT 992 FEL (L64)	120.5	110.3	114.7	129.7	113.1	114.8	116.6	111.6	105.6	97.8	4.5	9605	16585	505	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
II / 4	6	Driltech D90 KS Drill	Drilling - BE 45R / SC 45M (L64)	115.7	108.0	109.5	121.2	115.0	110.7	111.1	108.3	101.4	94.7	2.0	9605	16585	505	9275	16460	670	9275	16460	670	9620	16900	670	9620	16900	670		Idle	
II / 4	3	CAT D11N Track Dozer	Pushing - CAT D11N (L64)	115.5	119.6	121.2	111.7	115.1	114.1	108.6	106.7	104.9	101.1	3.0	9170	16880	670	9230	13830	777	10050	14600	777	-	-	-	-	-	-	-	-	-
II / 4	2	CAT 834 Wheel Dozer	Estimate - CAT 834 Wheel Dozer (L64)	113.2	117.3	118.9	109.4	112.8	111.8	106.3	104.4	102.6	98.8	2.7	9310	16305	655	9730	16830	655	-	-	-	-	-	-	-	-	-	-	-	-
II / 4	2	CAT 16G Grader	Downhill Passby - CAT 16G (L64)	113.6	103.0	104.4	109.9	109.4	108.5	110.4	105.2	101.8	99.0	2.3	9915	16230	685	9275	15975	740	-	-	-	-	-	-	-	-	-	-	-	-
II / 4	1	CAT 777 Water Cart	Estimate - (L64)	115.3	105.6	110.3	115.0	113.6	113.0	111.3	105.7	100.5	95.9	3.3	9750	16155	700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
II / 6	2	P&H 2800 Electric Shovel	Dumping - P&H 2800 (L64)	122.5	118.6	129.1	124.1	116.3	121.5	118.4	112.5	103.0	93.0	6.0	9480	16830	520	9255	16630	520	-	-	-	-	-	-	-	-	-	-	-	-
II / 6	6	CAT 793B Haul Truck (240T)	Uphill Loaded - Euclid 190T (L64)	119.7	110.4	111.4	116.7	117.0	115.9	115.7	112.4	106.0	103.0	4.3	9500	16350	520	9480	16830	520	9255	16630	520	9225	16885	565	9975	16415	655	9435	15955	730
II / 6	6	CAT 793B Haul Truck (240T)	Uphill Loaded - Euclid 190T (L64)	119.7	110.4	111.4	116.7	117.0	115.9	115.7	112.4	106.0	103.0	4.3	9315	15875	750	9495	15770	750	9800	15000	809	10600	14850	809		Idle			Idle	
II / 6	6	CAT 793B Haul Truck (240T)	Downhill Empty - Euclid 190T (L64)	123.4	120.1	119.3	120.2	127.3	123.8	112.6	106.7	100.3	94.1	4.3	9605	16585	505	9480	16830	520	9255	16630	520	9195	16525	520	9775	16760	625	9590	16095	715
II / 6	5	CAT 793B Haul Truck (240T)	Downhill Empty - Euclid 190T (L64)	123.4	120.1	119.3	120.2	127.3	123.8	112.6	106.7	100.3	94.1	4.3	9360	16035	730	9600	15420	750	9800	15000	609	9400	14000	809		Idle		-	-	-
II / 6	1	LeTourmeau L1400 FEL	Loading - CAT 992 FEL (L64)	120.5	110.3	114.7	129.7	113.1	114.8	116.8	111.8	105.6	97.8	4.5	9605	16585	505	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
II / 6	6	Driltech D90 KS Drill	Drilling - BE 45R / SC 45M (L64)	115.7	108.0	109.5	121.2	115.0	110.7	111.1	108.3	101.4	94.7	2.0	9750	16480	520	9750	16480	520	9750	16480	520	9660	16690	520	9680	16690	520		Idle	
II / 6	3	CAT D11N Track Dozer	Pushing - CAT D11N (L64)	115.5	119.6	121.2	111.7	115.1	114.1	108.6	106.7	104.9	101.1	3.0	9250	16510	520	10600	14850	809	9400	14000	809	-	-	-	-	-	-	-	-	-
II / 6	2	CAT 834 Wheel Dozer	Estimate - CAT 834 Wheel Dozer (L64)	113.2	117.3	118.9	109.4	112.8	111.8	106.3	104.4	102.6	98.8	2.7	9480	16830	520	9255	16630	520	-	-	-	-	-	-	-	-	-	-	-	-
II / 6	2	CAT 16G Grader	Downhill Passby - CAT 16G (L64)	113.6	103.0	104.4	109.9	109.4	108.5	110.4	105.2	101.8	99.0	2.3	9915	16230	685	9275	15975	740	-	-	-	-	-	-	-	-	-	-	-	-
II / 6	1	CAT 777 Water Cart	Estimate - (L64)	115.3	105.6	110.3	115.0	113.6	113.0	111.3	105.7	100.5	95.9	3.3	9750	16155	700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Primary Crusher																														
I / II	1	Allis 60 x 110	750 kW, 5000 tph with noise controls	112.5	104.8	112.6	115.0	110.1	104.8	109.0	104.7	101.3	97.3	5.0	9315	15850	722	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Grinding and Floatation Plant																														
I / II	2	SAG Mills	2 off @ 9800 kW, 1700 tph	121.0	112.2	116.9	114.9	115.9	118.0	115.8	114.3	110.5	104.8	3.0	9190	15460	737	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I / II	4	Ball Mills	4 off @ 4100 kW, 1700 tph																													
I / II	16	Copper Rougher & Scan Cells	16 off @ 90 kW, 92 m^3 cells																													
I / II	20	Pyrite Rougher and Scan Cells	20 off @ 90 kW, 92 m^3 cells																													
I / II	12	Pyrite Cleaner Cells	12 off @ 22 kW, 16 m^3 cells																													
I / II	-	Flotation Cell Low Pressure Blowers	CIP Circuit and leach temps																													
I / II	1	Gold Recovery Plant	-																													
I / II	-	CIP Plant and Compressors	CIP Plant																													
I / II	-	Regrind	-																													

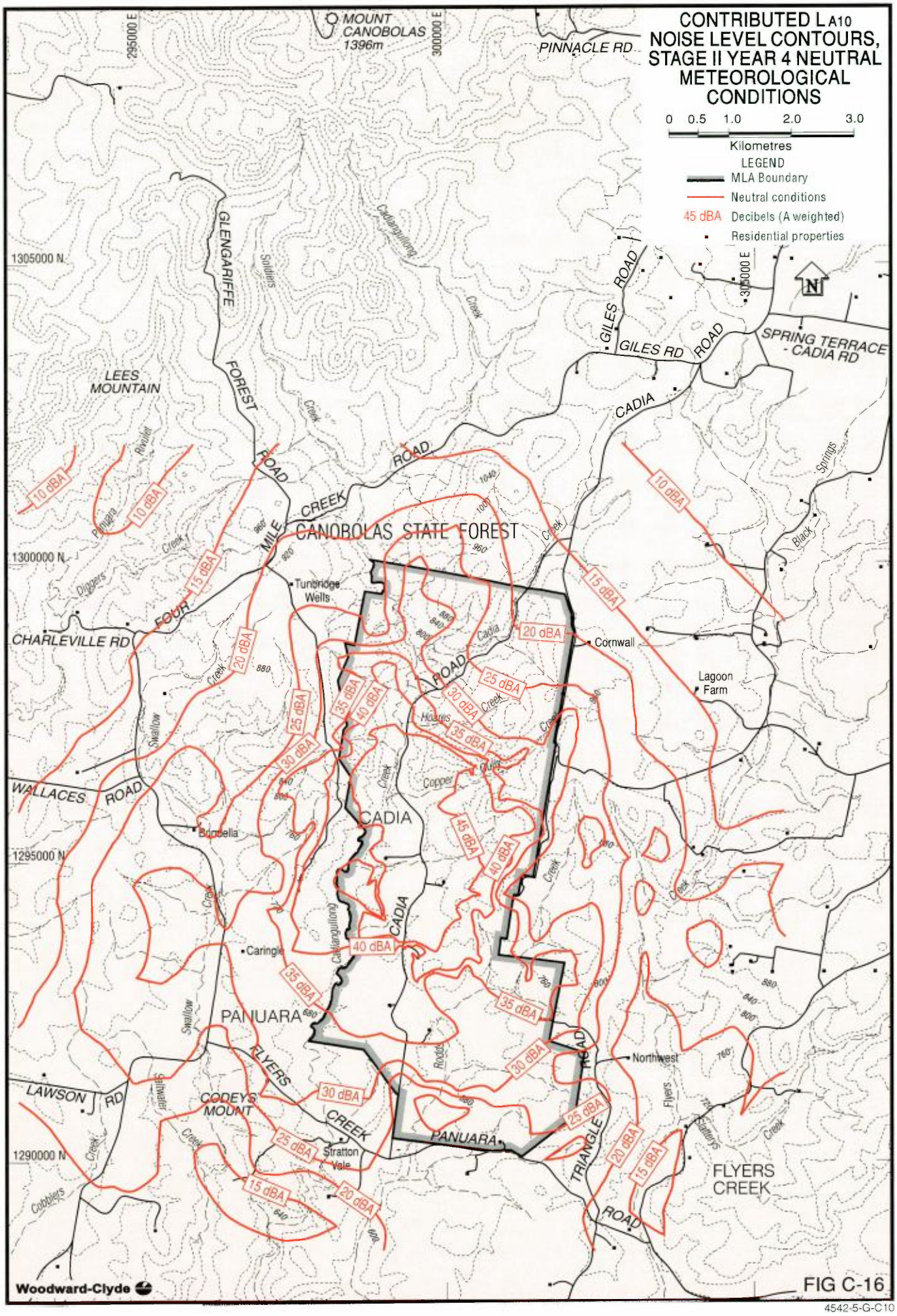
ATTACHMENT C-9

WIND ROSES

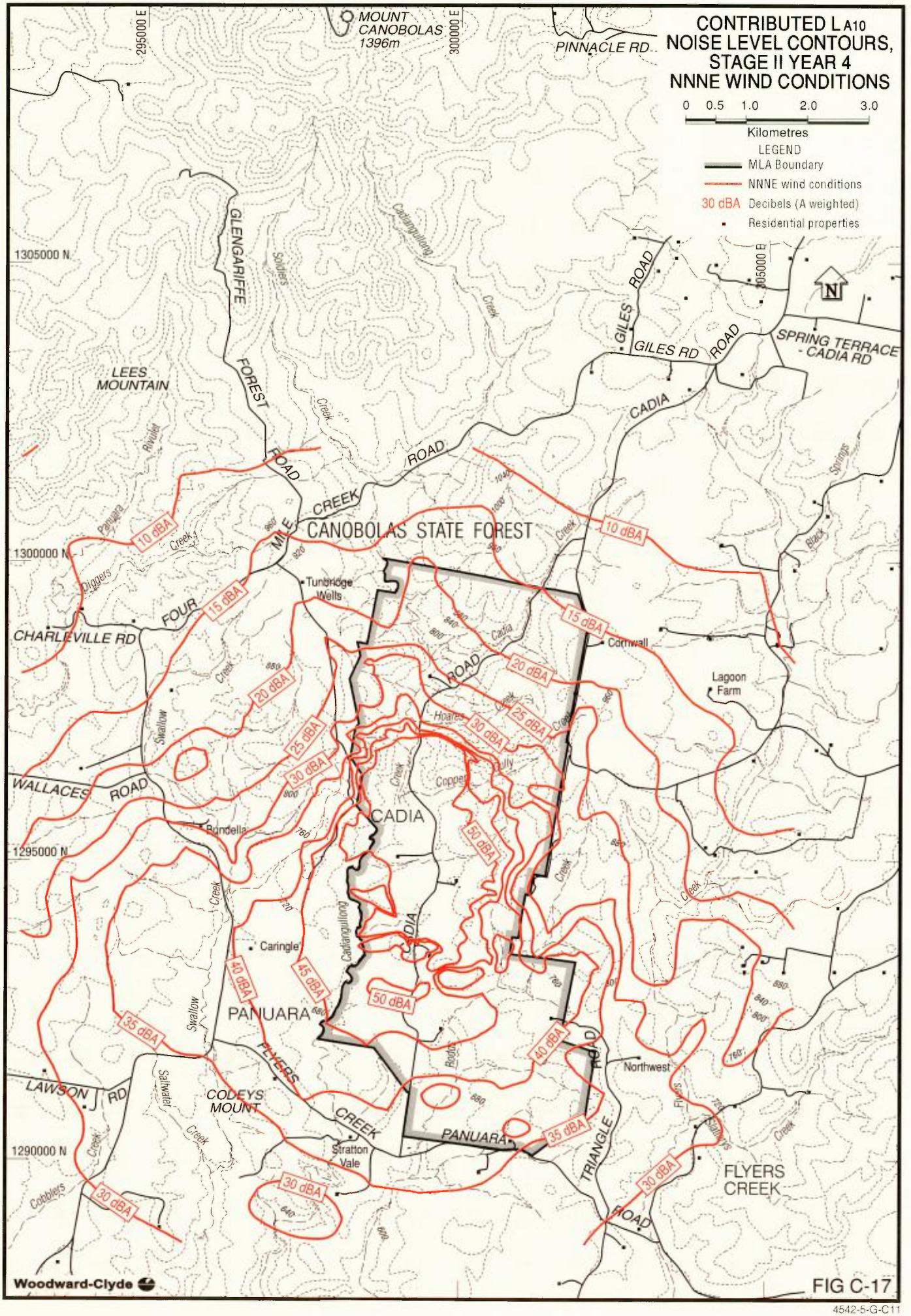
(NOT INCLUDED IN THIS APPENDIX REFER TO FIGURES B-17, B-18 AND B-19 OF APPENDIX B)

ATTACHMENT C-10

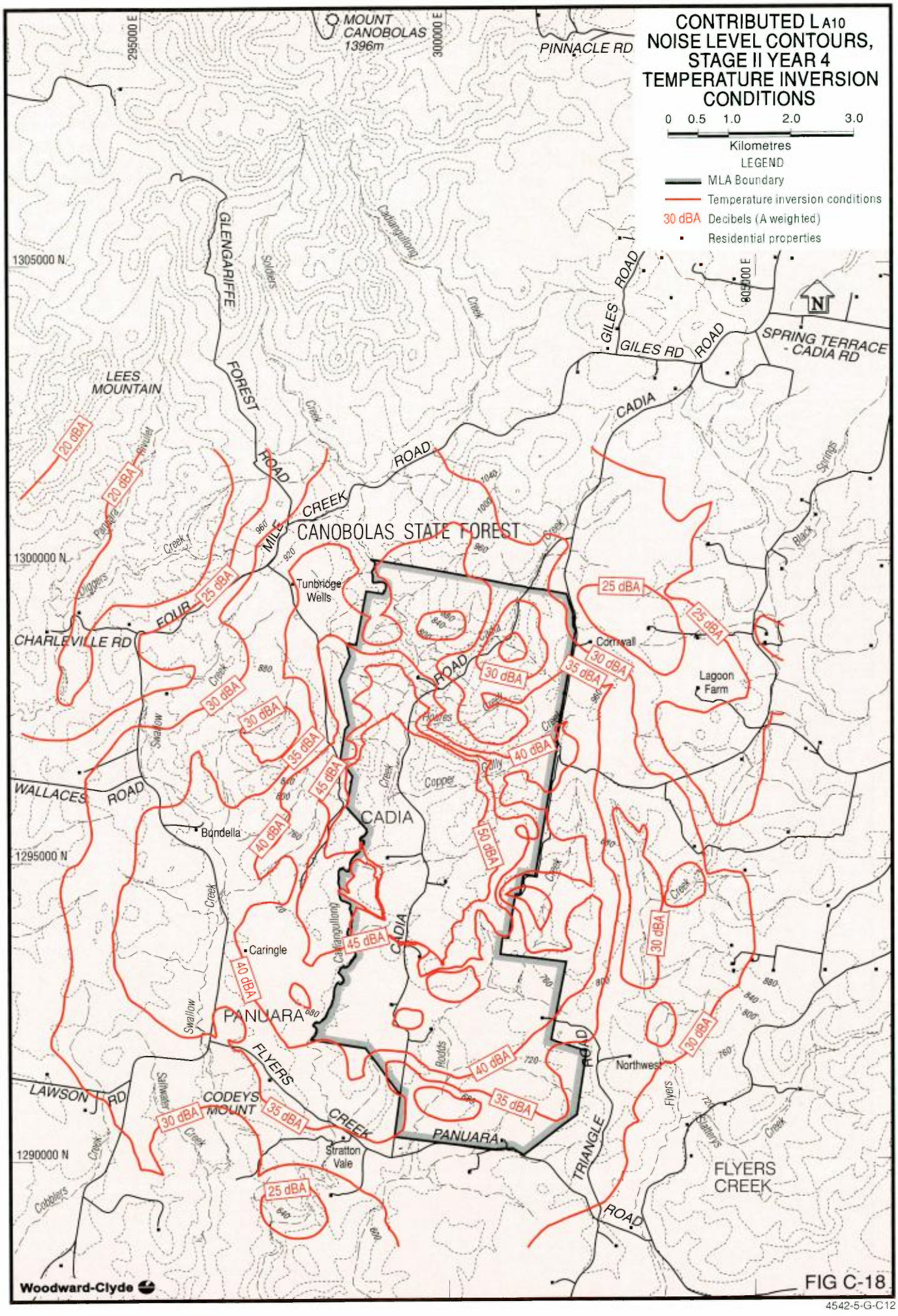
CONTRIBUTED L_{A10} NOISE CONTOUR DIAGRAMS - STAGE II YEAR 4.


CONTRIBUTED LA10 NOISE LEVEL CONTOURS, STAGE II YEAR 4 NEUTRAL METEOROLOGICAL CONDITIONS
0 0.5 1.0 2.0 3.0
Kilometres
LEGEND
MLA Boundary
Neutral conditions
45 dBA Decibels (A weighted)
Residential properties
MOUNT CANOBOLAS 1396m
PINNACLE RD
295000 E
300000 E
305000 E
1305000 N
1300000 N
1295000 N
1290000 N
GLENGARIFFE FOREST ROAD
LEES MOUNTAIN
GILES ROAD
SPRING TERRACE - CADIA RD
CADIA ROAD
CANOBOLAS STATE FOREST
MILE CREEK
FOUR
CHARLEVILLE RD
WALLACES ROAD
LAWSON RD
FLYERS CREEK ROAD
TRIANGLE ROAD
Tunbridge Wells
Cornwall
Lagoon Farm
Brucella
Caringle
PANUARA
CODEYS MOUNT
Stratton Vale
Northwest
FLYERS CREEK
CADIA
10 dBA
15 dBA
20 dBA
25 dBA
30 dBA
35 dBA
40 dBA
45 dBA
N
Woodward-Clyde
FIG C-16

4542-5-G-C10


CONTRIBUTED LA10 NOISE LEVEL CONTOURS, STAGE II YEAR 4 NNNE WIND CONDITIONS
0 0.5 1.0 2.0 3.0
Kilometres
LEGEND
MLA Boundary
NNNE wind conditions
30 dBA Decibels (A weighted)
Residential properties
MOUNT CANOBOLAS 1396m
295000 E
300000 E
305000 E
1305000 N
1300000 N
1295000 N
1290000 N
PINNACLE RD
GLENGARIFFE FOREST ROAD
LEES MOUNTAIN
GILES ROAD
SPRING TERRACE - CADIA RD
CADIA ROAD
MILE CREEK ROAD
CANOBOLAS STATE FOREST
FOUR CHARLEVILLE RD
WALLACES ROAD
LAWSON RD
FLYERS CREEK ROAD
TRIANGLE ROAD
Tunbridge Wells
Cornwall
Lagoon Farm
Hoares
Copper
Rondella
Caringle
Stratton Vale
Northwest
CADIA
PANUARA
CODEYS MOUNT
FLYERS CREEK
10 dBA
15 dBA
20 dBA
25 dBA
30 dBA
35 dBA
40 dBA
45 dBA
50 dBA
Woodward-Clyde
FIG C-17

4542-5-G-C11


CONTRIBUTED L A10
NOISE LEVEL CONTOURS,
STAGE II YEAR 4
TEMPERATURE INVERSION
CONDITIONS
0 0.5 1.0 2.0 3.0
Kilometres
LEGEND
MLA Boundary
Temperature inversion conditions
30 dBA Decibels (A weighted)
Residential properties
MOUNT CANOBOLAS 1396m
PINNACLE RD
GLENGARIFFE FOREST ROAD
LEES MOUNTAIN
GILES ROAD
SPRING TERRACE - CADIA RD
CADIA ROAD
MILL CREEK ROAD
CANOBOLAS STATE FOREST
Tunbridge Wells
FOUR MILE CREEK
CHARLEVILLE RD
WALLACES ROAD
Bundella
Caringle
PANUARA
FLYERS CREEK ROAD
LAWSON RD
CODEYS MOUNT
Stratton Vale
CADIA
Cornwall
Lagoon Farm
Northwest
TRIANGLE ROAD
FLYERS CREEK
2950000 E
3000000 E
3050000 E
1305000 N
1300000 N
1295000 N
1290000 N
20 dBA
25 dBA
30 dBA
35 dBA
40 dBA
45 dBA
50 dBA
Woodward-Clyde
FIG C-18

4542-5-G-C12

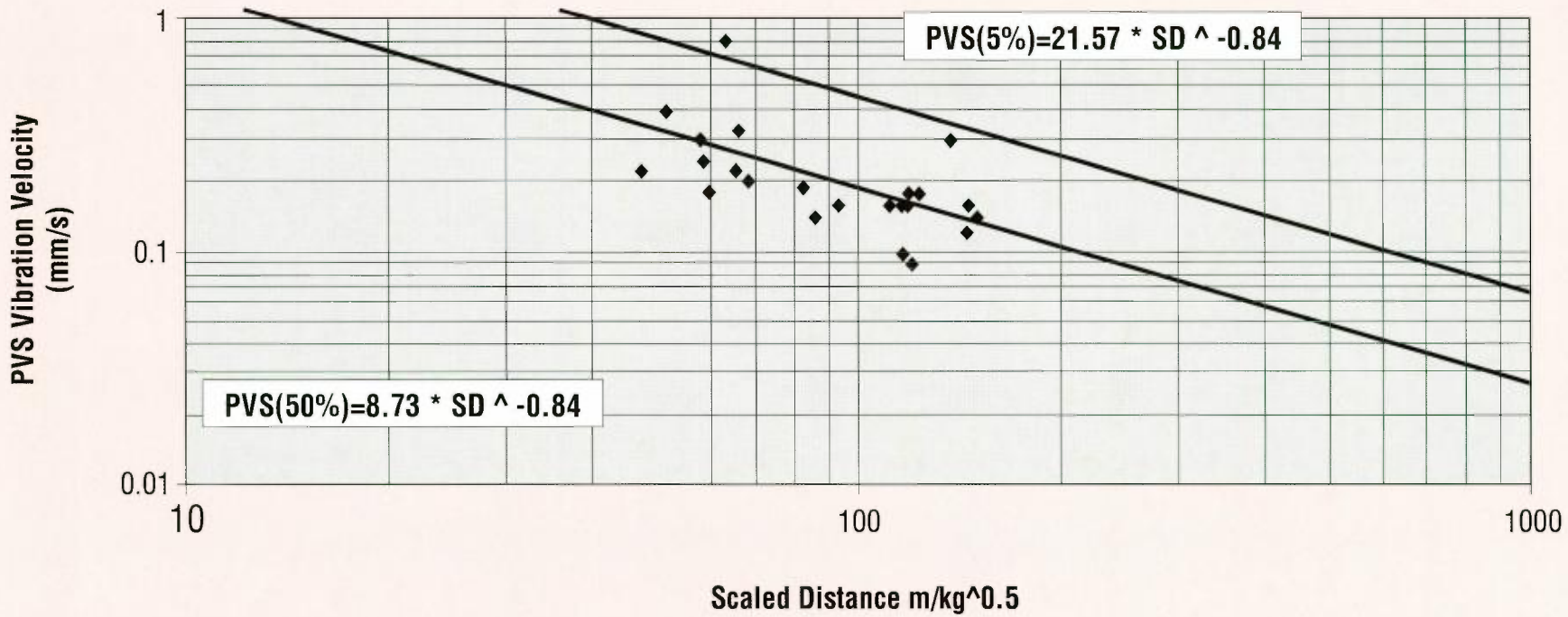
ATTACHMENT C-11

BLAST DESIGN CALCULATIONS - FRESH WASTE AND ORE.

(NOT INCLUDED IN THIS APPENDIX)

ATTACHMENT C-12

TRIAL BLAST RESULTS.



TRIAL BLAST RESULTS
PVS GROUND VIBRATION VELOCITY SITE LAW
24 DATA POINTS

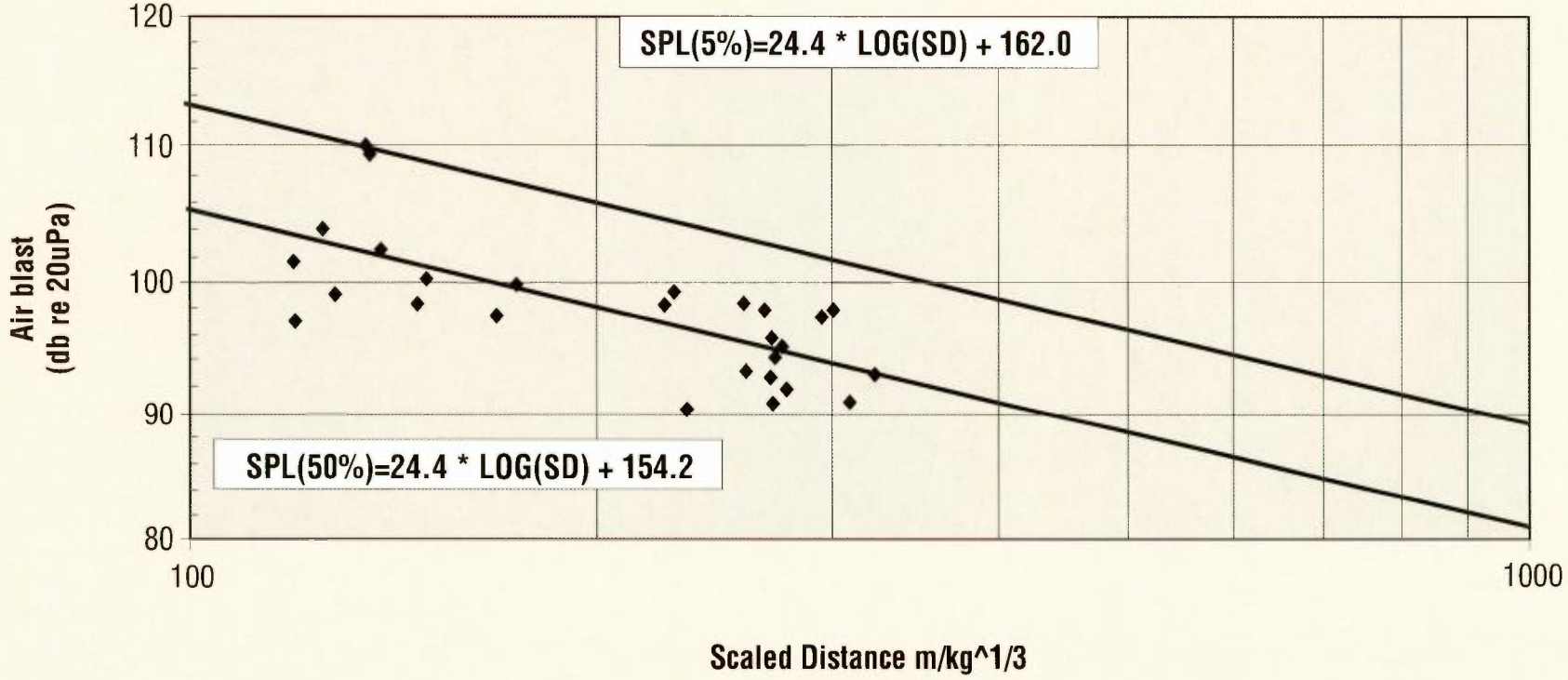
FIG C-19

SOURCE- S:\A32\4541-2.1\EXCEL\FLOW-CAD.XLS

Woodward-Clyde

4542.2.24-G-C.13

CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



TRIAL BLAST RESULTS
PEAK LINEAR AIRBLAST SITE LAW
28 DATA POINTS

FIG C-20

SOURCE- S:\A32\4541-2.1\EXCEL\FLOW-CAD.XLS

Woodward-Clyde

ATTACHMENT C-13

EXISTING TRAFFIC MEASUREMENT LOCATIONS

(NOT INCLUDED IN THIS APPENDIX, REFER TO FIGURE 3-19 OF VOLUME 1)

APPENDIX D

Flora

FLORA REPORT FOR NEWCREST MINING ON THE "CADIA PROJECT"

BY

CC. BOWER AND R.W. MEDD

in association with

Orange Field Naturalist and Conservation Society Incorporated

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FIGURE D-2
Habitat Details of the Newcrest Cadia Project Study Area Surveyed.

LIST OF ATTACHMENTS

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Checklist of Species Observed in Newcrest Cadia Project Study Area D-7

1.0 RECOMMENDATIONS

1. Relocate populations of appropriate regionally rare orchid species from Cadia Reserve to other suitable local reserves. This would be feasible for *Pterostylis alata*, *Prasophyllum* aff. *odoratum* and *Pterostylis longifolia* biotype 2.

2. Place regionally rare or other significant shrub species into cultivation for long term conservation and use in land rehabilitation and in landcare projects. This would be appropriate for *Acacia acinacea*, *Pultenaea microphylla* and *Olearia erubescens*, in addition to the above mentioned orchids.

   Endeavours to relocate and place into cultivation regionally significant taxa should involve several bodies of expertise including the Wollongong Orchid Society, Burrendong Arboretum, Royal Botanic Gardens, Orange Botanic Gardens along with interested community groups.

3. Submit specimens of unnamed orchid species to the Australian National Botanic Gardens for taxonomic research and determination of significance.

4. Should mining be approved in Cadia Reserve, any areas not required for mining should be protected, where possible, from disturbance because of the regional importance of many of the habitats.

5. Likewise to recommendation Four, areas of Cadia Reserve disturbed by surveying and exploration, which are not required for mining, should be rehabilitated.

2.0 INTRODUCTION

The Orange Field Naturalist and Conservation Society Inc. (OFNCS) was commissioned by Newcrest Mining Ltd. to provide an account of the flora of Cadia Reserve and surrounding remnant bushland.

The Cadia Reserve, which forms part of the Canobolas Regional Parkland (CRP) is part of the area under consideration for mining development in the "Newcrest Cadia Project" (NCP). The CRP is managed by a Trust, consisting of a voluntary committee, which comes under the jurisdiction of the Department of Conservation and Land Management.

The OFNCS has an ongoing project to document the native flora of remnant bushland with particular emphasis on the CRP. The survey involves extensive field exploration of the flora, development of an herbarium collection and a computer database of the remnant flora. The Cadia Reserve had previously been surveyed as part of this work.

This report compiles the plant alliances observed in the NCP remnant bushland areas bounded approximately by Cadiangullong Creek, Hoares Creek and eastern and southern limits of Cadia Reserve. A list of all recorded native species together with details of distribution, abundance, habitat and conservation status is appended. The regional significance of the flora in the NCP is discussed and comment is made on species considered to be vulnerable.

3.0 METHOD

At least 12 field excursions have been undertaken in the NCP area since mid-1987 to survey all habitats and alliances. These excursions encompassed the Cadia Reserve and adjacent remnant bushland areas. Common widespread species were recorded as observations and other species of particular interest were preserved as herbarium specimens. Where necessary, identification was verified by submitting specimens to the Royal Botanical Gardens, Sydney. All herbarium specimens and observations have been recorded in the database.

4.0 PHYSIOGRAPHY OF THE NCP AREA

The NCP area is situated near the western transition of the Central Tablelands/Central Western Slopes botanical subdivisions (Figure D-1). It consists of two parallel valleys descending WSW from approx. 900 m to 750 m altitude and is characterised by steep topography, impoverished skeletal soils, varied aspects and a range of habitats (Figure D-2). The ridges are dominated by dry sclerophyll forests with a sparse understorey of shrubs and grasses. Vegetation in the valleys consists of taller forests along the creeks with a more diverse understorey of herbs, grasses and shrubs.

Cadia Reserve is located towards the centre of the NCP area and is dissected by a semi-permanent watercourse, Copper Gully Creek. It consists of numerous rocky outcrops, steep gullies and occasional alluvial flats. These features provide the basis for several notable habitats. The predominant topographical feature of the reserve is a large hill (890 m alt.) to the south of Copper Gully Creek. Its steep northerly slope is an important dryland habitat, as to a lesser extent is the western face. The northern boundary of the reserve comprises the steep south-facing slope of Sharpes Ridge. A similar south-facing slope occurs in the south eastern corner. Both these areas host a suite of herbaceous species adapted to cool moist sheltered conditions. A small area of open woodland on deeper alluvial soils and more gentle terrain occurs along Copper Gully Creek in the north western corner.

5.0 HABITATS OF SPECIAL SIGNIFICANCE

The area is topographically diverse and contains three particular habitats worthy of comment. The two sheltered slopes with southerly aspects (habitats 3 and 4, Figure D-2) host a regionally unique diversity of terrestrial orchids. Of the two slopes, habitat 3 supports especially large colonies of seven of the orchid species. Habitat 4 supports colonies of three of the regionally rare orchid species (*Pterostylis alata*, *Prasophyllum* aff. *odoratum* and *Pterostylis longifolia* biotype 2).

Habitats 5 and 6 (Figure D-2), the steep, rocky, dry slopes with northerly aspect, support the only known populations of *Acacia acinacea* and *Pultenaea microphylla* in the region.

Copper Gully Creek divides habitats 3 and 6 and supports a more diverse range of ferns than any other watercourse known in the region, including the only known regional occurrences of *Hypolepis rugosula* and *Pteris tremula*. Both species occur in the upper reaches of the creek opposite a vertical curved northern face which is largely protected from direct sunlight. This is not a spectacular gorge but its unique combination of topographical features, not common in the area, is particularly suitable for ferns.

6.0 LAND USE HISTORY

Much of the NCP area has been heavily logged in the past, either for fuel for smelters during previous mining activities or for supplies of pit props, hardwood, fencing material and possibly firewood. The existing tree cover is therefore mainly regrowth timber with isolated old-growth trees and occasional old-growth stands in the less accessible areas. Prior to its dedication in 1986 as parkland under the CRP the reserve was leased for grazing. Little recreational use of the reserve has occurred.

7.0 FLORA

7.1 REGIONAL CONTEXT

Much of the landscape in the Orange district has been cleared for agricultural and horticultural activities. Islands of remnant bushland are dominated by Mount Canobolas and environs to the near north of the NCP area and the Mullion Range complex further north. There are no major gazetted conservation reserves or wilderness areas close to Orange. However, there are two small nature reserves (Barton NR and Freemantle NR) and two flora reserves in the northern Mullion Range. The Canobolas Regional Parkland initiative has provided a network of regional conservation reserves to protect the most valuable remnants and to service recreational interests. The Cadia Reserve is situated in the south western corner of the region and is most closely linked geographically and floristically to the Mount Canobolas massif.

The natural vegetation of the Orange district comprises mainly eucalypt forests and woodlands. No detailed description of the flora has been published but it is known to be a transitional zone containing elements from the sandstone flora to the east, the cool temperate flora to the south and the semi-arid western slopes flora.

The remnant forests and woodlands consist of eight alliances (Bower and Semple, 1993), the most widespread on the dry, rugged ranges being *Eucalyptus rossii/E. macrorhyncha*. The *E. blakelyi/E. melliodora* and *E. albens* alliances are typically dominant on land below 800 m alt. in the areas cleared for agriculture. The *E. rossii/E. macrorhyncha* alliance contains a large number of associated trees including, *E. dives*, *E. goniocalyx*, *E. polyanthemos*, *E. bridgesiana*, *E. viminalis*, *E. albens*, *E. mannifera* and *Callitris endlicheri*. It is not uncommon for *E. rossii* to be absent from many of these associations. Much of the more fertile areas above 800 m alt., that have been cleared for horticultural, agricultural and silvicultural purposes, were dominated by the *E. fastigata/E. viminalis* alliance. *E. fastigata* is absent from the alliance in the Orange region and associated species include *E. pauciflora*, *E. dalrympleana* subsp. *dalrympleana*, *E. robertsonii* subsp. *hemisphaerica*, *E. viminalis*, *E. dives*, *E. rubida* subsp. *canobolensis*, *E. rubida* subsp. *rubida*, *E. radiata* subsp. *radiata*, *E. melliodora*, *E. bridgesiana and E. aggregata*. Most permanent streams below 800m alt. are lined by the *Casuarina cunninghamiana* alliance.

The majority of the NCP remnant bushland area is covered by the *Eucalyptus rossii/E. macrorhyncha* alliance as is typical of the region. The *E. blakelyi/E. melliodora* alliance covers the small area of woodland in Cadia Reserve and nearby areas on gentle terrain, and *Casuarina cunninghamiana* occurs along Cadiangullong Creek (Figure D-2).

7.2 DESCRIPTION OF TREE ALLIANCES IN THE NCP

7.2.1 E. rossii/E. macrorhyncha

This alliance occurs on the steeper terrain in Cadia Reserve and nearby areas, and consists of *E. macrorhyncha*, *E. goniocalyx* and *E. polyanthemos* in varying proportions depending on site characteristics. *E. macrorhyncha* and *E. goniocalyx* are common throughout the area, while *E. polyanthemos* is more frequent on the drier north and west facing slopes, which also support stands of *Callitris endlicheri*; a species that is locally uncommon. Minor occurrences of *E. dives* occur on sheltered slopes with a southerly aspect. *E. rossii* is absent from the NCP even

though it is usually a dominant tree in the alliance in the region, especially north of Orange. The tree species composition in the *E. rossii/E. macrorhyncha* alliance in the NCP is typical of that in areas to the west and south west of Mt Canobolas including Barton NR.

7.2.2 E. blakelyi/E. melliodora

Only small remnants of this alliance occur in the NCP area, but it would once have dominated the surrounding agricultural lands of the Cadia district. It occurs on deeper soils on flat to undulating terrain. There is a small occurrence in the north western corner of the Cadia Reserve on either side of Copper Gully Creek extending for short distances upstream and along the western boundary on the gentler terrain. Outside the reserve remnants of this alliance border the steep hills beside Cadia Road. As well as *E. blakelyi* and *E. melliodora*, *E. bridgesiana* and *E. viminalis* also occur in small numbers, the former in the north western corner of the reserve and areas bordering the remnant bushland, and the latter along Copper Gully Creek in the reserve near the eastern boundary.

7.2.3 Casuarina cunninghamiana

This alliance is confined to a narrow strip along Cadiangullong Creek and is highly disturbed due to past agricultural and mining activities. However, *C. cunninghamiana* serves an important role in stabilising the banks of creeks and rivers, and for this reason is a protected tree in New South Wales. Permits are required from CaLM before this tree can be removed.

7.3 CONSERVATION STATUS OF ALLIANCES

All three alliances in the NCP area are widespread in central western New South Wales and beyond. The *E. rossii/ E. macrorhyncha* and *C. cunninghamiana* alliances are well conserved in National Parks and Nature Reserves. The *E. blakelyi/E. melliodora* alliance, although widespread, is poorly conserved in its pristine state in the central western region. The remnants in the NCP are too small and too highly disturbed to be viable for conservation.

7.4 SIGNIFICANT FEATURES OF CADIA FLORA

A checklist of the flora, arranged by plant family into pteridophytes (ferns), monocotyledons (lilies and grasses) and dicotyledons (broadleaf herbs, shrubs and trees) is appended. The list gives details of the distribution of each species, its abundance, habitat and national and regional conservation status.

We have identified 168 species in the NCP area, comprising nine pteridophytes, 55 monocotyledons and 104 dicotyledons. The dominant families are Fabaceae (subfamily Faboideae 12 species; subfamily Mimosoideae nine species), Asteraceae (16 species), Orchidaceae (22 species), Poaceae (11 taxa), Myrtaceae (nine species) and Lomandraceae (seven species). In view of our limited resources we consider this census unlikely to be complete.

7.5 GROUPS WITH HIGH DIVERSITY

Of the dominant groups the Orchidaceae, Lomandraceae and Pteridophytes express higher diversity in the NCP than at any similar location within the region.

The Orchidaceae are represented by 22 species, of which four are rare or poorly known locally. The recorded diversity is most probably an under-estimate of the family, given the poor seasons during the survey and the difficulty in detecting non-flowering plants. The only local sites with greater diversity are the Calula Range, north of Orange, and Wambool Nature Reserve, east of Bathurst, although neither of these sites contain all four of the threatened species.

As mentioned, there are very few regional sites with a wide diversity of ferns, the most notable being Mingham Springs north west of Cudal. Ferns require cool moist shady sites and such habitats are rare within the region, even on the Mount Canobolas massif, which has considerably higher altitude and supports a different suite of fern species.

The Lomandras, grass-like rushes, also exhibit high diversity in the NCP. No other area within the region supports as many of the species known to occur in the Central Tablelands, and rarely are more than four species ever observed together.

7.6 REGIONALLY RARE OR SIGNIFICANT SPECIES

The NCP area supports at least 10 regionally significant species. As such it is an important representation of the local flora and its loss would result in a significant depletion of the regional biodiversity. In this section the reasons for classifying each species as regionally rare or significant are presented.

7.6.1 Pultenaea microphylla. An egg and bacon flower

This bush pea is not known to occur anywhere else in the Orange district. Within the NCP it occurs in habitats 5 and 6, the dry north facing slopes south of Hoares and Copper Gully Creeks respectively, where it extends from the lower slope to the tops of the hills. The plants of *P. microphylla* are low and severely pruned as a result of grazing by macropods. *P. microphylla* is not considered at risk in New South Wales or nationally.

7.6.2 **Acacia acinacea.** Gold dust wattle

A small open wattle, *A. acinacea* is confined to the Cadia Reserve where it grows only on the lower slopes of habitat 6 with *Pultenaea microphylla* and other shrubs. It is reasonably common within a small area of the reserve. Although rare within the Orange district it is not at risk at the state or national levels.

7.6.3 **Pterostylis alata.** Striped greenhood orchid

This species is known from only two small populations in the Orange district; one in habitat 4 of the Cadia Reserve and one nearby in the western part of Canobolas State Forest. The taxonomic status of this species is currently under review and New South Wales populations may be assigned to *Pterostylis striata* an uncommon taxon restricted to central western New South Wales. However, it appears to be conserved in Conimbla National Park near Grenfell and is well represented in Nangar State Forest near Eugowra.

7.6.4 **Prasophyllum** aff. **odoratum.** Sweet leek orchid

An orchid thought to be *Prasophyllum odoratum* occurs in habitat 4 of the Cadia Reserve and possibly elsewhere in the reserve as well. This species is known from several locations in the Orange district; northern Mullion Range (two sites) and Calula Range, but is very rare. *Prasophyllum odoratum* and related taxa are currently under revision and it is likely the Orange district populations represent an undescribed species. A related taxon occurs on Mt Canobolas. Due to the taxonomic uncertainty surrounding this group, we are unable to determine the state or national conservation status of the Cadia taxon.

7.6.5 **Pterostylis** aff. **longifolia.** Tall greenhood orchid

Two undescribed species related to *Pterostylis longifolia* occur in the Cadia Reserve. One of these is very widespread in habitats 3 and 4, and the other is known from only a single colony in habitat 4, nearby to *Pterostylis alata*. The common species in the reserve appears also to be widespread in southern New South Wales; the Cadia population is the northernmost so far recorded. The smaller, less common species in the reserve is poorly known, but also occurs in the Calula Range north of Orange. Its conservation status is uncertain.

7.6.6 **Pterostylis** aff. **parviflora.** Tiny greenhood orchid

Two undescribed species near *Pterostylis parviflora* have been found in the Cadia Reserve. One is widespread and common in the reserve and central western region generally. The other has not been found elsewhere in the Orange district, but is common in the Blue Mountains to the east. The second species has only been found in habitat 7 of the reserve in very small numbers.

7.6.7 **Xanthorrhoaea glauca** subsp. **glauca.** A grass tree

A small colony of grass trees occurs on the northern side of Copper Gully Creek just outside the north east corner of the reserve. Grass trees are uncommon in the Orange district. There is a small occurrence on Mt Canobolas and a larger stand in Canobolas State Forest near Lapstone Hill. The grass trees in the NCP area have very long "skirts" of dead leaves indicating they have not been burnt by bushfires for a very long time - many decades, possibly 50 years or more. This species is not endangered at the state and national levels.

7.6.8 **Olearia erubescens.** Silky daisy bush

One plant of this species was found in a gully in habitat 4 and two plants along Copper Gully Creek in habitat 3. It is rare in the Orange district. No other specimens have been collected by the Orange Field Naturalist and Conservation Society, but at least one specimen from Orange is in the National Herbarium in Sydney.

7.6.9 **Pteris tremula.** Tender brake

A few plants of this species were found at the base of a very steep slope beside Copper Gully Creek in Cadia Reserve in association with other ferns. It is not known elsewhere in the central west but is generally common throughout its range.

7.6.10 **Hypolepis rugosula.** A ground fern

Colonies of this species occur over a short distance along Copper Gully Creek in Cadia Reserve adjacent to a very steep south facing slope. Although not known from elsewhere in the Orange district it is widespread on the coast and ranges to the east.

8.0 DISCUSSION AND CONCLUSIONS

Due to its small area and the few plant associations represented, the total number of native species found in Cadia Reserve and nearby is relatively small. Nevertheless, the high topographic variation has resulted in an extreme diversity of microclimates ranging from the cool, moist sheltered south facing slopes of habitat 3 to the hot, dry north facing slopes of habitat 6. These extreme microhabitats are uncommon in a natural condition in the Orange district. This has resulted in the NCP area providing refuge for a number of plant species that are rare or unknown in the rest of the district. However, it is likely that greater numbers of species occur in the NCP than indicated on the checklist since surveys in spring were carried out in poor seasons and some herbaceous species are likely to have been overlooked.

The Cadia Reserve is a significant and important regional conservation reserve for the following reasons:

- Although there are few old growth trees due to past disturbance it is in good condition and appears to be supporting most of its likely original flora. The lack of fire in the reserve for many decades indicates the understorey is in or close to a climax condition.

- The landscape of the Orange district has been largely cleared for agriculture, horticulture and softwood forestry. Cadia Reserve is one of a limited network of reserves which preserve samples of the original flora.

- It supports three plant species not known to occur anywhere else in the Orange district, five that are rare in the district, and one whose status is uncertain.

In view of these findings the destruction of the Cadia Reserve by open-cut mining would result in a reduction in regional biodiversity and a significant loss to the local reserve system. Therefore, if approval for mining at Cadia is granted, action should be taken to retain as much of the regionally important biodiversity at Cadia as possible. The recommendations address this issue.

9.0 ACKNOWLEDGEMENTS

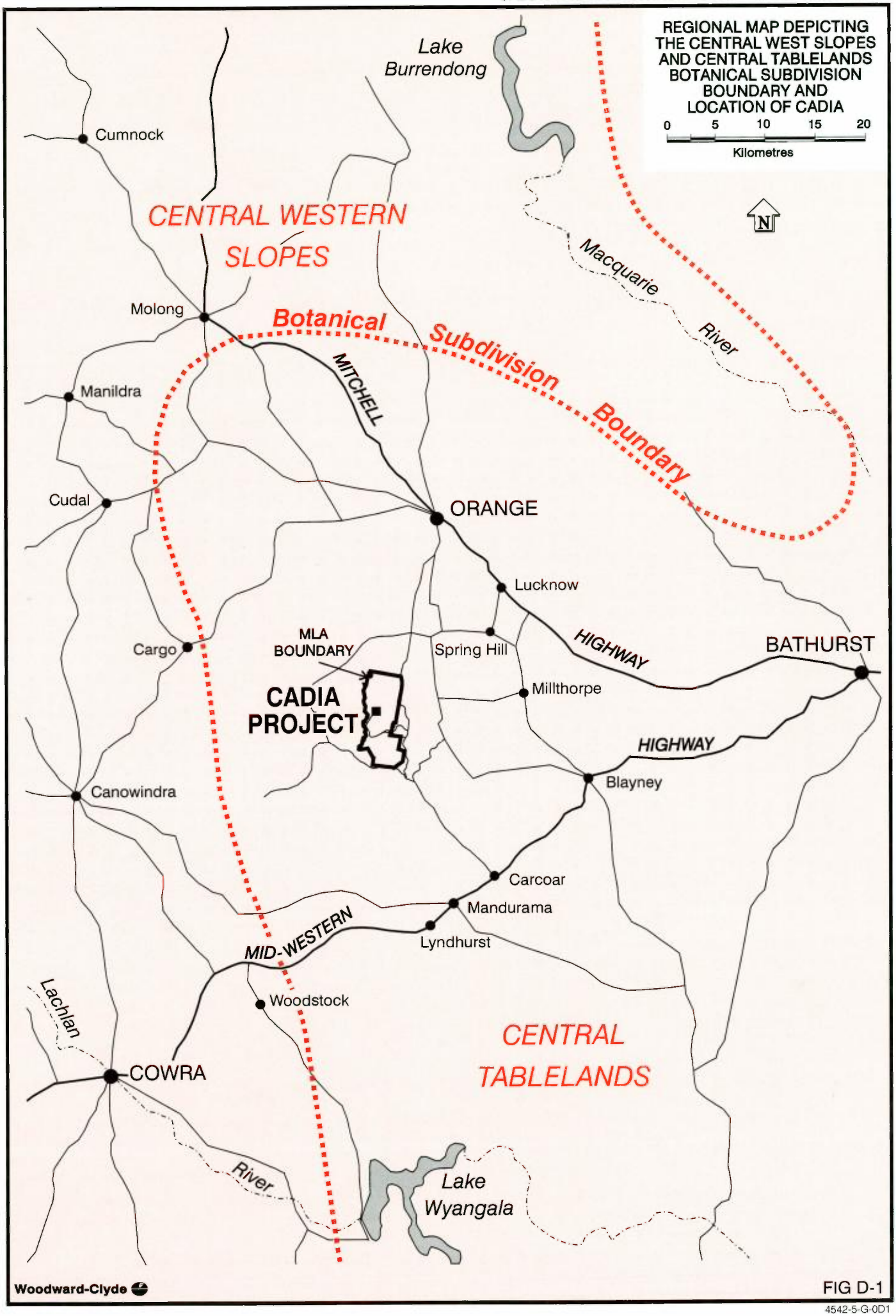
Curation activities were assisted greatly by Mr Winston Guymer between July and October 1994, whose employment was funded by Newcrest Mining Ltd. The donation of herbarium boxes by Newcrest Mining Ltd. is also appreciated. We are sincerely grateful to the Royal Botanic Gardens, Sydney, for expert botanical assistance in plant identification and to fellow members of the Orange Field Naturalist and Conservation Society for assistance with the survey. Woodward-Clyde drafted Figures D-1 and D-2.

10.0 REFERENCES

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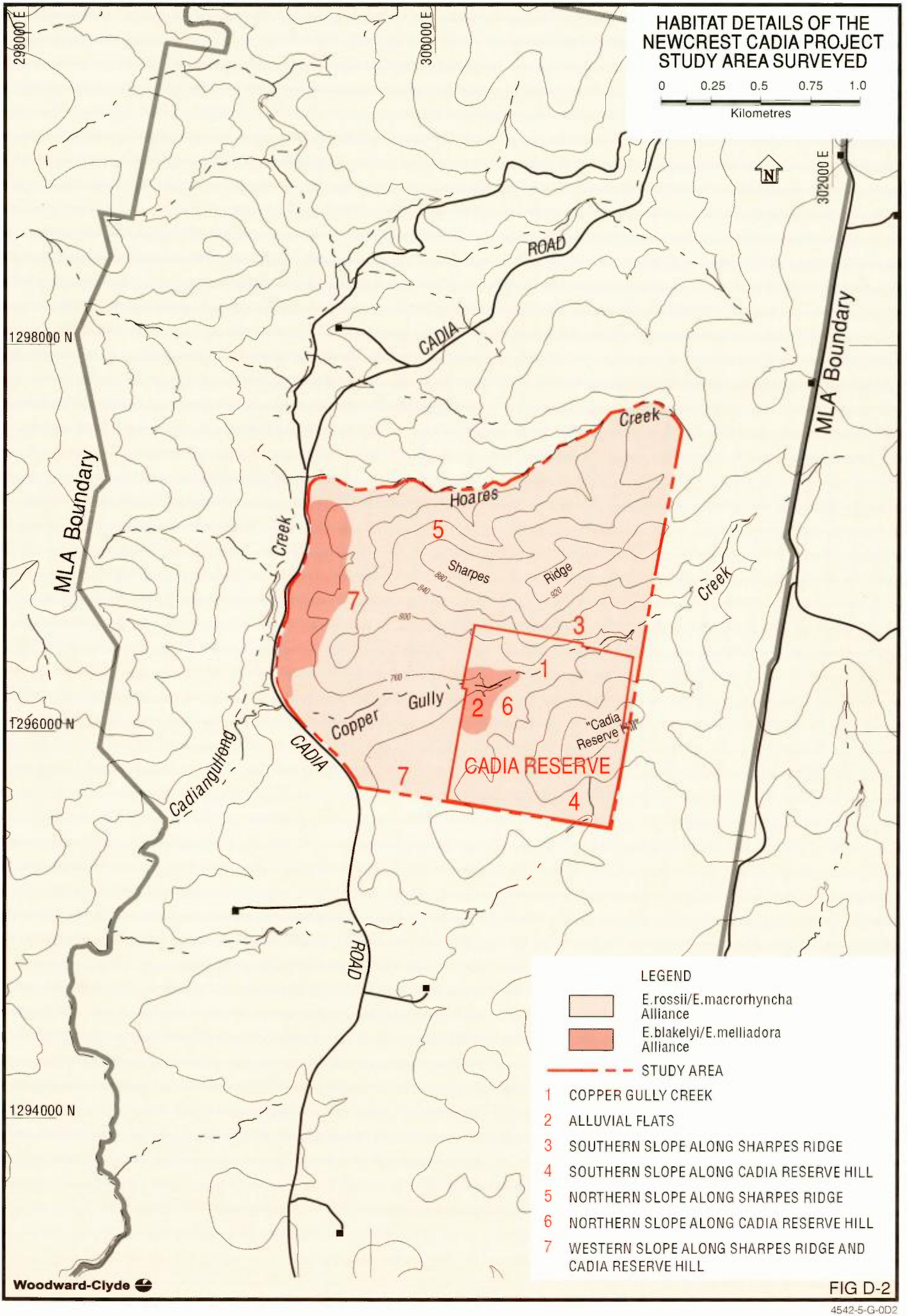
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Woodward-Clyde

FIG D-1

4542-5-G-0D1


HABITAT DETAILS OF THE NEWCREST CADIA PROJECT STUDY AREA SURVEYED
0 0.25 0.5 0.75 1.0
Kilometres
N
298000 E
300000 E
302000 E
1298000 N
1296000 N
1294000 N
MLA Boundary
MLA Boundary
ROAD
CADIA
Creek
Hoares
Creek
Sharpes
Ridge
Creek
Copper
Gully
CADIA
ROAD
Cadiangullong
"Cadia Reserve Hill"
CADIA RESERVE
1
2
3
4
5
6
7
LEGEND
E.rossii/E.macrorhyncha Alliance
E.blakelyi/E.melliadora Alliance
STUDY AREA
1 COPPER GULLY CREEK
2 ALLUVIAL FLATS
3 SOUTHERN SLOPE ALONG SHARPES RIDGE
4 SOUTHERN SLOPE ALONG CADIA RESERVE HILL
5 NORTHERN SLOPE ALONG SHARPES RIDGE
6 NORTHERN SLOPE ALONG CADIA RESERVE HILL
7 WESTERN SLOPE ALONG SHARPES RIDGE AND CADIA RESERVE HILL
Woodward-Clyde
FIG D-2
4542-5-G-0D2

ATTACHMENT D-1

CHECK LIST OF SPECIES OBSERVED IN NEWCREST CADIA PROJECT STUDY AREA

ATTACHMENT D-1
CHECK LIST OF SPECIES OBSERVED IN NEWCREST CADIA PROJECT STUDY AREA

Nomenclature follows Flora of New South Wales (Harden, 1990-93)

Family	Species	Growth Form	Habitat	Distribution	Abundance	Conservation Status
PTERIDOPHYTES						
Adiantaceae	*Adiantum aethiopicum*	F	3,4	W	o	N,n
Aspleniaceae	*Asplenium flabellifolium*	F	3,4	W	o	N,n
Blechnaceae	*Blechnum cartilagineum*	F	1	L	r	N,k
Dennstaedtiaceae	*Hypolepis rugosula*	F	1	L	o	N,v
	Pteridium esculentum	F	3	L	o	N,n
Pteridaceae	*Pteris tremula*	F	1	L	r	N,k
Sinopteridaceae	*Cheilanthes austrotenuifolia*	F	8	W	o	N,n
	Cheilanthes sieberi subsp. sieberi	F	8	W	o	N,n
	Pellaea falcata var. falcata	F	3,4	W	o	N,n
MONOCOTYLEDONS						
Anthericaceae	*Dichopogon fimbriatus*	G	3,4	L	o	N,n
Asphodelaceae	*Bulbine bulbosa*	G	3,4	L	o	N,n
Colchicaceae	*Wurmbea dioica subsp. dioica*	G	2	L	o	N,n
Cyperaceae	*Lepidosperma laterale*	G	8	W	o	N,n
	Schoenus apogon	G	3,4	L	o	N,n
Iridaceae	*Patersonia sericea*	G	6	L	o	N,n
Juncaceae	*Juncus subsecundus*	G	1	W	f	N,n
	Juncus usitatus	G	1-4	W	o	N,n
	Juncus vaginatus	G	1	L	o	N,n
	Luzula densiflora	G	3,4	W	o	N,n
	Luzula falccida	G	3,4	W	o	N,n
Lomandraceae	*Lomandra collina*	G	3-7	W	f	N,n
	Lomandra confertifolia subsp. pallida	G	5-7	W	f	N,n
	Lomandra filiformis subsp. coriacea	G	3,4	W	f	N,n
	Lomandra filiformis subsp. filiformis	G	5,6	W	c	N,n
	Lomandra glauca	G	3,4	L	o	N,n
	Lomandra montana	G	3,4	W	o	N,n
	Lomandra multiflora subsp. multiflora	G	3-7	W	f	N,n
Orchidaceae	*Acianthus collinus*	H	3	W	o	N,n
	Caladenia carnea	H	3,4	W	f	N,n
	Caladenia cucullata	H	3-7	W	f	N,n
	Caladenia phaeoclavia	H	3-7	W	o	N,n
	Calochilus robertsonii	H	3,4	W	o	N,n
	Chiloglottis trapeziformis	H	3	L	o	N,n
	Corybas incurvus	H	3	W	f	N,n
	Cyrtostylis reniformis	H	3	W	f	N,n
	Eriochilus cucullatus	H	3-7	W	f	N,n
	Genoplesium rufum	H	3-7	W	f	N,n
	Glossodia major	H	3-7	W	f	N,n

ATTACHMENT D-1 (Continued)
CHECK LIST OF SPECIES OBSERVED IN NEWCREST CADIA PROJECT STUDY AREA

Family	Species	Growth Form	Habitat	Distribution	Abundance	Conservation Status
MONOCOTYLEDONS (Continued)						
Orchidaceae (Cont.)	*Prasophyllum aff. odoratum*	H	3,4	L	r	N,v
	Pterostylis alata	H	4	L	r	N,v
	Pterostylis curta	H	3	W	f	N,n
	Pterostylis longifolia (biotype 1)	H	3,4	W	f	N,n
	Pterostylis longifolia (biotype 2)	H	4	L	r	N,k
	Pterostylis nutans	H	3,4	W	f	N,n
	Pterostylis parviflora (biotype 1)	H	3-7	W	f	N,n
	Pterostylis parviflora (biotype 2)	H	7	L	r	N,v
	Pterostylis reflexa	H	3-7	W	f	N,n
	Pterostylis revoluta	H	5-7	W	o	N,n
	Thelymitra ixioides var. isioides	H	3-7	W	f	N,n
Phormiaceae	*Dianella longifolia var. longifolia*	G	1	L	o	N,n
	Dianella revoluta	G	3-7	W	c	N,n
	Stypandra glauca	G	6	L	o	N,n
Poaceae	*Bothriochloa macra*	G	2	L	o	N,n
	Chionochloa pallida	G	3-7	W	c	N,n
	Danthonia eriantha	G				N,n
	Danthonia racemosa var. racemosa					
	Phragmites australis	G	1	L	o	N,n
	Poa labillardieri	G	2	W	o	N,n
	Poa sieberiana var. cyanophylla	G	1	L	f	N,n
	Poa sieberiana var. sieberiana	G	8	W	c	N,n
	Stipa nodosa	G				N,n
	Stipa scabra	G	3,4	W	o	N,n
	Themeda australia	G	3,6	L	o	N,n
Xanthorrhoeaceae	*Xanthorrhoea glauca subsp. angustifolia*	G	3	L	o	N,r
DICOTYLEDONS						
Apiaceae	*Daucus glochidiatus complex*	H	2-4	W	o	N,n
	Hydrocotyle laxiflora	H	2-4	W	f	N,n
	Platysace ericoides	H	5-7	W	f	N,n
Asteraceae	*Brachycome spathulata*	H	2-4	W	o	N,n
	Bracteantha bracteata	H	5-7	W	o	N,n
	Bracteantha viscosa	H	2-7	W	o	N,n
	Cassinia arcuata	LS	8	W	f	N,n
	Cassinia longifolia	LS	3,4	W	f	N,n
	Cassinia quinquefaria	LS	3	L	o	N,n
	Chrysocephalum apiculatum	H	2-4	W	o	N,n
	Chrysocephalum semipapposum	H	3,4	W	o	N,n
	Cymbonotus preissianus	H	2-7	W	o	N,n
	Gnaphalium sphaericum	H	3	L	o	N,n
	Leptorhynchos squamatus	H	3	L	o	N,n

ATTACHMENT D-1 (Continued)
CHECK LIST OF SPECIES OBSERVED IN NEWCREST CADIA PROJECT STUDY AREA

Family	Species	Growth Form	Habitat	Distribution	Abundance	Conservation Status
DICOTYLEDONS (Continued)						
Asteraceae (Cont.)	*Microseris lanceolata*	H	2-7	W	f	N,n
	Olearia erubescens	LS	3,4	L	r	N,v
	Ozothamnus diosmifolius	LS	6	L	r	N,n
	Senecio hispidulus var. dissectus	H	3,4	W	o	N,n
	Senecio minimus	H	3	L	o	N,n
	Senecio quadridentatus	H	2-7	W	f	N,n
	Senecio sp. E	H	3,4	W	f	N,n
	Vittadinia cuneata complex	H	1	L	o	N,n
Boraginaceae	*Cynoglossum australe*	H	2-4	W	o	N,n
	Myosotis australis	H	2-4	W	o	N,n
	Myosotis discolor	H	2-4	W	o	N,n
Campanulaceae	*Wahlenbergia communis*	H	2	L	o	N,n
	Wahlenbergia gracilis	H	8	W	o	N,n
	Wahlenbergia luteola	H	2-7	W	f	N,n
	Wahlenbergia stricta subsp. alterna	H	2-7	L	o	N,n
	Wahlenbergia stricta subsp. stricta	H	2-7	W	f	N,n
Caryophyllaceae	*Stellaria pungens*	H	3,4	W	f	N,n
Clusiaceae	*Hypericum gramineum*	H	2-7	W	f	N,n
Convolvulaceae	*Convolvulus erubescens*	H	2-4	W	o	N,n
	Dichondra species A	H	2-4	W	f	N,n
Crassulaceae	*Crassula sieberiana*	H	2-4	W	o	N,n
Cupressaceae	*Callitris endlicheri*	T	5-7	W	f	N,n
Dilleniaceae	*Hibbertia obtusifolia s.lat.*	LS	2-7	W	f	N,n
	Hibbertia riparia	LS	2	L	o	N,n
Epacridaceae	*Acrotriche serrulata*	LS	2-7	W	o	N,n
	Brachyloma daphnoides	LS	2-7	W	o	N,n
Euphorbiaceae	*Phyllantus hirtellus forma B*	LS	5-7	W	f	N,n
Fabaceae subfamily Faboideae	*Bossiaea buxifolia*	LS	7	W	o	N,n
	Daviesia leptophylla	LS	2-7	W	o	N,n
	Dillwynia juniperina	LS	6	L	o	N,n
	Dillwynia phylicoides	LS	2-7	W	f	N,n
	Glycine clandestine	V	2-4	W	f	N,n
	Glycine tabacina	V	2	L	o	N,n
	Hardenbergia violacea	V	3-7	W	o	N,n
	Indigofera australis	LS	3,4	W	o	N,n
	Pultenaea cunninghamii	LS	5-7	W	f	N,n
	Pultenaea microphylla	LS	6	W	c	N,v
	Pultenaea procumbens	LS	5-7	W	o	N,n
	Pultenaea subternata	LS	3-4	L	o	N,n

ATTACHMENT D-1 (Continued)
CHECK LIST OF SPECIES OBSERVED IN NEWCREST CADIA PROJECT STUDY AREA

Family	Species	Growth Form	Habitat	Distribution	Abundance	Conservation Status
DICOTYLEDONS (Continued)						
Fabaceae subfamily Mimosoideae	*Acacia acinacea*	LS	2,6	L	o	N,v
	Acacia brownii	LS	6	L	o	N,n
	Acacia buxifolia	LS	6	L	o	N,n
	Acacia dealbata	LT	2-4	W	o	N,n
	Acacia genistifolia	LS	2,5-7	W	f	N,n
	Acacia gunnii	LS	5-7	W	o	N,n
	Acacia implexa	LT	2-7	W	o	N,n
	Acacia melanoxylon	LT	1	L	o	N,n
	Acacia paradoxa	LS	6,7	W	f	N,n
Geraniaceae	*Geranium soladeri*	H	2-4	W	f	N,n
Goodeniaceae	*Goodenia hederacea subsp. hederacea*	H	2-7	W	c	N,n
Haloragaceae	*Gonocarpus elatus*	H	3,4	W	f	N,n
	Gonocarpus tetragynus	H	3-7	W	f	N,n
Lamiaceae	*Ajuga australis*	H	2	L	o	N,n
	Scutellaria humilis	H	2	L	o	N,n
Lauraceae	*Cassytha pubescens*	V,P	6	L	o	N,n
Loranthaceae	*Amyema miquelii*	P	2-7	W	c	N,n
	Muellerina eucalyptoides	P	3	L	o	N,n
Myrtaceae	*Calytrix tetragona*	LS	5-7	W	o	N,n
	Eucalyptus blakelyi	T	2	L	f	N,n
	Eucalyptus dives	T	3,4	W	o	N,n
	Eucalyptus goniocalyx	T	3-7	W	vc	N,n
	Eucalyptus macrorhyncha	T	3-7	W	vc	N,n
	Eucalyptus melliodora	T	2,3	L	f	N,n
	Eucalyptus polyanthemos	T	3-7	W	vc	N,n
	Eucalyptus viminalis	T	3	L	o	N,n
	Kunzea ericoides	LS	3,4	L	f	N,n
Onagraceae	*Epilobium billardierianum subsp.*	H	3	L	o	N,n
Oxalidaceae	*Oxalis perennans*	H	2	W	f	N,n
Pittosporaceae	*Billardiera scandens*	H	3-7	W	o	N,n
	Bursaria spinosa	TS	3,4	L	o	N,n
Plantaginaceae	*Plantago varia*	H	2-4	W	f	N,n
Polygonaceae	*Persicaria prostrata*	H	1	L	o	N,n
	Rumex brownii	H	1,2	L	o	N,n
Proteaceae	*Grevillea ramosissima*	LS	5-7	W	f	N,n
	Hakea decurrens	LS	6,7	W	o	N,n
	Persoonia rigida	LS	5-7	W	o	N,n
Ranunculaceae	*Ranunculus lappaceus*	H	2	L	o	N,n

ATTACHMENT D-1 (Continued)
CHECK LIST OF SPECIES OBSERVED IN NEWCREST CADIA PROJECT STUDY AREA

Family	Species	Growth Form	Habitat	Distribution	Abundance	Conservation Status
DICOTYLEDONS (Continued)						
Ranunculaceae	*Ranunculus lappaceus*	H	2	L	o	N,n
Rosaceae	*Acaena novae-zelandiae*	H	2-4	W	f	N,n
	Acaena ovina	H	2,3	L	o	N,n
	Rubus parvifolius	V	3	L	o	N,n
Rubiaceae	*Asperula conferta*	H	2-4	W	f	N,n
	Galium gaudichaudii	H	2-4	W	f	N,n
	Pomax umbellata	H	2,5-7	W	c	N,n
Santalaceae	*Exocarpos cupressiformis*	TS,P	3,4	W	o	N,n
Sapindaceae	*Dodonaea viscosa subsp. angustifolia*	LS	2,3	L	o	N,n
	Dodonaea viscosa subsp. spatulata	LS	2-7	W	f	N,n
Stackhousiaceae	*Stackhousia monogyna*	H	2	L	f	N,n
Urticaceae	*Urtica incisa*	H	3	L	o	N,n
Violaceae	*Viola betonicifolia*	H	2,3	W	f	N,n
	Viola hederacea	H	2,3	W	f	N,n

Key:
Growth form: F = ferns; G = grasses and lilies; H = herbs; LS = low shrub; TS = tall shrub; LT = low tree; T = tree; V = vine, climber; P = parasite
Habitat: Numbers 1 to 7 refer to habitat types shown in Figure D-2; number 8 indicates the species occurs in all habitats
Distribution within study area: W = widespread; L = localised
Abundance within the study area: r = rare; o = occasional; f = frequent; c = common; vc = very common
Conservation status: Capital letters refer to national status, lower case letters refer to regional status. N = not endangered; K = poorly known; V = vulnerable; R = rare (Ref. Briggs and Leigh, 1988)

APPENDIX E

Fauna

FAUNA SURVEY

CADIA HILL

NEWCREST MINING WA LTD
FOR AGC WOODWARD-CLYDE PTY LTD
FINAL REPORT FEBRUARY 1995

A.M. FISHER
D.C. GOLDNEY

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1.0 INTRODUCTION

This study has been undertaken to:

1. document the vertebrate fauna of the proposed mining area at Cadia Hill;
2. identify site conservation values, with particular reference to rare and endangered species;
3. identify any biophysical constraints to the proposed mining activity;
4. make recommendations in order to ameliorate the impacts of mining; and
5. apply the seven point test on Schedule 12 species present on site or where suitable habitat for such species exists.

It is concluded that the project is not likely to significantly affect the environment of any endangered fauna within the meaning of the *Environmental Planning and Assessment Act, 1979*. Consequently, a fauna impact statement is not formally required for the project. Representatives of the National Parks and Wildlife Service advised at a meeting on 28 February 1995 that a fauna impact statement would not be required for the project. Nevertheless, a cautious approach has been adopted and Attachment E-3 has been prepared in accordance with section 92D(1) of the *National Parks and Wildlife Act, 1974*.

2.0 SITE DESCRIPTION

2.1 LOCATION

The study site is located 20 km SW of Orange, NSW, and approximately 12 km south of Mt Canobolas (Figure E-1) and incorporates land within the MLA and the land outside the MLA which is part of the development application as identified in Volume 1. The area of interest is a woodland remnant in the south-east section of the Cadia site, which is continuous with a system of woodland managed by the Canobolas Regional Parkland Trust and Kinross-Wolaroi School. This area of remnant woodland is typical of the fragmented native vegetation throughout the Central Western Region, hereafter referred to as the CWR (Figure E-2). In addition a section of the Cadiangullong Creek south of the intersection with Cadia Creek was also surveyed.

2.2 SOIL AND GEOLOGY

The Cadia area lies within the Molong Geoanticline of the Lachlan Geosynclinal belt in southwestern NSW. The study area traverses five main soil landscapes, namely Panuara, Spring Hill, Quarry, Towac and Canobolas (Kovac and Lawrie 1990). The Panuara Soil Landscape dominates the survey area, incorporating red podzolic soils on the mid to upper slopes, with yellow podzolics, brown/red earths and red earths on the lower slopes, and yellow solodics in the drainage lines. Siliceous and earthy sands of the shallow Quarry Soil Landscape occupy the central western section of the study area.

2.3 CLIMATE AND TOPOGRAPHY

The climate of the Cadia area is fairly mild with cold winters, the mean annual precipitation being about 875 mm. The study area reaches an elevation of around 930 m in the northwestern portion of the remnant woodland, while dropping to 720 m along Cadiangullong Creek. The land thus rises and falls fairly significantly and incorporates a range of climatic aspects. Numerous drainage lines run from the highest portion of the remnant into intermittent streams, namely Creekline A and Copper Gully Creek, then into the permanent Cadiangullong Creek, which is also fed upstream by Cadia Creek.

3.0 METHODOLOGY

The survey of the vertebrate fauna of Cadia Hill was conducted over two periods, namely autumn (April 1994) and late spring (November/December 1994). This report concentrates on the results of the late spring survey, with the findings from the autumn survey integrated where appropriate.

During the late spring survey four transects were established (Figure E-3), representing the range of habitats found in the area. These were:

(i) Creekline A - along northern edge of woodland remnant;
(ii) Copper Gully Creek - through the middle of the remnant woodland from east to west;
(iii) Grassy ridge - in south-eastern section of remnant woodland; and
(iv) Cadiangullong Creek - downstream from the intersection with Cadia Creek.

The methods used for detecting the vertebrate fauna were:

Mammals

Elliot type 'A' baited with oatmeal and peanut butter were used to trap small mammals along the four transects. Traps were placed approximately 20 m apart along creeklines or following a contour. One kilometre transects were used along Creekline A, Copper Gully Creek and the grassy ridge, while a trapline of 500 m was employed along Cadiangullong Creek. Along each transect at least two of the traps were set off the ground in mature trees. Some 600 trap nights were completed over three nights. Traps were checked each morning.

Spotlighting was carried out along tracks from a four-wheel drive vehicle, covering Creekline A, Copper Gully Creek, Cadiangullong Creek, the southern edge of the remnant woodland and the ridge through the middle of the remnant.

Six Harp traps were set along tracks or over water to capture bats - one along Creekline A, five along Copper Gully Creek, and one on the grassy ridge.

An Anabat II electronic bat detector was also used to record the echolocation calls of bats along Creekline A and Copper Gully Creek during the first two hours after sunset.

Mammal presence was also assessed using bones, tracks and scats, as well as by opportunistic observations.

Birds

Birds were identified by sight and sound while systematically walking along the four transect lines each morning. Transect walks after sunrise were conducted at different times over three days. Opportunistic observations were also recorded.

Reptiles and Amphibians

Reptiles were searched for under rocks and logs, with dispersal of ground litter. Frogs were captured in creeklines or identified from their calls. Opportunistic encounters were also noted.

Fish

Fish were observed opportunistically in Cadiangullong Creek.

4.0 HABITAT DESCRIPTIONS

(Including a conservation rating from Low to High - determined by a rapid assessment technique utilising habitat and management parameters (Stone *et al.* 1993)).

(i) Creekline A - dominant trees are *Eucalyptus goniocalyx* and *E. macrorhyncha* with some *E. viminalis*, with a range of age classes present. Understorey species include *Acacia dealbata*, *Brachyloma daphnoides*, Biddy Bush (*Cassinia arcuata*), *Poa* spp., *Juncus* spp., *Xanthorrhoea* and Blackberry (*Rubus fruticosus*). There are also regenerating *E. goniocalyx* saplings along with some Mistletoe (*Ameyama* spp.). As this watercourse runs along the northern edge of the remnant woodland it has suffered weed invasion and infestation by rabbits.
Conservation Rating = Moderate.

(ii) Copper Gully Creek - an *E. goniocalyx* - *E. macrorhyncha* association plus *E. viminalis*. A range of size classes are represented, from old growth with hollows to regenerating saplings. Understorey is mainly *Acacia dealbata* and *A. melanoxylon*, along with *A. paradoxa*, *Dodonea* spp., *Poa* spp., *Chielanthes* spp. and Biddy Bush (*Cassinia arcuata*). There are areas of blackberry (*Rubus fruticosus*) in the watercourse itself. Adjacent to the eastern boundary the remnant woodland has suffered significant weed invasion plus heavy mistletoe infestation. Runoff from past mining activity has entered the creek along its upper reaches.
Conservation Rating = Moderate.

(iii) Grassy ridge - an area of mature *E. macrorhyncha* with an understorey consisting of tall *Poa* spp. The main shrub species present are *Hibbertia obtusifolia* and *Brachyloma daphnoides* and there is significant litter and log cover.
Conservation Rating = Moderate.

(iv) Cadiangullong Creek - a permanent waterway which flows through cleared grazing land, having a narrow fringing forest of *Casuarina cunninghamiana* and *E. viminalis*. In places there has been significant bank erosion and exotics such as willow (*Salix* spp.) and blackberry (*Rubus fruticosus*) are widespread.
Conservation Rating = Low.

5.0 DESCRIPTION OF FAUNA

A complete list of vertebrate species identified during the late spring survey is given in Attachment E-1, showing in which transects the animals were observed. Species found in the autumn survey are also indicated, along with an assessment of their regional status (based on Goldney and Bowie 1987).

A total of 73 vertebrate species were identified during the late spring survey, while the autumn survey yielded 62 species. A study of an adjacent area of the Cadia site in 1991 identified 71 species of vertebrates (Goldney 1992).

The comparisons between the surveys are indicated in Table E-1.

TABLE E-1
COMPARISON OF FAUNA SURVEYS

	1991	Autumn 1994	Late Spring 1994	Total 1994 species
Fish	2	1	1	1
Amphibians	2	2	4	5
Reptiles	6	6	6	11
Birds	49	39	50	59
Mammals	12	14	12	17
Total	71	62	73	93

The combined surveys in 1994 identified a total of 93 vertebrate species. This figure represents 35.8 per cent of the vertebrate species which have been recorded in the 30' quadrat centred on Orange (the most species-rich of the four 30' quadrats which surround the Cadia site) (Goldney 1987).

Table E-2 indicates the relative numbers and percentages for each vertebrate group.

Fish

The introduced Brown Trout (*Salmo trutta*) was the only species recorded in the 1994 surveys, found in Cadiangullong Creek. It is likely that native *Galaxias* species also occur in this waterway, being identified in the 1991 survey (Goldney 1992).

Amphibians

Five frog species were recorded during the 1994 surveys, inhabiting Cadiangullong and Copper Gully Creeks. Verreaux's Tree Frog (*Litoria verreauxii*) was found in autumn, and while it is uncommon in the CWR it is not listed on Schedule 12.

TABLE E-2
VERTEBRATE GROUPS - RELATIVE NUMBERS AND PERCENTAGES

	Identified in 1994 (I)	Recorded in 30' quadrat (R)	%I/R
Fish	1	6	16.7
Amphibians	5	11	45.5
Reptiles	11	39	28.2
Birds	59	178	33.1
Mammals	17	26	65.4
Total	93	260	35.8

Reptiles

A total of 11 reptile species were identified while surveying in 1994, comprising one tortoise, nine lizards and a snake. While all species are regarded as common, identification of the Weasel Skink (*Saproscincus mustelinus*) marks an extension of its previously known range. Discussions with the mining staff and local landholders indicated that both the Copperhead (*Austrelops superbus*) and the Red-bellied Black Snake(*Pseudechis porphyriacus*) are common on the site over summer. The Bearded Dragon (*Pogona barbata*), Eastern Bandy Bandy (*Vermicella annulata*) and Southern Death Adder (*Acanthophis antarcticus*) have also been recorded in the Cadia area (M. Wilkinson, pers. comm.).

Birds

The 59 species of birds identified represent a subset of a regionally rich avifauna. 49 of these species are common in the CWR, eight are moderately common, while the Brush Cuckoo (*Cuculus variolosus*) and Satin Flycatcher (*Myiagra cyanoleuca*) are regarded as uncommon. Three exotic species were recorded. The majority of species were found along Creekline A and Copper Gully Creek where there is a well-developed *Acacia* understorey.

Mammals

Of the 17 mammal species recorded, five were feral. Five species of bats were captured in the harp traps over the course of the two surveys in 1994, and numerous bats were seen while spotlighting. The echolocation calls recorded using the Anabat II bat detector have yet to be analysed, however it is presumed that the calls will be of those species captured in the traps. All of the species caught are moderately common in the CWR. While not recorded during 1994, the Common Bent-wing Bat (*Miniopterus schreibersii*) was caught during the 1991 study (Goldney 1992) of Big Cadia. This species is listed as Vulnerable and Rare on Schedule 12 (see Attachment E-2) and is likely to inhabit caves and abandoned mine shafts on the Big Cadia site. In the area of proposed development there are no old mine shafts present, hence it is unlikely the Common Bent-wing Bat will be impacted. The only arboreal mammals detected were the Common Brushtail Possum (*Trichosurus vulpecula*) and Common Ringtail Possum (*Pseudocheirus peregrinus*). The Elliot traps only caught two species of native small mammals, the Yellow-footed Antechinus (*Antechinus flavipes*) and the Brown Antechinus (*Antechinus stuartii*), both of which are common in the CWR.

6.0 RARE AND ENDANGERED SPECIES

No threatened or rare and endangered vertebrate species as listed under Schedule 12 (August, 1994) legislation were identified during the 1994 surveys. Two regionally uncommon birds were recorded, the Brush Cuckoo (*Cuculus variolosus*) and Satin Flycatcher (*Myiagra cyanoleuca*) and the record of the Weasel Skink (*Saproscincus mustelinus*) is an extension of the species' known distribution.

Schedule 12 species which are considered to possibly occur in the Cadia area are presented in Attachment E-2. This list is based on data for the Orange, Cudal, Cowra and Blayney 1:100 000 map sheets. Species for which suitable habitat occurs within the study site and have a range which includes the Cadia area are the Green and Golden Bell Frog (*Litoria aurea*), Superb Parrot (*Polytelis swainsonii*), Squirrel Glider (*Petaurus norfolcensis*), Koala (*Phascolarctos cinerus*) and Common Bent-wing Bat (*M. schreibersii*). This last species was captured at Big Cadia in 1991 (Goldney 1992). The Yellow-bellied Glider (*Petaurus australis*) has been recorded at nearby Mt. Canobolas, but the degree of landscape fragmentation, habitat requirements and site isolation is such that this species is unlikely to be found at Cadia Hill.

The range of vertebrate species found within the survey area is representative of this region of NSW. It is possible that some of the species identified are locally endangered, but the nature of the study is such that this could not be determined with any certainty.

7.0 CONSERVATION VALUES OF THE SITE

7.1 AMENITY

Cadia Hill represents one of the few wooded areas remaining between Orange and Cargo, which coupled with its elevation, gives the site scenic value. This fact has been recognised by the Canobolas Regional Parkland Trust and the Kinross-Wolaroi School who utilise the area.

7.2 REMNANT WOODLAND

The Cadia Hill site is one of hundreds of "island" remnants found in the tablelands of the Central Western Region. These "islands" are significant for native wildlife (flora and fauna) for the following reasons:

- these "islands" remain as wildlife habitat in a "sea" of cleared agricultural land primarily because of their unsuitability for grazing and cropping (Saunders and Ingram 1987). These areas have an essential role to play in nature conservation due to the fact that clearing for farming purposes has been so extensive in the CWR.

- the connectivity of these remnants provides corridors, allows movement, migration and dispersal of wildlife (Saunders and Hobbs 1989). In this instance the thin fringing forest along the Cadia and Cadiangullong Creeks provides a linkage with Mt. Canobolas, but otherwise the site is fairly isolated. This isolation means that species which become locally extinct due to land management practices are unable to recolonise the remnant unless they can traverse cleared agricultural land.

- these remnants provide minimal habitat areas which support population numbers higher than a critical level, below which species may be threatened with local extinction.

7.3 REGIONAL PERSPECTIVE

The wildlife and other conservation values of the Cadia Hill site are equally well represented at Mt. Canobolas, some 12 km to the north. This site does however, provide an important refuge and "stepping-stone" for both flora and fauna. The isolation of this remnant and pressures of continuing land management practices in the area means that some species, currently present, will become locally extinct.

8.0 IMPACTS ON FAUNA

The major impacts on fauna of the proposed developments are:

- Removal of vegetation - in order to establish the mining area, plus build and upgrade roads and infrastructure, clearing of areas of native vegetation will be necessary, potentially removing the majority of existing vegetation cover. This will decrease the amount of habitat available to many species. Individual animals may also perish in the clearing process.

- Noise from mine operation - the noise of machinery, vehicles, etc. may affect fauna. Noise will be concentrated at the centre of the operation but declines quickly as distance from the source increases. Fauna often adapt to repetitious noise once the initial shock is overcome. Most vertebrates will be able to move away where the noise is too disturbing and establish new territories. Noise control programs will be required by the EPA.

- Dust from mine operation and vehicle movement - dust from construction and vehicular movement can impair photosynthesis in plants and further degrade the habitat value of the site. Dust control procedures will be required by the EPA. In a well-managed mining site, overall dust will not constitute a threat to vertebrate fauna.

- Pollution of creeks and drainage lines - runoff from the mining site will collect oil, soil chemicals, dirt, etc. which could find its way into Creekline A, Copper Gully Creek and Cadiangullong Creek. Pollution control measures will be required by the EPA. Frog species are particularly sensitive to changes in water quality, and an impoverished aquatic invertebrate fauna will affect some bird species.

- Road kills - movement of vehicles along access roads is likely to result in the death of many individual animals as they move between habitat areas. This is particularly so for reptiles, macropods and the echidna.

9.0 MANAGEMENT RECOMMENDATIONS

The Cadia Hill site is not one of high regional or national conservation value. None of the potential impacts outlined above will have long-term deleterious effects on vertebrate species of the Cadia site if the following recommendations are implemented:

- Removal of vegetation should be undertaken during late Autumn/early Winter when disruption of breeding and nesting is likely to be minimal.

- Where possible minimise the removal of vegetation cover, for instance upgrading existing roads rather than building new access routes. The clearing of mature trees, particularly those with hollows, should be kept to an absolute minimum.

- Top soil removed from the mining site should be stored in readiness for the rehabilitation process.

- Avoid windrowing of cleared trees and shrubs, which attracts introduced vermin such as rats and mice. Instead, cut and scatter timber on regeneration sites.

- Implement an adequate noise control program as determined by the EPA.

- Undertake an adequate dust control program under the direction of the EPA. Procedures will include restricting truck movement to designated roads, watering surfaces, covering loads and controlling overall dust from the plant.

- Create bunding walls in order to prevent the movement of sediment and protect the water quality of Copper Gully and Cadiangullong Creeks. The water monitoring program currently in place should continue, incorporating any further EPA directives, to ensure the quality of the watercourses in the area is maintained.

- Develop a policy amongst the workers of collecting animals (excluding snakes) which are found in the active mining site and/or on access roads and removing them to safer locations. Limiting the speed of vehicles, as is already the case along the main road to Orange, will reduce the number of unnecessary collisions with kangaroos in particular, as well as allow time for vehicles to stop for reptiles, birds and echidnas.

- Minimal disturbance to areas outside the active mining site should be a high priority.

- Make a commitment to regenerate areas from which native vegetation has been removed, once active mining has ceased, using local seed stock where possible.

- Seek to regenerate areas of native vegetation equal to or greater than that which is being removed. This will include returning unworkable drill-sites to their original condition in order to provide appropriate faunal habitat.

10.0 CONSULTATION

The findings of this report were presented to the NSW National Parks and Wildlife Service (Bathurst district) in a meeting held on the 28th February 1995.

11.0 ASSESSMENT OF ENDANGERED FAUNA

Attachment E-2 identifies the five Schedule 12 species which potentially could be found on site. Attachment E-3 contains an assessment of the affect of the development on the environment of these species and an assessment of the impact of the development on these species.

It was concluded that the proposed development will not significantly affect the environment of any endangered fauna. Consequently, a fauna impact statement is not formally required for the Project. Nevertheless, a cautious approach has been adopted and Attachment E-3 has been prepared in accordance with section 92D(1) of the *National Parks and Wildlife Act, 1974.*

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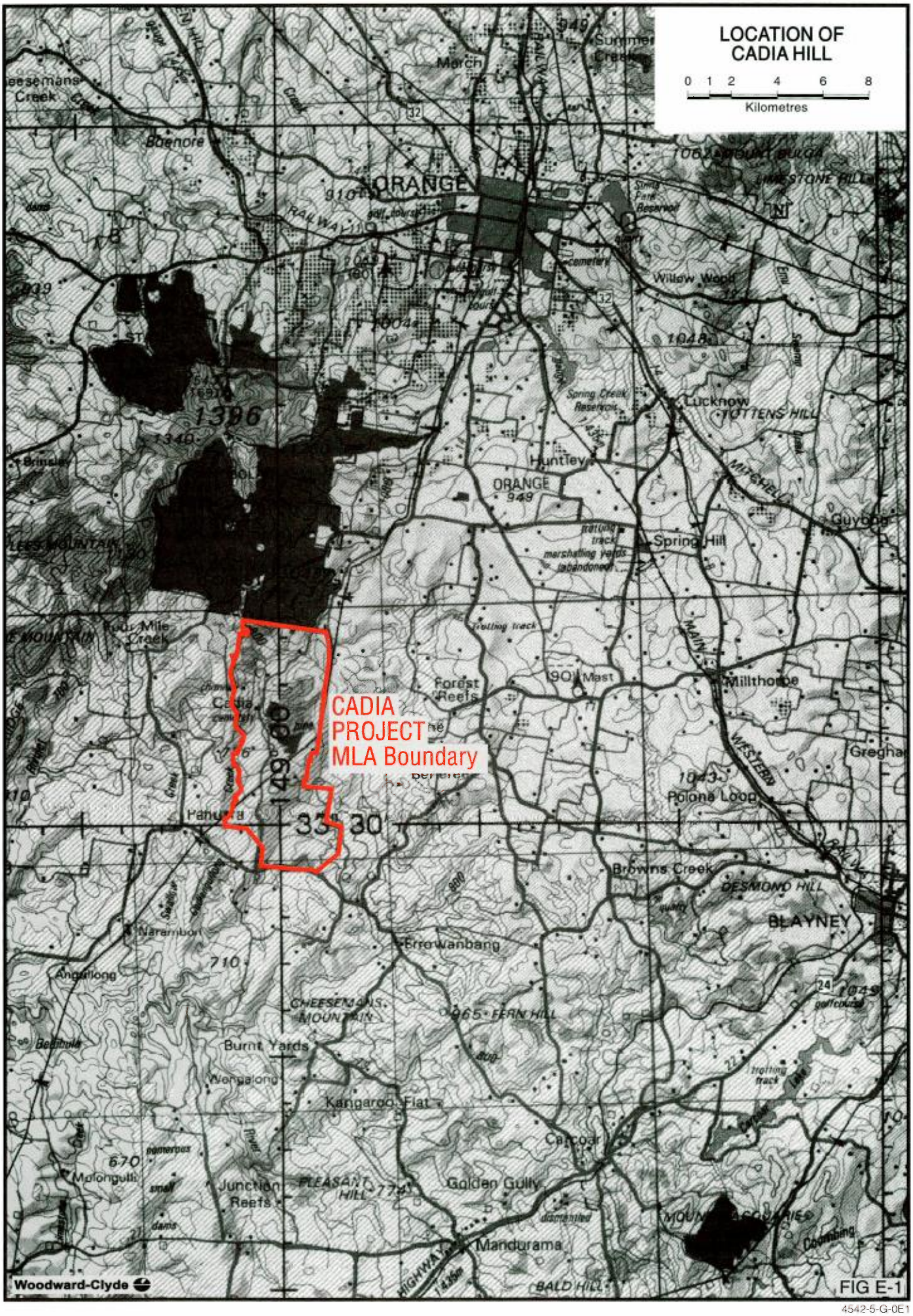
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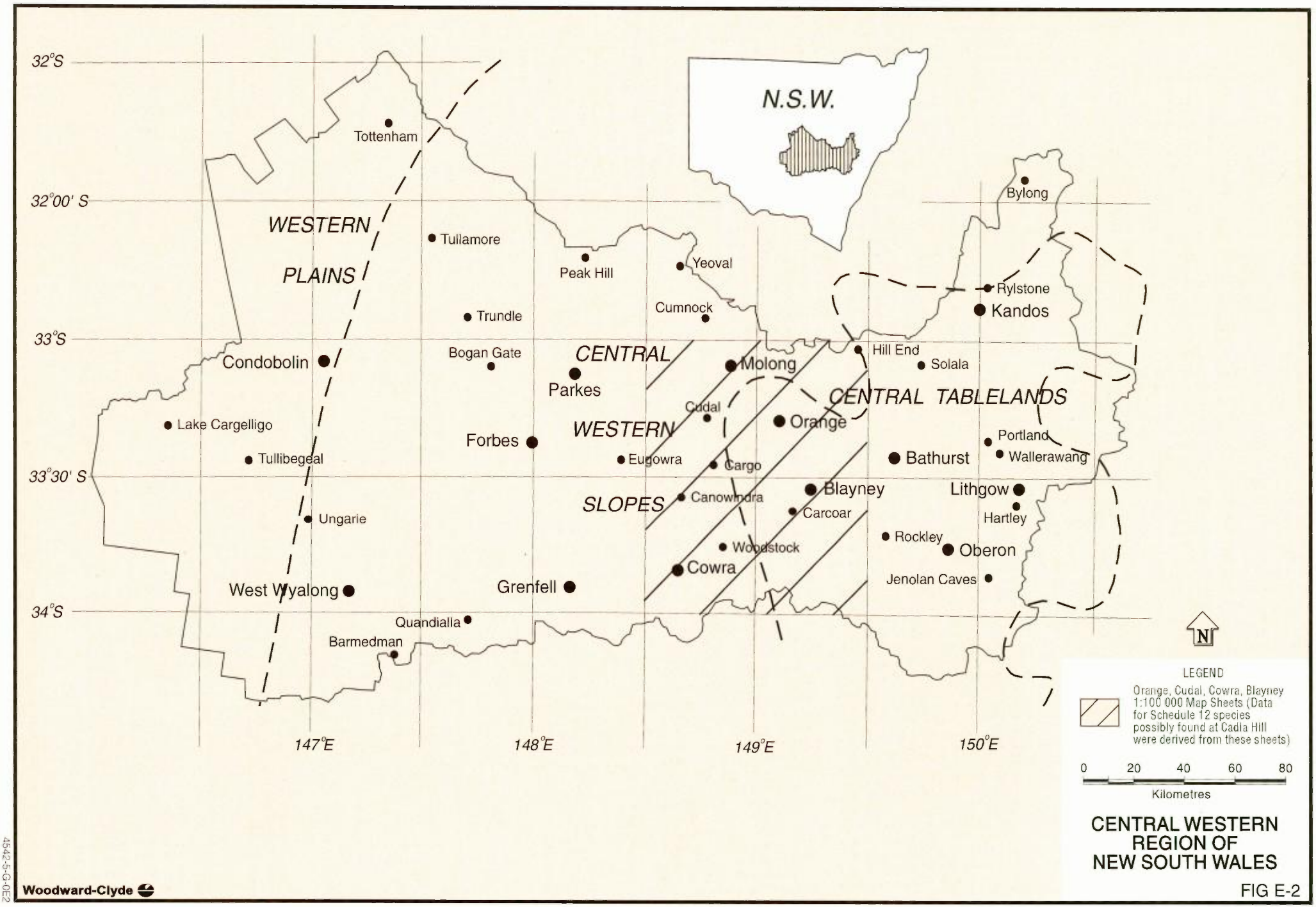
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LOCATION OF CADIA HILL
0 1 2 4 6 8
Kilometres
CADIA PROJECT MLA Boundary
ORANGE
Woodward-Clyde
FIG E-1

4542-5-G-0E1

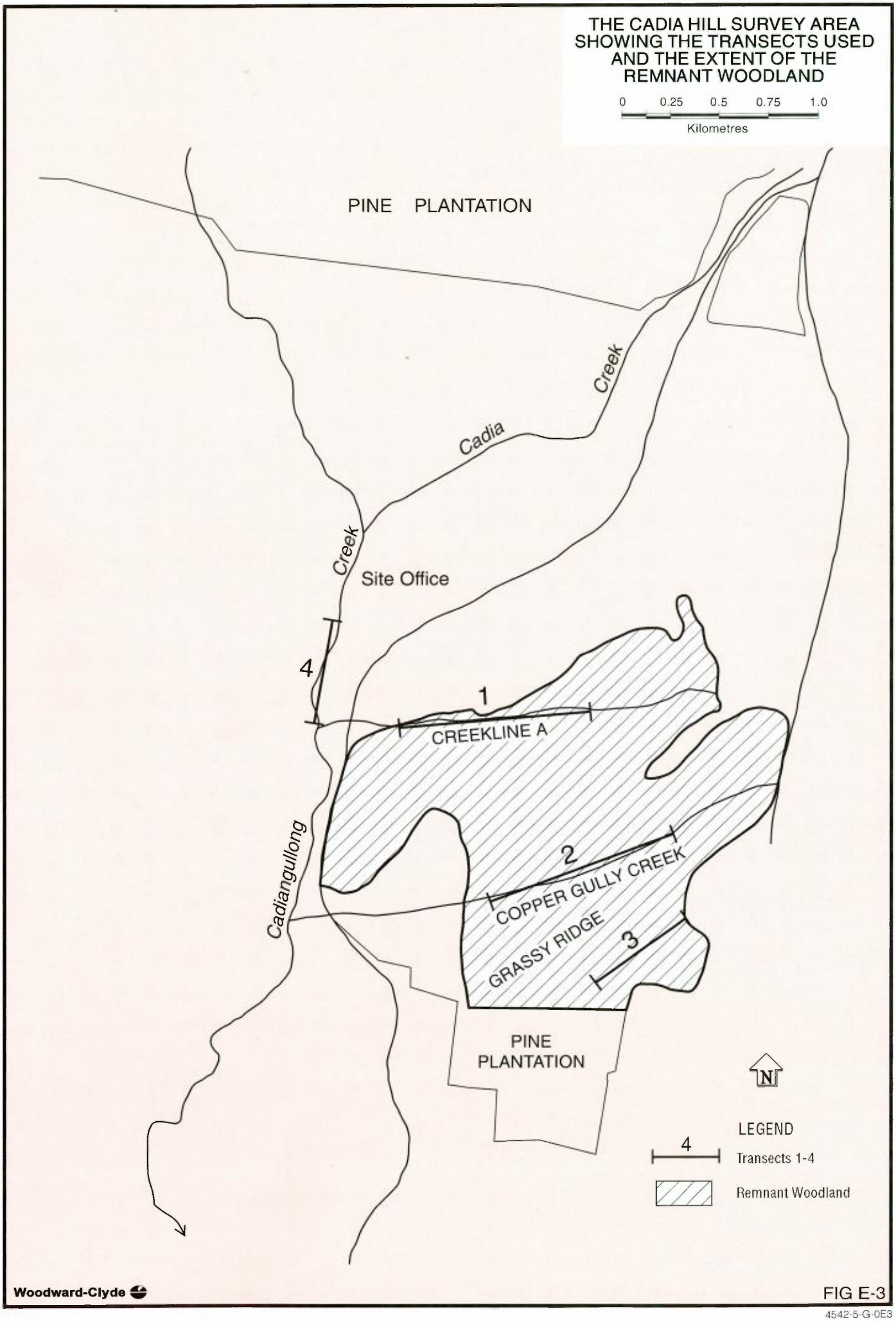


CENTRAL WESTERN REGION OF NEW SOUTH WALES

FIG E-2

Woodward-Clyde

45442-5-G-0E2



Woodward-Clyde

FIG E-3

4542-5-G-0E3

ATTACHMENT E-1

VERTEBRATE SPECIES LIST FOR CADIA HILL

ATTACHMENT E-1

VERTEBRATE SPECIES LIST FOR CADIA HILL

SYMBOLS:

+	=	introduced
1	=	Creekline A (northern edge of remnant woodland)
2	=	Copper Gully Creek
3	=	Grassy ridge (south-eastern section of remnant)
4	=	Cadiangullong Creek
AS	=	Species recorded during Autumn Survey (April 1994)
RS	=	Regional Status (based on Goldney & Bowie 1987)
c	=	common
mc	=	moderately common
u	=	uncommon

	1	2	3	4	AS	RS
FISH						
Salmonidae						
Salmo trutta+ Brown Trout					*	c
AMPHIBIANS						
Hylidae						
Litoria ewingii Brown Tree Frog				*		u
Litoria verreauxii Verreaux's Tree Frog					*	u
Leptodactylidae						
Crinia signifera Common Brown Froglet		*		*	*	c
Limnodynastes dumerilii Eastern Banjo Frog				*		c
Limnodynastes tasmaniensis Spotted Grass Frog		*		*		c
REPTILES						
Chelidae						
Chelodina longicollis Common Long-necked Tortoise					*	c
Agamidae						
Amphibolurus muricatus Jacky Lizard	*					c
Pogona barbata Bearded Dragon	reliably recorded in Cadia area					c

	1	2	3	4	AS	RS
REPTILES (Continued)						
Scincidae						
Carlia tetradactyla Rainbow Skink					*	c
Ctenotus taemiolatus Copper-tailed Skink				*		c
Egernia cunninghami Cunningham's Skink	*	and throughout				c
Hemiergis decresiensis Three-toed Skink					*	c
Lampropholis delicata Sunskink spp.	throughout					?
Tiliqua nigrolutea Blotched Bluetongue					*	c
Tiliqua scincoides Common Bluetongue				*		c
Saproscincus mustelinus Weasel Skink					*	?
Elapidae						
Austrelaps superbus Copperhead	reliably recorded in survey area					c
Pseudechis porphyriacus Red-bellied Black Snake	reliably recorded in survey area					c
Pseudonaja textilis Eastern Brown Snake				*		c
Vermicella annulata Eastern Bandy-bandy	reliably recorded in Cadia area					u
Acanthophis antarcticus Southern Death Adder	reliably recorded in Cadia area					?

ATTACHMENT E-1 (Continued)
VERTEBRATE SPECIES LIST FOR CADIA HILL

	1	2	3	4	AS	RS
BIRDS						
Phalacrocoracidae						
Phalacrocorax carbo Great Cormorant				*		c
Ardeidae						
Ardea novaehollandiae White-faced Heron				*		c
Anatidae						
Anas superciliosa Pacific Black Duck		*				c
Accipitridae						
Aquila audax Wedge-tailed Eagle	overhead throughout					c
Elanus notatus Black-shouldered Kite				*		mc
Falconidae						
Falco cenchroides Australian Kestrel				*		mc
Psittacidae						
Cacatua roseicapilla Galah	*	*		*	*	c
Cacatua galerita Sulphur-crested Cockatoo	*				*	c
Platycercus elegans Crimson Rosella	*	*	*	*	*	c
Platycercus eximius Eastern Rosella	*				*	c
Cuculidae						
Cuculus pyrrhophanus Fan-tailed Cuckoo	*	*			*	c
Cuculus pallidus Pallid Cuckoo				*		c
Cuculus variolosus Brush Cuckoo		*				u
Podargidae						
Podargus strigoides Tawny Frogmouth	*					c
Alcedinidae						
Dacelo novaeguineae Laughing Kookaburra	*	*	*		*	c
Halcyon sancta Sacred Kingfisher	*					c

	1	2	3	4	AS	RS
BIRDS (Continued)						
Meropidae						
Merops ornatus Rainbow Bee-eater				*		c
Coraciidae						
Eurystomus orientalis Dollarbird				*		c
Hirundinidae						
Hirundo neoxena Welcome Swallow		*		*	*	c
Campephagidae						
Coracina novaehollandiae Black-faced Cuckoo-shrike	*	*	*			c
Muscicapidae						
Turdus merula+ Blackbird		*				c
Eopsaltridae						
Eopsaltria australis Eastern Yellow Robin	*				*	c
Petroica multicolor Scarlet Robin		*			*	mc
Petroica phoenicea Flame Robin					*	mc
Pachycephalidae						
Colluricincla harmonica Grey Shrike-thrush	*	*	*	*	*	c
Falcunculus frontatus Crested Shriketit		*				mc
Pachycephala pectoralis Golden Whistler					*	c
Pachycephala rufiventris Rufous Whistler	*	*	*	*	*	mc
Monarchiae						
Myiagra cyanoleuca Satin Flycatcher	*	*	*	*		u
Myiagra inquieta Restless Flycatcher					*	c
Rhipidura fuliginosa Grey Fantail	*	*	*	*		c
Rhipidura leucophrys Willie Wagtail					*	c
Maluridae						
Malurus cyaneus Superb Fairywren	*	*		*	*	c

ATTACHMENT E-1 (Continued)
VERTEBRATE SPECIES LIST FOR CADIA HILL

	1	2	3	4	AS	RS
BIRDS (Continued)						
Acanthizidae						
Gergone olivacea White-throated Warbler	*	*	*	*		c
Acanthiza chrysorrhoa Yellow-rumped Thornbill				*		c
Acanthiza lineata Striated Thornbill		*				c
Acanthiza pusilla Brown Thornbill	*	*	*	*	*	c
Acanthiza reguloides Buff-rumped Thornbill	*		*		*	c
Sericornis frontalis White-browed Scrubwren	*	*		*	*	c
Neosittidae						
Daphoenositta chrysoptera Varied Sittella					*	c
Climacteridae						
Cornobates leucophaea White-throated Treecreeper	*	*	*	*	*	c
Pardalotidae						
Padalotus punctatus Spotted Pardalote	*			*	*	c
Pardalotus striatus Striated Pardalote	*	*	*		*	c
Meliphagidae						
Acanthorhynchus tenuirostris Eastern Spinebill					*	mc
Anthochaera chrysoptera Red Wattlebird					*	c
Meliphaga chrysops Yellow-faced Honeyeater	*	*	*	*	*	c
Meliphaga penicillata White-plumed Honeyeater					*	c
Melithreptus lunatus White-naped Honeyeater		*			*	c
Philemon corniculatus Noisy Friarbird	*	*	*	*	*	c
Zosteropidae						
Zosterops lateralis Silvereye					*	c
Dicaeidae						
Dicaeum hirundinaceum Mistletoebird	*					c

	1	2	3	4	AS	RS
BIRDS (Continued)						
Estrildidae						
Emblema temporalis Red-browed Firetail	*	*		*	*	c
Fringillidae						
Carduelis carduelis+ Goldfinch	*					c
Sturnidae						
Sturnus vulgaris+ Common Starling				*		c
Corcoracidae						
Corcorax melanorhamphos White-winged Chough	*	*	*		*	c
Cracticidae						
Gymnorhina tibicens Australian Magpie	*			*	*	c
Streptera graculina Pied Currawong	*	*	*		*	c
Streptera versicolor Grey Currawong	central ridge					mc
Corvidae						
Corvus coronoides Australian Raven		*		*	*	c
MAMMALS						
Tachyglossidae						
Tachyglossus aculeatus Echidna	throughout				*	c
Dasyuridae						
Antechinus flavipes Yellow-footed Antechinus			*			c
Antechinus stuartii Brown Antechinus					*	c
Phalangeridae						
Trichosurus vulpecula Common Brushtail Possum	*	and central ridge			*	c
Pseudocheiridae						
Pseudocheirus peregrinus Common Ringtail Possum	*	*	*		*	c
Macropodidae						
Macropus giganteus Eastern Grey Kangaroo	*		*		*	c
Wallabia bicolor Swamp Wallaby	*		*		*	c

ATTACHMENT E-1 (Continued)
VERTEBRATE SPECIES LIST FOR CADIA HILL

	1	2	3	4	AS	RS
MAMMALS (Continued)						
Molossidae						
Mormopterus planiceps Little Mastiff-bat		*				?
Vespertilionidae						
Chalinolobus gouldii Gould's Wattled Bat		*				mc
Chalinolobus morio Chocolate Wattled Bat	*	*	*		*	mc
Eptesicus pumilus Eastern Cave Eptesicus					*	mc
Nyctophilus geoffroyi Lesser Long-eared Bat					*	mc
Felidae						
Felis catus+ Cat	*	and pine plantation			*	mc
Vulpes vulpes+ Red Fox	*				*	c
Leporidae						
Orytolagus cuniculus+ European Rabbit		*			*	c
Mus musculus+ House Mouse					*	c
Rattus rattus+ Black Rat					*	c

ATTACHMENT E-2

SCHEDULE 12 SPECIES IDENTIFIED AS POSSIBLY OCCURRING IN THE CADIA AREA

(based on data for Orange, Cudal, Cowra and Blayney 1:100 000 map sheets, and the amended Schedule 12 list, August, 1994).

ATTACHMENT E-2

SCHEDULE 12 SPECIES IDENTIFIED AS POSSIBLY OCCURRING IN THE CADIA AREA

(based on data for Orange, Cudal, Cowra and Blayney 1:100 000 map sheets and the amended Schedule 12 list, August, 1994).

* Denotes species possibly occurring - in principle (1) suitable habitat occurs within the study site, and (2) the study site is within the species known range.

** Denotes species considered doubtful - either the habitat requirements for species do not exist, or the level of landscape fragmentation and site isolation suggest the species is unlikely to occur. The species are placed in this category because they have been found within a radius of approximately 50 km from the survey site.

Part 1 - Threatened

Amphibians		
Litoria aurea	Green and Golden Bell Frog	*
Litoria raniformis	Southern Bell Frog	**
BIRDS		
Xanthomyza phrygia	Regent Honeyeater	**
Mammals		
Dasyurus viverrinus	Eastern Quoll	**
Isodon obesulus	Southern Brown Bandicoot	**

Part 2 - Vulnerable and Rare Species

Birds		
Botaurus poiciloptilus	Australasian Bittern	**
Strictonetta naevosa	Freckled Duck	**
Rostratula benghalensis	Painted Snipe	**
Calyptorhynchus lathami	Glossy Black-Cockatoo	**
Neophema pulchella	Turquoise Parrot	**
Polytelis swainsonii	Superb Parrot	*
Grantiella picta	Painted Honeyeater	**
Mammals		
Dasyurus maculatus	Tiger Quoll	**
Petaurus australis	Yellow-bellied Glider	**
Petaurus norfolcensis	Squirrel Glider	*
Phascolarctos cinereus	Koala	*
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	**
Nyctinomus australis	White-striped Mastiff-bat	**
Miniopterus schreibersii	Common Bent-wing Bat	*
Nyctophilus timoriensis	Greater Long-eared Bat	**

ATTACHMENT E-3

ENDANGERED SPECIES IMPACT REPORT

1.0 GREEN AND GOLDEN BELL FROG
Litoria aurea

NSW NPWS Act 1974 - Schedule 12 listing

Part I Threatened

Information Sources

Cogger, H.G. (1994) *Reptiles and Amphibia of Australia.* (Revised Edition) Reed, Sydney.

Swan, G. (1990) *A Field Guide to the Snakes and Lizards of NSW.* Three Sisters Productions, Winmalee, NSW.

Wilson, S.K. and Knowles, D.G. (1988) *Australia's Reptiles. Collins, Australia.*

Goldney, D.C. and Bowie, I.J.S. (1988) *A Scenic and Scientific Survey of the Central Western Region of NSW.* (Vols 1 & 2), Mitchell CAE, Bathurst.

NPWS and State Forests of NSW (1994) *Guidelines for the preparation of Fauna Impacts Statements for Forestry Operations Within State Forests.* NSW NPWS and SF of NSW, Sydney, Version 1.

Data bases

NPWS fauna data base;
CSU data base.

SECTION 92D ASSESSMENT

1. A full description of the fauna to be affected by the actions and the habitat used by the fauna.

Lives in emergent (reeds, sedges) vegetation within or at the edges of permanent water (e.g. streams, dams, etc. where they may shelter under debris nearby. Tends to favour undisturbed habitats. Bulrushes may be very important.

2. An assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them.

(a) Distribution

Eastern and south-eastern NSW and far eastern Victoria. In the Central Western Region it is confined to the tablelands. Has been found infrequently in the Bathurst-Orange area and is regarded as very endangered in the region. In serious decline in the region. Species has only rarely been identified in numerous surveys in the Tablelands. No known colonies exist in the area.

(b) Habitat to be affected by the actions

The study site does contain permanent water bodies in the form of creeks and dams. Most dams do not have emergent vegetation. Suitable habitat is located on Cadiangullong Creek, Creekline A and Copper Gully Creek in the form of emergent vegetation, with bulrushes generally poorly represented because of impacts of cattle. There are few permanent pools in the ephemeral creeklines. Cadiangullong Creek contains suitable habitat along much of its length because it is permanent and contains emergent vegetation, suitable pools and appropriate cover. The creek system in the impact area is degraded to significantly degraded. The creekline habitats are sub-optimal because of impacts from agriculture, grazed emergent vegetation and clearing to banksides.

(c) Environmental Pressures

Degradation of aquatic conditions, such as through foraging by domestic stock.

3. A description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term.

The proposed actions will modify the potential environment of the species in the following way :

- Clearing along and/or alterations to Copper Gully Creek and Creekline A;
- The diversion of a small section of Cadiangullong Creek;
- The creation of dams and weirs;
- The placement of the tailings storage on Rodds Creek;
- Activities and infrastructure near the potential environment; and
- Altering water flows regime.

The above actions will remove some areas of sub-optimal potential habitat and modify existing water flows. The main impact is loss of potential habitat along the creeklines described above. The impact on the species is expected to be minimal to non-existent since there is ample similar potential habitat in the locality. Additionally, the species has not been found in the area.

4. Details of the measures to be taken to ameliorate the impacts

The impact identified will be ameliorated by the creation of new dams and weirs which may develop appropriate habitat and by the exclusion of agriculture and cattle from segments of the creeklines which will enable the rehabilitation of emergent vegetation. In the longer term amelioration will also occur through the post mining rehabilitation program.

SEVEN POINT TEST

1. The extent of modification or removal of habitat in relation to the same habitat in the locality

A relatively small amount of creek line will be directly impacted on by the project. The type of habitat impacted upon is common in the locality. Since these creeklines are already degraded (including the disturbed emergent vegetation as part of the habitat component), the impacts on this species are expected to be minimal.

2. The sensitivity of the species to removal or modification of its habitat

The species is sensitive to the removal of habitat. The potential habitat which may be impacted by the development is sub-optimal.

3. The time required to regenerate critical habitat in whole or part which is essential for the survival of species

No critical habitat was identified for the species. Rather sub-optimal habitat was located which could be used by the species if present. The sub-optimal habitat is common in the land system.

4. The effect on the ability of the population to recover, including interaction between the subject land and adjacent habitat that may influence the population beyond the area proposed for development

Potential sub-optimal habitat was identified on parts of the study site. The species was not located at these sites. It is not expected that there will be any impact on this species. Under the predicted flow regimes the downstream creek systems will be impacted upon only marginally because of the stringent pollution control measures which will be in place.

5. Any Proposal to ameliorate the impact

Any impact identified will be partly ameliorated by the creation of new dams and weirs which may develop appropriate habitat and by the exclusion of agriculture and cattle from segments of the creeklines which will enable the rehabilitation of emergent vegetation. In the longer term amelioration will also occur through the post mining rehabilitation program.

6. Whether the land is currently being assessed for wilderness by the Director of NPWS under the Wilderness Act, 1987

No.

7. Any adverse effect on the survival of the species of endangered fauna or of populations of that fauna

Given that the species was not found on location, no adverse effects on the survival of the species/population would be expected from the proposed development.

Conclusion

The development will not have a significant effect on the environment of this species.

2.0 SUPERB PARROT
Polytelis swainnsonni

NSW NPWS ACT 1974 - Schedule 12 listing

Part 2: Vulnerable and Rare species

Information Sources

Blakers, M. Davies S.J. and P.N. Reilley (1984). *The Atlas of Australian Birds.* Melbourne Univ. Press, Melbourne.

Garnett, S. (Ed) (1993). *Threatened and Extinct Birds of Australia.* RAOU/ANPWS, Melbourne.

Goldney, D.C. and Bowie, I.J.S. (1988) *A Scenic and Scientific survey of the Central Western Region of NSW.* (Vols. 1&2), Mitchell CAE, Bathurst.

NPWS and State forests of NSW (1994) *Guidelines for the preparation of Fauna Impacts Statements for Forestry Operations Within State Forests.* NSW NPWS and SF of NSW, Sydney, Version 1.

Schodde, R. and Tidemann, S.C. (eds) (1986) *The complete Book of Australian Birds.* Reader's Digest, Sydney.

Data base

NPWS fauna data base;
CSU data base
RAOU data base.

SECTION 92D ASSESSMENT

1. A full description of the fauna to be affected by the actions and the habitat used by the fauna

The Superb Parrot is long-tailed with yellow face and red throat or with blue cheeks.

Found in open woodlands, riparian forests and in agricultural lands. The species nests in large trees with deep hollows (usually river Red-Gum located within riparian forests) in inland NSW. The species forages in Box woodlands.

2. An assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them

(a) Distribution

Occurs in woodlands, riparian forests and agricultural lands in central NSW as well as in north and central Victoria. Populations disperse north in winter as far as the Queensland border. The distribution of the species in the region is patchy, with breeding along some major river systems e.g. the Lachlan, but feeding areas throughout the Box woodlands in the region. Species has been found infrequently in the Bathurst - Orange area. Overall population is in decline. In the last half decade the number seen in parts of the region e.g. Cowra and Peak Hill have increased.

(b) Habitat to be affected by the actions

The potential habitat of the species in the study area and locality is the open woodlands dominated by Yellow Box trees. The open woodlands occur within the cleared agricultural lands which are abundant in the area.

The habitat in the study area and the surrounding agricultural lands is sub-optimal because of the degrading processes occurring in the Box woodlands, including tree 'die-back', decreasing seed yields from affected trees and lack of tree regeneration. Available habitat in the impact area and immediate surrounding lands is generally best suited for foraging purposes, rather than for breeding.

(c) Environmental Pressures

Habitat clearing and degradation of Box woodlands in general.

3. A description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term

The proposed development will involve the clearing of some open woodland in the southern part of the mining area. The removal of this woodland section will have minimal impact on the species because of the small area of potential sub optimal habitat involved compared with the available Box woodland in the locality. Additionally the species was not located in the locality during the two survey periods.

4. Details of the measures to be taken to ameliorate the impacts

No specific proposals are needed because of the significant areas of Box woodlands in the area. During the revegetation rehabilitation phase at the mine site, Yellow Box trees are amongst the species that will be used.

SEVEN POINT TEST

1. The extent of modification or removal of habitat in relation to the same habitat in the locality

Relatively little of the habitat which could be used by the species will be impacted on by the proposed development, compared with the available habitat in the locality. Significant and very much greater areas of suitable habitat can be located in the extensive Box woodlands in other parts of the Central Western Region and in the immediate locality. Box woodlands are found throughout the Orange area although often in a degraded state.

2. The sensitivity of the species to removal or modification of its habitat

The species is sensitive to the removal of habitat. The potential habitat in the study area is sub-optimal.

3. The time required to regenerate critical habitat in whole or part which is essential for the survival of species

No critical habitat was identified for the species. Rather sub-optimal habitat was located which could be used by the species if present. The sub-optimal habitat is common in the land system. Newcrest now own the surrounding farm lands where the Box woodlands are found and have developed long term management plans for these areas. Additionally some of the longer term rehabilitation plans will include tree species which can be utilised by the species.

4. The effect on the ability of the population to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development

Potential sub-optimal habitat was identified on parts of the study site. The species was not located at these sites. The impact is confined to the removal of limited numbers of potential foraging trees. It is not expected that there will be any impact on this species.

5. Any Proposal to ameliorate the impact

No specific proposals are needed because of the significant areas of Box woodlands in the area. During the revegetation rehabilitation phase at the mine site, Yellow Box trees are amongst the species that will be used.

6. **Whether the land is currently being assessed for wilderness by the Director of NPWS under the Wilderness Act, 1987**

No.

7. **Any adverse effect on the survival of the species of endangered fauna or of population of that fauna**

No adverse effects on the survival of the species/population would be expected from the proposed development.

Conclusions

The development will not have a significant affect on the environment of this species.

3.0 SQUIRREL GLIDER
Petaurus norfolcensis

NSW NPWS ACT 1974 - Schedule 12 listing

Part 2 - Vulnerable and Rare Species

Information sources

Strahan, R. (ed) (1983) *Complete Book of Australian Mammals.* The National Photographic Index of Australian Wildlife, Sydney

Goldney, D.C. and Bowie, I.J.S. (1988) *A Scenic and Scientific survey of the Central Western Region of NSW.* (Vols. 1 & 2),Mitchell CAE, Bathurst.

NPWS and State Forests of NSW (1994) *Guidelines for the preparation of Fauna Impacts Statements for Forestry Operations Within State Forests.* NSW NPWS and SF of NSW, Sydney, Version 1.

Data bases

NPWS fauna data base;
CSU data base.

SECTION 92D ASSESSMENT

1. **A full description of the fauna to be affected by the actions and the habitat used by the fauna**

The Squirrel Glider is closely related to the Sugar Glider. It is twice the size of the latter animal but resembles it in all other respects.

The species is found predominantly in dry sclerophyll forests but has been reported in some wetter areas. It is known to inhabit bushland remnants along the NSW-Victorian border as well as being found in some riparian strips.

The species nests in tree hollows and feeds on invertebrates, flowers, fruits and tree exudates. The habitat of the species is relatively widespread west of the Divide. Suitable habitat exists in the study area, particularly in the section of remnant bushland which will be cleared for the development.

2. **An assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them**

(a) Distribution

Species prefers open dry sclerophyll forest west of the Great Divide in Victoria, NSW and Queensland. Species has been found infrequently in the Bathurst-Orange area and is regarded as very endangered in the region. Museum specimens have been reported from the Lithgow area. Other sightings in the Central Western Region have been from the Parkes area although potentially the species could be widespread. The range of habitat in which it is found in NSW has not been fully reported. The species has been rarely identified in fauna surveys in the region. It may be naturally very dispersed in distribution as well as low in numbers.

(b) Habitat to be affected by the actions

The proposed mining program will clear potential habitat from the site. The potential habitat is the area of remnant bushland part of which will be removed. The bushland on site is rated as Category 3, that is, it has some conservation value, is not pristine, and has evidence of some degradation including weed invasion and areas of regrowth.

Consequently the numbers of hollows present in trees have been reduced from what would be expected in an old growth situation. Little is known about the biology/ecology of the species and hence it is not possible to categorically define what is optimum habitat for the species.

(c) Environmental Pressures

Habitat clearing, loss of flowering eucalyptus diversity and loss of tree hollows.

3. **A description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term**

The proposed mining program will result in the clearing of a portion of the remnant bushland. If any of the species are located on site they could be affected by the activity. It is possible that these animals could relocate to the remaining uncleared bushland. However no evidence of Squirrel Gliders being on site was found during the survey. The species has not been located in the Orange area. A bushland corridor will also be retained in the north of the site which would enable some continuity to be maintained between the

bushland remnant and the old Cadia site to the west. It is expected that there will be no impact on the species.

4. Details of the measures to be taken to ameliorate the impacts

There are no specific proposals to ameliorate the impacts for this species given that no evidence of the species was found during the survey. The minimum amount of clearing will be undertaken. Better management of the remnant bushland in surrounding lands, particularly those now owned by Newcrest should enable potential habitat for this species to be conserved compared to practices carried out by previous landowners.

SEVEN POINT TEST

1. The extent of modification or removal of habitat in relation to the same habitat in the locality

Significant amounts of on-site suitable habitat will be impacted on by the proposed development. However this is still a relatively small amount compared to suitable habitat off-site in nearby remnants. Significant and extensive habitat can be found in the fragmented remnant landscape across the Central Western Region.

2. The sensitivity of the species to removal or modification of its habitat

The species is sensitive to the removal and fragmentation of its habitat, both in forest and woodland.

3. The time required to regenerate critical habitat in whole or part which is essential for the survival of species

No critical habitat was identified for the species.

4. The effect on the ability of the population to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development

Potential habitat was identified on parts of the study site. The species was not located at these sites. It is not expected that there will be any impact on this species and from which it would need to recover.

5. Any Proposal to ameliorate the impact

There are no specific proposals to ameliorate the impacts for this species given that no evidence of the species was found during the survey. The minimum amount of clearing will be undertaken. Better management of the remnant bushland in surrounding lands, particularly those now owned by Newcrest should enable potential habitat for this species to be conserved compared to practices carried out by previous landowners.

6. Whether the land is currently being assessed for wilderness by the Director of NPWS under the Wilderness Act, 1987

No.

7. Any adverse effect on the survival of the species of endangered fauna or of populations of that fauna

No adverse effects on the survival of the species/population will be expected from the proposed development.

Conclusion

The development will not have a significant affect on the environment of this species.

4.0 KOALA
Phascolarctos cinereus

NSW NPWS Act 1974 - Schedule 12 listing

Part 2 - Vulnerable and Rare species

Information Sources

Lee, A. and Martin, R. (1988) *The Koala - A Natural History.* NSW Univ. Press, Sydney.

Stahan, R. (ed) (1983) *Complete Book of Australian Mammals.* the National Photographic Index of Australian Wildlife, Sydney.

Goldney, D.C. and Bowie, I.J.S. (1988) *A Scenic and Scientific Survey of the Central Western Region of NSW.* (Vols 1 & 2), Mitchell CAE, Bathurst.

NPWS and State Forests of NSW (1994) *Guidelines for the preparation of Fauna Impacts Statements for Forestry Operations Within State Forests.* NSW NPWS and SF of NSW, Sydney, Version 1.

Data bases

NPWS fauna data base;
CSU data base.

SECTION 92D ASSESSMENT

1. A full description of the fauna to be affected by the actions and the habitat used by the fauna

Koalas are found mainly in woodlands. Most common in dry forests and woodlands on high nutrient soils along river flats and drainage lines. Only eats leaves of certain eucalyptus species, including three found on the study site.

In the Central Western Region, the optimal habitat is found along creek lines with Ribbon Gum and Yellow Box trees. Both of these Eucalypt species are known to be feed trees for Koalas. Blakely's Red Gum is also a favoured food tree in the region. No studies of the species have been conducted in the region and hence differences between coastal and inland populations are not known.

2. **An assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them**

(a) **Distribution**

Patchily distributed throughout forests and woodlands in eastern Australia. In the Central Western Region it is patchily distributed across the Tablelands and Slopes as far west as Forbes. The fragmented landscape has resulted in the isolation of Koala colonies across the region. Landowners report the Koala traversing open country as it moves between remnants. The Koala has been found infrequently in the Bathurst-Orange area and is regarded as very endangered in the region. There are no known colonies in the study area or the immediate vicinity of the proposed development although sightings have been made in the Orange area.

(b) **Habitat to be affected by the actions**

The study site contains some of the preferred food trees of the Koala. Koalas could potentially be found in the remnant bushland. The preferred sites would be along Creekline A, Copper Gully Creek and possibly Cadiangullong Creek because of the presence of food trees at these locations. The cleared savanna farmland with Yellow Box and Red Gum is also potential habitat and some of this vegetation community will be removed as a result of the proposed mining program. Some prime habitat sites exist within the remnant bushland predominantly along the drainage lines where there are high levels of nutrients available for optimising tree growth. The remainder of the habitat provides areas for possible movement and behavioural interactions and is sub-optimal habitat which could be used by the species if present. The sub-optimal habitat is common in the land system.

(c) **Environmental Pressures**

Clearing along river flats, dieback and habitat clearing in general.

3. **A description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term**

The proposed development will involve the clearing of part of the remnant bushland and the removal of some of the cleared savanna farmland. Similar areas of habitat will remain in the areas which will not be cleared or removed. Similar scattered bushland remnants are found in the Orange area. The proposed action has some potential to impact adversely on Koala ecology and behaviour if the species was present. However, no Koalas were found on the site nor have they been reported in the locality. It is not expected that there will be any impact on the species.

4. **Details of the measures to be taken to ameliorate the impacts**

No specific amelioration measures are proposed. However, loss of potential habitat will be replaced by plantings of trees in the ongoing rehabilitation phase of the project with particular emphasis on Koala food trees.

SEVEN POINT TEST.

1. **The extent of modification or removal of habitat in relation to the same habitat in the locality**

The major impact of the proposed development on the potential habitat of this species will be along creek lines and open Box woodlands. This is a relatively small area compared to similar habitat in the locality and across the region.

2. **The sensitivity of the species to removal or modification of its habitat**

The species is sensitive to the removal of habitat. Little prime habitat exists in the immediate vicinity of the mine site.

3. **The time required to regenerate critical habitat in whole or part which is essential for the survival of the species**

No critical habitat was identified for the species.

4. **The effect on the ability of the population to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development**

Potential habitat was identified on parts of the study site. The species was not located at these sites nor has been recorded in the area. It is not expected that there will be any impact on this species and from which it would have to recover.

5. **Any Proposal to ameliorate the impact**

No specific amelioration measures are proposed. However, loss of potential habitat will be replaced by plantings of trees in the ongoing rehabilitation phase of the project with particular emphasis on Koala food trees.

6. **Whether the land is currently being assessed for wilderness by the Director of NPWS under the Wilderness Act, 1987**

No.

7. **Any adverse effect on the survival of the species of endangered fauna or of population of that fauna**

No adverse effects on the survival of the species/populations would be expected from the proposed development.

Conclusion

The development will not have a significant affect on the environment of this species.

5.0 COMMON BENT-WING BAT *Miniopterus schreibersii*

NSW NPWS Act 1974 - Schedule 12 listing

Part 2 - Vulnerable and Rare species

Information Sources

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Data bases

NPWS fauna data base;
CSU data base.

SECTION 92D ASSESSMENT

1. **A full description of the fauna to be affected by the actions and the habitat used by the fauna**

The Common Bent-wing Bat belongs to the Family Vespertilionidae. It is one of the bats capable of living successfully in colder areas of Australia partly due to their ability to hibernate.

The species is found in rainforest and sclerophyll forest. It favours valley areas. The species is considered a canopy forager. Recorded roosts include caves, mines, tunnels and houses. The species has been found infrequently in the Bathurst-Orange area and is regarded as very endangered in the region. Because of man made structures such as old mines adjacent to the study site, but not on the study site, there may be ample roosting sites available enabling it to forage in the locality. Suitable potential feeding habitat is found in the areas to be impacted on. The remnant bushland on the proposed mining site provides potential quality foraging habitat.

2. **An assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them**

(a) Distribution

Inhabits tropical rainforests to warm temperate wet and dry sclerophyll forests occurring along the coastal plains and adjacent ranges from Cape York to Adelaide. Scattered populations are known to exist in the Orange area and in the eastern section of the region. The areas of potential distribution extend to the boundary of the slopes-plains. Populations are scattered and in decline. The local population centred on the old Cadia Mine site is known to be a relatively small colony.

(b) Habitat to be affected by the actions

No roosting sites were located in the impact areas but are known to exist in the Old Cadia Hill site. The species may also at times potentially fly over the savanna woodlands as part of its foraging area. No bats were detected in the remnant bushland. However it is possible that the species may use this site from time to time. Similar and extensive habitat exists in other locations in the locality and in the region.

(c) Environmental Pressures

Habit clearing, disturbance of nursery caves.

3. **A description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term**

The proposed development will involve the clearing of part of the remnant bushland and some open woodland. The areas of bushland to be cleared in the mining process have the potential to be foraging areas for the species including the creek line areas. However the species was not found on site either in roosts or in feeding mode. The colony of Bent-wing bats identified in the old Cadia Hill site in a previous study could at times forage in the area of the proposed development, since this species is able to forage over long distances. The loss of a potential foraging area reduces the insect resources available to the bats, and would be a minor loss given the areas of alternate bushland and creek lines available within foraging dis-

tance. This scenario is strengthened by the small size of the Cadia colony, estimated to be approximately six bats. The impacts on the bats will be negligible.

4. Details of the measures to be taken to ameliorate the impacts

No specific proposals are planned. The availability of alternate foraging sites, the lack of evidence to suggest that the Bent-wings utilise the proposed mining site and the size of the small colony located at Cadia Hill in 1991, suggest this to be an appropriate strategy.

SEVEN POINT TEST.

1. The extent of modification or removal of habitat in relation to the same habitat in the locality

Feeding habitat but not roosting sites are available in the proposed development area. Some of this woodland habitat will be cleared and hence could potentially impact on a small colony of this species known to inhabit the Old Cadia Mine site in the extant tunnel system. The relative amounts of habitat to be destroyed compared to off-site habitat is relatively small.

2. The sensitivity of the species to removal or modification of its habitat

The species is sensitive to the removal of habitat required for foraging and/or roosting. No animals were found to utilise the available on-site foraging habitat nor is suitable roosting habitat available in the area proposed to be mined. Nevertheless, the remnant bushland area may be utilised by the bats at times as a foraging area

3. The time required to regenerate critical habitat in whole or part which is essential for the survival of the species

No critical habitat was identified for the species. It is possible that from time to time the Cadia colony forages in the area, but was not located doing so during this study. If the bats did forage in the development area, the bushland area would be part of an extensive foraging system and would not in itself be regarded as a critical resource for a small colony.

4. The effect on the ability of the population to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development

Potential feeding habitat was identified on parts of the study site. The species was not located at these sites. It is not expected that there will be any impact on this species.

5. Any Proposal to ameliorate the impact

No impact has been identified which would require amelioration.

6. Whether the land is currently being assessed for wilderness by the Director of NPWS under the Wilderness Act, 1987

No.

7. Any adverse effect on the survival of the species of endangered fauna or of population of that fauna

No adverse effects on the survival of the species/ populations would be expected from the proposed development.

Conclusion

The development will not have a significant affect on the environment of this species.

This report has been prepared with the requirements of Section 92D(1) of the National parks and Wildlife Act, 1974.

Associate Professor David Goldney
6th October 1995

Details of the qualifications and experience in biological science and fauna management of the persons preparing thios report are provided in Attachment E-4

ATTACHMENT E-4

PERSONNEL

ATTACHMENT E-4

PERSONNEL

(Giving experience and qualifications as required under Schedule 12 legislation.)

Assoc. Prof. David Goldney, BSc Dip Ed PhD - project supervision.
Senior Lecturer at Charles Sturt University and Associate Director of the Johnstone Centre.

Wildlife ecologist with over 20 years research experience, consulting for governments, NPWS and industry in the CWR. Specialising in conservation biology, platypus ecology, fauna surveys and remnant woodland ecology.

Mr Andrew Fisher, BSc(Hons) - mammals and birds.
Associate Lecturer at Charles Sturt University and member of the Johnstone Centre; PhD student in vertebrate ecology, focussing on birds and bats.

Mr Steven Cox, BSc - mammals and birds.
Honours student at Charles Sturt University; special interest in ornithology.

Mr Darren Benger, BSc - mammals.
Field assistance.

Mr Ian McArtney - fish, reptiles and amphibians.
Bathurst City Council (Sir Joseph Banks Nature Park and Winburndale Dam); amateur herpetologist with over 40 years experience in the CWR.

APPENDIX F

Fish Fauna

FISH FAUNA AND STREAM CONDITION OF THE UPPER FLYERS AND CADIANGULLONG CREEKS, CENTRAL TABLELANDS, NSW.

RESULTS OF A SUMMER SURVEY 24 / 28 FEB 1995

FOR WOODWARD-CLYDE, ENVIRONMENTAL CONSULTANTS FOR NEWCREST GOLDMINE, CADIA, ORANGE.

J.J. BAUER

JOHNSTONE CENTRE OF ECOSYSTEM MANAGEMENT
ALBURY-BATHURST
CHARLES STURT UNIVERSITY

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Relationship Between the Size of Rockpools and the Size of Galaxia Juvenile Swarms in the Upper Flyers Creek (24.2.95).

1.0 OBJECTIVES OF THE STUDY

This follow-up survey of a winter/spring study conducted at the upper Flyers Creek (Bauer, 1994) seeks to establish the creek's fish population in the summer months (24.2.95). During the winter survey no native fish were detected in the surveyed creek section, however a reconnaissance walk in the headwaters of the stream suggested ideal conditions for a native group of fish known as galaxids. There is little information on migration habits of galaxid species, however it was considered a possibility that fish had migrated downstream during winter and could therefore not be detected.

Regulating State agencies (NPWS, EPA, DWR, CALM) do not allow unacceptable impacts by mines. Required controls are enforced via any development consent conditions including riparian flow conditions downstream. For the Cadiangullong Creek, a water system which has been directly affected by past activities including forestry and the abandoned historic Cadia mines and which without appropriate control and mitigation measures will be further affected by new downstream development, a summer survey (28.2.95) was carried out to establish the condition of the fish fauna as well as to provide baseline information on which to measure further potential impacts e.g. caused by the changes of macro-invertebrate faunas, breeding habitats and migration suitability of the stream. The following is a summary of the findings of these surveys with a discussion on the implications of these for the proposed development.

2.0 SITE LOCATION

The location of the first study site (Flyers Creek) is upstream of the surveyed region in winter 1994 (Bauer 1994). Three transects with 10 survey sites each (50 m apart) were chosen for the Cadiangullong Creek. Two of the sites were directly below the proposed mining site. The third transect (C) samples the shallow rock pools in the eastern section of the upper headwaters of Cadiangullong Creek. Figure F-1 shows the location of the study sites.

3.0 SITE DESCRIPTION

3.1 THE UPPER FLYERS CREEK

The summer survey concentrated on the upper parts of the Flyers Creek close to its headwaters. The creek in this upper portion transects steep and almost entirely rocky ground material where it has little opportunity to erode its creek bed and/or to collect bedload. Abundant rock terraces with waterfalls in between have created small yet stable pools ranging from less than one Sq m to 40-50 Sq m and a max. depth of 1.7 m at the time of both surveys. Waterflow is moderate to low in this area with a water flow of less than 1 L/sec. Above the v-shaped rock faces native forest has been mostly cleared by agriculture. Only some adult large-sized Eucalypt trees (*E. melliodora*) remain. Pastures are overgrazed and weed infested (Scottish Thistles, Nettles, Horehound). Cattle have little access to this section of the stream, however, especially in the upper sections, sheep utilise the streambed heavily.

Although agricultural land around the creekline is heavily degraded it has not been colonised by willows, as is the case in the lower creek portions, no doubt due to the rocky ground substrate.

3.2 THE CADIANGULLONG CREEK

The Cadiangullong Creek was surveyed below the new proposed mining site and its upper headwater portions. The creek showed good water flow at the time of the survey (2-4 L/sec.) water quality however was considerably lower than in the Flyers Creek possibly due to upstream forestry (*Pinus radiata*) and outflow from old abandoned mine sites. Relatively high copper loads seem to be at least partly responsible for this.

The vegetation of the creekline at the lower headwater sections of the Cadiangullong Creek below the development is of significance as it contains good sections of old-growth River She-oak (*Casuarina cunninghamiana*) large Blackwood *(Acacia melanoxylon)*, Yellowbox *(Eucalyptus melliodora)*, Applebox (*Eucalyptus bridgesiana*) and only moderate and young stands of willow (*Salix sp.)* which have only invaded recently. Streambed and streambank is in poor condition. The creekline is heavily utilised and trampled by cattle, with abundant faeces in and around the streambed. Aquatic vegetation mainly consists of *Ceratophyllum* and *Potamogeton sp.*. Small stands of *Phragmites sp.* and *Juncus sp.* along the creekline have persisted despite cattle grazing. The water quality has been affected by nutrient influx as testified by the presence of *Phragmites* as well as various forms of algae.

The upper headwater is different in appearance. Few trees are retained in this section, however the stream, almost entirely contained within a bed of basalt rock slabs is framed by dense and sometimes wide stands of large native grass tussocks which are little affected by grazing.

4.0 METHODOLOGIES AND LIMITATIONS OF STUDY

This study was carried out on the 24th and 28th February during suitable weather and water conditions (see Bauer 1994). Twenty-five survey sites were examined and described in detail in the upper headwater sections of the Flyers Creek. Fish surveys followed the procedures described in the previous report. The number of fish was approximated as the mean value for a maximum and

minimum estimate of sightings per pool. The description and evaluation of fish habitat followed the methods developed for the winter survey. In the upper section however instead of applying 50 m survey site intervals all pools were examined and sampled with the handnet. Condition of the riverbed and streamside was recorded as in the winter survey (Bauer 1994). The size of individual pools was calculated with an approx. formula (Vol = Length × mean Width × mean Depth (1/2 max Depth). Detailed survey results on the recording forms were not included in this report however they can be obtained if requested.

In the Cadiangullong Creek, 30 sites were chosen for the survey. Transect A consisted of 10 sites spaced 50 m apart below the proposed impact site (open site) and 10 sites (Transect B) above proposed impact site. One more transect with 10 sites (10 rock pools) was selected in the upper headwater sections (see Figure F-1) sampling a series of 10 pools. Detectability in the lower Cadiagullung Creek sections was limited due to relatively poor transparency of the water which limited the observability of deeper water sections in pools or around submerged snags. These conditions applied also to the upper sections however here handnetting could mitigate this limitation.

5.0 RESULTS

5.1 THE UPPER FLYERS CREEK

5.1.1 Streambed Morphology and Flow Characteristics

The upland stream section consists mostly of slabs of stone or medium to large-sized boulders. Flow characteristics are characterised by the alteration of little cascades, often followed by fast, narrow (< 50 cm) riffle sections and small pools varying in size between 0.5-40 Sq.m and 0.20 - 1.7 m depth. Due to the small catchment and the compact nature of bedrock there is little bedload movement in this creek section. Small sized (< 2 cm diameter) creek sediment forms a relatively thin cover in the larger pools (2-5 cm) where some sedimentation takes place. As the pools are a main characteristic of the suitability of the creek for Galaxias a frequency distribution of the pools encountered in the upper section is given in Figure F-2. The distribution shows that most of the pools are small and that over a length of approx. 1 km only 5 pools with a volume of more than 5 Cub. m. are present.

5.1.2 Aquatic Macrophyte Abundance

Introduced watercress dominates the banks in the lower less rocky sections of the creek, often entirely covering small and shallow (0.5 sq.m.) to deep (1.7 m) and rather large rock pools. (> 20 sq.m.) or forming dense mats along the banks of the lower sections of the upper creek. Filamentous green algae appeared to be less prominent than in winter however were still an abundant element in the upper sections of the stream.

5.1.3 The Invertebrate Fauna

The invertebrate fauna of the upper stream section is shown in Figure F-3. If compared with the results of the winter survey it has diminished both in numbers and in diversity. In particular Mayflies were present in much lower numbers than in winter. Notable was the abundance and diversity of Odonata with more than 12 species of larvae and adults encountered. The invertebrate fauna seems to find an ideal plant substrate in water cress which seems to be especially rich in numbers and species. Filamentous green algae seem to be less suitable as habitat substrate for invertebrates. Survey results are given in Figure F-3. The most common species of Crustacea were juvenile common yabbies.

5.1.4 The Fish Fauna

The majority of pools of this upper section (22 out of 30) had schools of juvenile Mountain Galaxias. Larger schools contained adult fish. A frequency distribution of fish encountered in the pools is given in Figure F-4.

A positive relationship between the number of Galaxias and the size of the pool (Polynom Regr. 3rd Ord. $r = 0.992$, ANOVA: $F = 390.3$, $p < 0.0001$) indicates that the species is close to maximum carrying capacity and has been breeding successfully this summer (Figure F-5), saturating breeding habitat. Close to 2000 juvenile fish (2-6 cm length) were discovered in the pools. Large schools utilized open water, while single fish were often seen within the water cress beds or under rocks in small pools. Adult fish were encountered mainly in the large swarms of juveniles.

5.2 THE CADIANGULLONG CREEK

5.2.1 The Stream

The lower portion of the Cadiangullong Creek, while being heavily disturbed and degraded by cattle still carries riparian woody vegetation which is regionally exceptional for farmland. This area will not be affected by the development. Macro-invertebrate fauna was similar in composition and abundance as the upper Flyers Creek.

5.2.2 The Fish Fauna

Lower sections

Single adult Mountain Galaxias were found at three of twenty sites. One juvenile Rainbow trout was caught amongst a mat of *Ceratophyllum*.

Eastern Headwaters

All the rockpools examined in the upper section were shallow with less than one cubic metre of water volume. Only small numbers of juvenile Galaxias were present . Altogether the number of juvenile Galaxias in this upper part of Cadiangullong Creek is unlikely to exceed 1-200 individuals.

6.0 DISCUSSION OF THE RESULTS

This survey was carried out to examine if the absence of galaxias as determined in the winter survey was due to unknown environmental or distributional factors or if seasonality was involved. The presence of adults as well as large numbers of juveniles in the upper sections as found in this summer survey not only confirmed the previously suggested suitability of the stream for galaxias (Bauer, 1994) but also suggested some migrational behaviour of the species. The upper creek section obviously provides a small yet very suitable summer environment for the breeding of this species. The much lower number of Mayfly larvae during summer would suggest some importance of this group for the nutritional requirements of the juveniles. Introduced watercress seems to have made some positive contribution to the suitability of this creek portion as breeding habitat, however there is also evidence, that the presence of filamentous green algae has negative implications for the suitability of the stream as breeding habitat. The only large pool with small numbers of Galaxias (< 100) was very much affected by green algae (and was therefore excluded from the analysis of the relationship between pool size and number of juveniles).

The survey has been too superficial and short-termed to provide quantifiable reliable information of what determined the creeks suitability for Galaxids, there are however two factors in the upper Flyers Creek which I would suggest affect habitat suitability for Galaxids. The two factors identified seem to be aquatic vegetation and size of rock pools.

In comparison, the Cadiangullong Creek, while carrying probably a good population of adult Galaxias seems to be less suitable for breeding in the upper sections. If this is natural or is caused by past (e.g. the activities of the old gold mine) or present degrading factors (forestry and agriculture) cannot be determined.

7.0 ENVIRONMENTAL IMPACTS OF WEIR CONSTRUCTION IN THE FLYERS CREEK

Too little is known on the biology of Galaxias to determine if the interception of the streamline by a relatively large body of water upstream will reduce its capability to carry out the suggested seasonal migrations into the headwaters of this creek. Galaxias are able to climb steep rockfaces as is evidenced in this study by their presence upstream. The provision of a fish ladder as suggested in the earlier report (Bauer, 1994) would therefore be adequate as long as steps do not exceed 1 m and are at an angle. Monitoring will have to assess if the weir will carry populations of introduced Brown and Rainbow Trout. Apart from potentially increased predation pressure on migrating Galaxias one of the long-term effects of the weir might well be an increase of the Trout population upstream which would most likely affect Galaxias negatively. These represent the most significant long-term and cumulative environmental impacts and are thus recommended for monitoring during operations.

There is however one further aspect about fish ladders which should be addressed. There is a possibility that a weir at the suggested position could provide a wintering habitat for Galaxias. In this case a weir with a non-negotiable fish ladder could well provide Galaxias with an upper stream section where it would be possible to exclude Trout. In this way a natural enclosure experiment could be set up, as has been done (e.g. in Tasmania).

8.0 ENVIRONMENTAL IMPACTS OF MINING ACTIVITIES ON GALAXIAS IN THE CADIANGULLONG CREEK

The prevention of increased silt loads as normally required by EPA, DWR and CaLM will be one of the most important mitigation activities in the years to come. Indicators of creek quality and health could be easily retrieved during regular monitoring. Without this information it will not be possible to determine future changes in sediment load and sediment type.

9.0 CONSERVATION SIGNIFICANCE AND SUGGESTIONS

Both streams warrant annual monitoring of water quality, streambed condition, fish fauna notably Galaxids and macro-invertebrate fauna. Both upstream breeding habitats could be affected by the proposed development without the implementation of the recommended mitigation measures. The weir at Flyers Creek has the potential to disrupt migration patterns, while adverse changes in water quality in the lower headwater sections of the Cadiangullong Creek have the potential to disrupt breeding. Fencing, tree planting and weed control can greatly improve the quality of both creeks as well as increase their resilience towards disturbance. Research should establish

the significance of the weir as potential wintering habitat for Galaxias. If it is suitable a weir without fish ladder could provide a possibility to exclude Trout from the upper stream sections and thus act as a natural Galaxid enclosure.

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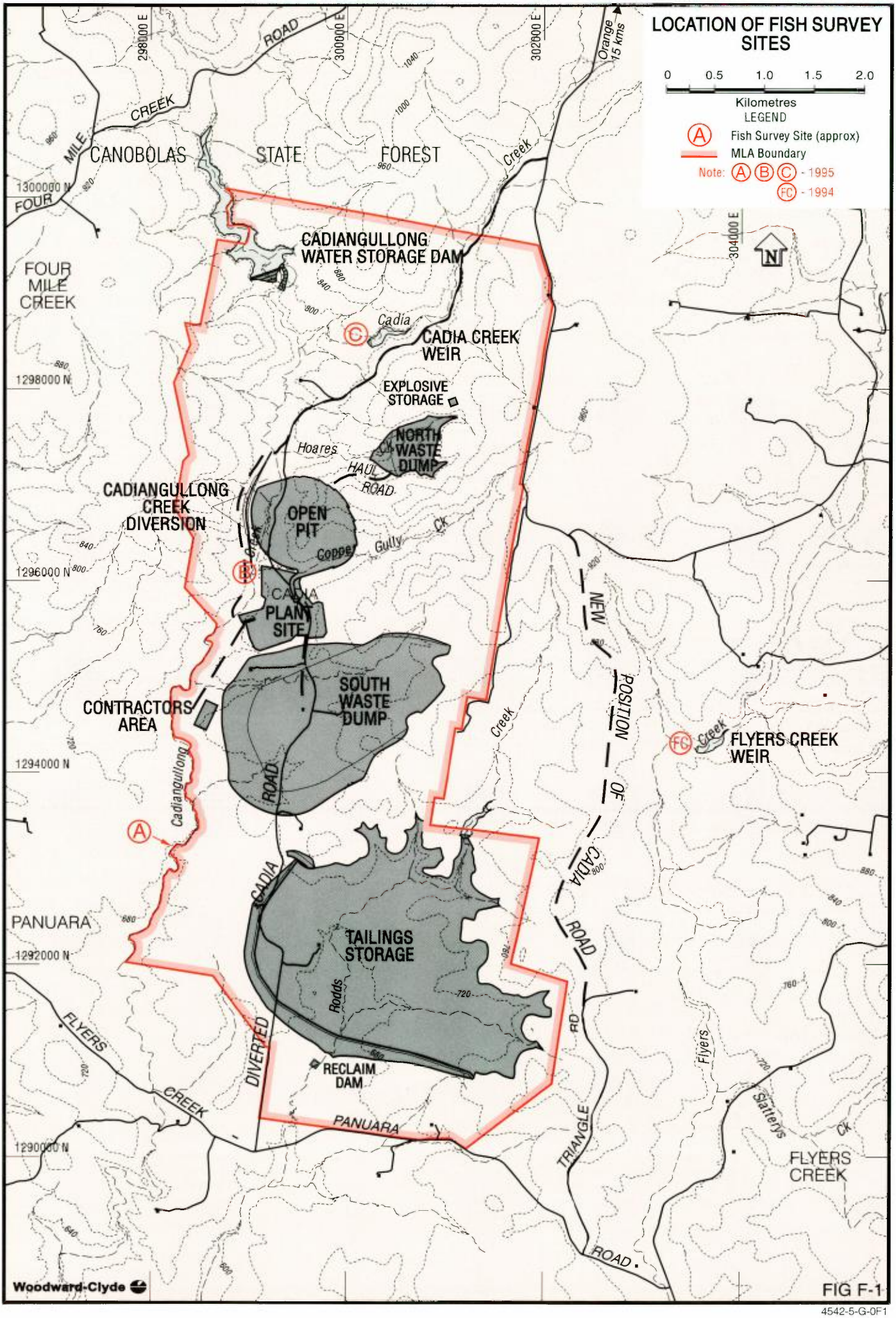
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Woodward-Clyde

FIG F-1

4542-5-G-0F1

SIZE CLASS DISTRIBUTION OF ROCKPOOLS (N=25) IN THE HEADWATERS OF THE FLYERS CREEK (24-2-95)

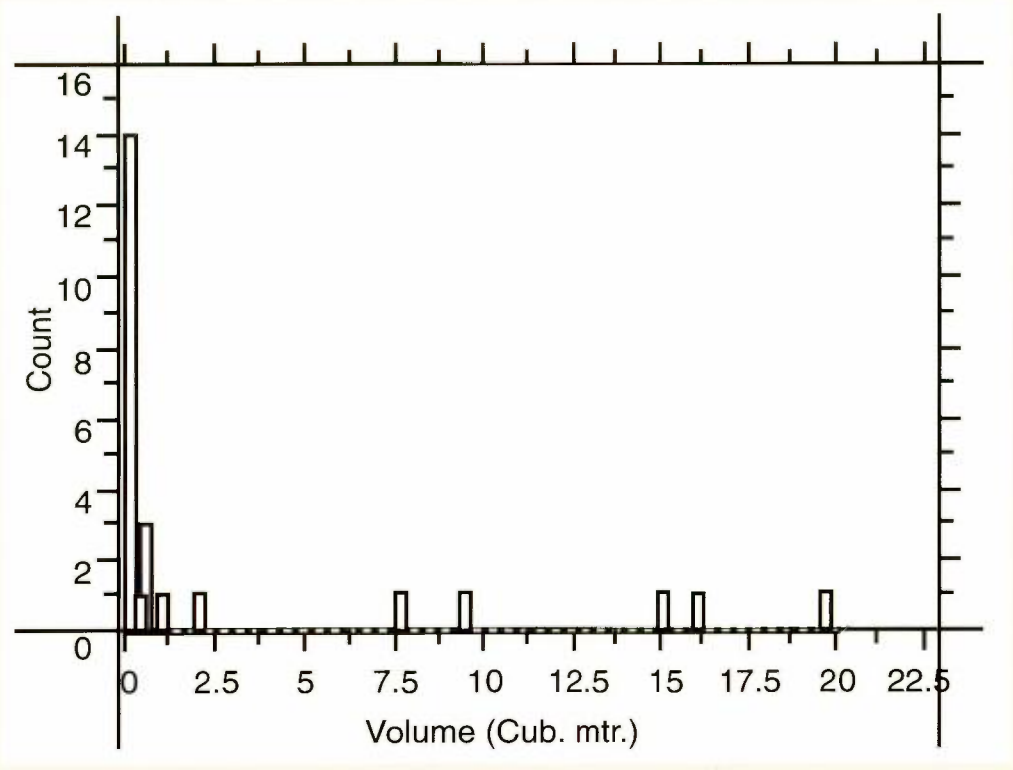
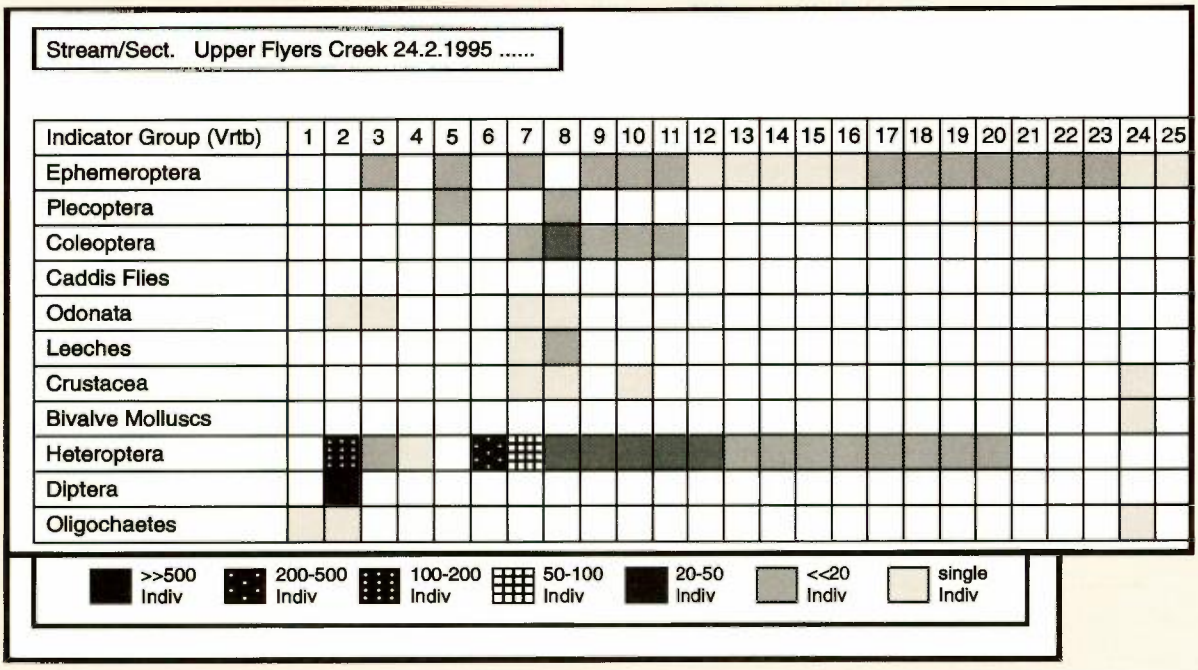


FIG F-2

COMPOSITION AND ABUNDANCE OF MACRO-INVERTEBRATES IN THE UPPER FLYERS CREEK (24-2-95)



Woodward-Clyde

FIG F-3

FISH SIGHTINGS IN THE UPPER FLYERS CREEK (24-2-95)

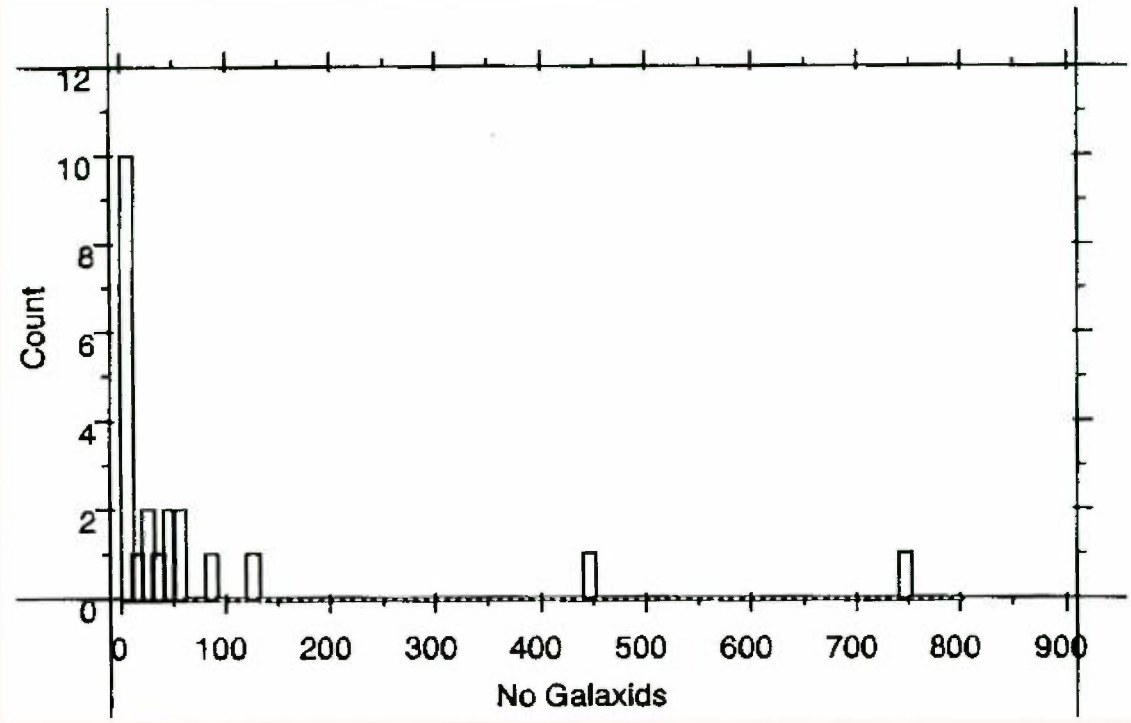
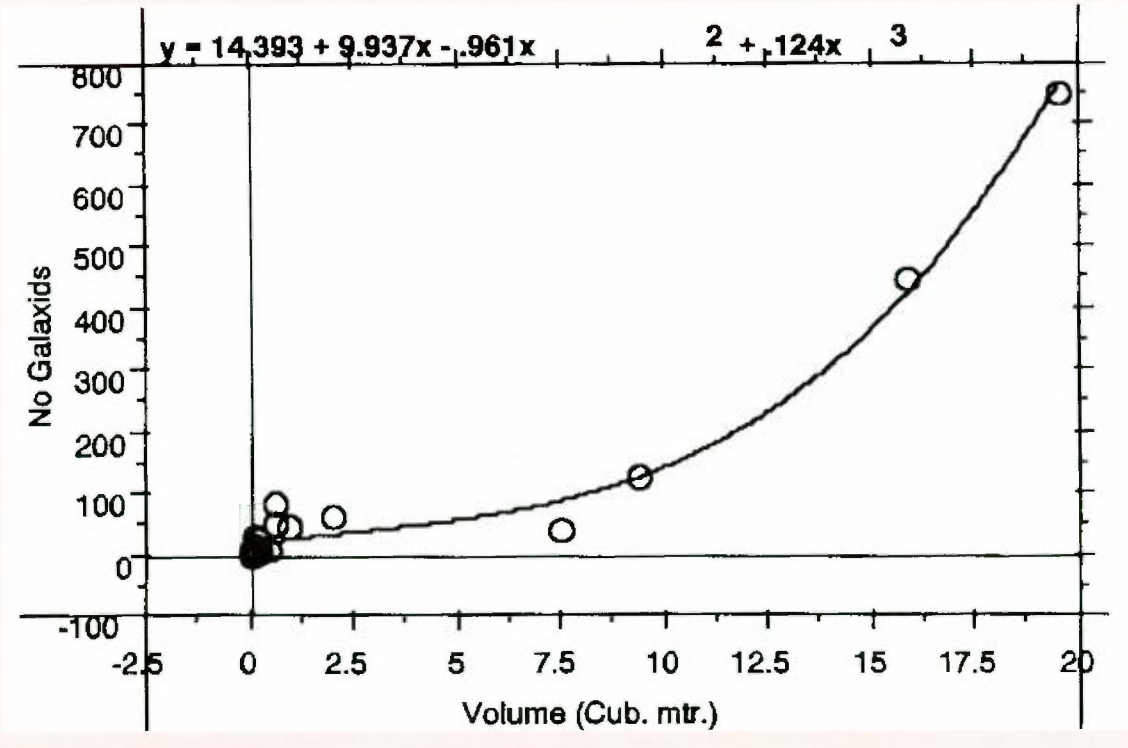


FIG F-4

RELATIONSHIP BETWEEN THE SIZE OF ROCK POOLS AND THE SIZE OF GALAXIA JUVENILE SWARMS IN THE UPPER FLYERS CREEK (24-2-95)



Woodward-Clyde

FIG F-5

APPENDIX G

Freshwater Macroinvertebrate Survey

FRESHWATER MACROINVERTEBRATE SURVEY

OF

NEWCREST MINING WA LTD
CADIA HILL SITE

REPORT TO

AGC WOODWARD-CLYDE PTY LTD

BY

A F GIBBS
MARCH 1995

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1.0 INTRODUCTION

This freshwater macroinvertebrate survey has been undertaken for AGC Woodward-Clyde Pty Ltd, to characterise the existing communities of freshwater macroinvertebrates in the Newcrest Mining WA Ltd proposed mining area at Cadia Hill in the Central Tablelands of New South Wales. In characterisation of the existing populations of freshwater macroinvertebrates, the requirements of the survey were: (Bartrim, 1994; Gibbs, 1994):

(i) a background survey of macroinvertebrates at six sites selected in consultation with Woodward-Clyde and site staff (G. Johnston);

(ii) surveys to be undertaken in two seasons (Spring and Summer);

(iii) identification of macroinvertebrates (insects) to at least Family level (preferably Genus), and for other organisms to Class;

(iv) determine relative abundance of each group; and

(v) make appropriate recommendations.

'Freshwater macroinvertebrates are a group of animals without backbones, sufficiently large to be seen with the unaided eye (i.e. more than 0.5 mm) and which live at least a part of their life in freshwater. Any available substrate (both natural and artificial) may provide a suitable habitat, including weirs and barrages, rocks, sediments, water plants and submerged logs (snags). Freshwater macroinvertebrates may be omnivores, carnivores, detritivores or herbivores and in a well-balanced system all four types are likely to be present.' (Bennison, Hillman and Suter, 1989, p1).

As macroinvertebrates are important members of the food chain and their well-being is reflected in the well-being of the higher animal forms such as fish, they are increasingly being used to monitor water quality and as an indicator of the health of aquatic systems. The major macroinvertebrate groups include a wide variety of insects (both adults and larvae), a range of worms, Crustacea (shrimps and yabbies), and molluscs (snails and bivalves).

This study, while characterising the populations of freshwater macroinvertebrates using a well established biological monitoring technique, will not by itself tell the full story about the health of the creeks in the area. The results of the study can only be a supplement to chemical analysis of water samples in determining the health of the aquatic environments. Chemical analysis is the subject of a separate study.

2.0 SITE DESCRIPTION

2.1 LOCATION

The Cadia Hill site is located approximately 20 km SW of Orange and 24 km NW of Blayney in the Central Tablelands region of New South Wales. A number of creeks transect the area. In relation to this survey, sample sites were on Cadiangullong Creek (4), Rodds Creek (1), and Copper Gully Creek (1) which flows into Cadiangullong Creek below the old mine site. Cadia Creek also flows into Cadiangullong Creek north of the old mine site (Figure G-1).

Cadiangullong Creek flows past the old mine site and the location of the present site office. The four sample sites on Cadiangullong Creek were located upstream of the old mine site (MV_1); adjacent to the old mine site (MV_2); a distance downstream of the old mine site but still well within the proposed mine boundary (MV_3); and well downstream of the mine site at the Panuara Road - Cadiangullong Creek bridge (MV_4).

The Copper Gully Creek sample site (MV_6) was in a gully on the edge of a pine plantation and an area of remnant native vegetation. The Rodds Creek sample site was at the Panuara Road - Rodds Creek bridge (MV_5) and is only approximately 1.4 km east of the Panuara Road - Cadiangullong Creek bridge sample site. Rodds Creek drains the south-east corner of the proposed mine area and flows into Cadiangullong Creek south of Panuara Road (Figure G-2).

In consultation with site staff (G. Johnston), the macroinvertebrate sample sites (MV 1-6) correspond, where appropriate, to the same sites where water samples (WS) were taken for analysis (Table G-1).

TABLE G-1
MACROINVERTEBRATE SAMPLE SITES

MV Code	WS Code	Location
MV1	WS1	Cadiangullong Creek - upstream of old mine
MV2	WS2	Cadiangullong Creek - adjacent to old mine
MV3	WS4	Cadiangullong Creek - downstream of old mine
MV4	-	Cadiangullong Creek - Panuara Road bridge
MV5	WS9	Rodds Creek - Panuara Road bridge
MV6	-	Copper Gully Creek

2.2 SAMPLE SITE DESCRIPTION

There was considerable variation between the six sample sites, particularly in the riverine vegetation. Common features of sample sites MV_1-MV_5 were that the creeks

were relatively narrow (less than 5 m) and consisted of interspersed pools separated by rocky riffles (no riffles at MV_5). All these sites had very rocky bottoms. The deepest pools were at sample sites MV_2 and MV_3.

Sample sites MV_1 - MV_5 all differed greatly in the riverine vegetation (Table G-2). Sample Site MV_6 on Copper Gully Creek, was rather unique in that the substratum was basically solid rock and very narrow (less than 1 m) and shallow (60 mm). At one end of the sample area there was a small rock pool and at the other end a very shallow riffle area. At this site it was difficult to find positions where all the five Artificial Substrate Samplers (ASS) were completely immersed. This problem did not exist at the other five sites. The water at MV_6 was also very unique in that it was a cloudy, bluish-white colour.

TABLE G-2
RIVERINE VEGETATION AT THE SIX SAMPLE SITES

Site	Location	Site Description
MV1	Cadiangullong Creek - upstream of old mine	Eucalyptus complex, some Willows, fringing grasses.
MV2	Cadiangullong Creek - adjacent to old mine	Scattered overhanging Willows, fringing grasses. Ground on eastern side greatly disturbed from site activities.
MV3	Cadiangullong Creek - downstream of old mine	Dense overhanging willows, few scattered Eucalyptus, tall dense fringing grasses.
MV4	Cadiangullong Creek - Panuara Road bridge.	Dense overhanging Casuarina, some Willows, fringing grasses.
MV5	Rodds Creek - Panuara Road bridge	Banks mainly bare as creek flows through cleared grazing land. Two small clumps of Willows and some dead trees. A number of clumps of Cumbungi. Banks heavily grazed and badly eroded.
MV6	Copper Gully Creek	Eucalyptus complex, no Willows. Cliff wall along one side, fringing grasses.

2.3 SOILS AND GEOLOGY

The Cadia Hill site lies within the Molong Geoanticline of the Lachlan Geosynclinal belt of south western NSW. The area includes five main soil landscapes, namely Panuara, Spring Hill, Quarry, Towac, and Canobolas (Kovac and Lawrie, 1990). The dominant landscape in the site area is the Panuara which includes red podzolic soils on the mid to upper slopes, with yellow podzolics, brown/red earths and red earths on the lower slopes, with yellow solodics in the drainage lines. In the central western section of the area, siliceous and earthy sands of the Quarry Soil Landscape are found.

2.4 TOPOGRAPHY AND CLIMATE

The elevation ranges from a height of 930 m in the north western region of the site area covered by remnant woodland, to around 720 m along Cadiangullong Creek. A number of ridges transect the area, dividing it into a number of small catchments drained by small creeks. The main drainage line is the permanent Cadiangullong Creek which is fed upstream by Cadia Creek. (See also Section 2.1)

The Cadia Hill area has a fairly mild climate, but the winters can be cold. The average daily minimum and maximum temperatures for July-December 1994 are shown in Table G-3. The mean annual precipitation is about 875 mm. The monthly total rainfall for July-December 1994, is shown in Table G-4.

TABLE G-3
AVERAGE DAILY MAXIMUM AND MINIMUM TEMPERATURES FOR JULY-DECEMBER, 1994*.

Month	Max. (°C)	Min. (°C)
July	11.1	2.3
August	11	1.6
September	14.9	4.1
October	19.3	7.8
November	22.1	10.7
December	29.2	16.3

* G Freak (1995)

TABLE G-4
MONTHLY TOTAL RAINFALL FOR JULY-DECEMBER, 1994*

Month	Rainfall (mm)
July	56
August	20
September	31
October	61
November	128
December	71

* G Freak (1995).

3.0 METHODOLOGY

The technique used in the survey of the freshwater macroinvertebrates was the artificial substrate sampler (ASS). This was similar to the design used in a major survey of macroinvertebrates of the Murray River by Benninson, Hillman and Suter (1989) who also discussed the advantages and limitation of the ASS technique.

Each ASS consisted of a cylinder of black plastic "Gutterguard" of mesh size 10 mm square; 180 mm high and 180 mm in diameter. A square of Gutterguard was attached to the bottom of the cylinder with nylon fishing line. Six knitted nylon citrus bags (each 380 x 380 mm) were loosely packed around half a house brick (added for ballast) inside the cylinder. The top of the sampler was pinched closed, secured by nylon fishing line, and a nylon cord attached which was used to anchor the ASS to the stream bank.

The nylon citrus bags act as a substratum for the colonization of firstly algae, and then a habitat for macroinvertebrates. The ASS's were placed on the creek beds at a depth less than 1.0 m to ensure algae colonization, and securely attached to the bank by the nylon cord.

Two surveys were undertaken. For the spring survey, the ASS's were set in August and collected in September 1994, and for the summer survey, the traps were set in November and collected in December, 1994. For each survey the traps were left for seven weeks.

When collecting the traps, a plankton net was placed under the ASS to remove it from the water, and the ASS placed in a bucket. The plankton net was inverted into the bucket and washed to remove any organisms. If necessary, additional water was added so that the ASS was at least half immersed in water. A lid was attached to the bucket for transport back to the laboratory.

Organisms were removed from the ASS on the same day as collection. After removing the nylon citrus bags, they were washed in a stream of water into the transport bucket, and the contents of each bucket (including the transport water), passed through a series of soil sieves to collect the macroinvertebrates. The contents of the sieves were transferred to sorting trays for collection of organisms, and all organisms from each ASS placed in separate jars containing 75 percent alcohol. At a later date the organisms from each collection were sorted, placed in separate jars and identified.

4.0 RESULTS

A summary of the results showing the total number of organisms collected from the five ASS's for each of the six sites for the two surveys, are presented in the Attachments. Attachment G-1 shows the results for the insects and Attachment G-2 the results for the macroinvertebrates other than insects.

A total of 2038 organisms were collected from the six sites during the two surveys; 1055 (51.8%) during the spring survey and 983 (48.2%) during the summer survey (Table G-5).

During the two surveys, the largest number of organisms, 981 (48.1%), came from site MV_5, followed by MV_1 (573, 28.1%); MV_4 (321, 15.7%); MV_3 (61, 2.9%); MV_2 (56, 2.7%); and MV_6 (46, 2.3%) (Table G-5). During any one survey, the largest number of organisms, 674 (33.1%), came from site MV_5 from the spring survey, followed by MV_1 (428, 21.0%) from the summer survey; and MV_5 (307, 15.1%) from the spring survey.

Excluding site MV_6 where the number of organisms was much the same (24 and 22), there was no consistent pattern in the number of organisms collected during the two surveys. At two sample sites, MV_4 and MV_5, the number of organisms collected during the summer survey were significantly less than the Spring survey (particularly at MV_5 where the summer number (307), was less than half the spring number (674)). At sites MV_1, MV_2, and MV_3, the summer numbers were significantly greater than the spring numbers (Table G-5).

Table G-6 summarises the number of organisms (insects and non-insects) from five ASS's during the two surveys. The majority of organisms (79%) were insects, with 21% non-insect macroinvertebrates.

TABLE G-5
SUMMARY OF TOTAL MACROINVERTEBRATES FROM TWO SURVEYS

Survey ++	Site*						Total
	MV1	MV2	MV3	MV4	MV5	MV6	
1	145	14	7	191	674	24	1,055
2	428	42	54	130	307	22	983
Total	573	56	61	321	981	46	2,038

*SITES	MV1	Upstream of old mine site on Cadiangullong Creek
	MV2	Adjacent to old mine site on Cadiangullong Creek
	MV3	Downstream of old mine site on Cadiangullong Creek
	MV4	Cadiangullong Creek and Panuara Road Crossing
	MV5	Rodds Creek and Panuara Road Crossing
	MV6	Copper Gully Creek
++	Survey 1:	Traps set in August, collected in September, 1994
	Survey 2:	Traps set in November, collected in December, 1994

The total number of Taxa[1] collected was 48. The number of invertebrate taxa and their proportional representation in each of the major faunal groups are given in Table G-7. The insects with 10 Orders and 48 Families made up by far the greatest numbers, accounting for 85.5 percent of the total, compared to 14.7 percent of taxa other than insects.

1. Taxa (pl), Taxon. A general term for a taxonomic group, whatever its rank. Used here as organisms have been identified to different levels.

TABLE G-6
NUMBER OF MACROINVERTEBRATES (INSECTS AND NON-INSECTS) FROM SIX SITES AND TWO SURVEYS

Site*	Insects			Non-Insects			Total
	Survey**		Total	Survey		Total	
	1	2		1	2		
MV1	126 (6.2)	365 (17.9)	491 (24.1)	19 (0.9)	63 (3.1)	82 (4.0)	573 (28.1)
MV2	13 (0.6)	41 (2.0)	54 (2.6)	1 (0.05)	1 (0.05)	2 (0.1)	56 (2.7)
MV3	7 (0.3)	31 (1.5)	38 (1.8)	0 (0)	23 (1.1)	23 (1.1)	61 (3.0)
MV4	161 (7.9)	113 (5.5)	274 (13.4)	30 (1.5)	17 (0.8)	47 (2.3)	321 (15.7)
MV5	613 (30.1)	97 (4.7)	710 (34.8)	61 (3.0)	210 (10.3)	271 (13.3)	981 (48.1)
MV6	20 (1.0)	21 (1.0)	41 (2.0)	4 (0.19)	1 (0.05)	5 (0.24)	46 (2.2)
Total	940 (46.1)	668 (32.6)	1608 (78.9)	115 (5.6)	315 (15.5)	430 (21.1)	2038 100

* Sites: as per Table G-2
** Surveys: as per Table G-2
( ) = percentages.

TABLE G-7
THE NUMBER OF TAXA IN EACH OF THE MAJOR FAUNAL GROUPS COLLECTED BY ARTIFICIAL SUBSTRATE SAMPLER

Faunal Group*	No. of Taxa	% of Total
Annelida	2	4.2
Mollusca	2	4.2
Platyhelminthes	1	2.1
Arthropoda (other than insecta)	2	4.2
Insecta		
Diptera	5	10.4
Odonata	8	16.7
Ephemeroptera	4	8.3
Plecoptera	2	4.2
Megaloptera	2	4.2
Trichoptera	6	12.5
Coleoptera	8	16.7
Lepidoptera	1	2.1
Hemiptera	4	8.3
Hymenoptera	1	2.1
TOTAL	48	100.2

* Insecta are for Families: others are for Class.

Table G-8 shows the percentage of individuals in the various taxa collected at each site during the two surveys.

At three sites (MV_1, MV_2 and MV_4) Ephemeroptera dominated, while Diptera were the largest group at one site (MV_5); Annelida at one site (MV_3); and Coleoptera at one site (MV_6).

Of the total organisms collected, Ephemeroptera with 551 organisms was the largest group accounting for 27% of the total; followed by Diptera (396; 19%); Annelida (267; 13%); and Coleoptera (159; 8%) (Table G-8).

Of the 396 Diptera collected, 384 (97%) were midge larvae (Chironomidae) from site MV_5. Overall, the majority of Diptera (287; 72.5%) were collected from site MV_5 (220, spring; 63, summer). The majority of Plecoptera (72; 82%) also came from site MV_5 (Attachment G-1).

While Annelida dominated at site MV_3 with 23 organisms from a total of 61, the majority of Annelida came from site MV_5 (177; 70%). All except one Annelida belongs to the class Oligochaeta. Site MV_5 also had the largest numbers of Mollusca (both Gastropoda and Bivalvia), although sites MV_1 and MV_4 also had reasonable numbers (Attachment G-1).

TABLE G-8
PERCENTAGE OF INDIVIDUALS IN THE VARIOUS TAXA COLLECTED AT EACH SITE DURING THE TWO SURVEYS.

Taxa	% of Individuals						No.
	MV1	MV2	MV3	MV4	MV5	MV6	
Diptera	7.3	7.1	32.8	11.2	29.3	15.2	396
Odonata	9.2	1.8	0	2.2	4.4	2.2	105
Ephemeroptera	53.4	42.8	1.6	38.6	9.2	10.9	551
Plecoptera	1.0	0	0	3.1	7.6	0	91
Megaloptera	4.8	16	21.3	2.5	0.2	13	66
Trichoptera	8.2	16	0	24	8.1	4.3	214
Coleoptera	0.9	8.9	3.3	1.9	13.3	23.9	159
Other insects (Lepidoptera, Hemiptera, Hymenoptera)	0.7	3.6	3.3	1.9	0.3	19.5	26
Annelida	9.0	0	37.7	3.4	18.1	8.7	267
Mollusca	4.2	1.8	0	9.3	9.0	0	143
Non Insect Others (Platyhelminthes Arthropoda)	1.0	1.8	0	1.9	0.6	2.2	20
Number of Individuals	573	56	61	321	981	46	2038

5.0 DISCUSSION

5.1 OVERVIEW

Data presented in this report is from only a limited survey of the freshwater habitats within and adjacent to the proposed mining site. Only six sites on three creeks, with four of the sites on Cadiangullong Creek, have been sampled in only two seasons (spring and summer), within one year. Even with these limitations, the results show a diversity of freshwater macroinvertebrates present in the various creeks with considerable variation between creeks and along the length of the main water course (Cadiangullong Creek) which drains the site. There is also evidence that runoff from the old mine site is affecting the macroinvertebrate populations in the reaches of Cadiangullong Creek adjacent to the old mine, and for some distance downstream.

Of most interest is what differences were noted in the number and composition of organisms at the four survey sites along Cadiangullong Creek. Looking firstly at the total number of organisms from the two sites, there was a large drop from site MV_1 above the old mine, to sites MV_2 and MV_3 (adjacent to and slightly downstream from the old mine site respectively), with a considerable increase in numbers at site MV_4 (well downstream from the old mine site). The numbers at site MV_4 were still 252 organisms less than at site MV_1 (Table G-6). There were also considerable differences within sites in the numbers and composition of organisms collected during the spring and summer surveys. No uniform trend could be identified.

Site MV_1 also had the greatest number of taxa (based on similar levels of identification) of the four sites along Cadiangullong Creek with 44. This reduced to 19 and 10 at sites MV_2 and MV_3 respectively, and increased again to 30 at site MV_4 (Attachment G-1 and G-2).

Site MV_5 had 37 taxa represented, and by far the largest number of organisms (981), while site MV_6 had only 17 taxa represented and the smallest number of organisms (46) of any of the sites.

Possible reasons for these differences include such things as climatic differences (temperature, rainfall), the amount of water and flow characteristics at the different sites, riverine vegetation differences, a range of microclimatic differences, and differences in land use of the catchments. The most likely reason though, is differences in the water chemistry, particularly as a result of runoff from the old mine site adjacent to site MV_2 on Cadiangullong Creek. Linkage of the findings of this survey with on-going water quality monitoring is to be undertaken by Newcrest Mining for inclusion in the EIS.

5.2 BIOTIC INDICES

In an attempt to classify the water quality based purely on the diversity and number of organisms, a number of rough indicators can be used. It is generally accepted that better quality water is characterised by a greater diversity of taxa than is poorer quality water. On this basis, the ranking of water quality at the six sites (from "best" to "poorest") would be MV_5, MV_1, MV_4, MV_3, MV_2, MV_6 (Table G-8). This ranking is based on the results for both surveys.

Looking at the two surveys separately, the rankings would be MV_5, MV_4, MV_1, MV_6, MV_2, MV_3 for the spring survey, and MV_1, MV_5, MV_4, MV_3, MV_2, MV_6 for the summer survey. Whether the changes in ranking of the two surveys is due to the October, November and December (Table G-4) rains causing more runoff from the old mine site to affect the water quality at site MV_4, or runoff from the overgrazed catchment of MV_5 to effect this site or not, will have to wait until the water data analysis is available. The data does show though, the importance of doing a number of surveys during different seasons and over a number of years to obtain a more detailed picture.

Another way of indicating water quality is to look at the sensitivity of organisms to "pollution". A number of biotic indices have been developed overseas, but, unfortunately, no detailed indices has been developed in Australia, due mainly to our incomplete knowledge of aquatic organisms present in most regions and poor knowledge of the taxonomy of many organisms.

One biotic index widely used in Britain is the Biological Monitoring Working Party (BMWP) Score (Mason, 1991). It was developed to give a broad indication of the biological condition of rivers throughout the United Kingdom. Identification to taxa is to the family level only and no account is taken of abundance. Each family is given a score, between 1 and 10, depending on the perceived susceptibility to pollution. Those taxa least tolerant, such as families of mayflies and stoneflies, are given the highest scores, and those most tolerant (the class Oligochaeta) the lowest score. The BMWP score is the sum of the individual scores.

Although all the families listed in the BMWP Score are not present in Australia, a number are. As representatives of most of the BMWP Score categories are found in the Cadia collection, this system has been used as a preliminary indicator of the water quality at the six sites. Based on this incomplete BMWP score, the water quality at the six sites can be ranked in the following order (in order of decreasing quality): MV_5, MV_4, MV_1, MV_2, MV_6, MV_3 (Table G-9). The difference between sites MV_1 and MV_4, and MV_3 and MV_6 is only one, and is probably not significant.

TABLE G-9
INCOMPLETE BIOLOGICAL MONITORING WORKING PARTY (BMWP) SCORE FOR CADIA MACROINVERTEBRATES

Order* /Class**	Family	BMWP Scope					
		MV1	MV2	MV3	MV4	MV5	MV6
*Diptera	Chironomidae	2	2	2	2	2	2
*Odonata	Lestidae					8	
	Aeshnidae	8	8		8	8	
	Corduliidae	8			8	8	
	Gomphidae				8	8	
*Ephemeroptera	Leptophlebiidae	10	10	10	10	10	
	Baetidae				4	4	
	Caenidaae	7	7		7	7	7
*Megaloptera	Sialidae	4					4
*Trichoptera	Leptoderidae	10	10				
	Hydropsychidae	5			5	5	
*Coleoptera	Dytiscidae		5	5		5	5
*Hemiptera	Corixidae			5			
	Mesoveliidae						5
**Oligochaeta		1		1	1	1	1
**Hirudinae						4	
**Gastropoda	Planorbidae	3	3		3	3	
**Bivalvia	Sphaeriidae	3				3	
**Turbellaria		5			5		
*Amphipoda	Gammaridae				6		
Total		66	45	23	67	76	24

Another rough indicator that can be used is the Stream Pollution Index (SPI) produced by The Streamwatch Program for use in schools (Van Dort, et al, n.d.). The SPI splits organisms into four groups depending on how sensitive they are to pollution. The groups are : very sensitive, sensitive, tolerant, and very tolerant. The organisms are identified by a series of drawings and by common name. No account is taken of abundance and organisms within each group are allocated a number from 8 to 1 (8 - very sensitive; 1 - very tolerant). In determining the SPI for the Cadia collection, all taxa in a particular group was given a score for that group.

Based on the SPI, the water quality of the six sites can be ranked in the following order (in order of decreasing quality): MV_1, MV_5, MV_4, MV_2, MV_3, MV_6 (Table G-10).

In the SPI, the water quality is determined from the following scale:

Pollution Index	Stream Quality Rating
20 or less	Poor
21 - 35	Fair
36 - 50	Good
51 +	Excellent

Based on this analysis only the water quality of the six Cadia sites would be classified as excellent, however this would give a false impression of the true situation. The instructions state 'if you have two or more morphologically distinct (they look different) organisms from the same group, count them separately'. Rather than use the SPI to indicate water quality, it has been used in this study to rank the sites only.

A summary of the rankings based on the three biotic indices is shown in Table G-11.

Recognising the limitations of the various methods, it is interesting to note that sites MV_1, MV_4 and MV_5 were always ranked in the top three, and sites MV_2, MV_3 and MV_6 were always ranked in the bottom three. An analysis of this type, although incomplete, still seems to be a valuable exercise in gaining an indication of relative water quality at different sites.

As has been discussed previously, a range of factors can influence water quality and the abundance and diversity of aquatic populations in a region. In relation to this study, the next step is to make correlations between the water quality data, and the number of organisms and the diver-

sity at the six sites found in this macroinvertebrate survey. Until this is done, the influence of water quality, and particularly the influence of runoff from the old mine site has on the Cadia aquatic microinvertebrates can only be assumed.

TABLE G-10
STREAM POLLUTION INDEX (SPI)
FOR CADIA MACROINVERTEBRATES

Group	Total Pollution Rating **					
	MV1	MV2	MV3	MV4	MV5	MV6
Stonefly nymphs (8)*	16			24	24	
Mayfly nymphs (7)	42	28	7	42	42	7
Freshwater mussel (6)	6				6	
Dragonfly-Damselfly nymphs (6)	35	6		24	60	6
Caddisfly larvae (6)	78	18		48	36	6
Amphipod (5)				5		
Beetle larvae (4)	8	4	4	4	8	8
True bugs (4)	4	8	4	4	8	8
Beetles (3)		3	3	3	3	3
Flatworm (3)	3			3		
Snails (3)	9				3	
Leech (3)					3	
Fly larvae (2)		2	2	2	2	2
Midge larvae (2)	2	2	2		2	
Blood worm (1)	1	1	1	1	1	1
Earthworms (1)	1		1	1	1	1
Total	205	72	24	161	199	42

* Pollution rating for group

** For total taxa in each group.

TABLE G-11
RANKINGS* OF THE SIX CADIA SITES
BASED ON THREE BIOTIC INDICES

Biotic Index	Sites					
	MV1	MV2	MV3	MV4	MV5	MV6
Diversity of organisms						
Both surveys	2	5	4	3	1	6
Spring survey	3	5	6	2	1	4
Summer survey	1	5	4	3	2	6
BMWP	3	4	6	2	1	5
SPI	1	4	5	3	2	6

* 1 indicates best quality water, 6 poorest.

5.3 THREATENED OR RARE AND ENDANGERED SPECIES

There is presently no Schedule 12 lists of threatened or rare and endangered species of invertebrates for either New South Wales or the Commonwealth. The Endangered Species Unit of the Australian Nature Conservation Agency will soon be releasing the final draft of *Overview of the Conservation Status of Non-Marine Invertebrates in Australia* (Pook, 1995). After comments are received, it is expected that a working party will be set up to establish a Commonwealth Schedule 12 list of non-marine invertebrates in Australia. It would be expected that as a result of this process, that threatened or rare and endangered freshwater macroinvertebrates would be listed in any schedule.

Letters were sent to the head offices of both the New South Wales Departments of Water Resources, and Fisheries, requesting information about the availability of reports on surveys of freshwater macroinvertebrates in the Central West region of New South Wales. Both agencies responded that there were no reports. A literature survey was also undertaken and no published reports could be located. It has not been possible, therefore, to make a comparative analysis between the Cadia collection of freshwater macroinvertebrates and collections from other streams in the Central West Tablelands region.

6.0 RECOMMENDATIONS

(i) To determine the influence of water quality on the distribution and abundance of macroinvertebrates in the Cadia Hill site, that the results from the independent water quality and macroinvertebrates surveys be collated, to try and determine if identified chemical parameters may be influencing the distribution patterns identified in the macroinvertebrate survey.

It is only in this way that potential sources of pollutants from the old mine site (and from the proposed new mine) can be identified, and management strategies proposed to reduce potential pollution of the freshwater environment in the future.

(ii) The results of this survey show that the use of Artificial Substrate Samplers are an effective methodology for sampling macroinvertebrates in small creeks, as found in the proposed mine site area. Although the drying of creeks was not a problem during this survey, Copper Gully Creek is now dry (March 1995) at the survey site (MV_6). To overcome this potential problem in the future (due to the 6-7 weeks time lag for ASS's to be set), it is recommended that a comparative study be undertaken to compare localised dip netting and creek bed sampling, and artificial substrate sampling, to compare the effectiveness of the two methods.

(iii) There is evidence that there is variation between seasons in the abundance and distribution of taxa (subject to determining the influence of chemical variations that may also be influenced by seasons). It is therefore recommended that a more long-term study, over all seasons and a number of years, be undertaken so that effective management decisions can be based on more detailed data than this limited survey provides.

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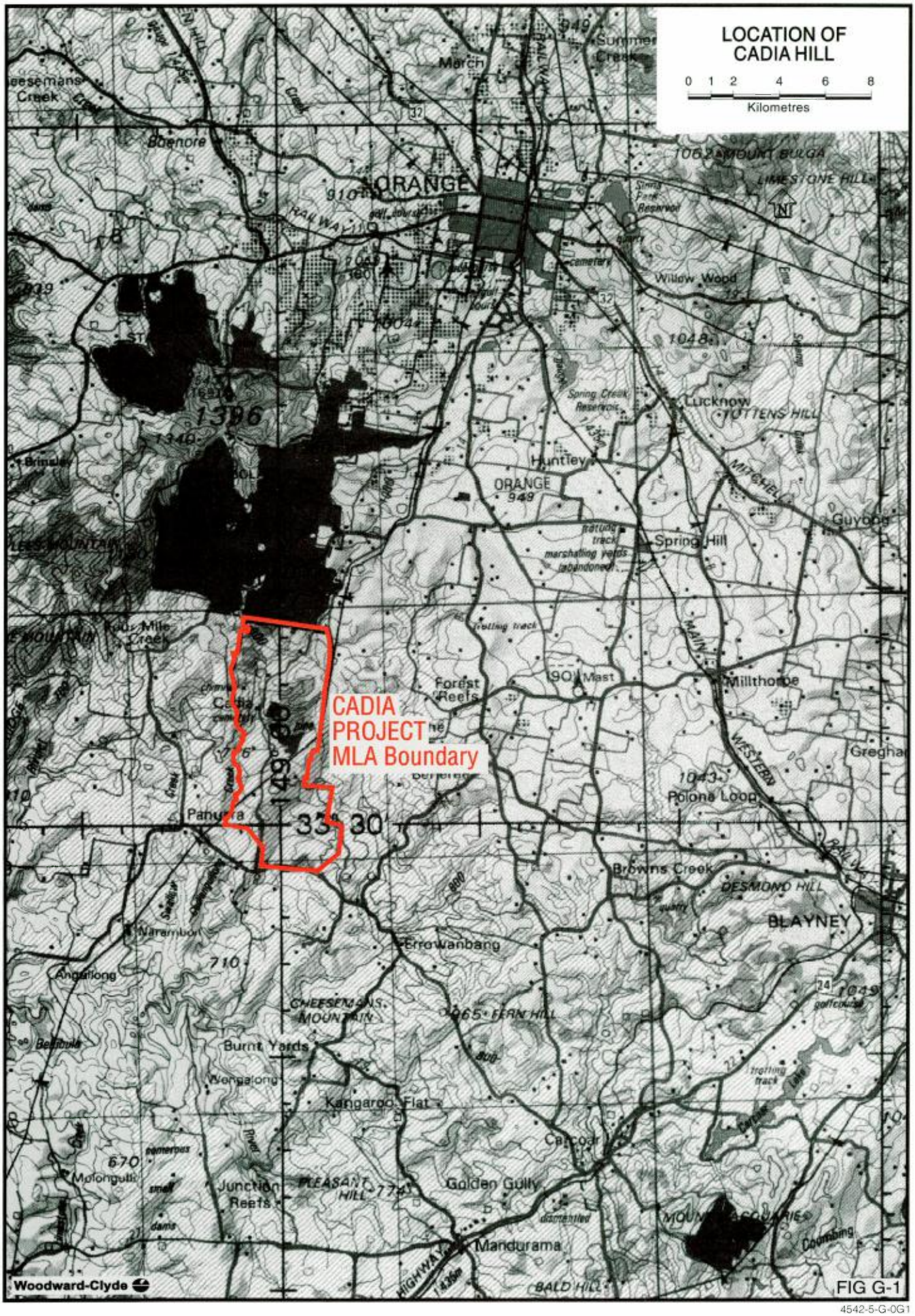
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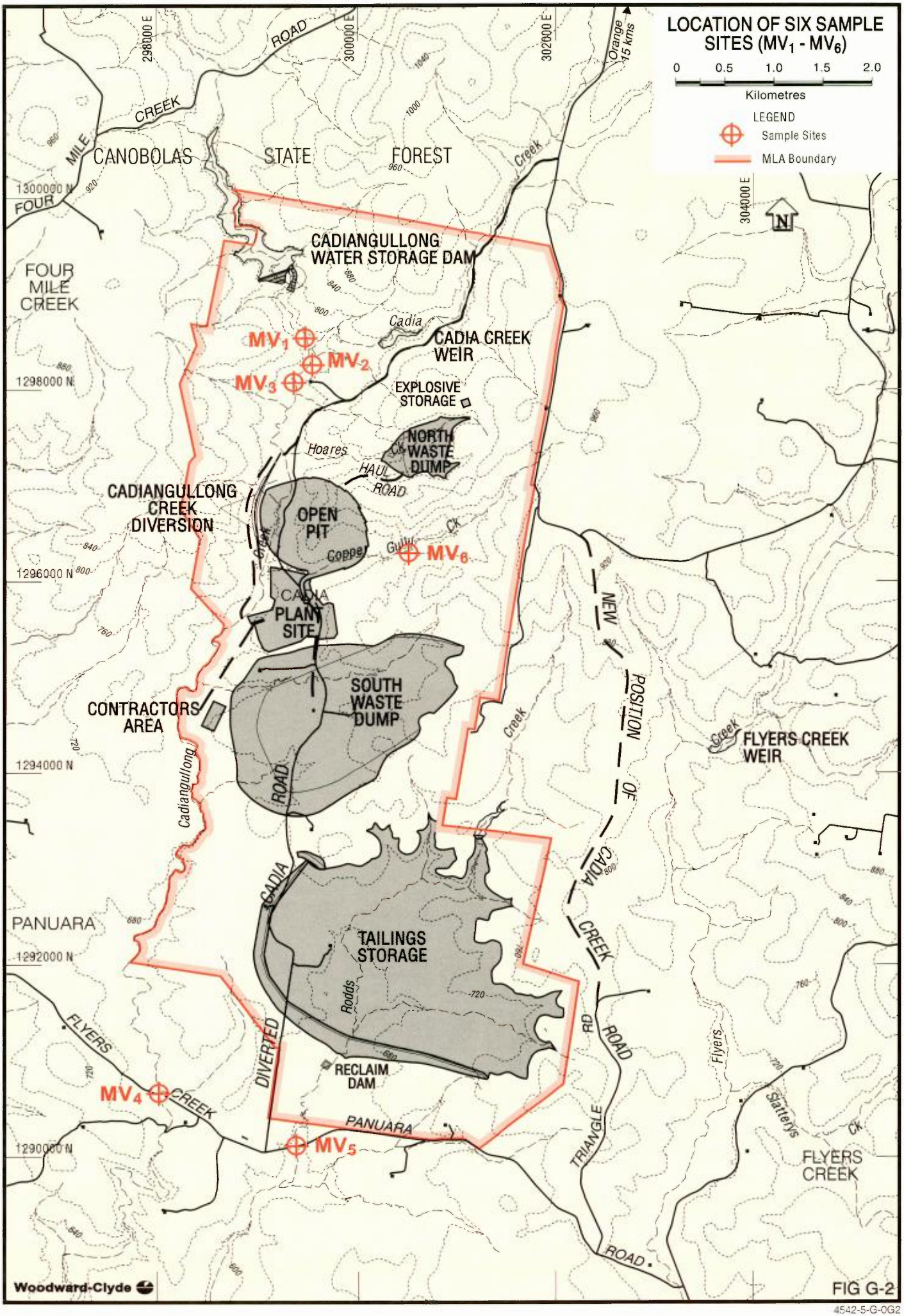
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LOCATION OF CADIA HILL
0 1 2 4 6 8
Kilometres
CADIA PROJECT MLA Boundary
ORANGE
Summer Creek
March
Beesemans Creek
Boenore
Willow Wood
MOUNT BULGA
LIMESTONE HILL
Lucknow
TOTTENS HILL
Huntley
Spring Hill
Guyong
Millthorpe
Forest Reefs
Mast
Four Mile Creek
Cadia
Panuara
Polona Loop
Browns Creek
DESMOND HILL
BLAYNEY
Errowanbang
Nanrambon
Angullong
CHEESEMANS MOUNTAIN
FERN HILL
Burnt Yards
Wongalong
Kangaroo Flat
Carcoar
Golden Gully
Junction Reefs
PLEASANT HILL
Mandurama
BALD HILL
Coombing
Woodward-Clyde
FIG G-1

4542-5-G-0G1


LOCATION OF SIX SAMPLE SITES (MV_1 - MV_6)
0 0.5 1.0 1.5 2.0
Kilometres
LEGEND
Sample Sites
MLA Boundary
CANOBOLAS STATE FOREST
FOUR MILE CREEK
CADIANGULLONG WATER STORAGE DAM
CADIA CREEK WEIR
EXPLOSIVE STORAGE
NORTH WASTE DUMP
HAUL ROAD
CADIANGULLONG CREEK DIVERSION
OPEN PIT
CADIA PLANT SITE
SOUTH WASTE DUMP
CONTRACTORS AREA
TAILINGS STORAGE
RECLAIM DAM
DIVERTED CADIA CREEK
NEW POSITION OF CADIA CREEK RD
FLYERS CREEK WEIR
FLYERS CREEK
PANUARA
ROAD
Orange 15 kms
298000 E
300000 E
302000 E
304000 E
1300000 N
1298000 N
1296000 N
1294000 N
1292000 N
1290000 N
MV_1
MV_2
MV_3
MV_4
MV_5
MV_6
N
Woodward-Clyde
FIG G-2

4542-5-G-0G2

ATTACHMENT G-1

CADIA HILL MACROINVERTEBRATE SURVEY - INSECTS

ATTACHMENT G-1
CADIA HILL MACROINVERTEBRATE SURVEY - INSECTS[1]

Order	Family	Genus	Species	MV1*		MV2*		MV3*		MV4*		MV5*		MV6*	
				1	2	1	2	1	2	1	2	1	2	1	2
Diptera	Chironomidae (L)	S.F. Tanypodinae		11	30		1		18	22	13	220	63	6	
	Sciaridae (A)	Scaria++		1											
	Tipulidae (L)					1			1		1	1	2	1	
	Ceratopogonidae (L)	Culicoides					2						1		
	Dolichopodidae								1						
Odonata	Megapodagrinidae	Argiolestes	icteromelas	2	9							19			
S.O. Zygoptera															
	Amphiterygidae	Diphlebia	lestoides	1	27							3	3		
	Lestidae	Austrolestes										1			
	Protoneuridae	Nosostic	solida									1			
	Synlest	Synlestes	tillyardi		3						1				
S.O. Anisoptera	Aeshnidae	Austroaeschna	selys	2						3		5			
	Aeshnidae	Austroaeschna	unicornis unicornis		7		1						4		
	Aeshnidae	Telephlebia	brevicauda		1										
	Corduliidae	Procordulia	jacksoniensis							1					
	Corduliidae	Hemicordulia	tau										2		
	Corduliidae	Austrocordulia	refracta							1					
	Corduliidae	Eusynthemis	brevistyla		1										
	Gomphidae	Austrogomphus	ochraceus									3		1	
	Gomphidae	Austrogomphus	sp. "C"								1		1		
	Gomphidae	Hemigomphus										1			
Ephemeroptera	Leptophlebiidae	Atalophlebia		48	89		18			26	12	4	2		
	Leptophlebiidae	Atalonella		1	23	1	1			8	6	2			
	Leptophlebiidae	Jappa		2	70				1				1		
	Leptophlebiidae	Atalophleboides		29	40		3			6	3				
	Baetidae	Centroptilum								10	9		1		
	Baetidae	Baetis								11	9				
	Baetidae	Cloeon											1		
	Caenidae	Tasmanocoenis			1		1			1	23	76	4	3	2
	Aeshnida	Austroaeshna	selys		3										
Plecoptera	Gripopterygidae	Leptoperla	bifida	5						3					
	Gripopterygidae	Leptoperla	kimminsi	1											
	Gripopterygidae	Leptoperla	neboissi							6		10			
	Notonemouridae	Notonemoura	lynchi							1		32			
	Notonemouridae	Notonemoura	notonemour									33			
Megaloptera	Corydalidae	Archichauliodes			22	5	4	6	7	4	4	2		3	2
	Sialidae	Austrosialis	australiensis		6									1	

ATTACHMENT G-1 (CONTINUED)
CADIA HILL MACROINVERTEBRATE SURVEY - INSECTS[1]

Order	Family	Genus	Species	MV1*		MV2*		MV3*		MV4*		MV5*		MV6*	
				1	2	1	2	1	2	1	2	1	2	1	2
Trichoptera	Leptoceridae	Triplectidina		13	1	1	6			1	1				
	Leptoceridae	Lectrides			5										
	Leptoceridae	Triplectides	volda	1											
	Leptoceridae	Triplectides	similis		3										
	Leptoceridae	Triplectides	australis		2										
	Leptoceridae	Triplectides	proximus			1									
	Leptoderidae	Triplectides	ciuskus		3										
	Hydropsychidae	Smicrophylax	species 4	1											
	Hydropsychidae	Cheumatopsych	species 2							5	2	3			
	Ecnomidae	Ecnomus	cygnitus		1							3			
	Ecnomidae	Ecnomus	russellius	1	2					6	4	67	2	2	
	Ecnomidae	Ecnomus	continentalis		2					2		2			
	Ecnomidae	Ecnomus	deani		2										
	Ecnomidae	Ecnomina	"E" group							2					
	Hydrobiosidae	Megogata	necopina	5	4	1				15	9	1			
	Hydrobiosidae	Apsilochorema	gisbum							18	10				
	Hydrobiosidae	Koetonga	clivicola							2		1			
	Philorheithridae			1											
Coleoptera	Scirtidae (L)			1						1		122		2	
	Dytiscidae (A)					2									
	Dytiscidae (L)					1	1		1			1	5		5
	Hydraenidae (A)							1							
	Carabidae (A)									1	3				3
	Limnichidae (A)				1		1				1				
	Hydrochidae (L)	Hydrochus			3										
	Staphylinidae (A)												2		
	Hydrophilidae														1
Lepidoptera	Pyralidae (L)				2					1				1	
Hemiptera	Veliidae	Microvelia			1		1			4	1		1		1
	Notonectidae	Anisops					1						2		
	Corixidae	Sigara							1						
	Mesoveliidae	Mesovelia													1
Hymenoptera	Formicidae				1				1						6
Total				126	365	13	41	7	31	161	113	613	97	20	21

1 1. Traps set in August, collected in September, 1994.
2. Traps set in November, collected in December, 1994.

*SITES MV1 - Upstream of old mine site on Cadiangullong Creek
MV2 - Adjacent to old mine site on Cadiangullong Creek
MV3 - Downstream of old mine site on Cadiangullong Creek
MV4 - Cadiangullong Creek and Panura Road Crossing
MV5 - Rodds Creek and Panura Road Crossing
MV6 - Copper Gully Creek

Totals are the number from five macroinvertebrate traps.
++ Usually not associated with water.
L : larva A : adult

ATTACHMENT G-2

CADIA HILL MACROINVERTEBRATE SURVEY - ORGANISMS OTHER THAN INSECTS

ATTACHMENT G-2
CADIA HILL MACROINVERTEBRATE SURVEY - ORGANISMS OTHER THAN INSECTS[1]

Order	Class	Family	Genus	MV1*		MV2*		MV3*		MV4*		MV5*		MV6*	
				1	2	1	2	1	2	1	2	1	2	1	2
Annelida	Oligochaeta			13	39				23	7	4	27	149	4	
Annelida	Hirudinae											1			
Mollusca	Gastropoda	shell destroyed			2						2				
Mollusca	Gastropoda	Planorbidae	Physastra	4	16	1				18	10	23	15		
Mollusca	Gastropoda	Planorbidae	Isidorella		1								1		
Mollusca	Bivalvia	Sphaeriidae	Sphaerium		1							9	40		
Platyhelminthes	Turbellaria	O. Tricladia		2	4					2					
Arthropoda	Arachnida	O. Araneae													
		SO. Aranaeomorpha					1			2			3		1
Arthropoda	Crustacea														
	O. Amphipoda	Gammaridae								1					
	O. Ostracoda	Limnocytheridae										1	1		
	O. Ostracoda	Cytherideidae									1		1		
Total				19	63	1	1	0	23	30	17	61	210	4	1

1 1. Traps set in August, collected in September, 1994.
2. Traps set in November, collected in December, 1994.

*SITES MV1 - Upstream of old mine site on Cadiangullong Creek
MV2 - Adjacent to old mine site on Cadiangullong Creek
MV3 - Downstream of old mine site on Cadiangullong Creek
MV4 - Cadiangullong Creek and Panura Road Crossing
MV5 - Rodds Creek and Panura Road Crossing
MV6 - Copper Gully Creek

Totals are the number from five macroinvertebrate traps.

APPENDIX H

Assessment of Impacts of the Cadia Water Supply Scheme on Riparian and Instream Integrity

AN ASSESSMENT OF THE IMPACTS OF WATER HARVESTING ON RIPARIAN AND INSTREAM INTEGRITY IN THE SUMMER HILL, CADIANGULLONG, CADIA AND FLYERS CREEKS, (INCLUDING THE EFFECTS ON THE SUMMER HILL PLATYPUS POPULATION) ASSOCIATED WITH THE CADIA MINING PROPOSAL.

10 June 1995

David Goldney BSc DipEd PhD

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1.0 INTRODUCTION

Newcrest Mining WA Ltd is planning the development of a major mining program adjacent to Cadia Hill approximately 20 km SW of Orange. A critical resource for the success of the mining program over a 12 year period, is the provision of a secure supply of water. Such a supply has been identified, based on the harvesting of flood waters from Cadiangullong, Cadia and Flyers Creeks supplemented by treated sewage effluent from Orange, borewater and recycled water from the tailings dam (Figures H-1 and H-2). Approximately 38.8 ML/day will be needed to operate the processing plant. It is the object of this paper to assess the impacts of this proposal on riparian and instream integrity in the impacted streams, particularly in regard to minimum downstream water flows.

The major water storage dam (3,400 ML) will be built on Cadiangullong Creek upstream of the proposed mining site. This dam will harvest water from the Cadiangullong Creek. Two small pipehead dams, one on Cadia and one on Flyers Creek will harvest water under high flow conditions. This water will be pumped to the Cadiangullong Dam (See Figure H-2) and would be used to supplement storage in the Cadiangullong Dam during periods of high flow (i.e. when storage levels in Cadiangullong Dam were drawn down and when flood flows were being experienced at the smaller dam sites). Based on modelling conducted by Woodward-Clyde, this would occur on some 20-30 days per year on average. An additional 10.0 ML/day of treated sewage effluent will be pumped directly from the Orange Treatment Works to the processing plant. 15.4 ML/day will be recycled water from the Tailings Dam and an additional 2.0 ML/day will be available on a needs basis from a bore supply.

The Cadiangullong Dam would be constructed with a low level outlet conduit for the maintenance of riparian and environmental releases. This system would be operated such that natural catchment inflows up to the environmental requirements would be released. During periods when natural inflows were above these requirements, outlet flows would be at least equal to these values. This would ensure maintenance of existing riparian flows. The variable and multiple pumps on the pipehead weirs would be operated so as to maintain the low flow regime and to prevent large reductions in larger creek flows.

2.0 MACQUARIE CATCHMENT

2.1 BLACKMANS SWAMP-SUMMER HILL CREEK

2.1.1 Hydrology

The N-E section of Orange city is drained by Blackmans Swamp Creek (BSC), which forms a minor catchment of the Summer Hill Creek (SHC) system. SHC is located within the Macquarie Catchment. The city's Sewage Treatment Plant (STP) is located on this creek approximately 1 km from the edge of the built environment. Blackmans Swamp Creek flows into the Summer Hill Creek approximately 1.5 km downstream of the STP. SHC continues to flow to the N-E and is fed by a number of minor creeks such as the Mullion Creek and eventually is joined by two larger creeks, the Emu Swamp and Lewis Ponds Creeks, around 20-25 creekline km below the STP.

The Summer Hill Creek Catchment has been significantly changed since European settlement. The upper catchment contains Suma Park Dam on the SHC. Downstream from the STP to the Mullion Range State Forest, the creek flows through undulating country with a mixture of larger rural holdings and those subdivided into smaller 'hobby farms'. In this section of the creek, the native riparian tree strip has been replaced in the main with introduced willow (*Salix* sp). The willow has tended to stabilise the system in the absence of native trees. Downstream from the Mullion Creek confluence, SHC flows through Crown Land and larger grazing properties through to the confluence with the Lewis Ponds Creek. This section of the creek is less disturbed, although in places weed invasion is significant, but the riparian vegetation is more-or-less intact (Goldney and Fisher, 1995).

The SHC catchment, downstream of the confluence with BSC, is about 220 km^2 in area. Little hydrological data is available for these catchments (SHC+BSC). The hydrology of BSC has been significantly modified by two developments;

- effluent outfall from the Orange STP; and
- by the effects of urbanisation of Orange which has resulted in increased and more rapid run-offs from the paved/developed areas and the effects of the Orange stormwater drainage system.

Figure H-3 illustrates effluent discharge over a 10 hour period measured on the 12th of April, 1995, illustrating flow rates varying between 4-18 ML/day. The flood wave effect can be clearly seen, and is generated by the variable flow coming into the treatment plant. On the same day flow rates at 5 points along the creek system were gauged (Water Resources, Dubbo). These data (measured under drought conditions) indicate that water was not only flowing into BSC above the STP but that additional sources other than from the STP (as would be expected) were coming progressively into the system as one moved downstream. The flow in the BSC above the STP at (0829-0910) was 2.14 ML/day, in the SHC upstream of the confluence with BSC but below Suma Park Reservoir 0.603 ML/day (1120-1150), 12.9 ML/day at the Third Crossing on the Ophir Road (1220-1320) and near Ophir Road Crossing 18.4 ML/day (1420-1500). Differences between the last two readings have been assessed as representing a real

increase in average base flows (L. Gilbert pers. com. April 1995). Figures H-4, H-5 and H-6 are hydrograph simulations for BSC, derived using the RORB uncalibrated model, illustrating the predicted flows against time over a 50 hour period, under low, medium and high rainfall regimes (24 hours), with and without an additional 10.0 ML/day effluent outfall. Background flows are 'swamped' by the effluent outflow under no/low rainfall scenarios (Figure H-4), but under higher rainfall scenarios (Figures H-5 and H-6), the effects of added effluent outflow becomes inconsequential.

Figure H-7 simulates the flow duration curve in the SHC below the confluence with BSC, with and without effluent flow. For 80% of the time it is predicted that baseline flows would be approximately 13.6 ML/day or greater and for 95 % of the time, 11.3 ML/day or greater.

2.1.2 Riverine Ecology

No baseline data exists for this creek system. Its ecology has been highly modified by the presence of the inflow of sewage effluent into the BSC. BSC prior to the establishment of the STP would have probably been an ephemeral stream subject to the typical 'boom and bust' changes accompanying the extremes of drought and flood. The outflow from the STP, not only has created a continuous supply of water in excess of 10.0 ML/day but also a cyclic rise and fall of water levels every 24 hours reflecting peaks in city usage and creating minor flooding along parts of the drainage system. This flow of water creates a continuum of riffle-pool units along the length of the SHC. Mild eutrophication combined with the flows that maintain the riffle-pool continuum, the presence of tree-lined banks more-or-less along the length of the SHC, shallow pools less than 1 m deep, are the conditions likely to optimise platypus numbers in the system, one of two top food chain vertebrate carnivores in the system (Goldney and Fisher, 1995). Optimisation of platypus numbers is mitigated through the provision of suitable habitat and the stimulatory effect on benthic organisms on which platypus feed, induced by mild eutrophic conditions (Bryant, 1993). Prior to the establishment of the STP, platypus numbers would have probably increased under conditions when the pool-riffle continuum was maintained and decreased in drought induced low-flow conditions.

3.0 LACHLAN CATCHMENT

3.1 CADIANGULLONG AND FLYERS CREEK CATCHMENTS

3.1.1 Hydrology

The Cadiangullong and Flyers Creeks drain part of the upper catchment of the Lachlan system. These creek systems are located in parallel subcatchments SSW of Orange City. Both are tributaries of the Belubula River (Figure H-1). Cadia and Rodds Creek are tributaries of the Cadiangullong system. These catchments have been significantly modified since European settlement. Both flow through undulating topography. The land use is mixed farming, predominantly sheep or cattle grazing, with some cropping. NSW Forests operate significant areas of *Pinus radiata* plantations in the upper catchment. Clearing has occurred throughout the catchment, together with probable changes in soil compaction, resulting in run-off dynamics having changed significantly. Parts of the riparian vegetation remain intact, but in other sections once dominant native trees have been replaced by Willows (*Salix* spp).

The catchment area above the confluence of the Cadiangullong and Cadia Creeks is approximately 40 km^2, at the Copper Gully Creek confluence 58 km^2, at Panuara Road 77 km^2 and the Rodds Creek confluence 80 km^2 (Figure H-8). This represents an approximate doubling of the catchment area over a river length of 12.5 km. As part of the Project water supply investigations, Woodward-Clyde have undertaken catchment modelling and water supply scheme simulation modelling to assess the likely yield and performance of the water supply scheme. Results of the modelling have been used to construct flow duration curves of Cadiangullong Creek which represent the substantial distribution of flows in the creek as they exist now and as they would be following construction and operation of the water supply scheme. Figures H-9 and H-10 are combined plots of flow duration both before and during mining. It is evident from the figure the effects on Cadiangullong Creek are greatest for moderate flows in the creek. For 80% of the time flows in Cadiangullong Creek would be approximately 1.9 ML/day or greater under both pre and during mine conditions.

Figures H-11 and H-12 illustrate water flows in Flyers Creek above and below the weir prior to, and during mining. The figures indicate that for 80% of the time, flows pre and during mining would be similar and of the order of 1.25 ML/day or greater.

3.1.2 Riverine Ecology

No base-line data exists for this catchment. The Cadiangullong Creek is a near perennial stream, and under the severe drought conditions of April 1995, it was still flowing. Below the proposed development, the riparian zone in the Cadiangullong is in reasonable condition. Further down stream, willows begin to replace native trees in the riparian zone. The streambed and banks however, are moderately degraded due to stock trampling. Cadia, Rodds and Copper Gully Creeks are tributaries of Cadiangullong.

Flyers Creek in the parallel eastern catchment, is also under normal circumstances a perennial stream and was maintaining good flow levels during the recent drought conditions. The riparian zone is heavily impacted by willow

growth and cattle grazing. Some sediment load is obvious near the proposed dam site, but in the upper headwaters, the system is more stable. The stream bed conservation rating was classified as moderately degraded by Bauer (1995).

As part of the studies carried out for the EIS, Gibbs (1995) has examined the distribution and abundance of macroinvertebrates in the Cadiangullong, Cadia, Flyers, Copper Gully and Rodds Creeks, and Bauer (1995) examined the fish fauna in the Cadiangullong and Flyers Creeks as well as stream habitat conditions. Gibbs demonstrated a diversity of freshwater macroinvertebrates were present in the various creeks with considerable variations between creeks and along the length of the main water course (Cadiangullong) which drains the site. Gibbs found evidence that runoff from the old mine site is affecting the macroinvertebrate populations in the reaches of the Cadiangullong Creek adjacent to the old mine site, and for some distance downstream. The macroinvertebrate biodiversity above the old mine site and at Panuara Crossing were much greater than the near mine sites. Using an established pollution index, he was able to rate the stream quality as poor, fair, good or excellent. Cadiangullong above the old mine site and at Panuara Crossing was judged by the three methods employed by Gibbs as fair to excellent, as was Rodds Creek. In contrast, Cadiangullong near the old mine sites rated poorly as did Copper Gully Creek.

4.0 RESEARCH INTO ENVIRONMENTAL FLOWS

Little research has been carried out in Australia to determine the riparian and environmental flows needed to maintain riverine ecosystem integrity. Rather northern hemisphere research has been modified to meet Australian conditions. Richardson (1988), reviewed the four most commonly used methods to assess the minimal survival and maintenance flows for rivers and streams (The Montana Method [Tenant, 1976], Flow Duration Curve Analysis [Stainaker and Arnette, 1976], Transect Analysis [Reviewed by Stainaker and Arnette, 1976] and the Incremental Method [Boree and Milhous, 1978]). They all rely on historical flow data for their assessment. The latter two also require the input of biological data. Only the Montana Method and the Flow Duration Curve Analysis techniques were used in this assessment.

4.1 THE MONTANA METHOD

The Montana Method (Tennant 1976) uses the mean annual flow (MAF) of a river or stream as the basis for determining stream health. No biological data is required. Since this method was developed primarily for USA conditions, minimal survival flows are based on a flow regime where the mean annual flow is nearer the median flow than occurs in Australian streams and rivers. In our river systems the median flows are more likely to be less than the mean which is often skewed. In Australia also, flash floods are superimposed on a generally low flow condition. The high variability of flows experienced in our rivers is significant compared to the US where slow release of snow melt over the summer months produces a steadily increasing discharge. Not withstanding these differences, Rooney (1988) suggested in his study in the Duckmaloi River, near Oberon, that it provides a 'preliminary reconnaissance' method for predicting acceptable flow levels. Richardson, an Australian Fisheries biologist (1986) argued that the Montana Method appears to conservatively predict minimal survival and acceptable flows, at least for fish in her Tweed Heads study.

The MAFs used in the calculations provided below are best estimates based on gauging data collected on site, long term rainfall records and the use of recognised modeling systems (L. Gilbert, Woodward-Clyde, Pers com, 1995). Table H-1 below, compares the MAFs of the Summer Hill, Cadiangullong and Flyers Creeks and the Duckmaloi River in respect to the (10, 20, 50, 80 and 100)% levels. Included also are the frequency that these flows could be expected and the catchment area for which MAF was calculated (in brackets).

TABLE H-1 (A)
COMPARISON OF MEAN ANNUAL FLOWS IN FOUR CENTRAL WESTERN CREEKS/RIVERS

Creek	Catchment Area (km^2)	Mean Annual Flow (ML/day)				
		10%	20%	50%	80%	100%
Duckmaloi (1)	110	5.9	11.8	29.5	47.2	59
Cadiangullong (2)	40	3.3	6.6	16.5	27.4	33
Cadiangullong (3)	77	4.0	8.0	20.0	32.0	40
Flyers (4)	57	3.5	7.0	17.5	28.0	35
Summer Hill (5)	220	6.4	12.8	32	51.2	64

TABLE H-1 (B)
A COMPARISON OF FLOW EXCEEDANCE PROBABILITY AT VARIOUS PERCENTAGES OF MEAN ANNUAL FLOW IN FOUR CENTRAL WESTERN CREEKS/RIVERS

Creek	Mean Annual Flow				
	10%	20%	50%	80%	100%
Duckmaloi (1)	82%	76%	53%	42%	34%
Cadiangullong (2)	69.5%	53%	41%	31%	28%
Flyers (4)	57%	48%	37%	30%	27%
Summer Hill (5)	100%	83%	35%		

1 = at pipehead weir; 2 = confluence with Cadia; 3 = at Panuara Road; 4 = at pipehead weir; 5= at confluence with Blackmans Swamp Creek.

A comparison of catchment area against MAFs using these data does not conform to a strictly linear relationship. Nevertheless the MAFs are of a similar order. In the case of Cadiangullong where two MAFs have been calculated at two different points in the catchment, local geological features and non-surface flow dynamics, largely explain the small increase in MAF with a near doubling of the catchment area.

These data illustrate a number of important points:

a. flow variability exists between streams;

b. ten percent of MAF varies from (3.5-6.4) ML/day;

c. there are significant differences between the reliability of flows at various percentages of MAFs in the range of catchments compared, although the frequencies at ten percent of MAF are similar.

The lowest 10% of MAF figure in the four catchments (3.5 ML/day at the Flyers Creek pipehead dam), when compared with the Duckmaloi catchment MAF (5.9), illustrate that significant differences can exist between streams. Similar differences in expected flow frequencies, (57% and 82%) respectively are also noted. Given that the frequency of low flows represented by 10% of MAF in Flyers Creek, is not predicted to change as a result of the weir operation, some caution needs to be exercised in determining what are appropriate environmental flows in upstream inland river systems.

4.2 FLOW DURATION CURVES

This method was developed by Stainaker and Arnette (1976). Monthly flow duration curves are used to recommend the 80th percentile flow for minimum habitat maintenance and the 40th percentile flow for suitable spawning conditions to occur. No biological data is required. The 80/20 rule is used as a guide by the Department of Water Resources to help maintain and protect the lowest 20% of flows in particular systems for environmental reasons. Where significant deviations from this rule are expected, justifications need to be made (Pers com DWR, 1995).

5.0 THE MONTANA ANALYSIS

5.1 BLACKMANS SWAMP CREEK-SUMMER HILL CREEK

The mean annual flow (MAF) immediately downstream of the confluence of the SHC and BSC is 64.0 ML/day, which excludes water harvested for Orange City Council water supply (6,500 ML/year) as well as effluent outflow from the STP. Applying the Montana Method, and using the quality of flow criteria developed by Tennant (1976), the following flows have been calculated for the SHC system against these flow criteria.

TABLE H-2
INSTREAM FLOW REQUIREMENTS FOR SUMMER HILL CREEK BASED ON MAF

Flows to Produce	MAF Flows Required % of MAF	ML/day at Confluence of SHC and BSC
Optimum	60 - 100	38.4 - 64.0
Outstanding	50 - 60	32.0 - 38.4
Excellent	40 - 50	25.6 - 32.0
Good	30 - 40	19.2 - 25.6
Fair	10 - 30	6.4 - 19.2
Poor or minimum	10	6.4
Severe Degradation	<10	<6.4

5.2 THE CADIANGULLONG-FLYERS CREEKS SYSTEM

The mean annual flow (MAF) for Flyers Creek at the proposed weir site is 12,770 ML or 35.0 ML/day. Applying the Montana Method, and using the quality of flow criteria developed by Tennant (1976), the following flows have been calculated for Flyers Creek against these flow criteria.

TABLE H-3
INSTREAM FLOW REQUIREMENTS FOR FLYERS CREEK BASED ON MAF

Flows to Produce	MAF Flows Required % of MAF	ML/day Downstream of Pipehead Weir
Optimum	60 - 100	21.0 - 35.0
Outstanding	50 - 60	17.5 - 21.0
Excellent	40 - 50	14.0 - 17.5
Good	30 - 40	10.5 - 14.0
Fair	10 - 30	3.5 - 10.5
Poor or minimum	10	3.5
Severe Degradation	<10	<3.5

The mean annual flow (MAF) for Cadia-Cadiangullong at their confluence is 12,000 ML/year or 33.0 ML/day. Applying the Montana Method, and using the quality of flow criteria developed by Tennant (1976), the following flows outlined in Table H-4 have been calculated against these flow criteria.

The mean annual flow (MAF) for the Cadiangullong at Panuara Road is 14,300 ML/year or 39.2 ML/day. Applying the Montana Method, and using the quality of flow criteria developed by Tennant (1976), the flows outlined in Table H-5 have been calculated against these flow criteria.

TABLE H-4
INSTREAM FLOW REQUIREMENTS FOR CONFLUENCE OF CADIA-CADIANGULLONG CREEKS BASED ON MAF

Flows to Produce	MAF Flows Required % of MAF	ML/day at Cadia and Cadiangullong Creek
Optimum	60 - 100	19.8 - 33.0
Outstanding	50 - 60	16.5 - 19.8
Excellent	40 - 50	13.2 - 16.5
Good	30 - 40	9.9 - 13.2
Fair	10 - 30	3.3 - 9.9
Poor or minimum	10	3.3
Severe Degradation	<10	<3.3

TABLE H-5
INSTREAM FLOW REQUIREMENTS FOR CADIANGULLONG CREEK AT PANUARA ROAD BASED ON MAF

Flows to Produce	MAF Flows Required % of MAF	ML/day at Confluence of SHC and BSC
Optimum	60 - 100	23.5 - 39.2
Outstanding	50 - 60	19.6 - 23.5
Excellent	40 - 50	15.7 - 19.6
Good	30 - 40	11.8 - 15.7
Fair	10 - 30	3.9 - 11.8
Poor or minimum	10	3.9
Severe Degradation	<10	<3.9

The above calculations, based on existing or estimated background flows, suggest that a minimum survival flow for maintaining 'fair' aquatic life would be >10% of MAF or about;

>6.4 ML/day	at the confluence of the Summer Hill-Blackmans Swamp Creeks;
>3.5 ML/day	at the Flyers Creek Weir site;
>3.3 ML/day	at the confluence of Cadiangullong and Cadia Creeks; and
>3.9 ML/day	in the Cadiangullong Creek at Panuara Road.

Rooney (1988) and Goldney (1988) demonstrated in the Duckmaloi River in an empirical experiment where they were able to divert water using an existing pipeline, that at a flow rate of 5.0 ML/day in a comparable stream system, an acceptable environmental quality was able to be maintained. Their measurements included dissolved oxygen, edge wetness and drying in pools and riffles and richness and health of aquatic life. The mean annual flow of the Duckmaloi River at the Pipehead Weir is 21,000 ML/year or 59.0 ML/day (Environmental Management, 1988). The physiography of the various systems described here has much in common, particularly the stream-bed cross sections. The catchment area upstream of the Duckmaloi Weir is 110 km^2; above Blackmans Swamp Creek, 220 km^2; above the confluence of the Cadiangullong and Cadia Creeks, 40 km^2; and above Panuara Road, 77 km^2. Differences in these catchment areas and/or the relative position along the stream transect, partly explain the different 'fair' Montana ratings arrived at above. One can expect that decreasing catchment area will correlate closely with reducing MAF.

5.3 BLACKMANS SWAMP AND SUMMER HILL CREEKS

Flow duration curves modelled for the SHC system downstream of the confluence with BSC and SHC predict that flows of 3.6 ML/day after harvesting water from the STP can be expected for 80% of the time (Figure H-7). Given that four additional inflow sources will still come into the system, viz:

- outfall from the STP above the required 10.0 ML/day (about 2.0 ML/day);
- inflow into the BSC from parks and garden run-off (up to 2.14 ML/day under drought conditions);
- riparian release from the Suma Park Dam (0.5-1.0 ML/day);
- inflows from the catchment downstream of the confluence; and
- spills from Suma Park Dam.

Then the probability of achieving a 'fair' Montana rating in the Summer Hill Creek system (flow rate >6.4 ML/day), will be greater than 90%. Non ideal conditions as judged by the Montana method, that is flows below 6.4 ML/day would be realized very infrequently.

5.4 FLYERS CREEK

The 'fair' Montana rating is for flows equal to or greater than 3.5 ML/day. Flow duration curve predictions (Figure H-11) are for flows as great or greater than this in the modified stream situation for approximately 60% of the time. Given that Richardson (1986) argues that the Montana system provides a conservative rating on instream requirements, and given that there is little difference between the pre and during mine flow scenarios, the 'natural' flow order is not changed significantly. Additional sources would appear to be available from this system as one moves further down the catchment. Under drought conditions in April 1995, the flow of water at the Flyers Creek-Panuara Crossing was estimated to be of the order of 2+ ML/day.

5.5 CADIANGULLONG-CADIA CREEKS

The 'fair' Montana rating at the confluence of these two creeks was calculated to be 3.3+ ML/day. The flow duration curves under pre and during mine scenarios are significantly different (Figure H-9). However, flows of this order will be experienced for approximately 70% of the time under both pre-mining and mining conditions. In the latter case, this will be achieved by an environmental-riparian flow safeguard trigger. The 'fair' Montana flow at the Panuara crossing is 3.9 ML/day. At this point in the creek system, the catchment area has increased by approximately 50% and the estimated MAF (pre-mining) has increased by 5 ML/day.

6.0 FLOW-DURATION CURVE ANALYSIS.

Table H-6 compares predicted flows in ML/day at the 50, 80 and 95 percentiles. The pre-mine 80 percentile flow (2.1 ML/day) in the Cadiangullong Creek, immediately downstream of the proposed weir, is less than the 'fair' derivation calculated using the Montana method (>3.4 ML/day), whereas in the Flyers Creek, the predicted flow at the 80 percentile (1.25 ML/day) is a little over half of the 'fair' Montana calculation (>2.3 ML/day). In the Summer Hill Creek, the 80 percentile flow (13.6 ML/day) is within the Montana derived 'fair' flows (6.4 - 19.2 ML/day). Between stream flow differences are due to such factors as rainfall and position in the catchment where MAF and flow duration models are determined.

The during mine scenario is quite different. The 80 percentile flow in the Summer Hill Creek is around 3.6 ML/day, much lower than the 'fair' derivation arrived at using the Montana technique (>6.4 ML/day). This drop in flow is due entirely to the harvesting of sewage outflow. In contrast the 80 percentile flows in both Flyers and Cadiangullong Creeks remain unchanged compared to the pre-mine situation. In the case of Flyers Creek, this is due to the relatively low impact of harvesting on the MAF (Figure H-11). In the case of the Cadiangullong-Cadia system (Figure H-9), low flows are maintained below the Weir through a range of management strategies and interventions (see discussion and recommendations below).

7.0 SUMMER HILL-BLACKMANS SWAMP CREEKS-CRITICAL ISSUES

Two critical issues were identified in the SHC and BSC catchment.

(1) The first related to the levels of flows that would be maintained in SHC with the removal of 10.0 ML/day effluent outfall. Given that the 'high' flows now maintained in the system are artificially created by the effluent outfall, local residents immediately downstream of the outfall are concerned about the level of post mine flows.

(2) While no baseline data exists for the ecology of this catchment, self evidently an equilibrium situation now prevails in relation to stream biodiversity, which has adjusted to both the level of flow and the added nutrient levels in the system. Will the reduced flows existing during the operational phase of the mine, be great enough to maintain instream viability and riparian needs? Anecdotal information from Orange residents suggested that there exists a viable population of platypus along the SHC. It is possible that the removal of 10.0 ML/day of water from the system could impact adversely on the platypus population downstream of the sewage outfall.

7.1 DURING MINING FLOWS

Under drought conditions flows of 2.14 ML/day can occur in the BSC above the STP. The origin of this water is not known but is believed to probably result from household garden use in Orange City. This flow can be expected to slowly increase over the 12 year life of the Cadia Project, concurrent with the growth of the number of people in Orange in this catchment.

TABLE H-6
PERCENTILE FLOWS - PREDICTED PRE AND DURING MINING FLOWS (ML/day)

Percentile	Flow (Pre-Mining)			Flow (Post-Mining)		
	Cadiangullong	Flyers	Summer Hill	Cadiangullong	Flyers	Summer Hill
95%	0.25	0.16	11.3	0.25	0.16	1.3
80%	1.9	1.2	13.6	1.9	1.2	3.6
50%	8.4	5.4	21.3	3.4	4.4	11.3

The flow duration curve (Figure H-7), predicts that for 80% of the time baseline flows downstream of the STP will in the during mining scenario, be as great or greater than 3.6 ML/day.

Under drought conditions between 0.5-1.0 ML/day are released from the Suma Park Dam (April 1995 measurement).

There is a natural increase in flow regime as one moves down the creek system resulting from other tributaries in the Summer Hill catchment .

The present flow coming from the STP varies during the day between (4-18) ML/day resulting in a 24 hour cyclic high and low flow scenario. This pattern will change significantly with the removal of 10.0 ML/day of outfall. The removal of 10.0 ML/day to the Cadia site will leave approximately 2.0 ML/day to flow down the system under drought conditions. The volume of the remaining effluent outfall will increase slowly over the life of the Cadia mine due to increases in the population connected to the STP.

Figures H-4, H-5 and H-6 indicate that background flows under no or low rainfall scenarios, are 'swamped' by a 10.0 ML/day flow. Under high rainfall conditions the addition of 10.0 ML/day becomes inconsequential. Conversely, property owners along the Creek system would, under the scenario where 10.0 ML/day of effluent are harvested, observe significantly lower flows down BSC under 'no-low' flow conditions but observe no differences under high flow conditions.

Under the drought conditions which were extant in April 1995, the flows at the STP, minus 10.0 ML/day would have been of the order of 4.14 ML/day, at the junction of BSC and SHC of the order of (4.64-5.14) ML/day. Furthermore this flow would be expected to increase with increasing inflows into the downstream system as the catchment area increases. Given that the flow duration curves predict that for 80% of the time, background flows will be of the order of 3.6 ML/day in the SHC downstream of the junction (Figure H-7), the periods of very low flows will occur infrequently.

The creek system will, over the life of the Cadia Project reflect more nearly the natural baseline flows prior to European settlement, but will still continue to be modified by flows emanating from gardens in Orange and the remaining effluent outfall in BSC.

These flows judged against the Montana Method suggest that the SHC system will maintain 'fair' or better rating over the life of the project. Judged against the 80 percentile requirement, the flows while being significantly less, nevertheless deliver flows able to maintain the riverine ecology.

7.2 THE IMPACT ON PLATYPUS

The results of this study are fully reported in Goldney and Fisher (1995) and summarised in this section. The study was designed to:

- determine the percentage of pools providing suitable habitat for platypuses from the outfall downstream to the confluence with Emu Swamp Creek, a distance of approximately 26 km;
- determine the distribution and abundance of platypuses along this length of Blackmans Swamp-Summer Hill Creeks;
- assess the impacts of the proposed water transfer from Blackmans Swamp Creek on the platypus population; and to
- determine the riparian and environmental flows required to conserve the platypus and other aquatic organisms in this creek system.

The data from this study confirmed the anecdotal reporting from Orange people, that significant numbers of platypus are to be found in the Summer Hill Creek system. Platypus have been found to be distributed throughout the system. Approximately 80% of sampled pools (n = 39) had medium to high habitat quality in relation to platypus needs. Fifty percent of 10 sampled pools were found to be used by one or more platypus. The results however cannot be used to comment on the dynamics of the population. The numbers of platypus can only be described in relative terms and are judged to be common and widely distributed in the Summer Hill Creek system. The security of water supply with its mild stimulatory effects on the food chain are believed to be the critical factors in maintaining this population level under the flow regime associated with the effluent outfall.

7.3 MAINTAINING THE CURRENT POPULATION LEVEL OF PLATYPUS

It is probable that the current levels of platypus in the SHC system may be artificially high due to those factors already outlined above, compared to the scenario before the input of sewage outfall into the system. Impacts on the platypus can be expected to be two fold;

- **loss of productivity in the stream system** due to loss of nutrient load and the stimulatory effects on benthic organisms due to mild eutrophication. It is not possible to quantify this effect, but it is unlikely to be very significant.

- **Decrease in water flow in the system** which could be expected to impact on the distribution and abundance of the species. Goldney (unpublished) has just completed an assessment of the effects of reduced flows (sometimes less than 5 .0 ML/day) on the platy-

pus population in 3 km of river section immediately downstream of the Duckmaloi Weir. He could find no difference in the numbers of animals captured before and after increased off-take via a pipeline was affected from the pipehead weir. The period of study (1990-1995) included both wet and dry years. At times the flow of water over the weir was estimated to be only 1.0 - 2.0 ML/day. Nevertheless the pool riffle complex appeared to be maintained in this narrow river.

In regards to this development, even under a drought scenario as severe as the 94/95 drought, at least 4.0 - 5.0 ML/day of water would have been available for instream flow after the harvesting of 10.0 ML/day. In addition there is the additional inflow with increasing distance down the catchment. This flow of water would appear to be great enough to maintain the riffle-pool complex in the SHC albeit at a sub optimal level (compared to the present artificial system). The numbers of platypus would probably decrease under such a regime if it persisted for significant periods of time. However, given that the predicted flows have a high probability of delivering about 3.6 ML/day into the system for about 80% of the time, the actual impacts of the proposed off-take may have only a marginal effect on the platypus population , provided the off-take is managed in an appropriate manner.

8.0 THE CADIANGULLONG-CADIA SYSTEM

Seven key issues have been identified as important in this system. These are:

(1) The presence of large and small dams with the likelihood of fluctuations in water depth over the life of Project.

Greater effects are likely to be experienced in the Cadiangullong Dam, due to fluctuations initiated by harvesting and release programs. The maximum water level fluctuations simulated in the Cadiangullong Dam over a 115 year period was 10 m over an eight month extreme drought. Water level fluctuations of 2-5 m would be expected in typical years (L. Gilbert, pers. com. 1995). The smaller pipehead dams can be utilised so that minimum movement of water levels occur within them. The greater the fluctuations experienced, and the greater the rate of change in water levels, the less habitat values the dams will have, particularly for edge species. At the end of the project (10-20) years, the water supplies can be positively managed for environmental, agricultural and recreational purposes.

(2) Dampening of flood regimes due to water harvesting, storage and use.

Figure H-9, the predicted monthly spill of water over the Cadiangullong Dam, indicates that flood phenomena will not be modified greatly when the proposed mining scheme becomes operational. In any 10 year period, flows in excess of 4000 ML/month will still be registered.

(3) Maintenance of acceptable riparian and environmental flows downstream of the weir and dampening of low flows due to storage.

This is regarded as a potentially significant impact on the creek system in this Project. The minimum 'fair' Montanta flow of 3.3 ML/day is maintained 70% of the time under the proposed management strategy for maintaining environmental flow (See Figure H-10). This will provide a greater flow reliability than that offered if the 80/20 rule is used as a basis for the maintenance of low flows in the system. Using the 80/20 rule, flows as great or greater than 1.9 ML/day after mining has commenced, occur for 80% of the time. This is identical with the pre-mine predicted flows.

In April 1995 under extreme drought conditions, it was estimated that 1.0-2.0 ML/day were flowing through the proposed dam site. A further complication is the use of downstream water by landholders of up to 0.32 ML/day (Based on existing downstream land use, typical stocking rates and stock water requirements). Some additional water will come into the catchment further down stream of the order of 5.0 ML/day (based on MAF) at Panuara road, some 6 km downstream. The movement of this water into the catchment is not linear through the system. The critical point which needs to be made is that low flows defined by the 80/20 rule remain unchanged in pre and post mine scenarios. In the latter case, this is arrived at by a number of management strategies. These include environmental releases from the dam and under extreme drought conditions the possibility of matching of inflow and outflow. Self evidently the presence of the Dam and the redirection of water to the processing plant will change flow regimes downstream significantly. Since it has been argued above for the Summer Hill Creek system, based on data from the Duckmaloi River, that minimum flows to maintain riverine ecological integrity were of the order of 4.0-6.0 ML/day in that system, does this mean that the Cadiangullong will be significantly impacted downstream from the dam, if flows of this order are not maintained? The siting of this dam is relatively high up in the catchment (area = 40 km^2), where by definition, MAF is lower than for sites further downstream. The stream has also evolved under flow regimes where for 20% of the time flows can

be expected to be less than 1.9 ML/day. This situation will not change under the post-mine scenario.

Under pre-mine conditions, when low flows were experienced, it is likely that changes in flow heights would occur very slowly, thus allowing edge organisms to relocate in the face of drying out unless under very extreme conditions. It would appear important on *a priori* grounds that under post mine conditions, similar conditions, or better should be maintained. This can be achieved by developing release protocols. Low flows, less than 2.0 ML/day, were under the extreme drought conditions of early 1995, able to maintain a riffle-pool continuum, albeit probably suboptimal for some organisms. The critical river stretch to maintain environmental flows will be the reach 2 - 3 km downstream of the dam, below the impact of the polluted section of the stream, resulting from previous mining. The 5 km stretch of the creek below this point to Panuara Road, will receive some additional water inflow (Table H-5). Under these post mine flows the likelihood of increasing predicted flows above background levels will increase substantially. Given that the company will maintain a minimum environmental-riparian flow downstream of the dam of 3.4 ML/day, under all but conditions of extreme drought, this should ensure maintenance of acceptable low flows. Only under drought conditions when inflow was less than 3.3 ML/day would a situation arise when it was possible that flows less than this would be released downstream.

(4) Change in water quality downstream of old mine site due to loss of dilution factor.

The decrease in MAF may cause the effects of existing stream pollution to be experienced further downstream. This effect can be monitored and is not likely to be very significant, given that low flows are maintained in a similar manner in both pre and post mine scenarios.

(5) Loss of flow variability, particularly in lower flows.

Significant changes in stream dynamics will occur as a result of this Project. For 50% of the time, flows will be as great or greater than 3.4 ML/day. Flows below 3.4 ML/day will parallel those in the pre-mine situation. The modification of high flows will not be as significant, as weir overtopping will still occur under high flood regimes. Given the degraded nature of the Cadiangullong Creek system, the possibility of a creek rehabilitation program could occur over the life of the program, given proactive management plans were in place.

(6) Year one of the mine operation will require the filling of Cadiangullong Dam to take place by natural inflow and intake from the STP. Flow protocols will need to be developed to enable riparian and environmental flows to be maintained downstream of the dam during this phase.

(7) The question of placement of fish ladders in the system will need to be resolved. Given the current movement of carp into the upper Lachlan system (McBryde, pers com, 1995) and their apparent absence in the Cadiangullong and Flyers system so far, to adopt a precautionary principle, would appear a wise course of action. Hence this author strongly advises that fish-ladders not be used in any of the proposed dam constructions. There is no guarantee that this action will prevent the spread of carp.

9.0 RECOMMENDATIONS

9.1 THE SUMMER HILL SYSTEM

(1) The off-take of water from the STP should not exceed 10 ML/day.

(2) The off-take should be regulated so that the unutilised outfall is released into BSC at a more or less constant rate within a 24 hour cycle, thus preventing excessive rises and falls in the creek system, an action which could cause a significant impact on aquatic organisms, particularly under lower flow conditions.

(3) The actual flows of water after off-take to Cadia commences, should be gauged above the STP on BSC, at the confluence of the BSC and the SHC, and at the Third and Fourth Crossings, so that changes in downstream water flow can be related to changes in system ecology.

(4) The platypus population, water quality and creek ecology should be the focus of an integrated monitoring program which will assess changes before and after off-take commences.

(5) A brochure should be prepared to prepare Landholders downstream as to the likely impacts of the water harvesting program, its effects on Landholders and wildlife.

9.2 THE CADIANGULLONG-FLYERS SYSTEM

9.2.1 Flyers Creek and Cadia Creek

(6) The pipehead dams should be constructed without fish ladders to provide a physical barrier to prevent potential carp incursion.

(7) Water should only be harvested from the dams at times of high flow. Protocols should be developed with clear guidelines established as to the timing of water off-take. Under such a scenario the downstream flows will be little affected by the dam's presence.

(8) Monitoring of appropriate aquatic ecology parameters should be based on comparisons of upstream, dam and downstream sites.

9.2.2 Cadiangullong Creek

(9) The Cadiangullong Dam should be constructed without a fish ladder to provide a physical barrier to prevent potential carp incursion.

(10) Protocols should be developed to enable environmental flows of 3.4 ML/day or greater to be maintained below the Cadiangullong Dam. These protocols should seek to emulate low baseline flow scenarios as far as possible based on water flow probability curves.

(11) Monitoring of appropriate aquatic ecology parameters should be based on comparisons of upstream, dam and downstream sites.

(12) In cooperation with Landholders, develop a management strategy to rehabilitate a 1 - 2 km section of the riparian zone of the river over the life of the mining Project. This should include fencing out nominated sections to exclude stock, providing water to stock, and replacing willows with native trees and shrubs.

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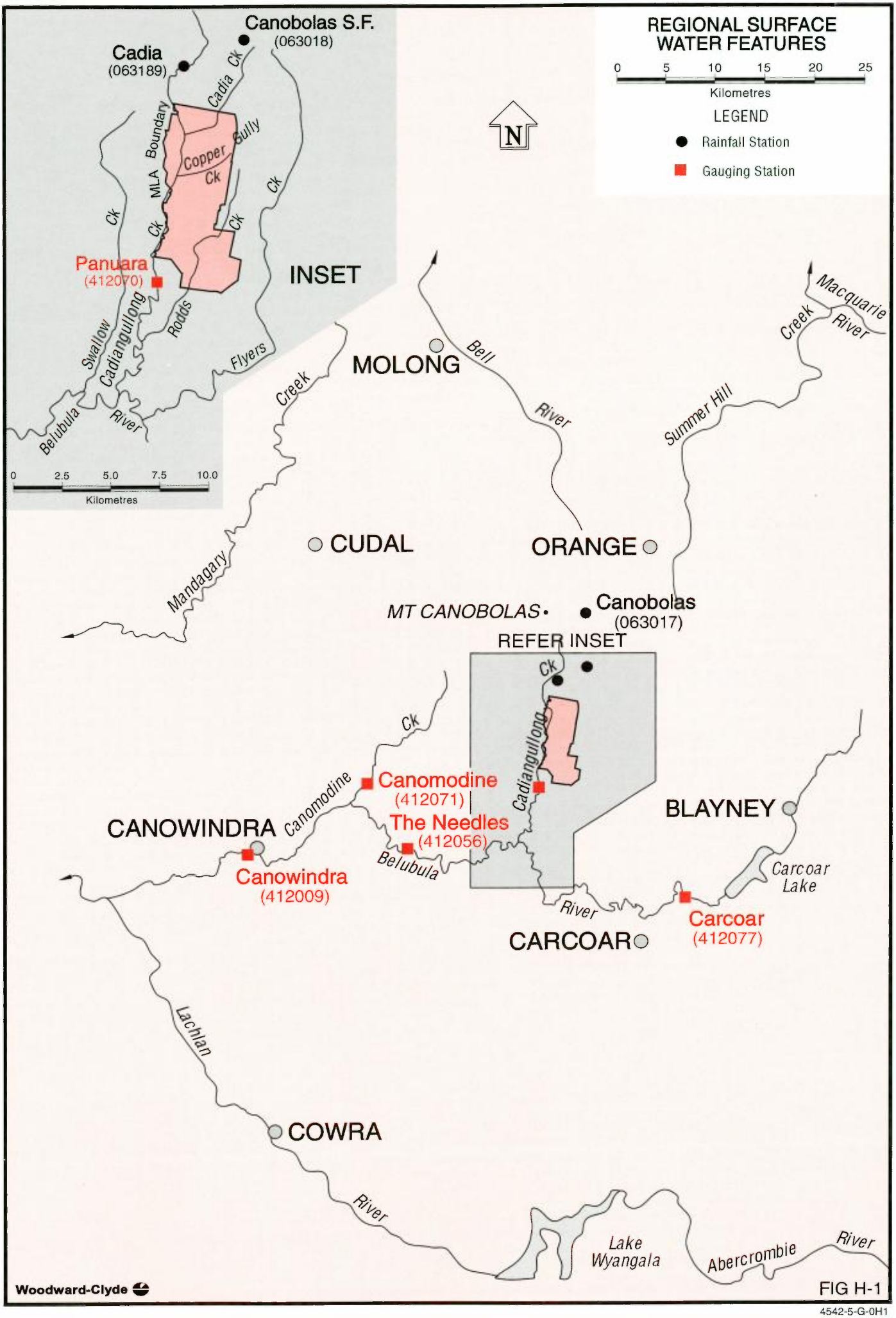
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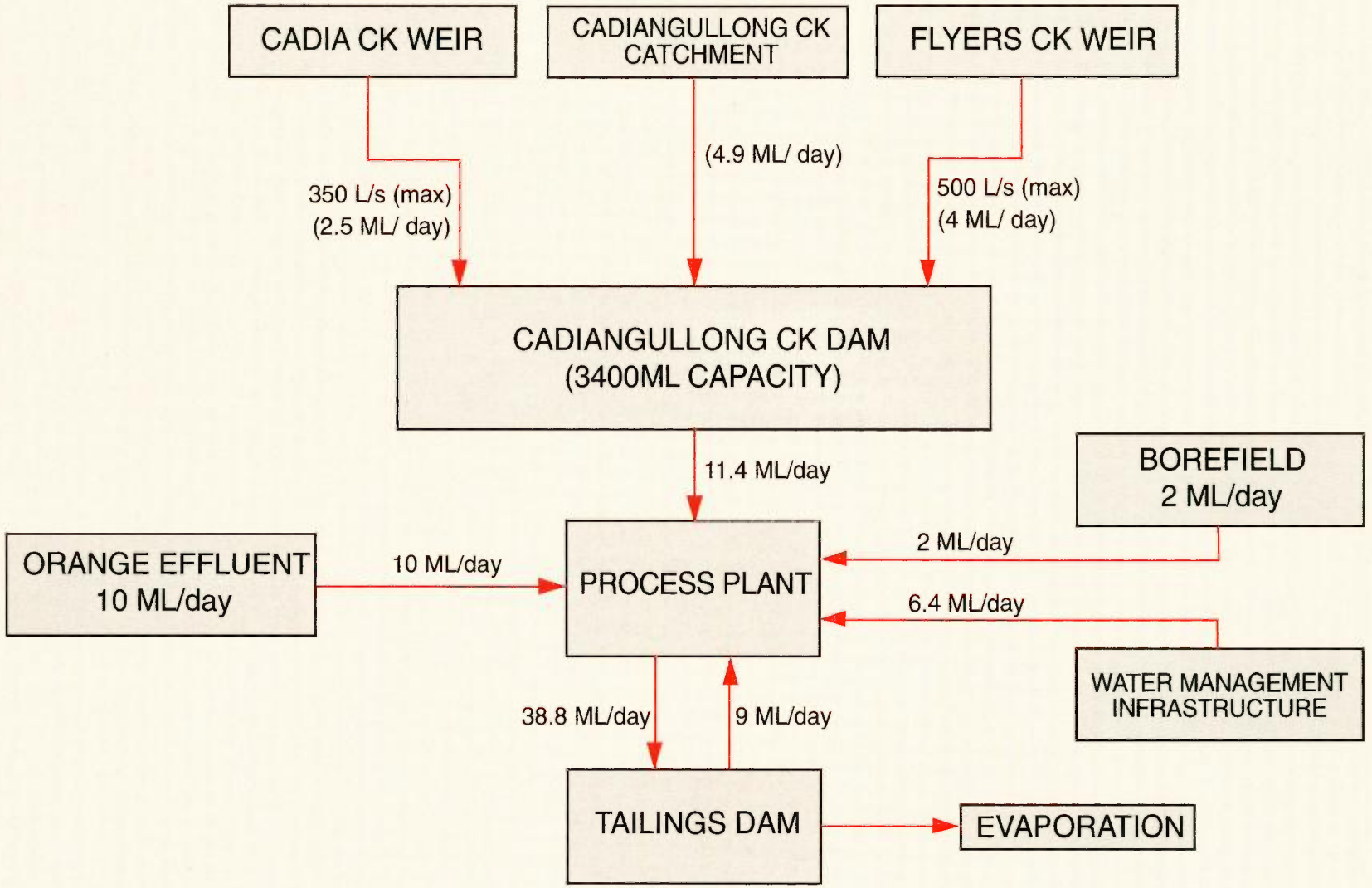
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Woodward-Clyde

FIG H-1

4542-5-G-0H1



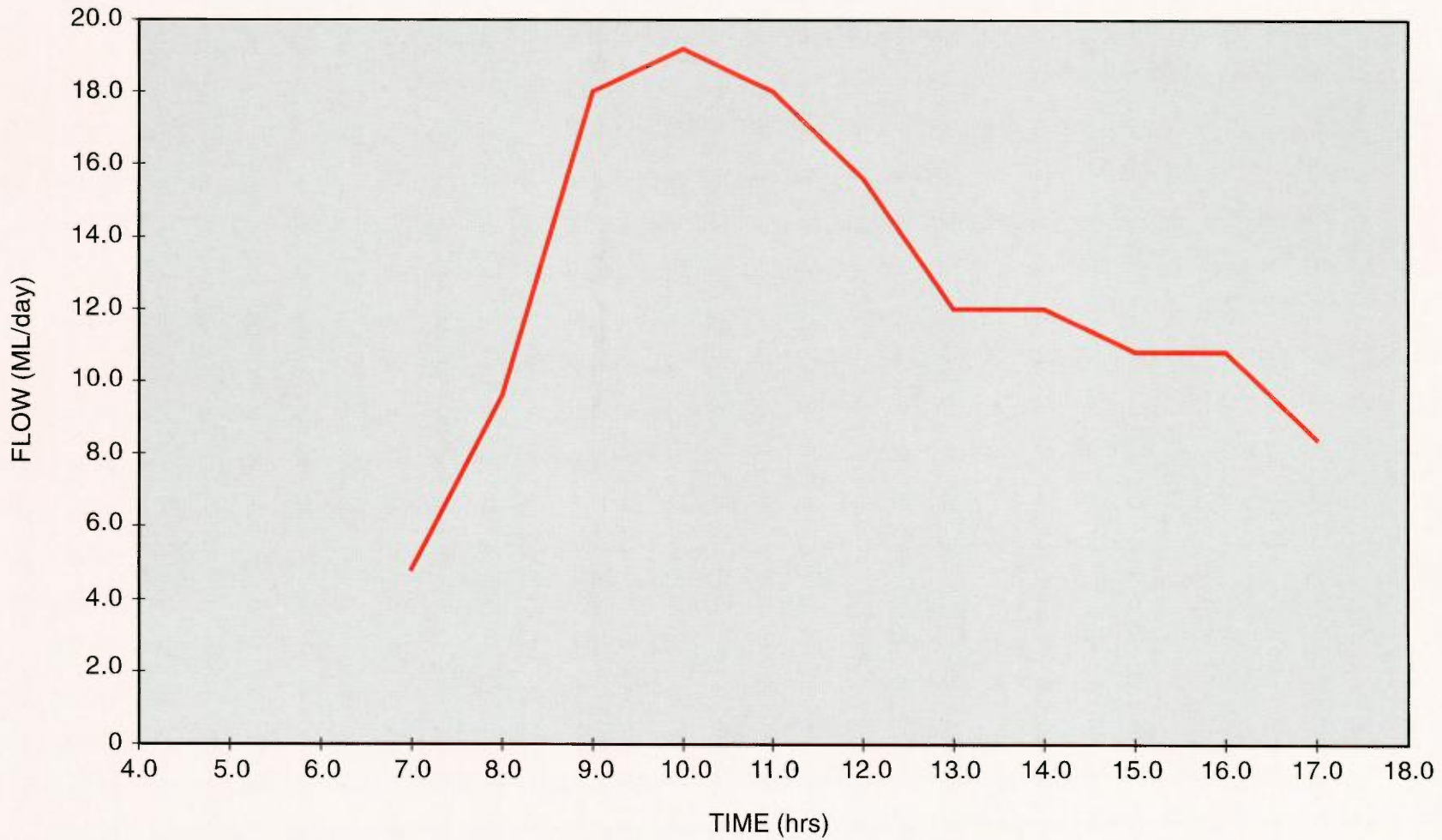
PROCESS WATER USE SCHEMATIC

FIG H-2

SOURCE- S:\A32\4541-2.1\CADIA.PPT

Woodward-Clyde

4542-5-G-0H2



EFFLUENT DISCHARGE FROM THE ORANGE SEWERAGE TREATMENT PLANT (12 April 95)

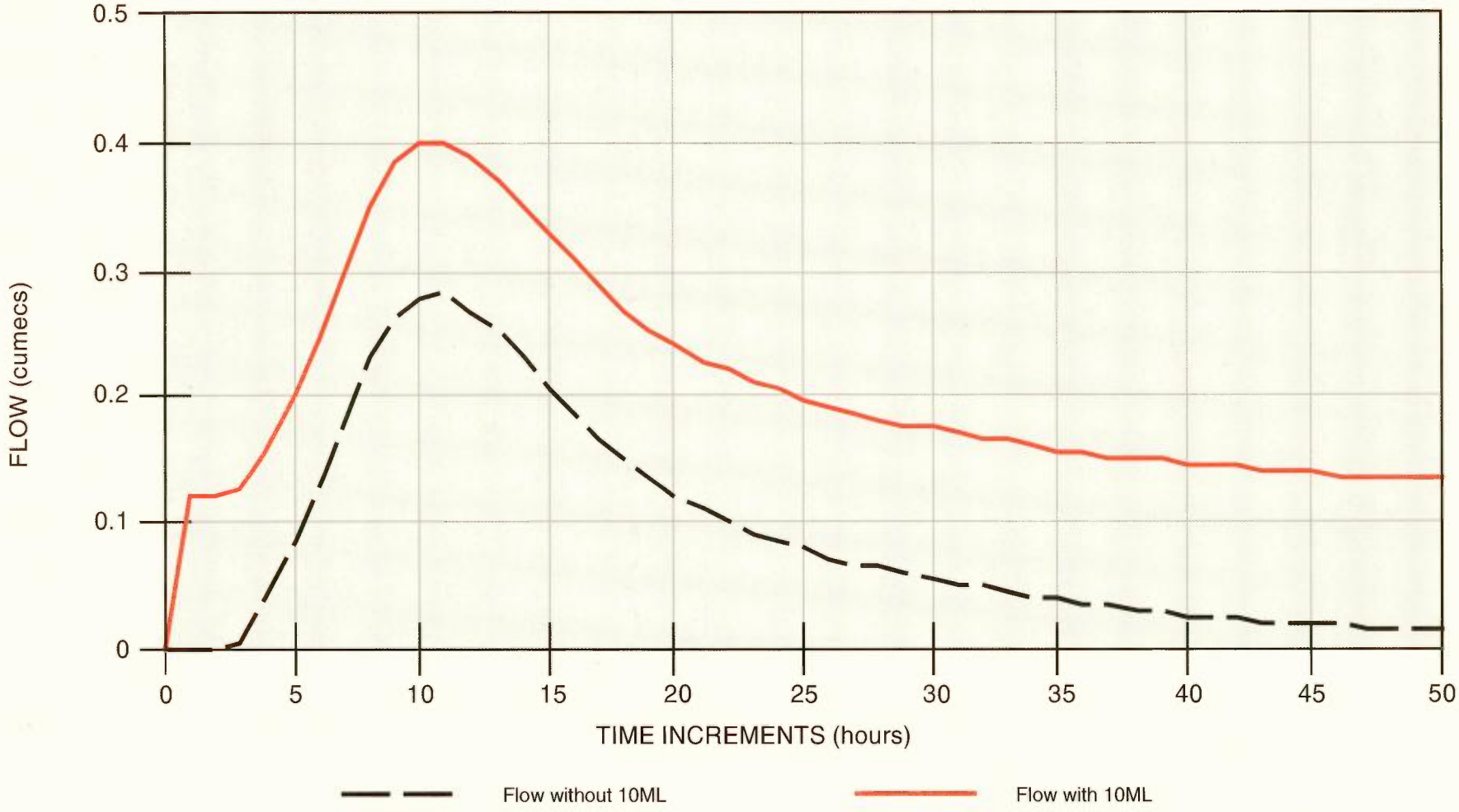
FIG H-3

SOURCE- S:\A32\4541-2.1\EXEL\OR-EFF.XLS

Woodward-Clyde

4542-2.24-G-0H3

CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



HYDROGRAPH FOR
BLACKMANS SWAMP CREEK
-LOW RAINFALL (6mm)

FIG H-4

SOURCE- S:\A32\4541-2.1\STREAMS\RORB6.XLS

Woodward-Clyde

4542-2.24-G-0H4



HYDROGRAPH FOR
BLACKMANS SWAMP CREEK
-MEDIUM RAINFALL (25mm)

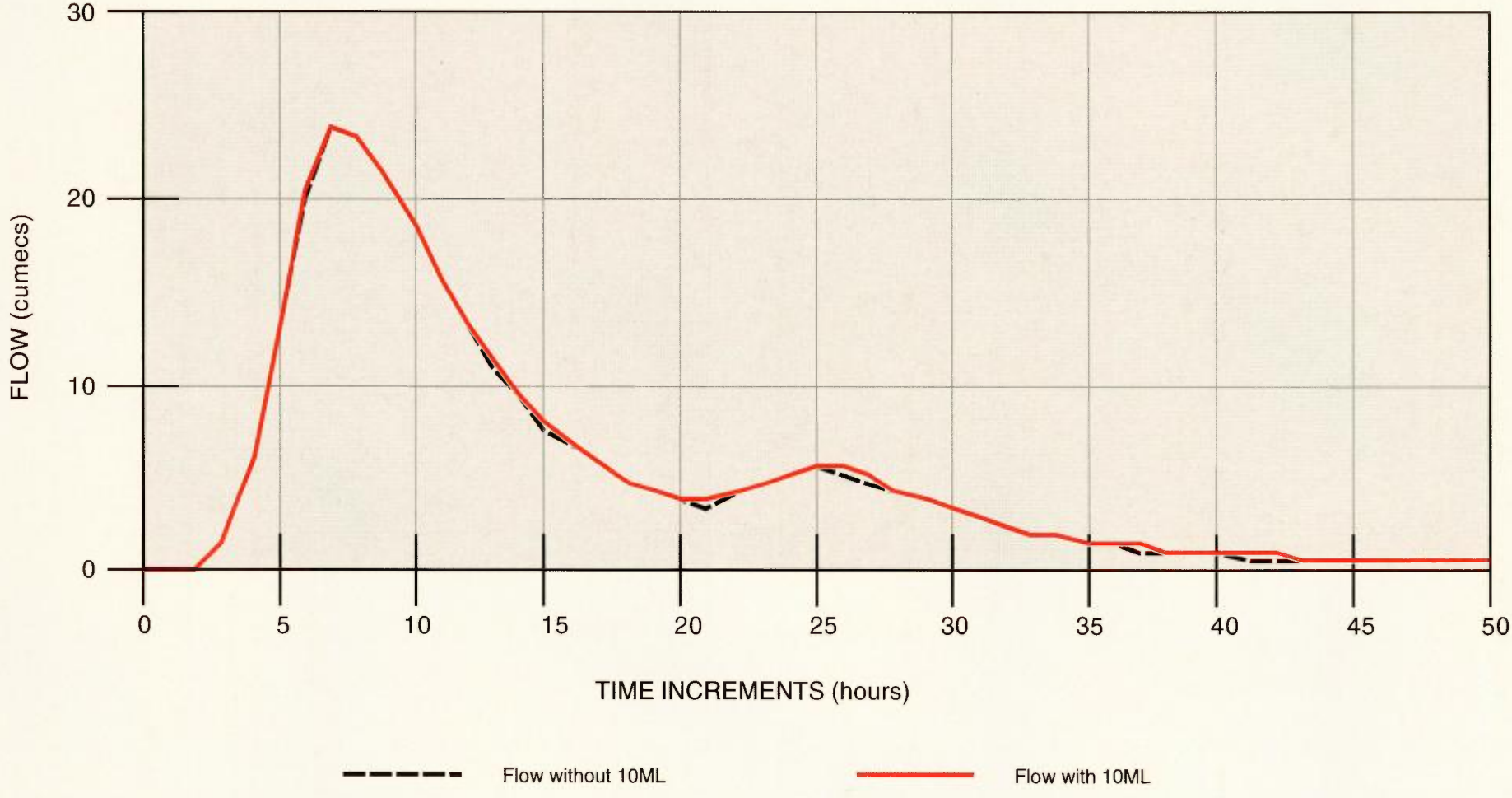
FIG H-5

Woodward-Clyde

SOURCE- S:\A32\4541-2.1\STREAMS\RORB25.XLS

4542-2.24-G-0H5

CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



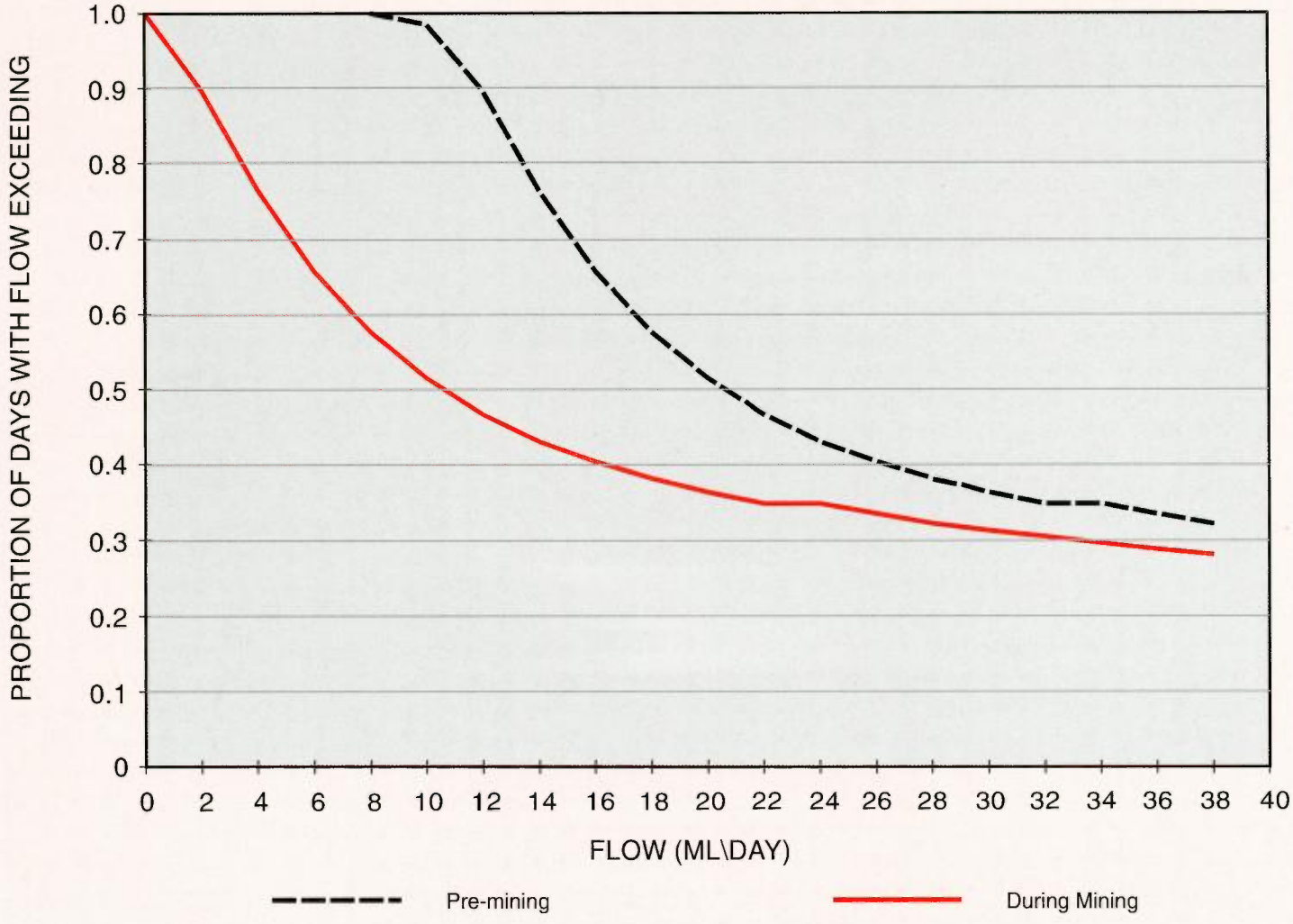
HYDROGRAPH FOR
BLACKMANS SWAMP CREEK
-HIGH RAINFALL (50mm)

FIG H-6

SOURCE- S:\A32\4541-2.1\STREAMS\RORB50.XLS

Woodward-Clyde

4542-2.24-G-0H6



SUMMER HILL
CREEK FLOW DISTRIBUTION
- AWBM RUNOFF MODEL

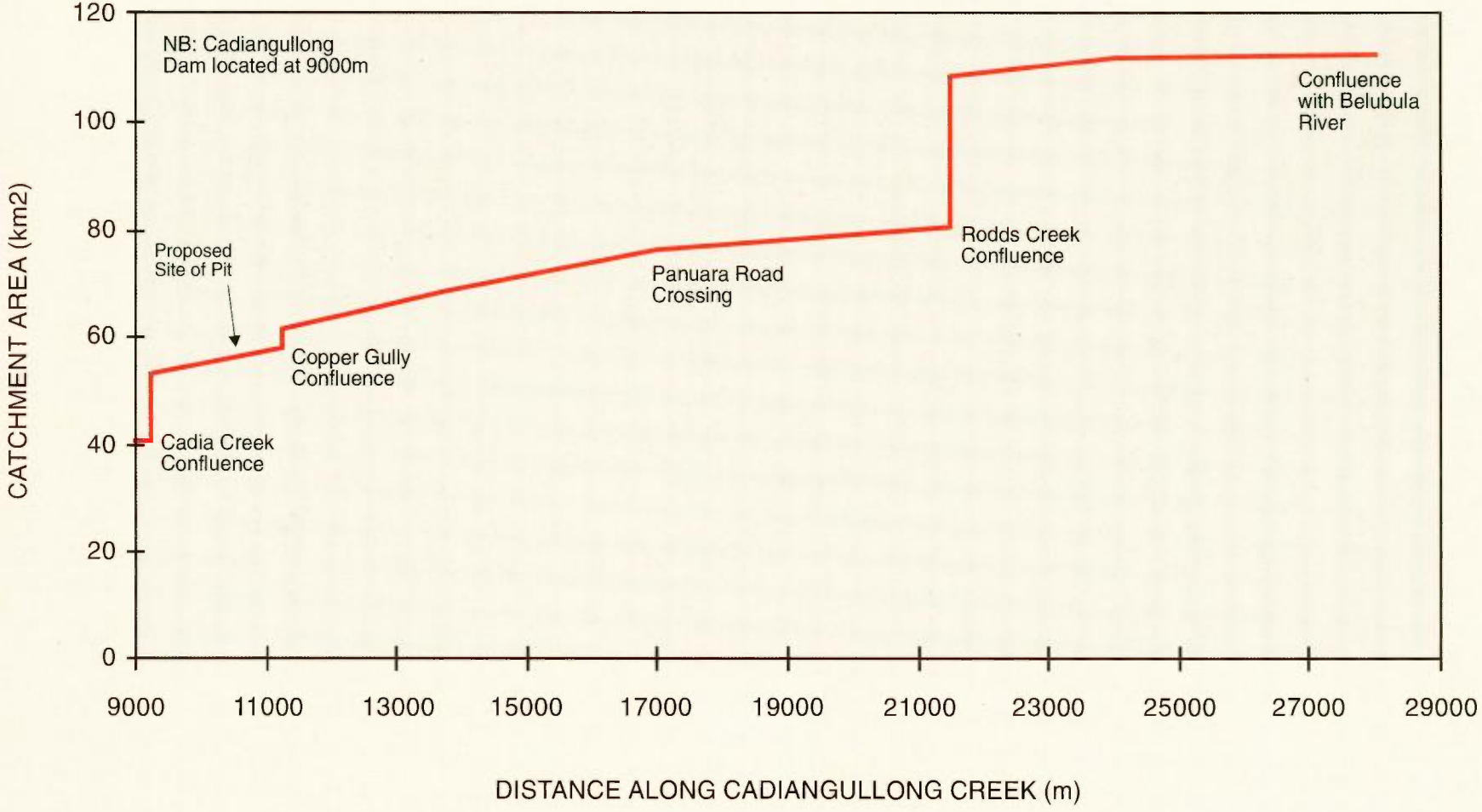
FIG H-7

SOURCE- S:\A32\4541-2.1\OR-FPRO2.XLS

Woodward-Clyde

4542-2.24-G-0H7

CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



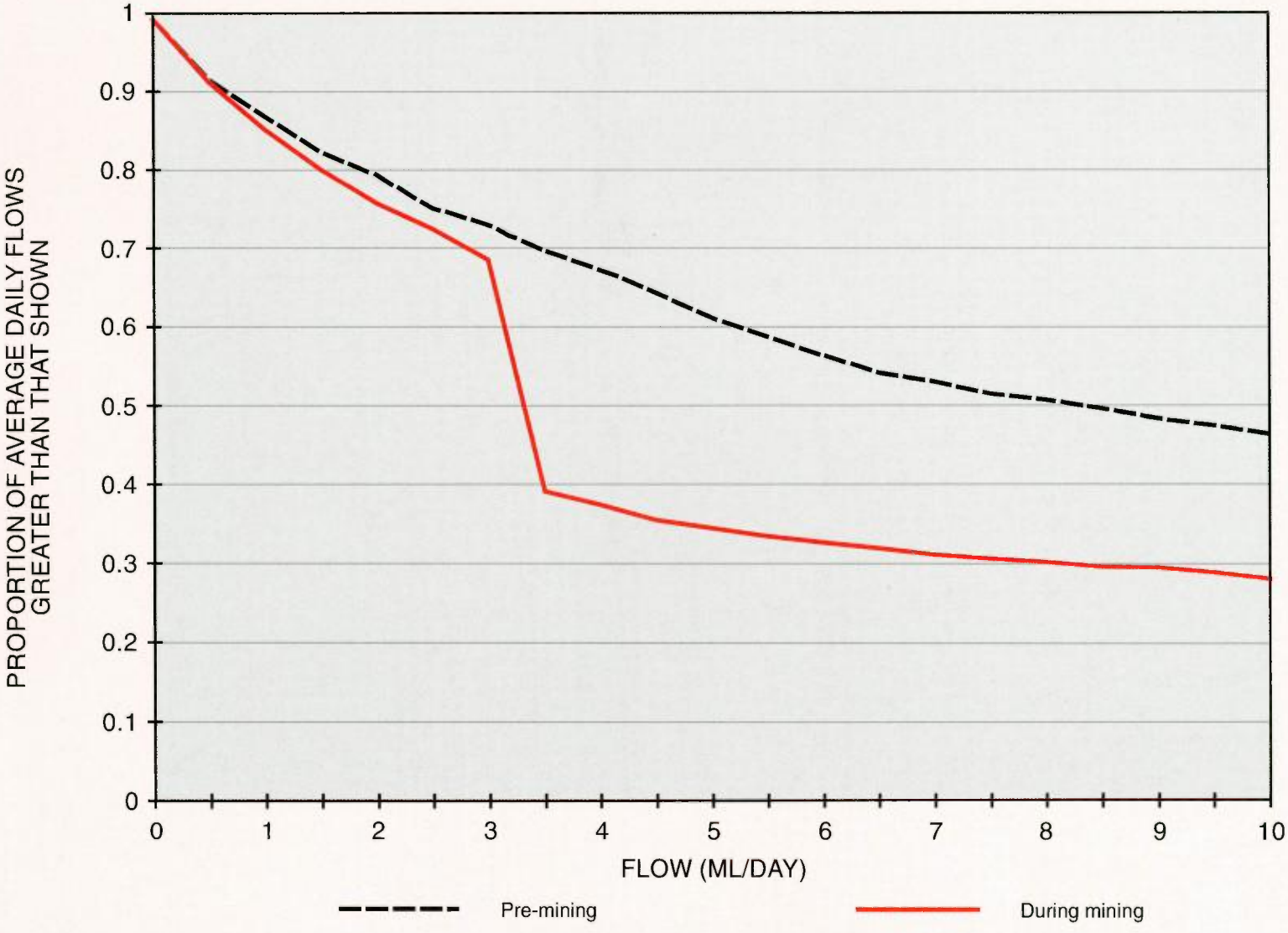
CADIANGULLONG CREEK - CATCHMENT AREA VERSUS DISTANCE ALONG CREEK

FIG H-8

SOURCE:- S:\A32\4541-2.1\EXCEL\CG-CATCH.XLS

Woodward-Clyde

4542-2.24-G-0H8



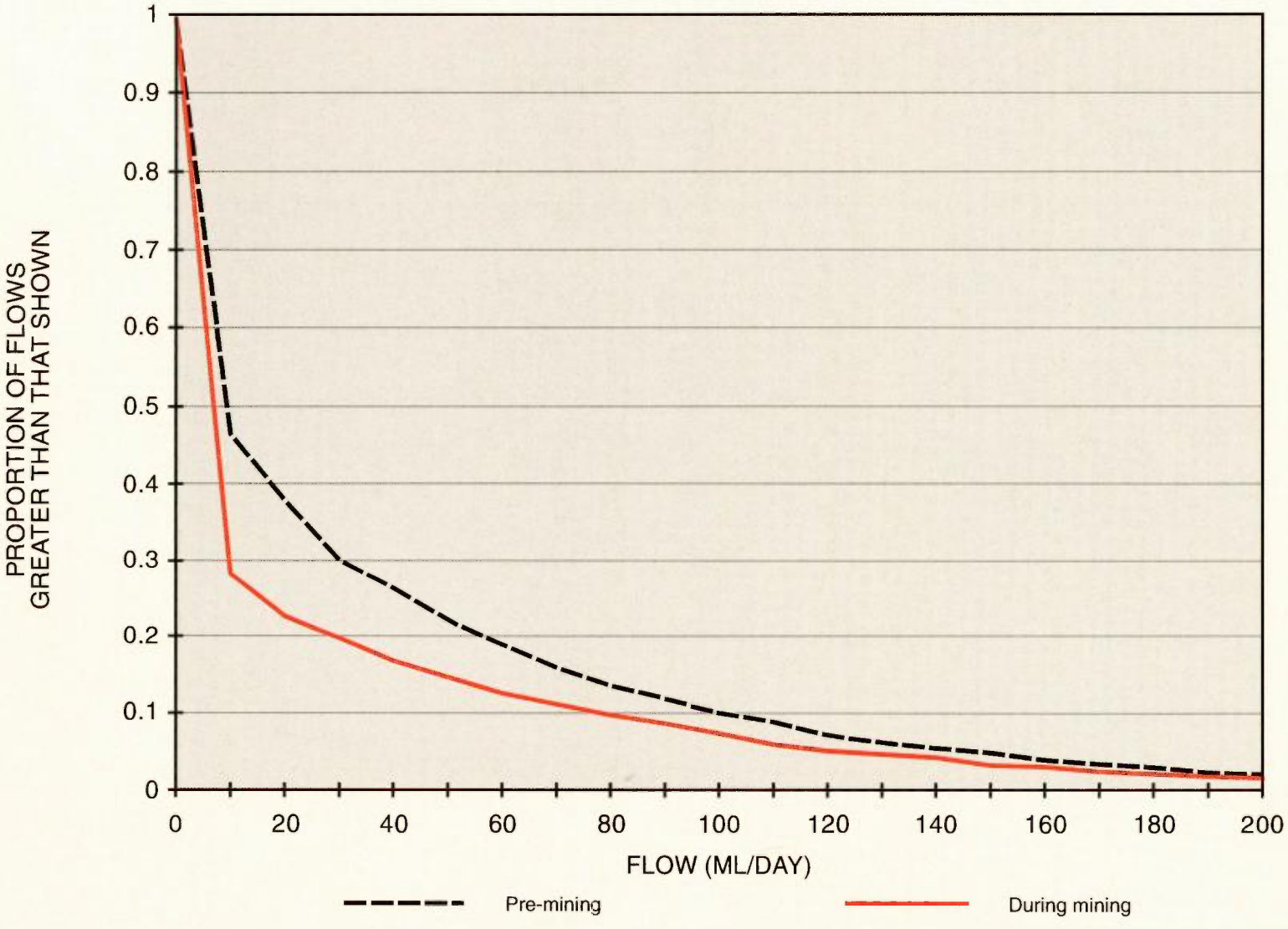
CADIANGULLONG CREEK
SIMULATED FLOWS - BEFORE
AND DURING MINING

FIG H-9

SOURCE- S:\A32\4541-2.1\EXCEL\FLO2-CAD.XLS

Woodward-Clyde

4542-2.24-G-0H9



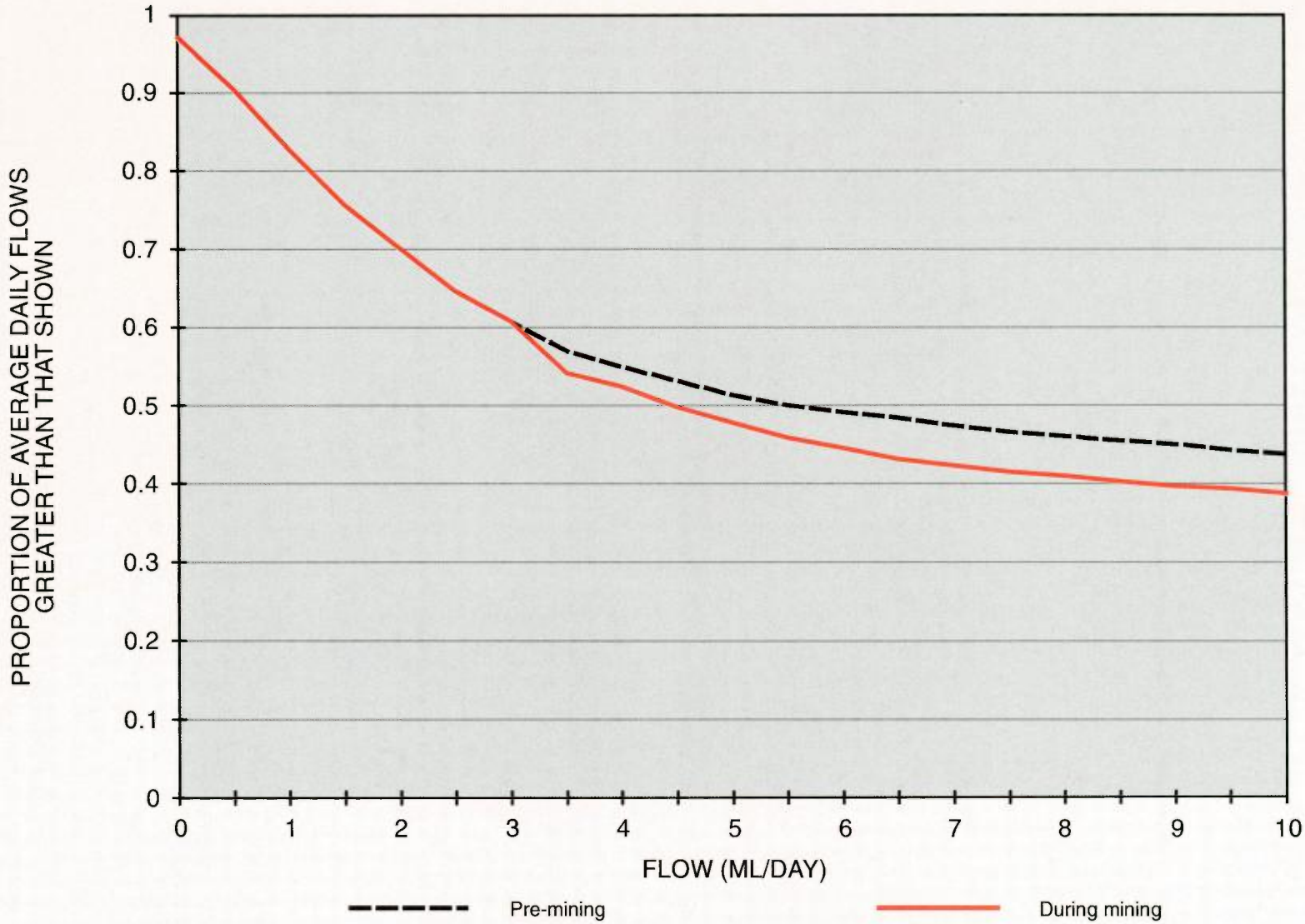
CADIANGULLONG CREEK
SIMULATED FLOW
PROBABILITY CURVES -
BEFORE AND DURING MINING

FIG H-10

SOURCE- S:\A32\4541-2.1\EXCEL\FLOW-CAD.XLS

Woodward-Clyde

4542-2.24-G-H10



FLYERS CREEK
SIMULATED FLOWS - BEFORE AND DURING MINING

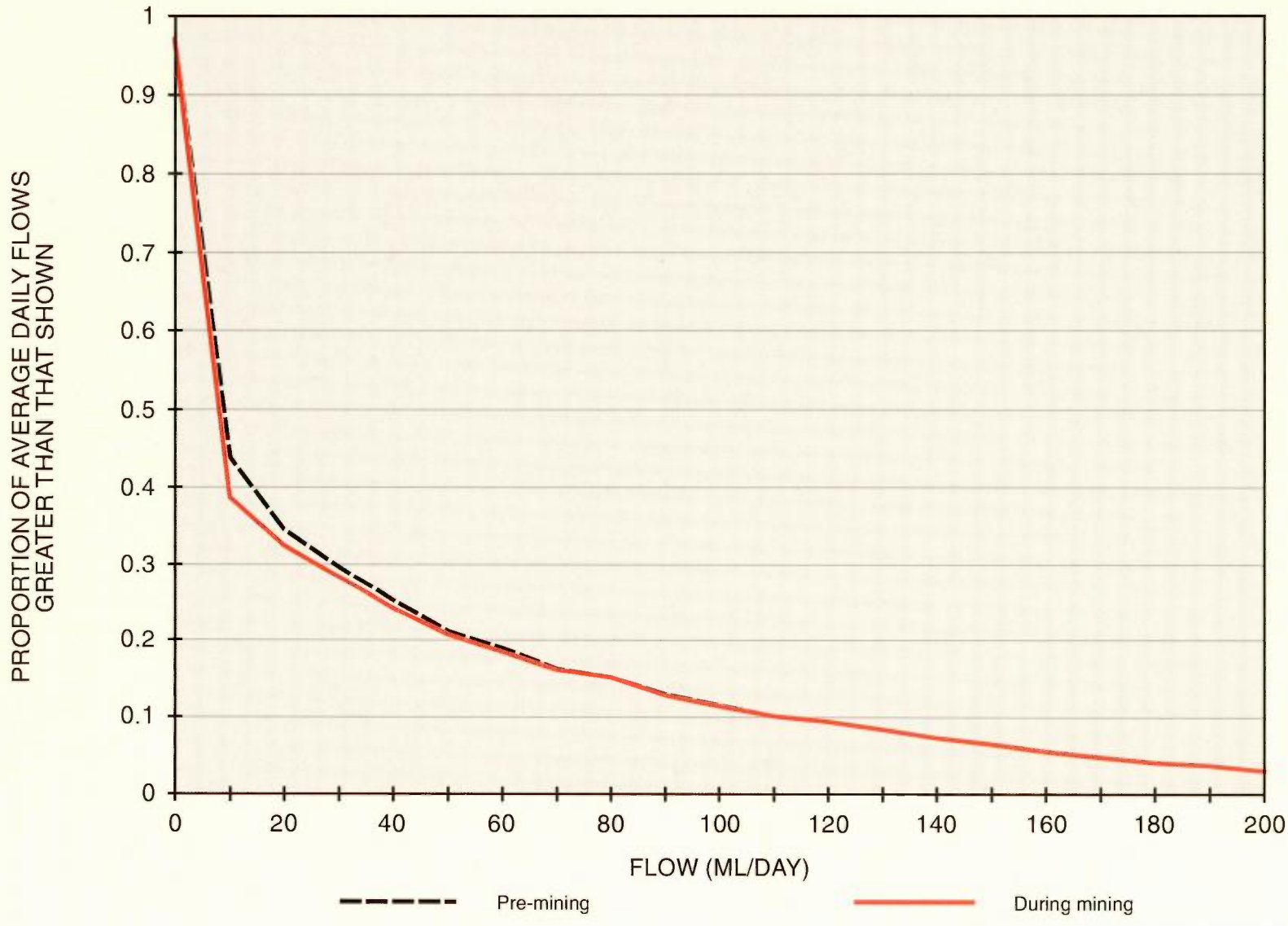
FIG H-11

SOURCE- S:\A32\4541-2.1\EXCEL\FLO2-FLY.XLS

Woodward-Clyde

4542-2.24-G-H11

CADIA PROJECT - ENVIRONMENTAL IMPACT STATEMENT



FLYERS CREEK
SIMULATED FLOW
PROBABILITY CURVES -
BEFORE AND DURING MINING

FIG H-12

SOURCE- S:\A32\4541-2.1\EXCEL\FLOW-FLY.XLS

Woodward-Clyde

4541-2.24-G-H12

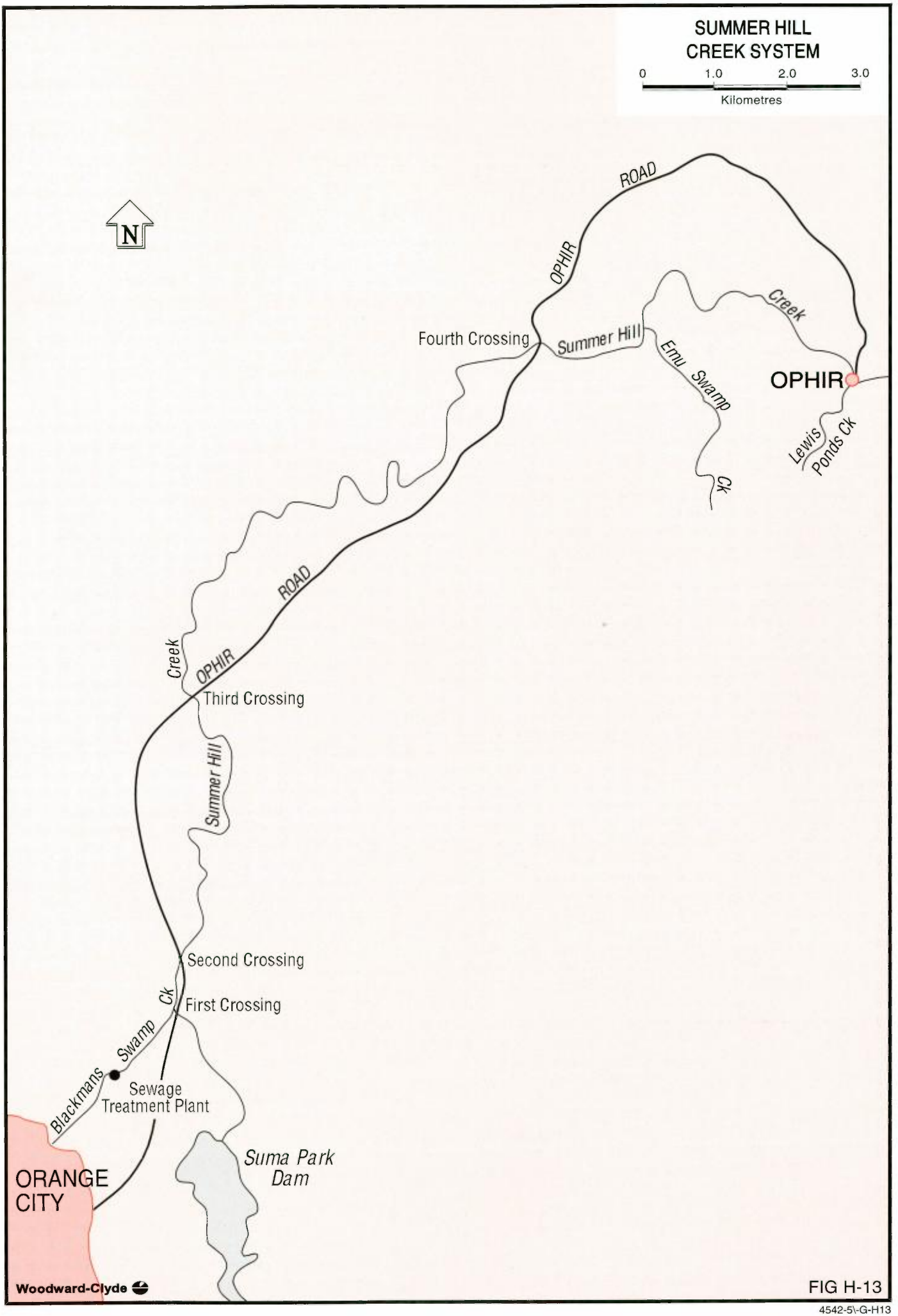


FIG H-13

4542-5\-G-H13

ATTACHMENT H-1

AN ASSESSMENT OF:

(1) PLATYPUS DISTRIBUTION AND ABUNDANCE IN THE SUMMER HILL CREEK DOWNSTREAM OF THE ORANGE CITY SEWAGE OUTFALL

(2) THE IMPACTS OF REMOVING 10 ML/ DAY EFFLUENT FROM THE SYSTEM ON THE PLATYPUS POPULATION

DAVID GOLDNEY AND ANDREW FISHER

JULY 1995

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1.0 INTRODUCTION

Newcrest Mining Company is looking at the option of using the treated outflow from the Orange Sewage Treatment Plant (STP) which normally flows down the Blackmans Swamp Creek and thence into the Summer Hill Creek, in the proposed mine development at Cadia. Up to 10 ML of the flow generated each day would be used in the mining process thus reducing the available water flowing down the Creek. Anecdotal information from Orange residents suggested that there exists a viable population of platypus along the Summer Hill Creek system. It is possible that the removal of this volume of water from Blackmans Swamp Creek could impact adversely on the platypus population downstream of the Sewage outfall. Hence this study was designed to:

- determine the percentage of pools providing suitable habitat for platypus from the outfall downstream to the confluence with Emu Swamp Creek, a distance of approximately 26 km;
- determine the distribution and abundance of platypus along this length of Blackmans Swamp-Summer Hill Creeks;
- assess the impacts of the proposed water transfer from Blackmans Swamp Creek on the platypus population; and to
- determine the riparian and environmental flows required to conserve the platypus and other aquatic organisms in this creek system.

2.0 SITE DESCRIPTION AND HYDROLOGY

The N-E section of Orange City is drained by Blackmans Swamp Creek (BSC), which forms a minor catchment of the Summer Hill Creek (SHC) system. SHC is located within the Macquarie Catchment. The city's Sewage Treatment Plan (STP) is located on this creek approximately 1 km from the edge of the built environment. Blackmans Swamp Creek flows into the Summer Hill Creek approximately 1.5 km downstream of the STP. SHC continues to flow to the N-E and is fed by a number of minor creeks such as the Mullion Creek and eventually is joined by two larger creeks, the Emu Swamp and Lewis Ponds Creeks, around 20-25 creekline kilometres below the STP (Figure H-13).

The Summer Hill Creek Catchment has been significantly changed since European settlement. The upper catchment contains Suma Park Dam on the SHC. Downstream from the STP to the Mullion Range State Forest, the creek flows through undulating country with a mixture of larger rural holdings and those subdivided into smaller "hobby farms". In this section of the creek, the native riparian tree strip has been replaced in the main with introduced willow (*Salix* sp). The willow has tended to stabilise the system in the absence of native trees. Downstream from the Mullion Creek confluence, SHC flows through Crown Land and larger grazing properties through to the confluence with the Lewis Ponds Creek. This section of the creek is less disturbed, although in places weed invasion is significant, but the riparian vegetation is more-or-less intact.

The BSC catchment is about 220 km^2 in area. Little hydrological data is available for the catchment. The hydrology has been modified because of effluent outfall from the Orange STP. Figure H-3 illustrates effluent discharge over a 10 hour period measured on the 12 April 1995, illustrating flow rates varying between 4-18 ML/day. The flood wave effect can be clearly seen, and is generated by the variable flow coming into the treatment plant. On the same day flow rates at five points along the creek system were gauged. These data (measured under drought conditions) indicate that water was not only flowing into BSC above the STP but that additional sources other than from the STP (as would be expected) were coming progressively into the system as one moved downstream. The flow in the BSC above the STP at (0829-0910) was 2.14 ML/day, in the SHC upstream of the confluence of the BSC but below Suma Park Reservoir 0.603 ML/day (1120-1150), 12.9 ML/day at the Third Crossing on the Ophir Road (1220-1320) and near Ophir Road Crossing 18.4 ML/day (1420-1500).

Differences between the last two readings have been assessed as representing a real increase in average base flows (L Gilbert pers. com., April 1995). Figures H-4, H-5 and H-6 are hydrograph simulations for BSC, derived using the RORB uncalibrated model, illustrating the predicted flows against time over a 50 hour period, under low, medium and high rainfall regimes (24 hours), with and without an additional 10 ML/day outfall. Background flows are "swamped" by the effluent outflow under no/low rainfall scenarios (Figure H-4), but under high rainfall scenarios (Figures H-5 and H-6), the effects of added effluent outflow becomes inconsequential. Figure H-7 simulates flow duration curves in the SHC (B = 0.75) below the confluence with BHC, with and without effluent flow. For 80% of the time it is predicted that baseline flows would be 13.6 ML/day or greater and for 95% of the time, 11.3 ML/day is greater.

3.0 WATER QUALITY

Self evidently water quality below the STP in BSC and SHC is affected by sewage outfall and incremental additions of nutrients from adjoining farm lands as one progresses down the system. Surprisingly little baseline data re water quality exists for SHC or BSC.

A water quality run was undertaken in BSC on 20 January 1995 on behalf of Woodward-Clyde and analysed by AWT EnSight and the NSW Department of Mineral Resources, three sample sites were used:

Site 1: BSC Upstream of the outfall;
Site 2: Effluent discharge waters from STP; and
Site 3: BSC downstream of the outfall, sufficiently far to ensure complete mixing occurred.

The sampling was undertaken following overnight rain. The creek was in recession and it is estimated to have been flowing at 20 ML/day including 12 ML/day from the STP (L Gilbert, pers. com.).

TABLE 1
NUTRIENT LEVELS ALONG THE BSC

Analytes	Site 1	Site 2	Site 3	Units
Ammonia	0.50	0.110	0.080	mg/L
NOx-N	0.630	11.5	4.95	mg/L
Total P	0.108	7.521	2.588	mg/L
Ortho-P	0.035	7.26	2.48	mg/L

The data is typical of point source pollution in a river system. Upstream the nutrient levels approximate expected baseline data, increase significantly at the point source and thereafter gradually return to lower nutrient level. It is confidently predicted that these levels of nutrients would continue to fall along the length of the creek system.

pH increased slightly along the sampling gradient (up to 0.4 units) whereas electrical conductivity increased significantly to 635 units (from 160) at the STP, reflecting changes in the levels of bicarbonate, chloride, sulphate and nitrate.

Given the flows at the time of sampling, these data are consistent with levels of nutrients necessary to induce mild eutrophication along the SHC. Concurrent visual inspection confirmed the presence of significant amounts of green algae (unidentified) at particular point sites along SHC, decreasing with distance downstream of the STP.

4.0 RIVERINE ECOLOGY

No baseline data exists for this creek system. Its ecology has been highly modified by the presence of the inflow of sewage effluent into the BSC. BSC prior to the establishment of the STP would have probably been an ephemeral stream subject to the typical "boom and bust" changes accompanying the extremes of drought and flood. The outflow from the STP, not only has created a continuous supply of water in excess of 10 ML/day but also a cyclic rise and fall of water levels every 24 hours reflecting peaks in city usage, creating minor flooding along parts of the drainage system. This flow of water creates a continuum of riffle-pool units along the length of the SHC. Mild eutrophication combined with the flows that maintain the riffle-pool continue, the presence of tree-lined banks more-or-less along the length of the SHC, shallow pools less than 1 m deep, are the conditions likely to optimise platypus numbers in the system. Optimisation of platypus numbers would be mitigated through the provision of suitable habitat and the stimulatory effect on benthic organisms on which platypus feed, induced by mild eutrophic conditions. Prior to the establishment of the STP, platypus numbers would have probably increased under conditions when the pool-riffle continuum was maintained and decreased in drought induced low-flow conditions.

5.0 ASSESSING PLATYPUS DISTRIBUTION AND ABUNDANCE

This programme was carried out in three phases.

- A preliminary assessment of platypus distribution and abundance along the BSC and SHC was carried out by contacting all property owners with boundaries in common with the creek and recording their observation about platypus numbers and distribution. A total of 47 property owners were phoned during April 1995 together with four targetted personnel (a WIRES member, Canobolas Park Trust Ranger, a local naturalist and a member of the Central Western Acclimatisation Society). Phone calls followed a strict protocol (see Appendix 1) and were carried out by a graduate student, Ms Heather Price. Properties covered in the survey were continuous from about the STP on BSC down to the confluence of the SHC and Lewis Ponds Creek approximately 30+ km downstream.

- As assessment of pool habitat suitable for platypus use along the BSC and SHC. Thirty nine pools were sampled along 30 km of the creek system. The number of pools sampled in relation to the class distance downstream of the STP are tabled below (Table 2).

TABLE 2
DISTRIBUTION OF SAMPLED POOLS

Distance Below STP (km)	No. Sampled
0 - 2	7
2 - 10	4
10 - 20	15
20 - 30	13

Pools were chosen on the basis of access, ease of obtaining the owner's permission to walk into the property, and the need to ensure representative sampling along the river system. A range of parameters were visually assessed at each pool based on a method developed by Bryant and Goldney described in Bryant (1992). The parameters assessed are listed in Appendix 2. These were found by Bryant (1992) to be important predictors of platypus presence or absence. Each pool was given an overall habitat rating on a 5 point scale ranging from 1 (very poor) to 5 (excellent). A 5 point rating does not necessarily equate to there being platypus present in a particular pool nor a 1 point rating the absence of platypus. No assessment of the non-pool habitat qualities of the system was attempted.

- An assessment of platypus distribution and abundance based on disciplined visual observation. A subsample of 10 pools selected from sites between the STP and the Fourth Crossing, were observed for two hours at sunrise and two hours at dusk for 5 observation sessions over 2.5 days. This represents 10 observation hours per pool and 100 observation hours in total. This work was carried out in May 1995 under a range of weather conditions by a group of graduate/postgraduate students from CSU. The method was developed by Bryant (1993) and Rohweder (1992). It represents a cost effective method for surveying presence or absence of platypus with a high level of reliability. It enables distribution and relative abundance only to be assessed. Both single and concurrent appearances of two or more platypuses were recorded together with the time of appearance.

6.0 RESULTS

6.1 DISTRIBUTION AND ABUNDANCE OF PLATYPUS BASED ON LANDHOLDER RESPONSES

The 32 Landholders contacted were located along the SHC system down to the confluences with the Emu Swamp Creek and the Lewis Ponds Creek. Eighteen respondents (56.3%) had observed platypus at some point along the creek system. However, positive (Table 3) sightings were not distributed evenly along the system. Platypus were observed throughout the Creek system from immediately below the STP through to Ophir. Platypus were also reported as present in the Emu Swamp and Lewis Ponds Creeks. A disproportionate number of sightings were made at well frequented places including the Third and Fourth Crossings on the Ophir Road and the Ophir Reserve.

TABLE 3
PLATYPUS OBSERVED BY LANDHOLDERS ALONG BSC AND SHC

Creek Section	Creek km approx.	No. Properties contacted ( )		Yes	No	O/R/?
STP to confl. with SHC	1.5	2	(2)	1	1	O
Confl. to 2nd crossing	1.0	1	(1)	0	1	?
2nd to 3rd crossing	5.0	18	(13)	5	8	O
3rd to 4th crossing	14.0	14	(10)	7	3	R-O
4th to Emu Swamp C	2.0	4	(4)	3	1	R-O
ESC to Ophir	4.0	4	(2)	2	0	R-O
Total	27.5	43	(32)	18	14	R-O

R = rarely seen
O = often seen
? = uncertain

6.2 AN ASSESSMENT OF POOL HABITAT QUALITY FOR PLATYPUS IN THE CREEK SYSTEM

Tables 4 and 5 identify the distribution of pool parameters in the system and the assessed habitat rating for each pool. The majority of pools were greater than 10 m in length and 1 m in depth, had consolidated banks, did not suffer from stock damage, were free of sand, had some or extensive native and/or willow vegetation overhang along the banks, had little or no aquatic macrophytes and green algae present and had some logs present in the pools (Table 4). Thirty one of the pools assessed (79.5%) were judged to have medium or greater habitat values (Table 5).

TABLE 4
POOL CHARACTERISTICS (n=39)

Pool Parameter					n
Length	4 < 5 m	2 × (5-10)m	10 × (10-25)m	23 > 25m	39
Depth	11 < 1m	18 × (1-2)m	10 > 2m		39
Water velocity	12 × (still)	27 × (slow)	0 × (fast)		39
Consolidated banks	28 × (yes)	11 × (no)			39
Stock damage	12 × (yes)	27 × (no)			39
Sand accumulation	32 × (none)	7 × (1-20)%	0 × (20-50)%	0 × (>50)%	39
Overhanging edge vegetation	2 × (none)	24 × (some)	13 × (extensive)		39
Type overhang	11 × (exotic)	5 × (native)	21 × (e + n)	2 - Not applic.	39
Aquatic macrophytes present	30 × (none)	7 × (1-20%)	2 × (20-50)%	0 × (>50%)	39
Green algae present	34 × (none)	5 × (1-20)%	0 × (20-50)%	0 × (>50)%	39
Logs present	7 × (none)	32 × (few)	0 × (many)		39

TABLE 5
PLATYPUS POOL HABITAT RATING

Pool Rating*	1	2	3	4	5	n
Number of Pools	5	3	14	15	2	39

1 = very poor habitat value
3 = medium habitat value
5 = excellent habitat value

6.3 PLATYPUS DISTRIBUTION AND ABUNDANCE BASED ON A SUBSAMPLE OF POOLS

TABLE 6
PLATYPUS OBSERVED IN POOL SUBSAMPLE

Pool No.	1	2	3	4	5	6	7	8	9	10
No. of observation hours	10	10	10	10	10	10	10	10	10	10
Platypus seen*	0	0	3	1	0	2	2	0	4	0

* It is not possible to differentiate between the number of platypus sightings made in a sequential series of sightings in a particular pool and the number of platypus present in the cases where two or more platypus have been together simultaneously.

The presence of platypus was demonstrated in five pools (50%) of the total sampled. These five pools returned 10 platypus observations in 25 by 2 hours observation periods (40%).

6.4 CONCLUSIONS

The data from this study confirm the anecdotal reporting from Orange people, that significant numbers of platypus are to be found in the Summer Hill Creek system. Platypus have been found to be distributed throughout the system. Approximately 80% of sampled pools had medium to high habitat quality in relation to platypus needs. Fifty percent of 10 sampled pools were found to be used by one or more platypus. The results however cannot be used to comment on the dynamics of the population. The numbers of platypus can only be described in relative terms and are judged to be common and widely distributed in the Summer Hill Creek system. The security of water supply with its mild stimulatory effects on the food chain are believed to be the critical factors in maintaining this population level.

7.0 IMPACTS ON THE REMOVAL OF UP TO 10 ML/DAY OF EFFLUENT FROM THE BLACKMANS SWAMP CREEK TO SERVICE THE NEEDS OF THE NEWCREST MINING PROPOSAL AT CADIA, ON THE SUMMER HILL CREEK PLATYPUS POPULATION

7.1 ON PLATYPUS

The proposed removal of effluent outfall from the STP will self evidently reduce the flows coming down the SHC by around 10 ML/day. This could affect the numbers of platypus in the creek system through a two fold process; loss of water in the system and a decrease in nutrient loading resulting in some loss of the hypothesised stimulatory effects on benthic organisms, both feed back loops which could impact on the population dynamics of platypus. The critical questions which need to be answered are:

a. What background levels of flow will be maintained in the SHC with the removal of the 10 ML/day effluent outfall?

b. Will these reduced flows be great enough to maintain the current platypus distribution and abundance patterns?

7.1.1 Background Levels of Flow

The limited hydrological data and the flow modelling in the creek system indicate the following:

- Under drought conditions flows of 2.14 ML/day can occur (see Section 2.0 above) in the BSC above the STP. The origin of this water is not known but is believed to probably result from household garden use in Orange City. The flow can be expected to slowly increase over the 12 year life of the Cadia Project, concurrent with the growth of the number of people in Orange in this catchment.

- The flow duration curve (Figure H-7), with and without effluent flow, predicts that for 80% of the time baseline flows downstream of the STP would be approximately 13.6 ML/day or greater, and for 95% of the time 11.3 ML/day or greater.

- Under drought conditions between 0.5-1.0 ML/day are released from the Suma Park Dam (April 1995 measurements).

- There is a natural increase in flow regime as one moves down the creek system resulting from other tributaries in the Summer Hill catchment (see Section 2.0 above).

- The present flow coming from the STP varies between 4-18 ML/day. The removal of the 10 ML/day to the Cadia site will leave approximately 2 ML/day to flow down the system. The volume of the remaining effluent outfall will increase slowly over the life of the Cadia mine due to increases in the population connected to the STP. Under current flow conditions, a 24 hour cyclic high and low flow scenario exists. This pattern will change significantly with the removal of 10 ML/day of outfall.

- Figures H-4 to H-6 in Section 2.0 above indicate the background flows under no or low rainfall scenarios, are "swamped" by a 10 ML/day flow. Under high rainfall conditions the addition of 10 ML/day becomes inconsequential. Conversely, property owners along the creek system would, under the scenario where 10 ML/day of effluent are harvested, observe significantly lower flows down SHC under "no-low" flow conditions but observe no differences under high flow conditions.

- Under the drought conditions which were extant in April 1995, the flows at the STP, minus 10 ML/day would have been of the order of 4.14 ML/day, at the junction of BSC and at SHC of the order of (4.64-5.14) ML/day. Furthermore this flow would be expected to increase with increasing inflows into the downstream system as the catchment area increases. Given that the flow duration curves predict that for 95% of the time, background flows will be of the order of 13.6 ML/day in the SHC downstream of the junction (Figure H-7), the periods of very low flows will occur infrequently.

- The creek system will, over the life of the Cadia Project reflect more nearly the natural baseline flows prior to European settlement, but will still continue to be modified by flows emanating from gardens in Orange and the remaining effluent outfall in BSC.

7.1.2 Research into Environmental Flows

Little research has been carried out in Australia to determine the riparian and environmental flows needed to maintain riverine ecosystem integrity. Rather northern hemisphere research has been modified to meet Australian conditions particularly the flood-drought extremes of the Australian environment. Richardson (1988) reviewed the four most commonly used methods to assess the minimal survival and maintenance flows for rivers and streams (The Montana Method (Tenant, 1976), Flow Duration Curve Analysis (Stainaker and Arnette, 1976), Transect Analysis (Reviewed by Stainaker and Arnette, 1976) and the Incremental Method (Boree and Milhous, 1978)). They all rely on historical flow data for their assessment. The latter two also require the input of biological data. Only the Montana Method and the Flow Duration Curve Analysis were used in this assessment.

The Montana Method

The Montana Method (Tennant 1976) uses the mean annual flow (MAF) of a river or stream as the basis for determining stream health. No biological data is required. Since this method was developed primarily for USA conditions, minimal survival flows are based on a flow regime where the mean annual flow is nearer the median flow than occurs in Australian streams and rivers. In our river systems the median flows are more likely to be less than the mean which is often skewed. Not withstanding these differences, Rooney (1988) suggested that his study in the Duckmaloi River, near Oberon, that it provides a "preliminary reconnaissance" method for predicting acceptable flow levels. Richardson, an Australian Fisheries biologist (1986) argued that the Montana Method appears to conservatively predict minimal survival and acceptable flows, at least for fish in her Tweed Heads study. The mean annual flow (MAF) immediately downstream of the confluence of the SHC and BSC is 23,500 ML/year of

64 ML/day, which excludes water harvested for Orange City Council water supply (6,500 ML/year) as well as effluent outflow from the STP. Applying the Montana Method, and using the quality of flow criteria developed by Tennant (1976), the following flows have been calculated for the SHC system against these flow criteria.

TABLE 7
INSTREAM FLOW REQUIREMENTS BASED ON MAF

Flows to produce	MAF Flows required % of MAF	ML/day at confluence of SHC and BSC
Optimum	60 - 100	38.4 - 64.0
Outstanding	50 - 60	32.0 - 38.4
Excellent	40 - 50	25.6 - 32.0
Good	30 - 40	19.2 - 25.6
Fair	10 - 30	6.4 - 19.2
Poor or minimum	10	6.4
Severe degradation	<10	<6.4

The above calculations suggest a minimum survival flow for aquatic life would be 10% of MAF or about 6.4 ML/day at the confluence of the SHC and BSC. Rooney (1988) and Goldney (1988) demonstrated in the Duckmaloi River in an empirical experiment where they were able to divert water using an existing pipeline, that at a similar flow rate (5 ML/day) in similar stream system, an acceptable environmental quality was able to be maintained. Their measurements included dissolved oxygen, edge wetness and drying in pools and riffles and richness and health of aquatic life. The mean annual flow of the Duckmaloi River at the Pipehead Weir is 21,000 ML/annum or 59 ML/day (Environmental Management, 1988). The physiography of the two systems has much in common, particularly the stream-bed cross-section. The catchment area upstream of the weir is 110 km^2 about half of the Blackmans Swamp Creek Catchment (220 km^2).

Flow duration curves modelled for the SHC system downstream of the confluence with BSC and SHC predict that flows of 11.3 ML/day can be expected for 95% of the time. Given that four additional inflow sources will still come into the system, viz:

- Outfall from the STP above the required 10 ML/day (about 2 ML/day);
- Inflow into the BSC from parks and garden run-off (up to 2.14 ML/day under drought conditions);
- Riparian release from Suma Park Downs (0.5 - 1.0 ML/day); and
- Inflows from the catchment downstream of the confluence.

then the probability of achieving a "good" Montana rating (flow rate >19.2 ML/day) is in fact greater. For about 95% of the time flows would exceed 4.5 ML/day under conditions when effluent is harvested. Non ideal conditions as judged by the Montana Method, that is flows below 6.4 ML/day, would be realised very infrequently.

Flow Duration Curve Analysis

This method was developed by Stainaker and Arnette (1976). Monthly flow duration curves are used to recommend the 80th percentile flow for minimum habitat maintenance and the 40th percentile flow for suitable spawning conditions to occur. No biological data is required. Eighty percent of the time, flow rates as great as or exceeding 13.6 ML/day would be predicted to occur.

7.1.3 Maintaining Current Population Level of Platypus

It is probable that the current levels of platypus in the SHC system may be artificially high due to those factors already outlined above, compared to the scenario before the input of sewage outfall into the system. Impacts on the platypus can be expected to be two fold;

Loss of productivity in the stream system due to loss of nutrient load and the stimulatory effects on benthic organisms due to mild eutrophication. It is not possible to quantify this effects, but is unlikely to be very significant.

Decrease in water flow in the system which could be expected to impact on the distribution and abundance of the species. Goldney (unpublished) has just completed an assessment of the effects of reduced flows (sometimes less than 5 ML/day) on the platypus population in 3 km of river section immediately downstream of the Duckmaloi Weir. He could find no difference in the numbers of animals captured before and after increased off-take via a pipeline was affected from the pipehead weir. The period of study (1990 - 1995) included both wet and dry years. At times the flow of water over the weir was estimated to be only 1-2 ML/day. Nevertheless the pool riffle complex appeared to be maintained in this narrow river. Even under a drought scenario as severe as the 94/95 drought, at least 4-5 ML/day of water would have been available for instream flow after the harvesting of 10 ML/day. In addition there is the additional inflow with increasing distance down the catchment. This flow of water would appear to be great enough to maintain the riffle-pool complex in the SHC albeit at a sub optimal level. The numbers of platypus would probably decrease under such a regime if it persisted for significant periods of time. However, given that the predicted flows have a high probability of delivering about 4.5 ML/day into the system or about 80% of the time, the actual impacts of the proposed off-take may have only a marginal effect on the platypus population, provided the off-take is managed in an appropriate manner.

8.0 RECOMMENDATIONS

1. The off-take of water from the STP should not exceed 10 ML/day.

2. The off-take should be regulated so that the unutilised outfall is released into BSC at a more or less constant rate within a 24 hour cycle, thus preventing excessive rises and falls in the creek system, an action which could cause a significant impact on aquatic organisms, particularly under lower flow conditions.

3. The actual flows of water after off-take to Cadia commences, should be gauged above the STP on BSC, at the confluence of the BSC and SHC, and at the Third and Fourth Crossings, so that changes in downstream water flow can be related to changes in system ecology.

4. The platypus population, water quality and creek ecology should be the focus of an integrated monitoring programme which will assess changes before and after off-take commences.

5. A brochure should be prepared to prepare Landholders downstream as to the likely impacts of the water harvesting programme, its effects on Landholders and wildlife.

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APPENDIX 1

SUGGESTED APPROACH TO PHONING LANDHOLDERS RE PLATYPUS ALONG SUMMER HILL CREEK SYSTEM

1. Introduce yourself by name as an employee of Charles Sturt University, working for A/Professor David Goldney. You are part of a team looking at the possible effects of the proposed mining development at Cadia on platypus and the river environment downstream from the Orange Sewage Treatment works.

2. Explain that the Newcrest Mining Company is looking at the option of using the treated outflow from the Orange Sewage treatment works, which normally flows down the Summer Hill Creek, in the proposed mine development at Cadia. Most of the 10 ML flow generated each day would be used in the mining process, thus reducing the available water flowing down the Creek. Rain induced water flows, that is the natural flows which would have been present prior to the construction of the sewage treatment works would not be affected by the proposed development.

3. We are particularly interested to tap into local resident's knowledge about platypus in the Summer Hill Creek, particularly those with a creek frontage. Would you be prepared to answer a few questions? You will not be identified in any report which results from this survey.

APPENDIX 2

PLATYPUS HABITAT - POOL SURVEY

APPENDIX 1
PLATYPUS HABIT - POOL SURVEY

Site: Distance from Sewage Works:				
Pool length	<5 m	5 - 10 m	10 - 25 m	> 25 m
Pool depth	<1 m	1 - 2 m	>2 m	
Water velocity	Still	Slow	Fast	
Consolidated banks	Yes	No		
Stock damage	Yes	No		
Sand accumulation	None (0%)	1 - 20%	20 - 50%	50+%
Overhanging vegetation	None	Some	Extensive	
Type of overhanding vegetation	Native	Exotic	Mixture	
Aquatic macrophytes	None	1 - 20%	20 - 50%	50+%
Aquatic algae	None	1 - 20%	20 - 50%	50+%
Number of logs	None	Few	Many	
Overall habitat rating (1-5)				

1 = very poor
2 = excellent