of the Authorisation at some stage of the operation. The greatest potential for the amenity criterion to be exceeded will be in the early years of mining.

Various dust control measures and safeguards have been built into the mine design and include the provision of bund walls, the placement of haul roads as far west from the site boundary as possible, and the use of terrain to shield the area which is located to the east of the project site from the traffic on the haul roads and other dust generating activities such as dumping of rock material.

The effect of all those measures on the dispersal of dust particles from the mine site and thus on the expected rates of dust deposition at locations outside the site was able to be included only partly in the modelling predictions. As a result, the modelling predictions are likely to be conservative and the actual dust deposition rates may be lower than the predicted values. On-going monitoring programmes will be carried out throughout the project life and thus provide information concerning the efficiency of the proposed dust controls and the relationship between the predicted and actual deposition rates.

A similar situation in relation to a potential for dust deposition in excess of the amenity criterion will exist outside the southern Authorisation boundary especially in the latter years of mining. This area may also be affected at some stage by mining at the adjacent Bengalla mine.

The envelope of contour lines in Figure 6.2 indicated a potential for increased dust deposition in excess of the amenity criterion outside the north-western corner of the Authorisation. The potentially affected area will be located directly downwind of mining and out-of-pit emplacement activities in frequent south-easterly winds. The extent of this generally non-residential area is shown in Figure 6.2.

Although in excess of the amenity criterion, increments in the mean annual dust deposition rates of more than 2.0 g/m2/month, and up to a maximum of about 8.0 g/m2/month as predicted near the boundary itself, do not normally affect non-residential land uses such as grazing to any significant degree.

Fine reject emplacement is proposed for the area which is located to the west of the western boundary of the Authorisation. Two gullies have been chosen to be sectioned into a series of separate storage dams. Each storage dam will be filled with fine reject pumped from the coal preparation plant (CMPS&F, 1997).

The internal storage walls will be constructed from coarse reject material. It is expected that approximately 5 per cent of the material will be used every year with a further

5 per cent for capping of completed dams. The dams will then be revegetated.

The total amount of coarse rejects to be used as construction material will be small requiring approximately 100 truck movements every year. Use of a water truck will control dust emissions from the haul road and from the construction. Two to three scrapers and a compactor will be involved in the construction together with a grader for final trimming.

All activities related to the construction, operation and rehabilitation of the fine reject emplacements will take place within the limits of the land acquired by the Company. The small size of dust generating activities at any given time and dust suppression measures will ensure that dust emissions will be only minor and remain largely confined to the immediate vicinity of the operation and thus within the Company owned land.

The land which will be used for the purpose of receiving fine reject material will also serve as an effective buffer for dust emissions generated by the activities at the out-of-pit emplacement (SW dump) and the coal handling and preparation plant under the influence of frequent south-easterly winds.

Product coal will be reclaimed from the product stockpile and conveyed to a loading bin at the rail loading loop. The loop will be constructed on a portion of land which has to be acquired for mining purposes. Use of conveyor systems, an enclosed loading bin and advanced coal loading procedures ensure that emissions of coal dust from the coal loading operation remain very small and will not affect the levels of dust in the air at the nearest privately owned properties.

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 fallout. The effects of inhaled dust are specifically related to the types of particles inhaled, the particles' size, 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) recommended mean annual concentration of 90 ug/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 ug/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 ug/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 ug/m3 as its objective but not the secondary standard of 150 ug/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 also 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 micrograms/m3. Similarly, the maximum concentrations of PM10 over an interval of 24 hours are limited to 150 micrograms/m3.

Recent epidemiological studies have reported consistent associations between PM10 concentrations and health effects. PM10 consists of two size fractions which have different physiological as well as source characteristics. Fine size fractions of less than 2.5 microns in diameter (PM2.5) were found to be specifically responsible for the observed associations with the health effects.

Mechanically generated particles from mining and related sources are generally larger than 2.5 microns. Consequently, the implication of the results of the epidemiological studies is a need to place the emphasis on promoting those control strategies which target fine particles (PM 2.5) as produced by direct emissions from other (non-mining) sources and by secondary reactions of pollutants related to combustion.

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 in relation to dust concentrations during the five selected years of mine development are shown in Figure 6.3. 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, 80 and 150 micrograms/m3 were used in the figures.

Year 2

The predicted increases in the mean annual concentration of total suspended particulates (TSP) in the ambient air in Year 2 of mining are presented in Figure 6.3(a). The main trends in the predicted dust levels which were displayed earlier by the dust deposition contours are also evident in the contour maps of TSP concentrations. The shape of the predicted concentration isopleths was again determined by the location of main dust sources and the prevailing wind direction.

The NHMRC guideline of 90 micrograms/m3 refers to a total concentration of TSP in the ambient air in residential environments. Taking into account the measured existing mean annual concentration of about 40 micrograms/m3, an increase of 50 micrograms/m3 would be needed for the total concentration to reach a limit of 90 micrograms/m3.

An increase of that magnitude will be almost entirely contained within the Authorisation boundary in Year 2.

Residential areas of Muswellbrook and South Muswellbrook and the area surrounding the racecourse were all predicted to receive an annual increment of less than 20 micrograms/m3.

Year 5

The predicted increases in the mean annual concentration of TSP as a result of mining in Year 5 are shown in Figure 6.3(b). The contour line which corresponds to a predicted increase of 50 micrograms/m3 is again almost entirely contained within the eastern and southern boundaries of the Authorisation.

Mean annual concentration of TSP in the township of Muswellbrook was predicted to increase by less than 20 micrograms/m3. The area surrounding the racecourse would receive about 15 micrograms/m3.

In the northern section, mining in the North Pit and prevailing south-easterly winds were predicted to place the contour line of 50 micrograms/m3 to about 1000 metres north of the northern boundary. This land is not used for residential purposes.

Year 10

Increased mining activity in the South Pit was predicted to bring the contour line corresponding to an increase in the mean annual concentration of 50 micrograms/m3 to about 300 metres outside the eastern Authorisation boundary. The predicted isopleths are shown in Figure 6.3(c).

Muswellbrook, South Muswellbrook and the area surrounding the racecourse were all predicted to receive TSP increments of less than 20 micrograms/m3.

Mining in the North Pit and the use of an out-of-pit emplacement area into the northwest of the Authorisation were predicted to result in the mean annual concentration of TSP increasing by 50 micrograms/m3 within an area which was delineated by the contour line in Figure 6.3(c).

Year 15

By Year 15, the contour line of 50 micrograms/m3 in Figure 6.3(d) was predicted to be again almost entirely contained within the eastern boundary of the Authorisation.

Residential areas of Muswellbrook, were predicted to receive a mean annual increase of less than 20 micrograms/m3. South Muswellbrook and the area surrounding the racecourse were predicted to receive between 20 and 25 micrograms/m3, and 20 and 30 micrograms/m3 respectively.

Continuation of out-of-pit emplacement activities in the north-western section of the project site will have a similar effect on the concentrations of TSP in the ambient air in that area as in Year 10. The extent of the contour line corresponding to an annual increment of 50 micrograms/m3 outside the site boundary was predicted to be reduced as shown in Figure 6.3(d).

Year 20

Mining in the South Pit will increase in Year 20 and the 50 ug/m3 contour line was predicted to extend up to 250 m outside the eastern Authorisation boundary. Outside the southern boundary, the 50 ug/m3 contour line was predicted to extend of up to 850 m downwind from the operation.

The town of Muswellbrook was predicted to receive an increment of less than 20 micrograms/m3, South Muswellbrook less than 25 micrograms/m3 and the area surrounding the racecourse less than 30 to 35 micrograms/m3.

In the north-western corner, the maximum extent of the contour line corresponding to a mean annual increment of

50 micrograms/m3 was reduced to about 1500 m.

6.2.3. Impact assessment

Figure 6.4 shows an envelope of predicted increases of 50 micrograms/m3 in the mean annual concentration of TSP as a result of mining at Mt. Pleasant. An increase of 50 micrograms/m3 would be needed to raise the total concentration from the current level of about 40 micrograms/m3 to the NHMRC objective for residential environments of 90 micrograms/m3.

The envelope of contour lines in Figure 6.4 is again a conservative estimate of the area within which there is a potential for the NHMRC objective for residential environments to be exceeded at some stage of the project development. The corresponding contour lines shown in Figure 6.4 outside the eastern Authorisation boundary indicated that a narrow strip of land up to 300 m wide, could be potentially affected by an annual increase in TSP concentrations.

Operations during the latter years of mining were predicted to be able to raise mean annual concentrations of TSP in the ambient air to values in excess of the objective in the areas located to the south and the north-west of the mine site. Overall, however, the area covered under the envelope of TSP contour lines in Figure 6.4 is smaller than the area covered under the envelope of dust deposition contour lines in Figure 6.2.

The NSW EPA has also included an annual concentration of 50 micrograms/m3 in relation to that portion of total suspended particulates (TSP) which have an aerodynamic diameter smaller than 10 microns (PM10). The PM10 particles typically form about 50 per cent or less of the TSP particles. As a result, the NSW EPA objective in terms of PM10 particles is likely to be met or bettered in those areas in which the objective in terms of TSP particles is met.

6.3. Estimates of Cumulative Dust Levels

Operating coal mines are located mostly further south from Muswellbrook and the proposed mine at Mt. Pleasant. Muswellbrook Coal operates its mine to the east of Muswellbrook on the northeastern side of the New England Highway. The development of an underground mine has commenced at Dartbrook approximately 6 km to the north of the northern side of Muswellbrook. Extension of mining at Bayswater Colliery into an area known as Bayswater No.3 was approved in 1995. Mining at Bayswater No.3 will take place at a distance of about 10 km to the southeast of Muswellbrook. Development of the Bengalla mine was proposed and has now been approved for the site which adjoins the Mt. Pleasant site in the south.

Existing levels of dust deposition and TSP/PM10 concentrations in the ambient air around Muswellbrook and the proposed site at Mt. Pleasant were documented in Section 2. The monitoring results reflect the presence of operating mines in the subregion, power generation activities as well as dust emissions released by traffic and agricultural activities.

In order to assess the potential for an accumulation of atmospheric dust resulting from the proposed developments in the area to the west of Muswellbrook including the Mt. Pleasant project, EIS documents which have been published for Dartbrook, Bayswater No.3 and Bengalla mines were used to obtain information concerning dust emissions from each of those developments. The positions and the extent of isopleths which correspond to a predicted increment of 2.0 g/m2/month in the mean annual dust deposition rate were extracted from the EIS documents and transposed on the map of the area shown in Figure 6.5. Also transposed on the map were the corresponding isopleths for Mt. Pleasant as shown earlier in Figure 6.2.

It is evident from Figure 6.5 that the developments at Dartbrook and Bayswater No.3 are located at such distances from both the Bengalla and Mt. Pleasant sites which effectively separate their respective areas of affectation in terms of dust levels. A similar situation exists in relation to the separation distance between the Muswellbrook mine in the east and Mt. Pleasant and Bengalla in the west. It is therefore necessary to consider the potential for cumulative dust levels with regard to the proposed Bengalla and Mt. Pleasant mines.

Figure 6.6 shows the combined isopleths from the proposed operation of the Bengalla and Mt. Pleasant mines. The isopleths refer to increments in the mean annual dust deposition rate as determined from the published predictions for operations in Year 14 at Bengalla and the predicted values for Year 10 at Mt. Pleasant. The combined isopleths represent a 'worst-case' scenario combining the two operations at their peak activity.

The combined isopleth of 2.0 g/m2/month which represents an increment in the mean annual dust deposition rate for the 'worst-case' scenario in Figure 6.6 remained restricted to an area located to the west of Muswellbrook. Increments of about 1.0 g/m2/month in the mean annual deposition rate were indicated for Muswellbrook and between 1.0 and 1.5 g/m2/month for South Muswellbrook should the mining activity at Bengalla and Mt. Pleasant reach its peak at the same time.

Details of another proposed coal mining operation, the Kayuga mine, started emerging towards the end of this study. The mine is considered for operation on the land which adjoins the northern boundary of the Authorisation at Mt. Pleasant. Whilst a full air quality assessment of the Kayuga mine is yet to be published, an agreement between the two proponents enabled a preliminary assessment of the cumulative effects to be included in this document. Modelling predictions of dust levels have been exchanged between the two project teams. Figure 6.7 shows the position and extent of 2.0 g/m2/month isopleths which were predicted individually for the developments at Mt. Pleasant and Kayuga.

It is evident from Figures 6.5 and 6.7 that the distance between the proposed mine at Kayuga and the mine at Bengalla is such as to separate their zones influence on ambient air quality. This finding is also consistent with the findings of the Upper Hunter Cumulative Impact Study (DUAP, 1996) which identified the localised nature of potential accumulation of atmospheric dust in a close vicinity to operating mines.

The cumulative effect of mining at Mt. Pleasant and Kayuga was then assessed using the same approach as for Mt. Pleasant and Bengalla earlier in this section. Assuming similar starting dates for both projects, the isopleths which were predicted for Year 2 of both operations were combined in Figure 6.8(a). At the early stage of development, the Kayuga mine would be at its most eastern extent whilst the mine at Mt. Pleasant would operate in the southeastern section of the Authorisation. The Kayuga mine will then progress further west gradually reducing dust deposition rates in the east as illustrated in Figure 6.7. As a worst-case scenario, a combination of Year 5 at Mt. Pleasant and Year 2 at Kayuga was added to Figure 6.8(a).

The situation near the completion of the first 20 years of operation at both mines was depicted in Figure 6.8(b). Figure 6.8(b) shows the estimated position of a combined 2.0 g/m2/month isopleth due to dust emissions from the two developments.

It is evident from Figures 6.8(a) and 6.8(b) that the potential for extending the area of influence as a result of cumulative emissions is far greater in the northwestern section towards the end of the first 20 years of operation than in the northeast at the early stage of mining. The latter is the result of an effective separation of the two operations in the early years of mining and the presence of prevailing SE and NW winds in the area.

The land which is located to the west and northwest of the proposed Kayuga and Mt. Pleasant mines is used predominantly for non-residential purposes, mostly grazing.

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.

The nature, strength and duration of a dust episode are determined by a variety of factors which are not easily quantified. Realistic predictions of dust concentrations in the air during the episodic event are more difficult to achieve than corresponding predictions of annual dust levels.

The Upper Hunter Cumulative Impact Study which was recently undertaken by the Department of Urban Affairs and Planning stated in relation to short-term air quality that despite the occurrence of short-term episodic events, there appears to be no evidence to suggest that long-term pollution goals are being exceeded.

The study also found that the short-term dust episodes had only localised effects and were limited to impacts on amenity, not on health.

Current experience indicates that in locations which are situated near operating mines, dust episodes are more frequent and lead to higher short-term concentrations of wind-blown dust in those locations for which the long-term predictions of annual dust levels indicated reduction in amenity. It was shown above that the locations at which the amenity criterion of 2.0 g/m2/month (mean annual increment) would be reached remained restricted to land outside the town of Muswellbrook.

The DUAP study draws attention to the fact that there is community concern at the intensity of episodic events such as visible blowing dust which occurs on windy days during dry periods and during blasting. It, however, concludes that no adverse effects on community health would be expected in the Upper Hunter due to dust emissions from coal mines. This conclusion takes into account the current range of air quality safeguards and dust control measures which are implemented at the mines.

The Mt. Pleasant mine as well as Bengalla and Kayuga will operate under strict EPA licence conditions which are designed to control dust emissions during intervals of dry weather and high winds. These dust control measures will be implemented in addition to the standard controls which were incorporated into the estimates of mean annual emissions during the modelling study. It is therefore not expected that atmospheric dust would escape during the isolated dust episodes and reach the residential areas of Muswellbrook in such quantities which could cause dust nuisance.

7. CONCLUSIONS

The generation and dispersion of atmospheric dust from the proposed Mt. Pleasant mine were examined and quantified. The mine will operate with standard dust controls and be subject to a range of approval and licence conditions.

Various dust control measures and safeguards have been built into the mine design and include the provision of bund walls, the placement of haul roads as far west from the site boundary as possible, and the use of terrain to shield the general area which is located to the east of the project site from the traffic on the haul roads and other dust generating activities such as dumping of rock material.

Five years of the proposed operations, Years 2, 5, 10, 15 and 20 were used to develop inventories of dust emissions. The calculated dust-to-coal ratios of between 0.82 and 1.21 kg/t were in a general agreement with the results of dust emission inventories for a number of open cut coal mines in the Hunter Valley. The value of 1.21 kg/t which was calculated for Year 2 reflected the initial stage of the project development with a low production of coal. The highest total emissions were estimated for years 10 and 15 of mining.

Monitoring results of existing dust deposition rates in the area surrounding the proposed development indicated mean annual levels of less than 2.0 g/m2/month. Hence, the impact of the dust emissions from the operation of the Mt. Pleasant mine was assessed by a direct reference to the EPA objective for protection of amenity by using dispersion modelling techniques which included meteorological data collected directly at the project site.

As a result of on-site monitoring, the most recent 24 months of records were used for inclusion in the air quality modelling.

Seasonal and annual wind roses for the Mt. Pleasant site confirmed a general orientation of the prevailing winds along the NW-SE axis which corresponds to the orientation of the Hunter Valley. Winds from the south-eastern quadrant were particularly frequent during the afternoon and evening. The highest proportion of winds from the north-western quadrant was recorded at night and in the morning.

Generally south-easterly winds dominated the summer season both in terms of frequency of occurrence and strength. About two thirds of all recorded wind directions were from between S and E in summer. These winds also accounted for 85 per cent of the recorded hourly speeds in excess of 30 kph.

The frequency of winds from a sector between W and N was approximately 25 per cent in summer. Winds from the remaining directions corresponding to north-eastern and south-western quadrants remained only infrequent.

In winter, the prevailing winds were from a sector between W and N accounting for about 60 per cent of the recorded directions. Nighttime and mornings were the times when W to N winds were most frequent. Winds from a sector between S and E accounted for about 30 per cent of the wind directions in winter.

The results of conservative modelling predictions were summarised in Figure 6.2. The figure shows an envelope of predicted mean annual increments in dust deposition equal to 2 g/m2/month from the operations at Mt. Pleasant and indicates that the amenity criterion may be exceeded within a narrow strip of land, approximately 700 to 800 m wide, outside the eastern boundary of the project site at some stage of the operation.

A similar result was obtained for the land which is located immediately to the south of the southeastern corner of the lease area and contains the Bengalla mine. The highest potential for dust deposition would be in the later years of the Mt. Pleasant operations when the Bengalla mine has progressed further to the west.

The results also indicated a potential for increased dust deposition in excess of the amenity criterion outside the north-western corner of the mine site. This generally non-residential area will be located directly downwind of mining and out-of-pit emplacement activities in frequent south-easterly winds. The predicted dust deposition rates for this area do not however affect non-residential land uses such as grazing.

With respect to the residential areas of Muswellbrook, the predictive results for the proposed Mt. Pleasant mine alone and, most importantly, for both the Mt. Pleasant and Bengalla mines combined, and Mt. Pleasant and Kayuga mines combined, showed that the increment in dust deposition in the town of Muswellbrook would remain within the EPA amenity criteria at all times of the operation.

In order to assess the potential for an accumulation of atmospheric dust resulting from the proposed developments in the area to the west of Muswellbrook including the Mt. Pleasant project, EIS documents which have been published for Dartbrook, Bayswater No.3 and Bengalla mines were used to obtain information concerning dust emissions from each of those developments.

It is evident from Figure 6.5 that the developments at Dartbrook and Bayswater No.3 are located at such distances from both the Bengalla and Mt. Pleasant sites which effectively separate their respective areas of affectation in terms of dust levels.

A similar approach was used to assess the cumulative effects from mining at Mt. Pleasant and the proposed development at Kayuga. The results were shown in Figures 6.7 and 6.8.

The combined isopleths represented 'worst-case' scenarios involving the adjoining operations at their peak activity in each case.

Despite the fact that the predictions were derived using conservative assumptions and thus are expected to be higher than the actual levels, the combined isopleths of 2.0 g/m2/month remained restricted to an area located to the west of Muswellbrook.

The modelling predictions showed further that in all those locations in which the amenity criteria for dust deposition will be met, the NHMRC and NSW EPA objectives for annual concentrations of TSP/PM10 in the ambient air will also be met. As the dust particles from mining activities are generated by mechanical forces (grinding, breaking), their shape, size and composition are significantly different from the particles which may be present in the ambient air as a result of combustion and industrial processes.

Recent epidemiological studies have reported consistent associations between PM10 concentrations and health effects. PM10 consists of two size fractions which have different physiological as well as source characteristics. Fine size fractions of less than 2.5 microns in diameter (PM 2.5) were found to be specifically responsible for the observed associations with the health effects.

Mechanically generated particles from mining and related sources are generally larger than 2.5 microns. The implication of the results of the epidemiological studies is a need to place the emphasis on promoting those control strategies which target fine particles (PM 2.5) as produced by direct emissions from non-mining sources and by secondary reactions of pollutants related to combustion.

There is community concern at the intensity of episodic events such as visible blowing dust which occurs on windy days during periods of dry weather and immediately after blasting. A range of air quality safeguards and dust control measures will be required for implementation by the EPA licence conditions in order to minimise the intensity and the frequency of episodic events. Short-term dust episodes will thus be limited to localised effects such as visible dust near the operation.

A recent study by the Department of Urban Affairs and Planning found that despite the occurrence of short-term dust episodes near operating coal mines there was no evidence to suggest that pollution goals were being exceeded and that public health was adversely affected.

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APPENDICES

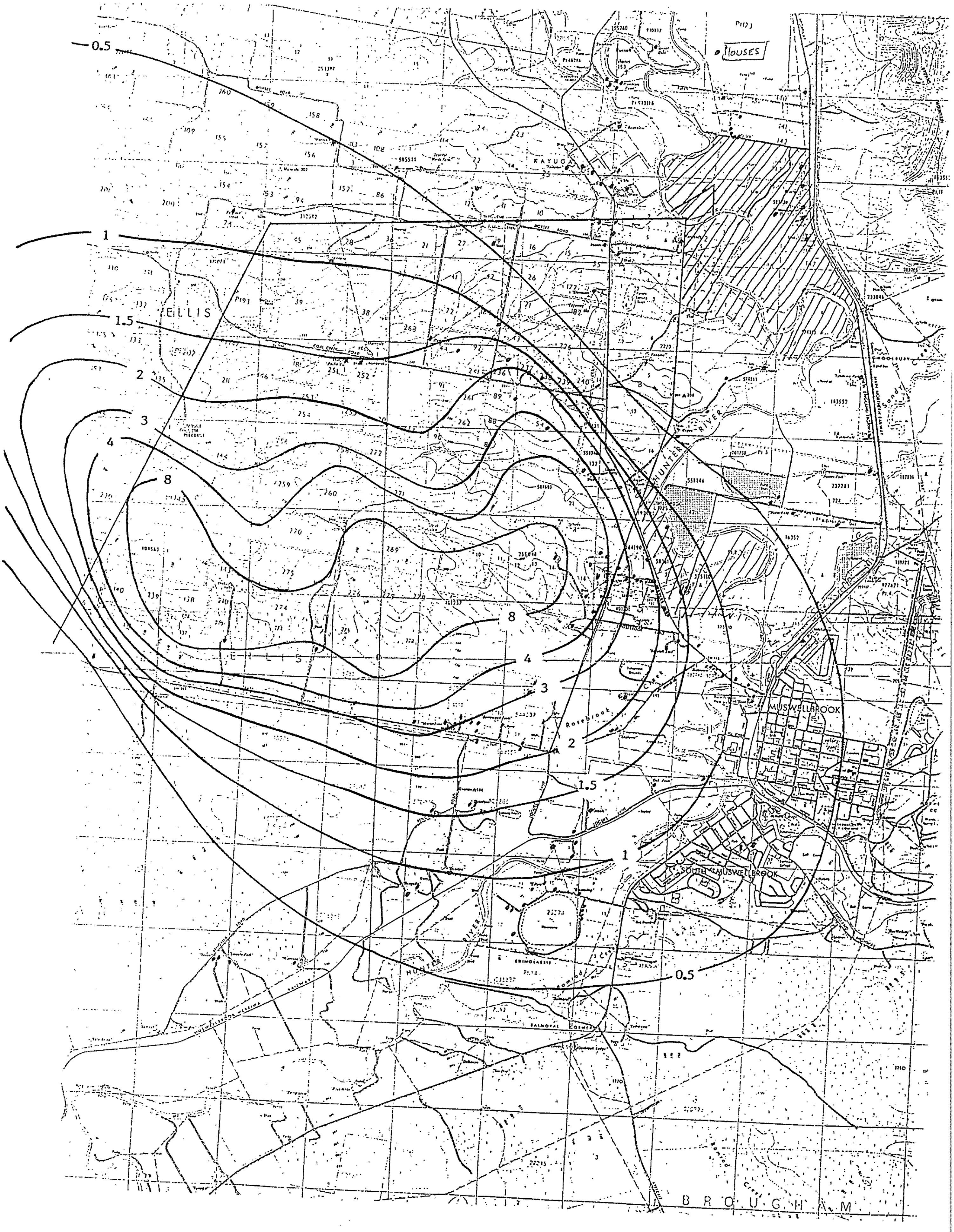


Figure 6.1(a) Predicted increases in the mean annual dust deposition (g/m2/month) - Year 2.

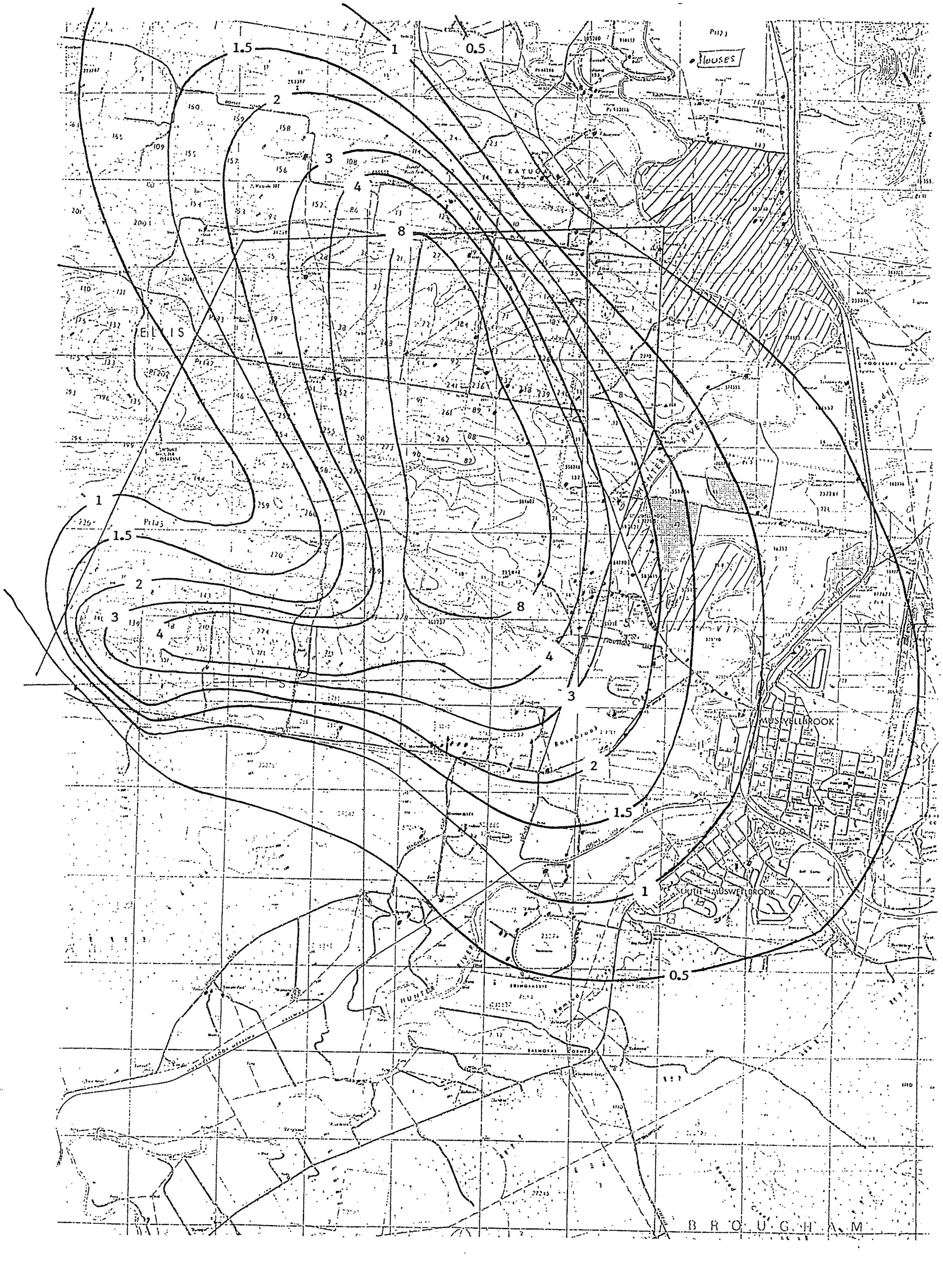


Figure 6.1(b) Predicted increases in the mean annual dust deposition (g/m2/month) - Year 5.

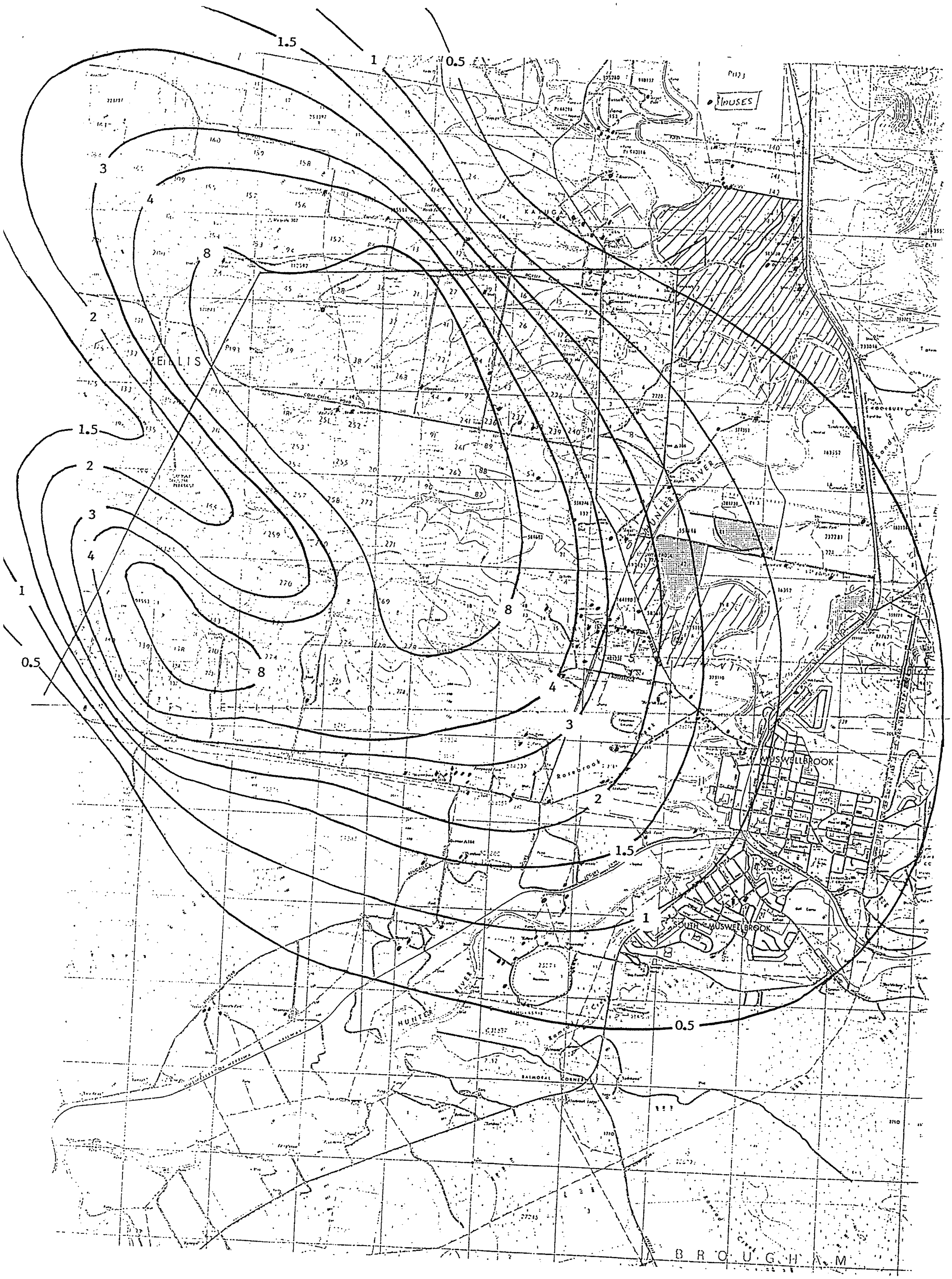


Figure 6.1(c) Predicted increases in the mean annual dust deposition (g/m2/month) - Year 10.

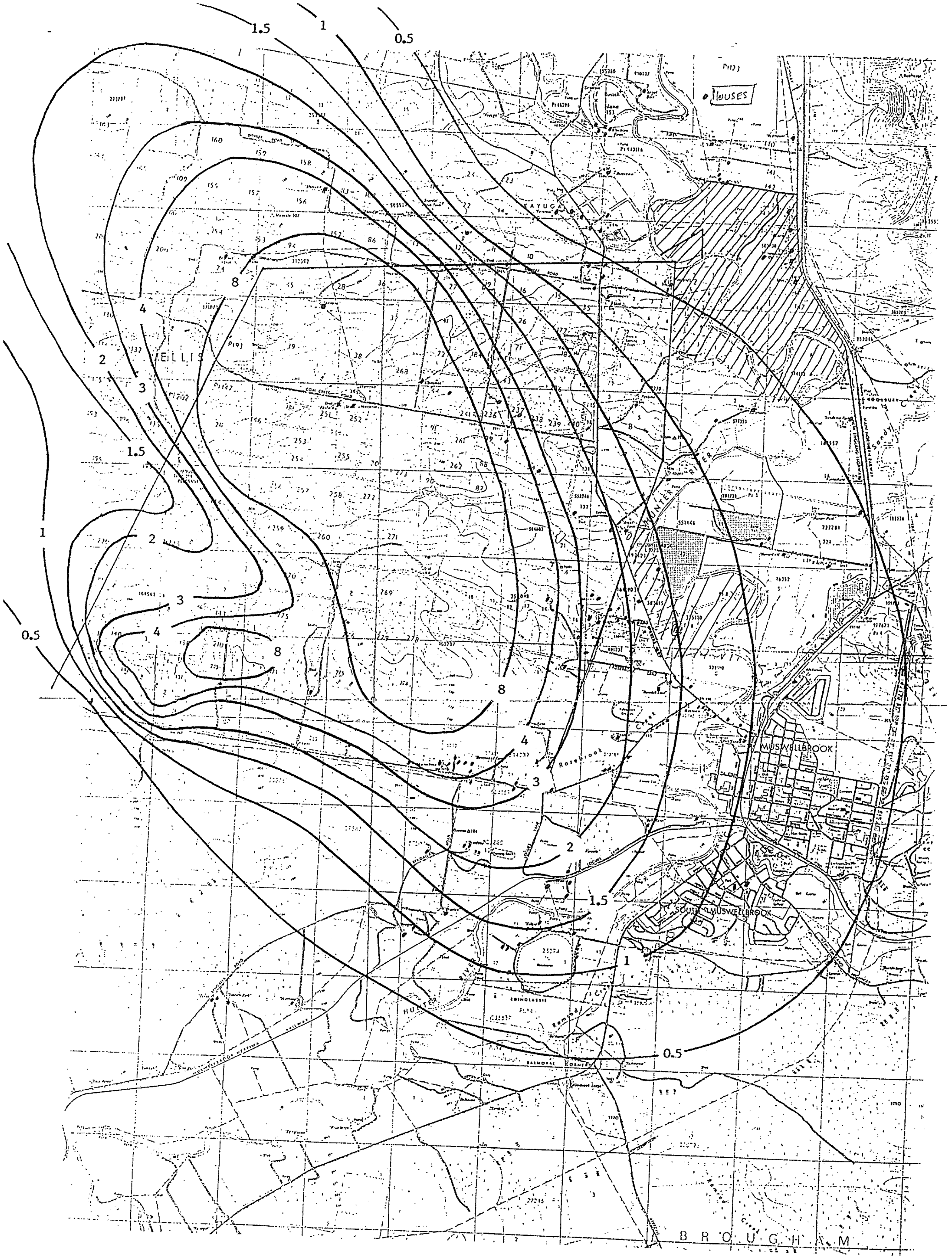


Figure 6.1(d) Predicted increases in the mean annual dust deposition (g/m2/month) - Year 15.

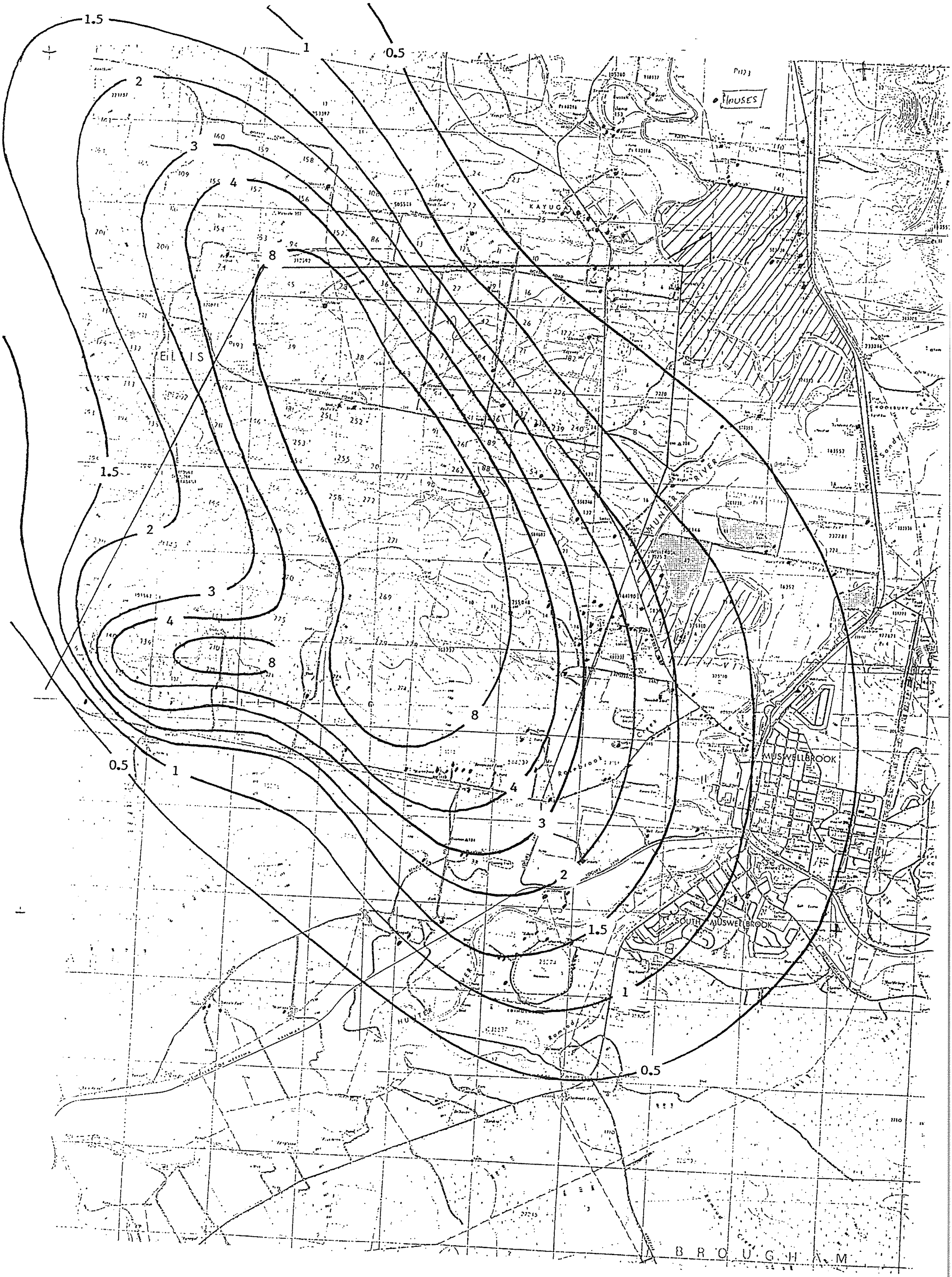


Figure 6.1(e) Predicted increases in the mean annual dust deposition (g/m2/month) - Year 20.

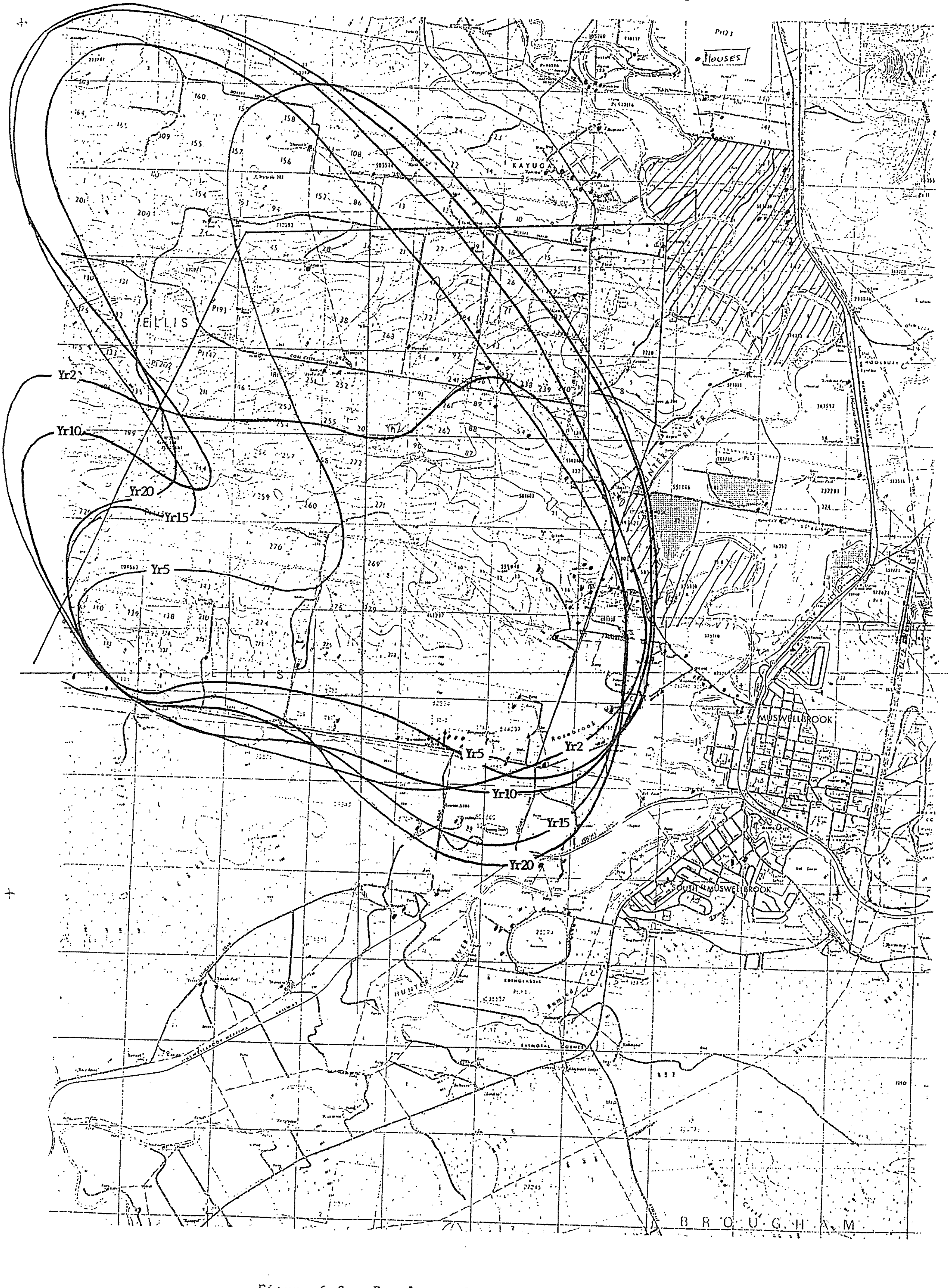


Figure 6.2. Envelope of contour lines corresponding to a predicted increase in mean annual dust deposition of 2.0 g/m2/month.

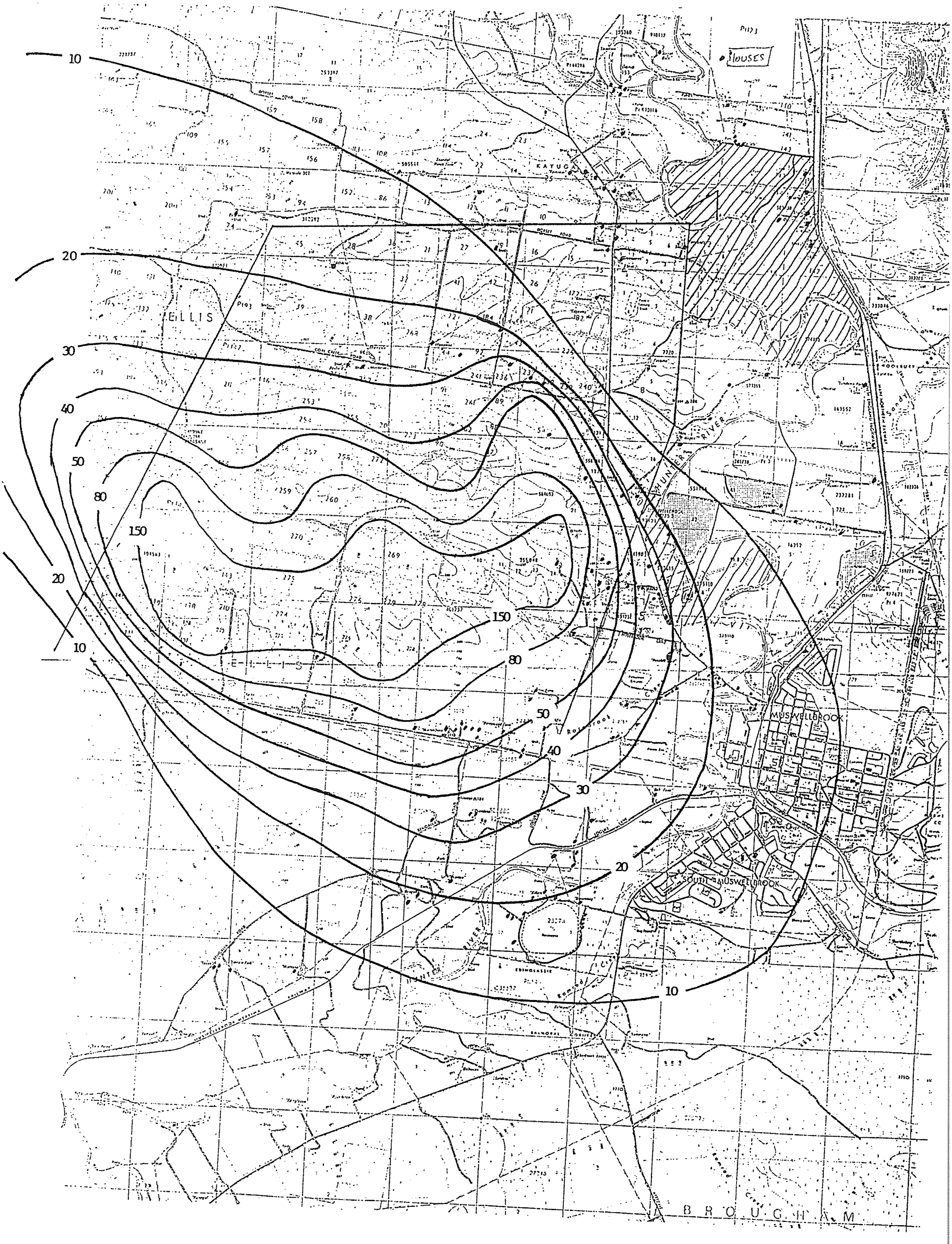


Figure 6.3(a) Predicted increases in the mean annual concentration of TSP (micrograms/m3) - Year 2.

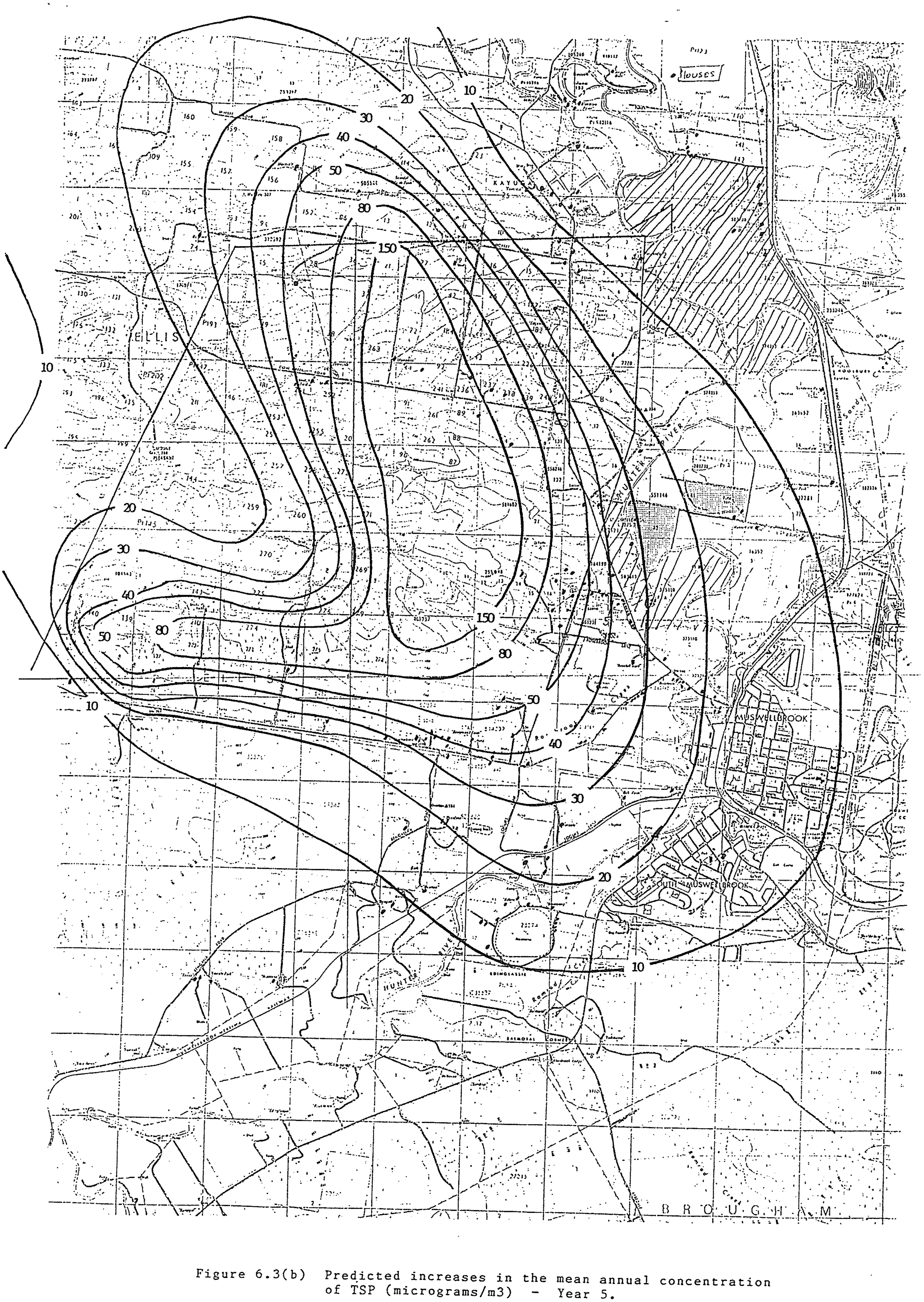


Figure 6.3(b) Predicted increases in the mean annual concentration of TSP (micrograms/m3) - Year 5.

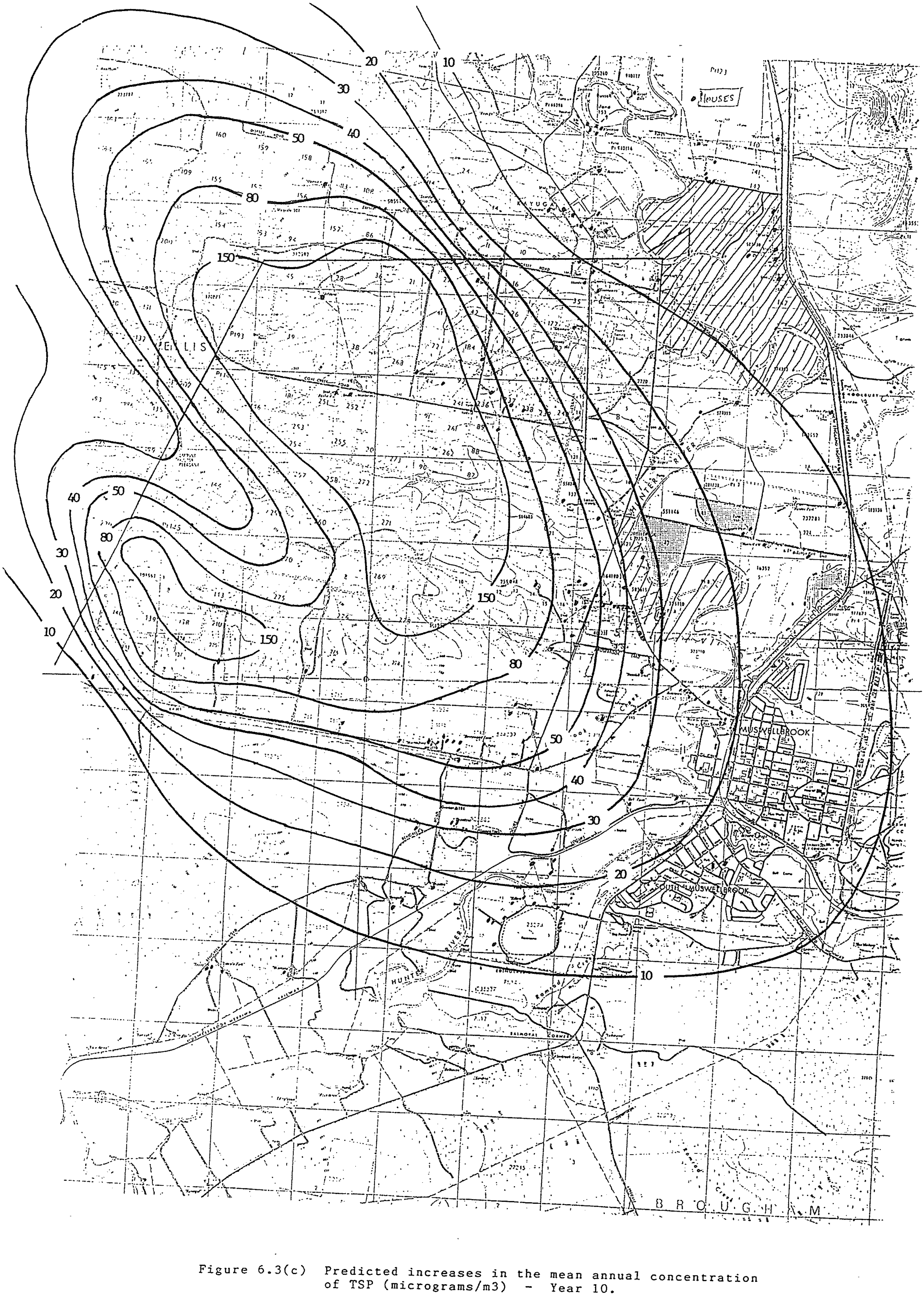


Figure 6.3(c) Predicted increases in the mean annual concentration of TSP (micrograms/m3) - Year 10.

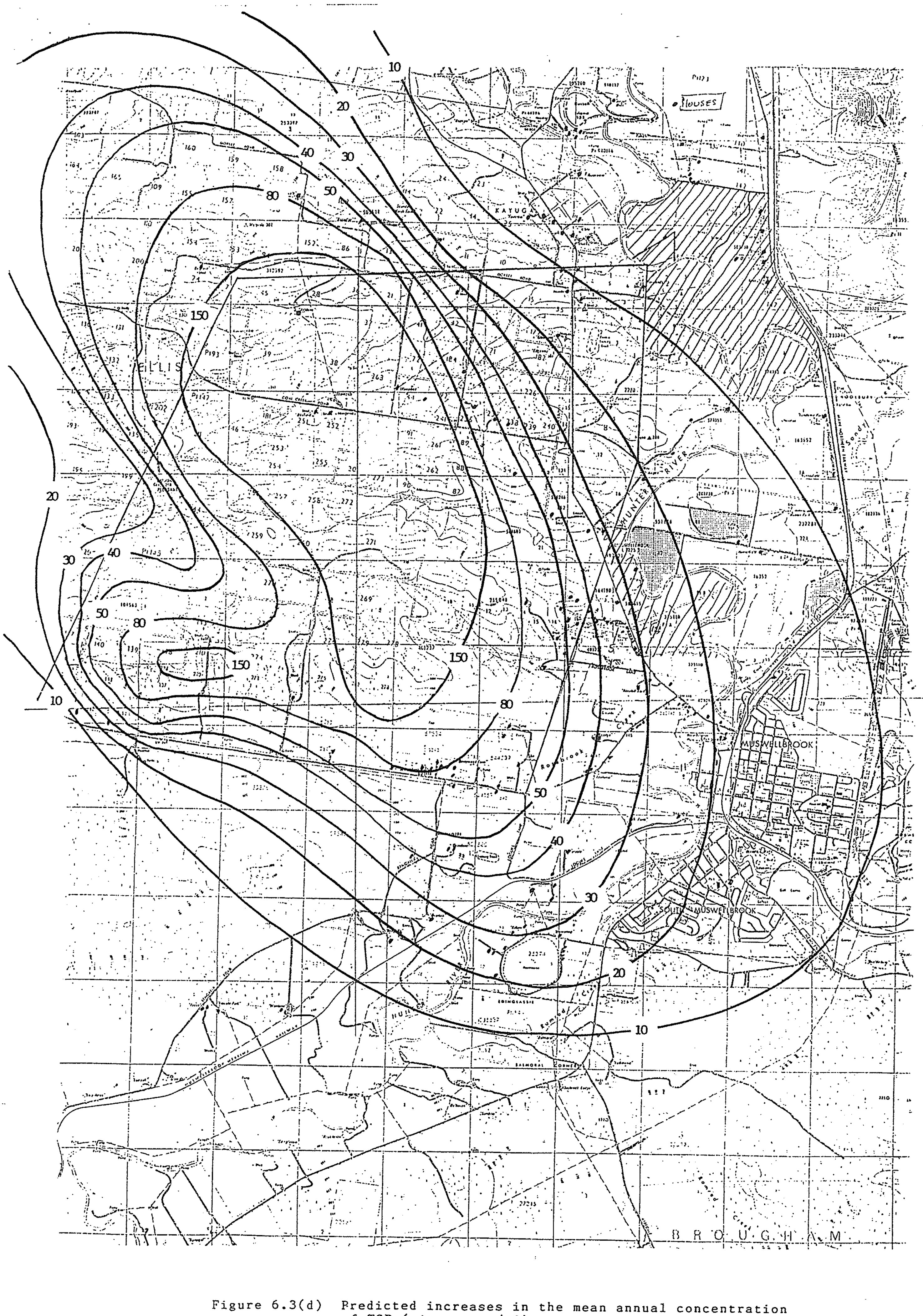


Figure 6.3(d) Predicted increases in the mean annual concentration of TSP (micrograms/m3) - Year 15.

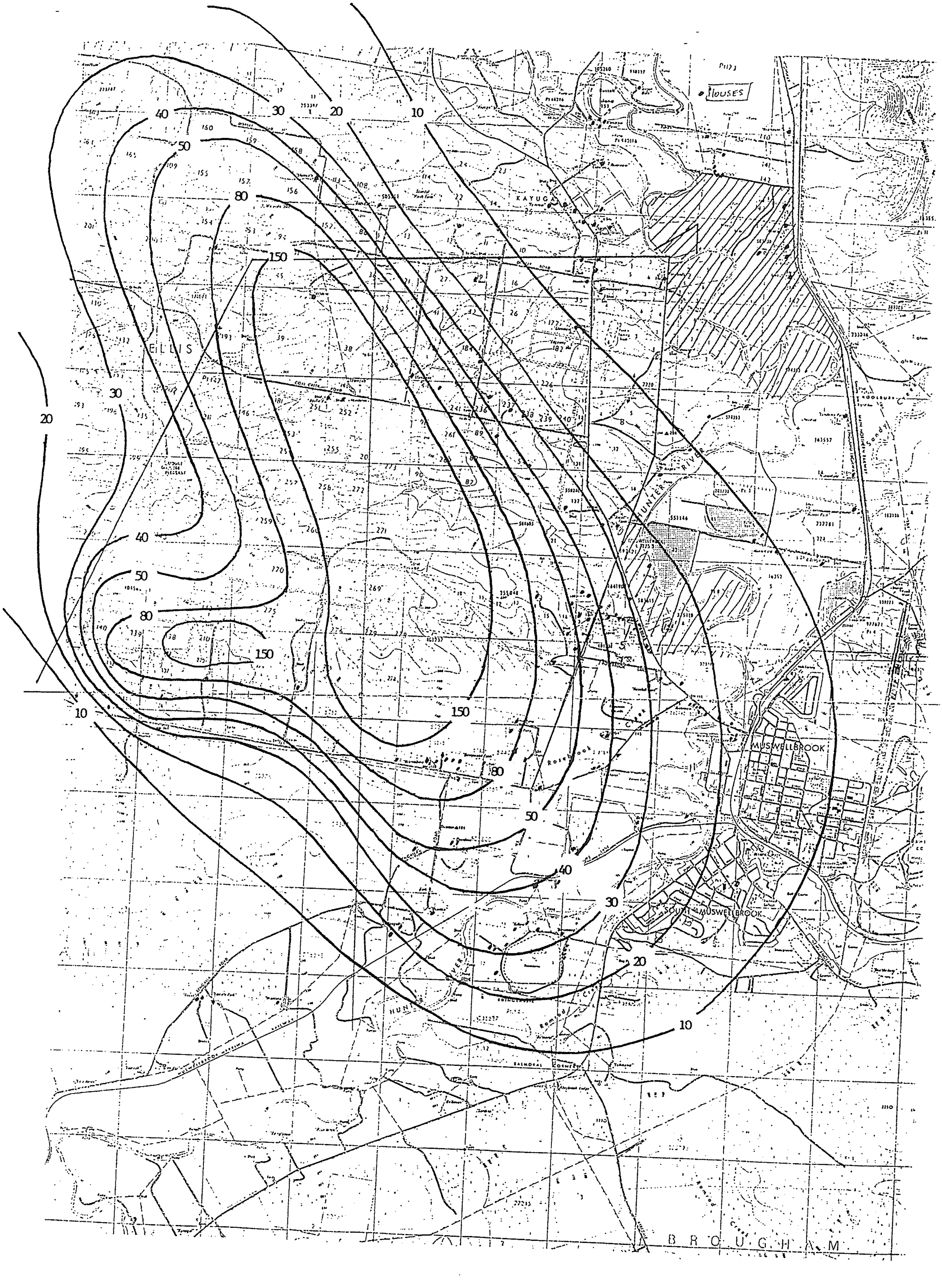


Figure 6.3(e) Predicted increases in the mean annual concentration of TSP (micrograms/m3) - Year 20.

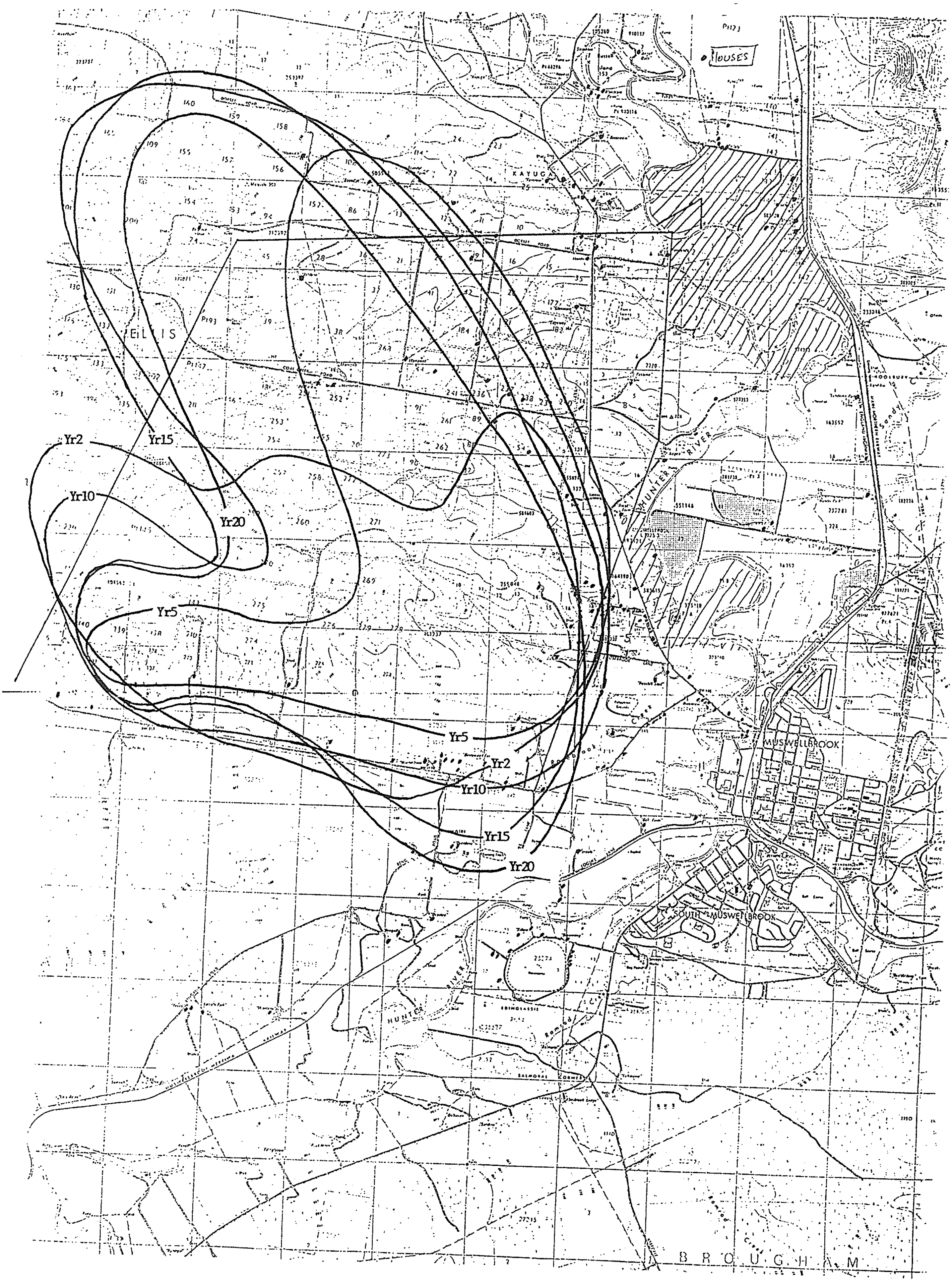
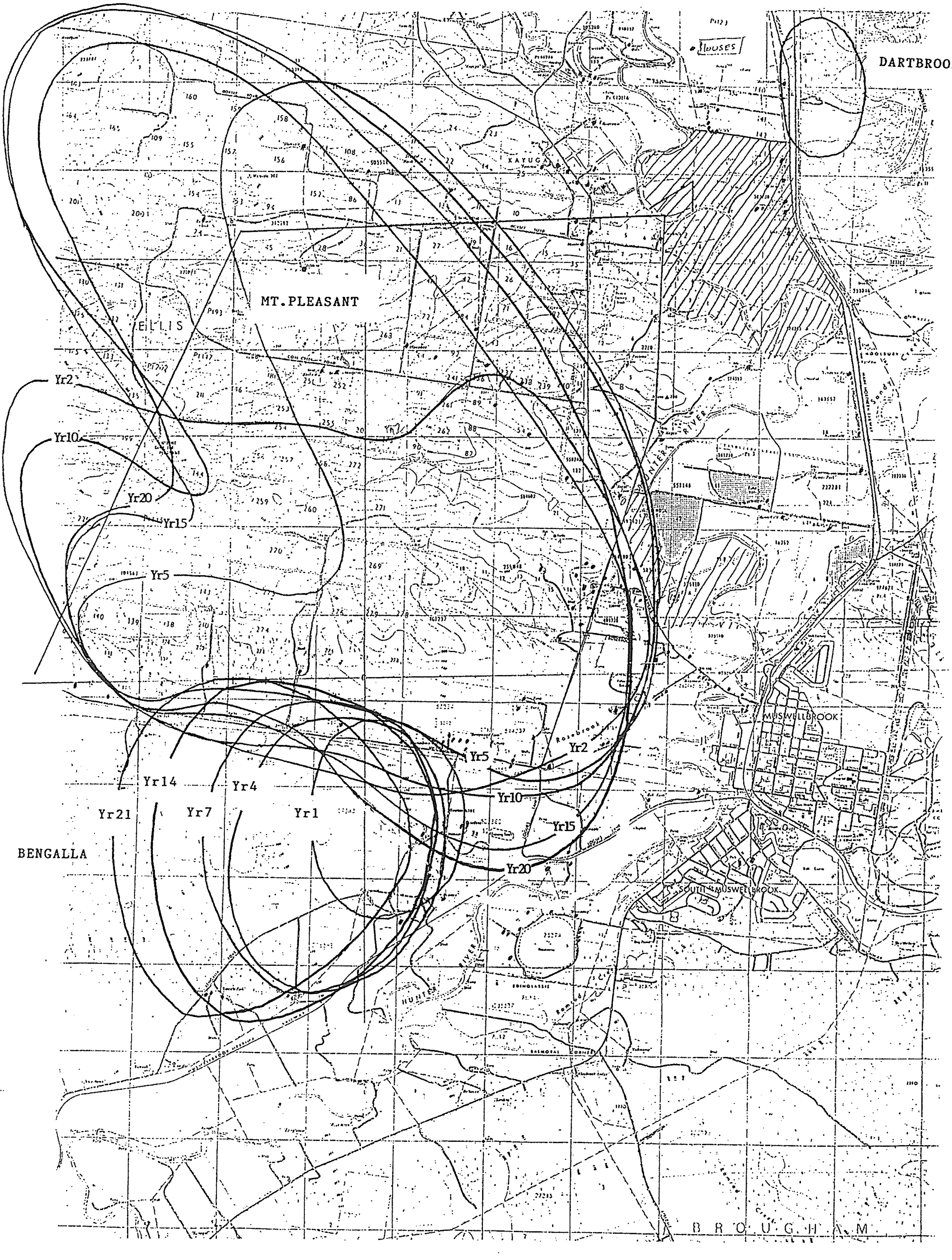


Figure 6.4. Envelope of contour lines corresponding to a predicted increase in mean annual concentration of TSP of 50 micrograms/m3.



BAYSWATER NO.3

Figure 6.5. The position and extent of 2.0 g/m2/month isopleths predicted for Dartbrook, Mt. Pleasant, Bengalla and Bayswater No.3 developments.

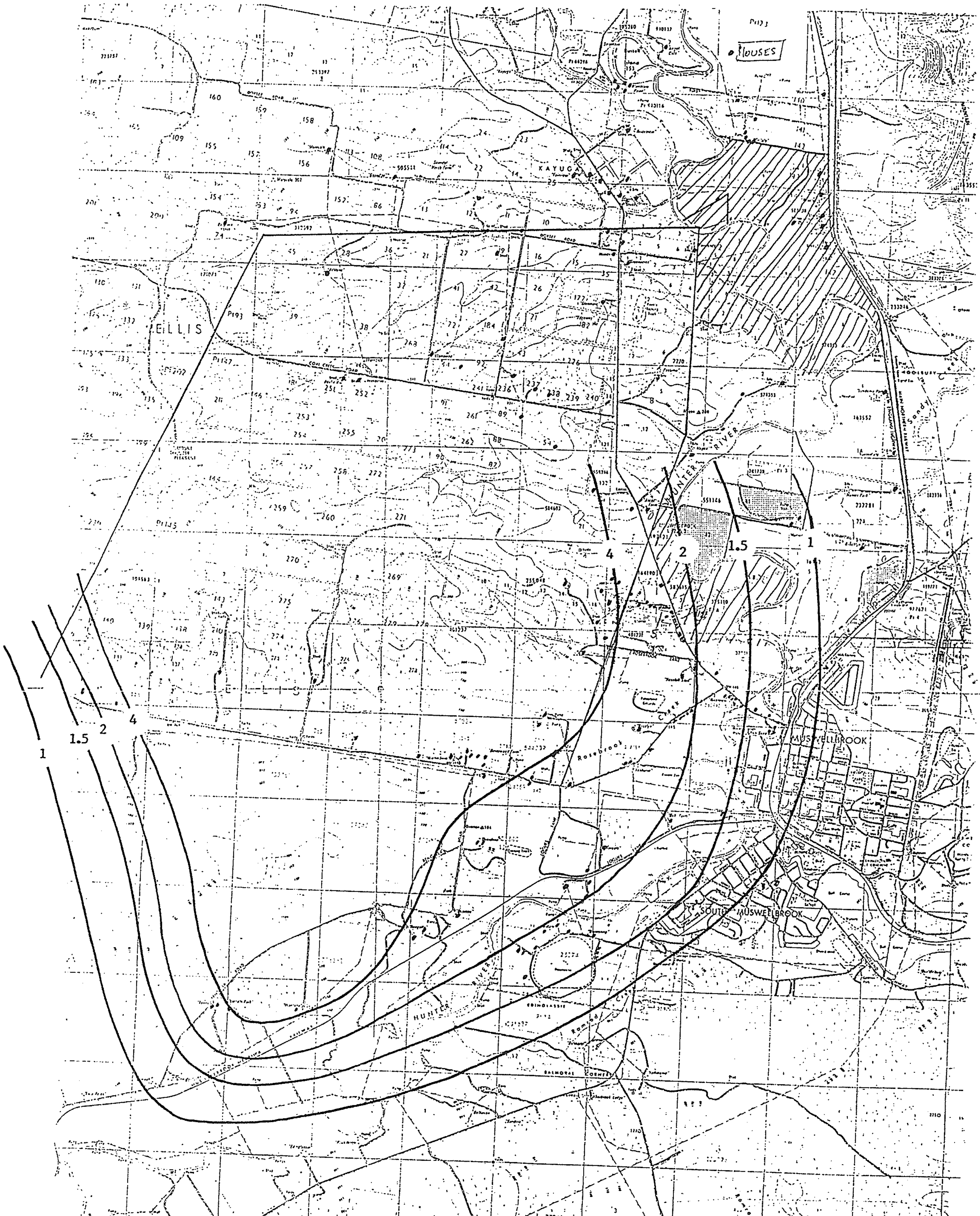


Figure 6.6. Combined isopleths of mean annual increments in dust deposition from mining at Bengalla (Year 14) and Mt. Pleasant (Year 10).

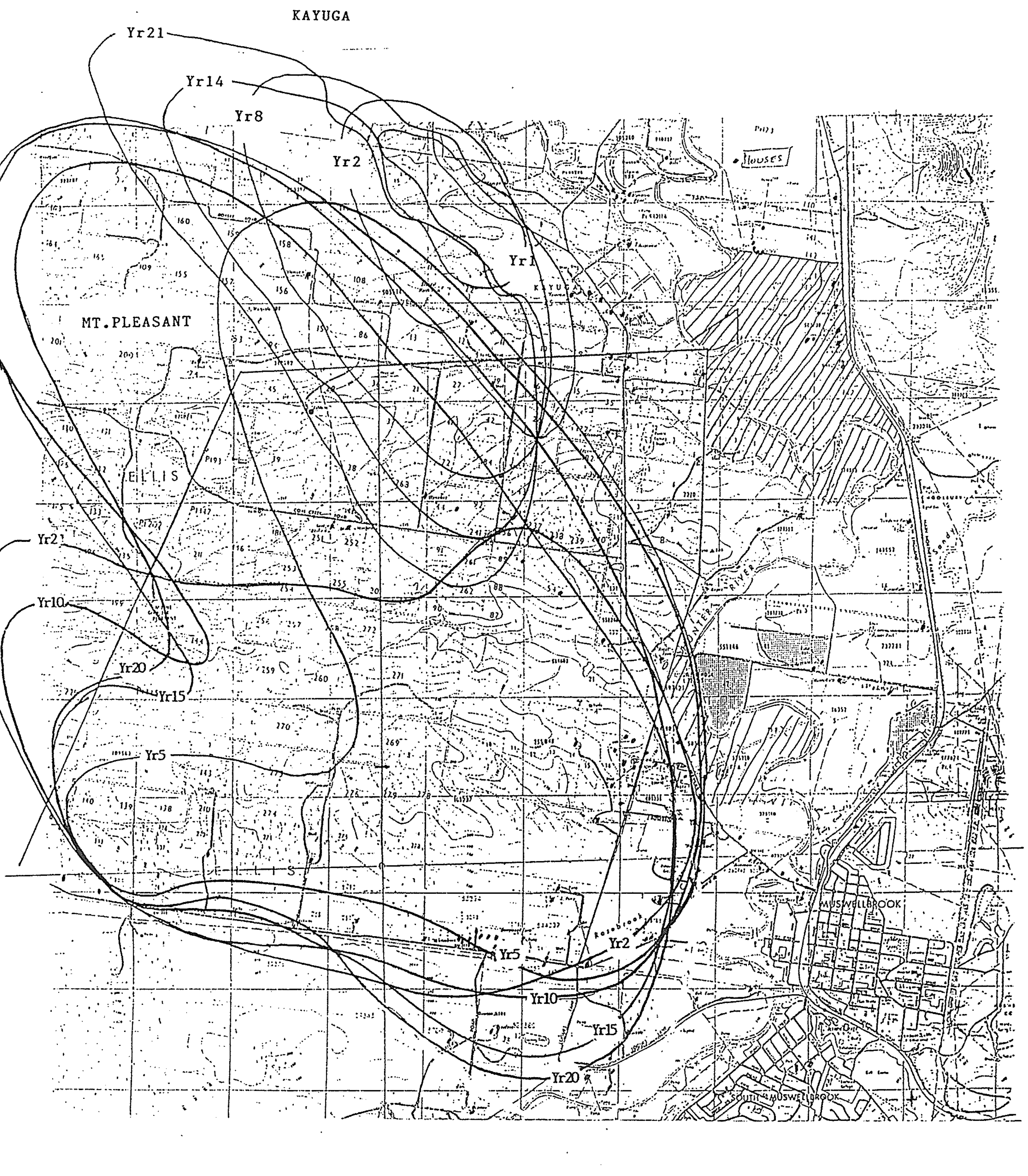


Figure 6.7. The position and extent of 2.0 g/m2/month isopleths predicted for Mt. Pleasant and Kayuga proposals.

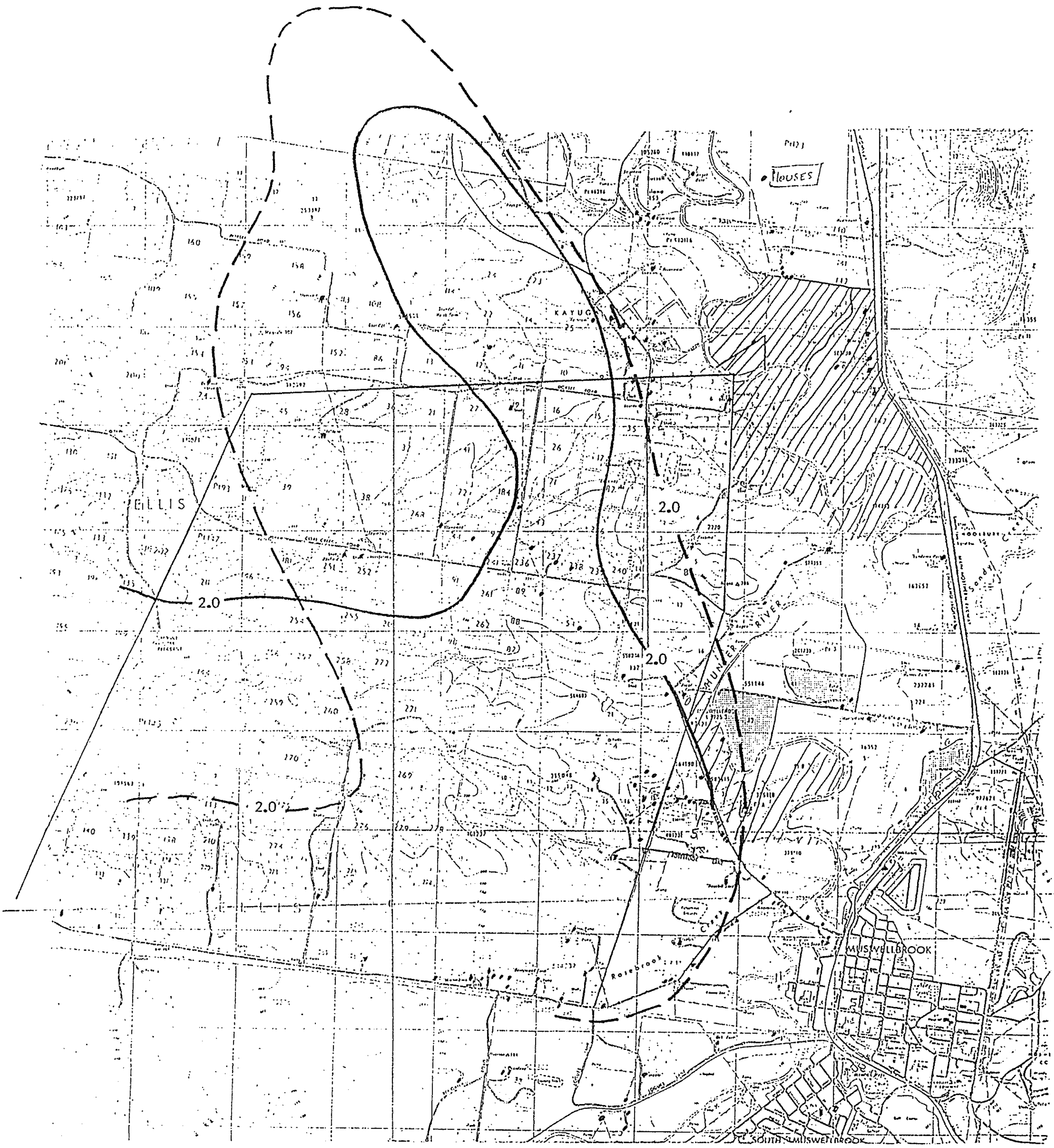


Figure 6.8(a). Combined isopleth corresponding to a mean annual increment of 2.0 g/m2/month from mining at Mt. Pleasant (Year 2) and Kayuga (Year 2). The broken line shows the combined isopleth for Year 5 at Mt. Pleasant and Year 2 at Kayuga.

Figure 6.8(b). Combined isopleth corresponding to a mean annual increment of 2.0 g/m2/month from mining at Mt. Pleasant (Year 20) and Kayuga (Year 21).

Appendix A.

DUST EMISSION INVENTORIES

Table A.1(a). Dust emission inventory for South pit - Year 2

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	760 hrs/yr	10.6 t/yr	
Overburden drilling	4 032 holes/yr	2.4 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	16 blasts/yr	32.2 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	4.9 Mbcm/yr	282.5 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	7 552 holes/yr	4.5 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	16 blasts/yr	6.4 t/yr	397.5 kg/blast Area of blast = 14830 m2
Overburden loading	0.8 Mbcm/yr	46.3 t/yr *	Density = 2.3 t/m3
Dozer ripping	440 hrs/yr	2.5 t/yr *	
Overburden haulage			217 t trucks
In-pit:	120 740 km/yr	241.5 t/yr *	In-pit distance = 1.0 km
Out-of-pit:			
to bund:	42 260 km/yr	84.5 t/yr	Out-of-pit distance = 0.7 km
to SW dump:	335 050 km/yr	670.1 t/yr	Out-of-pit distance = 5.55 km
Wind erosion			
Pre-stripping area	31.2 ha	109.3 t/yr	2 strips ahead of mining
	Subtotal	1492.8 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	171.8 t/yr	
	Subtotal	1321.0 t/yr	

Table A.1(a) continued

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	5 130 holes/yr	3.1 t/yr	1.2 Mtpa of coal drilled and blasted Depth = 4 m Pattern = 6.1 m x 6.1 m
Coal blasting	19 blasts/yr	4.2 t/yr	220.0 kg/blast Area of blast = 10 000 m2
Coal ripping (dozer)	1800 hrs/yr	3.1 t/yr *	1.15 Mtpa ripped Mean silt content = 4% Mean moisture content = 5%
Coal loading	2.35 Mtpa	68.2 t/yr *	
Coal haulage			160 t trucks
In pit:	29 380 km/yr	58.8 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	142 490 km/yr	285.0 t/yr	Out-of-pit distance to CPP = 4.85 km
	Subtotal	422.4 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	39.0 t/yr	
	Subtotal	383.4 t/yr	
	TOTAL (SOUTH PIT)	1704.4 t/yr	

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Table A.1(a) continued

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN PLACEMENT			
Dumping			
to bund (from South pit)	2.85 Mbcm/yr	78.6 t/yr	
(from Satellite pit)	6.07 Mbcm/yr	168.0 t/yr	
to Ex-pit emplacement (SW)			
(from South pit)	2.85 Mbcm/yr	78.6 t/yr	
(from Satellite pit)	7.23 Mbcm/yr	199.2 t/yr	
Dozer (pushing, shaping)			
at bund	2920 hrs/yr	21.3 t/yr	
at Ex-pit	3300 hrs/yr	24.1 t/yr	
Bund rehabilitation, topsoiling	500 hrs/yr	7.0 t/yr	
Wind erosion			
Bund (northern)	13.5 ha	47.3 t/yr	
Bund (central)	25.0 ha	87.6 t/yr	
Bund (southern)	27.0 ha	94.6 t/yr	
Ex-pit emplacement (SW)	60.0 ha	210.2 t/yr	
Grading of roads	32 000 km/yr	19.7 t/yr	Grading of haul and access roads, 4000 hrs/yr Mean speed = 8 km/hr
	Subtotal	1036.2 t/yr	
	TOTAL (OVERBURDEN PLACEMENT)	1036.2 t/yr	

Table A.1(b). Dust emission inventory for Satellite pit - Year 2

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	760 hrs/yr	10.6 t/yr	
Overburden drilling	9 072 holes/yr	5.4 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	36 blasts/yr	72.5 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading (shovel)	26.2 Mbcm/yr	655.0 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	16 992 holes/yr	10.2 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	36 blasts/yr	14.3 t/yr	397.5 kg/blast Area of blast = 14830 m2
Overburden loading	1.9 Mbcm/yr	110.0 t/yr *	Density = 2.3 t/m3
Dozer ripping	960 hrs/yr	5.4 t/yr *	
Overburden haulage			217 t trucks
In-pit:	282 020 km/yr	564.0 t/yr *	In-pit distance = 1.0 km
Out-of-pit:			
to bund:	219 350 km/yr	438.7 t/yr	Out-of-pit distance = 1.7 km
to SW dump:	711 430 km/yr	1422.9 t/yr	Out-of-pit distance = 4.65 km
Wind erosion			
Pre-stripping area	17.6 ha	61.7 t/yr	2 strips ahead of mining
	Subtotal	3370.7 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	400.3 t/yr	
	Subtotal	2970.4 t/yr	

Table A.1(b) continued

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	6 480 holes/yr	3.9 t/yr	1.5 Mtpa of coal drilled and blasted Depth = 4 m Pattern = 6.1 m x 6.1 m
Coal blasting	24 blasts/yr	4.8 t/yr	220.0 kg/blast Area of blast = 10 000 m2
Coal ripping (dozer)	1800 hrs/yr	3.7 t/yr *	Mean silt content = 4% Mean moisture content = 5%
Coal loading	2.9 Mtpa	84.1 t/yr *	
Coal haulage			160 t trucks
In-pit:	36 250 km/yr	72.5 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	143 190 km/yr	286.4 t/yr	Out-of-pit distance = 3.95 km
	Subtotal	455.4 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	48.1 t/yr	
	Subtotal	407.3 t/yr	
	TOTAL (SATELLITE PIT)	3377.7 t/yr	

Table A.1(c). Dust emission inventory for coal preparation plant - Year 2

Operation	Extent of operation	Annual emission	Comments
COAL PREPARATION			
ROM coal (5.25 Mtpa)			
Dumping to hopper	5.25 Mtpa	52.5 t/yr	
Conveyor transfer	5.25 Mtpa	3.0 t/yr	Total of 3 transfers
Loading to stockpile (stacker)	3.95 Mtpa	0.1 t/yr	Assume 75 per cent of ROM coal to stockpiles
Maintenance, wind erosion		37.7 t/yr	Total frequency of u > 20 kph of 20.1% Base area = 2.2 ha
Reclamation, conveyor transfer	3.95 Mtpa	2.3 t/yr	
Haulage of rejects	1.13 Mtpa	65.0 t/yr	Mean distance = 2.3 km
Product coal (3.7 Mtpa)			
Conveyor stacking	3.7 Mtpa	0.1 t/yr	
Maintenance, wind erosion		80.4 t/yr	Base area = 4.7 ha
Reclamation, conveyor transfer, train loading	3.7 Mtpa	2.1 t/yr	
	Subtotal	243.2 t/yr	
	TOTAL (CPP)	243.2 t/yr	

TOTAL (ALL OPERATIONS) = 1704.4 t/yr (South Pit)

1036.2 t/yr (Overburden Placement)

3377.7 t/yr (Satellite Pit)

243.2 t/yr (Coal preparation)

6361.5 t/yr

Ratio (dust : ROM coal) = 1.21 kg per tonne of ROM coal

Table A.2(a). Dust emission inventory for South pit - Year 5

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	760 hrs/yr	10.6 t/yr	
Overburden drilling	3 024 holes/yr	1.8 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	12 blasts/yr	24.2 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	3.3 Mbcm/yr	190.0 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	5 192 holes/yr	3.1 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	11 blasts/yr	4.4 t/yr	397.5 kg/blast Area of blast = 14830 m2
Overburden loading	0.52 Mbcm/yr	30.0 t/yr *	Density = 2.3 t/m3
Dozer ripping	300 hrs/yr	1.7 t/yr *	
Overburden haulage			217 t trucks
In-pit:	48 710 km/yr	97.4 t/yr *	In-pit distance = 0.6 km
Out-of-pit:			
to bund:	81 180 km/yr	162.4 t/yr	Out-of-pit distance = 1.0 km
Wind erosion			
Pre-stripping area	31.2 ha	109.3 t/yr	2 strips ahead of mining
	Subtotal	634.9 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	95.7 t/yr	
	Subtotal	539.2 t/yr	

Table A.2(a) cont.

Operation	Extent of operation	Annual emission	Comments
Dragline operation			
Overburden drilling	2 772 holes/yr	1.7 t/yr	Mean depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	11 blasts/yr	22.1 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Dragline	2.77 Mbcm/yr	202.2 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	2.70 Mbcm/yr	197.1 t/yr	
Dozer operation	1200 hours/yr	6.7 t/yr	
	Subtotal	429.8 t/yr	
OVERBURDEN PLACEMENT			
Dumping			
to bund (South pit)	3.83 Mbcm/yr	105.6 t/yr	
Dozer (pushing, shaping)	2920 hrs/yr	21.3 t/yr	
Bund rehabilitation, topsoiling	500 hrs/yr	7.0 t/yr	
Wind erosion			
Bund (southern)	43.0 ha	150.7 t/yr	
Spoil piles (central, northern)	28.0 ha	91.1 t/yr	
Grading of roads	32 000 km/yr	19.7 t/yr	Grading of haul and access roads, 4000 hrs/yr Mean speed = 8 km/hr
	Subtotal	395.4 t/yr	

Table A.2(a) cont.

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	6 120 holes/yr	3.7 t/yr	1.87 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	19 blasts/yr	5.5 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	1100 hrs/yr	1.9 t/yr *	0.70 Mtpa ripped Mean silt content = 4% Mean moisture content = 5%
Coal loading	2.57 Mtpa	74.5 t/yr *	
Coal haulage			160 t trucks
In pit:	41 760 km/yr	83.5 t/yr *	In-pit distance = 1.3 km
Out-of-pit:	155 780 km/yr	311.6 t/yr	Out-of-pit distance to CPP = 4.85 km
	Subtotal	480.7 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	48.0 t/yr	
	Subtotal	432.7 t/yr	
	TOTAL (SOUTH PIT)	1797.1 t/yr	

Table A.2(b). Dust emission inventory for North pit - Year 5

Operation	Extent of operation	Annual emission	Comments
<u>OVERBURDEN MINING</u>			
<u>Shovel / Excavator operation</u>			
Topsoil removal (scraper)	1520 hrs/yr	21.2 t/yr	
Overburden drilling	9 576 holes/yr	5.7 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	38 blasts/yr	76.5 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading (shovel)	11.95 Mbcm/yr	687.5 t/yr *	Density = 2.3 t/m3
<u>FEL operation</u>			
Overburden drilling	17 460 holes/yr	10.5 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	37 blasts/yr	14.7 t/yr	397.5 kg/blast Area of blast = 14 830 m2
Overburden loading	1.92 Mbcm/yr	110.0 t/yr *	Density = 2.3 t/m3
Dozer ripping	880 hrs/yr	4.9 t/yr *	
<u>Overburden haulage</u>			217 t trucks
Northern route (4.17 Mbcm):			
In-pit:	88 400 km/yr	176.8 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	70 720 km/yr	141.4 t/yr	Out-of-pit distance = 0.8 km
Central route (4.17 Mbcm):			
In-pit:	44 200 km/yr	88.4 t/yr *	In-pit distance = 0.5 km
Out-of-pit:	35 360 km/yr	70.7 t/yr	Out-of-pit distance = 0.4 km
Southern route (5.53 Mbcm):			
In-pit:	117 220 km/yr	234.4 t/yr *	In-pit-distance = 1.0 km
Out-of-pit:	87 920 km/yr	175.8 t/yr	Out-of-pit distance = 0.75 km

Table A.2(b) cont.

Operation	Extent of operation	Annual emission	Comments
Wind erosion			
Pre-stripping area	36.4 ha	127.5 t/yr	2 strips ahead of mining
		-----------	
	Subtotal	1946.0 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	390.6 t/yr	
	Subtotal	1555.4 t/yr	
Dragline operation			
Overburden drilling	5 792 holes/yr	3.5 t/yr	Mean depth = 40 m Pattern = 9.1 m x 9.1 m
Overburden blasting	16 blasts/yr	7.4 t/yr	459.8 kg/blast Area of blast = 30 000 m2 Moisture content = 2%
Dragline	14.2 Mbcm/yr	1038.1 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	5.24 Mbcm/yr	382.5 t/yr	

	Subtotal	1431.5 t/yr	
OVERBURDEN PLACEMENT			
Dumping			
to North pit	13.87 Mbcm/yr	382.8 t/yr	
Dozer (spreading)	4000 hrs/yr	31.4 t/yr	
Wind erosion			
Spoil piles, dump area, reshaping	97.2 ha	340.6 t/yr	

	Subtotal	754.8 t/yr	

Table A.2(b) cont.

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	14 490 holes/yr	8.7 t/yr	4.32 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	45 blasts/yr	13.0 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	2520 hrs/yr	4.3 t/yr *	Mean silt content = 4% Mean moisture content = 5%
Coal loading	5.93 Mtpa	172.0 t/yr *	
Coal haulage			160 t trucks
In pit:	74 120 km/yr	148.2 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	389 130 km/yr	778.3 t/yr	Out-of-pit distance = 5.25 km
	Subtotal	1124.5 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	97.3 t/yr	
	Subtotal	1027.2 t/yr	
	TOTAL (NORTH PIT)	4768.9 t/yr	

Table A.2(c). Dust emission inventory for coal preparation plant - Year 5

Operation	Extent of operation	Annual emission	Comments
<u>COAL PREPARATION</u>			
<u>ROM coal</u> (8.5 Mtpa)			
Dumping to hopper	8.5 Mtpa	85.0 t/yr	
Conveyor transfer	8.5 Mtpa	4.8 t/yr	Total of 3 transfers
Loading to stockpile (stacker)	6.4 Mtpa	0.2 t/yr	Assume 75 per cent of ROM coal to stockpiles
Maintenance, wind erosion		37.7 t/yr	Total frequency of u > 20 kph of 20.1% Base area = 2.2 ha
Reclamation, conveyor transfer	64 Mtpa	3.6 t/yr	
Haulage of rejects	1.63 Mtpa	135.5 t/yr	Mean distance = 5.95 km 0.91 Mtpa to south dump
<u>Product coal</u> (6.19 Mtpa)			
Conveyor stacking	6.19 Mtpa	0.2 t/yr	
Maintenance, wind erosion		80.4 t/yr	Base area = 4.7 ha
Reclamation, conveyor transfer, train loading	6.19 Mtpa	3.5 t/yr	
	Subtotal	350.9 t/yr	
	TOTAL (CPP)	350.9 t/yr	

<u>TOTAL (ALL OPERATIONS)</u> = 1797.1 t/yr (South Pit)

4768.9 t/yr (North Pit)

350.9 t/yr (Coal preparation)

<u>6916.9 t/yr</u>

Ratio (dust : ROM coal) = 0.82 kg per tonne of ROM coal

Table A.3(a). Dust emission inventory for South pit - Year 10

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	760 hrs/yr	10.6 t/yr	
Overburden drilling	3 276 holes/yr	2.0 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	13 blasts/yr	26.2 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	4.08 Mbcm/yr	235.0 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	6 608 holes/yr	4.0 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	14 blasts/yr	5.6 t/yr	397.5 kg/blast Area of blast = 14830 m2
Overburden loading	0.72 Mbcm/yr	41.3 t/yr *	Density = 2.3 t/m3
Dozer ripping	360 hrs/yr	2.0 t/yr *	
Overburden haulage			217 t trucks
In-pit:	101 740 km/yr	203.5 t/yr *	In-pit distance = 1.0 km
Out-of-pit:			
to SW dump:	550 810 km/yr	1101.6 t/yr	Out-of-pit distance = 6.2 km
to South pit:	7 740 km/yr	15.5 t/yr	Out-of-pit distance = 0.6 km
Wind erosion			
Pre-stripping area	26.0 ha	91.1 t/yr	2 strips ahead of mining
Subtotal		1738.4 t/yr	
* Less 30% of in-pit emissions (due to pit retention)		Less 144.5 t/yr	
Subtotal		1593.9 t/yr	

Table A.3(a) cont.

Operation	Extent of operation	Annual emission	Comments
<u>Dragline operation</u>			
Overburden drilling	4 032 holes/yr	2.4 t/yr	Mean depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	16 blasts/yr	32.2 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Dragline	3.43 Mbcm/yr	250.4 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	1.17 Mbcm/yr	85.4 t/yr	
Dozer operation	1200 hours/yr	6.7 t/yr	
	Subtotal	377.1 t/yr	
<u>OVERBURDEN PLACEMENT</u>			
Dumping			
to South pit:	0.60 Mbcm/yr	16.8 t/yr	
to SW dump:	4.20 Mbcm/yr	115.8 t/yr	
Dozer (spreading,shaping)	1260 hrs/yr	9.2 t/yr	
<u>Wind erosion</u>			
Spoil piles	96.0 ha	336.4 t/yr	
SW dump	15.0 ha	52.6 t/yr	
<u>Grading of roads</u>	32 000 km/yr	19.7 t/yr	Grading of haul and access roads, 4000 hrs/yr Mean speed = 8 km/hr
	Subtotal	550.5 t/yr	

Table A.3(a) cont.

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	4 830 holes/yr	2.9 t/yr	1.49 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	15 blasts/yr	4.3 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	1260 hrs/yr	2.1 t/yr *	0.80 Mtpa ripped Mean silt content = 4% Mean moisture content = 5%
Coal loading	2.29 Mtpa	66.4 t/yr *	
Coal haulage			160 t trucks
In pit:	28 620 km/yr	57.2 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	158 840 km/yr	317.7 t/yr	Out-of-pit distance to CPP = 5.55 km
		----------	
	Subtotal	450.6 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	37.7 t/yr	
	Subtotal	412.9 t/yr	
	TOTAL (SOUTH PIT)	2934.4 t/yr	

Table A.3(b). Dust emission inventory for North pit - Year 10

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	1520 hrs/yr	21.2 t/yr	
Overburden drilling	20 916 holes/yr	12.5 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	83 blasts/yr	167.0 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	26.1 Mbcm/yr	1500.0 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	24 544 holes/yr	14.7 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	52 blasts/yr	20.7 t/yr	397.5 kg/blast Area of blast = 14 830 m2
Overburden loading	2.7 Mbcm/yr	155.0 t/yr *	Density = 2.3 t/m3
Dozer ripping	1260 hrs/yr	7.0 t/yr *	
Overburden haulage to North pit:			217 t trucks
Northern route (6.14 Mbcm):			
In-pit:	91 160 km/yr	182.3 t/yr *	In-pit distance = 0.7 km
Out-of-pit:	91 160 km/yr	182.3 t/yr	Out-of-pit distance = 0.7 km
Central route (6.15 Mbcm):			
In-pit:	78 140 km/yr	156.3 t/yr *	In-pit distance = 0.6 km
Out-of-pit:	78 140 km/yr	156.3 t/yr	Out-of-pit distance = 0.6 km

Table A.3(b) cont.

Operation	Extent of operation	Annual emission	Comments
Southern route (6.14 Mbcm):			
In-pit:	169 300 km/yr	338.6 t/yr *	In-pit-distance = 1.3 km
Out-of-pit:	156 280 km/yr	312.6 t/yr	Out-of-pit distance = 1.2 km
to NW dump:			
In-pit:	109 910 km/yr	219.8 t/yr *	In-pit-distance = 0.5 km
Out-of-pit:	593 510 km/yr	1187.0 t/yr	Out-of-pit distance = 2.7 km
Wind erosion			
Pre-stripping area	36.4 ha	127.5 t/yr	2 strips ahead of mining
	Subtotal	4760.8 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	767.7 t/yr	
	Subtotal	3993.1 t/yr	

Operation	Extent of operation	Annual emission	Comments
Dragline operation			
Overburden drilling	3 620 holes/yr	2.2 t/yr	Mean depth = 40 m Pattern = 9.1 m x 9.1 m
Overburden blasting	10 blasts/yr	4.6 t/yr	459.8 kg/blast Area of blast = 30 000 m2 Moisture content = 2%
Dragline	12.09 Mbcm/yr	882.6 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	5.15 Mbcm/yr	376.0 t/yr	
	Subtotal	1265.4 t/yr	

Table A.3(b) cont.

Operation	Extent of operation	Annual emission	Comments
<u>OVERBURDEN PLACEMENT</u>			
Dumping			
to North pit	18.43 Mbcm/yr	508.8 t/yr	
Dozer (spreading)	4800 hrs/yr	35.0 t/yr	
to NW dump	10.37 Mbcm	286.2 t/yr	
Dozer (spreading)	2400 hrs/yr	17.5 t/yr	
<u>Wind erosion</u>			
Spoil piles, dump area, reshaping	121.5 ha	425.7 t/yr	
NW dump	45.0 ha	157.7 t/yr	
	Subtotal	1430.9 t/yr	

Table A.3(b) cont.

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	18 032 holes/yr	10.8 t/yr	5.36 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	56 blasts/yr	16.2 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	4460 hrs/yr	7.5 t/yr *	Mean silt content = 4% Mean moisture content = 5%
Coal loading	8.21 Mtpa	238.1 t/yr *	
Coal haulage			160 t trucks
In pit:	174 460 km/yr	348.9 t/yr *	In-pit distance = 1.7 km
Out-of-pit:	487 450 km/yr	974.9 t/yr	Out-of-pit distance = 4.75 km
	Subtotal	1596.4 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	178.3 t/yr	
	Subtotal	1418.1 t/yr	
	TOTAL (NORTH PIT)	8107.5 t/yr	

Table A.3(c). Dust emission inventory for coal preparation plant - Year 10

Operation	Extent of operation	Annual emission	Comments
COAL PREPARATION			
ROM coal (10.5 Mtpa)			
Dumping to hopper	10.5 Mtpa	105.0 t/yr	
Conveyor transfer	10.5 Mtpa	6.0 t/yr	Total of 3 transfers
Loading to stockpile (stacker)	7.9 Mtpa	0.2 t/yr	Assume 75 per cent of ROM coal to stockpiles
Maintenance, wind erosion		56.5 t/yr	Total frequency of u > 20 kph of 20.1% Base area = 3.3 ha
Reclamation, conveyor transfer	7.9 Mtpa	4.5 t/yr	
Haulage of rejects	1.88 Mtpa	105.8 t/yr	Mean distance = 2.25 km
Product coal (7.9 Mtpa)			
Conveyor stacking	7.9 Mtpa	0.2 t/yr	
Maintenance, wind erosion		80.4 t/yr	Base area = 4.7 ha
Reclamation, conveyor transfer, train loading	7.9 Mtpa	4.5 t/yr	
	Subtotal	363.1 t/yr	
	TOTAL (CPP)	363.1 t/yr	

TOTAL (ALL OPERATIONS) = 2934.4 t/yr (South Pit)

8107.5 t/yr (North Pit)

363.1 t/yr (Coal preparation)

11 405.0 t/yr

Ratio (dust : ROM coal) = 1.09 kg per tonne of ROM coal

Table A.4(a). Dust emission inventory for South pit - Year 15

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	760 hrs/yr	10.6 t/yr	
Overburden drilling	3 024 holes/yr	1.8 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	12 blasts/yr	24.2 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	3.71 Mbcm/yr	212.5 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	8 968 holes/yr	5.4 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	19 blasts/yr	7.6 t/yr	397.5 kg/blast Area of blast = 14830 m2
Overburden loading	1.0 Mbcm/yr	57.5 t/yr *	Density = 2.3 t/m3
Dozer ripping	560 hrs/yr	3.1 t/yr *	
Overburden haulage to South Pit (2.55 Mbcm)			217 t trucks
Northern route (0.76 Mbcm):			
In-pit:	21 875 km/yr	43.5 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	21 875 km/yr	43.5 t/yr	Out-of-pit distance = 1.0 km
Central route (1.03 Mbcm):			
In-pit:	28 750 km/yr	57.5 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	28 750 km/yr	57.5 t/yr	Out-of-pit distance = 1.0 km

Table A.4(a) cont.

Operation	Extent of operation	Annual emission	Comments
Southern route (0.76 Mbcm):			
In-pit:	21 875 km/yr	43.8 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	19 690 km/yr	39.4 t/yr	Out-of-pit distance = 0.9 km
to NWOOP dump (2.16 Mbcm)			
In-pit:	55 890 km/yr	111.8 t/yr *	In-pit distance = 0.9 km
Out-of-pit:	204 930 km/yr	409.9 t/yr	Out-of-pit distance = 3.3 km
Wind erosion			
Pre-stripping area	24.7 ha	86.5 t/yr	2 strips ahead of mining
	Subtotal	1216.1 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	158.9 t/yr	
	Subtotal	1057.2 t/yr	
Dragline operation			
Overburden drilling	3 276 holes/yr	2.0 t/yr	Mean depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	13 blasts/yr	26.2 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Dragline	2.84 Mbcm/yr	207.3 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	3.31 Mbcm/yr	241.6 t/yr	
Dozer operation	900 hours/yr	5.0 t/yr	
	Subtotal	482.1 t/yr	

Table A.4(a) cont.

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN PLACEMENT			
Dumping			
to South pit:	2.55 Mbcm/yr	69.6 t/yr	
to NWOOP dump:	2.16 Mbcm/yr	60.0 t/yr	
Dozer (spreading,shaping)	1100 hrs/yr	8.0 t/yr	
Wind erosion			
Spoil piles	90.0 ha	315.4 t/yr	
Grading of roads	32 000 km/yr	19.7 t/yr	Grading of haul and access roads, 4000 hrs/yr Mean speed = 8 km/hr
	Subtotal	472.7 t/yr	
COAL MINING			
Coal drilling	6 762 holes/yr	4.1 t/yr	2.43 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	21 blasts/yr	6.1 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	2100 hrs/yr	3.5 t/yr *	1.33 Mtpa ripped Mean silt content = 4% Mean moisture content = 5%
Coal loading	3.36 Mtpa	97.4 t/yr *	

Table A.4(a) cont.

Operation	Extent of operation	Annual emission	Comments
Coal haulage			160 t trucks
Northern route (75%):			
In pit:	85 050 km/yr	170.1 t/yr *	In-pit distance = 2.7 km
Out-of-pit:	184 280 km/yr	368.6 t/yr	Out-of-pit distance to CPP = 5.85 km
Southern route (25%):			
In-pit:	26 250 km/yr	52.5 t/yr *	In-pit distance = 2.5 km
Out-of-pit:	35 180 km/yr	70.4 t/yr	Out-of-pit distance = 3.35 km
	Subtotal	772.7 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	97.0 t/yr	
	Subtotal	675.7 t/yr	
	TOTAL (SOUTH PIT)	2687.7 t/yr	

Table A.4(b). Dust emission inventory for North pit - Year 15

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	1520 hrs/yr	21.2 t/yr	
Overburden drilling	19 152 holes/yr	11.5 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	76 blasts/yr	153.0 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	23.92 Mbcm/yr	1375.0 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	22 656 holes/yr	13.6 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	48 blasts/yr	19.1 t/yr	397.5 kg/blast Area of blast = 14 830 m2
Overburden loading	2.49 Mbcm/yr	142.5 t/yr *	Density = 2.3 t/m3
Dozer ripping	1160 hrs/yr	6.5 t/yr *	
Overburden haulage			217 t trucks
to North pit:			
Northern route (4.8 Mbcm):			
In-pit:	131 800 km/yr	263.6 t/yr *	In-pit distance = 1.3 km
Out-of-pit:	101 380 km/yr	202.8 t/yr	Out-of-pit distance = 1.0 km
Central route (6.4 Mbcm):			
In-pit:	102 300 km/yr	204.6 t/yr *	In-pit distance = 0.75 km
Out-of-pit:	177 320 km/yr	354.6 t/yr	Out-of-pit distance = 1.3 km

Table A.4(b) cont.

Operation	Extent of operation	Annual emission	Comments
Southern route (4.8 Mbcm):			
In-pit:	172 350 km/yr	344.7 t/yr *	In-pit-distance = 1.7 km
Out-of-pit:	182 480 km/yr	365.0 t/yr	Out-of-pit distance = 1.8 km
to NWOOP dump: (10.41 Mbcm):			
In-pit:	220 740 km/yr	441.5 t/yr *	In-pit-distance = 1.0 km
Out-of-pit:	331 110 km/yr	662.2 t/yr	Out-of-pit distance = 1.5 km
Wind erosion			
Pre-stripping area	26.0 ha	91.1 t/yr	2 strips ahead of mining
	Subtotal	4672.5 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	833.5 t/yr	
	Subtotal	3839.0 t/yr	
Dragline operation			
Overburden drilling	4 344 holes/yr	2.6 t/yr	Mean depth = 40 m Pattern = 9.1 m x 9.1 m
Overburden blasting	12 blasts/yr	5.5 t/yr	459.8 kg/blast Area of blast = 30 000 m2 Moisture content = 2%
Dragline	14.12 Mbcm/yr	1030.8 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	5.74 Mbcm/yr	419.0 t/yr	
	Subtotal	1457.9 t/yr	

Table A.4(b) cont.

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN PLACEMENT			
Dumping			
to North pit	16.0 Mbcm/yr	441.6 t/yr	
Dozer (spreading)	3680 hrs/yr	26.9 t/yr	
to NWOOP dump	10.41 Mbcm	287.4 t/yr	
Dozer (spreading)	2400 hrs/yr	17.5 t/yr	
Wind erosion			
Spoil piles, dump area, reshaping	92.0 ha	322.4 t/yr	
NWOOP dump	30.0 ha	105.1 t/yr	
	Subtotal	1200.9 t/yr	

Table A.4(b) cont.

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	14 490 holes/yr	8.7 t/yr	4.32 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	45 blasts/yr	13.0 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	4460 hrs/yr	7.5 t/yr *	Mean silt content = 4% Mean moisture content = 5%
Coal loading	7.14 Mtpa	207.1 t/yr *	
Coal haulage			160 t trucks
In pit:	240 980 km/yr	482.0 t/yr *	In-pit distance = 2.7 km
Out-of-pit:	522 120 km/yr	1044.3 t/yr	Out-of-pit distance = 5.85 km
	Subtotal	1762.6 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	209.0 t/yr	
	Subtotal	1553.6 t/yr	
	TOTAL (NORTH PIT)	8051.4 t/yr	

Table A.4(c). Dust emission inventory for coal preparation plant - Year 15

Operation	Extent of operation	Annual emission	Comments
<u>COAL PREPARATION</u>			
<u>ROM coal</u> (10.5 Mtpa)			
Dumping to hopper	10.5 Mtpa	105.0 t/yr	
Conveyor transfer	10.5 Mtpa	6.0 t/yr	Total of 3 transfers
Loading to stockpile (stacker)	7.9 Mtpa	0.2 t/yr	Assume 75 per cent of ROM coal to stockpiles
Maintenance, wind erosion		56.5 t/yr	Total frequency of u > 20 kph of 20.1% Base area = 3.3 ha
Reclamation, conveyor transfer	7.9 Mtpa	4.5 t/yr	
Haulage of rejects	2.0 Mtpa	137.5 t/yr	Mean distance to turn off = 2.75 km
Northern route	1.3 Mtpa	136.6 t/yr	Mean distance = 5.2 km
Southern route	0.7 Mtpa	63.1 t/yr	Mean distance = 3.6 km
<u>Product coal</u> (7.7 Mtpa)			
Conveyor stacking	7.7 Mtpa	0.2 t/yr	
Maintenance, wind erosion		80.4 t/yr	Base area = 4.7 ha
Reclamation, conveyor transfer, train loading	7.7 Mtpa	4.4 t/yr	
	Subtotal	594.4 t/yr	
	TOTAL (CPP)	594.4 t/yr	

<u>TOTAL (ALL OPERATIONS)</u> = 2687.7 t/yr (South Pit)

8051.4 t/yr (North Pit)

594.4 t/yr (Coal preparation)

11 333.5 t/yr

Ratio (dust : ROM coal) = 1.08 kg per tonne of ROM coal

Table A.5(a). Dust emission inventory for South pit - Year 20

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Shovel / Excavator operation			
Topsoil removal (scraper)	1520 hrs/yr	21.2 t/yr	
Overburden drilling	23 436 holes/yr	14.1 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	93 blasts/yr	187.2 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	25.28 Mbcm/yr	1453.8 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	35 872 holes/yr	21.5 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	76 blasts/yr	30.2 t/yr	397.5 kg/blast Area of blast = 14830 m2
Overburden loading	3.95 Mbcm/yr	227.5 t/yr *	Density = 2.3 t/m3
Dozer ripping	1860 hrs/yr	10.4 t/yr *	
Overburden haulage to North pit (21.37 Mbcm)			217 t trucks
In-pit:	545 050 km/yr	1090.1 t/yr *	In-pit distance = 1.0 km
Out-of-pit:			
to main dump:	920 510 km/yr	1841.0 t/yr	Out-of-pit distance = 2.5 km
to south dump:	144 160 km/yr	288.3 t/yr	Out-of-pit distance = 1.7 km
to South pit (7.86 Mbcm)			
Northern route (3.92 Mbcm)			
In-pit:	100 090 km/yr	200.2 t/yr	In-pit distance = 1.2 km
Out-of-pit:	83 410 km/yr	166.8 t/yr	Out-of-pit distance = 1.0 km

Table A.5(a) cont.

Operation	Extent of operation	Annual emission	Comments
Central route (1.97 Mbcm)			
In-pit:	37 580 km/yr	75.2 t/yr	In-pit distance = 0.9 km
Out-of-pit:	25 060 km/yr	50.1 t/yr	Out-of-pit distance = 0.6 km
Southern route (1.97 Mbcm)			
In-pit:	50 110 km/yr	100.2 t/yr	In-pit distance = 1.2 km
Out-of-pit:	37 580 km/yr	75.2 t/yr	Out-of-pit distance = 0.9 km
Wind erosion			
Pre-stripping area	29.9 ha	104.8 t/yr	2 strips ahead of mining
	Subtotal	5957.8 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	947.2 t/yr	
	Subtotal	5010.6 t/yr	
Dragline operation			
Overburden drilling	5 292 holes/yr	3.2 t/yr	Mean depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	21 blasts/yr	42.3 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Dragline	5.60 Mbcm/yr	408.8 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	3.71 Mbcm/yr	270.8 t/yr	
Dozer operation	800 hours/yr	4.5 t/yr	
	Subtotal	729.6 t/yr	

Table A.5(a) cont.

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN PLACEMENT			
Dumping			
to South pit:	7.86 Mbcm/yr	216.6 t/yr	
Dozer (spreading)	2400 hrs/yr	18.1 t/yr	
to North pit:	29.23 Mbcm/yr	589.8 t/yr	
Dozer (spreading,shaping)	4000 hrs/yr	29.2 t/yr	
Wind erosion			
Spoil piles, dump	90.0 ha	315.4 t/yr	
Grading of roads	32 000 km/yr	19.7 t/yr	Grading of haul and access roads, 4000 hrs/yr Mean speed = 8 km/hr
	Subtotal	1188.8 t/yr	
COAL MINING			
Coal drilling	25 760 holes/yr	15.5 t/yr	4.78 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	80 blasts/yr	23.1 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	5160 hrs/yr	8.7 t/yr *	3.30 Mtpa ripped Mean silt content = 4% Mean moisture content = 5%
Coal loading	8.08 Mtpa	234.3 t/yr *	

Table A.5(a) cont.

Operation	Extent of operation	Annual emission	Comments
Coal haulage			160 t trucks
Northern route (40%)			
In pit:	40 000 km/yr	80.0 t/yr *	In-pit distance = 1.0 km
Out-of-pit:	106 000 km/yr	212.0 t/yr	Out-of-pit distance to CPP = 2.65 km
In South pit:	140 000 km/yr	280.0 t/yr *	In-pit distance = 3.5 km
Southern route (60%)			
In-pit:	91 500 km/yr	183.0 t/yr *	In-pit distance = 1.5 km
Out-of-pit:	161 650 km/yr	323.3 t/yr	Out-of-pit distance to CPP = 2.65 km
	Subtotal	1359.9 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	235.8 t/yr	
	Subtotal	1124.1 t/yr	
	TOTAL (SOUTH PIT)	8053.1 t/yr	

Table A.5(b). Dust emission inventory for North pit - Year 20

Operation	Extent of operation	Annual emission	Comments
OVERBURDEN MINING			
Excavator operation			
Overburden drilling	756 holes/yr	0.5 t/yr	Depth = 15 m Pattern = 9.1 m x 9.1 m
Overburden blasting	3 blasts/yr	6.1 t/yr	2012.6 kg/blast Area of blast = 20 900 m2 Moisture content = 2%
Overburden loading	0.94 Mbcm/yr	53.8 t/yr *	Density = 2.3 t/m3
FEL operation			
Overburden drilling	3 304 holes/yr	2.0 t/yr	Depth = 3.5 m Pattern = 5.6 m x 5.6 m
Overburden blasting	7 blasts/yr	2.8 t/yr	397.5 kg/blast Area of blast = 14 830 m2
Overburden loading	0.36 Mbcm/yr	21.3 t/yr *	Density = 2.3 t/m3
Dozer ripping	210 hrs/yr	1.2 t/yr *	
Overburden haulage to North pit:			217 t trucks
In-pit:	35 940 km/yr	71.9 t/yr *	In-pit distance = 1.3 km
Out-of-pit:	27 650 km/yr	55.3 t/yr	Out-of-pit distance = 1.0 km
	Subtotal	214.9 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	44.5 t/yr	
	Subtotal	170.4 t/yr	

Table A.5(b) cont.

Operation	Extent of operation	Annual emission	Comments
Dragline operation			
Overburden drilling	2 534 holes/yr	1.5 t/yr	Mean depth = 40 m Pattern = 9.1 m x 9.1 m
Overburden blasting	7 blasts/yr	3.2 t/yr	459.8 kg/blast Area of blast = 30 000 m2 Moisture content = 2%
Dragline	8.48 Mbcm/yr	619.0 t/yr	Mean drop height = 12 m Moisture content = 2%
Rehandle	3.90 Mbcm/yr	284.7 t/yr	
	Subtotal	908.4 t/yr	
OVERBURDEN PLACEMENT			
Dumping			
to North pit	1.30 Mbcm/yr	36.0 t/yr	
Dozer (spreading)	480 hrs/yr	3.5 t/yr	
Wind erosion			
Spoil piles, dump area	120.0 ha	420.5 t/yr	
	Subtotal	460.0 t/yr	

Table A.5(b) cont.

Operation	Extent of operation	Annual emission	Comments
COAL MINING			
Coal drilling	7 728 holes/yr	4.6 t/yr	1.43 Mtpa of coal drilled and blasted Depth = 5 m Pattern = 6.1 m x 6.1 m
Coal blasting	24 blasts/yr	6.9 t/yr	289.2 kg/blast Area of blast = 12 000 m2
Coal ripping (dozer)	1550 hrs/yr	2.6 t/yr *	Mean silt content = 4% Mean moisture content = 5%
Coal loading	2.42 Mtpa	70.2 t/yr *	
Coal haulage			160 t trucks
In pit:	75 630 km/yr	151.3 t/yr *	In-pit distance = 2.5 km
Out-of-pit:	110 420 km/yr	220.9 t/yr	Out-of-pit distance = 3.65 km
In South pit:	105 880 km/yr	211.8 t/yr *	In-pit distance = 3.5 km
	Subtotal	668.3 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	130.8 t/yr	
	Subtotal	537.5 t/yr	
	TOTAL (NORTH PIT)	2076.3 t/yr	

Table A.5(c). Dust emission inventory for coal preparation plant - Year 20

Operation	Extent of operation	Annual emission	Comments
<u>COAL PREPARATION</u>			
<u>ROM coal</u> (10.5 Mtpa)			
Dumping to hopper	10.5 Mtpa	105.0 t/yr	
Conveyor transfer	10.5 Mtpa	6.0 t/yr	Total of 3 transfers
Loading to stockpile (stacker)	7.9 Mtpa	0.2 t/yr	Assume 75 per cent of ROM coal to stockpiles
Maintenance, wind erosion		56.5 t/yr	Total frequency of u > 20 kph of 20.1%
			Base area = 3.3 ha
Reclamation, conveyor transfer	7.9 Mtpa	4.5 t/yr	
Haulage of rejects	2.0 Mtpa	137.5 t/yr	Mean distance to turn off = 2.75 km
Central route	0.7 Mtpa	52.5 t/yr * 10.5 t/yr	3.0 km in South pit 0.6 km out-of-pit
Southern route	1.3 Mtpa	105.0 t/yr * 29.3 t/yr	2.0 km in South pit 0.9 km out-of-pit

Table A.5(c) cont.

Operation	Extent of operation	Annual emission	Comments
Product coal (7.6 Mtpa)			
Conveyor stacking	7.6 Mtpa	0.2 t/yr	
Maintenance, wind erosion		80.4 t/yr	Base area = 4.7 ha
Reclamation, conveyor transfer, train loading	7.6 Mtpa	4.3 t/yr	
	Subtotal	591.9 t/yr	
* Less 30% of in-pit emissions (due to pit retention)	Less	47.2 t/yr	
	TOTAL (CPP)	544.7 t/yr	
	TOTAL (ALL OPERATIONS) =	8053.1 t/yr	(South Pit)
		2076.3 t/yr	(North Pit)
		544.7 t/yr	(Coal preparation)
		10 674.1 t/yr	

Ratio (dust : ROM coal) = 1.02 kg per tonne of ROM coal

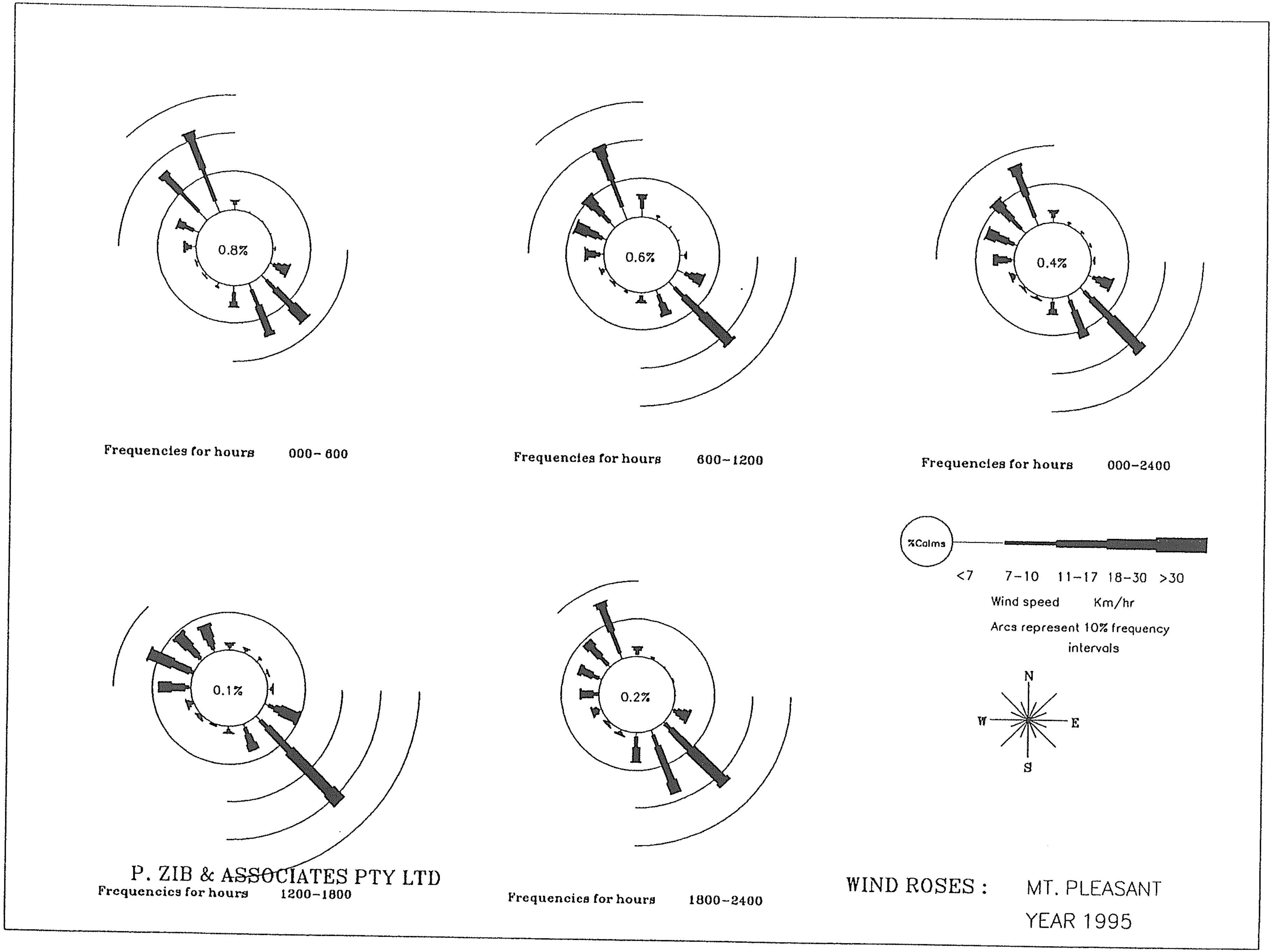
Appendix B.

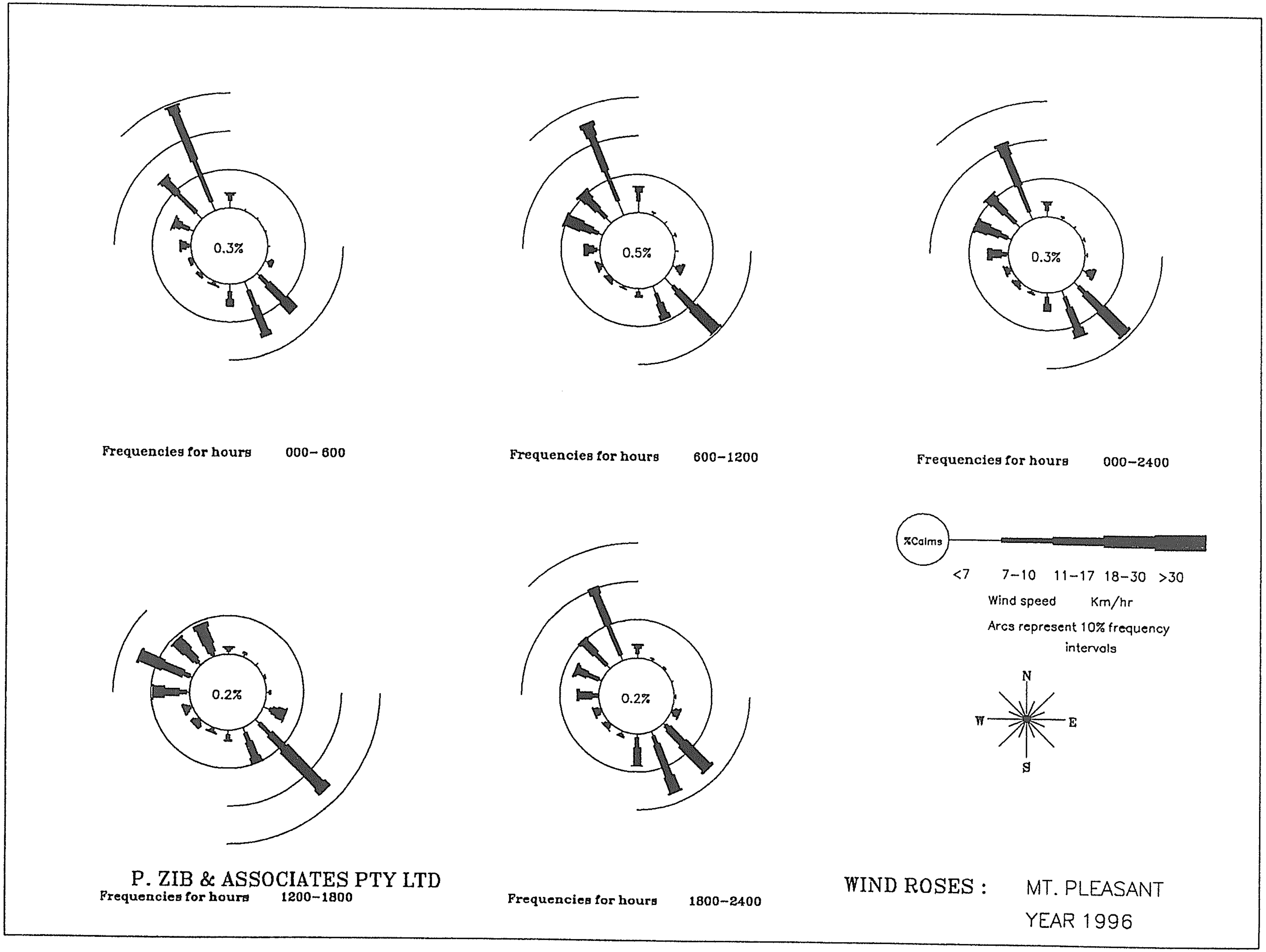
WIND ROSE DIAGRAMS

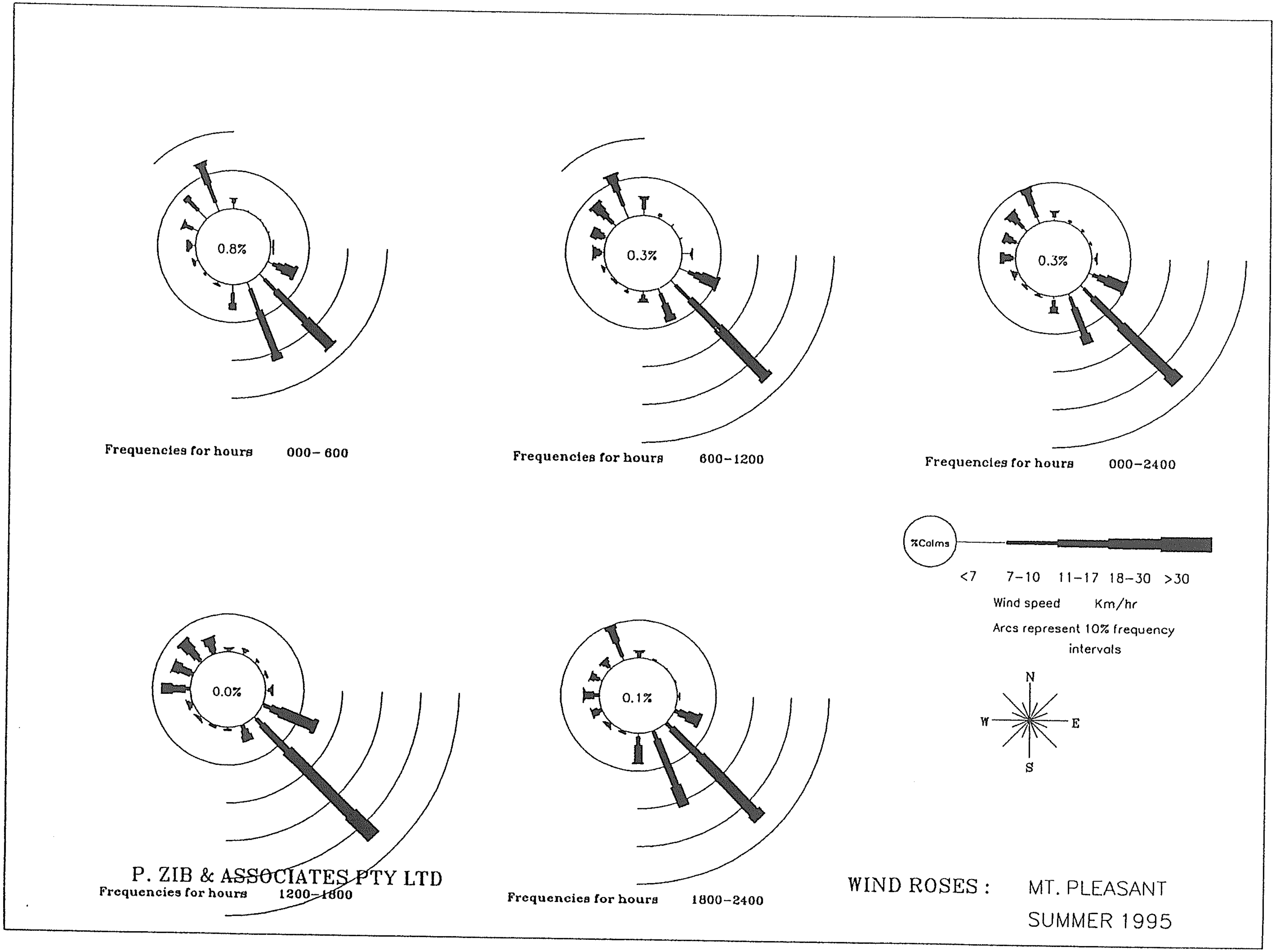
Appendix B.1. Annual and seasonal wind roses recorded at the main meteorological station.

Year 1995 (December 1994 to November 1995)

Year 1996 (December 1995 to November 1996)


0.8%
Frequencies for hours 000- 600
0.6%
Frequencies for hours 600-1200
0.4%
Frequencies for hours 000-2400
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
W
E
S
0.1%
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 1200-1800
0.2%
Frequencies for hours 1800-2400
WIND ROSES : MT. PLEASANT
YEAR 1995


0.3%
Frequencies for hours 000- 600
0.5%
Frequencies for hours 600-1200
0.3%
Frequencies for hours 000-2400
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
W
E
S
0.2%
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 1200-1800
0.2%
Frequencies for hours 1800-2400
WIND ROSES : MT. PLEASANT
YEAR 1996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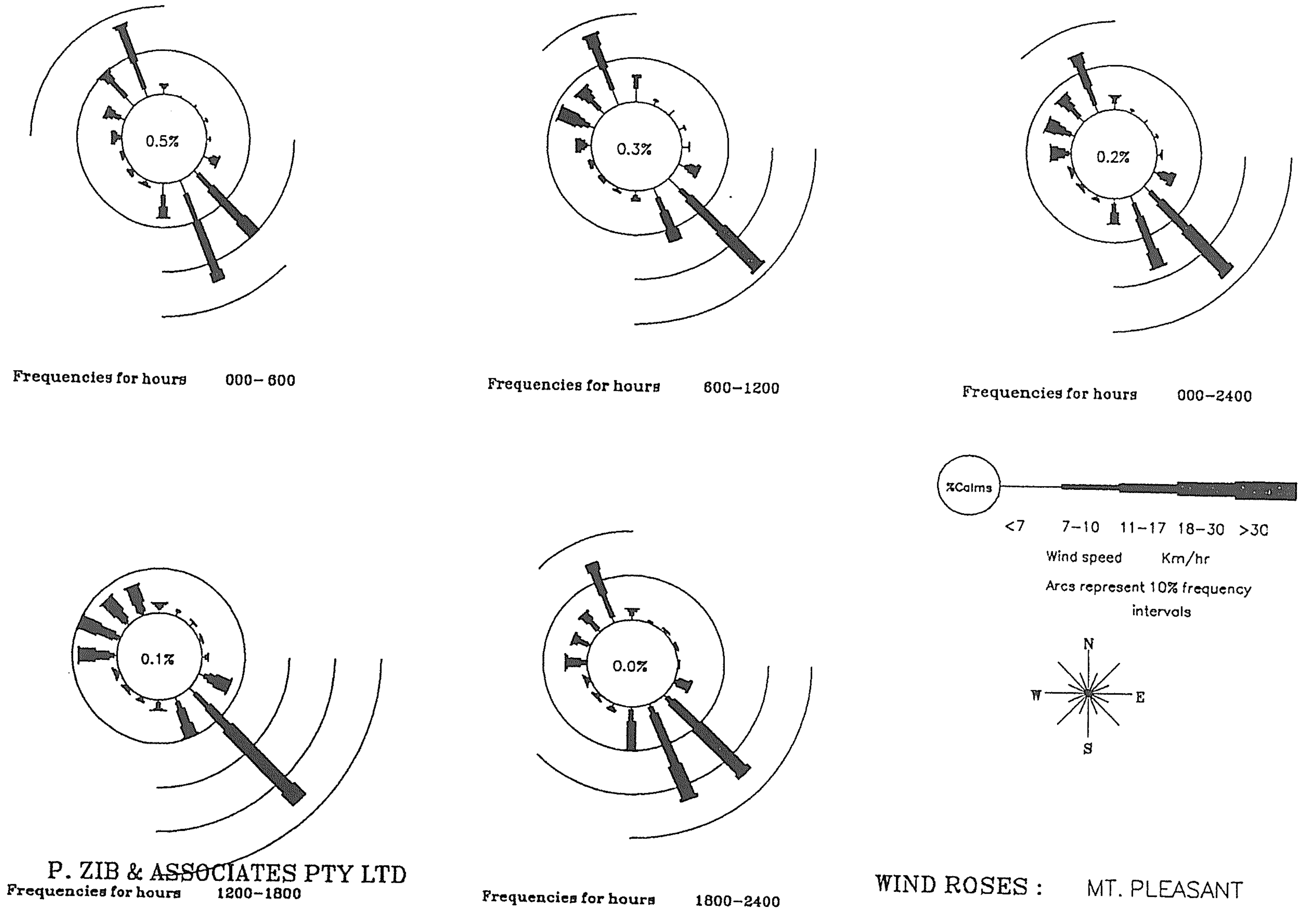
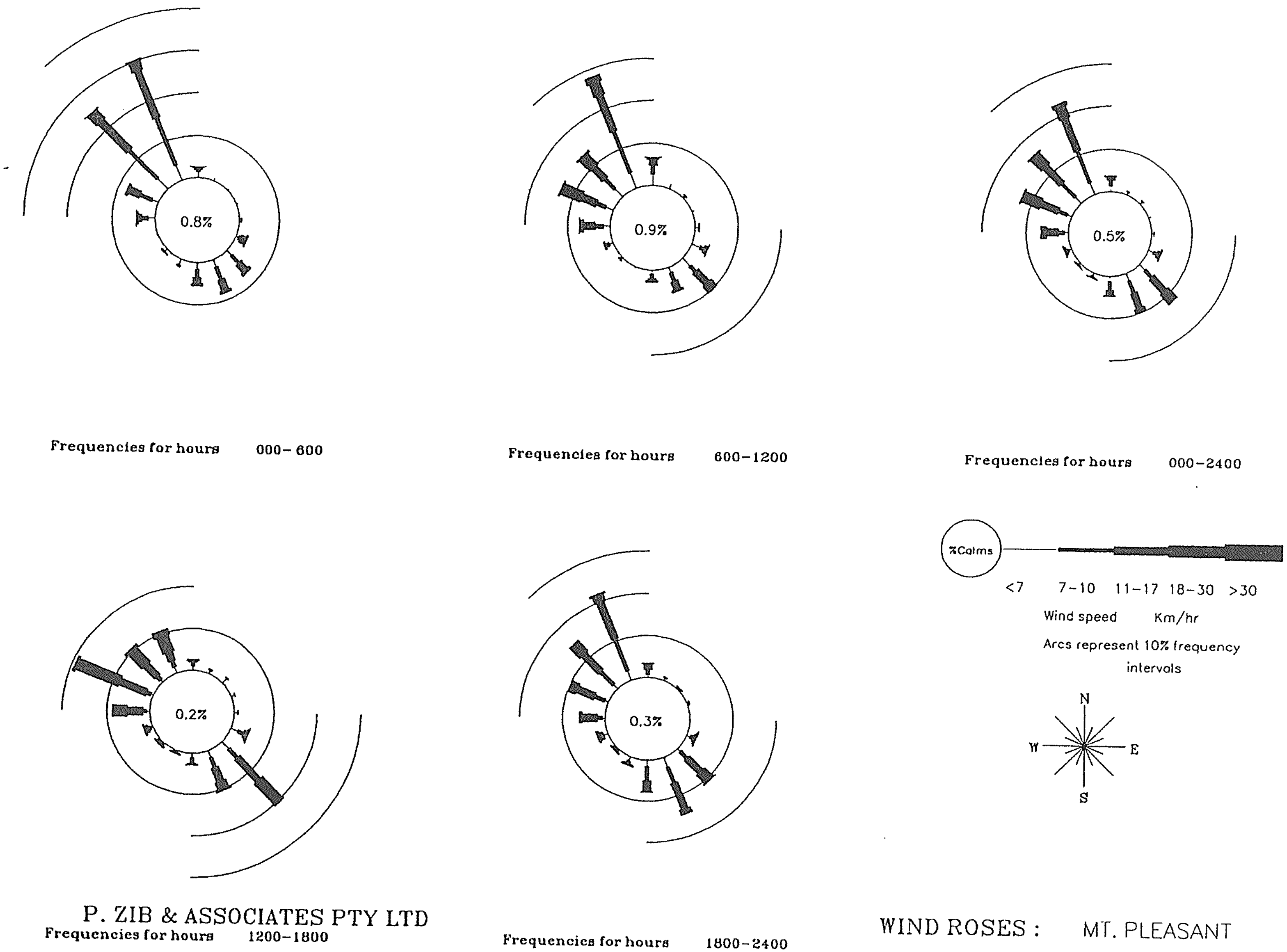
Frequencies for hours 000- 600
0.3%
Frequencies for hours 600-1200
0.3%
Frequencies for hours 000-2400
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
W
E
S
0.0%
Frequencies for hours 1200-1800
0.1%
Frequencies for hours 1800-2400
P. ZIB & ASSOCIATES PTY LTD
WIND ROSES : MT. PLEASANT
SUMMER 1995



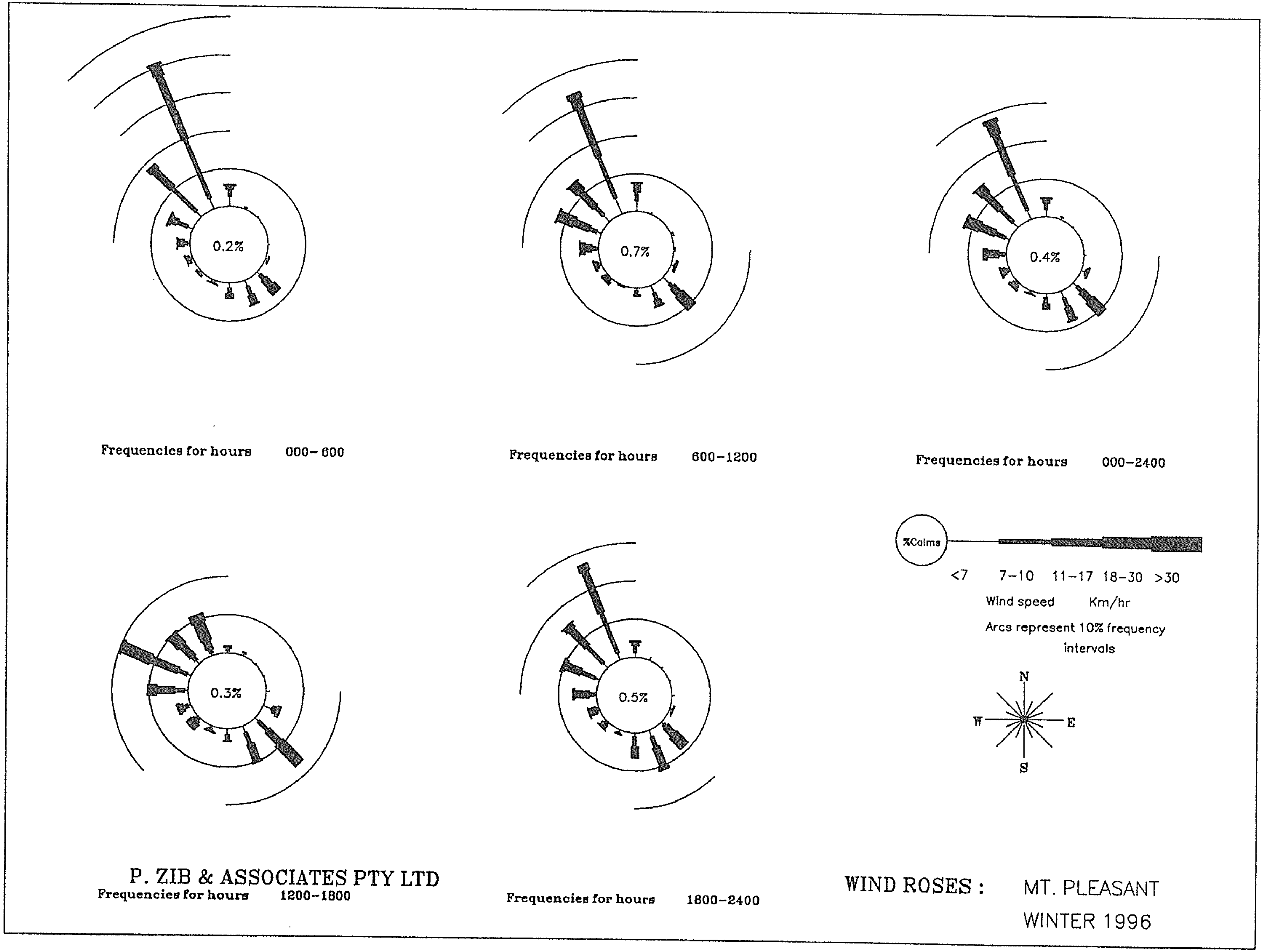
P. ZIB & ASSOCIATES PTY LTD

WIND ROSES : MT. PLEASANT SUMMER 1996



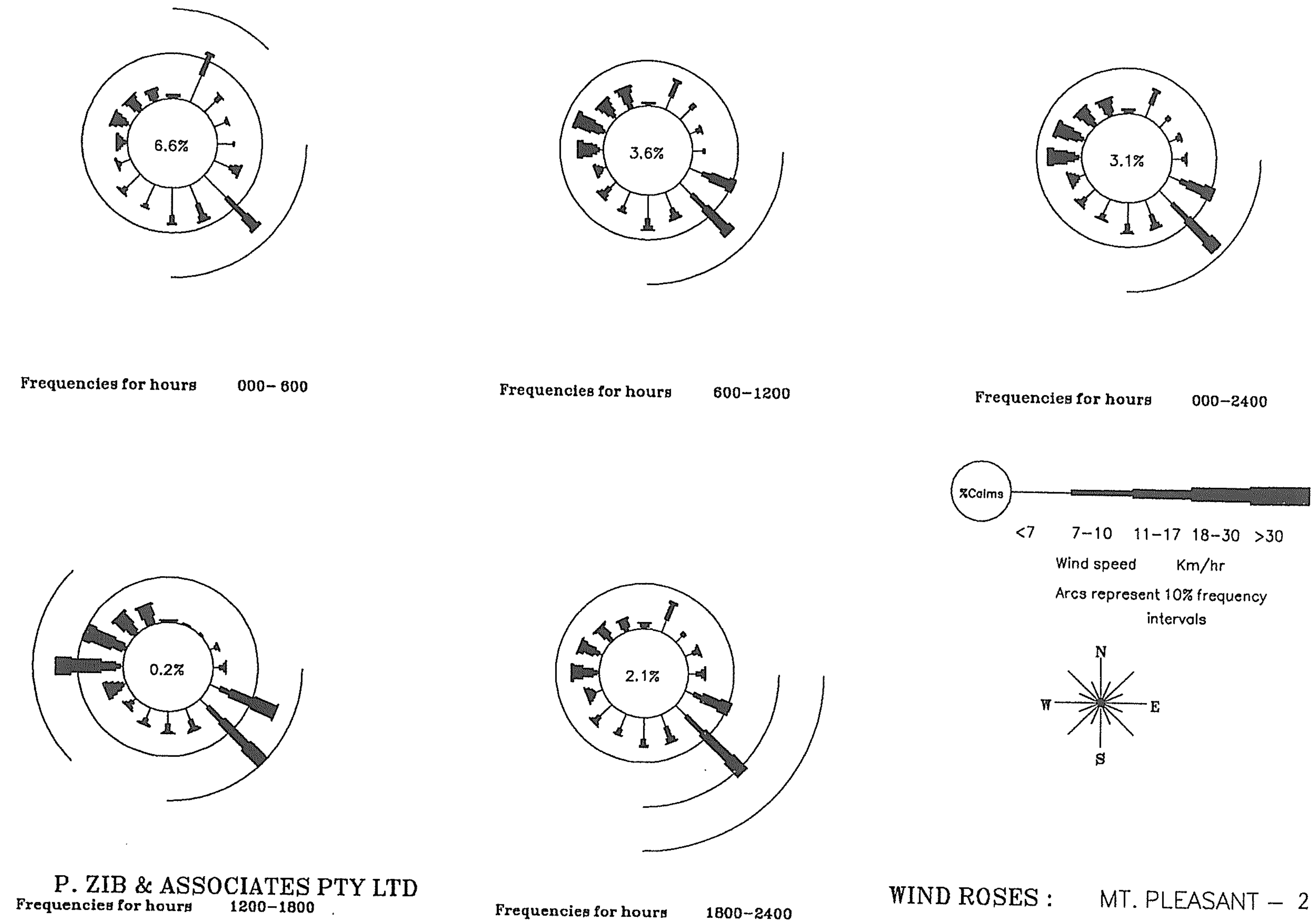
P. ZIB & ASSOCIATES PTY LTD

WIND ROSES : MT. PLEASANT
WINTER 1995


0.2%
Frequencies for hours 000- 600
0.7%
Frequencies for hours 600-1200
0.4%
Frequencies for hours 000-2400
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
W
E
S
0.3%
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 1200-1800
0.5%
Frequencies for hours 1800-2400
WIND ROSES : MT. PLEASANT
WINTER 1996

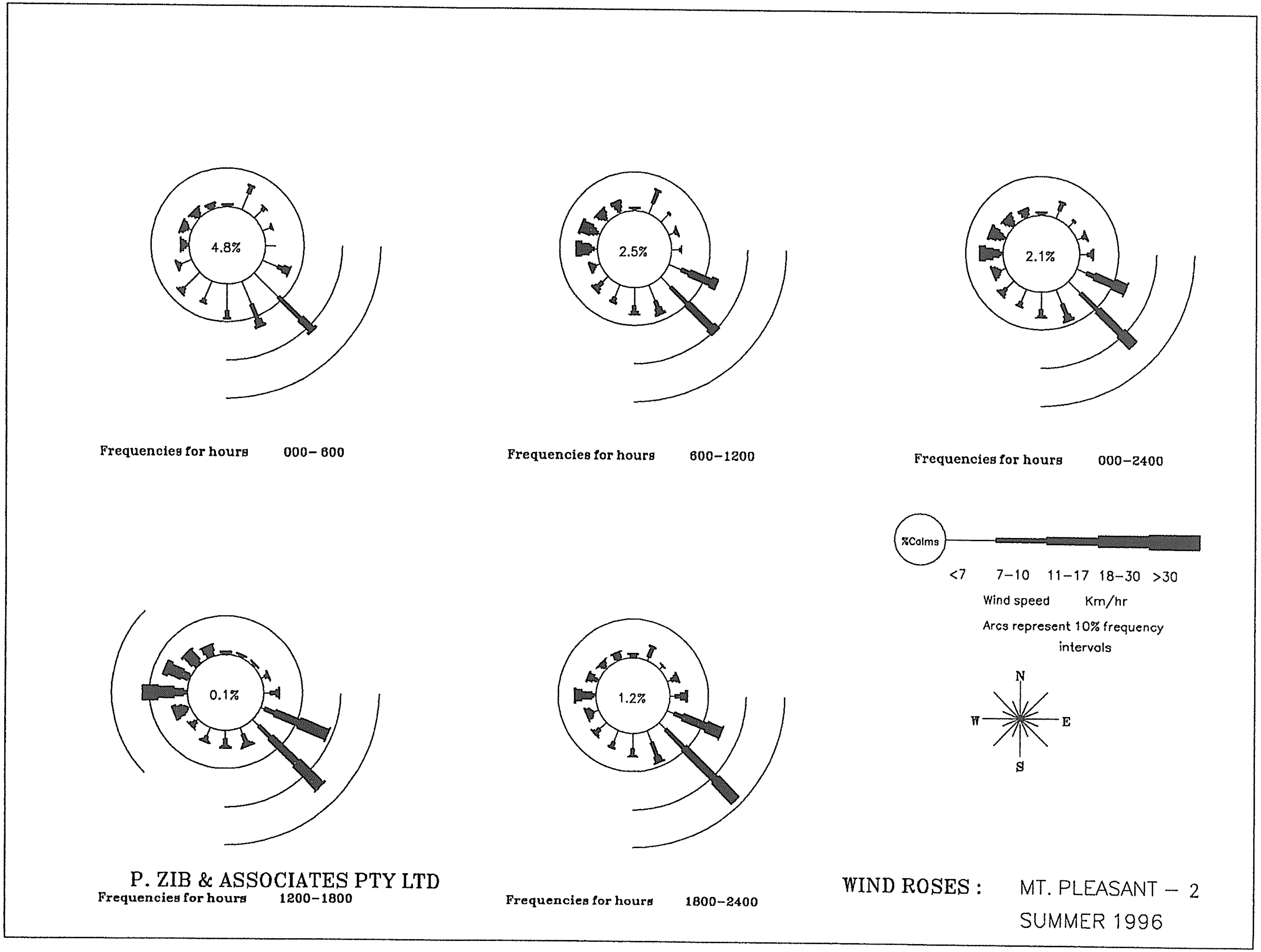
Appendix B.2. Annual and seasonal wind roses recorded at the second meteorological station (Mt. Pleasant - 2).

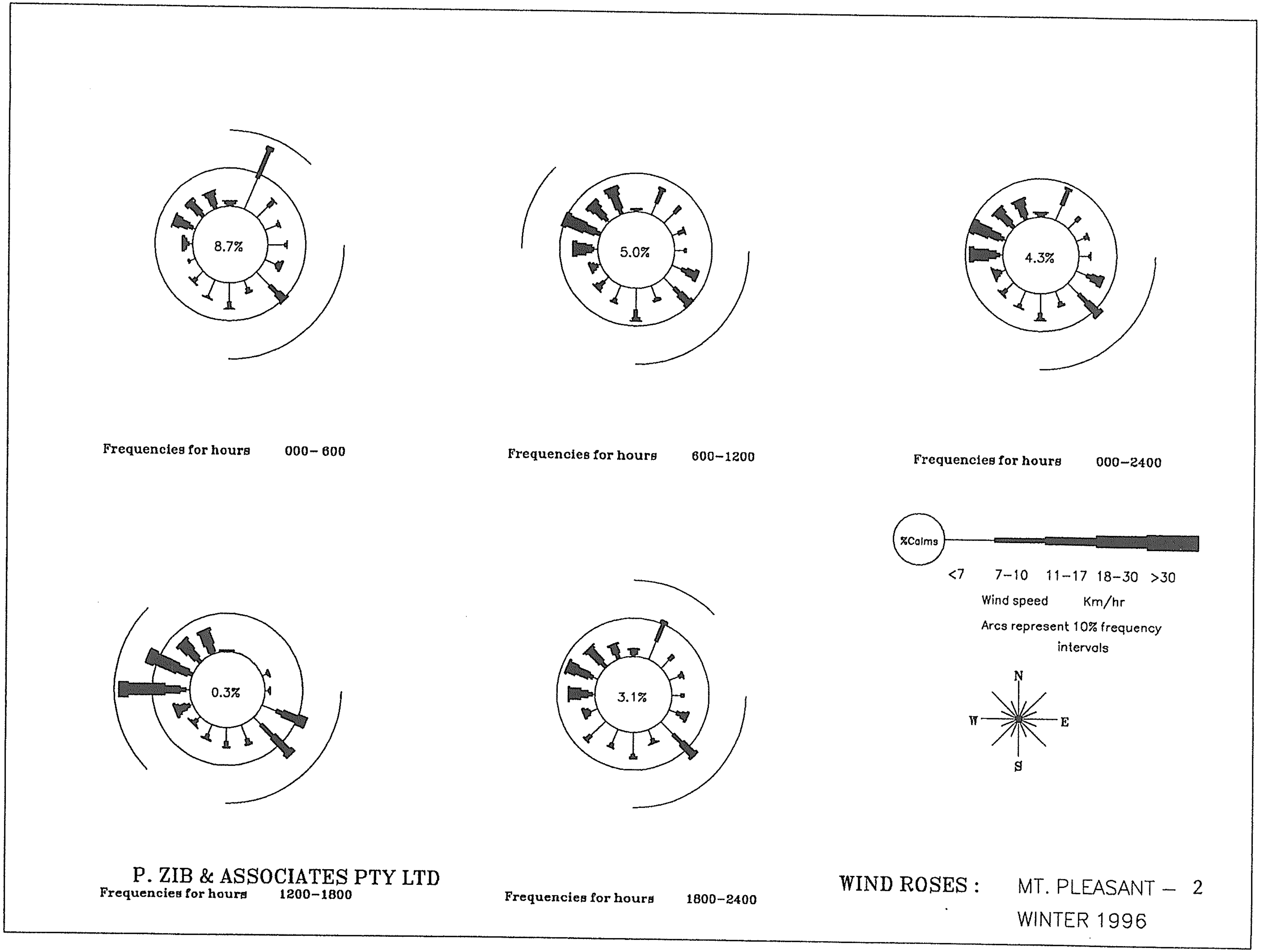
Year 1996 (December 1995 to November 1996)



P. ZIB & ASSOCIATES PTY LTD

WIND ROSES : MT. PLEASANT – 2
YEAR 1996


4.8%
Frequencies for hours 000- 600
2.5%
Frequencies for hours 600-1200
2.1%
Frequencies for hours 000-2400
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
W
E
S
0.1%
1.2%
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 1200-1800
Frequencies for hours 1800-2400
WIND ROSES : MT. PLEASANT – 2
SUMMER 1996


8.7%
Frequencies for hours 000- 600
5.0%
Frequencies for hours 600-1200
4.3%
Frequencies for hours 000-2400
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
W
E
S
0.3%
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 1200-1800
3.1%
Frequencies for hours 1800-2400
WIND ROSES : MT. PLEASANT - 2
WINTER 1996

Appendix C.

DISPERSION MODEL FOR DUST EMISSIONS

Appendix. 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

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

where C = the ground level concentration of particles in the air in the direction θ at a distance x from the source, in 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 sector j and atmospheric stability category k,

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 sectors 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) x 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

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 homogeneous 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 than 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 ot 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 term 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 than 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.

7 COAL DUST AND PLANT GROWTH

A Report to

ERM Mitchell McCotter

on

Coal Dust and Plant Growth

by

Lindsay C. Campbell

University of Sydney

1995

Coal dust on vegetation: Mount Pleasant.

Report of a consultancy undertaken on behalf of

ERM Mitchell McCotter

SUMMARY:

This report examines the literature on the effects of coal dust on plant growth. Coal dust is taken as the dust arising from the overburden of the proposed mine, dust from roads and a small component of black dust arising from the coal itself. The literature on dust is scarce with the exception of dust from cement kilns or limestone dust. Cement kiln and limestone dust can not be equated to dust from the proposed development at Mount Pleasant. Cement kiln dust is alkaline and forms a solid cake on surfaces ie the discrete particles of cement dust are lost into a large aggregate body.

Photosynthesis is one of prime factors contributing to growth of plants. In many ways it can be used as a defacto measure of growth and productivity provided other factors such as temperature, nutrition, pests and diseases are not limiting. Dust rates up to 4 g m^{-2} $month^{-1}$ above background dust levels are unlikely to affect photosynthesis adversely under high light intensities which are generally experienced in Australia. Under very cloudy conditions, dust accumulation on leaves may cause a reduction in photosynthesis. Dust can be lost from leaves by wind and rain; therefore the monthly loading is unlikely to occur on a leaf surface. In many but not all instances, overhead irrigation is used and would contribute to washing dust from leaves. Also, as most crops and pastures have a leaf area index greater than one, the dust loadings on individual leaves are likely to be lower than the dust loadings expressed on a land area basis.

Any adverse effect on photosynthesis is more likely to occur by physical blocking of the amount of light intercepted by the leaf surface than by any other mechanism. At dust deposition rates of 10 g m^{-2} $month^{-1}$, such dust deposition levels may cause a reduction in photosynthesis and thus growth.

There is one paper which may argue that the proposed dust loadings are likely to inhibit photosynthesis. However, it is proposed that the author of the paper made a typographical error in expressing the units. The units are completely out of line with the dust levels reported in other studies.

If dust were to cause an increase in leaf temperature, it would usually be beneficial. Under very high ambient air temperatures (>40°C), a further increase in temperature could be quite detrimental. Dust colour, especially dark coloured dust, would tend to increase the leaf temperature.

Chemical reactions of the dust with the leaf are most unlikely to be significant.

In the interests of all concerned, commodity yields should be obtained for the past few years and in the future. This would provide a basis for discussion about any adverse effects of mining in the area.

Introduction:

In this document, coal dust has been taken to include dust arising from weathering of parent rocks and being wind blown, dust from roadsides blown by wind or disturbed by vehicular movements, and a small component of (black) coal. ERM Mitchell McCotter verbally said that the great majority of the dust will not be arising from the coal itself but from the overburden materials and from the general operations eg dust from unpaved vehicular roads.

Dust and pollutants.

As noted by Farmer (1993) in a review on the effects of dust on vegetation nearly all the work has been done on cement / limestone dust. They are not typical of other types of dust. Dust from cement works has particular properties. Cement (kiln) dust readily forms an amorphous layer of cement on whatever it falls provided some moisture is available ie a layer of cement. This also occurs on leaves of plants. Cement dust is also highly alkaline. Work on cement dust is not discussed in this document because it is not at all representative of any dusts which may arise from coal mining at Mount Pleasant.

It is often difficult to separate the effects of dust per se from other pollutants. Sources of dust include road sides, vehicles, cement kilns, coal fired power plants, dusts from industrial processes, coal dust, mining operations, flyash, overburdens etc. Dust can arise from road sides and thus be of soil or rock origin. Dust may occur concurrently with other forms of pollution eg gaseous emissions.

For example, a coal fired power station can emit both dust particles and oxidised sulphur compounds such as sulphur dioxide. Singh et al. (1994) examined the effect of dust on mango (*Mangifera indica*) and guava (*Psidium guajava*) emitted from a power plant. The power station emitted high levels of particulate matter comprising of mainly flyash and black coal particles. Particulate matter sizes varied from 85-115 µm near the site of emission to 24-31µm at distant sites[1]. Deposition rates were more than 1g m^{-2} day^{-1}; the range varied between 1.32 to 2.65g m^{-2} day^{-1} which is

1 Particulate size deposition rates are prepared by another consultant for the Mount Pleasant project. Wind speed will affect the transport characteristics of the size of various particles. Therefore quoting distances is not appropriate here. Particle sizes in the Singh et al. study are considered quite large. ERM Mitchell McCotter has advised that the particle size distribution is 50-60% of particles in the range 2.5-15 um, 40-50% in the range 15-30µm and 5-10% <2.5µm.

equivalent to 40 to 80 g m^{-2} per month[2]. In addition to the particulate matter, sulphur dioxide was emitted at high concentrations. Sulphur dioxide should not be emitted from the proposed mining operations.

Singh et al. (1994) showed that the combined effects of very high dust deposition rates coupled with sulphur dioxide adversely affected chlorophyll concentrations in the leaves, ascorbic acid concentrations and specific leaf area of the species. The data show that both sulphur dioxide and high dust fall-out depress chlorophyll and specific leaf area. By implication, reduced growth would be expected.

The potential adverse effects of dust on plants can be broadly divided into physical effects and chemical effects. The former relate to deposition of dust on leaves, effects of dust on photosynthesis, blockage of stomata by dust etc. and the latter relate to the formation of chemical species which react with components of the leaf.

Stomatal density.

It has been suggested that dust may block the stomata [pores] in the leaf and prevent gas exchange. The following table illustrates the stomatal density of leaves[3]. The density of stomata varies between the adaxial and abaxial surfaces and both between species and within a species - there are no general rules.

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2 The consultant has asked for comments at dust deposition rates of <2, 2-4, and 4-10 g /square metre / month. The dust levels in Singh et al (1994) study are more than 4 times the extreme for the proposed development and probably more than 10-20 fold more than is anticipated at Mount Pleasant.

3 The adaxial surface is the upper surface of a leaf. The abaxial surface is the lower surface of the leaf.

Species	Adaxial stomatal density (no. of stomata mm^{-2})	Abaxial stomatal density (no. of stomata mm^{-2})	Stomatal length (μm)	Stomatal width (μm)
Maize (Zea mays) [Krajickova and Mejstrik, 1984]	68-103	53-77	32	12
Hordeum distichon [Krajickova and Mejstrik, 1984]	52-64	59-78	30	9
Bean (Phaseolus vulgaris) [Krajickova and Mejstrik, 1984]	23-46	74-101	14	8
Soybean (Glycine max) [Kemp, 1981]	100-129	253-294		
Lucerne (Medicago sativa) Two cultivars [Jung and Larson, 1972]	163, 301	130, 222		
Lucerne [Sheaffer et al., 1988]	217	174		
Lucerne [Grove and Carlson, 1972]	100-165	76-108		
Grapes [During, 1980]	0	200 - 250		

Brown et al. (1972) give stomatal areas between 45 and 66 μm^{-2} for lucerne. The stomatal areas of species in the above table are 100 to 300 μm^{-2}.

The percentage of the leaf which is occupied by stomata is relatively low. For example, at 100 stomata mm^{-2} and a diameter[4] of the stoma of 20µm the percentage area of stomata is 13% of the leaf. This is probably an overestimate of the area occupied by stomata (vide footnote 4). Thus if dust falls randomly on a leaf, there is about 10% probability that it would land on a stoma. Also, the particle size would have to be such that it would cause blockage of the stoma.

If dust has a density of 4 g/cc (cf iron sulphide is 4.3) and the individual particle size is 20µm and assuming that no dust falls off the leaf, then the number of particles / mm^{-2} for different monthly dust deposition rates is given in the following table.

Dust rate $g\ m^{-2}$	Particles mm^{-2}
1	60
1.5	90
2	119
2.5	149
3	179
3.5	209
4	239
4.5	269
5	298
5.5	328
6	358
6.5	388
7	418
7.5	448
8	477
8.5	507
9	537
9.5	567
10	597

The number of dust particles per mm^2 of leaf surface is thus comparable to the number of stomata on the leaf surface especially at the rates of dust deposition likely at Mount Pleasant. If the particle size is much smaller, then the number of particles notionally falling on a leaf is substantially greater.

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[4] Assuming that the stomata are circular. If the stomata are more elongated as in the grasses, the percentage area occupied is about 2% (using the same density of stomata, but length 30 µm and width 12 µm cf dimensions in the table).

The stomatal density on fruit eg grapes is very low (Swift et al., 1973) about 1 -2 per mm^{-2} (Blanke and Leyhe, 1987). Fruit are not carrying out photosynthesis and it is not surprising to find few stomata.

Effects of dust on plant photosynthesis.

There is a scarcity of data on dust other than cement/limestone dust on photosynthesis. Cement dust deposition rates tend to be usually greater than 1g m^{-2} day^{-1}. The work of Krishnamurthy and Rajachidambaram (1986) is typical of much work with cement dust; rates of dust deposition were 2.7-3.7 1g m^{-2} day^{-1}. In essence, they found that irradiance [light] falling on the leaf surface was reduced by dust and thus depressed photosynthesis. A dust layer of 0.2-0.4 mm reduces irradiance by 50% or more. They also found that the cement dust clogged the stomata [pores for gas exchange into leaves], that the cement formed a layer over the leaf, and that guard cells [which surround the stomata] shrank under the alkaline conditions generated by the cement dust. Other reports on cement dust (vide Farmer, 1993) also note that leaf diffusive resistance tends to be reduced. This can be interpreted as increased gas exchange and transpiration ie potentially greater water loss from the leaf under certain conditions.

Armbrust (1986) examined the effect of a soil dust (particle size <0.106 mm) on cotton photosynthesis and short term growth. Dust was applied as a single event by blowing air over the soil dust which resulted in some of it being deposited on leaves. One day after application of dust at 38.5 $\mu g/m^2$ and above , the photosynthetic rate was significantly reduced. At 3 days after application, the rate of photosynthesis was depressed only at the highest level 51.1 $\mu g/m^2$. After 7 and 14 days, the initial dust deposition had no significant effect on photosynthesis. Dark respiration increased briefly (days 1 and 2) but subsequently there was no difference between highest and control levels of dust. Textual statements concerning the effects of dust on growth are not supported by the data presented. However, it is clear that growth is reduced after 14 days by rates of dust 28.6 $\mu g/m^2$ and above.

Armbrust calculated regression equations of the effect of dust on photosynthesis, dark respiration and dry weight. The effect of dust on each of these parameters could explain 0.36%, 45% and 35% respectively. In other words, factors other than dust deposition were virtually totally responsible for the photosynthesis results. Although dust has some effect on growth (dry weight), other factors explain 65% of the variation.

The levels of dust on leaves in Armbrust's work are extremely low (cf Hirano et al. (1990, 1991) worked generally at levels up to 5 g m^{-2}). Armbrust also quotes a study using cement kiln dust applied at rates of 0.5 to 3.0 g m^{-2} to beans. It is possible that Armbrust used an incorrect symbol (μ) or a typographical error crept in with 'mm' being replaced with 'm' thus making his units incorrect. I am of the latter opinion[5]. If Armbrust actually used μg mm^{-2} rather than μg m^{-2} then the rates of dust which he applied would be in the range of 1 to 6 g m^{-2} . This is then similar to all other studies. In the introduction to his paper he notes rates of dust deposition on the Great Plains in the USA of 17-459 kg ha^{-1} $month^{-1}$. This is equivalent to 1.7 - 45.9 g m^{-2} $month^{-1}$. [Deposition rates to be considered for the Mount Pleasant project are up to 10 g m^{-2} $month^{-1}$]. Later in the discussion he refers to 'low natural deposition rates of 1.5 μg m^{-2} and quotes Smith et al (1970). Smith et al (1970) do not use that number; they say that 1650 km from the dust centre, the deposition rate is 17 kg ha^{-1} $month^{-1}$ [which is equivalent to 1.7 g m^{-2} $month^{-1}$]. As this is the lowest value given in their paper, it is reasonable to assume this is the background level and presumably the one used by Armbrust.

Armbrust (1986) concludes "The rapid removal by wind and rain[6,7] of dust deposited on leaves, low natural deposition rates (1.5μg m^{-2}) [citing Smith et al., 1970] , and the short time reduction in dry weight accumulation (< 3 days) would seem to indicate that dust deposited on plant leaves would not be a major problem to cotton production under normal growing conditions".

Hirano et al. (1990, 1991) have made a useful contribution to the debate on the effects of dust on leaves. Four classes of dust were used in their experiments - carbon black and Kanto-loam powder of three grades viz

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5 Farmer (1993) summarises a number of papers on the effects of dust. Road dust in Alaska is about 10 g m^{-2} day^{-1}. In one of his tables, the range is 0.6-7 10 g m^{-2} day^{-1}. These rates are about 30 times greater than could be anticipated in the worst case for Mount Pleasant.

6 Armbrust also cites other work saying that wind / rain result in substantial losses of dust from leaves and that larger particles (0.088 - 0.77 mm) were retained on plant leaves for up to 10 days. Smaller particle sizes tended to fall off more rapidly. These large particle 0.088 mm (ie 80 μm) are substantially larger than the expected upper end (30 μm) of particles from Mount Pleasant. Thus one would anticipate that the particles generated at Mount Pleasant may have a short residence time of several days on leaves. The implication is that dust is simply not accumulating on the leaves but that substantial losses of dust occur from the leaves.

7 Peters and Witherspoon (1972) applied small quartz particles at rate of almost 20 g m^{-2} to grasses. Although the leaves shed the particles, only 31% reached the ground; much of the particulate matter remained on stems or dead leaves on the ground.

coarse, fine and ultrafine. Coarse, fine and ultrafine particles had median diameters of 30, 8 and 1.9 μm respectively. The pH of all these materials was near neutral. The colour was black for carbon black, and reddish-brown for the Kanto-loam dusts. Dusts were applied to either bean (*Phaseolus vulgaris*) or cucumber (*Cucumis sativus*) plants. The important results from their experiments are summarised below.

(i) Irradiance [photosynthetically active light] was reduced by 50% at 2 to 5 g m^{-2} for the different dusts; carbon black reduced the incident radiation onto the [leaf] surface at the lowest rate viz 2 g m^{-2}. Another way of saying this is that the light intensity at the leaf surface is reduced as the dust level increases and is dependent on the type of dust.

(ii) For bean leaves, net photosynthetic rate is reduced at low light intensities (<500 μmol m^{-2} s^{-1}) by about 10-20% but not at higher light intensities. For bean leaves, light intensities up to 750 μmol m^{-2} s^{-1} showed some reduction in photosynthesis depending on the amount of dust applied. However, if the rate of photosynthesis is plotted as a function of actual light intensity received at the leaf surface then there is no effect of dust on the net photosynthetic rate (Fig 5 and 6, Hirano et al., 1990).

(iii) Increasing the dust density to 4 g m^{-2} resulted in reductions in photosynthesis up to 40% at a low light intensity (210 μmol $m^{-2}s^{-1}$); carbon black tended to reduce photosynthesis more quickly than the other dusts due to its absorbing more light. This reduction in photosynthesis was directly (linearly) related to the reduction in light intensity and was virtually independent of dust type.

(iv) At low light (550 μmol $m^{-2}s^{-1}$), the stomatal conductance diminishes as the amount of dust increases provided dusting occurs in the light. If dusting occurs during the night, then there is no change in the stomatal conductance. An examination of the data suggests that there may be no statistical difference between no dust and dust applied at 5 g m^{-2}. Notwithstanding the statistics, it may be prudent to assume a trend that increasing dust applied during the light period may reduce the stomatal conductance. Reduced stomatal conductance implies reduced transpiration (ie water loss) from the leaves.

(v) There is a suggestion that finer particle sizes may reduce the stomatal conductance. Again there are statistical problems as outlined in (iv) above.

(vi) Leaf temperatures were higher only when carbon black was used as the dust. The other dusts had no effect.

Hirano et al. (1991) interpret the decreased stomatal conductance as blockage of the stomata. Unfortunately no electron micrographs were done so this interpretation has no definitive evidence. Another interpretation is that the stomata close (or at least partially close) in response to dust but are not plugged by the dust. In other studies, dusts seem to be found around the stomata but not actually blocking them. Certainly flyash dust accumulates around the stomatal opening but does not plug it (Krajickova and Mejstrik, 1984). Krajickova and Mejstrik showed that the flyash dust accumulated on the surface of the guard cells of the stomata but not in the stomatal pore[8].

Auclair (1977) sprayed a coal dust (from the coal itself rather than overburden material) on leaves of scotch pine and poplar. At high light levels, there was no inhibition of photosynthesis. At low and medium levels of light, there was some reduction in photosynthesis. He also showed that dust absorbs part of the incident light and transmits only a fraction of the energy. In other words, there was a shading effect of the dust on the leaves. This is similar to the findings of Hirano et al. Likewise Thompson et al. (1984) attributed the reduction in photosynthesis of *Vibernum tinus* plants by black dust from car exhausts to shading of the leaves; the effects on photosynthesis occurred at dust loadings of 5 - 10 g m^{-2}.

The studies reviewed refer to a dust loading at a single point in time. As noted by Armbrust (1986), a considerable proportion of the dust is lost by wind and rain from the leaf. Furthermore, the 88 year long term records of Muswellbrook rainfall give 6 to 8 rain days each month (Bureau of Meteorology, 1977). Monthly median rainfall for Muswellbrook varies from 27 mm (May) to 59 mm (December). In the case of the Mount Pleasant development, the dust levels are given on a monthly basis. Assume a worst case scenario of 12 g m^{-2} $month^{-1}$ including background levels of 2g m^{-2} $month^{-1}$. As Armbrust indicates that most of the dust from a single event is lost in ten days, it would seem that the worst case equilibrium level of dust would be about 3-4 g m^{-2}. In the more likely scenario, dust levels of 4 g m^{-2} $month^{-1}$ including background[9] may be predicted (ERM Mitchell McCotter). This would probably translate to an equilibrium level of less than 1.5 g m^{-2} on the leaf surface.

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8 The actual deposition of flyash was not stated but the levels were probably quite high. However the paper indicated that large amounts of flyash were produced daily.

9 The total predicted dust loading consists of a background of 2 g m^{-2} $month^{-1}$ and an additional loading up to 2 g m^{-2} $month^{-1}$ (ERM Mitchell McCotter).

The leaf area of a crop is usually more than the land area on which a crop is growing[10]. If the crop has a leaf area index more than 1, then the notional dust level intercepted by the leaves would be less than a single flat covered area. In other words, the dust loadings on individual leaves are likely to be lower than that simply given on a land area basis.

If these dust levels are correct, then it is highly unlikely that photosynthesis of plants would suffer to any appreciable extent at total dust levels up to 4 g m^{-2} $month^{-1}$. At levels of dust of 12 g m^{-2} $month^{-1}$, there is a reasonable chance that photosynthetic activity may be reduced by 10-20% at low light levels[11]. Low light levels would equate to overcast days with a reasonably thick cloud cover.

As it seems that the interception of light falling on leaves is the most important factor limiting photosynthesis when dust is applied to the leaves, then incident radiation becomes important. Under sunny conditions, Anderson (1971) cited by Kemp (1981) gives full sun conditions of about 2000 μmol $m^{-2}s^{-1}$. Thus the light intensity of full sun is more than double the maximum light intensity in Hirano's studies. Thus high dust loads would be needed to achieve the reduction in light intensity to about 25% or less of the incident light.

In summary, photosynthesis of crops is most unlikely to be reduced at total dust levels up to 4 g m^{-2} $month^{-1}$. At 12 g m^{-2} $month^{-1}$, photosynthesis may be reduced on cloudy days. Growth of the crop should similarly follow the pattern for photosynthesis. This opinion may have to be revised if Armbrust's stated rates of dust deposition are correct.

The evidence for changes in transpiration [water loss] from leaves is ambiguous. The results [conductance studies] of Hirano et al. may be interpreted as reduced water loss whereas those of Euling (1969) would argue for increased transpiration. Euling used small particles (99% less than 5 μm, 82% less than 2 μm) which would correspond more with Hirano's ultrafine Kanto loam. On the other hand, Hirano et al. (1991) had increased transpiration rates when carbon black was used as a dust - the increased transpiration was attributed to high leaf temperatures.

Leaf temperature.

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10 The ratio of leaf area to land area is called the Leaf Area Index (LAI). Only in the initial stages of growth is the LAI less than 1. Mostly leaf area indices are 3-5 or more.

11 This assumes that light is the limiting factor. Often on cloudy days, temperature is lower and may be limiting photosynthesis and growth.

Leaf temperature only increased when carbon black was used as a dust (Hirano et al., 1991); the other red / brown dusts had no effect on leaf temperature. The increase in temperature was between 1.7°C and 3.7°C. Increased temperature of leaves has also been reported for road dust (Eller, 1977). If leaf temperatures rose, the consequences for growth would generally be favourable up to the temperature optimum for the plant. Transpiration may also rise with increased temperature but this may be offset by a variable effect of dust on stomatal conductance.

At high ambient air temperatures, an effect which caused additional heating of the leaf would be undesirable and damage may be caused. This could be a significant problem when ambient air temperatures are greater than 40°C.

Chemical effects.

The following comments are offered on the basis of the report from the Department of Mineral Resources (NSW) on the characterisation of overburden and interburden materials of the Mount Pleasant area. With the exception of six samples[12], the rest of the samples had no significant acid producing materials[13]. These samples were characterised by having greater than 0.5% total sulphur.

Assume that the sulphur percentage of the material is 1% ie about twice that given in the Department of Mineral Resources report, has a density of 4 g /cc and a particle size of 20 μm diameter. The weight of a particle is about 17 ng and thus the amount of sulphur is 0.17 ng. If all of this were oxidised to sulphuric acid, this would account for approximately 50 ng of sulphuric acid or 0.5 nmole of sulphuric acid. This is a negligible amount of acid and is most unlikely to do any significant chemical damage to plant tissues.

If this calculation were extrapolated to high rates of dust deposition (10 g m^{-2} $month^{-1}$), then there would be 0.1 μg sulphur per $millimetre^{-2}$ if no losses of dust from the leaf occurred. This equates to about 3 nanomoles of sulphuric acid. Again it would be most unlikely to do any chemical damage of significance to plant tissues.

Other samples of the overburden and interburden were neutral or had carbonates present. Given the amounts present, it is extremely

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12 See section 3.1.1. of the report of the Department of Mineral Resources.

13 Samples which produced a pH of less than 5.5. These samples have the capacity to be oxidised to sulphuric acid.

unlikely that any significant chemical damage would occur. Likewise the amounts of sodium that would come from dust deposition should have no adverse effects on plant growth.

The author of this report is not in a position to comment on any heavy metals or organic compounds which may occur in the dust. No data have been provided on these metals or compounds.

Effects of dust on pollination (of pecans).

No literature has been found on this subject viz dust affecting pollination. Pecans are strongly dependent on outcrossing ie the source of pollination is important. Losses of nuts occur if the flowers are not cross pollinated (Wood and Marquard, 1992). Increasing humidity decreases the release of pollen from the anthers and increasing temperature promotes pollen release (Yates and Sparks, 1993). Germination and rapid entry of the pollen occurs within 3 hours of the pollen landing on the stigma (Wetzstein and Sparks, 1989). Pollen arriving 24 hours after the first pollen arrival was less than 3% effective (Marquard, 1992).

Mr Yore (owner of a pecan nut farm which may be in the zone affected by the Mount Pleasant development) said that a pecan nut farm at Moree stopped the use of vehicles due to dust affecting pollination. There are no data to confirm or refute that assertion. However, on black soils such as Moree, vehicular traffic may cause compaction and this may have contributed to the decision. Also compaction is likely to make the zinc deficiency problems of that area worse. Pecans are a crop which is sensitive to zinc deficiency (Hu and Sparks, 1991).

General.

The amounts of dust which may fall on leaves or flowers is generally unlikely to affect their quality. In the case of the Gladiolus flowers, dust is unlikely to be seen on the blooms given the short duration of exposure. However, it is possible that at high deposition levels of a dust, which had a contrasting colour to the flower colour, may be seen as a band on the flower as it emerged. This would depend on the geometry of the spike, whether dust fell or was washed down and on the ability of the emerging flower to brush against the dust.

Leaf pubescence (hairiness) is likely to have both positive and negative aspects with respect to dust deposition. Leaves with many trichomes (hairs) are more likely to prevent dust from the reaching the leaf surface and interfering with stomatal performance. On the other hand, trichomes may impede the loss of dust particles by wind and rain. Further investigations using scanning electron microscopy would assist in resolving this matter.

Coal dust has been applied to orchards in the USA as a possible means of frost protection (Sharratt and Glenn, 1988; Davis et al., 1989). Rates of coal dust were very high (up to 44 Mg ha^{-1}). One point to emerge from Sharratt and Glenn's study was that coal dust applied in successive years to the orchard had no detrimental effects on the trees.

Conclusion:

The effects of dust arising from the proposed Mount Pleasant coal mine are not likely to be significant for plant growth. In many instances, overhead irrigation is used and this water should assist in washing dust off leaves. Overhead irrigation occurs in lucerne production, growing of Gladiolus flowers, vegetable and turfgrass production. It may be used in vineyards but drip irrigation is gaining in popularity. Pecan nut trees would rarely be watered by overhead sprinklers as it would be a most inefficient use of water.

Photosynthesis can be reduced by dust due to the physical blocking of light from penetrating to the leaf surface. However, under most conditions the light intensity should be sufficiently high not to inhibit photosynthesis to any appreciable extent. Photosynthesis may be reduced under very cloudy conditions; under such conditions temperature may also be a limiting factor.

Leaf temperature may rise under dust but this is dependent on dust colour. Farmer (1993) notes that urban road dust may increase leaf temperature of trees. Increased leaf temperature up to the temperature optimum for the species is usually beneficial. At very high temperatures in excess of 40°C, further heating of the leaf could be quite detrimental.

The evidence for changes in transpiration and leaf conductance is variable under various levels of dust. It is unlikely to be a major factor. The most important factor is the physical shading of a leaf which in turn reduces photosynthesis.

Pollination is important when fruit is the commodity for markets. No literature was found on the effects of dust on pollination. At the levels of dust up to twice background, it is unlikely that dust will affect pollination. Studies with cement dust at levels ten times greater show decreased fruit set.

Given that the commodities have been grown in the area for a long time, it would be prudent for all concerned to monitor crop / pasture / flower / vegetable yields both before and after the onset of mining activities. This would then provide a basis for assessment of any economic calculations.

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Faculty of Agriculture

The University of Sydney
N.S.W. 2006 Australia

Friday, 26 May 1995

Mr Jan Parsons,
Mitchell McCotter and Associates Pty Ltd.,
24 Falcon Street,
Crows Nest, NSW. 2065

Dear Jan,

Re: Mount Pleasant Project EIS

Please find attached a report on a field visit requested by Coal and Allied through your office. In essence, the main purpose was to visit a number of growers who had expressed concern about the proposed development. Growers were encouraged to list their concerns.

The visit took place on Friday 19th May.

Yours sincerely,

Lindsay C. Campbell. B.Sc.(Hons.) Ph.D. MAIAS.

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REPORT OF VISIT TO GROWERS
EXPRESSING CONCERNS
ABOUT MT PLEASANT DEVELOPMENT

On Friday 19th May, I visited Muswellbrook to meet owners or managers of properties who had expressed concerns about the proposed Mt Pleasant coal mining development. On arrival at Muswellbrook, I first met Mr John Dwyer and Mr Rory Gordon at the offices of Coal and Allied. They instructed me that the prime purpose of this field visit was to listen to the concerns of several primary producers in the area.

Before proceeding to the properties, I expressed my preference to follow their vehicle but I would travel in the University's vehicle when practicable. This was to maintain a degree of independence from the company. I also informed them that I had brought some coloured chalk/salt mixture in a vial to illustrate what 2g and 10g represented. This mixture could be scattered on a 1 metre squared piece of white cardboard to illustrate dust fallout. Limitations of this demonstration include the comparatively large particle size of the chalk/salt mixture and the colour (blue in this case to contrast with the white cardboard).

1. Property of Alan and Sandra Matthews : flower growers.

This property grows Gladiolus flowers for the cut flower trade. Approximately 12 acres of flowers are grown per year; this corresponded to 800,000 corms. The Matthews grow their own replacement stock. The main colours are yellow, gold, pale pink, white and red. Other than the period late May till August, there are plants in the ground (and growing). First flowering occurs in October / November and lasts till mid May. The soil depth was said to be about 8 - 9 metres and is supposed to be sandier at depth. Water was applied by overhead sprinklers with the water being supplied by a well. The flower spike was cut and kept in a cool store at 2 - 4 C until transport to the markets - usually with 24 hours. Mr Matthews said that flowers were harvested when the first flower was just opening; from first open to bloom it is 2 days. Flowers should last 3-4 weeks in the market place.

The concerns raised were: (i) the effect of dust on the marketability of the flowers. In particular, a layer of dark coloured dust or dust which contrasted with the flower colour would adversely affect marketability. (ii) Mr Matthews notices a layer of dust on cars especially after windy conditions. (iii) On a still day, he notices an inversion layer of dust which was attributed to the coal mines. (iv) The flower spike acts like a funnel and so traps dust which then adheres to the opening flower. (v) He may decide to grow other commodities - what is the effect of dust on them. (vi) Mr Matthews also asked about the bund wall heights. John Dwyer said that the concept is to keep with the general landscape. (vii) Mr Matthews asked how much sunlight will be lost by increasing the height of the hill. He said this may affect his crop of flowers. John Dwyer replied that the company had access to an architectural program which evaluated shadows.

With respect to the last point, the company should note that there are two components viz light for photosynthesis and light for photoperiodic effects. Changes in the latter could be quite significant for some crops but not others. *This warrants further consideration by the company.*

2. Property of Mr Keith Yore (wife Georgina, and son David) : Pecan nut grower (and has a vineyard).

This looked to be a well managed established orchard of pecans. It is between 30-40 acres. There were 10 or 12 varieties of pecan trees, which were mostly bred by USDA. Bud burst occurs in September / October and the crop grows to mid May. Pollination lasts for two weeks. The vineyard was established in 1971. He has put in dust collectors to monitor dust levels.

The concerns were: (i) Dust affecting pollination of the crop was the chief concern. He said that dust from trucks going in and out of the orchard of a major pecan nut producer at Moree had adversely affected pollination. (ii) Dust on leaves affecting photosynthesis was raised as an issue. (iii) Undue levels of sulphur may affect the crop; he noted the high levels of dust from power stations in the valley. (iv) The proximity of infrastructure and traffic on Kayuga Road with respect to dust, noise and number of vehicles using the road was a problem. Mr Keith Yore expressed concern for these effects on his home, his wife and lifestyle. (v) He also raised concerns about the increased levels of dust in the valley and it implications for asthma.

3. Maurice and Kath Gray : vegetable growers.

This was an irrigated property of some 10 to 12 acres of river flats. One of the major crops is lettuces supplying up to 100-200 cases of lettuce per week to Woolworths. Other vegetables included cauliflower, onions, capsicum, spinach, broccoli, and a number of other green vegetables. Overhead sprinklers were used and water was pumped from a well.

The property was well run on traditional lines but Mr Gray was not keen to change his ways. The water in the holding dam had considerable algal growth indicative of high nitrogen and high phosphorus usage.

The concerns expressed were : (i) resale value of the property would decrease as a result of the mine. (ii) Relocation to another place was not a ready option as he could lose his contracts to the (local) Woolworths. (iii) Mr Gray had noted black particles on cauliflowers growing near Liddell power station. The vegetable grower there had lost his living and was bought out . (iv) Mr Gray was concerned that increased dust levels would affect his produce.

4. De-Arne Dewar: vineyard owner.

A telephone conversation was conducted with this lady. It was not easy to follow the line of discussion as she tended to jump verbally from topic to topic. The main concerns raised seemed to be: (i) concerned for the investment put into the vineyard; (ii) concerned about dust and acid rain; (iii) concerned about the effect of dust on vines, leaf temperature and development and (iv) expressed the opinion that her husband had seen areas devastated by coal mining.

De-Arne Dewar alleged that the equipment monitoring the wind was faulty. She also said that the levels of sulphur dioxide in the air this season was high. She wants to know (a) how dust is accurately estimated; (b) what is the composition of coal dust and (c) what is the texture of coal dust.

She indicated she is well connected politically.

It is suggested that the company make efforts to meet and discuss the proposed development with this property owner.

5. Yvonne Barrell - dairy.

This appeared to be a well managed property with about 95 cows. About 12000 litres / week of milk were produced for the surplus market. She has been on this property for 18 months and has invested considerable capital in upgrading the property.

The concerns raised were (i) the effect of the mining operations including the bund wall on periodic floods. (ii) Where was the water going from the mining operations? (iii) In a flood, people take cows to the hills. Was this still going to be an option and would access be available to that land? (iv) What effect will the mine have on the quality of the water? Special concerns were raised with respect to salinity. (v) What effects of dust on lucerne hay may occur? (v) Dust (on a windy day) could readily result in contamination of the milk and its rejection. *The siting of the vat building and its ventilation may need to be carefully considered by the company so that rejection of the milk does not occur.*

6. Keith and Noeleen Googe : turfgrass and lucerne growers.

This property has had capital improvements and may indicate a successful enterprise. Currently there is 16 acres under turf including couch and buffalo for the amenity market with planned expansion to 16 acres. Fifty acres of lucerne (cultivar Aurora) were also on the property.

The concerns were (i) vibration from mining operations (ii) noise from mining operations (iii) dust on the productivity of lucerne (iv) dust on lucerne which was then being eaten by horses and (v) dust was noted on the leaves of the lucerne near the road verge when Mr Googe was cutting the lucerne.

It is assumed that judgements will be made on the points raised in this report as to whether further investigations or consultations are needed. Several have been highlighted in italics.

8

EFFECTS OF DUST ON GRAZING ANIMALS

REPORT EXAMINING THE IMPACT OF INCREASED DUST DEPOSITION ON GRAZING ANIMALS

RE: MT PLEASANT PROJECT

N J KANNEGIETER
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University of Sydney
NSW 2006

Summary

The possible effects of an increase in dust deposition levels, whether it be in the range of :

0-2 gms/m2/month

2-4 "

or 4-10 "

on grazing stock have not been adequately documented or investigated. There is little data in the scientific literature which has demonstrated a definitive adverse effect of increases in levels of "dust" alone on grazing animals. Most reports would indicate that feed, bedding, manure or urine contamination of dust is responsible for the majority of respiratory problems seen in production and racing animals. Therefore given the absence of these additional contaminations in coal dust, it would seem unlikely that an increase in dust deposition would adversely affect grazing horses or dairy cattle. Exceptions to this may arise in horses that have a pre-existing respiratory disease, which may be exacerbated by increases in dust inspiration, or in horses in full race training that are constantly exposed to high dust levels. Many of these horses would also be exposed to other dust contaminants such as fungi and actinomycetes etc from bedding and manure. Such horses may be at risk of having an increase in severity and incidence of respiratory disease, and an increase in exercise induced pulmonary haemorrhage.

Adverse effects of possible ingestion of dust-contaminated pastures would be dependent on the precise composition of the coal dust and mineral contaminants. In grazing stock, particularly where mineral imbalances can predispose to major problems, such as osteochondrosis in growing foals and milk fever in dairy cattle, this may potentially be a more serious problem that dust inhalation. However, in reality this would be considered unlikely to create any problems.

Introduction

Increases in dust deposition in the vicinity of grazing animals have two mechanisms of effect. This may be on the respiratory tract by inhalation of irritant particles or systemically by ingestion of dust which may result in direct toxicity or mineral imbalances being dependent on the composition of the dust. The majority of comments in this report will be in relation to inhalation of dust, as this would be considered to be the major area of concern in the racing industry.

The importance of respiratory disease on the equine industry can be assessed by the report of Rossdale et al (1985) who reported that 20.5% of all training missed was a consequence of respiratory disease.

Respirable airborne particles have been classified into four categories as follows (Leadon 1986):

1 Pathogens eg viruses, bacteria
2 Allergens eg fungus
3 Irritants eg ammonia
4 Nuisance eg dust

In the absence of specific data relating to the composition of the dust at this time comments will be restricted to effects of dust in terms of being nuisance or irritant substances.

The size of dust particles is of importance in determining the effects on the respiratory tract. Information from humans suggests that respirable particles are in the vicinity of 10 um in size, and these will be deposited in the lungs.

The deposition and clearance parameters of inhaled particles have not been described in horses or cattle, although they have been documented in the donkey (Albert et al 1968). However Clarke (1987) discussing unpublished results using non-soluble radiolabelled monodispersed aerosols suggested that pulmonary disposition of aerosols is similar in the horse to other species. This finding tended to confirm the theoretical considerations of deposition of aerosols in the lungs of different species as described by Stauffer (1975).

In view of this it may be reasonable to adopt similar guidelines for horses and cattle in regard to respirable dust as have been utilised in humans, as reported in the Bengalla Coal Mine EIS, November 1993. This would include recommendations of an annual average limit of 90 ug/m3 for Total Suspended articles, and 24 hour concentrations of particle size less than 10 um in size (pm10) should be no grater than 150 um3. In view of the Environmental Protection Agency acceptance of an increase in dust deposition rates of up to 2 g/m2/mth based on a background of 1-2 g/m2/mth, it may be that increases of 4-10 g/m2/mth may be unacceptable. However, as discussed later, there is little scientific evidence in the veterinary literature to support that the larger increase may be detrimental. Extrapolation from human medicine would be required to support the concept that higher levels of contamination are unacceptable. As the effects of marginal increases in environmental pollution and dust deposition rates would appear to be controversial (Abramnson & Voight 1991), possible adverse effects in grazing stock in relation to specific increases in dust levels can not be further discussed in this report due to the lack of adequate scientific data.

Literature review (CAB Abstracts 1984-1995)

Effects of dust and environmental contamination on grazing animals

There is very little available literature concerned with the effects of dust on grazing animals. A report by Rebes et al (1992) studies the effects of environmental pollution in cattle, horses, deer and pigs. This study examined the incidence of cytogenic abnormalities in blood cells and found a significant increase in abnormalities in severely impaired environments. Unfortunately quantitative details on the degree and type of pollution present are not available.

A survey undertaken by Szwarc (1983) reported the levels of production achieved in dairy cattle in a coal mining region in Russia. Unfortunately no comparative data from other areas are available, although no comments on possible adverse effects of dust were reported.

A report by Chen et al (1988) concluded that aluminium silicates and quartz were the chief mineral components in environmental dusts.
The same minerals were consequently present in significant amounts in the lungs of horses with respiratory disease in the same area. However they concluded that the free silicon dioxide in the lungs did not result in silicosis lesions as seen in man. The relevance of this report is unclear, as information regarding the environment of sampling and also the mineral content of coal dust, is not available.

The effects of particles arising from a coal combustion plant in Brazil on cattle and sheep was reported by Riet-Correa et al (1986). The main finding was excessive teeth wear, which it was concluded was a result of the abrasive effect of particles from coal combustion, particularly silica, and a decrease in enamel resistance due to associated fluoride poisoning.

Schwartz et al (1981) documented the occurrence of silicate pneumoconiosis and pulmonary fibrosis in horses in California as a result of environmental pollution.

Perhaps the most significant report detailing the effects of increased dust on horse health is that of Collins (1985) who investigated increased dust levels as a result of construction work in training centres in Hong Kong. This was considered to be the cause of an increase in the incidence of exercise induced pulmonary haemorrhage (bleeding) which occurred as a result of a low grade bronchiolitis, considered to be the result of increased dust inhalation.

There have been several reports of an increased incidence of osteochondrosis, which is a developmental bone and cartilage disorder seen in growing foals, in association with environmental pollution (Eamens et al 1984; Wisniewski et al 1994). These problems appear to have occurred as a result of imbalances of primarily copper and zinc which occur as a result of fallout from smelters onto pasture.

Effects of dust on stabled animals

In contrast to the lack of documentation of effects of dust on grazing animals, there is considerable information on effects of dust in stabled animals. There appears to be little doubt that increases in dust levels in stabled animals will result in considerable increase in respiratory disease. (McPherson et al 1979; Leadon 1986; Clarke et al 1987). The effect of this increase will vary greatly between dairy cattle and horses. In cattle low grade respiratory disease will be tolerated to a far greater degree than it would in horses. The reason for this is that a normal respiratory tract is of far greater importance in horses expected to perform to maximum athletic ability than it is in cattle, where feed conversion to either milk or meat is of primary importance (Clarke 1987; Wilson et al 1986).

One of the difficulties in extrapolating data derived from stabled conditions is that there is a very high content of fungi and actinomycetes in the dust, as well as significant chemical irritation as a result of high levels of ammonia. This would not be expected to occur in grazing animals where high ventilation rates and lack of exposure to dust from hay, bedding and manure would result in different clinical syndromes.

Despite these shortcomings however, some useful information can be obtained from such studies.

Leadon (1986) suggested that while "dust may be thought to be relatively amorphous", that it could be composed of a great number of differing particles, some of which may be harmless, but others of which may be irritant. In addition, even though dust may be considered non-pathogenic, it was capable of upsetting the clearance and killing mechanisms of the lungs and lower respiratory tract, which may provoke the onset of clinical disease by organisms which would normally be rendered harmless.

A study in stabled horses by Zeitler et al (1986) concluded by stating that "dust concentrations were highest during the morning cleaning-out period (2-4 mg/m3) and that of particles small enough to enter the pulmonary alveoli was 0.68 mg/m3, both values being too low to cause mechanical irritation of the horses respiratory tract."

In an earlier report Zeitler (1984) stated that in relation to allergic respiratory disease in horses the composition of the dust was more important that its amount.

<u>Ingested contamination</u>

The effects of ingestion of excessive amounts of dust in relation to pasture contamination should also be considered. There are a number of reports whereby environmental pollution from industry has resulted in severe disease, which is particularly manifested in young growing stock. (Schwartz et al 1981; Eamens et al 1984; Wisncewski et al 1994).

This may be of more importance in this situation where the stock primarily affected are grazing animals. The specific composition of the coal dust, particularly in relation to mineral content would need to be determined to allow further consideration of this potential health hazard.

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EFFECTS OF DUST ON HUMAN HEALTH

9

DOUGLAS CONSULTING AUSTRALIA
PTY LIMITED

AIR QUALITY and HUMAN HEALTH

in relation to

PROPOSED MT PLEASANT PROJECT

A REPORT

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1. INTRODUCTION

1.1 Coal & Allied Operations Pty Limited proposes to establish and operate an open cut coal mine to be known as Mt Pleasant, 2-3 kms north-west of Muswellbrook, NSW. During the proposed 20 year consent period, approximately 141 million tonnes of black coal will be extracted, to produce about 104 million tonnes of saleable coal.

1.2 Mining will use methods virtually identical to other Hunter Valley open-cut coal mines, including Coal & Allied's existing mine at Mt Thorley. Large earth moving equipment including a dragline, shovels and dump trucks will be used to remove topsoil, overburden and interburden to expose the coal seams. Blasting will be required to loosen the rock and coal. The raw coal will be transported by truck to a coal stockpile and preparation area. Spoil will be placed in and over previously mined areas, then shaped and topsoiled prior to revegetation.

1.3 Initially, an earth bund will be constructed and progressively vegetated along the south-eastern boundary of the proposed mine site so as to form a visual and physical screen between the mine site and the town of Muswellbrook. In addition, the purchase of properties within and near the mine lease will result in the closest residential property being some distance from the mining activity.

1.4 Since open-cut coal mines have the potential to generate dust from blasting, earth moving activities, coal preparation activities, and wind erosion, it is probable that members of the community will be concerned about potential health effects from the dust. This report will address the potential impacts on air quality and human health likely to arise from the proposed Mt Pleasant mine, will review the current state of knowledge on the human health aspects of air pollution in the Hunter Valley, and will review the general issue of particulate air pollution and health effects.

2. AIR QUALITY IMPACTS - DUST

2.1 Although large tonnages of material will be moved during the life of the proposed mine, the concentrations of airborne dust within and external to the mine will be minimised through implementation of the proposed management practices outlined in the EIS. Additional factors that will assist in dust suppression include the following:

- overburden to coal ratios are uniformly low in the Hunter Valley;
- coarse coal rejects will be transported from the coal preparation areas to the reject bin by conveyor;
- fine coal rejects will be transported by pipeline as a slurry; and
- progressive rehabilitation will be undertaken, thus minimising the generation of dust from wind erosion.

2.2 In addition to the assessment of dust levels predicted by the modelling of Dr P Zib, probable dust levels at the proposed Mt Pleasant mine can be assessed by extrapolation from the results of occupational and environmental dust monitoring carried out in recent years at the Mt Thorley open-cut coal mine which is another Hunter Valley mine owned by Coal & Allied Operations Pty Limited:

(i) The Joint Coal Board[1] carries out annual dust monitoring as prescribed by the NSW Coal Mines Regulation Act 1982 at Mt Thorley open-cut coal mine:

(a) In the coal preparation areas, where the exposure is predominantly to coal dust, the concentrations of airborne respirable dust, that is the very fine dust that is able to reach the lower bronchioles and alveolar regions of the lung, have not exceeded 480 $\mu g/m^3$ when measured as time-weighted averages

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1 Joint Coal Board. Gravimetric dust sampling and ventilation reports for Mt Thorley open-cut coal mine, 1992 - 1996.

over working shifts during the past five years - 13 samples: range 100 - 480 $\mu g/m^3$; mean 185 $\mu g/m^3$.

(b) In the general mine areas during drilling and loading of overburden and interburden, where the exposures were to the host rock, the concentrations of airborne respirable dust have not exceeded 930 $\mu g/m^3$ when measured as time-weighted averages over working shifts during the past five years 24 samples: range 100 - 930 $\mu g/m^3$; mean 474 $\mu g/m^3$.

(c) Respirable crystalline silica (quartz) concentrations did not exceed 150 $\mu g/m^3$ when measured as time-weighted average concentrations over working shifts during the past five years. The measurements indicated that crystalline silica (quartz) constituted approximately 15 - 18% of the total respirable dust.

(ii) The P Zib & Associates Pty Ltd[2] report on environmental monitoring in the vicinity of Mt Thorley open-cut mine in 1995 provided the following results:

(a) **Deposition rates**, measured at eleven sites, ranged from annual average of 1.01 to 4.84 g/m^2/month. For both the annual average and the 30 day average, the highest results were obtained at a sampling site 50 metres from the overburden dump operated by the neighbouring mine.

(b) **Dust-in-air concentrations** were determined as total suspended particulates (TSP) and particulate matter < 10 μm diameter (PM_{10}). Forty three samples of TSP ranged from < 5 $\mu g/m^3$ to 100 $\mu g/m^3$ when measured as 24 hour samples. The annual mean TSP was calculated as 33 $\mu g/m^3$. Thirty five samples of PM_{10}, measured as 24 hour samples ranged from < 5 $\mu g/m^3$ to 32 $\mu g/m^3$. The annual mean PM_{10} concentration was calculated as 13.7 $\mu g/m^3$.

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2 P Zib & Associates Pty Ltd. Air quality and meteorological monitoring at the Mount Thorley Mine. 1995 Annual Report.

2.3 The results summarised above in paragraphs 2.2(i) and (ii) compare favourably with current standards for both occupational and environmental exposures. The occupational exposure standards prescribed by the NSW Coal Mines Regulation Act 1982 are 3,000 $\mu g/m^3$ for respirable dust, and none exceeded 150 $\mu g/m^3$ for respirable quartz, both measured as time-weighted averages over working shifts. Since all measured dust levels at Mt Thorley mine in the past five years were well below 3,000 $\mu g/m^3$ respirable dust and most were below 150 $\mu g/m^3$ respirable quartz, the dust-related health risks for people working at Mt Thorley can be assumed to be low. This has been confirmed by the results of regular health surveillance carried out by the Joint Coal Board[3]: no cases of dust-related disease (coal miners pneumoconiosis, silicosis, bronchitis), attributable to open-cut mining in the Hunter Valley, have ever been found.

2.4 The levels of dust would be expected to be even lower outside the mine boundaries because of the rapid settling of most dust particles, the screening effects of bunds and vegetation, and the distance between the mine activities and the surrounding residences. These expected lower dust levels have been confirmed by the environmental monitoring carried out for Mt Thorley mine by P Zib & Associates. Even though Mt Thorley mine is situated between two other mines and monitoring instruments were likely to collect dusts from more than just Mt Thorley mine, the environmental measurements of TSP and PM_{10} were well below the NSW Environment Protection Authority's (EPA) objectives of 90 $\mu g/m^3$ annual mean for TSP, 50 $\mu g/m^3$ annual mean for PM_{10} and 150 $\mu g/m^3$ 24-hour maximum for PM_{10}. The environmental measurements were negligible compared with the occupational exposures, which in turn were well below the prescribed standards.

2.5 These low environmental dust levels are indicative of the levels which can be expected from the proposed Mt Pleasant operation. Even though Mt Thorley is a smaller operation than that proposed, it is situated in an area of intense mining activity, so the environmental dust monitoring reflects more than Mt Thorley alone. The environmental dust levels measured in the vicinity of Mt Thorley mine would pose a zero risk for health effects such as

3 Joint Coal Board. Personal communication with Dr W Kirby, Assistant General Manager, Occupational Health, 1997.

silicosis, coal miners' pneumoconiosis, bronchitis or asthma in those people exposed continuously to such dust concentrations.

2.6 The extrapolation from the Mt Thorley results as in paragraph 2.5 provides reassuring conclusions about the lack of environmental health effects likely to arise from the proposed Mt Pleasant project. The extrapolation and reassurance are supported by the latest modelling by P. Zib and Associates[4] in relation to this proposal. The results of the modelling indicate that, apart from narrow strips of boundary land which will be subject to acquisition, environmental air quality will not be significantly affected by the proposal in that dust deposition and airborne particulate concentrations (TSP and PM_{10}) will be well within EPA criteria. The Zib report also draws the important conclusion that measurement of PM_{10}, as currently recommended by the EPA and other environmental agencies, is a conservative measure of airborne pollution when applied to dusts generated by open-cut mining. The importance of particle size is further discussed below in Section 6 of this report.

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4 Zib P. *Air quality assessment for the proposed Mt Pleasant Mine near Muswellbrook, NSW (Revision 3.0).* A report prepared by P. Zib & Associates Pty Ltd. Newcastle. March, 1997.

3. AIR QUALITY IMPACTS - EPISODIC EVENTS

3.1 Episodic events such as strong winds during dry conditions, and blasting of the host rock and coal, have the potential for dust impacts on air quality. While this potential exists, objective evidence for it has not been found from the monitoring cited above in relation to Mt Thorley mine. There are many reasons why strong dry winds, and episodic blasting need not produce the actual impacts which might be expected in theory.

3.2 Strong dry winds have the potential to raise dust from a variety of sources in the Hunter Valley apart from mines: unsealed roads, ploughed fields, construction sites and other industries. At the proposed mine, as at existing mines, special management plans can be implemented during dry windy conditions which will reduce the potential for dust generation. Such management plans are not readily available for the farms, unsealed roads etc. Similarly, restriction of blasting during dry windy conditions, or when light winds are in an unfavourable direction, will reduce the potential for the downwind spread of dust from blasting.

3.3 Unless dust modelling, or field measurements, demonstrate that airborne dust levels outside the proposed Mt Pleasant mine are likely to be orders of magnitude greater than currently measured in the vicinity of Mt Thorley mine, it is not expected that the dusts arising from episodic events will have any adverse effects on human health.

4. AIR QUALITY IMPACTS - OTHER AGENTS

4.1 Whilst dust from the proposed mine has the most obvious potential for an impact on air quality, other agents should be considered:

(i) SO_2 and NO_x from blasting;

(ii) salts in the airborne dusts;

(iii) diesel and other vehicle emissions from rail locomotives, mine vehicles and employees' vehicles;

(iv) dusts, including dry fertiliser, from the aerial topdressing of land being rehabilitated; and

(v) spontaneous combustion of coal.

4.2 In general, these agents have been considered in relation to other mine development proposals; and in relation to (i) and (ii) have been dismissed as not making any measurable contribution to environmental air quality[5]. The aerial application of dry fertiliser must only be done under approved safeguards as applied to the agricultural industry elsewhere in the Hunter Valley. Provided this is done, the aerial application methods used in the rehabilitation of land should have no impact on the health of the community.

4.3 The impacts from the emission of gases and particulates from diesel and other vehicles associated with the proposed mine are most difficult to assess. As discussed below in Section 6, particulate emissions from diesel and other internal combustion engines are probably the agents most responsible for adverse health effects associated with air pollution. However, the emissions from the mine associated vehicles are likely to contribute less than five percent of all vehicle emissions generated in the Muswellbrook district.

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5 Cleland K. Report to the Honorable Robert Webster, Minister for Planning and Minister for Housing. *Establishment and operation Bengalla open cut coal mine, Muswellbrook.* August 1994.

4.4 Smoke from the spontaneous combustion of coal contains a complex mixture of particulates and gases which can cause short and long-term health effects. The potential for spontaneous combustion of coal is well recognised, and has been addressed in detail in Section 3.3.7 of the EIS. The prevention initiatives (3.3.7(ii)) and response strategy (3.3.7(iii)) outlined in the EIS should ensure that a spontaneous combustion event and any potential environmental smoke exposures due to spontaneous combustion of coal are eliminated. The health risks, if spontaneous combustion occurs in spite of the prevention measures, will be confined to occupational exposures within the mine only. These risks should be readily minimised by the use of respiratory protective equipment during the rapid response phase of controlling the spontaneous combustion.

5. AIR QUALITY IMPACTS - CUMULATIVE

5.1 The cumulative impacts from the existing and proposed coal mines around Muswellbrook are likely to be of concern to many people in the district. However, since most dusts and other agents are expected to be contained within the mine sites, the potential for cumulative impacts should be minimised. Exceptions to this may occur along boundaries between mines as demonstrated in the Mt Thorley dust deposition data above (see section 2.2 (ii) (a)). In the case of Mt Pleasant, the boundary zones are already within areas where noise and air quality criteria are likely to be exceeded and therefore subject to acquisition.

5.2 The issue of cumulative impacts was addressed in the Report of the Commission of Enquiry into the Bengalla mine[5]:

"The EPA states that:

Generally, most dust generated is contained within the mine site. Where dust is emitted it is occasional and usually at incremental levels which are within the range of fluctuations normally occurring in rural areas. To date, in areas where two or more mines are located and cumulative dust levels could be anticipated, the EPA has no evidence (based on monitoring) or perception (based on observation) that dust accumulates in the atmosphere in a manner which would preclude subsequent mine developments operating within 4 $g/m^2/month$ (annual average) criterion.

It may be inferred from results to date that further development can reasonably be considered."

5.3 The results of ongoing environmental monitoring will be important in reassuring the people in the Muswellbrook district that the Mt Pleasant project does not contribute in any measured way to the cumulative dust depositions and/or airborne dust concentrations in their district.

6. PARTICULATE AIR POLLUTION AND HEALTH EFFECTS

6.1 The current air quality objectives of the NSW EPA concerning total suspended particulates (TSP) and particulate material < 10 μm diameter (PM_{10}) have been developed because of the numerous studies, particularly in the United States, which have found associations between particulate air pollution and adverse health outcomes. These studies were reviewed at the Colloquium on Particulate Air Pollution and Human Mortality and Morbidity held in the US in 1995[6] and summarised as follows:

Numerous studies have reported that acute exposure to elevated levels of particulate air pollution is associated with changes in various human health endpoints, including (1) increased mortality, especially cardiopulmonary mortality, (2) increased hospitalization for respiratory disease, (3) exacerbation of asthma, (4) increased incidence and duration of respiratory symptoms, (5) declines in lung function, and (6) restricted activity. Acute health effects were observed at levels common to many U.S. cities, including levels well below current U.S. National Ambient Air Quality Standards. The studies generally observed that health effects increase monotonically with pollution levels, often with a near linear dose-response relationship. Furthermore, these studies suggest a coherence or cascade of associations across various health endpoints.

Studies have also observed human health effects associated with chronic exposure to respirable particulate air pollution. Population-based cross-sectional studies that evaluated spatial distributions of mortality and air pollution have observed associations between mortality and sulfate or fine particulate pollution. These population-based studies have been criticized partly because they were not able to control directly for individual differences in cigarette smoking and other risk factors. Recent studies that could adjust for individual differences in other risk factors, however, have observed that long-term exposure to respirable particulate air pollution was associated with small deficits in lung function and higher risk of chronic respiratory disease and symptoms. Furthermore, two recent prospective cohort studies have

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6 Pope C A, Dockery D W, Schwartz J. *Review of the epidemiological evidence of health effects of particulate air pollution.* Inhalation Toxicology. 7: 1 - 18, 1995.

observed increased mortality risks associated with air pollution - even after directly controlling for individual differences in age, sex, race, cigarette smoking, and other risk factors.

Although the biological linkages remain poorly understood, the results of the acute and chronic exposure studies are complementary. In all epidemiologic studies there is the concern that the observed association is due to confounding, that is, that it results from a risk factor that is correlated with both exposure and mortality but is not adequately controlled for in the study design and analysis. Important potential confounders in cross-sectional studies, such as unaccounted for differences in occupational exposure or socioeconomic variables, are not likely to be confounders in daily time-series studies because such factors are unlikely to change daily in correlation with air pollution levels. The fact that daily time-series studies and cross-sectional studies observe qualitatively coherent associations between respirable particulate pollution and mortality further supports the hypothesis that this pollution is an important risk factor for respiratory disease and cardiopulmonary mortality.

6.2 In 1996, the Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society[7] published its review of the health effects of outdoor air pollution and listed ozone, oxides of nitrogen, sulphur dioxide, acid aerosols, carbon monoxide, lead, air toxics, and particles (PM_{10}) as the principal pollutants. In the review of particles, the "health effects of exposure to particles, sulfur oxides and acid aerosols were presented together because these distinct pollutants are among the products of fossil fuel combustion processes and are usually present together as components of a complex mixture". The authors stated that this was "a rapidly evolving area of research with provocative new epidemiological information linking low-level particle exposure with mortality, possibly in older people with pre-existing cardio-respiratory disease. Because the mechanism for the effect of mortality is not yet understood, interpretation of these findings must be tempered by the recognition that biologic plausibility has not yet been established with certainty".

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7 American Thoracic Society. *State of the Art. Health Effects of Outdoor Air Pollution.* American Journal of Respiratory and Critical Care Medicine. 153: 3 - 50, 1996.

6.3 Accordingly, a great deal of research continues to be done on the physio-chemical characterisation of the constituents of PM_{10} in order to determine the components responsible for adverse health effects. The current EPA standard for PM_{10} is a refinement on the previous TSP; but it requires a great deal more work yet in the classification of inhalable particulate matter and the establishment of ambient standards for specific chemical species, eg aerosol acidity. Such refinements are urgently needed, because the present standard implies that a PM_{10} value in central Sydney carries the same health risk as an equivalent PM_{10} value several kilometres outside Muswellbrook.

6.4 The components of PM_{10} most likely to result in adverse human health effects are those derived from the burning of fossil fuels (motor vehicles, incinerators and power plants) because they are typically much smaller ($< 1.0\ \mu m$) and more acidic than particles from other sources. The PM_{10} particles derived from abrasion (open cut mines, quarries, roads, farms etc) are generally in the 5 - 10 μm range and very rarely as small as 1.0 μm. The toxicity of particles varies with size and physico-chemical compositions which are highly variable. Although particle concentrations in air are expressed as mass per unit volume, the particle surface-to-mass ratio increases with decreasing size and may be a most important factor in determining particle toxicity[7].

6.5 The importance of ultrafine particles, ie those $< 0.05\ \mu m$ diameter, has been found in repeated inhalation studies, and it has been suggested that the ultrafine particles (derived most commonly from burning fossil fuels) play a key role in causing acute lung injury in sensitive members of the population[8]. Clearly, this has great significance for the control measures required to reduce the health effects of air pollution.

6.6 The measurement and control of particles less than 1.0 μm diameter ($PM_{1.0}$) has the potential to result in a greater benefit on human health than the current measurement and control of PM_{10}.

8 Oberdörster G, Gelein R M, Ferin J, Weiss B. *Association of particulate air pollution and acute mortality: involvement of ultrafine particles?* Inhalation toxicology. 7: 111 - 124, 1995.

7. ASTHMA

7.1 The prevalence of asthma in the Hunter Valley population is of continuing concern to the community and led to the establishment in 1994 of *The Hunter Area Health Service Expert Advisory Group on Asthma.* The 1996 report of the Group[9] indicated that progress had been made in the collation of epidemiological data on asthma, particularly from hospital records, in the Hunter Valley. But the causes of asthma are complex, and the Expert Advisory Group has no current information which implicates any particular environmental agents. Nevertheless, known respiratory irritants such as hydrogen fluoride from the aluminium smelting industry, and SO_2 and NO_x from the electricity generating stations in the Hunter Valley are considered potential aetiological agents [10]. European research[11] suggests that inhalation of SO_2 and NO_x in relatively low concentrations may enhance the response to inhaled allergens in people with asthma.

7.2 One of the world's leading centres in asthma research is the Institute of Respiratory Medicine (IRM) in Sydney headed by Professor Ann Woolcock. During the past decade, the IRM has been studying the distribution and causation of asthma in children and adults in a wide variety of geographical locations in Australia. In a recent publication[12] on the prevention of asthma, the conclusions derived from all the research done by the IRM were summarised as follows:

Environmental factors which have changed in the last decade or so appear to be largely responsible for the increase in the prevalence of asthma in different countries. It should, therefore, be possible to define interventions to reverse these recent trends and reduce the incidence of asthma. Primary preventive

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9 The Hunter Area Health Service Expert Advisory Group on Asthma. 1996 Asthma Report.

10 Halliday J A, Henry R L, Hankin R G, Hensley M J. *Increased wheeze but not bronchial hyper-reactivity near power stations.* Journal of Epidemiology and Community Health. 47: 282 - 286, 1993.

11 Devalia J L, Rusznak C, Herdman M J, Trigg C J, Harraf H, Davies R J. *Effect of nitrogen dioxide and sulphur dioxide on airway response of mild asthmatic patients to allergen inhalation.* The Lancet. 344: 1668 - 1671, 1994.

12 Peat J K. *Prevention of asthma.* European Respiratory Journal. 9: 1545 - 1556, 1996.

strategies have the potential not only to reduce the acquisition of sensitisation to common allergens and the risk that symptoms will develop subsequently, but also to reduce morbidity in those who already have persistent disease. There is accumulating epidemiological evidence that a dietary excess of sodium and omega-6 fatty acids, a dietary deficiency of antioxidant vitamins and omega-3 fatty acids, reduced rates of breast feeding and exposure to allergens and environmental tobacco smoke are all involved in the aetiology of asthma. The modification of these factors has the potential to reduce the incidence and thus the prevalence of this disease. Environmental intervention should be particularly effective in children who have inherited or acquired characteristics which put them at high risk of developing asthma. With the evidence now available, it seems reasonable to assume that interventions which are based on our current knowledge of risk factors could achieve a 50% reduction in the prevalence of asthma in the next generation of children.

7.3 Based on the available research results, the pollutants in the external environment which can contribute most to the causation and aggravation of asthma are acute irritants such as SO_2 and NO_x, and allergens such as mould spores and grass pollens. Inorganic materials such as the dusts from the proposed mine site have not been implicated as aetiological factors for asthma.

8. CONCLUSIONS

8.1 The conclusions concerning air quality and human health in relation to the Mt Pleasant open-cut coal mine site proposal are as follows:

(i) Dusts from earth moving, coal extraction and coal preparation will be the principal potential air pollutants.

(ii) Dusts generated by the proposed mine site, as indicated by extrapolation and modelling, will be controlled by the appropriate environmental safeguards outlined in the EIS so as to be well below EPA objectives for environmental particulates.

(iii) Other potential pollutants, including vehicle emissions, SO_2 and NO_x from blasting, salts from deep excavation, smoke from spontaneous combustion of coal, and dry fertiliser dust from aerial applications will be readily controllable or be in such low airborne concentrations as to have negligible impact on air quality.

(iv) The operation of the proposed mine will not cause adverse acute or chronic health effects, or alter the incidence or prevalence of asthma in the population living and/or working in the Muswellbrook district.

(v) Measurement of PM_{10}, as an indicator of particulate air pollution in relation to human health, is an improvement on total suspended particulate (TSP) measurement, but more sophisticated measurement techniques are needed.

(vi) There needs to be ongoing collaboration between the mining industry and the NSW EPA in the utilisation of monitoring methods which provide better characterisation of the constituents of airborne particulates.

Dr David Douglas

8 August 1997

VISUAL ASSESSMENT

10

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Mount Pleasant
Environmental Impact Statement

Visual Assessment

Prepared for
Coal & Allied Operations Pty Ltd

April 1997

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1 Introduction

This component of the EIS concerns the main visual issues associated with the proposed Mount Pleasant mining project.

By its nature an open-cut mine represents a contrasting visual element within the overall setting of a largely rural - specifically agricultural - landscape. The Mount Pleasant project will generate some changes to the landscape. Many of these changes will not be visible from outside the site while others will be more obvious at certain times of the project. Mitigatory measures incorporated as integral components of the development will assist in substantially reducing many of the potential contrasts between the existing landscape and the mine-related changes.

Variables such as viewer distance, elevation, aspect, quality of light and duration of view all impinge on the perception of visual impact. Even more personal parameters such as the background familiarity, comprehension and bias of the viewer in relation to mining may have a bearing on how impacts are perceived. There is therefore inherent in a study of this kind a degree of subjectivity especially when determining the perceived severity of visual impact.

Much has been written on the topic of landscape assessment methodology over the last three decades - particularly in the USA, the UK and, more recently, in Australia. Studies have involved emphases as varied as psychological aspects of perception, scenic preference assessments, cultural and biophysical classification systems, parametric procedures and scoring systems. However no single technique has been either recommended or adopted by planning authorities in NSW as a guide for the assessment of visual change.

This assessment is in four parts. A brief description and analysis of the existing regional and local landscape context provides the first part (**Section 2**). This is followed by a description of the mine activities that will cause changes to the existing landscape (**Section 3**). The third part considers the key areas from which views of the project will be visible (**Section 4**). It includes a consideration of distance and other factors affecting visibility as well as the relative importance of viewing areas. This section also briefly discusses the Mount Pleasant project within the context of the adjacent mine projects - the proposed Kayuga Mine to the north and the Bengalla Mine to the south - operating simultaneously. The final part describes specific actions to reduce, and in some cases eliminate, the assessed potential visual impact of the mine project (**Section 5**). A brief conclusion summarises the key issues of the visual assessment.

In reading this assessment helpful reference material to have at hand would be a topographic plan of the area, the series of mine excavation/refill plans through Years 2 to 20 of mining and a plan of the proposed mine surface facilities.

2 Existing Visual Character

2.1 Regional Landscape Setting

The regional landscape around Muswellbrook is characterised by several distinct landscape types. They range from rugged, forested landforms incised by numerous tributaries of the Hunter and Goulburn Rivers through to undulating pasture lands and the crazy-checkered pattern of crops, vineyards and orchards within the broader alluvial flood plain.

Some parts of the regional landscape are regarded as especially picturesque and have been classified by the National Trust of Australia (NSW). The proposed Mount Pleasant Mine site lies between, though outside, two National Trust-classified areas of rural landscape. Both of these classified landscapes contain rural scenery of great charm and importantly also draw on the dramatic, forested highlands beyond as backdrops to views. To the north of the Mount Pleasant site is the Momberoi-Scone rural landscape starting north of the village of Kayuga and west of Aberdeen then continuing north to encompass the area between Towarri Mountain and the villages of Wingen and Parkville. South of the site is the Muswellbrook-Jerrys Plains rural landscape. This mostly centres on the lower reaches of the Goulburn River and the Hunter River below the confluence. However the northern spine of this classified landscape continues along the Hunter River flood plain as far as the vicinity of Muswellbrook Racecourse.

In classifying these areas the Trust is recognising scenic cultural landscapes it considers to have heritage significance and to be worthy of conservation. The classifications do not empower the Trust to exercise any legislative control however the actions of the Trust as a large community-based organisation generally reflect strong community interest and support.

In the more immediate vicinity of the site the sinewy course of the Hunter River forms a distinctive linear graphic across the broad alluvial flats. This flood plain provides the setting for numerous agricultural and recreational land uses as well as separates the undulating foothills to the west and east.

Foothills east of the flood plain are characterised by urban development - Muswellbrook, Aberdeen and Scone. Those to the west are mostly pasture and grazing land with varying amounts of remnant *Eucalyptus* woodland. It is over some of this land that the Mount Pleasant mine site is located. Beyond these western foothills the landform rapidly becomes more rugged with dense forest cover. Such areas include Black Jack Mountain (499m), the massif between Castle Gap and Owens Gap and the deeply incised landforms between Sandy Hollow, Wybong and Bunnan including Manobolai Nature Reserve. Distinctive features on the southern horizon include the high ranges of Wollemi National Park.

A number of isolated peaks surround Muswellbrook including Mount Arthur (482m) to the south, Colonel (668m) and Bells (689m) Mountains to the north-east and Browns Mountain (352m) to the north.

Other notable visual elements within the landscape around the project area provide evidence of various industrial activities. These include the Muswellbrook open-cut mines between Bells Mountain and Muswellbrook, the Bayswater No 3 open-cut mine to the south (visible from the Denman Road), the major electricity easement east of Muswellbrook with its various substations and the Bayswater Power Station cooling towers and their prominent steam plumes. Also evident along the New England Highway are the timber mill just north of Muswellbrook and, further north near Aberdeen, the coal stockpiles and rail loading facility of the Dartbrook Mine and, from Kayuga Road, the main plant area of the Dartbrook Mine.

2.2 Visual Catchment

Views of the site area are in the majority of cases from the south, east and north (**Figure 1**). View potential from the west is restricted owing to the landform and elevation of this area; although some proposed mine-related changes would be visible from several properties and public roads in the south-western vicinity of the site.

The visual catchment is defined generally by areas between Scone and Aberdeen to the north; the New England Highway, Main Northern Railway and Muswellbrook to the east; Denman Road to the south; and, in the west, parts of the elevated land around Wybong and Roxburgh Roads.

Distances from the urbanised vantage points to the corresponding closest parts of the site range from about 2km at Muswellbrook to 5km at Aberdeen.

Close range views of the site are provided by the three rural roads traversing the southern, eastern and northern site boundaries; Wybong, Kayuga and Dorset Roads respectively. Between these roads and the outer parts of the visual catchment are generally low elevation viewing points within the Hunter River flood plain. Higher land in close proximity to the site includes parts of the foothills system directly to the south ('Overton' ridge), east (Negoa ridge) and north (Maryvale ridge).

Of particular note are the vantage points of highest elevation coinciding with the two largest urban settlements within the visual catchment - parts of Muswellbrook at a height of about 200 metres and parts of Aberdeen at about 230 metres.

2.3 Mine Site

The landscape within the proposed Mount Pleasant Mine site is surmounted by the peak of Mount Pleasant at an elevation of 368m. Radiating drainage lines from this point have produced a series of well modulated ridges (**Figure 2**).

The ridges east of Mount Pleasant form a pattern of gently descending fingers towards the north-east, east and south-east. Most of these spurs appear to be abruptly truncated as they reach the western edge of the Hunter River flood plain.

The character of vegetation cover across the area is indicative of extensive clearing such that the densest areas of trees lie to the middle and western parts of the site. Even here the density of tree cover is best described as scattered. The few stands of older trees are near Mount Pleasant and in the south-western corner of the site.

The eastern edges of the site are only sparsely vegetated with many ridges and valleys virtually treeless. As a result the landscape morphology is more readily apparent. The extent of clearing in the eastern part of the site together with occasional derelict areas such as the disused quarry at the corner of Kayuga Road and Castle Rock Road contrast this part of the site with the western part. The only permanent water elements on the site are numerous farm dams and some springs.

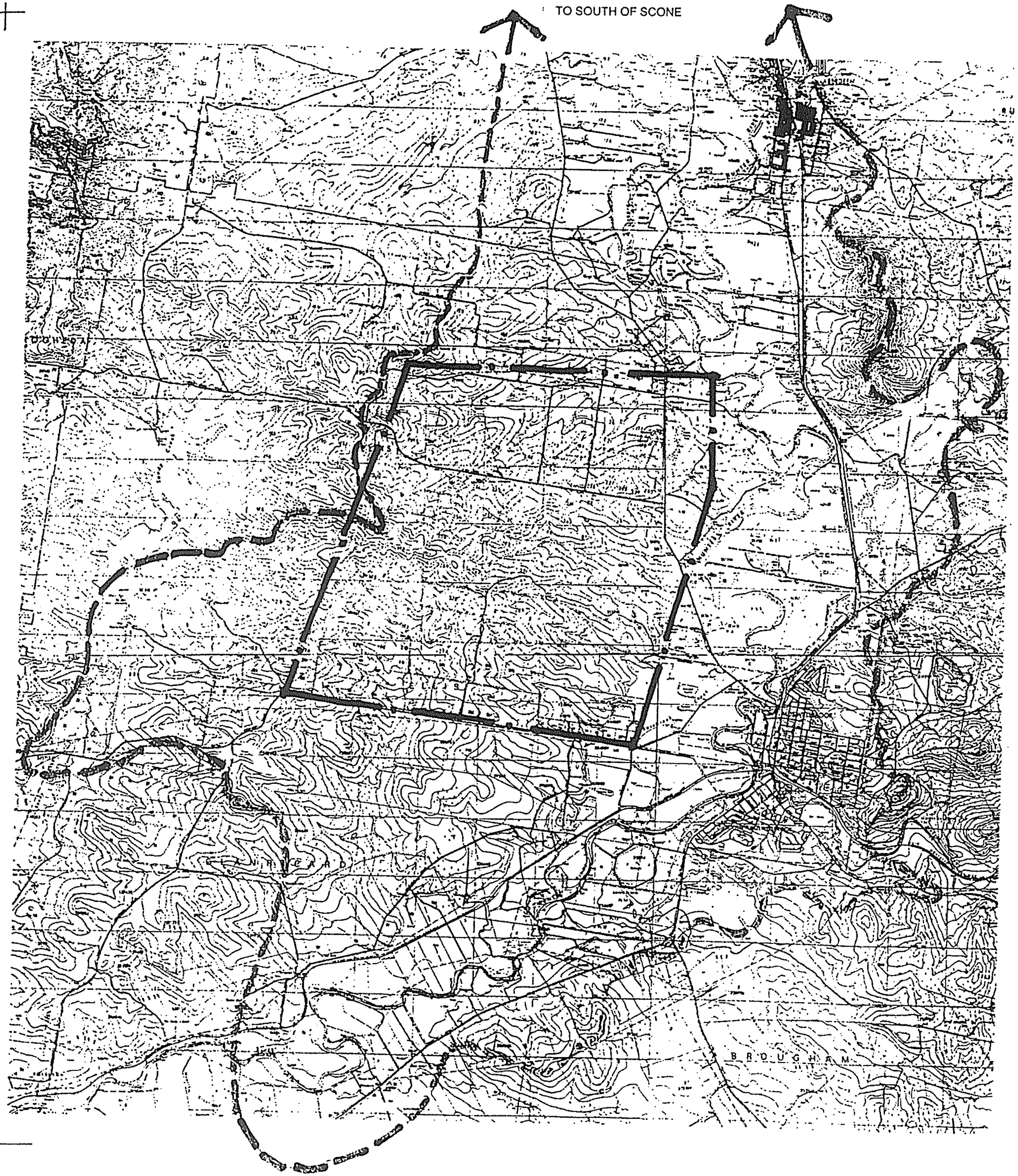
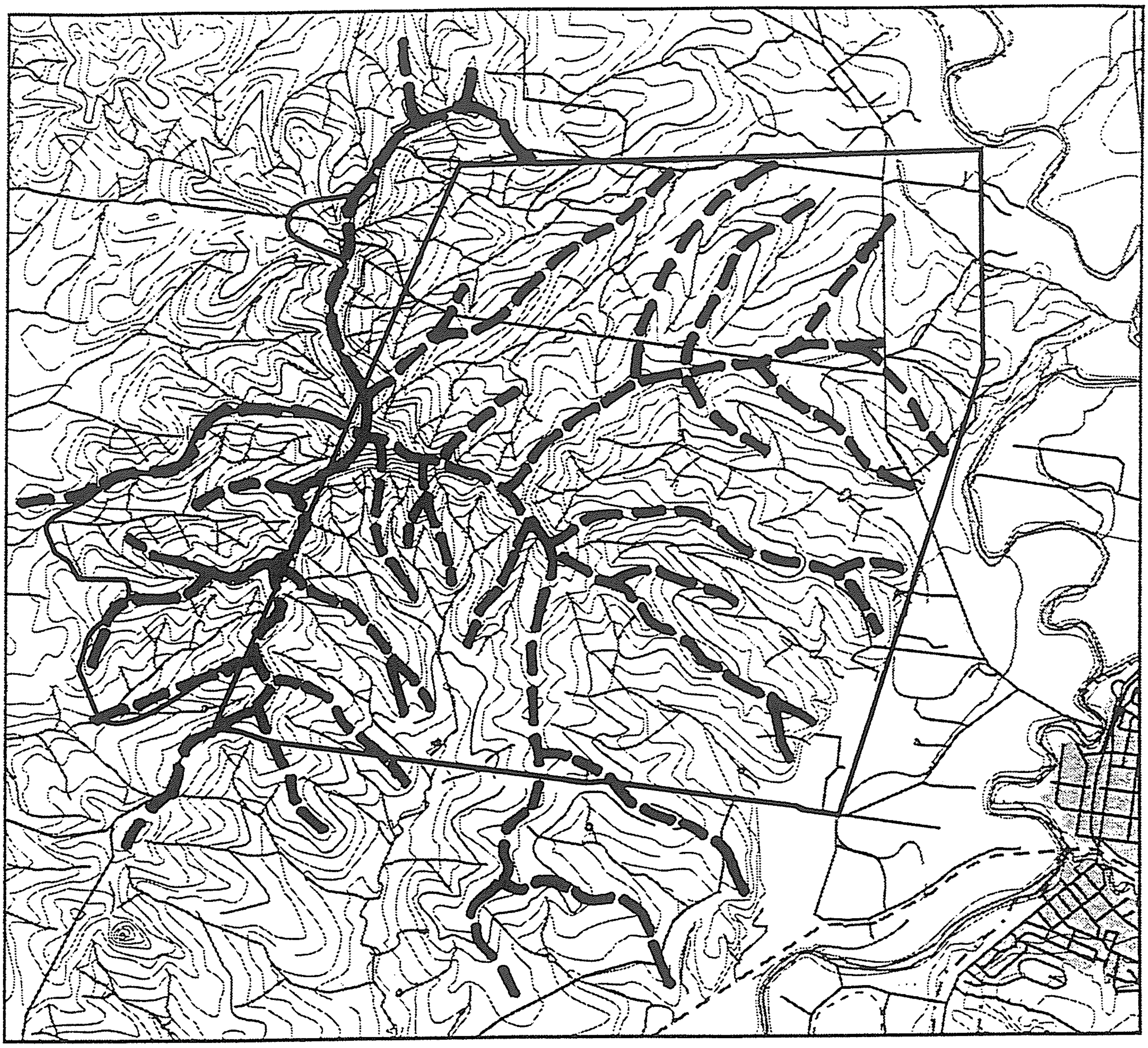


Figure 1 GENERAL VISUAL CATCHMENT



MAIN RIDGELINES (GENERALLY DESCENDING WEST TO EAST AND ENDING ABRUPTLY AT EDGE OF FLOODPLAIN)

Figure 2 LANDFORM ANALYSIS

3 Landscape Changes Generated by the Project

This section describes changes to the landscape generated by mine-related activities. All of these changes have the potential to create visual impact to varying degrees.

3.1 Mine Areas

Mining will directly generate two basic kinds of change to the existing landscape within the site. Firstly, excavations will be made across the area the largest of which will be the two main pits each about 3km long and about 150-200m deep. Secondly, much of the material extracted from these excavations will be used to rebuild new landforms. This second form of change is discussed further under **Section 3.3.**

Of the main pits the north pit would straddle the current Castle Rock Road and end just south of Dorset Road while the south pit would occupy the southern half of the site to just north of Wybong Road. Also in the southern part of the site would be two additional pits - a 'Piercefield' pit to the west of the main south pit, and a smaller 'Warkworth' pit further west again.

By Year 2 of mining the 'Piercefield' and 'Warkworth' pits would be developed to their maximum areas; the south pit would be commenced to about half its eventual length while the north pit would be scheduled to commence the following year.

From about Year 5 of mining the two pits would be linked by a continuous cutting. After Year 20 the north pit would be substantially filled and the batters rehabilitated.

The most visible components of the mine areas would be parts of the highwalls, the overburden emplacements prior to rehabilitation, and the characteristic gap where the flow of landscape is missing between the highwall and the finished landforms to the east of the pits.

3.2 Bunding

A key mitigatory technique proposed for the Mount Pleasant project is the use of an extensive earth and rock bund to the eastern edge of the south pit. This landform would take several years to construct during which time it would be particularly visible. It would be commenced early in the project programme in order to reduce not only the visual impact of mining activities but also noise and dust. Progressively during construction the bund would be vegetated with appropriate grass cover and trees and would remain for the duration of mining. The trees would, from an age of about five years, also begin to heighten the screening effect of the bund.

The bund is proposed to start near Castle Rock Road and snake over the existing topography for a distance of some 4km to the Wybong Road boundary. Smaller bunds are proposed to assist in screening the administration and workshop areas in the south-western corner of the site.

3.3 Overburden Emplacement

Four main areas of overburden emplacement are proposed for the Mount Pleasant project - two emplacement landforms east of the main pits with the north pit emplacement being larger; and two large 'out-of-pit' emplacement areas to the west of the pits.

The south-western emplacement, immediately south of Mount Pleasant, would reach an elevation of about RL 280 within the first two years after the commencement of mining. By Year 5 of mining the next emplacement to become evident would be the north refill landform also to about RL 280. By about Year 10 of mining this landform would have increased to about RL 300 while the north-western emplacement would have become established ranging in elevation from about RL 285 in the north to about RL 310 immediately below Mount Pleasant. Also by this stage the south-western emplacement would have reached its maximum extent with an elevation of about RL 325.

The two northern emplacements would have reached maximum elevation by Year 20 of mining - about RL 315 for the refill area and about RL 335 for the north-western emplacement. Refill landforms for the south pit will have reached about RL 255 (north) and RL 240 (south) by the same time.

3.4 Coal Plant Area

This area, located near the south-western corner of the site, contains the raw and product coal stockpiles and the coal preparation plant. Components within this area with the potential to be seen above the proposed screening vegetation along the southern boundary include:-

* the tallest transfer station tower (up to about RL 260),
* the reject bin and tower (up to about RL 259),
* the surge bin and tower (up to about RL 249),
* the coal preparation plant building and the product coal stockpile (both up to about RL 240) and
* the product coal transfer station tower (up to about RL 238).

All of these structures, even up to their maximum heights, would sit below the enclosing tree-lined ridge further to the west which represents the western boundary of the site. This would ensure that none of these items would be seen in profile along the ridgeline horizon from the east.

Many of these structures would be of open steel frame construction and over a distance of about 6km would not be readily noticeable except from reflection if the surfaces were untreated.

3.5 Administration/Industrial Area

This area is also located in the south-western corner of the site and includes several low-profile buildings - the administration block, operations/changehouse and workshop office - as well as the large workshop block up to an elevation of RL 270.

As with the plant area structures, the buildings in this area would be mostly evident during their construction in the early years of the Mount Pleasant project programme. A combination of bunding, architectural design treatment to minimise the buildings' potential obtrusiveness and dense screen planting along Wybong Road and within the industrial area would after a few years effectively mitigate views of most of this part of the site.

3.6 Fine Rejects Emplacement Areas

A series of fine rejects emplacements are proposed within several gullies to the west of the site. The gullies are defined by south-westerly trending ridges such that opportunities to view these emplacements from public property would be limited to two sections of the Wybong Road - immediately west of the junction with Roxburgh Road and where the road crosses the spur between Spring and Sandy Creeks. In both these cases sightlines to the proposed locations of the emplacements are presently obscured by belts of remnant woodland vegetation.

The most likely places from which views of the fine rejects emplacements would be evident are cleared private property directly facing the gullies.

With the establishment of extensive screen planting from the commencement of the Mount Pleasant project the most likely potential visual impacts would arise during the construction of the dams.

3.7 Ancillary Infrastructure

Other components of the mine infrastructure with the potential to contribute changes to the existing landscape include the the rail network with associated cuttings and embankments; coal loading bin and drive house compartment; the rerouted 66kv power line; and construction of the pipeline from the Hunter River pump station.

The rail loadout bin and its open steel-framed tower together with the drive house structure would be potentially visible in this vicinity. These structures would be mostly evident from the south to east until dense screen planting reaches sufficient maturity at about 12 to 15 years. Other proposed measures include the use of appropriate colours and finishes for the structures with revegetation proposed for cuttings and embankments.

The diversion of the 66kv power line involves moving an existing structure to a new alignment to the east of the main bund then along Kayuga Road. From about the intersection of Kayuga Road and the northern site boundary, a line would run along the northern boundary then along the western boundary with a link to the main plant area. As the new line would be supported by single poles - probably hardwood - rather than large pylon towers this is not anticipated as a major source of potential visual impact.

For the pipeline linking the Hunter River and the process water dam the construction would be the only phase likely to offer any visual impact. This change would be short term and would be controlled through minimising the width of the pipeline trench as well as the area available for construction access.

3.8 Mine Vehicles and Dragline

At various stages of the mine some of the larger machinery may be visible moving across parts of the site. The kinds of machinery likely to be intermittently visible would be haul trucks operating over most of the site, the upper part of the dragline boom and vehicles such as electric shovels operating on the areas immediately to the west of the highwalls.

Throughout the mining period haul trucks would operate on a 24 hour basis. The positions of haul roads have been designed to take advantage of rehabilitation landforms for screening purposes and screen planting is also proposed for alongside the haul routes. Mine operations are proposed to enable haul trucks to use access ramps on the western sides of emplacement areas for much of the time. However there may be places along the higher parts of the emplacement landforms, especially before the proposed tree planting has matured sufficiently, where the driving lights of haul trucks or, less frequently, the flashing safety lights of smaller vehicles may be momentarily visible at night.

For the duration of the mine the bulk of the dragline machinery would not be visible except from within the mine site and, until screen planting developed, from parts of Dorset and Wybong Roads. Only when operating from the higher benches may the upper part of the dragline boom be visible from elevated vantage points some kilometres away. The boom structure would be comprised of an open frame with bracing spars and thick cables. As such, and together with an appropriate non-reflective colour surface, the boom should not represent a major source of visual impact.

Other mine machinery that may be intermittently visible at various stages of the project include overburden drills and loaders where they operate on the higher parts of the site and along the initial overburden removal benches.

3.9 Nightlighting

As mining operations are proposed to run continuously light effects - either as localised direct light or a soft light haze or both - may be visible on occasions during the night.

Particular attention has been given to designing the mast lighting for the main plant and industrial areas. Luminaires would be fixed as low as possible and would be directed to the ground or away from Muswellbrook.

Similarly the mobile lighting towers for the more elevated operational areas such as the prestripping benches and highwalls are proposed to incorporate hoods and screens to reduce light spillage and to be focussed on immediate work areas and away from likely off-site viewing points.

Luminaires operating from the dragline boom are proposed to be mounted on the lower half of the boom. The only lights retained higher along the boom would be for emergency maintenance and these would be considerably less powerful than those required to illuminate the mine work areas.

The possibility of haul truck driving lights and flashing orange safety lights of small vehicles being seen from areas beyond the site has been discussed in the previous section. The extent to which vehicle lights would be visible at night would be reduced by the use of staggered emplacement construction shifts where between certain hours machinery would only operate behind (to the west of) or on the lower parts of the emplacement landforms.

In considering nighttime views from the larger settlements such as Muswellbrook and Aberdeen it should be taken into account that there would likely already be a light haze in the vicinity of the settlement.

Where a soft, overall light haze may be evident over parts of the project site it is likely to be more apparent with low, heavy cloud cover with light being reflected off the lower clouds.

3.10 Ephemeral Effects

Another possible change to the existing landscape setting, observable from a distance of some kilometres, would be localised dust clouds created by blasting. It is likely that blasting would be undertaken on a daily basis, six days a week.

Apart from the normal care and planning involved in setting the explosive charges little can be done to reduce the visible effects of blasting. However, the dust plumes would not be envisaged as a cause of major visual impact.

3.11 New Roadworks

As a result of proposed mine activities in the area some changes to the local rural road system would be necessary. These would involve an alternative route for a section of the Wybong Road and a new section of road, to the west of most of the proposed Mount Pleasant mine, linking the Wybong and Dorset Roads. The new section of Wybong Road is necessary to allow for mining operations in both the Bengalla and Mount Pleasant Mine sites, and would extend around to the south of the Bengalla Mine site.

Anticipated visual effects concerning the new roads would centre on the construction of the roads and would represent a short term disturbance.

4 Review of Visual Impact Potential

4.1 Preamble

This section reviews in more detail the visual catchment from which the proposed changes to the landscape would be visible, combining the considerations of **Sections 2** and **3**.

The visual catchment for the proposed mine site has been described in **Section 2** while **Figure 1** indicates the general extent of this catchment. However the context of the various vantage points within the visual catchment is important. The vantage points differ both in the extent of views as well as direction and distance in relation to the site and the duration of time taken to view the site is also relevant.

For these reasons a basic weighting system has been adopted to assist in differentiating the relative sensitivity or importance of the vantage points. Three contextual aspects have been used:-

* relative vantage point elevation (height),
* relative number of viewers using the vantage point, and
* 'permanence' of viewers (ie. residents of area or transitory).

In applying this weighting system the following emphases in consideration have been determined:-

* views of the site where mining activities would be visible from more elevated vantage points may be more important than vantage points of lower elevation where, for example, only the emplacement landforms or bund may be visible,

* vantage points from which a greater number of people may view the site may be more important than those from which only a few people view the site,

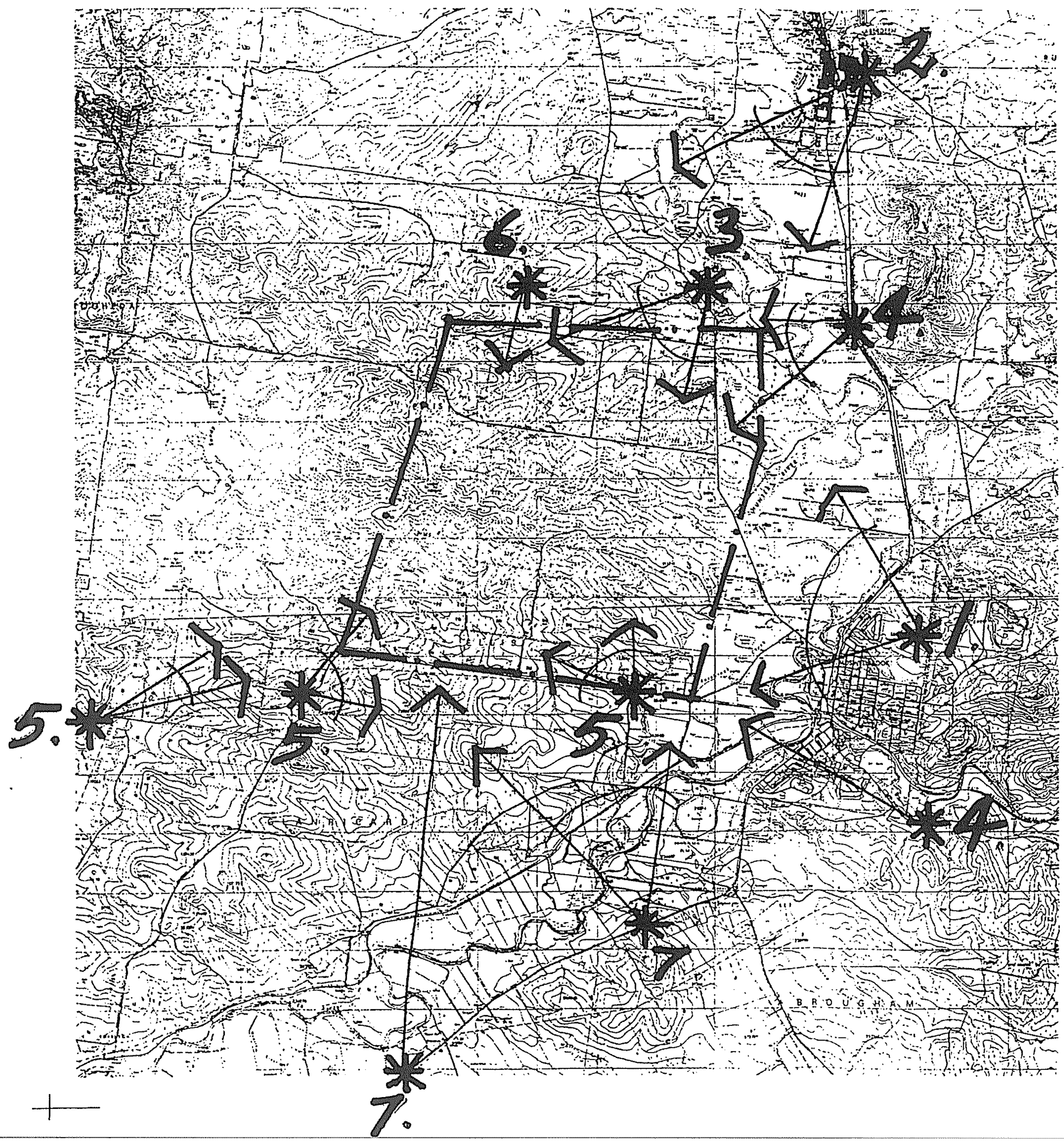
* areas where viewers are resident and therefore have opportunities for views of the site over a longer period of time may be more important than areas such as travel routes where viewers are only transitory.

Considered in this way, one of the most important parts of the visual catchment is the area of recent subdivisions on land generally at a height of between RL 180 and RL 200 metres to the north-east of Muswellbrook. This area is the highest settled part of Muswellbrook; it currently has relatively unimpeded views over much of the project site; and, with more houses in the process of being built, will have a large resident population.

Other parts of Muswellbrook also have views to the site including those of similar or slightly lower elevation such as South Muswellbrook (about RL 170). However given the difficulty of reviewing every potential vantage point this assessment concentrates on particular vantage points on the basis that, providing the greatest opportunities for observing changes to the site landscape, they are regarded as representative of other nearby vantage points within the visual catchment.

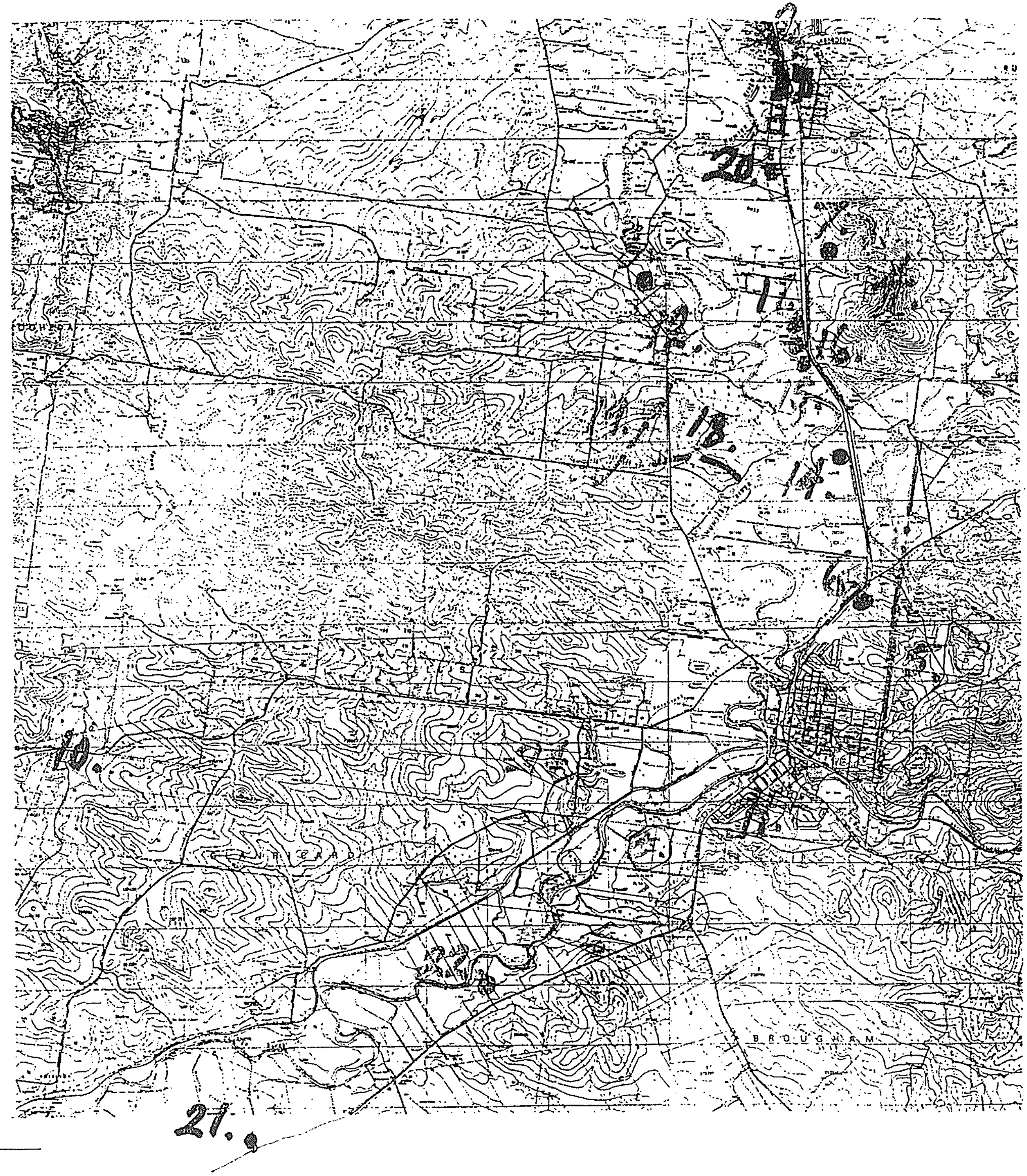
Further down the scale of this weighting system are isolated, individual properties within the alluvial flats of the Hunter River plain. While they are closer to the site than the new Muswellbrook housing subdivisions these rural properties are much lower in elevation so that the most visible changes to the landscape would be the initial construction activities, bund formation and, to a varying extent, the emplacement landforms.

Using the framework of the relative weighting system the following discussion reviews the various parts of the visual catchment in order of relative potential visual sensitivity.



1. MUSWELLBROOK
2. ABERDEEN
3. KAYUGA
4. NEW ENGLAND HWY
5. WYBONG ROAD
6. DORSET ROAD
7. DENMAN ROAD

Figure 3 REPRESENTATIVE VIEWPOINTS



1. Muswellbrook
2. Aberdeen
3. Muswellbrook Racecourse
4. Browns Mountain
5. Powerline easement
6. Timber Mill
7. Dartbrook Coal Storage/Loading Faci[lities]
8. Dartbrook Mine Surface Facilities
9. Spring Creek
10. Sandy Creek
11. South Muswellbrook
12. Kayuga
13. Black Hill
14. 'Lyndema Park'
15. 'Elgin'
16. 'Dartmouth'
17. 'Roselea'
18. Negoa ridge
19. 'Glenmore' ridge
20. Electricity substation
21. 'Lyndhurst'
22. 'Edinglassie'
23. 'Delhaven'
24. 'Overton' ridge

Figure 4 NAMES AND PLACES WITHIN THE VISUAL CATCHMENT

Nb. Names based on CMA 1:25,000 Topographic Map Series (1981)

2

4.2 Muswellbrook

The township of Muswellbrook is considered the most visually sensitive area within the visual catchment. It is the largest settlement within the catchment and has areas of high elevation and relatively close proximity. Most of Muswellbrook is located on land below about 180 metres in elevation. From the main potential vantage points in these areas visual effects would include the main bund and the emplacement landscapes - particularly that for the north pit.

For land over about 180 metres in elevation a representative site has been selected in order to describe potential visual impact. The site is at the junction of Lexia and Burgundy Streets within an area of recent subdivisions north-east of the commercial part of Muswellbrook. It is at approximately RL 200 and about 3.5 to 4km from the closest parts of the mine area with extensive views to the west. It is anticipated that the new residential development will gradually have less view prospects as street and allotment vegetation matures and the area takes on the more established character of the older residential areas.

For the first few years the most evident mine-related changes to the site landscape would be the construction and planting of the main bund along the eastern edge of the foothills; much of the length of the 'Piercefield' pit highwall at a distance of 6km; the developing upper levels of the south-western emplacement landform at a distance of about 8.5km; and a small section of the cut batter at the extreme northern edge of the south pit, though this view would be eliminated within 3 to 5 years as the bund vegetation matured.

Another potential source of visual impact may be the upper sections of the tallest structures in the vicinity of the coal preparation plant. While the tops of the tallest transfer tower and bin and the coarse reject bin may be visible it would be more likely for the top of the workshop block to be visible albeit over a distance of about 8.5km. By Year 3 of mining the 'Piercefield' pit highwall would be blasted down and revegetated.

Over about Years 5 to 10 of mining the main potential sources of visual change would be the completion of and establishment of vegetation over the entire length of the bund; and the upper levels of the north pit, north-western and south-western emplacements would be apparent. In addition to these, by about Year 15 of mining the following components of the development would become visible:-

* south-facing batters of the north pit emplacement,
* sections of highwall of the north pit,
* the upper sections of the south pit emplacement, and
* some of the prestrip sections above the highwall of the south pit.

By Year 20 of mining the bund and lower areas of the emplacement landforms would be well established with vegetation while the upper emplacement sections would be mostly grassed prior to a final reshaping at the cessation of mining. Following this final process no sections of highwall or cut/fill batters would be apparent.

Generally at night the anticipated visual effects would be a soft haze from reflected light as well as small areas of intermittent and localised light from mine vehicles.

The revegetated new landforms arising from the placement of overburden would be the noticeable long-term components of the mine project from this location.

4.3 Aberdeen

The town of Aberdeen is about 5 to 6km away from the closest parts of the mine area. Most of the elevated sections of Aberdeen, as well as sites at the western edge of the town, offer views of the northern and eastern parts of the site.

As with Muswellbrook a representative site has been selected to summarise the visual impact potential for Aberdeen. The site is the northern end of Campbell Street at about 235 metres in elevation.

Initial mine-related changes evident from parts of Aberdeen would be the construction of the upper sections of the main bund by Year 2 of mining. From this time to about Year 20 of mining, potential visual impact would centre on the construction and rehabilitation of the north pit emplacement landform and views of sections of the north pit highwall.

Over successive years the sections of highwall visible would change depending on the line of sight, progress of the north pit emplacement as well as progress of the proposed adjacent proposed Kayuga Mine emplacement landform. After cessation of mining in the north pit all views of highwalls would be eliminated with the regrading and rehabilitation of these areas.

From about Year 10 of mining the north-western emplacement formation would become visible.

Effects from nightlighting would be similar to those described in the previous section however they would be perceived from a greater distance which would reduce the degree of potential impact.

4.4 Kayuga

The small, yet long established (c. 1827), village of Kayuga is situated on low-lying land immediately to the west of the Hunter River and north-east of the proposed mine site. It would be less than 1.5km from the closest part of the north pit excavation at about Year 2 of mining.

The most visible components of the mine development from Kayuga would be the main emplacement landform for the north pit after Year 2 of mining; the north-western emplacement by about Year 10 of mining; and from about Year 5 of mining, parts of the north pit highwall. As mining progressed to the west advanced screen planting along Dorset Road would have reached sufficient height by 10 to 15 years to contribute to reducing the extent of visible highwall.

Nightlighting effects would be an ambient haze in the vicinity of the active mine areas as well as intermittent and localised light from mine vehicles traversing the emplacement landforms.

In context however the northern part of Kayuga is already the site of the central plant area of the Dartbrook Mine while the proposed open-cut Kayuga Mine would be located to the west of the village with the main emplacement landform less than 1km away. Assuming the Kayuga Mine is approved and operational, this same emplacement would screen parts of the Mount Pleasant development from Kayuga.

4.5 Main Travel Routes

4.5.1 New England Highway

The New England Highway is an important travel corridor carrying large volumes of traffic relative to other roads in the vicinity of the proposed Mount Pleasant Mine. The highway is to the east of the proposed mine site and about 2km away at its closest point. The southern part of the site is visible from the New England Highway - near Black Hill - when entering Muswellbrook. From this prospect the 'Piercefield' pit highwall would be potentially visible, at a distance of about 8km, as would the southern part of the bund (6km away) and the south-western emplacement (10km away).

The main section of the highway along which views of the mine site would be evident is the section between Muswellbrook and Aberdeen though most of these views would be of limited prospect opportunity owing to the generally low elevation of the highway. Some intermittent views of the emplacement landforms from about Year 8 of mining would be possible for southbound travellers along the highway between Scone and Aberdeen. Viewing distances in that area range from 12 to 17 km away.

Most of the highway section from Muswellbrook to the vicinity of 'Lyndema Park' is barely higher than the adjacent alluvial flats. From these parts of the highway potential visual impacts arising from the mine project would result from the construction and rehabilitation of the northern emplacement landforms. As a result of the low viewer position, all of these new landforms would be perceived as very narrow horizontal bands fitting mostly below the immediate western horizon defined by the main north-trending ridge off Mount Pleasant. The landscape to the west is presently perceived as having a characteristically low profile unlike, for example, the views to the north and east where the enclosing Browns, Colonel and Bells Mountains make a relatively dramatic and high profile horizon. Importantly none of the proposed changes to the site landscape would impede views to the higher ranges to the far west.

The section of highway from just north of 'Lyndema Park' to the bottom of the ridge on which is located 'Elgin', 'Dartmouth' and 'Roselea' is generally screened from the mine site by the adjacent Negoa ridge and the 'Glenmore' ridge to the west of Kayuga Road which would be retained intact during the entire mine project.

Of greatest interest is the section of the highway at the 'Dartmouth' ridge at about 180m elevation and the unimpeded viewing points up to about 500m north of the Dartbrook Mine road junction with the highway. As these prospects are more elevated than the view points further south it would be possible for mainly southbound travellers to notice more of the mine-related changes to the western landscape.

The first activities potentially visible from the 'Dartmouth' ridge would be the construction and rehabilitation of the north pit emplacement landform by Year 5 of mining. The extreme northern end of the north pit highwall may be visible as limited glimpses. By about Year 10 of mining the north-western emplacement would be visible over a distance of about 6km.

Also in the vicinity of this part of the highway are industrial features such as the main product coal stockpiles and coal loadout facilities of the Dartbrook Mine several hundred metres east of the road and about 2km south of Aberdeen; and a large electricity substation to the west of the road at the southern entry to Aberdeen. Of additional relevance is the proposed Kayuga mine of closer proximity to this section of the highway than is the Mount Pleasant Authorisation.

For travellers along the highway, views toward the mine site would also be limited by the time it takes to travel this section of roadway.

Nightlighting effects visible from the highway would be a general haze of reflected light over the site with small points of intermittent light from moving mine vehicles traversing the emplacement landforms.

4.5.2 Main Northern Railway

As with the highway the section of the Main Northern Railway most relevant to this assessment is that between Muswellbrook and Aberdeen. The railway runs virtually next to the road for most of this section and is generally at a slightly higher elevation as a result of almost continuous embankments. There are only two cuttings.

Potential mine-related visual impacts noticeable from the railway would be generally those described for the highway although, as a result of the higher elevation of several metres, it is likely that slightly more of the mine site would be visible. Potential nightlighting effects would be similar to those described for the highway.

Southbound passengers on the western side of carriages would likely have more opportunities of looking in the direction of the mine as northbound passengers would be required to turn around much more to see directly to the mine site.

4.6 Hunter River Flood Plain

This section broadly considers the productive alluvial flats from the vicinity of Aberdeen through to the dairies near 'Lyndhurst' to the south.

Potential visual impacts would centre mostly on 'secondary' activities arising from mining such as the bund and emplacement construction rather than the actual mine pit areas because of the low elevation of viewing points. However an early, yet temporary, prospect in the vicinity of Logues Lane would be views of the 'Piercefield' pit highwall until completion of the bund.

From the flood plain to the north-east and east of the proposed mine site the only noticeable long-term changes would be the construction of the higher parts of the emplacement landforms. The treeless ridge on which Negoa Geodetic Station is located together with the ridge further west effectively form barriers to views of the mine site from this part of the flood plain.

The low-lying area from the south of the Negoa ridge down to Kayuga Road would reveal views of the main bund and the emplacement landforms under construction.

From the vicinity of 'Edinglassie' to 'Lyndhurst' the most significant perceived changes to the landscape would be the south-western emplacement as the Bengalla Mine emplacement would effectively screen other proposed aspects of the Mount Pleasant project.

Potentially visible nightlighting effects would be similar to those described for the two previous report sections though, owing to the generally lower elevation, less of the mine vehicle lights would be visible. Some fixed lighting may be visible in the vicinity of the coal preparation plant area and the rail loadout area over distances of between 4 to 6km from parts of the flood plain south-west of Muswellbrook.

4.7 Other Travel Routes

4.7.1 Kayuga Road

After crossing the Hunter River from Muswellbrook along the Kayuga Road the eastern edge of the site landscape appears as a low, extended sequence of foothills rising above the flood plain. Likely sources of visual impact from the mine would be the construction of the main bund and the construction and rehabilitation of the north pit emplacement landform.

For the section of Kayuga Road near the village of Kayuga visual impact potential (including nightlighting effects) would be similar to that described in **Section 4.3.**

For the southern part of Kayuga Road potentially visible nightlighting effects would be similar to those described in **Section 4.5.**

4.7.2 Wybong Road

From the intersection with Kayuga Road up to the area where Wybong Road rises from the alluvial flats into the eastern edge of the foothills, noticeable impacts arising from the proposed mine would be the construction of the main bund and, until completion of the bund, the 'Piercefield' pit highwall.

Sections of Wybong Road of higher elevation would provide close range views of the 'Piercefield' and 'Warkworth' pits and their highwalls, the south-western emplacement, the coal stockpiles and preparation plant areas and the coal loadout structure.

From about Year 8 of mining the Wybong Road would be diverted such that all of the section from near the coal loadout conveyor line down to Bengalla Road would cease to operate as a public road.

It is from the section of the Wybong Road at the junction with Roxburgh Road to the vicinity of Sandy Creek that there are potential view opportunities to the proposed sites of the fine rejects emplacements. Owing to the density of remnant woodland vegetation on intervening ridgelines it is anticipated that views of the fine rejects emplacements will be minimal - the most evident being during the construction phase.

The greatest potential for visual impact arising from the location of the fine rejects emplacement areas is in relation to several residences in the vicinity of the gullies proposed for the series of emplacements.

4.7.3 Castle Rock Road

Also known as Coal Creek Road this is one of only two public roads to traverse the site of the proposed mine. The eastern-most section of the road would fall within the central part of the north pit and as a consequence a diversion of Castle Rock Road is proposed around the western boundary of the site.

The closest mine activity would be the north-western emplacement landform and as this has been designed to sit below the enclosing western ridgeline visibility from the road diversion would be minimised. The construction of the upper levels of the emplacement would likely be evident though this would become less apparent as screen planting matures. Nightlighting effects would be similar to those described for **Section 4.3** though at closer range.

4.7.4 Dorset Road

Dorset Road is at the northern boundary of the site and runs partly parallel to Castle Rock Road. As with parts of Wybong Road it is proposed to retain a boundary buffer zone within which substantial screen planting would be undertaken. Part of Dorset Road would be diverted to the north of the site and would pass between the emplacement landforms of the proposed Mount Pleasant and Kayuga mines.

While the screen planting matured, early construction works such as the formation of the emplacement would be visible as would the earliest phases of mining of the north pit.

Visible nightlighting effects would be similar to those described for Castle Rock Road with the additional effect of close range lighting for active mine areas.

4.7.5 Denman Road

From South Muswellbrook the first two kilometres of Denman Road are of low elevation and view prospects of the site, like those from the New England Highway, offer a low profile landscape stretching horizontally across the field of vision. Visible changes would be the 'Piercefield' pit development - particularly the highwall - and the construction of the main bund and the south-western emplacement in the first years of the project and eventually the tops of the north and south pit emplacement landforms as they emerge from behind the bund after about Year 12 of mining.

Denman Road traverses the edges of a foothill north of Mount Arthur about 3km from South Muswellbrook. The road reaches about 180 metres in elevation at this point and it is here - in the vicinity of 'Delhaven' - that the most revealing views of the project site from Denman Road would be possible. As with the other section of Denman Road, visible changes within the site by Year 2 of mining until Year 20 would include:-

* the 'Warkworth' pit highwall,
* the south-western emplacement landform,
* the southern part of the main bund and
* possibly the tops of the tallest components of the rail loadout facility.

Views of the 'Piercefield' pit highwall would be possible from this vantage point however owing to the intervening emplacement landforms of the Bengalla Mine - even at an early stage of the Mount Pleasant project - such views would be screened. Some advanced planting has already been undertaken along this part of Denman Road for the Bengalla project.

From about Year 10 of mining the north pit emplacement would become visible. By about Year 15 to Year 20 views may be evident of the uppermost parts of the south-facing batters of the north pit emplacement. One of the existing easterly-trending ridges extending from the Mount Pleasant peak would conceal views of the north-western emplacement.

Nightlighting effects would be similar to those described for **Sections 4.5.1** and **4.5.2.**

4.7.6 Roxburgh Road

About one kilometre from the junction with Wybong Road, Roxburgh Road passes over a high ridge at an elevation of about RL 270 from which potential views of mine-related changes for northbound commuters may be the top of the workshop building over a distance of 2.5km and the top of the rail loadout tower and bin structure over a distance of about 2km. Between the proposed locations of these facilities and Roxburgh Road there is much remnant woodland vegetation and in the vicinity of the structures additional screen tree planting is proposed.

Other potential visual effects would be a soft light haze at night and ephemeral changes.

4.7.7 Western Link Road

A new link road is proposed to connect the Wybong and Dorset Roads which would be located along the ridges forming the western edge to most of the Mount Pleasant site. In this location potential visual impacts would include the administration and plant areas, the two western emplacement landforms and the fine rejects emplacement areas.

Where required to reduce view potential from these areas, a combination of bunding and screen planting would be used.

4.8 Western Properties

4.8.1 J Moore House (c. RL 245)

Potential mine-related visual impacts observable from this house would be the top few metres, over a distance of more than a kilometre, of the workshop building; a soft light haze at night; and ephemeral changes such as blast plumes.

From 10 to 12 years after advanced tree planting, intervening screen trees would begin to reduce the visible extent of the workshop, as would the application of architectural design treatments from the time of construction of the building.

4.8.2 'Gilgai' Homestead (RL 240) & Driveway (c. RL 255)

Some of the northern-most parts of the three fine rejects emplacements in the gully south of the 'Broomfield' ridge may be visible through intervening trees from 'Gilgai' homestead. Also the top few metres of the workshop building may be visible over a distance of 2km. A combination of screen tree planting and architectural design of the workshop would assist in ameliorating potential views of the building.

From the more elevated driveway of 'Gilgai', the fine rejects emplacements would be screened by intervening woodland vegetation while the top few metres of the workshop building may be visible beyond an intervening knoll and mature vegetation within the property.

Other potential visual effects would include a soft light haze at night and ephemeral changes.

4.8.3 B Bates Property

From the eastern ridge fenceline (about RL 248) of the Bates property the three southern-most fine rejects emplacements would be visible through intervening trees as would the top 5m of the workshop building in between trees along the eastern horizon ridgeline.

The Bates house at an elevation of about RL 235 would have potential, though intermittent, views of some of the southern-most fine rejects emplacement area and only minimal potential views of the northern-most area. The top few metres of the workshop building may be intermittently visible through the dense band of horizon trees and the closer, intervening trees over a distance of 2km.

About the middle of the Bates property on a ridge just west of Sandy Creek and at an elevation of RL 230, the northern sides of the emplacements in the gully north of the 'Broomfield' ridge would be visible over a distance of 2 to 4km.

Other mine-related changes potentially visible from the Bates property would be a soft light haze at night and ephemeral effects.

4.9 Classified Rural Landscapes

The two rural landscape areas classified by the National Trust of Australia (NSW) are described in **Section 2.1** and, although the proposed Mount Pleasant Mine site is outside of the boundaries of both of these rural landscapes, they still need to be considered.

The Muswellbrook-Jerrys Plains rural landscape to the south and the Momberoi-Scone rural landscape to the north of the site are defined by enclosing landforms with a central water feature - mostly the Hunter River - as an important focus.

In the case of the northern area, where the southern limit is near the confluence of Dart Brook and the Hunter River at Kayuga, the defining landforms include the ridges running north-east from Mount Pleasant. From within the rural landscape area Mount Pleasant is visible. Aspects of the mine project potentially visible would be the highest parts of the two northern emplacement landforms. These are proposed to be rehabilitated in a character sympathetic to the landscape types within the rural landscape area. Of relevance to this consideration is that, as with the observations for Kayuga village and assuming the Kayuga Mine is approved and operational, the proposed Kayuga Mine emplacement would obscure parts of the Mount Pleasant project from within this area.

The Muswellbrook-Jerrys Plains rural landscape area closest to the Mount Pleasant site is defined at its northern limit by the 'Overton' ridge and adjacent western foothills. Owing to these enclosing landforms and the low elevation of this part of the rural landscape potentially visible mine-related changes to the landscape beyond would be the main bund and, until completion of the bund, the 'Piercefield' pit highwall.

Potential visual impacts from the Mount Pleasant project on both rural landscape areas would be restricted in extent and only visible from extreme parts of the overall range of the conservation zones; and these potential impacts would be limited in time as the altered mine landscapes would be rehabilitated to a compatible character.

Nightlighting effects would correspond to those described for the respective parts of the flood plain. Both rural landscape areas would be potentially influenced more by the proposed mine-related activities of the two adjacent mine projects.

4.10 Broader Context of Visual Impact Potential

The proposed mine plans of the two adjoining mine authorisations either side of the Mount Pleasant site need to be considered as part of the review of the visual impact potential of the Mount Pleasant project.

The potential visual effects analyses for **Sections 4.2** to **4.9** indicated that the proposed emplacement landforms of the two adjoining developments will screen aspects of the Mount Pleasant project.

While there are benefits in having views of rehabilitated landforms replace those of mine pit highwalls other kinds of visual effects must be considered. One of these is the visible cumulative potential - with all three projects underway - of about 11km of mine-related landscape changes from the southern part of the Bengalla Mine to the northern part of the proposed Kayuga Mine facing Muswellbrook.

Assuming the three commence within a five year period the most evident relationship between them would be the rapid development of the emplacement formations most of which would continue to grow throughout the approved life of each project until the final reshaping process.

5 Mitigatory Measures

This section describes specific actions proposed as integral parts of the Mount Pleasant project that are designed to reduce, and in some cases eliminate, potential visual impacts arising from mine-related activities. Mitigatory measures were developed as part of the mine plan and infrastructure proposals during the early phases of planning for the Mount Pleasant project.

Several basic design principles are briefly discussed after which there follows a more detailed description of the various proposed mitigatory measures.

5.1 Design Principles

Generally the choices for reducing visual impact fall within two broad categories. Either screen the activities or structures potentially causing visual impact or treat these elements in such a way that they are perceived as being acceptably less incongruent than would otherwise be the case. The following principles exemplify both of these basic directions and were considered as part of the mine planning.

5.1.1 Retention of Useful Site Features

Where feasible those parts of the site area of potential use in assisting with the screening or visual integration of mine-related changes should be retained. Such features may include both ridgelines and existing vegetation - particularly mature trees.

5.1.2 Emulating Existing Topographic Character

From the description of the site landscape in **Section 2.3** one of the characteristics of the existing topography is that the elongated ridgelines trend in a generally easterly direction. Where seen from the public roads the landforms are generally without dramatic relief though the ends of the ridges appear to be truncated as the foothills reach the western edge of the alluvial plain.

Since the mine project would entail a substantial amount of landform remodelling as well as the use of large-scaled earthworks for bunding it would be appropriate and desirable to design the new landforms so that they conform to the morphological characteristics of the local landscape. This means articulating the new landforms so that the existing pattern of ridges and valleys is respected and, where possible, ridgelines run in an easterly direction to form an appropriate link between the retained land to the west and east of the mine-disturbed area.

5.1.3 Use of Vegetation

Vegetation would have an important role in the effective visual management of the mine from its earliest development phase until well after the cessation of mining.

Principles relevant to the use of vegetation on the mine project include the following:-

* undertaking extensive planting programmes from the beginning of the project in order to establish effective screens as quickly as possible,

* using mixed Australian native species (particularly natural companion species such as *Acacia* and *Eucalyptus*) and as much as possible indigenous site species,

* concentrating greater densities of plants along ridgelines and gullies with a few trees drifting out from these areas across the side slopes,

* using direct seeding techniques for broad-acre revegetation areas (eg. emplacement landforms) and more advanced size species in limited high-profile areas where immediate results are required (eg. main administration area), and

* where viable, considering the allocation of rehabilitated side slopes for commercial orchards (eg. Olive groves).

5.1.4 Site Planning and Design

Wherever possible naturally low-lying parts of the site should be used to accommodate major infrastructure and storage areas especially where these include large-scaled, massive or tall elements.

Where haul roads are required to traverse the more prominent parts of the site the roads should be sited so that they are shielded by existing (retained) ridgelines, bunding or emplacement landforms.

5.1.5 Modifying Standard Structures

Where there would clearly be a significant potential visual impact from the use of standard structures or components and the basic design of the structures would permit various modifications in order to eliminate or reduce the visual impact, it is desirable to do so.

An example would be the modification of fixed operational lighting systems. Where possible working lights on structures such as the dragline boom should be attached lower and screening hoods used. The direction of fixed lighting should always be away from adjacent settlements.

The use of appropriate architectural design detailing could be employed on prominent fixed structures such as the main workshop block.

5.2 Specific Proposals

5.2.1 Bunding

One main bund of about 4km length is proposed for the Mount Pleasant mine project. This has been previously described in **Section 3.2** and would contribute significantly to the reduction of visual impact potential. Other much smaller bunds are proposed for around the south-western corner of the proposed mine site and where required for the proposed western link road

The bund has been designed within site constraints to emulate the existing landform in scale and form including a variable ridgeline elevation.

5.2.2 Retention of Desirable Ridgelines and Vegetation

Throughout the site area there are existing ridgelines of benefit in reducing or, in some cases, eliminating potential views of mine-related changes to the site. Many of these ridges would be retained throughout the project while a few would only be mined towards the final stages of the project.

The main ridge system enclosing the site to the west would be retained in total with mine-related changes in close proximity designed to sit, in most cases, below the ridgelines in order to preserve the existing horizon character. The central easterly-trending ridge from Mount Pleasant is also an important one and would be retained down to the upper levels of the 'Piercefield' pit.

In the north-eastern part of the site two existing ridges trending to Kayuga Road would be retained.

As much as possible existing site vegetation - especially mature trees - would be retained.

5.2.3 New Plantings

Integral with the bunding, rehabilitated landforms and fine rejects emplacement formations is the use of new plantings to both reinforce the screening effect of the earthworks or ridges and re-establish vegetation patterns across the landscape more consistent with its former woodland character.

The bund would be either planted or directly seeded using mixed native species including indigenous tree species. Vegetation would be more densely concentrated along the ridges and upper sides becoming sparser down the side slopes. Details of proposed species are given elsewhere in this EIS.

Appropriate plantings would be interspersed throughout the industrial area with an emphasis on upper canopy species. Trees would also be interspersed across the adjacent areas as shown in **Figures 8.1 to 8.5.**

The new landforms created as part of the rehabilitation process would be quickly stabilised with appropriate grasses and seeded with native tree species. Trees would be concentrated over ridgelines and some gullies while sparser drifts of trees would be planted across the side slopes.

Experience with rehabilitation and stabilisation techniques gained from the Hunter Valley No 1 Mine by the proposed operator of the present project, Coal and Allied Operations Pty Ltd, would be brought to the detailed planning and management of the Mount Pleasant development. This experience would be vital in maintaining the extensive and important vegetative infrastructure proposed for the project. The approach to monitoring and maintaining the site vegetation is discussed elsewhere in this EIS.

5.2.4 Specific Siting Proposals

Existing gullies would provide the locations for the proposed rail loop, coal preparation and administration/industrial areas as well as the fine rejects emplacement areas.

Haul roads are proposed to be located as much as possible behind or on the side of ridges.

5.2.5 Detailing of Structures

Specific structures identified as potentially visible owing to height or massing requirements are proposed to be treated using architectural detailing including expressing structural elements, the articulation of planar surfaces as well as use of non-reflective angles, finishes and appropriate colours.

5.2.6 Nightlighting

Basic design criteria used to minimise visual impacts arising from site lighting include:-

* providing only sufficient lighting necessary for safe and efficient operation,
* providing time delay automatic switch-off for access lighting,
* restricting the use of mine vehicles at night to the western and lower parts of emplacements,
* enclosing all buildings, conveyor galleries and parts of the conveyor transfer stations,
* using luminaire hoods, bunding and vegetation to screen lighting and
* using the latest innovative technology and design methods.

Specific lighting modifications include the use of luminaires fixed only to the lower part of the dragline boom; the directing of lights for work areas away from settlements; and strict controls for the use of lighting generally. These are described in more detail elsewhere in the EIS.

5.2.7 Rehabilitation Design

As with the design of the bund the emplacement landforms are proposed to reflect the character of the existing landscape. This would be achieved by the reinstatement of long ridgelines generally descending in an easterly direction.

The application of appropriate vegetation patterns as described in **Section 5.2.3** would further reinforce the intended character of the rehabilitated mine areas.

As a result of final voids remaining in both southern and northern mine areas it would not be possible to restore the continuity between the western and eastern parts of the landscape completely although this would be noticeable from only a few places.

The rehabilitation of the mined areas would be undertaken on a progressive basis so that potential visual impacts resulting from large areas of exposed overburden would be minimised.

After the completion of mining of the 'Piercefield' and 'Warkworth' pits by about Year 2 of the mining schedule the highwalls would be blasted out and rehabilitated.

5.2.8 Road Diversions

The proposed diversion of Castle Rock Road and the eventual Wybong Road diversion would also assist in reducing the extent of the mine area visible from the west and the south.

5.3 Mitigatory Treatment Priorities

Phase of project	*Proposed Actions*
Year 1 of project (before commencement of mining):	Fence off existing areas to be retained and reinforce existing vegetation with additional plantings (**Figure 5**).
	NB. At the time of writing of this section a substantial amount of advanced tree planting had already been undertaken within the Authorisation area.
	Boundary screen planting within the site along parts of Wybong and Dorset Roads (**Figure 6**).
	Initial screen planting for fine rejects emplacement areas.
	Commencement of bund construction.
Years 2-4 of project (up to the start of mining):	Progressive planting of bund and infrastructure areas as well as the rehabilitation of the 'Piercefield' and 'Warkworth' pits highwalls.
Years 2-20 of mining:	Progressive rehabilitation of mined areas (**Figures 8.1 to 8.5**).
	Completion of additional screen planting where required for fine rejects emplacement areas.
Completion of mining:	Final rehabilitation of mine landscape and fine rejects emplacements

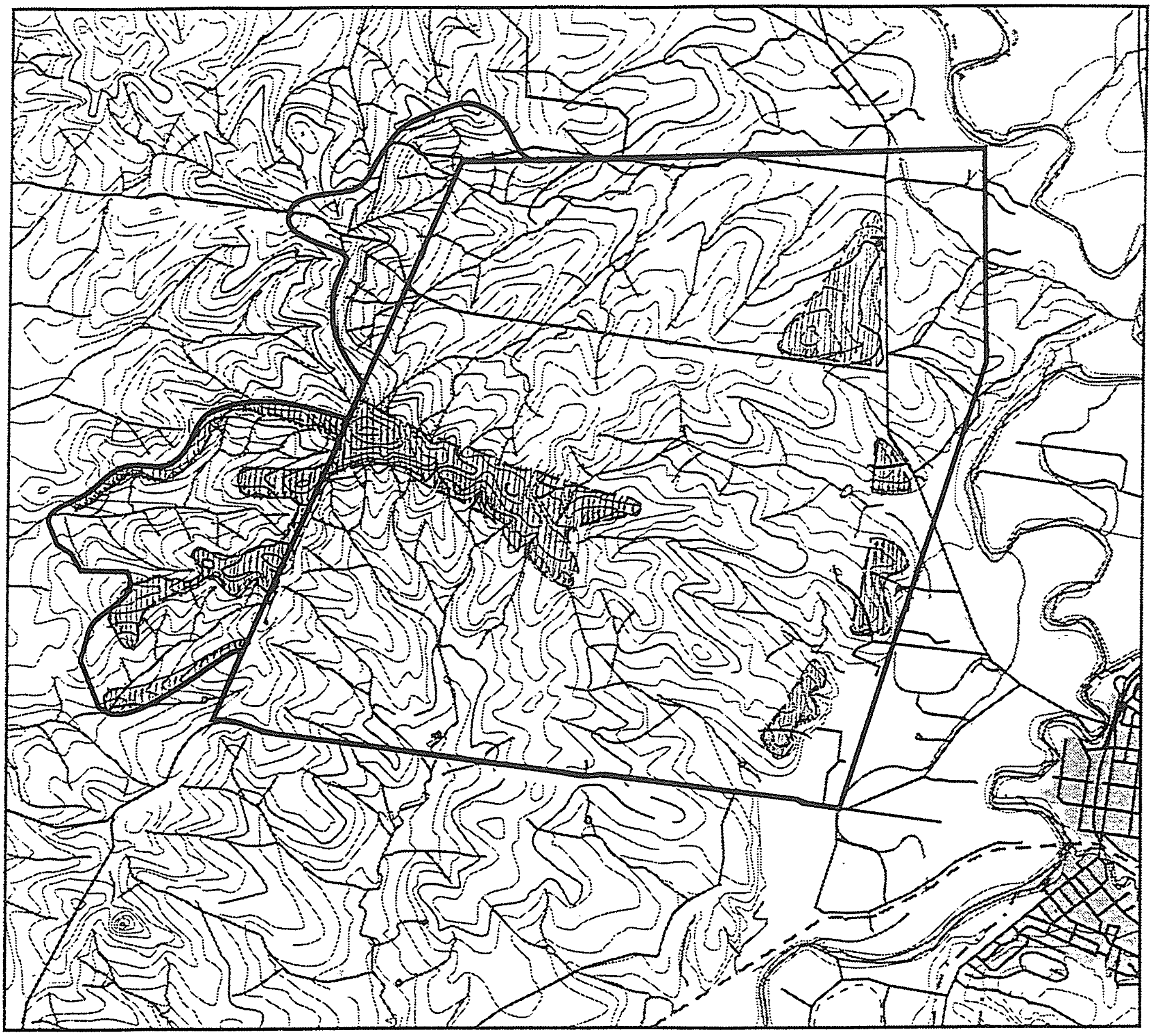


Figure 5 GENERAL AREAS TO BE FENCED OFF AND RETAINED

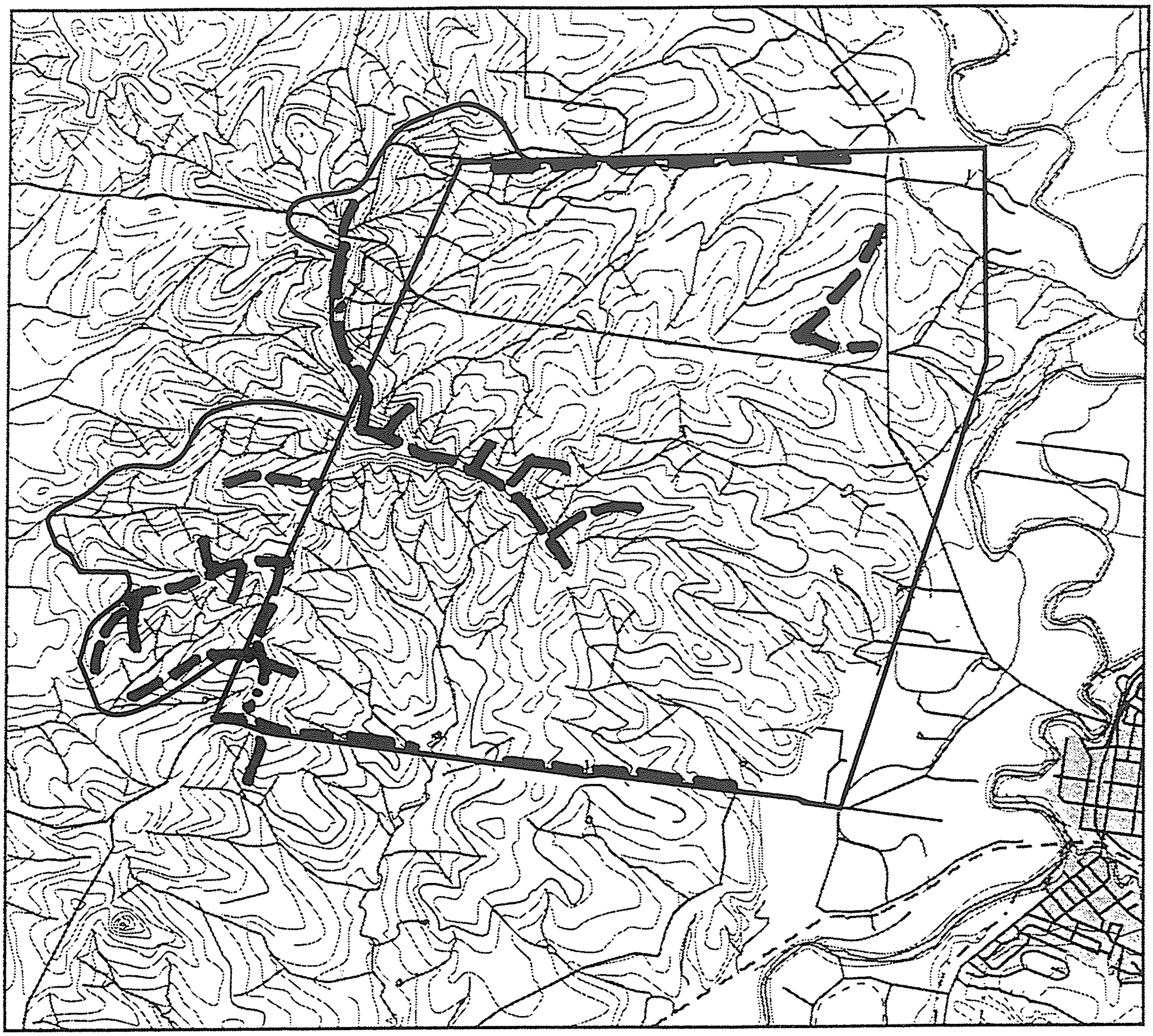


Figure 6 GENERAL AREAS OF ADVANCED TREE PLANTING

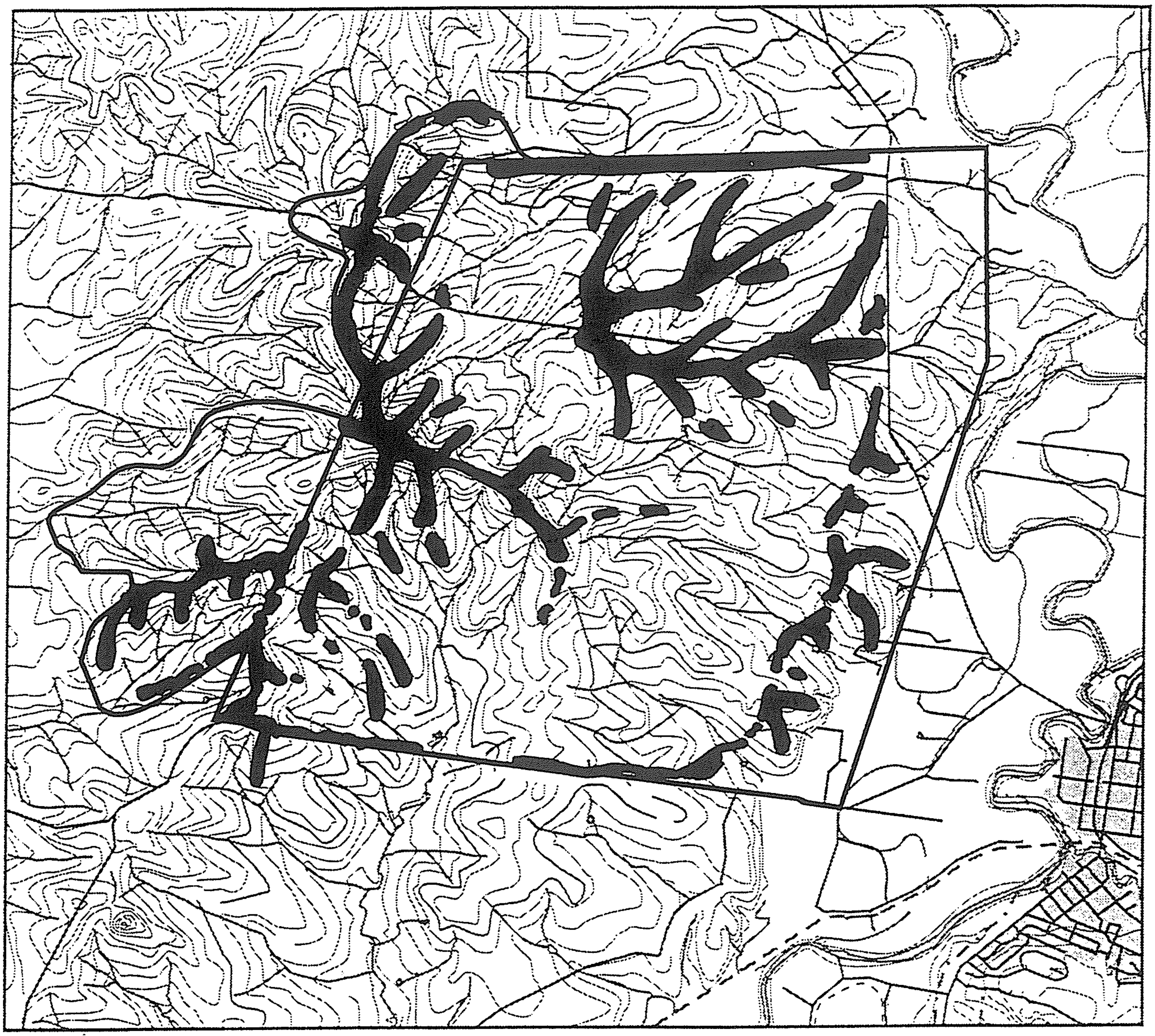


Figure 7 OVERALL LANDSCAPE CONCEPT

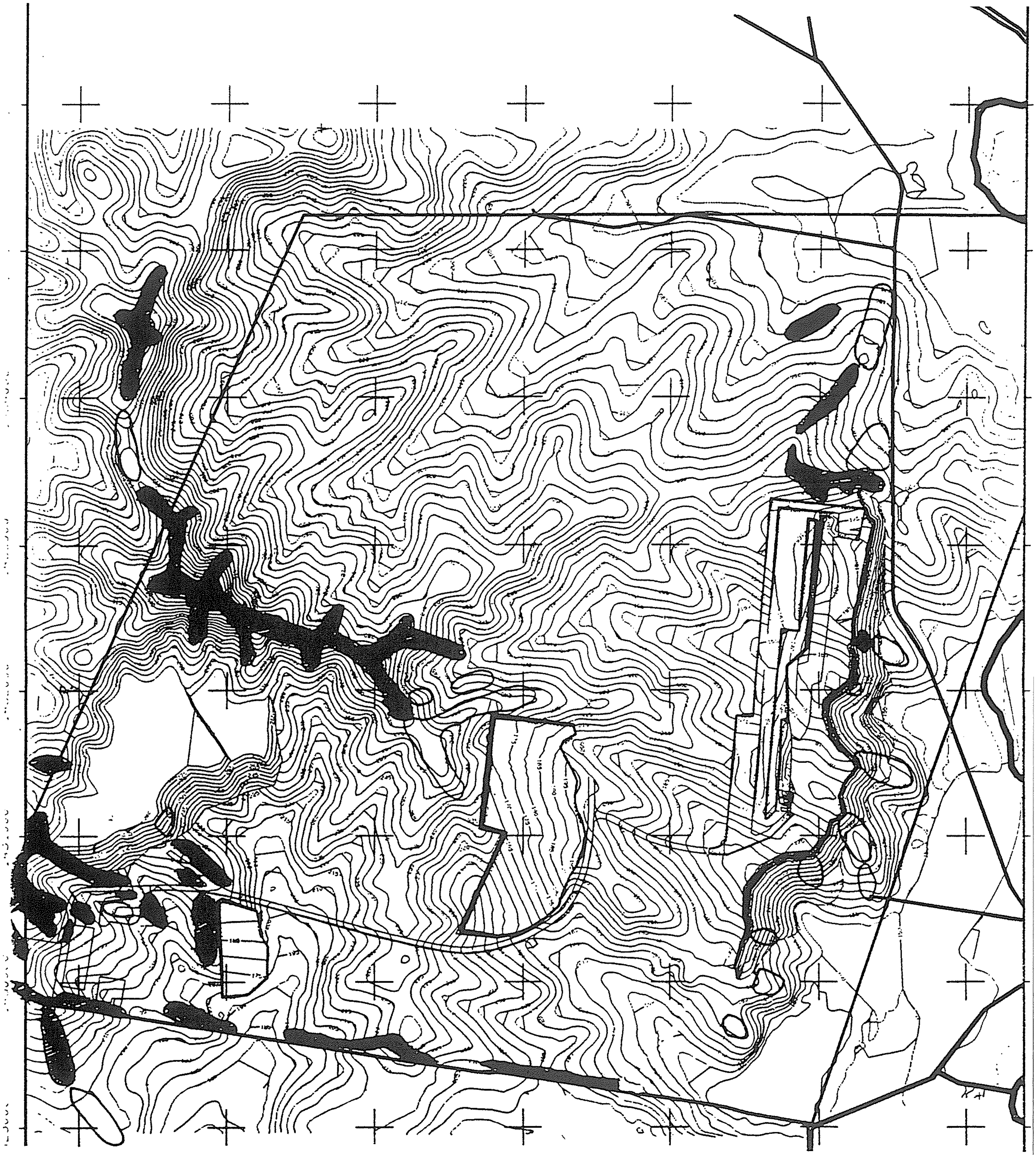


Figure 8.1 CONCEPTUAL MINE REHABILITATION/TREE PLANTING AREAS (YEAR 2)

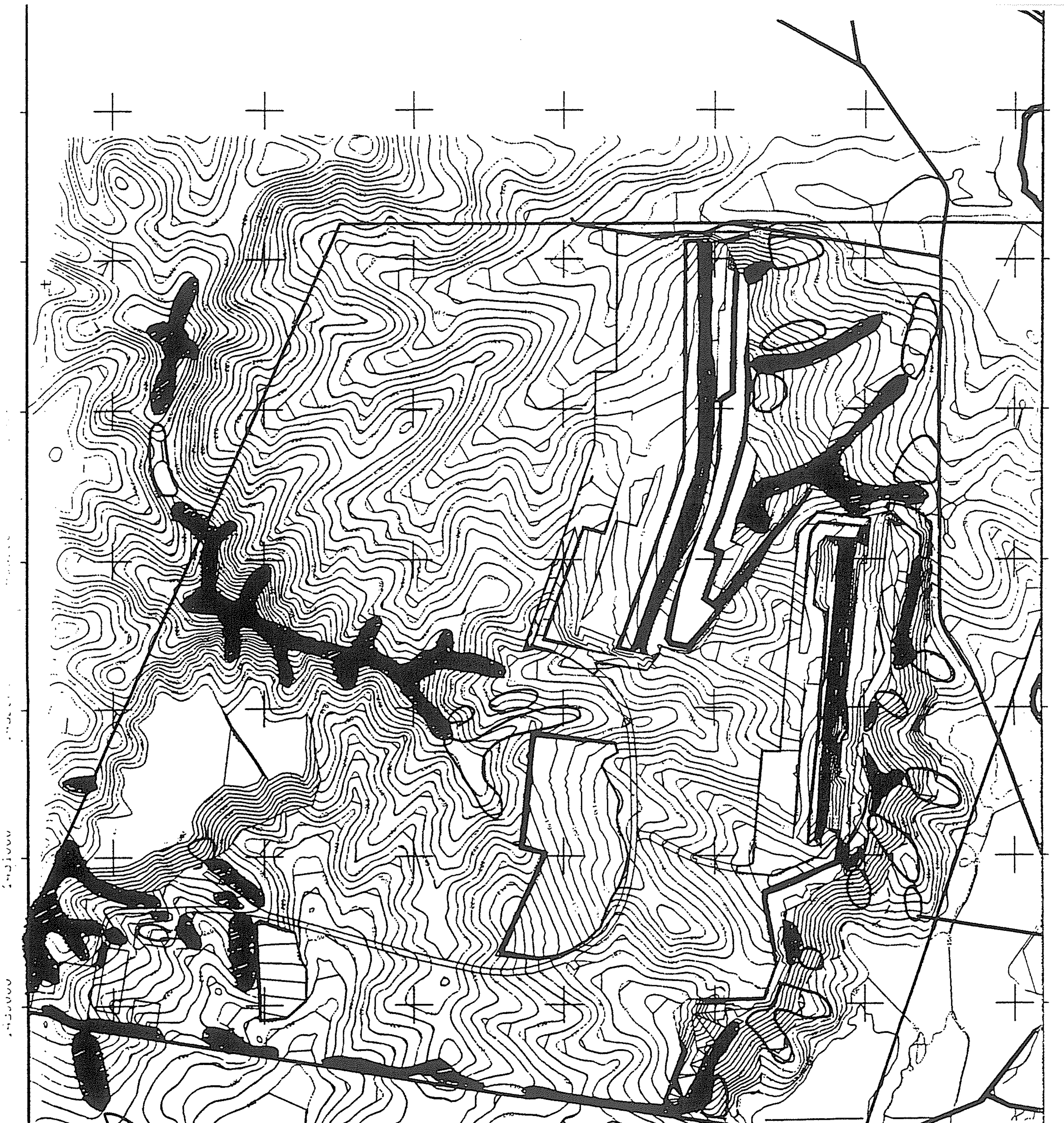


Figure 8.2 CONCEPTUAL MINE REHABILITATION/TREE PLANTING AREAS (YEAR 5)

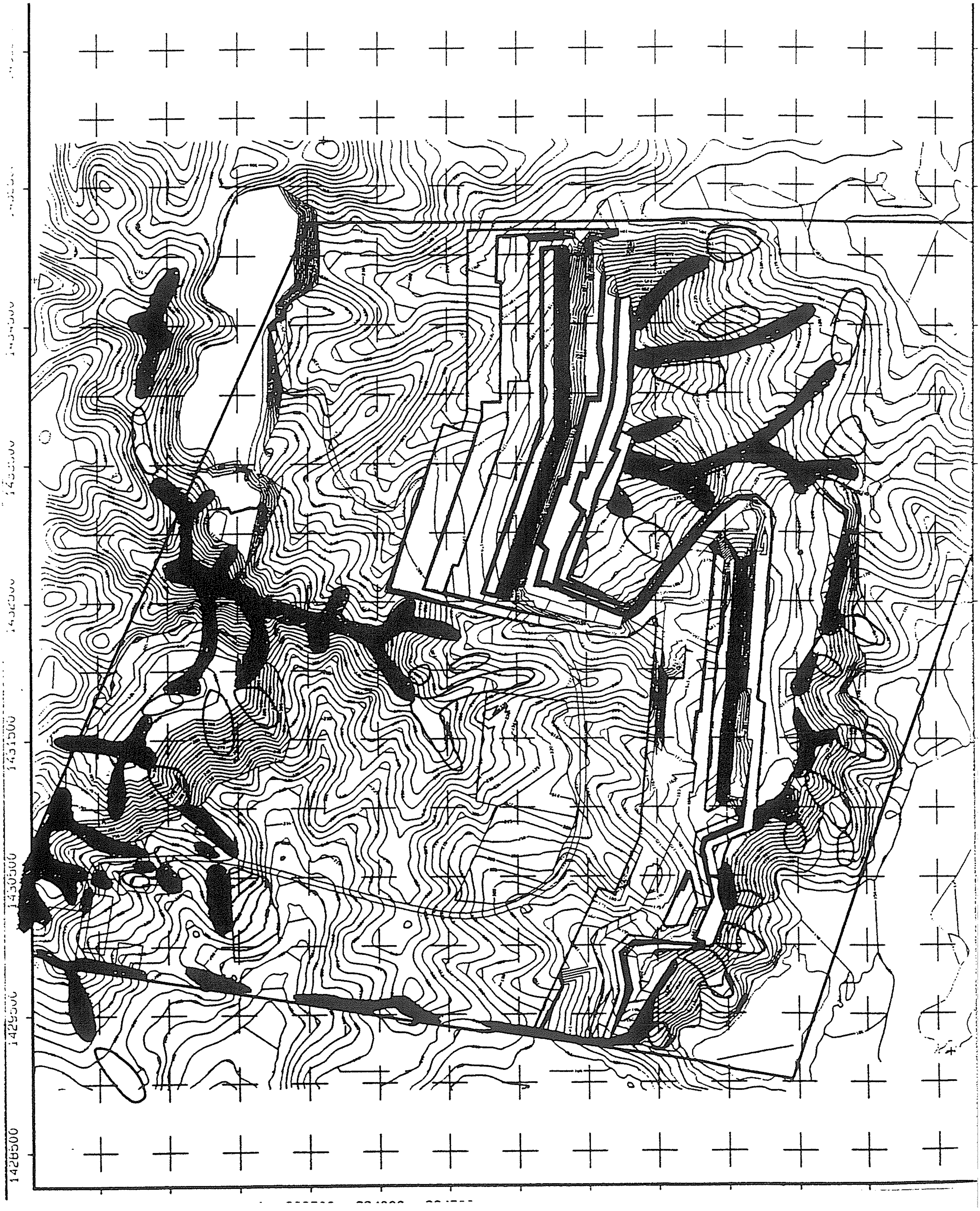


Figure 8.3 CONCEPTUAL MINE REHABILITATION/TREE PLANTING AREAS (YEAR 10)

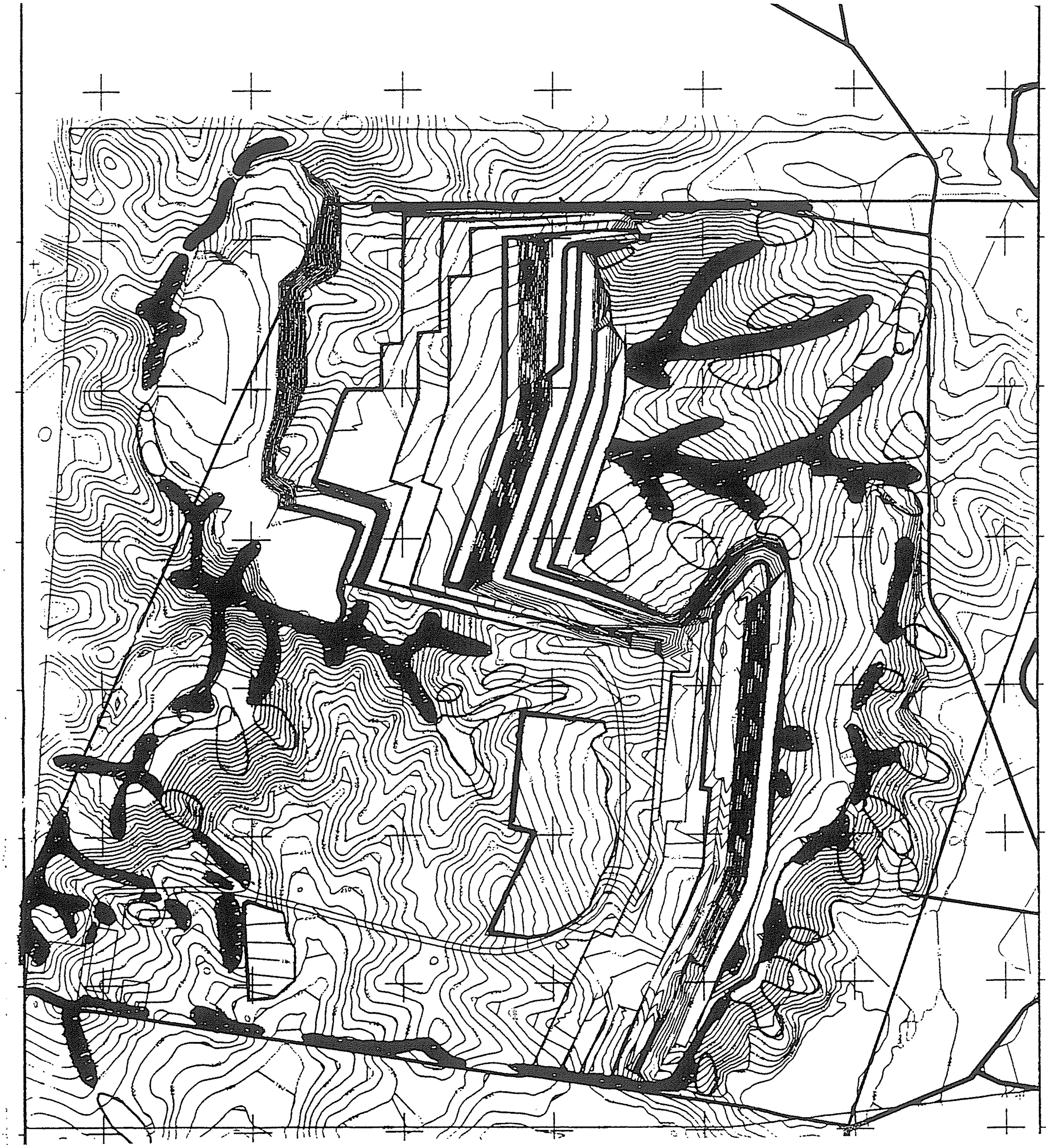


Figure 8.4 CONCEPTUAL MINE REHABILITATION/TREE PLANTING AREAS (YEAR 15)

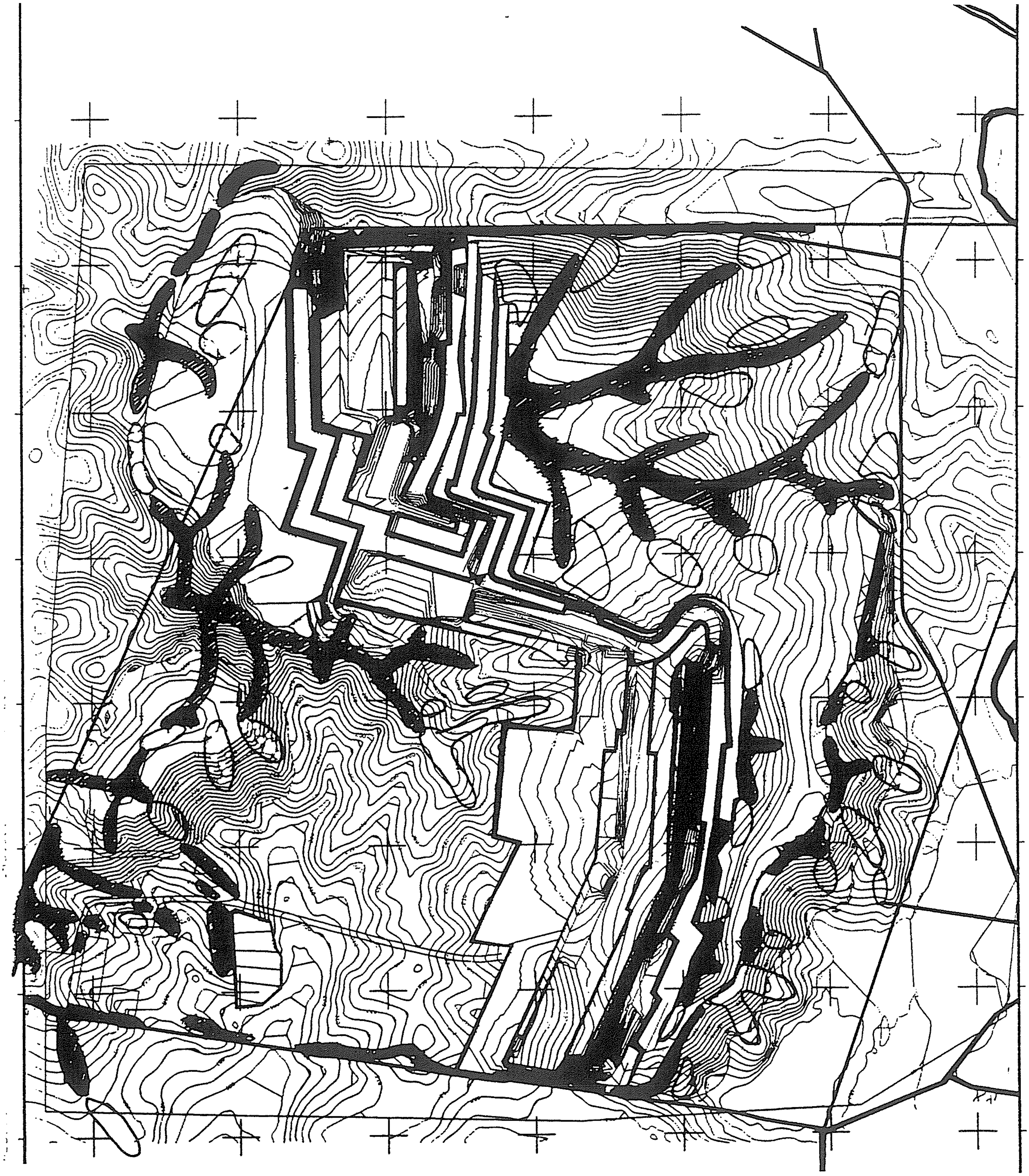


Figure 8.5 CONCEPTUAL MINE REHABILITATION/TREE PLANTING AREAS (YEAR 20)

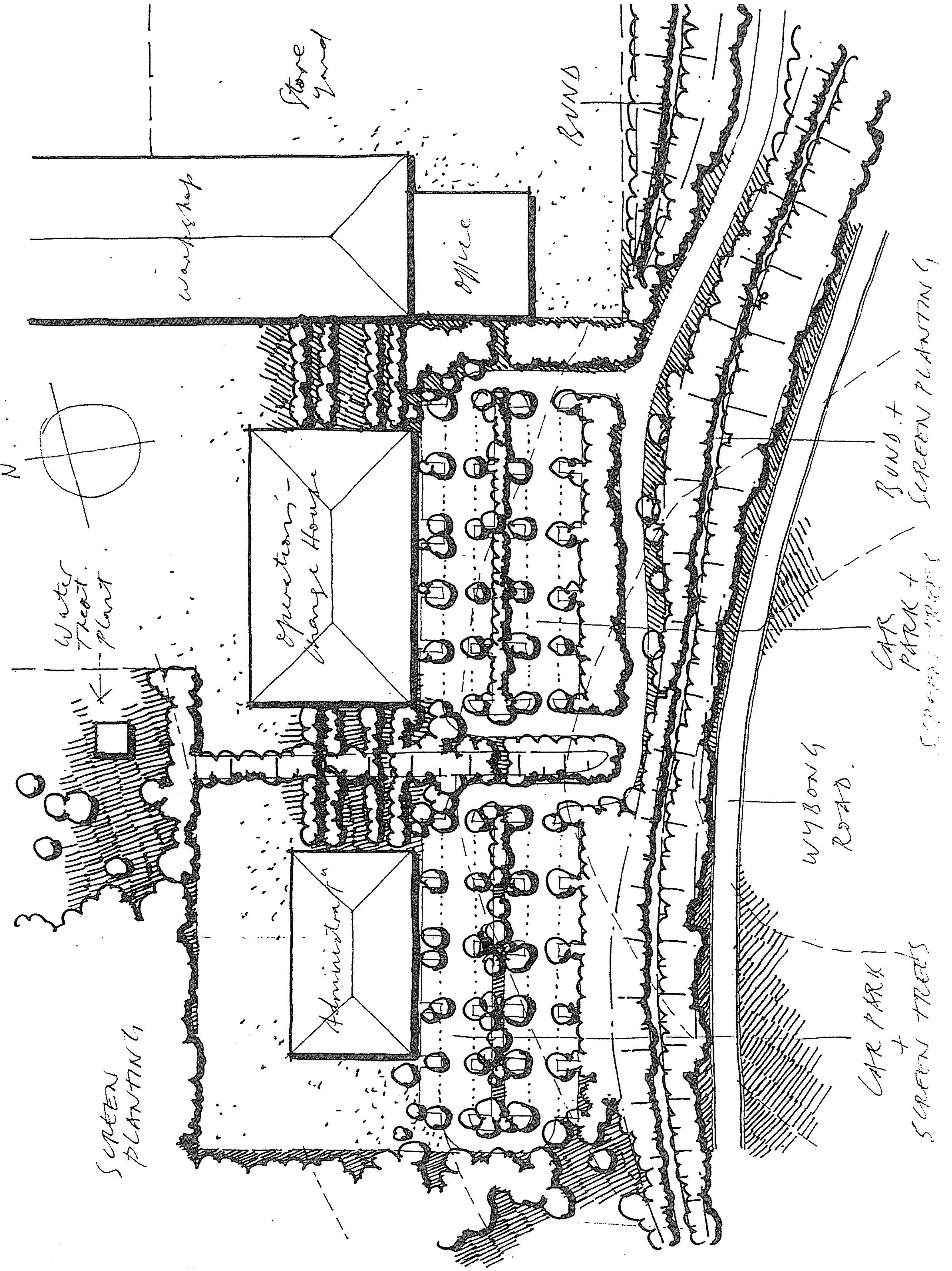


Figure 9 CONCEPTUAL SITE TREATMENT OF ADMINISTRATION AREA

6 Conclusion

Having considered the existing landscape setting of the proposed mine site, the potential changes to this setting arising from the project and the relative importance of key vantage points within the visual catchment, the following discussion summarises the main issues.

Areas assessed as being potentially affected by the project include parts of the urban areas of Muswellbrook and Aberdeen; the rural settlement of Kayuga; parts of the travel corridors between Muswellbrook and Scone, entering Muswellbrook from the east, between Muswellbrook and Denman as well as the rural roads and some properties close to the site boundaries; and parts of the alluvial flats and some adjacent foothills.

For these areas a range of mitigatory measures have been devised to minimise, and in some cases eliminate, the anticipated visual effects. As previously indicated many of these mitigatory proposals have been built into the overall mine plan as integral components of the site development.

During the initial development phase the construction of the bund and surface facilities and the two early mine areas - 'Piercefield' and 'Warkworth' pits - would be unavoidably potentially visible from many places in the eastern, southern and some western sections of the visual catchment.

Some visual effects would appear at certain stages of the mine development only to be screened at a subsequent stage. For example from about Year 3 of mining the potential visibility of the highwalls of the 'Piercefield' and 'Warkworth' pits would be significantly reduced by a combination of reshaping, rehabilitation and screening from the bund.

On the basis of a weighting system adopted to differentiate the relative importance of the various vantage points within the visual catchment the area of recent subdivisions to the north-east of the Muswellbrook commercial centre has been identified as the most potentially sensitive to visual effects. This is on account of its elevation, distance to the site and the number of permanent residents as potential viewers. It is expected that view prospects to the west from this area will gradually diminish as the planted street and allotment vegetation matures.

Two rural landscapes in the vicinity of the site have been classified by the National Trust of Australia (NSW) as recognition that they are of aesthetic and cultural value to the community and are worthy of protection through conservation. The classifications have no legal basis though in taking this step it is likely that the Trust would have broad community support. However the site is outside both rural landscape areas and no permanent visible changes to the site landscape are proposed that would detract from the internal settings of either classified rural landscape area.

Mine-related activities from the two adjacent mine projects - the Bengalla Mine to the south and the proposed Kayuga Mine to the north - would impinge on potential visual impacts in relation to the proposed Mount Pleasant Mine. The most notable of these would be the combined effect from Muswellbrook of the new emplacement landforms of all three projects.

This summary is further developed in the following two tables where the main or representative vantage points within the catchment are listed and visual impact potential is qualified in relation to the main components of the mine development. They are then rated in terms of anticipated high, medium or low visibility.

Table 1 reviews overall visibility based on no mitigatory measures being included as part of the mine development while **Table 2** assesses the overall visibility of the mine development from the same key vantage points taking into account the inclusion of mitigatory measures. **Table 1** therefore considers the basic mine proposal without the shaping of new landforms based on the existing topographic character; without screen planting; without the retention of useful existing features (ridges and mature trees); without the main bund and without the application of specific treatments to structures and nightlighting to reduce their inherent obtrusiveness.

The tables in effect provide a matrix where issues from **Section 3** of this assessment are reviewed against those from **Section 4** with (**Table 2**) and without (**Table 1**) the measures from **Section 5** being applied.

The relative ratings used in these tables (high, medium or low) are based on 'high' being basically those visual changes that would be clearly potentially intrusive on the landscape setting; 'low' being visual changes that would be noticeable but not intrusive; while 'medium' describes visual changes more noticeable than 'low' but not as intrusive as 'high'.

The use of ratings arises from a need to differentiate between the potential causes of visual impact from the various components of the mine development on each vantage point. A comparison between the two tables also indicates the desirable effect of applying mitigatory measures as an integral part of the project.

0Table 1 Potential Visual Impact Summary (Without Mitigatory Measures)

Representative Vantage Points	High	Medium	Low
Muswellbrook	* Active mine areas * Emplacements * Nightlighting	* Main plant area * Admin. & workshop * Mine vehicles & dragline	* Ephemeral changes * Ancillary structures
Aberdeen	* Active mine areas * Emplacements	* Nightlighting	* Mine vehicles/dragline * Ephemeral changes
Kayuga	* Active mine areas * Emplacements * Mine vehicles/dragline * Nightlighting * Blast plumes		
New England Highway	* Active mine areas * Emplacements	* Main plant area * Admin. & workshop * Nightlighting	* Mine vehicles/dragline * Ephemeral changes
Main Northern Railway	* Active mine areas * Emplacements	* Nightlighting	* Mine vehicles/dragline * Ephemeral changes
Flood plain	* Active mine areas * Emplacements * Main plant area * Mine vehicles * Nightlighting	* Workshop * Ancillary structures	* Ephemeral changes
Kayuga Road	* Active mine areas * Emplacements * Mine vehicles/dragline * Nightlighting * Blast plumes		* 66kv power line
Wybong Road	* Active mine areas * Emplacements * Main plant area * Admin. & workshop * Ancillary structures * Mine vehicles/dragline * Nightlighting * Blast plumes * Construction of fine rejects emplacements	* Fine rejects emplacements after establishment	* 66kv power line
Roxburgh Road	* Workshop building * Rail loadout structure	* Nightlighting * Ephemeral changes	

Table 1 continued

Representative Vantage Points	High	Medium	Low
Western Properties	* Fine rejects emplacements * Workshop	* Nightlighting	* Ephemeral changes
Castle Rock Road (Diversion)	* North-western emplacement * Mine vehicles * Nightlighting * Blast plumes		
Dorset Road	* Active mine areas * Emplacements * Mine vehicles/dragline * Nightlighting * Blast plumes		* 66kv power line
Denman Road (incl. Bengalla Mine)	* Active mine areas * Emplacements * Main plant area * Mine vehicles * Nightlighting	* Workshop * Ancillary structures	* Ephemeral changes
Momberoi-Scone Classified Landscape Area (National Trust)	* Active mine areas * Emplacements * Nightlighting * Mine vehicles		* Ephemeral changes
Muswellbrook-Jerrys Plains Classified Landscape Area (National Trust)	* Active mine areas * Emplacements * Main plant area * Nightlighting * Mine vehicles	* Workshop * Ancillary structures	* Ephemeral changes

Notes :

1. Representative vantage points are described in **Section 4** of this assessment.
2. The rating categories used above are explained on p. 24 of this report.
3. Mine activities or structures mentioned in this table are described in **Section 3**.
4. Considerations above assume the proposed Kayuga Mine is operating.

Table 2 Anticipated Visual Impact Summary (with Mitigatory Measures)

Representative Vantage Points	**High**	**Medium**	**Low**
Muswellbrook	* Bund * Emplacements	* Active mine areas * Ancillary structures * Mine vehicles * Nightlighting	* Main plant area * Mine vehicles * Ephemeral changes
Aberdeen	* Emplacements	* Active mine areas	* Mine vehicles * Nightlighting * Ephemeral changes
Kayuga	* Active mine areas * Emplacements * Mine vehicles * Ephemeral changes	* Nightlighting * Ephemeral changes	
New England Highway	* Bund * Emplacements	* Active mine areas	* Ancillary structures * Mine vehicles * Nightlighting * Ephemeral changes
Main Northern Railway	* Bund * Emplacements	* Active mine areas	* Mine vehicles * Nightlighting * Ephemeral change
Flood plain	* Bund * Emplacements * Active mine areas (initially only)	* Active mine areas * Mine vehicles * Emplacements	* Nightlighting * Ephemeral changes * Ancillary structures * Mine vehicles
Kayuga Road	* Bund * Emplacements * Ephemeral changes * Mine vehicles	* Ephemeral changes * Nightlighting	* 66kv power line
Wybong Road	* Bund * Emplacements * Ancillary structures * Active mine areas (initially only) * Construction of fine rejects emplacements	* Ancillary structures * Mine vehicles * Ephemeral changes * Fine rejects emplacements	* Mine vehicles * Nightlighting * Ephemeral changes * 66kv power line
Castle Rock Road (Diversion)	* Emplacement * Mine vehicles * Nightlighting * Ephemeral changes	* Mine vehicles * Nightlighting	
Roxburgh Road		* Workshop building * Rail loadout structure * Ephemeral changes	* Workshop building * Rail loadout structure * Nightlighting

Table 2 continued

Representative Vantage Points	High	Medium	Low
Western Properties	* Construction of fine rejects emplacements (FRE)	* FRE after establishment * Nightlighting	* Workshop building * Nightlighting * Ephemeral changes
Dorset Road	* Active mine areas * Emplacements * Mine vehicles/dragline * Ephemeral changes * Nightlighting	* Ephemeral changes * Nightlighting	* 66kv power line
Denman Road (incl. Bengalla Mine)	* Bund * Active mine areas (initially only)	* Emplacements * Mine vehicles	* Ephemeral changes * Ancillary structures * Mine vehicles * Nightlighting
Momberoi-Scone Classified Landscape Area (National Trust)	* Emplacements * Active mine areas	* Active mine areas	* Nightlighting * Mine vehicles * Ephemeral changes
Muswellbrook-Jerrys Plains Classified Landscape Area (National Trust)	* Bund * Active mine areas (initially only)	* Mine vehicles * Emplacements	* Nightlighting * Ephemeral changes * Mine vehicles * Ancillary structures

Notes:

1. With mitigatory measures in place some mine activities or structures may overlap two rating categories either because the potential visual impact is ameliorated over time from a higher rating to a lower one or because it becomes too difficult to differentiate between two rating categories.

2. Representative vantage points are described in **Section 4**.

3. Rating categories are explained on p. 24.

4. Mine activities or structures with visual impact potential are described in **Section 3**.

5. Mitigatory measures are described in **Section 5**.

6. The summary assumes that the proposed Kayuga Mine is operating.

LIGHTING REPORT

11

CMPS&F

REPORT

FOR

MOUNT PLEASANT LIGHTING

TO

COAL & ALLIED OPERATIONS PTY LIMITED

FOR

MOUNT PLEASANT PROJECT

Prepared By:
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CMPS&F Pty Limited
66 Eagle Street
Brisbane Qld 4000
Telephone No: (07) 3233 1611
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20 January 1997

CMPS&F

DOCUMENT NO: NB0178-TR-G007

REPORT FOR

MOUNT PLEASANT LIGHTING

Client: **Coal & Allied Operations Pty Limited**

Project Title: **Mount Pleasant Project**

Work Plan No: **NB0178-WP106**

B	20/1/97	Revised and Reissued for Approval	JET	SKB	JET	JET	
A	25/1/96	Issued for Approval	JET	JH	JET	JET	
Rev	**Date**	**Description**	**By**	**Chk**	**Eng**	**Appd**	**Appd**

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APPENDIX A

1. INTRODUCTION

The Mt Pleasant project will comprise an open cut mining operation with overburden drills, electric shovels, a dragline, haul trucks and mine support vehicles, dump station, coal handling plant, coal preparation plant, industrial facilities and rail loadout facility. All of the parts of the mine operations will operate at night and require lighting.

CMPS&F were retained to undertake a feasibility study of the coal preparation, coal handling and infrastructure associated with the mine. Part of the overall feasibility study was the preliminary design of the mine lighting requirements including the mining equipment. This report specifically addresses the engineering design of the lighting proposed for the mine site which may impact on surrounding properties.

2. LIGHTING DESIGN CRITERIA

The preliminary lighting for the Mt Pleasant project has been designed to minimise the impact on the properties surrounding the project ATP (Authority to Prospect). The design criteria are as follows:

- Provide only sufficient lighting necessary for safe and efficient operation.
- Provide time delay automatic switch off of access lighting.
- Enclose all buildings, conveyor galleries, and conveyor transfer stations.
- Use latest innovative technology and design methods.

3. GENERAL

The outdoor areas to be lit, are the dump station to allow rear dump haul trucks to manoeuvre safely and deposit the coal in the coal receival hoppers, (this area lit to an average of 50 lux), the coal stockpiles, the stackers and reclaimer, the industrial area hardstand for haul truck manoeuvring, the employee car park, access roadways, a dragline, drills and shovels and pit bottom work areas. Other specific area lighting will be required around the coal preparation plant and rail loadout.

3.1 LIGHTING OF MINING EQUIPMENT

The lighting of the overburden drills will be low level localised lighting to allow these machines to operate at night. The impact on the surrounding properties from these machines will be insignificant, but since these operate at near natural ground surface level, and hence are visible, then the lighting will be designed for minimum safe levels.

The two electric shovels will operate as overburden prestripping shovels and have lighting to enable night time digging operation. These machines will be fitted with luminaires aimed down, and luminaire hoods and screens will be employed to reduce light spillage and glare.

The dragline will present a major source of light which will be visible and moving. The dragline lighting will be restricted to luminaires mounted only on the lower half of the boom to keep the height of luminaires to as low as possible. The luminaires mounted on the boom will be aimed down, have sharp cut off features, and make use of hoods and screens.

Twelve mobile lighting towers have been allowed in the preliminary design. These folding towers are typically positioned on the pit high wall and aimed into the pit to light the mining operation in the pit. Similarly to the dragline, these luminaires will utilise hoods and screens to reduce spillage of light. Used in this fashion these lights are visible from surrounding properties and consideration will be given to locating some, or all of these mobile towers on the pit bottom.

3.2 AREA FLOODLIGHTING

The dump station haul road area is an area typically requiring high levels of lighting. The area in which the haul trucks manoeuvre for rear dumping has been designed to be 50 lux at ground level. This lighting is achieved by using 30 metre high mast lighting with the luminaires aimed down to minimise light spillage and glare. In addition the lighting masts have been positioned so that no luminaire is aimed to the east ie the direction of Muswellbrook.

The industrial area hardstand has been provided with an average 15 lux of lighting to provide safe parking and manoeuvring, of haul trucks and other heavy mine service vehicles. This is achieved with 20 metre high mast lighting using shielded fittings aimed downwards.

The employee car park will be lit with multiple low pole height and sharp cut off luminaires, as will access roadways.

Similarly provision has been made to light the product coal stockpile from high mast lighting located on the eastern side of the stockpile and aimed to the west. This lighting will be necessary for the operation of one dozer during product stacking and two dozers during trainloading. These dozers will also utilise their standard headlights.

3.3 COAL HANDLING MACHINERY

Adequate local lighting will be provided from the stackers and reclaimer. Lighting provided on board the stackers and reclaimer will also be designed for minimum upward component by careful selection of luminaires. The provisional raw coal stacker and bridge reclaimer planned for Mt Pleasant are normally unmanned and during the period that personnel access is not required, these machines will have the majority of their exterior lighting turned off. The product coal stacker will also be unmanned but will operate in conjunction with the dozer and floodlighting will be mounted under the stacker boom to light the stockpile and assist the dozer driver. This lighting will be aimed downward onto the coal. For all of these machines access and maintenance lighting will be selected for instant start features to provide immediate lighting upon entry.

3.4 INTERIOR LIGHTING

Where practical all coal handling and coal preparation plant where lighting is required will be fully clad. Translucent sheets in walls and roofs have not been included both to reduce light emission. Office buildings, bathhouses and workshops will be fitted with louvres or venetian blinds to allow natural light during daylight but to block internal lighting at night.

Conveyors at ground level will not be lit. Where conveyors are above ground level, walkways will be provided both sides of the conveyor and fully enclosed. Lighting inside these galleries will not be visible externally.

The truck wash down station requires a high level of lighting both from above and from the sides. This building is a drive through building with open ends allowing light spillage. The truck washdown station will be screened locally and is to be positioned behind the main workshop on the western side.

The rail load out bin will be fully clad at the top for both lighting and noise containment. The loading operation will be lit with luminaires mounted on the bottom of the bin structure and aimed directly down onto the rail wagon. This facility is located in a cutting and the only light visible outside this immediate area will be reflected light producing a glow around the area. The railway loop itself will not be illuminated.

4. SITE LIGHTING PLOT PLANS AND ISOLUX DRAWINGS

A preliminary design has been carried out by Eye Lighting Industries Pty Ltd for the area floodlighting required for the coal handling and industrial area for the Mt Pleasant project. The drawings in the appendix show the areas to be illuminated, the position of the lighting towers and their height, together with the type and number of fittings. The luminaire (light) selected is the latest type which features sharp cut off characteristics to reduce glare and spillage of light. The multiple high towers, either 20 or 30 metres in height, enable the luminaires to be aimed sharply downward which also reduces glare and spillage.

In addition to showing the position of the lighting towers the drawings show the level of illumination in terms of `lux'. The areas intended to be illuminated are shown shaded dark. Around each area is a lightly shaded area that shows the illumination of areas beyond that area required to be lit. This spillage illumination drops off rapidly in intensity and a cut off level of 0.5 lux has been chosen to show the extent of significant illumination. As a comparison moonlight gives an illumination of 0.1 lux and sunlight is measured in thousands of lux.

CMPS&F

COAL & ALLIED OPERATIONS
PTY LIMITED

MOUNT PLEASANT LIGHTING

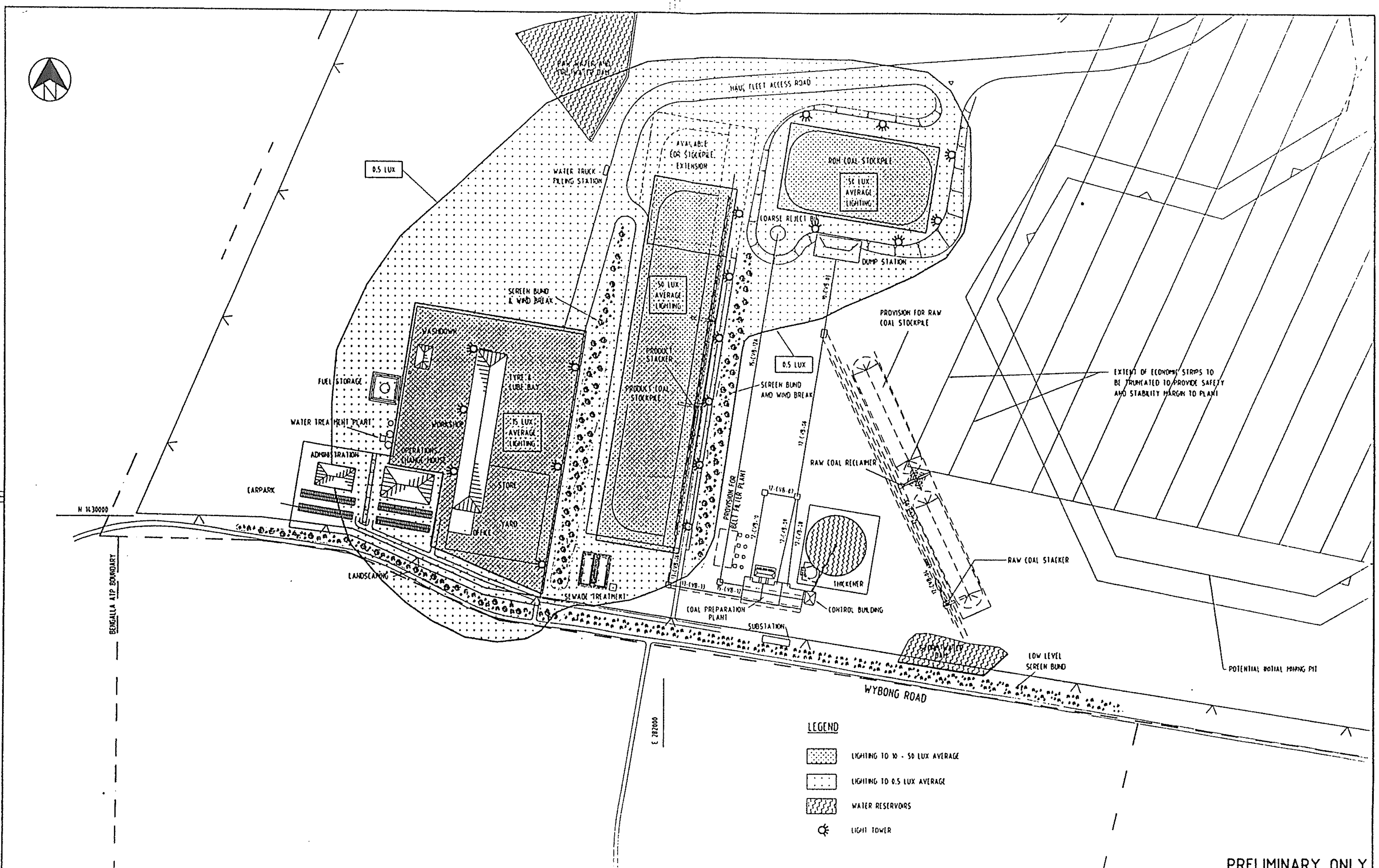
APPENDIX A

DRAWINGS

NB0178.006/NR951590.010 7+

DN - NB0178-TR-G007

Rev. B



PRELIMINARY ONLY

B	GENERAL REVISIONS	SLP					
A	ISSUED FOR PROJECT STUDIES REPORT	B.R.					
REV	DESCRIPTION	BY	CKD	APPD	APPD	DATE	

DRAWING No. | REFERENCE DRAWINGS

SCALES: 25 0 50 100 150 m — 1 : 2500

DRAWN	B. RALPH	17.1.96
DRG. CHECKED		
DESIGNED		
ENG. CHECKED		
APPROVED		
CLIENT		
JOB No.	NB0178.006	

COAL AND ALLIED OPERATIONS PTY LTD
MT PLEASANT PROJECT
EXTERNAL FLOOD LIGHTING LAYOUT
PLANT & INDUSTRIAL AREA

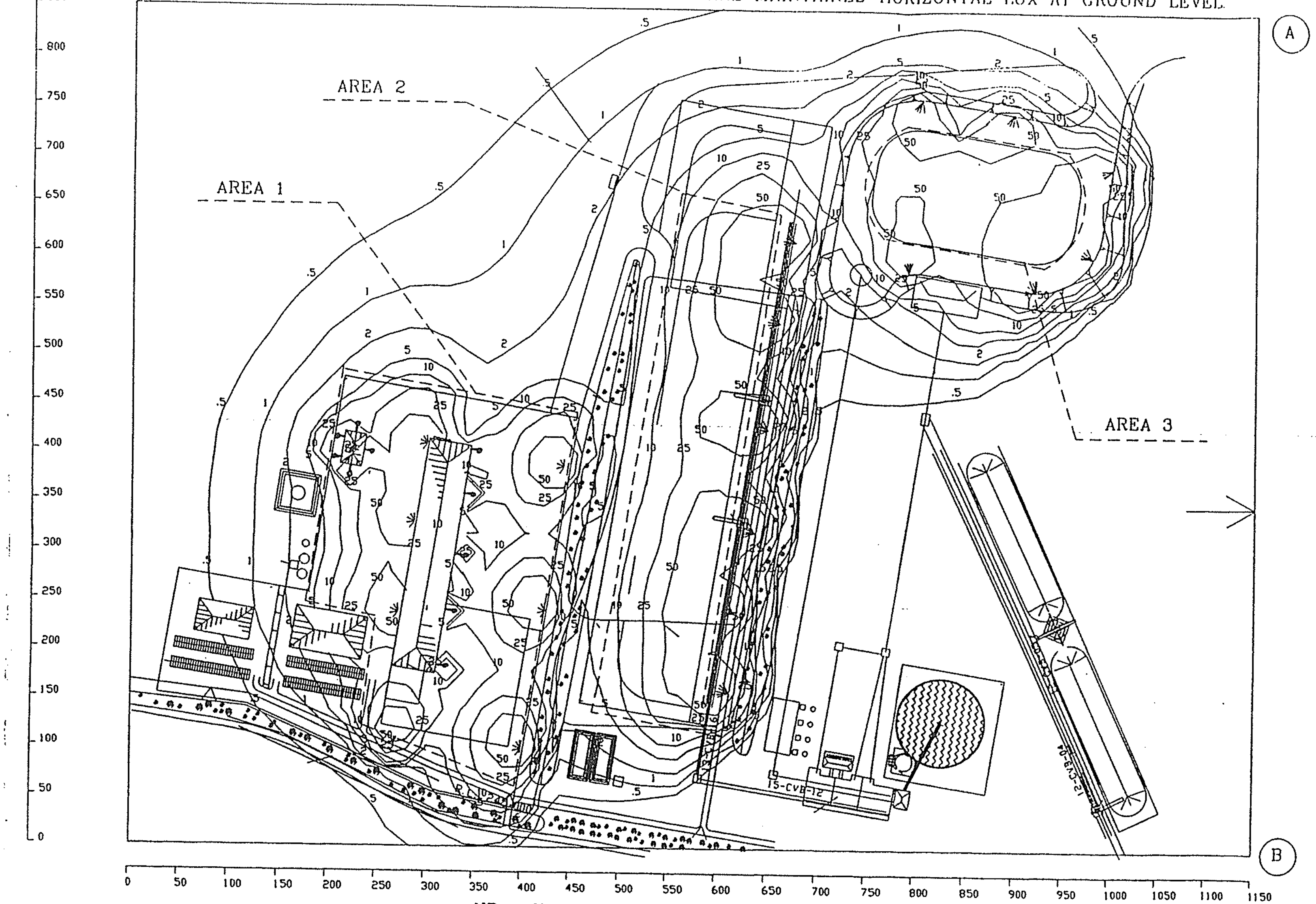
CMPS&F ENGINEERS MANAGERS
CMPS&F Pty Limited
BRISBANE QLD 4000

DRAWING No. NB0178 - E04 REV B

CAD FILE No. NEC0477-

A1

ILLUMINATION LEVELS SHOWN IN ISOLUX CONTOURS BELOW ARE MAINTAINED HORIZONTAL LUX AT GROUND LEVEL.



NB:- Vertical Illumination calculations along plane A-B above has revealed 0 Lux at each individual point when calculated on a 10m x 10m grid to a height of 100m.

The vertical illumination levels calculated were Maintained Lux incident an plane A-B in direction of arrow.

The Illumination levels shown are HORIZONTAL MAINTENANCE LUX on the calculation plane.

Illumination Lvels:	Average	Maximum	Minimum
AREA 1	17	185	1
AREA 2	51	177	10
AREA 3	53	162	11

CALCULATION PLANE = GROUND.
MAINTAINENCE FACTOR = 0.8

EYE LIGHTING Industries Pty Limited

Fixture Types:
LASER-M USING MT2000B
LASER-M USING NHT940LX (AREA 1)
H802 USING NH360FLX →

No. Required: SEE 96/284R1 2/2 "INSTALLATION DETAILS"

Mounting Details: ALL POLES ARE 30m EXCEPT AREA 1 POLES WHICH ARE 20m

Supply Volts:
LASER-M / MT2000B COMBINATION REQUIRES 415V.

ALL OTHER COMBINATIONS REQUIRE 240V

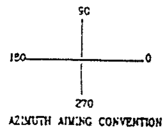
Project:
MT PLEASANT PROJECT

FOR CMPS+F

Drawn: [signature]	Checked: [signature]
Date: 13/1/97	Scale: NTS
Job No.: 96-284R1 1/2	

COORDINATES IN METERS

NO.	LUMINAIRE LABEL	X-COORD	Y-COORD	Z-COORD	ORIENT	TILT	AIMING COORDINATES X	Y	Z
1	LASER-M	805	762	30	225	22	796.4	753.4	0
2	LASER-M	805	762	30	236	22	798.2	752	0
3	LASER-M	805	762	30	251	22	801	750.6	0
4	LASER-M	805	762	30	277	22	806.4	750	0
5	LASER-M	898	748	30	225	22	889.4	739.4	0
6	LASER-M	898	748	30	241	22	892	737.4	0
7	LASER-M	898	748	30	259	22	895.6	736.1	0
8	LASER-M	898	748	30	286	22	901.3	736.3	0
9	LASER-M	1001	692	30	182	22	988.9	691.5	0
10	LASER-M	1001	692	30	196	22	989.3	688.7	0
11	LASER-M	1001	692	30	222	22	992	683.9	0
12	LASER-M	1001	692	30	212	22	990.7	685.6	0
13	LASER-M	980	602	30	117	22	974.6	612.8	0
14	LASER-M	980	602	30	140	22	970.8	609.9	0
15	LASER-M	980	602	30	158	22	968.7	606.5	0
16	LASER-M	980	602	30	174	22	968	603.3	0
17	LASER-M	921	568	30	122	22	914.5	578.2	0
18	LASER-M	921	568	30	140	22	911.8	575.9	0
19	LASER-M	921	568	30	107	22	917.4	579.6	0
20	LASER-M	921	568	30	86	22	921.8	580.1	0
21	LASER-M	792	586	30	113	22	787.2	597.1	0
22	LASER-M	792	586	30	99	22	790.1	598	0
23	LASER-M	792	586	30	86	22	792.8	598.1	0
24	LASER-M	792	586	30	75	22	795.2	597.7	0
25	LASER-M	921	568	30	167	22	909.2	570.7	0
26	LASER-M	921	568	30	185	22	908.9	566.9	0
27	LASER-M	979	603	30	117	22	973.6	613.8	0
28	LASER-M	979	603	30	140	22	969.8	610.9	0
29	LASER-M	979	603	30	158	22	967.7	607.5	0
30	LASER-M	979	603	30	174	22	967	604.3	0
31	LASER-M	613	159	30	117	22	607.6	169.8	0
32	LASER-M	613	159	30	135	22	604.4	167.6	0
33	LASER-M	613	159	30	171	22	601	161	0
34	LASER-M	613	159	30	185	22	600.9	158	0
35	LASER-M	614	159	30	198	22	602.5	155.2	0
36	LASER-M	614	159	30	153	22	603.2	164.4	0
37	LASER-M	637	322	30	117	22	631.6	332.8	0
38	LASER-M	637	322	30	135	22	628.4	330.6	0
39	LASER-M	637	322	30	171	22	625	324	0
40	LASER-M	637	322	30	185	22	624.9	321	0
41	LASER-M	638	322	30	198	22	626.5	318.2	0
42	LASER-M	638	322	30	153	22	627.2	327.4	0
43	LASER-M	617	240	30	117	22	611.6	250.8	0
44	LASER-M	617	240	30	135	22	608.4	248.6	0
45	LASER-M	617	240	30	171	22	605	242	0
46	LASER-M	617	240	30	185	22	604.9	239	0
47	LASER-M	618	240	30	198	22	606.5	236.2	0
48	LASER-M	618	240	30	153	22	607.2	245.4	0
49	LASER-M	650	426	30	117	22	644.6	436.8	0
50	LASER-M	650	426	30	135	22	641.4	434.6	0
51	LASER-M	650	426	30	171	22	638	428	0
52	LASER-M	650	426	30	185	22	637.9	425	0
53	LASER-M	651	426	30	198	22	639.5	422.2	0
54	LASER-M	651	426	30	153	22	640.2	431.4	0
55	LASER-M	676	616	30	117	22	670.6	626.8	0
56	LASER-M	676	616	30	135	22	667.4	624.6	0
57	LASER-M	676	616	30	171	22	664	618	0
58	LASER-M	676	616	30	185	22	663.9	615	0
59	LASER-M	677	616	30	198	22	665.5	612.2	0
60	LASER-M	677	616	30	153	22	666.2	621.4	0
61	LASER-M	661	534	30	117	22	655.6	544.8	0
62	LASER-M	661	534	30	135	22	652.4	542.6	0
63	LASER-M	661	534	30	171	22	649	536	0
64	LASER-M	661	534	30	185	22	648.9	533	0
65	LASER-M	662	534	30	198	22	650.5	530.2	0
66	LASER-M	662	534	30	153	22	651.2	539.4	0
67	LASER-M_HPS	301	409	20	92	22	300.8	417.1	0
68	LASER-M_HPS	301	409	20	119	22	297.1	416.1	0
69	LASER-M_HPS	301	409	20	155	22	293.7	412.5	0
70	LASER-M_HPS	301	409	20	191	22	293.1	407.5	0
71	LASER-M_HPS	301	409	20	233	22	296.2	402.5	0
72	LASER-M_HPS	288	330	20	92	22	287.8	338.1	0
73	LASER-M_HPS	288	330	20	119	22	284.1	337.1	0
74	LASER-M_HPS	288	330	20	155	22	280.7	333.5	0
75	LASER-M_HPS	288	330	20	191	22	280.1	328.5	0
76	LASER-M_HPS	288	330	20	233	22	283.2	323.5	0
77	LASER-M_HPS	272	238	20	92	22	271.8	246.1	0
78	LASER-M_HPS	272	238	20	119	22	268.1	245.1	0
79	LASER-M_HPS	272	238	20	155	22	264.7	241.5	0
80	LASER-M_HPS	272	238	20	191	22	264.1	236.5	0
81	LASER-M_HPS	272	238	20	233	22	267.2	231.5	0
82	LASER-M_HPS	443	386	20	92	22	442.8	394.1	0
83	LASER-M_HPS	443	386	20	119	22	439.1	393.1	0
84	LASER-M_HPS	443	386	20	155	22	435.7	389.5	0
85	LASER-M_HPS	443	386	20	191	22	435.1	384.5	0
86	LASER-M_HPS	443	386	20	233	22	438.2	379.5	0
87	LASER-M_HPS	400	100	20	92	22	399.8	108.1	0
88	LASER-M_HPS	400	100	20	119	22	396.1	107.1	0
89	LASER-M_HPS	400	100	20	155	22	392.7	103.5	0
90	LASER-M_HPS	400	100	20	191	22	392.1	98.5	0
91	LASER-M_HPS	424	240	20	92	22	423.8	248.1	0
92	LASER-M_HPS	424	240	20	119	22	420.1	247.1	0
93	LASER-M_HPS	424	240	20	155	22	416.7	243.5	0
94	LASER-M_HPS	424	240	20	191	22	416.1	238.5	0
95	LASER-M_HPS	424	240	20	233	22	419.2	233.5	0
96	LASER-M_HPS	269	103	20	70	22	271.8	110.6	0
97	LASER-M_HPS	269	103	20	107	22	266.7	110.7	0
98	LASER-M_HPS	269	103	20	85	22	269.7	111	0
99	H802	216	414	8	167	10	214.6	414.3	0
100	H802	213	394	8	168	10	211.6	394.3	0
101	H802	228	419	8	80	10	228.2	420.4	0
102	H802	237	401	8	351	10	238.4	400.8	0
103	H602	223	385	8	262	10	222.8	383.6	0
104	H802	347	403	8	351	10	348.4	402.8	0
105	H802	339	359	8	346	10	340.4	358.7	0
106	H802	329	298	8	347	10	330.4	297.7	0
107	H802	320	241	8	342	10	321.3	240.6	0
108	H802	312	185	8	345	10	313.4	184.6	0
109	LASER-M_HPS	400	100	20	214	18	394.6	96.4	0



AZIMUTH AIMING CONVENTION

LASER-M: TOTAL NUMBER OF LOCATIONS = 66

LASER-M_HPS: TOTAL NUMBER OF LOCATIONS = 33

H802: TOTAL NUMBER OF LOCATIONS = 10

AVERAGE TILTED LAMP CORRECTION FACTOR APPLIED = 1

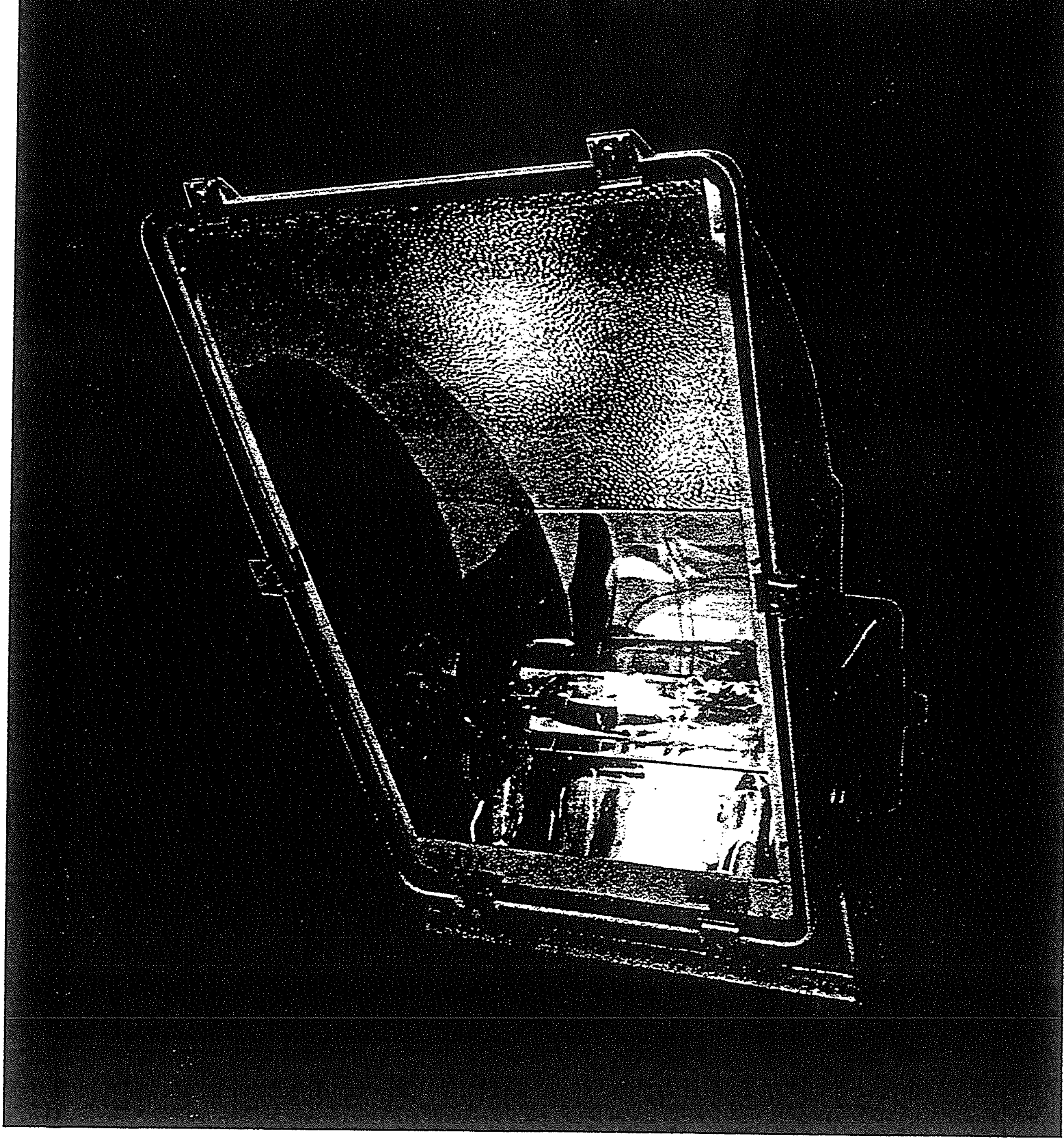
INSTALLATION DETAILS	EYE LIGHTING Industries Pty Limited	
Project: MOUNT PLEASANT PROJECT FOR CMPS+F	Drawn: [signature]	Checked: [signature]
	Date: 13/1/97	
	Job No.: 96-284R1 2/2	

Sfb 63
Sept '95

LASER

FLOODLIGHT

IP 65 – 2000W METAL HALIDE / 1000W HPS FLOODLIGHT



DURABLE, LOW GLARE FIXTURE WITH ASYMMETRICAL REFLECTOR.
RELAMPING FROM REAR. LAMP SUPPORT FITTED.

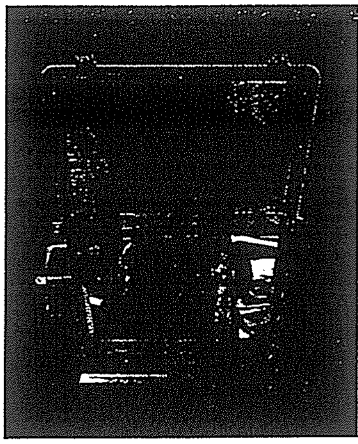
EYE LIGHTING INDUSTRIES

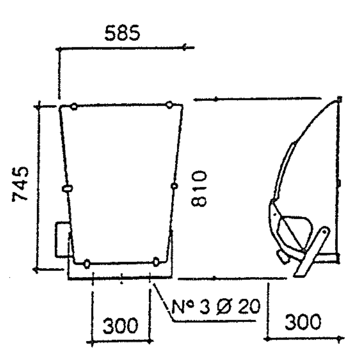
FEATURES

- Fixture manufactured in a one piece, die cast aluminium alloy injected body for extra strength and smooth exterior lines, with off white epoxy powder finish.
- Asymmetrical reflector of pure polished aluminium ensures excellent beam control to minimise stray light. Reflector is available in two versions:
  - Narrow Beam (INT)
  - Medium Beam (M)
- Toughened front plate glass with silicon rubber gasket.
- Zinc plated fixing bracket with goniometer (marked in degrees) for angle adjustment.
- All external screws of corrosion resistant stainless steel.
- Fitting is supplied with three way terminal block suitable for cable diameters up to 14mm.
- Use of high quality, durable materials and components throughout fixture ensures constant operational reliability.
- Laser is made to IEC 598 standards.

TYPICAL APPLICATIONS

- Designed for external applications, especially where a high standard of light output and area coverage with minimal spill light is required.
- Sporting fields, tennis & netball courts
- Airport surrounds
- Parking lots
- Roads, railways & industrial yards

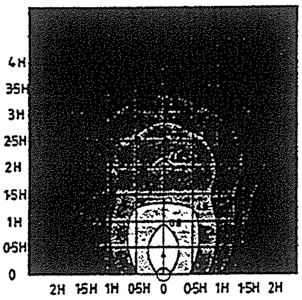




WEIGHT: 20 KG

ISOLUX PLOT FOR ELI LASER/M WITH 2000W LAMP

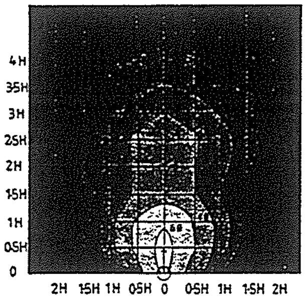
SCALE 1/1000



MOUNTING HEIGHT 20 M
AIMING ANGLE 22° ABOVE HORIZONTAL

ISOLUX PLOT FOR ELI LASER/INT WITH 2000W LAMP

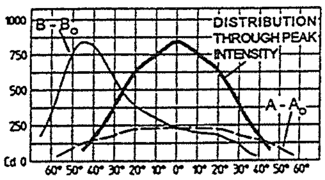
SCALE 1/1000



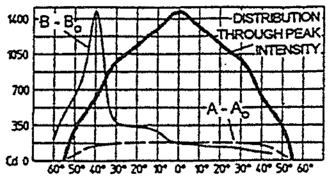
MOUNTING HEIGHT 20 M
AIMING ANGLE 25° ABOVE HORIZONTAL

INTENSITY DISTRIBUTION DIAGRAMS

LASER/M MT2000W



LASER/INT MT2000W



ORDERING DETAILS

Catalogue No.	*Fixture Supplied With*	*Product Code*
ELI LASER/M M2000 GTS/L	2000W Multi-Metal lamp & open gear tray	7509A
ELI LASER/M M2000 CB/L	2000W Multi-Metal lamp & weatherproof gear (IP65)	7509B
ELI LASER/M S940 GTS/L	940W Sunlux Ace lamp & open gear tray	7509C
ELI LASER/M S940 CB/L	940W Sunlux Ace lamp & weatherproof gear (IP65)	7509D
ELI LASER/M MA1000 GTS/L	1000W Multi-Metal lamp, open gear tray & ignitor	7509E
ELI LASER/M MA1000 CB/L	1000W Multi-Metal lamp, weatherproof gear (IP65) & ignitor	7509F
ELI LASER/INT M2000 GTS/L	2000W Multi-Metal lamp & open gear tray	7509G
ELI LASER/INT M2000 CB/L	2000W Multi-Metal lamp & weatherproof gear (IP65)	7509H
ELI LASER/INT S940 GTS/L	940W Sunlux Ace lamp & open gear tray	7509J
ELI LASER/INT S940 CB/L	940W Sunlux Ace lamp & weatherproof gear (IP65)	7509K
ELI LASER/INT MA1000 GTS/L	1000W Multi-Metal lamp, open gear tray & ignitor	7509L
ELI LASER/INT MA1000 CB/L	1000W Multi-Metal lamp, weatherproof gear (IP65) & ignitor	7509M

*Specify supply voltage.
**Control gear is mounted remotely - refer to EYE technical data for recommended maximum separation distances.

MARKETED BY: EYE LIGHTING INDUSTRIES PTY LTD
A.C.N. 001 253 318

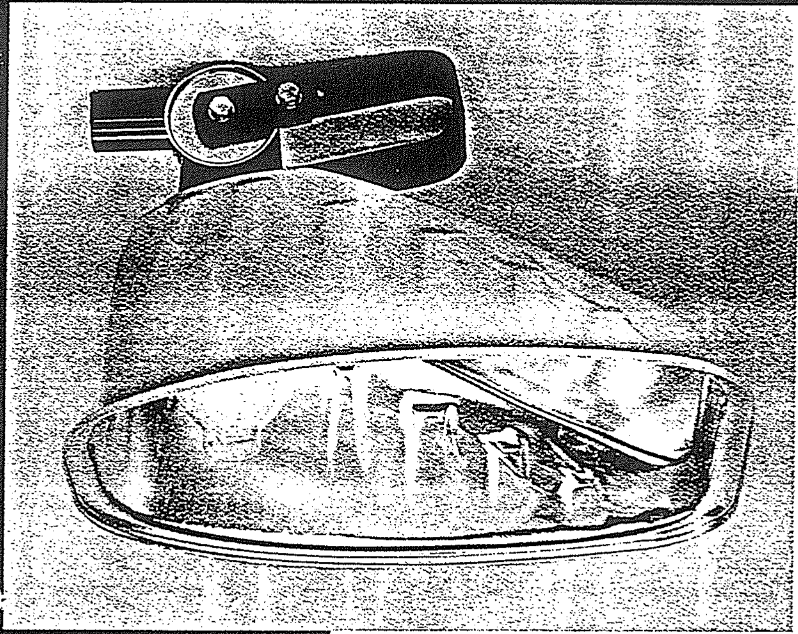
HEAD OFFICE: 151 Wellington Road, East Brisbane, Qld 4169
Phone: (07) 3391 7255 Fax: (07) 3891 1999

BRANCHES: Adelaide, Auckland, Brisbane, Melbourne, Perth, Sydney, Townsville

EYE

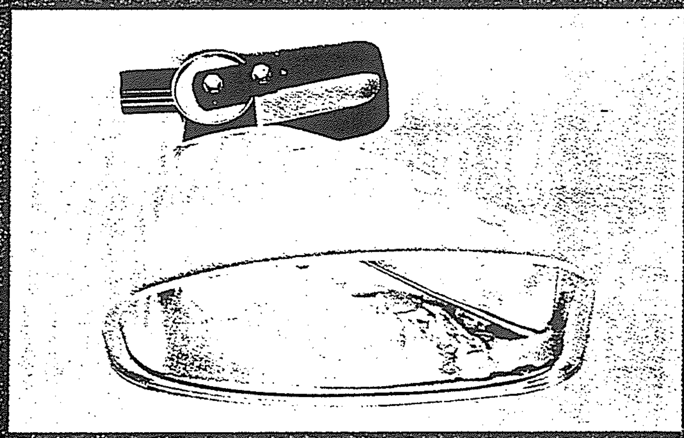
H802

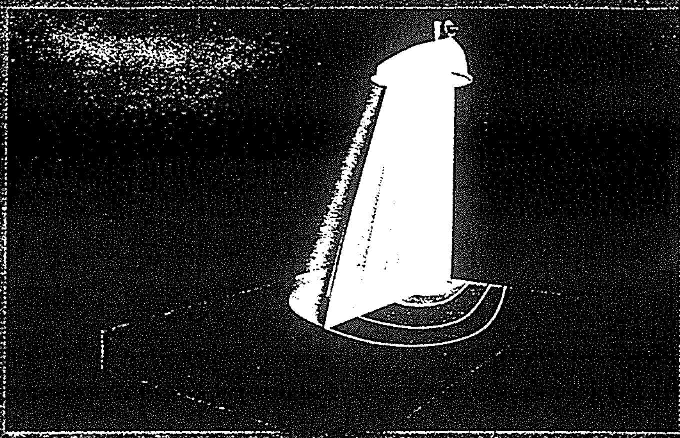
Area Light



- Vertical Illumination
- Security Lighting
- Area Lighting

EYE LIGHTING INDUSTRIES





H802 FEATURES

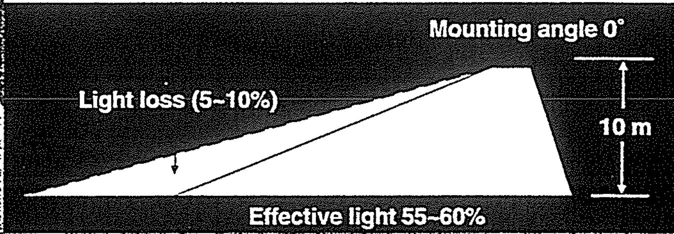
- Unique computer designed curvature and facets, project no light upward and more than 60% of light forward
- Efficient design minimises glare and reduces stray light [illegible] enhancing visibility and comfort levels
- Vertical burning lamp
- Adjustable mounting bracket (to ± 30°) enables optimal lighting coverage and control
- High efficiency aluminium alloy reflector with durable *ALGLAS coating
- Lightweight fixture
- Lampholder sealed against ingress of water and insects
- Smart, modern appearance with painted body
- Wire guard available
- Special model available for use in highly corrosive atmosphere.

*Registered Trademark of General Electric Company, USA

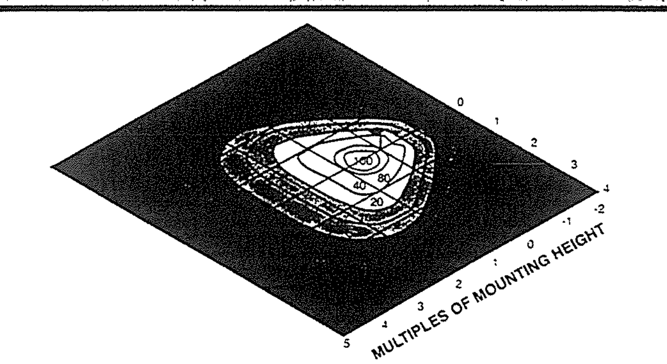
TYPICAL APPLICATIONS

- Areas where cut off lighting is required or where spill light may create a problem
- Lighting near and within airports
- Car Parks
- Loading docks
- Security lighting
- Domestic tennis courts
- Swimming pools
- Wall mounting in factories

EXCELLENT LIGHT CONTROL PROVIDED BY THE H802

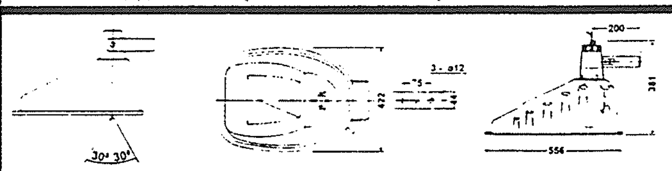


ISOLUX DIAGRAM FOR A SINGLE FIXTURE USING NH360FLX LAMP



MOUNTING HEIGHT 10M AIMING ANGLE 10° INITIAL LUX VALUES

DIMENSIONAL DRAWINGS



WEIGHT 3.1 KG MEASUREMENT 0.09 M³

H802 LAMP DETAILS

Mercury Vapour H(F)175 - 400(X,PD)
Multi Ace M(F)250 - 400LE/BUH
Multi Metal M(F)250, 400X/U
Sunlux 150 - 400(F)
Sunlux Ace NH110 - 360(F)LX

Please no[illegible]

EYE Lighting Indus[illegible]
Head Office [illegible] Wellington [illegible]
Phone: [illegible]
Branches in Adelaide, Auckland, [illegible]