

Report

Air Quality Assessment Batchelor Magnesium Project

Prepared for
Mt Grace Resources Limited

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This report is an air quality assessment prepared by URS Australia Pty Ltd (URS) for Mt Grace Resources Limited (Mt Grace) for a proposed magnesium mine and refining plant in Batchelor, NT. This report is to form part of an Environmental Impact Statement (EIS) for the development. A full process description is contained within the EIS and shall not be reproduced here except where directly relevant to the air quality assessment. This report contains significant technical detail and non-technical readers are advised to refer to the summary chapter contained within the EIS.

Air pollution is not a single entity, but comprises a number of pollutants, which may have separate sources and effects. In the case of the Batchelor Project, the main emission with potential for off-site effects is particulate, primarily from large open sources associated with mining activities. Other potential discharges to air include products of combustion from the calcining and refining process.

These emissions and their potential impacts on the air environment are addressed in this report. The structure of the report is as follows;

Section 2. Pollutants Under Review

This section describes each pollutant individually, discusses their chemistry and their potential impact upon human health or amenity.

Section 3. Assessment Criteria

This section details the relevant assessment criteria to be applied to stack emission discharges and ambient concentrations.

Section 4. Assessment Methodology

This section outlines the methods used in undertaking the assessment, including atmospheric dispersion modelling techniques and the calculation of pollutant emission data for inventory purposes.

Section 5. Existing Environment

This section considers the local winds and topographical effects that may impact on dispersion of emissions from the development in the vicinity of the proposed site.

Section 6. Impact Assessment

Ground level pollutant concentrations predicted by the modelling study are presented and discussed.

Section 7. Mitigation Measures

This section considers the environmental safeguards currently in place and includes recommendations to eliminate or minimise any adverse impacts.

Section 8. Conclusions

This section sums up the findings of the impact assessment.

Emissions of potential concern from the proposal include the following:

- Particulate: from drilling and blasting, process plant and equipment including the Magnesite Kiln & crusher, stockpiles, exposed areas and loading & unloading activities;
- Products of combustion: from the Magnesite Kiln which burns natural gas;
- Sulphur dioxide: from the acid scrubber;
- Magnesium oxide: from the Magnesite Kiln and fugitive sources such as exposed areas containing waste; and
- Ammonia: from the ammonia scrubber.

Emissions of particulate matter may give rise to both suspended particulate and deposited particulate. Products of natural gas combustion include carbon dioxide and carbon monoxide, oxides of nitrogen (of which nitrogen dioxide is of most concern) and small quantities of sulphur dioxide. Magnesium oxide is the oxidised version of the magnesium metal. This is formed only after combustion, i.e. in the calcining process. Prior to this magnesium is present as magnesite, the naturally occurring magnesium carbonate mineral which constitutes the ore. Ammonia is generated during the process and extracted by a scrubber to produce ammonium sulphate liquor.

Full details of each pollutant and their potential impacts on human health or amenity are given below.

2.1 Particulate

Suspended Particulate

Suspended particulate matter is dust or aerosol that stays suspended in the atmosphere for significant periods. The current nomenclature is to describe fractions of suspended particulate as:

- PM₁₀: all particulate effectively less than 10 microns (µm) in diameter;
- PM_{2.5}: all particulate effectively less than 2.5 µm in diameter; and
- TSP: total suspended particulate, generally less than 50 µm in diameter.

Within the range of suspended particulate, the group of particles which are sized 10 µm or less (PM₁₀) have been associated with health effects including increases in mortality, aggravation of existing respiratory and cardiovascular disease, increased hospital admissions and increased asthma incidents. More recent research however, indicates that it may be the PM_{2.5} fraction that has the greatest impact on human health. Particulate that are larger than 10 µm, tend not to be able to penetrate the respiratory tract and do not appear to be significant with respect to potential health effects.

Major natural sources of background particulate levels include forest fires, pollen and wind-blown dust from exposed areas. Anthropogenic sources include stationary and mobile combustion sources, road dust, agriculture, mining, major fires and emissions from industrial processes. Background levels vary widely depending on location, meteorology and proximity of major point or area sources.

Deposited Particulate Matter

Deposited particulate matter is dust that, because of its aerodynamic diameter and density, rapidly falls from the air. In general terms, deposited particulate has a diameter of greater than about 20 μm . However there is no sharp dividing line between these particles and the smaller particles of suspended matter that fall more slowly out of the air. Because of the size of the particulate matter, most of this material will not enter the body. Hence the effects of deposited particulate are primarily nuisance, and may only affect health via annoyance reactions and the like.

The dust deposition rate is measured as the amount of dust deposited on a horizontal surface as a result of gravitational settling over a specified time period. The units for this parameter are grams per square metre per month ($\text{g}/\text{m}^2/\text{month}$).

2.2 Products of Combustion

Oxides of Nitrogen (NO_x)

Oxides of nitrogen are formed through a thermal process of combining oxygen and nitrogen. Typically this is from combustion of nitrogen in the presence in oxygen, such as in motor vehicles and thermal power generating plants, but also naturally in the nitrogen cycle. Oxides of nitrogen include nitrogen dioxide (NO_2), nitric oxide (NO) and traces of nitrous oxide (N_2O). The principal species of concern, in terms of human health effects, is NO_2 . However, emissions of NO will react with oxygen in the atmosphere to form additional NO_2 as the plume travels downwind, hence stack discharge emission limits are normally specified for NO_x (expressed as NO_2).

Nitrogen dioxide is soluble in water and excessive amounts in the atmosphere can result in “acid rain”. In the stratosphere, oxides of nitrogen play a crucial role in maintaining ozone levels (essential to protect against the greenhouse effect). In the lower atmosphere, oxides of nitrogen play a major role in the formation of photochemical smog in a complex set of reactions that lead to the formation of a variety of nitrated organic compounds (from volatile organic matter) and excessive levels of ozone. It is to protect against potential adverse health impacts from the formation of ozone, as well as the potential for nitrogen dioxide to cause health effects when present in high concentrations, that ambient criteria for nitrogen dioxide are set.

Carbon Monoxide (CO)

Carbon monoxide occurs naturally in forest fires, volcanic ash and marsh gases. It is also sourced from incomplete combustion of fuels (particularly in motor vehicles), smoking cigarettes, burning wood and industrial plant exhaust.

Sulphur Dioxide

Sulfur dioxide (SO₂) is a colourless, pungent, irritating and reactive gas, which is soluble in water. SO₂ and its reaction products (sulfurous and sulfuric acids and sulfate particles) are generally removed from the atmosphere by rain, and by direct uptake at plant, soil and water surfaces.

Natural sources of SO₂ are volcanic and geothermal activity. Bacterial and algal processes can produce organic sulfur compounds that are readily converted to SO₂. The main human activities that are sources of SO₂ include power generation from the burning of coal, oil or gas containing significant amounts of sulfur, the roasting or smelting of mineral ores containing sulfur, oil refining, and industrial plants that burn large quantities of fuels with a high sulfur content. In urban areas motor vehicles contribute about 10% to ambient SO₂ levels.

2.3 Magnesium Oxide

Magnesium oxide (MgO) fume is an odourless white opaque smoke. MgO is formed during the calcining process where the magnesium carbonate is oxidised to MgO.

At high concentrations (> 580 mg/m³) MgO can irritate the eyes and nose.¹ At extremely high concentrations it can cause metal fume fever, triggering symptoms such as headache, cough, sweating, nausea, fever, oppression in the chest and leucocytosis (increase in the number of white blood cells in the blood). The symptoms of metal fume fever might not become manifest until 4-12 hours after exposure and may last for 24 hours. Metal fume fever is not believed to have permanent effects. No chronic (long-term) health effects are known at this time from MgO.²

Typical ambient levels are far below such levels.

¹ *Documentation of the Threshold Limit Values and Biological Exposure Indices*, ACGIH, Virginia.

² *Contextual information available on NPI database*, Environment Australia, December 2001.
<http://www.npi.gov.au/>

2.4 Ammonia

Ammonia is a colourless gas with a sharp, irritating odour that is first detectable between 0.04 – 53 ppm.³

Ammonia is used as a refrigerant, a cleaning and bleaching agent, and a household cleaner. It is used to produce fertilisers, plastics, explosives, and pharmaceuticals, and to control fungal growth on grapefruit, lemons, and oranges. In this proposal, ammonia is scrubbed and sold as a liquor.

³ *Odor Thresholds for Chemicals with Established Occupational Health Standards*, American Industrial Hygiene Association, Akron, USA.

There are three types of criteria that apply to atmospheric pollutants. These are:

- **Discharge Emission Limits** – These are concentration or mass emission limits applied at the point of discharge (typically a stack).
- **Impact Assessment Criteria** – These are ground level concentration limits designed to be used in conjunction with dispersion modelling. If maximum predicted downwind concentrations are less than the impact assessment criteria, then there should be no adverse impacts on the environment.
- **Ambient Air Quality Criteria** – These are concentrations set to protect public health and amenity and are designed as criteria for ambient monitoring programs.

3.1 Discharge Emission Limits

National stack emission limits were published in 1986 by the National Health and Medical Research Council (NHMRC) and are given in Table 3-1. Some of these are considered outdated in light of today’s pollution control technology and the stack emission limits proposed for the development are therefore, lower for a number of pollutants.

**TABLE 3-1
REGULATORY AND PROPOSED STACK EMISSION LIMITS**

Parameter	Regulatory Emission Limit	Proposed Emission Limit	Typical Operating Emission Concentration
	(mg/m ³)	(mg/m ³)	(mg/m ³)
Carbon Monoxide	1,000	500	330
Sulphur Dioxide	100	50	< 1
Nitrogen Oxides (as NO ₂)*	350	350	285
Total Particulate	250	100	20 – 50
Magnesium Oxide (MgO)	-	50	2 - 10
Ammonia	-	50	25

*Steam Boiler burning gaseous fuel.

3.2 Impact Assessment Criteria

Impact assessment criteria apply downwind of a proposed facility. They are set to protect against adverse effects on human health and are therefore, much lower than emission limits set for concentrations in the stack. There are currently no nationally recognised impact assessment criteria nor are there any impact assessment criteria set by the NT Department of Infrastructure, Planning and Environment (NT DIPE, formerly DLPE).

A comprehensive approach to date has been taken by the New South Wales Environment Protection Agency (NSW EPA) with the publication of impact assessment criteria to be applied in the design stages of an activity to ensure that there will be no impact on people's health or amenity. These criteria are set on the basis of the toxicity of a chemical or, if more stringent, the odour threshold of a pollutant. These criteria cover the full range of pollutants associated with the proposed development and are considered appropriate to this proposal. NSW EPA impact assessment criteria are given in Table 3-2.

TABLE 3-2
NSW EPA IMPACT ASSESSMENT CRITERIA

Pollutant	Design Criteria ($\mu\text{g}/\text{m}^3$)	Time Average
Carbon Monoxide	100,000	15-minutes
	30,000	1-hour
	10,000	8-hours
Nitrogen Oxides (as NO_2)	246	1-hour
	62	annual
Sulphur Dioxide	712	10-minutes
	570	1-hour
	228	24-hours
	60	annual
PM_{10}	50	1-hour
	30	annual
TSP	90	annual
Magnesium Oxide (MgO)	330	3-minutes
Ammonia	600	3-minutes

3.3 Ambient Air Quality Criteria

In June 1998, the National Environment Protection Council (NEPC) released a National Environment Protection Measure (NEPM) for Ambient Air Quality, ⁴ setting out national standards and goals for criteria pollutants. It should be noted however, that these goals are designed for use as regional goals and are not intended to be used as near-source or site boundary criteria.

Ambient air quality criteria applicable to this proposal are given in Table 3-3. In addition to these, the NSW EPA have set a criterion of 4 g/m²/month for deposited dust to protect amenity.

**TABLE 3-3
NEPC AMBIENT AIR QUALITY CRITERIA**

Pollutant	Design Criteria (µg/m³)	Time Average
Carbon Monoxide	10,000	8-hours
Nitrogen Oxides (as NO ₂)	229	1-hour
	57	annual
Sulphur Dioxide	532	1-hour
	213	24-hours
	53	annual
PM ₁₀	50	annual

⁴ *National Environment Protection Measure for Ambient Air Quality*, NEPC, 1998. Available at www.nepc.gov.au

4.1 Emissions Inventory

An emissions inventory for each stage of the project was prepared in accordance with the National Pollutant Inventory (NPI) Emission Estimation Technique (EET) Manual for Mining⁵ and process data supplied by Mt Grace. Full calculations are given in Appendix A. Annual emissions are summarised and discussed in Section 6.

The inventory comprises a large number of fugitive sources such as truck loading, wind erosion of exposed areas, etc. Emission estimates from these types of sources relies heavily upon calculations using emission factors. A full discussion of the limitations and appropriateness of the emissions factors promulgated by Environment Australia is given in the NPI EET Manual for Mining.

Process data was supplied by Mt Grace following the preparation of mass and energy balances by Alpha Omega Engineering, Inc. Calculation of gas exhausting the magnesite kiln was corrected for carbon dioxide production from oxidation of carbonates within the ore. All flows were corrected for temperature and water when calculating emission rates based upon proposed concentration limits. Full details are given in the spreadsheet calculations supplied in Appendix A.

Assumptions used for the preparation of process data and emissions estimation are given below:

Stage One

- Year 1 – 2.
- 1.925 million tonnes of overburden, ore and waste removed from the pit.
- 17 blasts per year.
- Mining carried out 9 hours per day (7 am – 4 pm), 92 days per year.
- Plant producing 12,500 tonnes magnesium per year, operating 24 hours per day, 365 days per year (conservative or ‘worst case’ scenario). One magnesite kiln exhausting through ST01.
- Areas subject to wind blown erosion were set at 50% of the full area specified for full production.* This is conservative bearing in mind that production will only be 25% of Stage Three.
- It was assumed that fines would be stockpiled separately (Mt Grace are considering mixing with slag to form a more stable waste for disposal).

* The exception to this is exposed Plant area for which a factor of 0.3 is specified in the NPI EET Manual for Mining to allow for area covered by plant and equipment.

⁵ Environment Australia, Version 2.1, October 2000.

Stage Two

- Years 3 - 4

As above with the following exceptions:

- 0.87 million tonnes of overburden, ore and waste removed from the pit.
- Mining carried out 9 hours per day (7 am – 4 pm), 83 days per year.
- Plant producing 25,000 tonnes magnesium per year, operating 24 hours per day, 365 days per year (conservative or ‘worst case’ scenario). Two magnesite kilns exhausting through ST01.

Stage Three

- Year 5 and subsequent years.

As above with the following exceptions:

- 1.925 million tonnes of overburden, ore and waste removed from the pit.
- Mining carried out 9 hours per day (7 am – 4 pm), 92 days per year.
- Plant producing 50,000 tonnes magnesium per year, operating 24 hours per day, 365 days per year (conservative or ‘worst case’ scenario). Three magnesite kilns exhausting through ST01 and ST06.

4.2 Dispersion Modelling

The atmospheric dispersion model AUSPLUME (version 5.3) was used to predict downwind concentrations from the proposed site. AUSPLUME was developed for use in air quality impact assessments by the Victoria Environmental Protection Agency (EPAV) and has recently been upgraded to improve its ability to simulate the dispersion of particulate matter from mining type sources.

Meteorological data was obtained by Katestone Scientific and formatted for use in AUSPLUME. Full details of data preparation and validation for the Batchelor area are given in Appendix B.

Modelling was carried out for all stages of the proposed operation as follows:

- Stage 1: 12,500 tonnes/annum production of Magnesium; and
- Stage 3: 50,000 tonnes/annum production of Magnesium.

Modelling was also carried out for the following time averages to enable direct comparison with the relevant guidelines for different pollutants:

- 3-minute 99.9 percentile (MgO, NH₃);
- 10-minute 99.9 percentile (SO₂);
- 1-hour 99.9 percentile (NO₂);
- 8-hour average (CO);
- 24-hour average (PM₁₀, SO₂); and
- Annual averages (PM₁₀, TSP, SO₂).

99.9 percentile concentrations were used for the 3-minute, 10-minute and 1-hour averaging times in accordance with the NSW EPA and EPAV approved modelling protocols. Removing the extreme peak short-term predictions is done to eliminate freak meteorological conditions and to provide realistic worst case predictions.

A receptor grid using Australian map grid co-ordinates was created to extend 3,000 m east and west, and 4,000 m north and south of the site. When identifying maximum predicted ground level concentrations, values predicted for receptors within the site boundary were removed from the assessment. Gridded files used for preparation of contour plots however, included all concentrations predicted at all receptors. The receptor grid is shown in Figure 4-1.

In addition to these gridded receptors, discrete receptors were located to calculate concentrations at the nearest residences to the site. These residences are located to the north east and west of the site as shown in Figure 4-1.

Terrain effects were taken into consideration using the Egan half-height method and data obtained manually from a topographical map.⁶

Building dimensions were entered into the model using the Building Profile Input Programme utility of the AUSPLUME model. Building downwash was simulated using the PRIME algorithm option.

The average canopy height of the terrain surrounding the site is approximately 8 m due to the presence of woodlands. A roughness factor of 0.6 m was therefore designated for land use.

All particulate emissions were assigned to either 'area' or 'volume' sources and included in the dispersion modelling as follows:

- Volume sources (such as truck un/loading) were located in the middle of the activity area and assumed to be 1 m above ground with an initial vertical and horizontal spread of 1 m.

⁶ Batchelor, Northern Territory, Series R722, Sheet 5171 4, Edition 2-AAS. Commonwealth of Australia, 1985.

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- The area sources were all approximated to rectangular shapes and were set at ground level. They were located based upon the south western corner of the area and aligned upon north within the grid co-ordinates and terrain already specified in AUSPLUME.
 - Terrain heights for all sources at each location (typically 80 m ADL across the site) were also included.

The only exception to the above were sources located within the pit which were assumed to be at 60 m ADL in Stage One, and 20 m ADL in Stage Three (initially 80 m ADL prior to open cut).

5.1 Climate and Meteorology

5.1.1 Wind Direction and Wind Speed

Wind roses for the area are presented in Appendix C. Wind speed and direction data were collected half-hourly from the Batchelor automatic weather station, which is located approximately 7 km west south west of the site. The data covers the period from 1 January 2000 to 31 December 2000, with approximately 17 days of data missing from late February to early March.

The Batchelor region experiences a tropical climate with two seasons – the dry season (May – October) and the wet season (November – April). The wind roses show the predominant wind patterns for this period were as follows:

- **Annual:** Winds are typically fresh to moderate and predominantly from the south east and east. The percentage of calm winds was 20%.
- **Dry Season (May – Oct):** The predominant winds during the dry season were light to strong and from the west to north west. The percentage of calm winds was 17%. Winds were stronger during the daytime than through the night, although the predominant wind directions were similar.
- **Wet Season (Nov – Apr):** Winds were light to strong with a high frequency of winds from the south east quadrant. The percentage of calm winds was 19%.

Frequency distribution tables are provided in Appendix C.

5.2 Existing Air Quality

There is no ambient air quality data available for the region. Given the rural nature of the area and the lack of either urban population or industry, existing air quality is expected to be good. On occasion suspended and deposited particulate levels may be elevated due to windblown dust, agricultural activities or bush fires. Despite the likelihood of existing background levels of particulates in the region being elevated on a seasonal basis, the modelling undertaken for this air quality assessment assumed zero background concentrations to represent a conservative estimate of the atmospheric impacts associated with the proposal.

The first year of operation (Stage One) will see the largest potential impact from fugitive particulate emissions as topsoil and overburden are removed to expose the ore. Stage Three, which has the maximum processing capacity (50,000 tpa Mg) gives maximum annual stack discharges. As a first step in the analysis, only Stages One and Three were therefore considered. Should emissions from neither of these Stages result in any adverse effects then Stage Two, which has lesser emissions, should also not result in any adverse impacts.

The following assessment therefore, addresses emissions from Stage One and Stage Three.

6.1 Stage One

6.1.1 Emissions

Mt Grace estimates approximately 1.925 million tonnes will be moved in the first year. Mining activities that have the potential to result in dust emissions include the following:

- topsoil removal and excavation;
- dumping, stockpiling & transfer of ore, overburden, fines, wastes & slag;
- machinery and vehicle movements on site; and
- dust pick-up from exposed areas.

These emissions are typically referred to as ‘fugitive’ emissions. That is, they arise from open ‘area’ or ‘volume’ sources (e.g unloading of trucks) and are often intermittent.

For the purposes of a worst-case conservative assessment, the plant was assumed to be fully operational at 12,500 T/yr in conjunction with the above removal of 1.925 million tonnes of overburden, ore and waste from the pit.

Emission sources have been grouped according to exhaust configuration as either point sources (i.e. stacks) or fugitive sources (such as exposed wind blown areas). The emission estimates for Stage One are shown in Table 6-1 (stack sources), Table 6-2 (vehicles) and Table 6-3 (fugitive sources). Annual emissions of PM₁₀ are further presented graphically, by source type, in Figure 6-1.

TABLE 6-1

STAGE ONE EMISSIONS INVENTORY: STACK SOURCES

Stack Sources	Pollutant	Height (m)	Diameter (m)	Velocity (m/s)	Flow (Nm ³ /s)	Conc (mg/Nm ³)	Rate (g/s)	Rate (T/yr)
Magnesite Kiln 1	TSP	63	1.5	14.8	7.8	20	0.2	4.9
	PM ₁₀	63	1.5	14.8	7.8	10	0.1	2.4
	MgO	63	1.5	14.8	7.8	17	0.1	2.1
	NO _x	63	1.5	14.8	7.8	282	2.2	69
	CO	63	1.5	14.8	7.8	328	2.5	80
	SO ₂	63	1.5	14.8	7.8	0.39	3.E-03	0.1
Acid Scrubber 1	SO ₂	18	1.0	15.0	9.0	0.9	0.01	0.3
NH ₃ Scrubber 1	NH ₃	18	0.5	15.0	2.2	25	0.06	1.8
Lime Storage	TSP	18	1.0	8.1	5.3	2	1.E-02	0.3
	PM ₁₀	18	1.0	8.1	5.3	2	1.E-02	0.3
Crusher	TSP	18	1.5	15.0	22	11	0.3	3.0
	PM ₁₀	18	1.5	15.0	22	4	0.1	0.9

TABLE 6-2

STAGE ONE EMISSIONS INVENTORY: ALL SITE VEHICLES

Pollutant	(kg/yr)
PM ₁₀	2,224
CO	2,493
NO _x	6,785
SO ₂	337
VOCs	481

TABLE 6-3
STAGE ONE EMISSIONS INVENTORY: FUGITIVE SOURCES

Fugitive Sources	Annual Emission TSP (kg/yr)	Annual Emission PM₁₀ (kg/yr)	Annual Emission MgO (kg/yr)
Open Cut	2,066	668	
Pit – Wind erosion	842	421	
Plant – Wind erosion	534	267	278
ROM – Wind erosion	925	463	
Fines – Wind erosion	2,638	1,319	
Slag – Wind erosion	999	500	520
Waste – Wind erosion	3,748	1,874	
Drilling & Blasting	43,671	22,709	
Pit – Loading	2,888	1,348	
ROM Pad – Unloading	300	140	
ROM Pad – Loading	300	140	
Waste – Unloading	2,588	1,208	1,346
Fines – Loading	1	0.6	
Fines – Unloading	60	28	
Slag – Unloading	132	62	
Crusher	2,966	947	
ROM - Stockpile loading	640	272	
ROM - Stockpile unloading	4,800	2,080	
Lime storage - unloading	5	2	
Conveyor	2,880	1,440	
TOTAL (kg/yr)	72,984	35,887	2,144

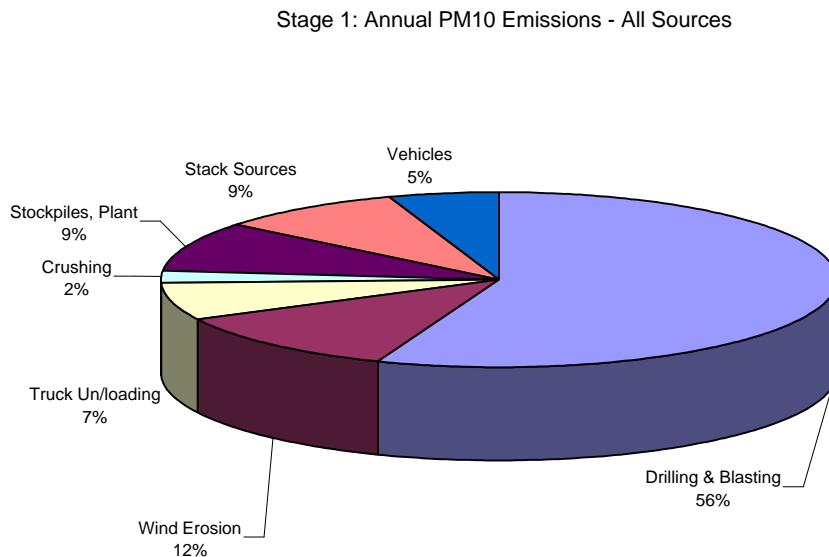


Figure 6-1. Stage One Annual PM₁₀ Emissions by Source

Figure 6-1 shows that, on an annual basis, the greatest contributor to dust emissions is blasting. This only occurs however, on an intermittent basis. Mt Grace estimates that blasting will be carried out on 17 days in the first year. Due to the short, intense nature of such emissions it is not technically feasible to include them in the dispersion modelling study. It is likely that during events such as blasting, short-term levels of TSP and PM₁₀ would be elevated downwind of the blast area beyond the site boundary. If appropriate dust minimisation practices are adopted during drilling and blasting (discussed in Section 7) it is unlikely, however that significantly elevated levels would be experienced as far afield as the Batchelor township or at either of the neighbouring residences, .

The next most significant source group is the stacks associated with the processing plant. These emissions have been included in the atmospheric dispersion study which is discussed below.

6.1.2 Dispersion Modelling

Stage 1 pollutants were modelled to predict maximum downwind concentrations as outlined in Section 4 (the exception to this being blasting). Table 6-4 presents a summary of the maximum predicted concentrations at all offsite receptor locations and at the discrete receptors (nearest residences) for comparison with the respective guidelines.

TABLE 6-4
STAGE ONE DISPERSION MODELLING RESULTS

Pollutant	Maximum Predicted Concentration	Guideline	Units, Time Average
MgO			
Off-site	13	330	$\mu\text{g}/\text{m}^3$, 3-minute
Discrete 1	2.6		
Discrete 2	6.5		
NH ₃			
Off-site	12	600	$\mu\text{g}/\text{m}^3$, 3-minute
Discrete 1	2.4		
Discrete 2	5.7		
SO ₂			
Off-site	1.6	712	$\mu\text{g}/\text{m}^3$, 10-minute
Discrete 1	0.3		
Discrete 2	0.3		
NO _x (as NO ₂)			
Off-site	5.5	246	$\mu\text{g}/\text{m}^3$, 1-hour
Discrete 1	1.0		
Discrete 2	1.1		
CO			
Off-site	4.4	10,000	$\mu\text{g}/\text{m}^3$, 8-hour
Discrete 1	0.7		
Discrete 2	0.3		
TSP			
Off-site	3.9	90	$\mu\text{g}/\text{m}^3$, annual
Discrete 1	0.4		
Discrete 2	0.6		
PM ₁₀ (24- hours)			
Off-site	15	50	$\mu\text{g}/\text{m}^3$, 24-hours
Discrete 1	4		
Discrete 2	7.6		
PM ₁₀ (annual)			
Off-site	1.9	30	$\mu\text{g}/\text{m}^3$, annual
Discrete 1	0.2		
Discrete 2	0.3		

The resulting contour plots of maximum predicted concentrations anticipated during Stage 1 production are shown in Figures 6-2 to 6-9 inclusive. The model results showed maximum off-site concentrations of all pollutants to be well below respective guideline limits. The discrete receptors, representing the nearest residential premises to the proposed Batchelor project, typically experienced concentrations in the range of only 0.05 – 2.0 % of the guideline values for most pollutants (MgO, NH₃, SO₂, NO_x, and CO). Predicted TSP and PM₁₀ ground level concentrations, although still well below acceptable limit values, were shown to be closest to their guidelines, reaching a maximum of 8 to 15 % of the 50 µg/m³ limit for PM₁₀ (24-hour average), at discrete receptors 1 and 2 respectively (Table 6-4).

The results for TSP and PM₁₀ are discussed further below.

TSP & PM₁₀

TSP and PM₁₀ emissions from both stack and fugitive sources, excluding blasting, were modelled to predict maximum downwind concentrations of TSP and PM₁₀. The results are shown in Figure 6-2 (PM₁₀, annual average), Figure 6-3 (PM₁₀, 24-hour average) and Figure 6-4 (TSP, annual average).

As shown in Table 6-4, the maximum predicted concentrations of TSP are well below the impact assessment criterion beyond the site boundary and at both neighbouring residences. This is clearly shown in Figure 6-4. The impact assessment criterion for TSP is amenity based and protects against nuisance due to deposited dust impacts. There should be no adverse impacts to amenity from TSP emissions under normal operations.

The maximum predicted concentration of PM₁₀ offsite was 15 µg/m³ as a 24-hour average. This represents 30 % of the impact assessment criterion of 50 µg/m³ as a 24-hour average. Similarly, long-term concentrations of PM₁₀ were predicted to be below impact assessment criteria as shown in Figure 6-2. It should be noted that slightly higher maximum downwind concentrations were observed beyond the plant boundary to the immediate south to south east of the Mt Grace lease, which were not detected at the grid receptors specified for the model. However, as this area represents rocky terrain which is uninhabited and in the opposite direction to the nearest residences to the north and west, these slightly elevated concentrations do not influence the conclusions in assessing human health- or amenity- based air quality impacts from the project.

An analysis of the contribution of each source for predicted PM₁₀ concentrations reveals that the main contributors are fugitive sources of particulate. This is despite the stack emissions being the second most significant source group in terms of annual emissions. Bearing in mind that PM₁₀ and TSP ground level concentrations are likely to be elevated during intermittent blasting events, control measures should focus on fugitive sources.

6.2 Stage Three

6.2.1 Emissions

Emissions from Stage 3 of operation (ie. year 5 and subsequent years) of the proposed Batchelor Magnesium project were estimated using the conservative assumption of a maximum production rate of 50,000 tpa Mg, and 1.925 million tonnes of overburden, ore and waste removed from the pit.

The inventory took into account the increased capacity and plant configuration proposed for Stage 3 production, whereby three magnesite rotary kilns, two acid scrubbers, two ammonia scrubbers and two crushers will be in operation.

As per Stage 1, Stage 3 emission sources were grouped according to point (stack) sources or fugitive (area and volume) sources. The resulting estimates are summarised in Table 6-5 (stack sources), Table 6-6 (vehicles) and Table 6-7 (fugitive sources).

TABLE 6-5
STAGE THREE EMISSIONS INVENTORY: STACK SOURCES

Stack Sources	Pollutant	Height (m)	Diameter (m)	Velocity (m/s)	Flow (Nm ³ /s)	Conc (mg/Nm ³)	Rate (g/s)	Rate (T/yr)
Magnesite Kiln (1& 2)	TSP	63	2	16.7	15.5	20	0.3	9.8
	PM ₁₀	63	2	16.7	15.5	10	0.2	4.9
	MgO	63	2	16.7	15.5	9	0.1	4.2
	NO _x	63	2	16.7	15.5	282	4.4	138
	CO	63	2	16.7	15.5	328	5.1	160
	SO ₂	63	2	16.7	15.5	0.39	6.3E-03	0.2
Acid Scrubber 1	SO ₂	18	1.0	15.0	9.0	1.8	0.02	0.5
NH ₃ Scrubber 1	NH ₃	18	1.0	15.0	9.0	12	0.11	3.5
Lime Storage	TSP	18	1.0	8.1	5.3	2	1.E-02	0.3
	PM ₁₀	18	1.0	8.1	5.3	2	1.E-02	0.3
Crusher 1	TSP	18	1.5	15.0	22	23	0.5	6
	PM ₁₀	18	1.5	15.0	22	7	0.2	2
Magnesite Kiln 3	TSP	63	3	16.0	33.1	20	0.3	9.8
	PM ₁₀	63	3	16.0	33.1	10	0.2	4.9
	MgO	63	3	16.0	33.1	9	0.1	4.2
	NO _x	63	3	16.0	33.1	141	4.4	138
	CO	63	3	16.0	33.1	176	5.1	160
	SO ₂	63	3	16.0	33.1	0.21	0.01	0.2
Acid Scrubber 2	SO ₂	18	1.0	15.0	9.0	2	0.02	1
NH ₃ Scrubber 2	NH ₃	18	1.0	15.0	9.0	12	0.1	4
Crusher 2	TSP	18	1.5	15.0	22	23	0.5	6
	PM ₁₀	18	1.5	15.0	22	7	0.2	2

TABLE 6-6
STAGE THREE EMISSIONS INVENTORY: ALL SITE VEHICLES

Pollutant	(kg/yr)
PM ₁₀	2,204
CO	2,429
NO _x	6,590
SO ₂	327
VOCs	466

TABLE 6-7
STAGE THREE EMISSIONS INVENTORY: FUGITIVE SOURCES

Fugitive Sources	Annual Emission TSP (kg/yr)	Annual Emission PM₁₀ (kg/yr)	Annual Emission MgO (kg/yr)
Pit – Wind erosion	3,702	1,851	
Plant – Wind erosion	534	267	278
ROM – Wind erosion	7,404	3,702	
Fines – Wind erosion	4,720	2,360	
Slag – Wind erosion	2,887	1,444	1,501
Waste – Wind erosion	18,972	9,486	
Drilling & Blasting	43,671	22,709	
Pit – Loading	2,888	1,348	
ROM Pad – Unloading	1,200	560	
ROM Pad – Loading	1,200	560	
Waste – Unloading	1,200	560	624
Fines – Loading	2.4	1.1	2
Fines – Unloading	120	56	
Slag – Unloading	551	257	
Crusher 1	5,932	1,894	
Crusher 2	5,932	1,894	
ROM - Stockpile loading	1,600	680	
ROM - Stockpile unloading	12,000	5,200	
Lime storage - unloading	19	8	

Fugitive Sources	Annual Emission TSP (kg/yr)	Annual Emission PM ₁₀ (kg/yr)	Annual Emission MgO (kg/yr)
Lime stockpile - unloading	1,314	569	
Conveyors 1 & 2	11,520	5,760	
TOTAL (kg/yr)	127,545	61,240	2,405

Stage 3: Annual PM10 Emissions - All Sources

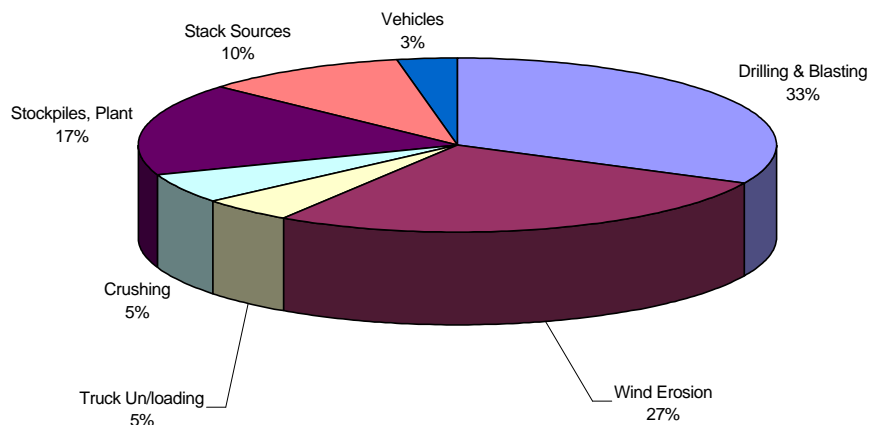


Figure 6-10. Stage Three Annual PM₁₀ Emissions by Source

As would be expected, an expansion to Stage 3 production will result in an increase in both stack and fugitive emissions from the Batchelor project. This is as a result of an increase in point sources as the plant and crusher section is expanded to meet additional demand for magnesite processing, as well as an increase in exposed areas (and hence fugitive sources of particulate) as the mine pit, fines storage, ROM pad and waste dump are expanded. It is noted that emissions from on-site vehicle are anticipated to decrease slightly from those estimated during Stage 1 (Table 6-6), as the level of vehicular activity is expected to decrease from the peak during Stage 1.

The trends observed for the Stage 1 inventory are again apparent for Stage 3, in that drilling and blasting activity is the largest contributor to dust emissions on an annual basis (Figure 6-10). However, this contribution decreases (from 56% in Stage 1 to 33% in Stage 3) as wind erosion from increased exposed areas are anticipated to become a more important contributor to particulates from the project (from 12% in Stage 1 to 27% in Stage 3). The dust management practices identified in Section 7 focus on minimising fugitive dust from such sources.

The potential air quality impacts from expansion to Stage 3 production are discussed in the following section.

6.2.2 Dispersion Modelling

Table 6-8 provides a summary of the predicted downwind concentrations of all pollutants anticipated from Stage 3 production of the Batchelor project. The maximum concentrations at all offsite receptor locations, and at each of the two discrete receptors, are compared with the relevant guideline limits.

TABLE 6-8
STAGE THREE DISPERSION MODELLING RESULTS

Pollutant	Maximum Predicted Concentration	Guideline	Units, Time Average
MgO			
Off-site	17.1	330	$\mu\text{g}/\text{m}^3$, 3-minute
Discrete 1	4.2		
Discrete 2	6.6		
NH ₃			
Off-site	50	600	$\mu\text{g}/\text{m}^3$, 3-minute
Discrete 1	5.9		
Discrete 2	9.3		
SO ₂			
Off-site	6.6	712	$\mu\text{g}/\text{m}^3$, 10-minute
Discrete 1	0.8		
Discrete 2	1.0		
NO _x (as NO ₂)			
Off-site	8.3	246	$\mu\text{g}/\text{m}^3$, 1-hour
Discrete 1	1.9		
Discrete 2	2.3		
CO			
Off-site	7.4	10,000	$\mu\text{g}/\text{m}^3$, 8-hour
Discrete 1	1.6		
Discrete 2	1.0		

Pollutant	Maximum Predicted Concentration	Guideline	Units, Time Average
TSP			
Off-site	6.5	90	$\mu\text{g}/\text{m}^3$, annual
Discrete 1	1.0		
Discrete 2	1.2		
PM ₁₀ (24- hours)			
Off-site	30	50	$\mu\text{g}/\text{m}^3$, 24-hours
Discrete 1	6.8		
Discrete 2	12		
PM ₁₀ (annual)			
Off-site	3.2	30	$\mu\text{g}/\text{m}^3$, 24-hours
Discrete 1	0.5		
Discrete 2	0.6		

Figures 6-11 to 6-18 show the resulting contour plots of maximum predicted concentrations anticipated during Stage 3 production for MgO, NH₃, SO₂, NO_x (as NO₂), CO, TSP and PM₁₀. The model results show maximum off-site concentrations of all pollutants to be higher than those anticipated during Stage 1, yet all are below their respective guideline limits. The addition of the second ammonia scrubber stack is anticipated to elevate downwind NH₃ concentrations to a maximum of 50 $\mu\text{g}/\text{m}^3$ to the south east of the project area (Figure 6-15), although this is still well below the 600 $\mu\text{g}/\text{m}^3$ assessment criterion (3-minute average).

Of all the pollutants considered in the modelling study, predicted maximum TSP and PM₁₀ ground level concentrations are the most significant. Short-term PM₁₀ concentrations, calculated over a 24-hour average, are predicted to reach maximum 'worst-case' concentrations of 30 $\mu\text{g}/\text{m}^3$, or 60 % of the 24-hour PM₁₀ impact assessment criterion of 50 $\mu\text{g}/\text{m}^3$. Further, the contour plot suggests there is the potential for the standard to be exceeded just beyond the southern boundary (although this is not reflected at the nearest receptors within the model domain). However, it should be noted that PM₁₀ levels at either of the nearest residences are still predicted to remain low (6.8 $\mu\text{g}/\text{m}^3$ and 12 $\mu\text{g}/\text{m}^3$ respectively). On an annual basis, particulate concentrations are expected to be less than 5 $\mu\text{g}/\text{m}^3$ this is less than 15 % of the annual criterion (Table 6-8).

A source contribution analysis reveals that fugitive sources are likely to remain the main contributors to predicted PM₁₀ concentrations during Stage Three. Area-based sources, and in particular wind erosion from increased exposed areas across the mine site, are integral in defining the extent to which the project may increase background dust levels in the region.

7.1 Environmental Safeguards

The following best practice environmental safeguards which would be implemented during mining and processing are listed below.

- An Environmental Monitoring and Management Plan will be prepared which addresses air monitoring and management issues (refer to Sections 4.10 and 5.2.10 of the main EIS).
- Water sprays will be used (as required) across work zones and unsealed areas to suppress dust. The water will be applied by water cart across ground surfaces whenever the surface has the potential to generate excessive levels of dust. Areas of excavation or works would not exceed the capacity of the water spray units.
- Ensure exposed surfaces and stockpiles are watered or sprayed where required.
- Schedule blasting or particularly dusty works under favourable meteorological conditions only. Terminate earth moving activity where wind speeds exceed 30 km/hr.
- Stabilise any long-term stockpiles using fast-seeding grass or synthetic cover spray. Minimise exposed areas through rehabilitation as soon as practicably possible.
- All major access roads would be sealed and vehicle speeds on unsealed areas will be strictly controlled to minimise dust.
- Vehicles would not be loaded above the height of the side and tailboards.
- Provide baghouses on all major plant and equipment generating significant point sources of dust (especially the crushing plants). Similarly, baghouses would be provided for drillers used in the pit. The conveyor belts will be covered to minimise dust emissions.
- Fines to be mixed with slag before disposal to minimise windborne emissions.
- Windbreak for limestone stockpile in Stage 3.

Emissions from the proposed Mt Grace Batchelor Magnesium project have been quantified for initial mine production (Stage 1, 12,500 tpa Mg) and at full production capacity (Stage 3, 50,000 tpa Mg). The potential impact of these emissions on air quality in the region of Batchelor has been assessed utilising the AUSPLUME Gaussian atmospheric dispersion model.

The air quality assessment showed that maximum ground level concentrations of pollutants are anticipated to be well below ambient air quality guideline limits in most instances. The primary exception is in relation to short-term concentrations of particulates, as PM₁₀, where there may be the potential for elevated levels especially during intermittent mining activity such as drilling and blasting. However, maximum ground level concentrations of particulate at either of the nearest residences, or the Batchelor township, are expected to be well below respective guideline limits

TSP and PM₁₀ are recognised as the primary pollutants of concern for the project, in particular, those arising from fugitive sources. As such, appropriate dust mitigation measures have been recommended to minimise off-site impacts during the life of the project. Similar dust management practices should also be adopted during construction of the mine and processing plant prior to commissioning.

Appendix A

Emission Spreadsheet Calculations

Appendix B

Met Data Preparation & Validation

Data Source & Validation

The file **batchelor00.aus** was created using the following data:

- Half hourly surface (10 m) meteorological data from Batchelor automatic weather station;
- Morning radiosonde data from Darwin Airport;
- Solar radiation for Darwin;

The Darwin Bureau of Meteorology supplied all meteorological data.

A large number of calm readings were recorded for the site (all recorded with zero wind direction), these records were set to 0.5 m/s and the wind direction randomised. The file covers the period from 1/1/00 to the 31/12/00 with some missing data during February, resulting in 8136 valid records.

Methodology

Night-time mixing heights were estimated from the local wind information using methods proposed by Venkatram (1977). The constants used in this methodology have been based on Australian studies.

For daytime periods prior to the radiosonde flight, mixing heights were estimated using linear interpolation between the nighttime value at daybreak and the radiosonde measurement (if non-zero). After the radiosonde hour, the mixing heights were derived using the iterative energy-budget methods proposed by Clarke (1990) and Raynor and Watson (1991). The convective velocity was then derived from the estimates of heat flux and mixing height in the standard fashion. Reduced mixing heights during sea breezes conditions (winds in sector 270° - 340°, wind speed greater than 2.0 m/s during the afternoon) were also included in the calculation based on Australian studies.

The stability classification was based on the ratio of convective velocity to wind speed for daytime conditions and on values of wind speed for nighttime. Katestone Scientific checked the frequency of stability classes by comparison with previous studies for locations in similar areas. Stability class assignment is given overleaf in Table B-1.

The minimum wind speed was set to 0.5 m/s.

Visual checks of the final data file along with inspection of parameters verses time of day have resulted in a validated data file suitable for use in the Ausplume dispersion model. Sigma thetas were not available for this site.

Appendix B

Met Data Preparation & Validation

TABLE B-1
STABILITY CLASSES ASSIGNMENT

Stability Class	%
A	20.0
B	19.4
C	10.1
D	14.0
E	14.0
F	22.6

Appendix C

Wind Roses & Frequency Distribution

Appendix C

Wind Roses & Frequency Distribution

TABLE C-1

ANNUAL FREQUENCY DISTRIBUTION OF WIND DIRECTION / WIND SPEED (COUNT)

(m/s)	0.5 – 1.8	1.8 – 3.3	3.3 – 5.4	5.4 – 8.5	8.5 – 11.1	> 11.1	TOTAL
N	62	214	67	3	0	0	346
NNE	27	124	27	1	0	0	179
NE	45	115	47	2	0	0	209
ENE	39	158	94	2	0	0	293
E	101	385	309	82	1	0	878
ESE	58	200	269	199	6	0	732
SE	65	295	424	145	2	0	931
SSE	75	228	143	17	0	0	463
S	101	156	21	1	0	0	279
SSW	39	55	5	1	0	0	100
SW	48	50	5	0	0	0	103
WSW	54	80	8	0	0	0	142
W	137	244	80	5	0	0	466
WNW	62	337	226	32	0	0	657
NW	70	239	153	23	0	0	485
NNW	47	152	50	7	0	0	256
TOTAL	1030	3032	1928	520	9	0	

Appendix C

Wind Roses & Frequency Distribution

TABLE C-2

ANNUAL NORMALISED FREQUENCY DISTRIBUTION WIND DIRECTION / WIND SPEED

(m/s)	0.5 – 1.8	1.8 – 3.3	3.3 – 5.4	5.4 – 8.5	8.5 – 11.1	> 11.1	TOTAL
N	0.008	0.026	0.008	0.000	0.000	0.000	0.043
NNE	0.003	0.015	0.003	0.000	0.000	0.000	0.022
NE	0.006	0.014	0.006	0.000	0.000	0.000	0.026
ENE	0.005	0.019	0.012	0.000	0.000	0.000	0.036
E	0.012	0.047	0.038	0.010	0.000	0.000	0.108
ESE	0.007	0.025	0.033	0.024	0.001	0.000	0.090
SE	0.008	0.036	0.052	0.018	0.000	0.000	0.114
SSE	0.009	0.028	0.018	0.002	0.000	0.000	0.057
S	0.012	0.019	0.003	0.000	0.000	0.000	0.034
SSW	0.005	0.007	0.001	0.000	0.000	0.000	0.012
SW	0.006	0.006	0.001	0.000	0.000	0.000	0.013
WSW	0.007	0.010	0.001	0.000	0.000	0.000	0.017
W	0.017	0.030	0.010	0.001	0.000	0.000	0.057
WNW	0.008	0.041	0.028	0.004	0.000	0.000	0.081
NW	0.009	0.029	0.019	0.003	0.000	0.000	0.060
NNW	0.006	0.019	0.006	0.001	0.000	0.000	0.031
TOTAL	0.127	0.373	0.237	0.064	0.001	0.000	

Mt Grace Emissions Inventory: Processing Plant, Stage One

Stack ID	Pollutant	X co-ord m	Y co-ord m	Height m	Diam m	Velocity m/s	Flow Am3/s	H2O %	Temp °C	Flow Nm3/s	Emission g/s	Emission mg/Nm3	Emission T/yr	Abatement / Comment
Magnesite Kiln														
Ex Magnesite Kiln, Casting Plant 1, DCF & condenser off-gases														
ST01	TSP	724130	8556255	63	1.5	14.8	26.2	16.4	500	7.8	0.16	20	4.9	Proposed Emission Limit Concentration
ST01	PM ₁₀	724130	8556255	63	1.5	14.8	26.2	16.4	500	7.8	0.08	10	2.4	Proposed Emission Limit Concentration
ST01	MgO	724130	8556255	63	1.5	14.8	26.2	16.4	500	7.8	0.07	8.7	2.1	Assumed to be 86.6% of particulate
ST01	NOx as NO ₂	724130	8556255	63	1.5	14.8	26.2	16.4	500	7.8	2.2	282	69	
ST01	CO	724130	8556255	63	1.5	14.8	26.2	16.4	500	7.8	2.5	328	80	
ST01	SO ₂	724130	8556255	63	1.5	14.8	26.2	16.4	500	7.8	0.003	0.4	0.1	
Acid Scrubber 1														
Ex Refining & Casting														
ST02	SO ₂	724295	8556250	18	1.0	15.0	11.8	10	50	8.96	0.01	0.9	0.3	Scrubber, 99% efficiency
Flow estimated based upon expected emissions														
Ammonia Scrubber 1														
Ex Sludge Processing & Condenser Residue Treatment														
ST03	NH ₃	724295	8556240	18	0.5	15.0	2.9	10	50	2.24	0.06	25	1.8	Scrubber, 99% efficiency
Flow estimated based upon expected emissions														
Lime Storage Baghouse														
ST04	TSP	724110	8556270	18	1	8.1	6.4	10	25	5.3	0.01	2	0.3	Baghouse
ST04	PM ₁₀	724110	8556270	18	1	8.1	6.4	10	25	5.3	0.01	2	0.3	Sized on Stage 3
Crusher Baghouse 1														
Loading of fines, loading crusher, primary & secondary crushing														
ST05	TSP	724050	8556280	18	1.5	15.0	26.5	10	25	22	0.3	11	3.0	Baghouse
ST05	PM ₁₀	724050	8556280	18	1.5	15.0	26.5	10	25	22	0.1	4	0.9	Diameter (& flow) sized on emissions from calcs to give realistic emission concentration in Stage 2

Mt Grace Emissions Inventory: Fugitive Dust Sources, Stage One

1. TOPSOIL REMOVAL INITIAL ACCESS TO OPEN CUT

X co-ord (m)	723,040		
Y co-ord (m)	8,556,650		
X-Area (m ²)	72,800		
Emission of TSP =	1.64	kg/VKT	Mining EET Handbook, pg 39 for silt content 10%
Emission of PM10 =	0.53	kg/VKT	
Assume scraper moves 10 km/hr	1260	VKT	
Assume scraper operates 9 hrs/day			
Assume scraper works for 2 weeks to clear area			

TSP Emission (kg/annum) = 2,066

TSP Emission (g/s) = 0.2

PM10 Emission (kg/annum) = 668

PM10 Emission (g/s) = 0.1

PM10 Emission (mg/s/m²) = 0.001

Comments

Fraction of TSP

2. WIND EROSION - EXPOSED AREAS

Emission of TSP = $1.9 * (s/1.5) * 365 * (365-p)/235 * (f/15) * C$
 Where: s = silt content (%) (Fraction less than 75 µm)
 p = days rainfall > 0.25 mm
 f = % time wind speed > 0.54 m/s
 C = % control

Emission of PM10 = Assume = 0.5 * TSP emissions

Area =	PIT	PLANT	ROM PAD	FINES	SLAG DUMP	WASTE DUMP
X co-ord (m)	723,040	724,000	724,050	724,340	723,870	723,700
Y co-ord (m)	8,556,650	8,556,130	8,556,350	8,556,350	8,555,700	8,555,980
Z (m)	60	80	80	80	80	80
X dist (m)	560	350	100	190	270	270
Y dist (m)	130	220	200	200	320	300
Angle (deg) from North	0	90	90	90	-30	-30
Exposed Area/total area	0.5	0.3	0.5	0.5	0.5	0.5
Exposed Area (ha)	3.64	2.3	1.0	1.9	4.3	4.1
Silt Content (%)	4	2	4	6	1	4
Days rainfall >0.25 mm	12	12	12	12	12	12
%Time wind speed >5.4 m/s	5	5	5	5	5	5
Control (%)	75	50	0	0	0	0
TSP Emission (kg/annum) =	842	534	925	2,638	999	3,748
TSP Emission (g/s) =	0.03	0.02	0.03	0.08	0.03	0.12
TSP Emission (g/s/m ²) =	7.3E-07	7.3E-07	2.9E-06	4.4E-06	7.3E-07	2.9E-06
PM10 Emission (kg/annum) =	421	267	463	1,319	500	1,874
PM10 Emission (g/s) =	0.01	0.01	0.01	0.04	0.02	0.06
PM10 Emission (mg/s/m ²) =	3.7E-04	3.7E-04	1.5E-03	2.2E-03	3.7E-04	1.5E-03
MgO Emission (kg/annum) =		278			520	
MgO Emission (g/s) =		0.01			0.02	
MgO Emission (g/s/m ²) =		3.8E-07			3.8E-07	

3. DRILLING & BLASTING

3.1 DRILLING

X co-ord (m)	723,340		
Y co-ord (m)	8,556,780		Volume Source, middle reference point

Emission of TSP =	0.59	kg dust/hole	Mining EET Handbook
Emission of PM10 =	0.31	kg dust/hole	

Control Efficiency	0.99	%	Baghouses on Drillers
Number of drill holes =	60	holes/day	
Mining days / yr	92	days	
Hours / day	9	hrs	

TSP Emission (kg/annum) = 33

TSP Emission (g/s) = 0.1

PM10 Emission (kg/annum) = 17

PM10 Emission (mg/s) = 74 Fraction of TSP
Approximate as Volume Source

3.2 BLASTING

X co-ord (m)	723,340
Y co-ord (m)	8,556,780

Emission of TSP = $344 * A^{0.8} * M^{1.9} * D^{-1.8}$
 Where: A = area blasted
 M = moisture content
 D = depth of blast holes

Emission of PM10 = Assume 0.52 * TSP Emissions

Area Blasted =	3600	m ²
Moisture Content =	2.0	%
Depth of Blast Holes =	6.0	m
No. Blasts / yr	17	

TSP Emission (kg/annum) = 43,638

PM10 Emission (kg/annum) = 22,692

Fraction of TSP

4. LOADING IN PIT

X co-ord (m)	723,340	
Y co-ord (m)	8,556,780	
$E = k \times 0.0016 (U/2.2)^{1.3} \times (M/2)^{-1.4}$		

Emission of TSP =	0.0015	kg/t
Emission of PM10 =	0.0007	kg/t
Mining days / yr	92	days
Hours / day	9	hrs
Tonnes Extracted =	1925000	t/yr

TSP Emission (kg/annum) =	2888
TSP Emission (g/s) =	1.0

PM10 Emission (kg/annum) =	1348
PM10 Emission (mg/s) =	452

5. UN/LOADING ROM PAD, WASTE DUMP, SLAG**5.1 LOADING TO ROM PAD**

X co-ord (m)	724,100	
Y co-ord (m)	8,556,450	

Emission of TSP =	0.0015	kg/t
Emission of PM10 =	0.0007	kg/t
Mining days / yr	92	days
Hours / day	9	hrs
Tonnes Unloaded =	200000	t/yr

TSP Emission (kg/annum) =	300
TSP Emission (g/s) =	0.10

PM10 Emission (kg/annum) =	140
PM10 Emission (mg/s) =	47

5.2 LOADING FROM ROM PAD TO CRUSHER

X co-ord (m)	724,100	
Y co-ord (m)	8,556,450	

Emission of TSP =	0.0015	kg/t
Emission of PM10 =	0.0007	kg/t
Operating days / yr	365	days
Hours / day	9	hrs
Tonnes Unloaded =	200000	t/yr

TSP Emission (kg/annum) =	300
TSP Emission (g/s) =	0.03

PM10 Emission (kg/annum) =	140
PM10 Emission (mg/s) =	12

Comments

Volume Source, middle reference point

where

k = 0.74 for particles less than 30 microns

k = 0.35 for particles less than 10 microns

U = mean wind speed = 2.4 m/s

M = material moisture content = 2%

Un/Loading trucks, p 43 Mining EET Handbook

Fraction of TSP

Approximate as Volume Source

Comments

Volume Source, middle reference point

Un/Loading trucks, p 43 Mining EET Handbook

Fraction of TSP

Approximate as Volume Source together with loading

Volume Source, middle reference point

Un/Loading trucks, p 43 Mining EET Handbook

Fraction of TSP

Approximate as Volume Source together with unloading

5.3 UNLOADING TO WASTE DUMP

X co-ord (m)	723,730		Volume Source, middle reference point
Y co-ord (m)	8,556,150		
Emission of TSP =	0.0015	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0007	kg/t	
Mining days / yr	92	days	
Hours / day	9	hrs	
Tonnes Unloaded =	1725000	t/yr	

TSP Emission (kg/annum) =**2588**

TSP Emission (g/s) =

0.87

PM10 Emission (kg/annum) =**1208**

PM10 Emission (mg/s) =

405

Fraction of TSP
Approximate as Volume Source**MgO Emission (kg/annum) =****1346**

MgO Emission (mg/s) =

451

Fraction of TSP for modelling

5.4 LOADING FINES (ex crusher)

X co-ord (m)	724,050		Crushing plant baghouse
Y co-ord (m)	8,556,280		
Emission of TSP =	0.0015	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0007	kg/t	
Operating days / yr	365	days	Performed daily
Hours / day	1	hrs	
Tonnes Extracted =	40000	t/yr	Baghouses on Dust Extraction
Control Efficiency	98	%	

TSP Emission (kg/annum) =**1.2**

TSP Emission (g/s) =

0.0009

Included in Crusher baghouse emissions total

PM10 Emission (kg/annum) =**0.56**

PM10 Emission (mg/s) =

0.43

Fraction of TSP
Included in Crusher baghouse emissions total**MgO Emission (kg/annum) =****1**

MgO Emission (mg/s) =

0.0043

Fraction of TSP for modelling

5.5 UNLOADING FINES

X co-ord (m)	724,450		Volume Source, middle reference point
Y co-ord (m)	8,556,450		
Emission of TSP =	0.0015	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0007	kg/t	
Mining days / yr	92	days	
Hours / day	9	hrs	
Tonnes Unloaded =	40000	t/yr	

TSP Emission (kg/annum) =**60**

TSP Emission (g/s) =

0.02

PM10 Emission (kg/annum) =**28**

PM10 Emission (mg/s) =

9

Fraction of TSP
Approximate as Volume Source

5.6 UNLOADING TO SLAG DUMP

Assume loading in enclosed environment with minimum emissions
 X co-ord (m) 723,910
 Y co-ord (m) 8,555,920

Volume Source, middle reference point

Emission of TSP = 0.0015 kg/t
 Emission of PM10 = 0.0007 kg/t

Un/Loading trucks, p 43 Mining EET Handbook

Operating days / yr 365 days
 Hours / day 9 hrs
 Slag ex DCF 80638 t/yr
 Slag ex Sludge Treatment 4750 t/yr
 ex Kiln Baghouse 2252 t/yr
 ex Lime Kiln Baghouse 0 t/yr
 ex Casting 100 t/yr
 ex Crusher 1 297 t/yr
 ex Crusher 2 0 t/yr
 Tonnes Unloaded = 88036 t/yr

Slag mixed with baghouse fines

Assume 99% efficiency in baghouse
 Lime Kiln in Stage 3

Assume 99% efficiency in baghouse
 Crusher 2 in Stage 3

TSP Emission (kg/annum) = 132
 TSP Emission (g/s) = 0.01

PM10 Emission (kg/annum) = 62
 PM10 Emission (mg/s) = 5

Fraction of TSP
 Approximate as Volume Source

6. PRIMARY AND SECONDARY CRUSHING**6.1 CRUSHER LOADING**

X co-ord (m)	724,050	
Y co-ord (m)	8,556,280	
Emission of TSP =	0.0015	kg/t
Emission of PM10 =	0.0007	kg/t
Operating days / yr	365	days
Hours / day	9	hrs
Tonnes Extracted =	200000	t/yr
Control Efficiency	98	%

TSP Emission (kg/annum) =**6**

TSP Emission (g/s) =

0.001

PM10 Emission (kg/annum) =**3**

PM10 Emission (mg/s) =

0.2

6.2 PRIMARY CRUSHING

X co-ord (m)	724,050	
Y co-ord (m)	8,556,280	
Emission of TSP =	0.2	kg/t
Emission of PM10 =	0.02	kg/t
Operating days / yr	365	days
Hours / day	9	hrs
Tonnes Extracted =	200000	t/yr
Control Efficiency	98	%

TSP Emission (kg/annum) =**800**

TSP Emission (g/s) =

0.1

PM10 Emission (kg/annum) =**80**

PM10 Emission (mg/s) =

7

6.3 SECONDARY CRUSHING

X co-ord (m)	724,050	
Y co-ord (m)	8,556,280	
Emission of TSP =	0.6	kg/t
Emission of PM10 =	0.24	kg/t
Operating days / yr	365	days
Hours / day	9	hrs
Tonnes Extracted =	180000	t/yr
Control Efficiency	98	%

TSP Emission (kg/annum) =**2160**

TSP Emission (g/s) =

0.18

PM10 Emission (kg/annum) =**864**

PM10 Emission (mg/s) =

73

Comments

Crushing plant baghouse

Un/Loading trucks, p 43 Mining EET Handbook

Note: Loader picks up ore and dumps into hopper.

Emission factor is same as for loading. In this case loader dumps into hopper instead of truck. Therefore no need to calc unloading emissions.

Assume operates only during day shift

Baghouses on Dust Extraction

Fraction of TSP

Crushing plant baghouse

Low moisture ore, default factor, pg 14 Mining EET handbook

Includes screens, crusher, surge bin, apron feeder, conveyer belt transfer points

Assume operates only during day shift

Baghouses on Dust Extraction

Fraction of TSP

Crushing plant baghouse

Low moisture ore, default factor, pg 14 Mining EET handbook

Assumed from ratio of emission factors for high moisture ore

Assume operates only during day shift

Baghouses on Dust Extraction

Fraction of TSP

7. STOCKPILES, PLANT HANDLING

7.1 LOADING TO ROM PAD STOCKPILE

X co-ord (m)	724,050	
Y co-ord (m)	8,556,260	
Emission of TSP =	0.004	kg/t
Emission of PM10 =	0.002	kg/t
Operating days / yr	365	days
Hours / day	9	hrs
Tonnes Loaded =	160000	t/yr
Control Efficiency	0	%

TSP Emission (kg/annum) =

640

TSP Emission (g/s) =

0.05

PM10 Emission (kg/annum) =

272

PM10 Emission (mg/s) =

23

7.2 UNLOADING FROM ROM PAD STOCKPILE

X co-ord (m)	724,050	
Y co-ord (m)	8,556,240	
Emission of TSP =	0.03	kg/t
Emission of PM10 =	0.013	kg/t
Operating days / yr	365	days
Hours / day	24	hrs
Tonnes Unloaded =	160000	t/yr
Control Efficiency	0.0	%

TSP Emission (kg/annum) =

4800

TSP Emission (g/s) =

0.15

PM10 Emission (kg/annum) =

2080

PM10 Emission (mg/s) =

66

7.3 LOADING TO LIME STORAGE

X co-ord (m)	724,110	
Y co-ord (m)	8,556,270	
Emission of TSP =	0.004	kg/t
Emission of PM10 =	0.002	kg/t
Operating days / yr	12	days
Hours / day	1	hrs
Tonnes Extracted =	7820	t/yr
Control Efficiency	99	%

TSP Emission (kg/annum) =

1

TSP Emission (g/s) =

0.01

PM10 Emission (kg/annum) =

0

PM10 Emission (mg/s) =

6.15

Comments

Northern end of stockpile

Default emission factor, Coal Mines, pg 12 Mining EET handbook

Default emission factor, Coal Mines, pg 12 Mining EET handbook

Fraction of TSP

Approximate as Volume Source

From middle reference point

Default emission factor, Coal Mines, pg 12 Mining EET handbook

Default emission factor, Coal Mines, pg 12 Mining EET handbook

Fraction of TSP

Approximate as Volume Source

Lime Storage Baghouse

Default emission factor, Coal Mines, pg 12 Mining EET handbook

Default emission factor, Coal Mines, pg 12 Mining EET handbook

Monthly delivery

0.626 kg/kg product (12,500 t/yr)

Enclosed with bag house

Fraction of TSP

7.4 UNLOADING FROM LIME STORAGE

X co-ord (m)	724,110		Lime Storage Baghouse
Y co-ord (m)	8,556,270		
Emission of TSP =	0.030	kg/t	Default emission factor, Coal Mines, pg 12 Mining EET handbook
Emission of PM10 =	0.013	kg/t	Default emission factor, Coal Mines, pg 12 Mining EET handbook
Operating days / yr	365	days	Daily loading to kiln
Hours / day	1	hrs	
Tonnes Extracted =	7820	t/yr	0.626 kg/kg product (12,500 t/yr)
Control Efficiency	99	%	Enclosed with bag house

TSP Emission (kg/annum) =**5**

TSP Emission (g/s) =

0.004

PM10 Emission (kg/annum) =**2**

PM10 Emission (mg/s) =

1.55

Fraction of TSP

7.5 CONVEYOR TO ROTARY KILN

X co-ord (m)	724,071		SW corner (line source)
Y co-ord (m)	8,556,240		
Emission of TSP =	0.06	kg/t	Low moisture ore, default factor, pg 14 Mining EET handbook
Emission of PM10 =	0.03	kg/t	Low moisture ore, default factor, pg 14 Mining EET handbook
Assume X =	1.5	m	
Assume Y =	64	m	
Operating days / yr	365	days	
Hours / day	24	hrs	
Tonnes Extracted =	160000	t/yr	
Control	0.7	%	Enclosed

TSP Emission (kg/annum) =**2880**

TSP Emission (g/s) =

0.09

TSP Emission (g/m²/s) =

0.00

PM10 Emission (kg/annum) =**1440**

PM10 Emission (mg/s) =

46

PM10 Emission (mg/m²/s) =

0.5

Fraction of TSP

Approximate as Line Source

SUMMARY (kg/annum)

	TSP	PM₁₀	MgO
Initial Open Cut	2,066	668	
Wind Erosion Exposed Areas	9,687	4,844	798
Drilling & Blasting	43,671	22,709	
Un/Loading Pit, ROM, Waste Dump, Fines, Slag	6,268	2,925	1,346
Primary & Secondary Crushing	2,966	947	
Stockpiles, Plant Handling	8,325	3,794	
TOTAL	72,984	35,887	2,143

Mt Grace Emissions Inventory: Vehicles, Stage One

Vehicle Type	Table 4, Mining EET Handbook	Fuel Used L/hr	Operation hrs/yr	Fuel Used L	PM10 CO NOx SO2 VOCs (kg/1000 L fuel)					PM10 CO NOx SO2 VOCs (kg/annum)				
					PM10	CO	NOx	SO2	VOCs	PM10	CO	NOx	SO2	VOCs
Track type tractor	1 x CAT 375 Excavator	50	500	25,000	3.03	9.4	34.16	1.7	3.31	76	235	854	43	83
Track type tractor	Drill (Equiv fuel use estimate)	50	800	40,000	3.03	9.4	34.16	1.7	3.31	121	376	1366	68	132
Scraper	Scaper for topsoil*	50	126	6,300	3.27	10.16	30.99	1.7	2.28	21	64	195	11	14
Grader	1 x CAT 12H Grader	15	200	3,000	2.66	6.55	30.41	1.7	1.53	8	20	91	5	5
Off-highway truck	6 x CAT 773 Truck	50	2000	100,000	17.7	14.73	34.29	1.7	1.58	1770	1473	3429	170	158
Off-highway truck	1 x Water Cart	50	200	10,000	17.7	14.73	34.29	1.7	1.58	177	147	343	17	16
Wheeled loader	1 x CAT 966G FEL	25	500	12,500	3.51	11.79	38.5	1.7	5.17	44	147	481	21	65
	Table 3, Combustion Engine EET Handbook	Ave km/hr		VKT	PM10	CO	NOx	SO2	VOCs	PM10	CO	NOx	SO2	VOCs
					(kg/VKT fuel)					(kg/annum)				
Light Vehicle	2 x Light Vehicles	20	2000	40,000	1.93E-04	7.78E-04	6.36E-04	6.70E-05	2.08E-04	7.7	31.1	25.4	2.7	8.3
TOTAL (kg/annum)										2,224	2,493	6,785	337	481

*Assumes scraper operates 9 hrs/day, 14 days only

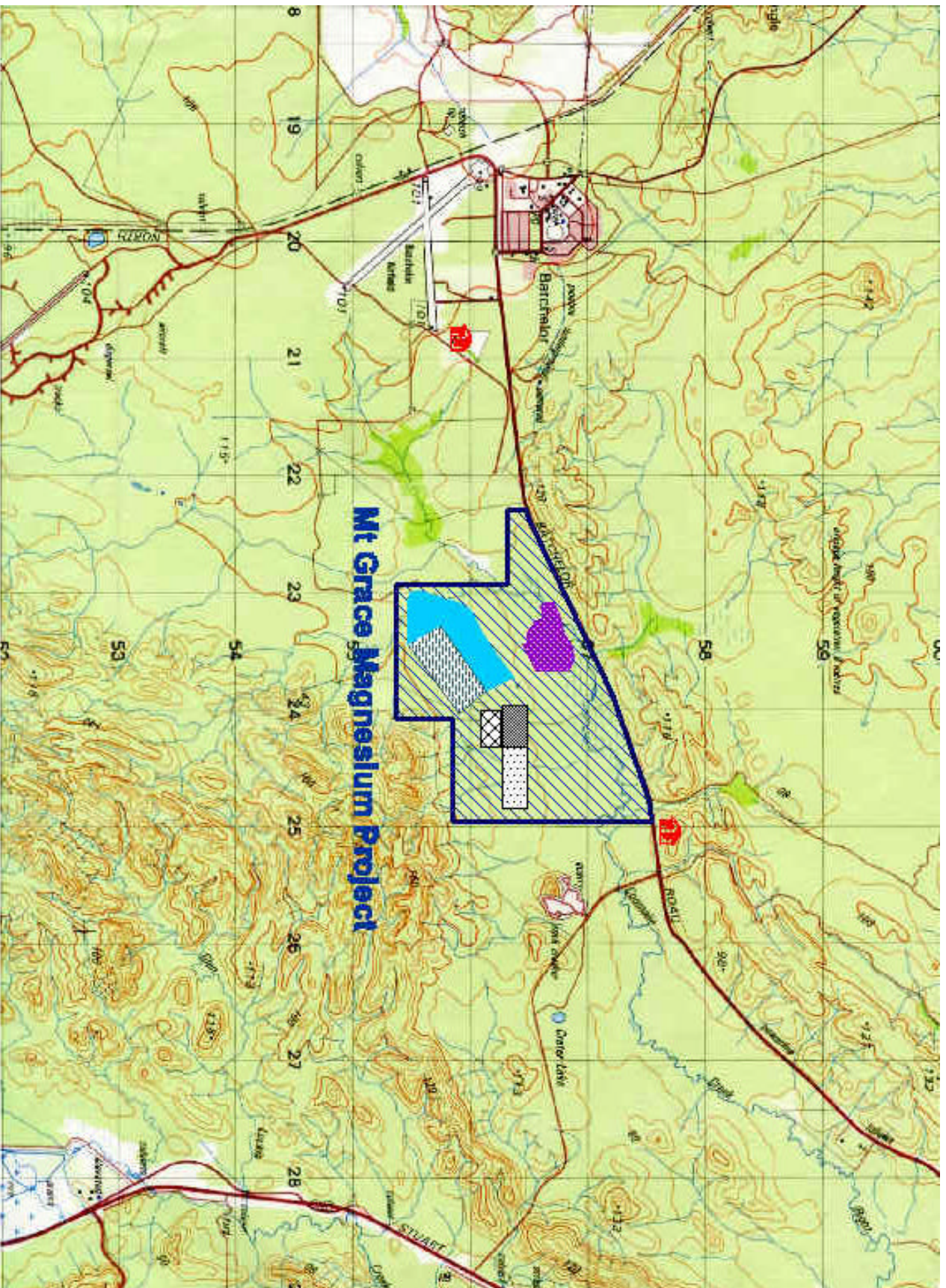
Mt Grace Emissions Inventory: Vehicles, Stage Two

Vehicle Type	Table 4, Mining EET Handbook	Fuel Used L/hr	Operation hrs/yr	Fuel Used L	PM10	CO	NOx	SO2	VOCs	PM10	CO	NOx	SO2	VOCs
					(kg/1000 L fuel)					(kg/annum)				
Track type tractor	1 x CAT 375 Excavator	50	500	25,000	3.03	9.4	34.16	1.7	3.31	76	235	854	43	83
Track type tractor	Drill (Equiv fuel use estimate)	50	800	40,000	3.03	9.4	34.16	1.7	3.31	121	376	1366	68	132
Scraper	Scaper for topsoil	50	0	0	3.27	10.16	30.99	1.7	2.28	0	0	0	0	0
Grader	1 x CAT 12H Grader	15	200	3,000	2.66	6.55	30.41	1.7	1.53	8	20	91	5	5
Off-highway truck	3 x CAT 773 Truck	50	1000	50,000	17.7	14.73	34.29	1.7	1.58	885	737	1715	85	79
Off-highway truck	1 x Water Cart	50	200	10,000	17.7	14.73	34.29	1.7	1.58	177	147	343	17	16
Wheeled loader	1 x CAT 966G FEL	25	400	10,000	3.51	11.79	38.5	1.7	5.17	35	118	385	17	52
	Table 3, Combustion Engine EET Handbook	Ave km/hr		VKT	PM10	CO	NOx	SO2	VOCs	PM10	CO	NOx	SO2	VOCs
					(kg/VKT fuel)					(kg/annum)				
Light Vehicle	2 x Light Vehicles	20	2000	40,000	1.93E-04	7.78E-04	6.36E-04	6.70E-05	2.08E-04	7.7	31.1	25.4	2.7	8.3
TOTAL (kg/annum)										1,310	1,663	4,779	237	375

*Non operational after Stage One

Mt Grace Emissions Inventory: Processing Plant, Stage Three








Stack ID	Pollutant	X co-ord m	Y co-ord m	Height m	Diam m	Velocity m/s	Flow Am3/s	H2O %	Temp °C	Flow Nm3/s	Emission g/s	Emission mg/Nm3	Emission T/yr	Abatement / Comment
Magnesite Kilns 1 & 2														Cyclone, Electrostatic Precipitator
Ex Magnesite Kilns 1 & 2, Casting, DCF & condenser off-gases														
ST01	TSP	724130	8556255	63	2.0	16.7	52.3	16.4	500	15.5	0.3	20.0	9.8	Equivalent to Stage 2 Emissions
ST01	PM ₁₀	724130	8556255	63	2.0	16.7	52.3	16.4	500	15.5	0.2	10.0	4.9	
ST01	MgO	724130	8556255	63	2.0	16.7	52.3	16.4	500	15.5	0.1	8.7	4.2	
ST01	NOx as NO ₂	724130	8556255	63	2.0	16.7	52.3	16.4	500	15.5	4.4	282	138	
ST01	CO	724130	8556255	63	2.0	16.7	52.3	16.4	500	15.5	5.1	328	160	
ST01	SO ₂	724130	8556255	63	2.0	16.7	52.3	16.4	500	15.5	0.01	0.4	0.2	
Acid Scrubber 1														
Ex Refining & Casting														
ST02	SO ₂	724295	8556250	18	1.0	15.0	11.8	10	50	9.0	0.02	1.8	0.5	Scrubber, 99% efficiency
														Equivalent to Stage 2 emissions
Ammonia Scrubber 1														
Ex Sludge Processing & Condenser Residue Treatment														
ST03	NH ₃	724295	8556240	18	1.0	15.0	11.8	10	50	9.0	0.1	12	3.5	Scrubber, 99% efficiency
														Equivalent to Stage 2 emissions
Lime Storage Baghouse														
ST04	TSP	724110	8556270	18	1.0	8.1	6.4	10	25	5.3	0.01	2.0	0.3	Assume 1/2 full, 5 room changes per hour, 50 x 20 x 10 m
ST04	PM ₁₀	724110	8556270	18	1.0	8.1	6.4	10	25	5.3	0.01	2.0	0.3	
Crusher Baghouse 1														
Loading of fines, loading crusher, primary & secondary crushing														
ST05	TSP	724050	8556280	18	1.5	15.0	27	10	25	22	0.5	23	5.9	Equivalent to Stage 2 emissions
ST05	PM ₁₀	724050	8556280	18	1.5	15.0	27	10	25	22	0.2	7	1.9	
Magnesite Kiln 3														
Ex Magnesite Kiln 3, Casting Plant 2, DCF 2 & Condenser 2 off-gases. Also includes Lime Kiln Emissions														
ST06	TSP	724110	8556210	63	3.0	16.0	113.0	17.1	500	33.1	0.7	20	21	Stack diameter increased from Stage 2 to accommodate increased flow
ST06	PM ₁₀	724110	8556210	63	3.0	16.0	113.0	17.1	500	33.1	0.3	10	10	Includes emissions from Lime Kiln
ST06	MgO	724110	8556210	63	3.0	16.0	113.0	17.1	500	33.1	0.3	8.7	9	
ST06	NOx as NO ₂	724110	8556210	63	3.0	16.0	113.0	17.1	500	33.1	4.7	141	147	
ST06	CO	724110	8556210	63	3.0	16.0	113.0	17.1	500	33.1	5.8	176	184	
ST06	SO ₂	724110	8556210	63	3.0	16.0	113.0	17.1	500	33.1	0.01	0.2	0.2	
Acid Scrubber 2														
Ex Refining & Casting Plant 2														
ST07	SO ₂	724295	8556175	18	1	15	11.8	10	50	9.0	0.02	1.8	0.5	Scrubber, 99% efficiency
														Assumed equivalent to Acid Scrubber 1
Ammonia Scrubber 2														
Ex Sludge Processing & Condenser Residue Treatment 2														
ST08	NH ₃	724295	8556165	18	1	15	11.8	10	50	9.0	0.11	12	3.5	Scrubber, 99% efficiency
														Assumed equivalent to Ammonia Scrubber 1
Crusher Baghouse 2														
Loading of fines, loading crusher, primary & secondary crushing														
ST09	TSP	724050	8556200	18	1.5	15.0	27	10	25	22	1	23	5.9	Equivalent to Crusher 1
ST09	PM ₁₀	724050	8556200	18	1.5	15.0	27	10	25	22	0	7	1.9	



**FIGURE 4-1 LOCATION OF SITE AND NEAREST RESIDENCES
MT GRACE RESOURCES MAGNESIUM PROJECT**



Key

-  Furnace Storage
-  ROM Pad
-  Plant & Crusher
-  Pit
-  Waste Dump
-  Slag Dump
-  Nearest Residences

Client:
Mt. Grace Resources

Project:
Magnesium Oxide Plant

Job No.: 48082-002

File: Site.aif
Source: Basemap.jpg
Date: 9 Jan 2012
Revisor: B
Designed: LPW
Checked: KRA

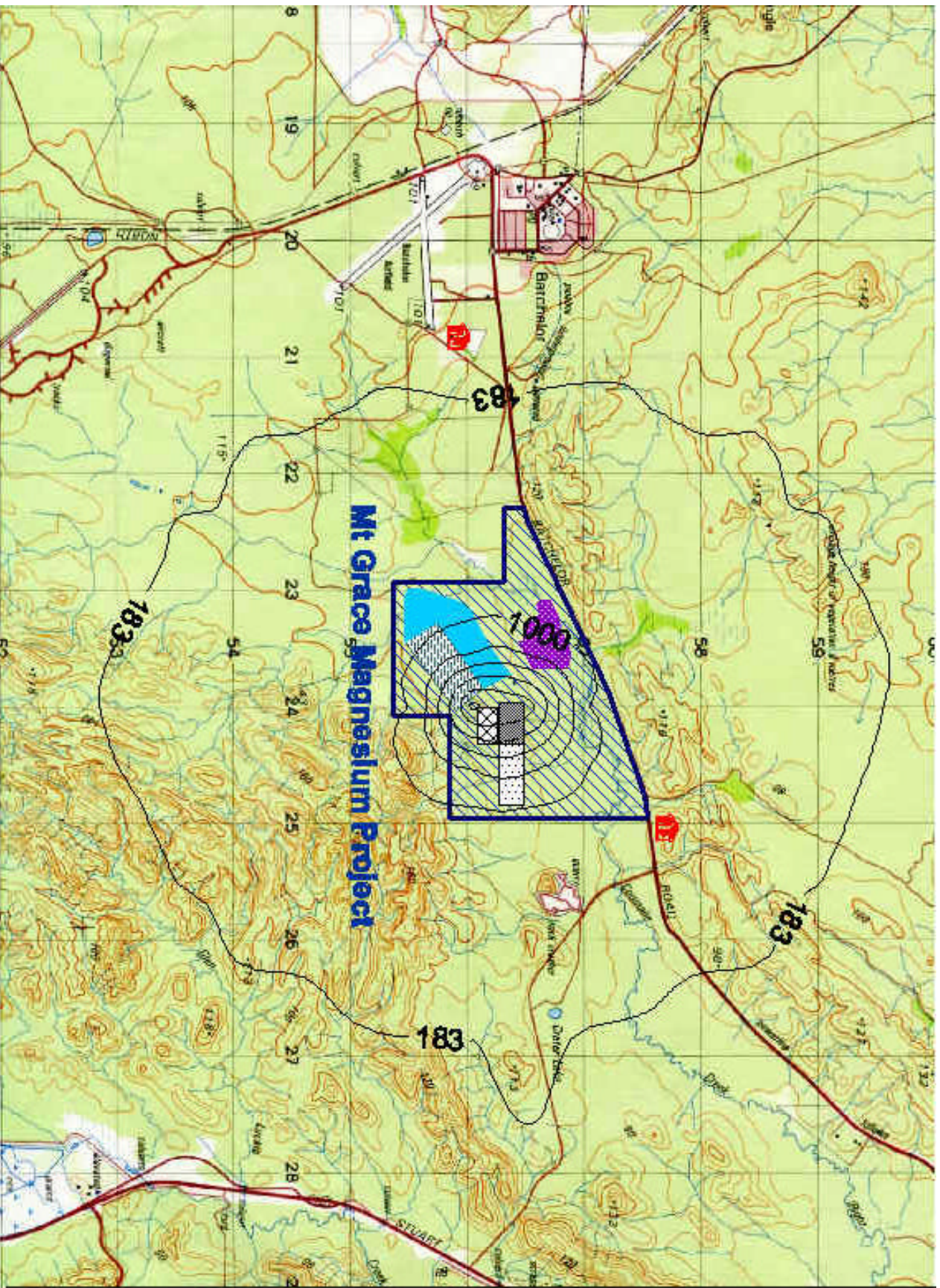









Figure 5-1 Stage One: Maximum Predicted Downwind Concentrations TSP (µg/m³), 1-hr average. (Guideline = 183 µg/m³)



Key

-  Fines Storage
-  ROM Pad
-  Plant & Crusher
-  PH
-  Waste Dump
-  Slag Dump
-  Nearest Residences

Client:
Mt Grace Resources

Project:
Magnesium Oxide Plant

Job No.: 48082-002

File: S1_TSP_01f
Source: Modelling S1.xls
Date: 18 Dec 2001
Revision: A
Designed: LFW
Checked: KFA

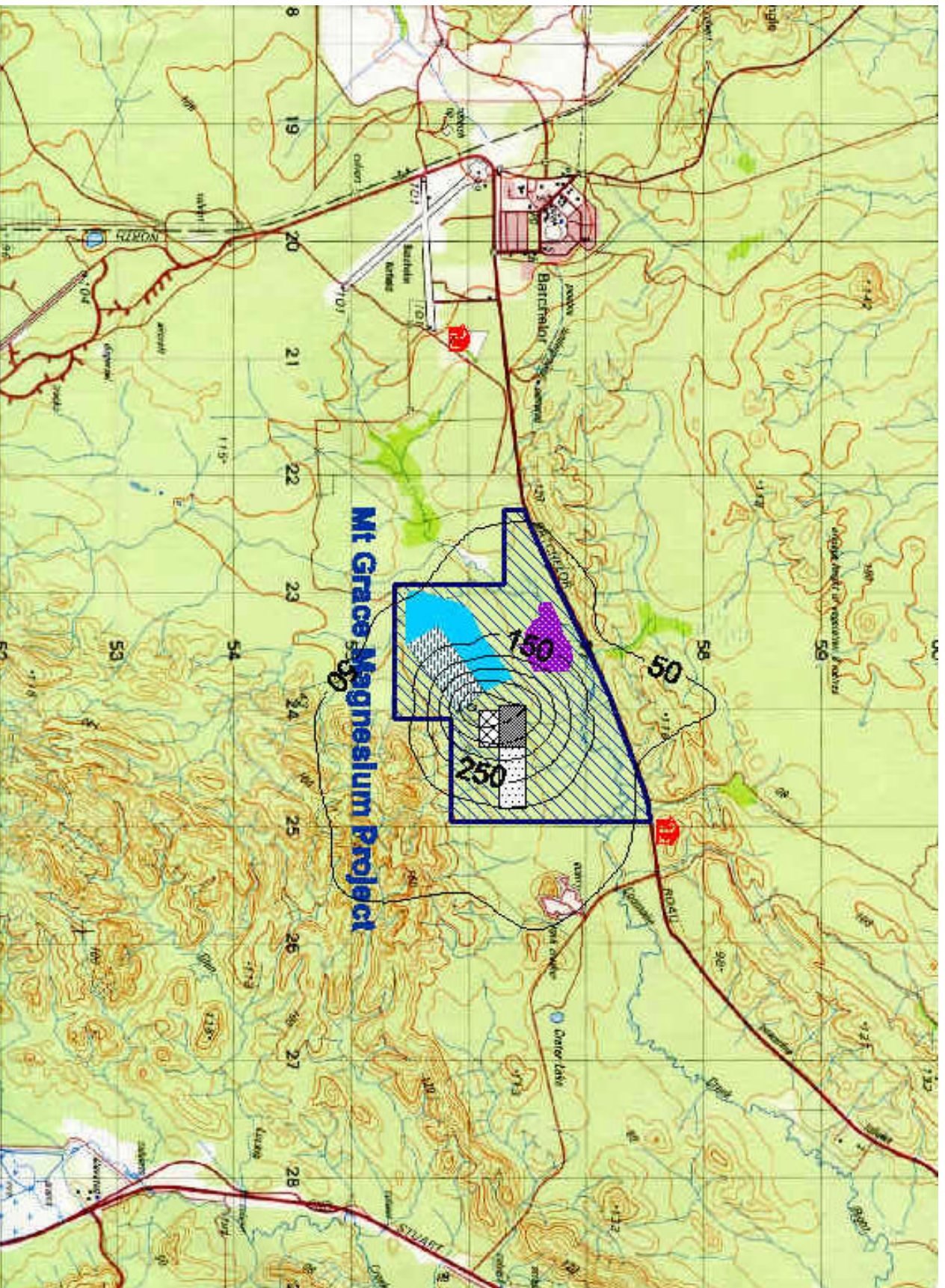
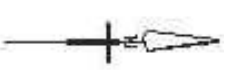









Figure 5-2 Stage One: Maximum Predicted Downwind Concentrations PM10 (µg/m³), 24-hr average. (Guideline = 110 µg/m³)



Key

-  Fine Storage
-  ROM Pad
-  Plant & Crusher
-  Pit
-  Waste Dump
-  Slag Dump
-  Nearest Residences

Client
Mt Grace Resources

Project
Magnesium Oxide Plant

Job No.: 48062-002

File: S1_pm10_24.srf
Source: Modelling S1.xls
Date: 18 Dec 2001
Revision: C
Designed: LPW
Checked: KRA

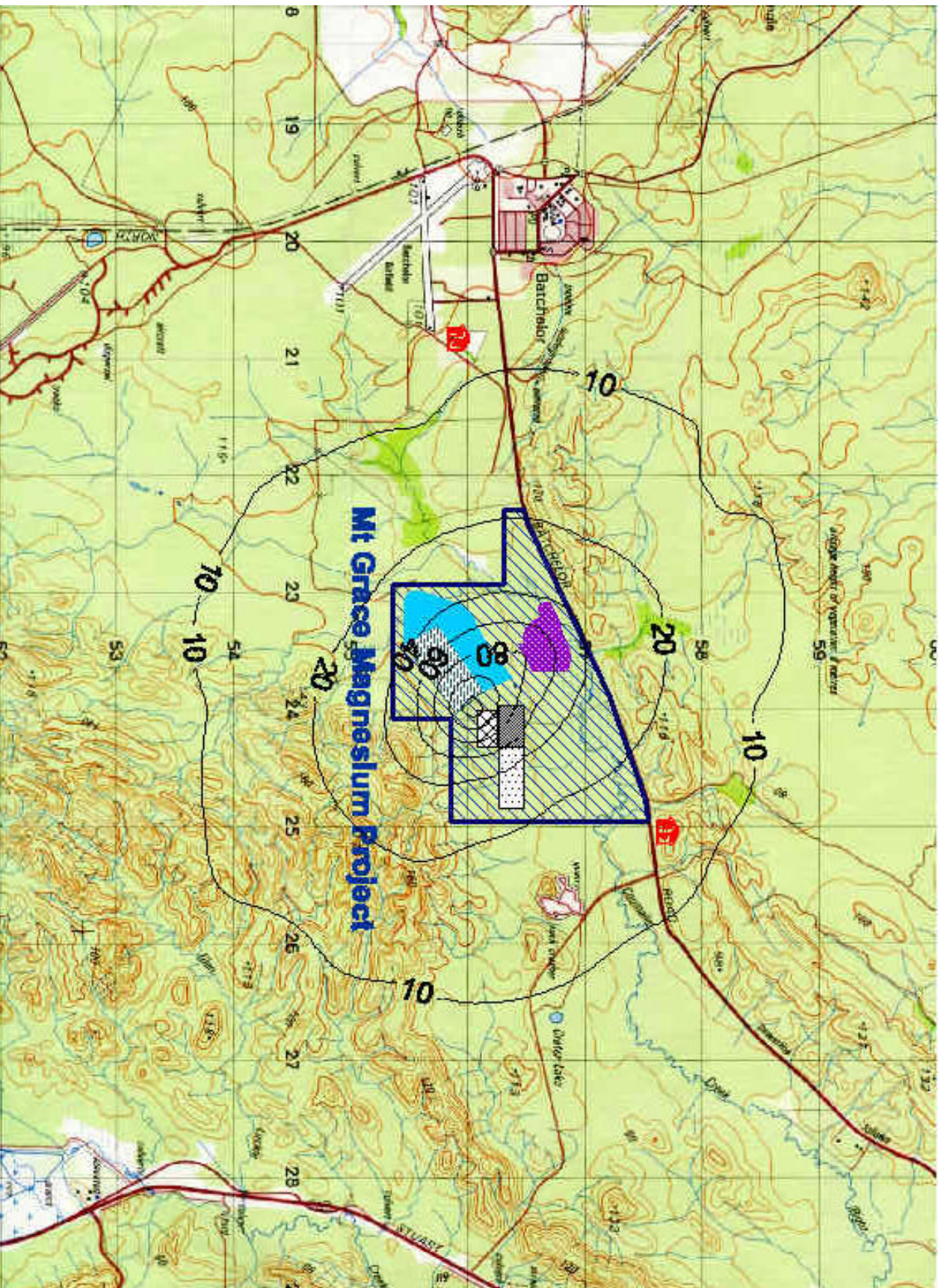


Figure 5-3 Stage One: Maximum Predicted Downwind Concentrations Magnesium Oxide (MgO) ($\mu\text{g}/\text{m}^3$), 1-hr average. (Guideline = 20 $\mu\text{g}/\text{m}^3$)



Key

-  Furnace Storage
-  ROM Pad
-  Plant & Crusher
-  Pit
-  Waste Dump
-  Slag Dump
-  Nearest Residences
- Client:**
Mt. Grace Resources
- Project:**
Magnesium Oxide Plant
- Job No.:** 48302-002
- File:** S1_MgO.dwg
- Source:** Modelling S1.xls
- Date:** 18 Dec 2001
- Revision:** A
- Designed:** LPW
- Checked:** KPA

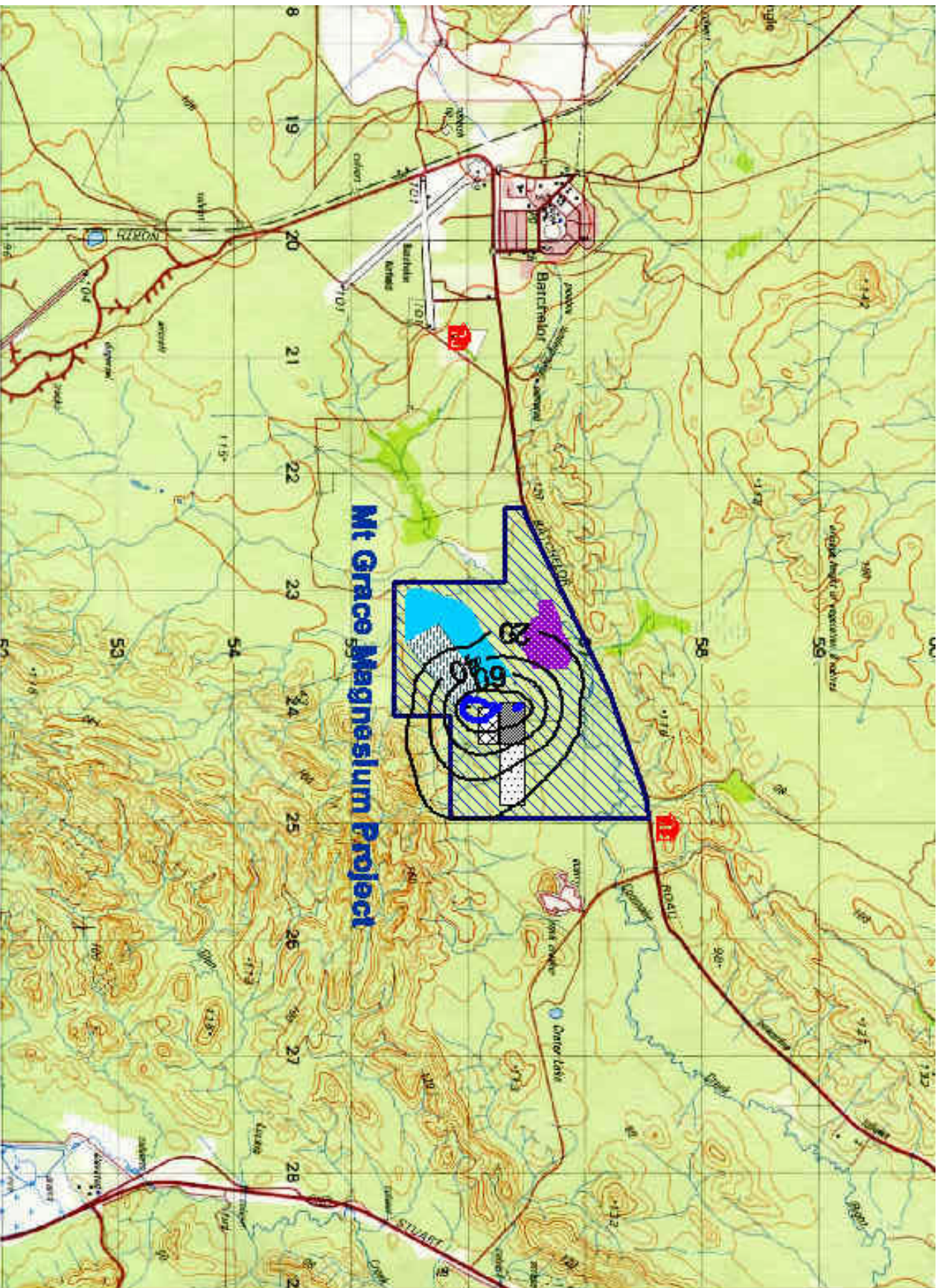


Figure 6-2 Stage One: Maximum Predicted Downwind Concentrations of TSP ($\mu\text{g}/\text{m}^3$). Annual average. (Guideline in blue = $90 \mu\text{g}/\text{m}^3$)



- Key**
- Fine Storage
 - ROM Pad
 - Plant & Crusher
 - Pit
 - Waste Dump
 - Slag Dump
 - Nearest Residences
- Client:**
Mt Grace Resources
- Project:**
Magnesium Oxide Plant
- Job No.:** 48082-002
- File:** S1_TSP.gif
Source: Modelling S1.xls
Date: 8 Jan 2002
Revisior: B
Designed: LPW
Checked: KPA

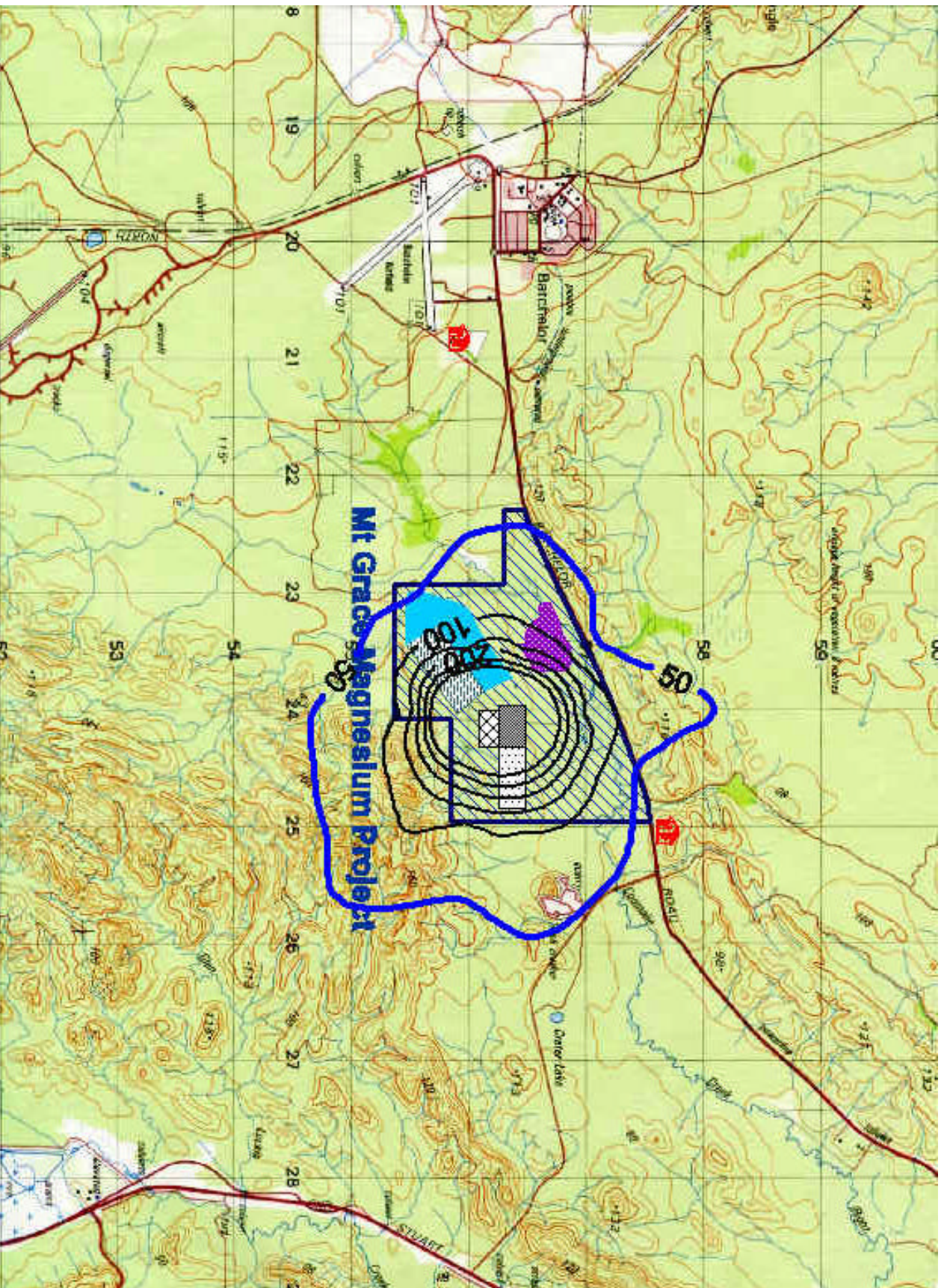
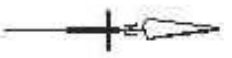


Figure 6-2 Stage One: Maximum Predicted Downwind Concentrations of PM10 (µg/m3), 24-hr average. (Guideline in blue = 50 µg/m3)



- Key**
- Fine Storage
 - ROM Pad
 - Plant & Crusher
 - Pit
 - Waste Dump
 - Slag Dump
 - Nearest Residences
- Client**
Mt Grace Resources
- Project**
Magnesium Oxide Plant
- Job No.:** 48062-002
- File:** S1_pm10_24.srf
Source: Modeling S1.xls
Date: 8 Jan 2002
Revision: D
Designed: LPW
Checked: KRA

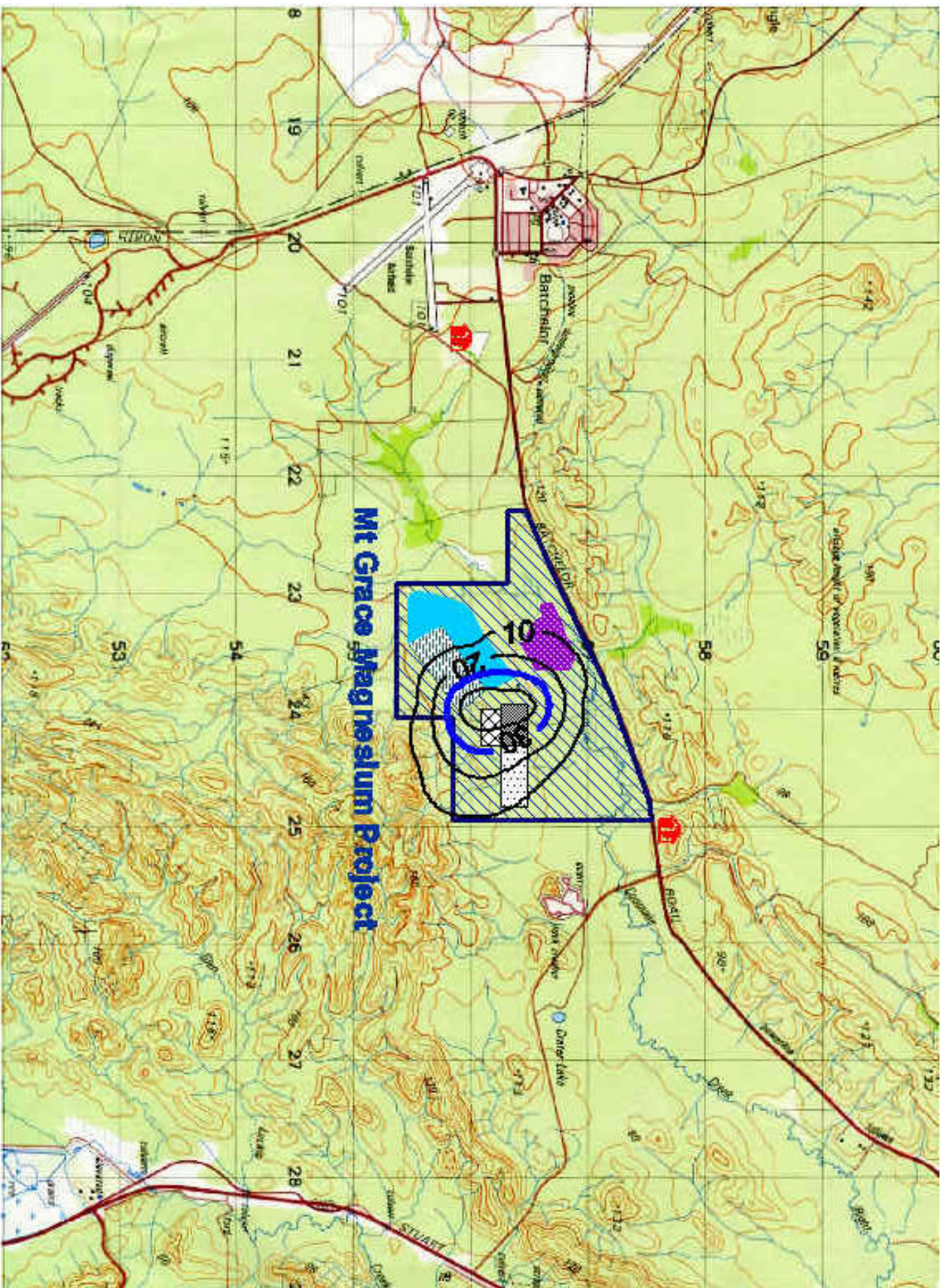









Figure 6-3 Stage One: Maximum Predicted Downwind Concentrations of PM10 (µg/m3), Annual average. (Guideline in blue = 30 µg/m3)



Key

-  Fines Storage
-  ROM Pad
-  Plant & Crusher
-  Pmt
-  Waste Dump
-  Stagg Dump
-  Nearest Residences

Client
Mt Grace Resources

Project
Magnesium Oxide Plant

Job No.: 48082-002

File: 81_pmt0_ann.rsf
Source: Modelling S1.xls
Date: 9 Jan 2012
Revised: D
Designed: LPW
Checked: KRA