Tungsten West Environmental Permit Application – H1 Screening and Atmospheric Dispersion Modelling

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Rev. No	Description / Comments	Author	Checked By	Approved By	Issue Date
1	Original document prepared and submitted by SLR Consulting Limited on behalf of Wolf Minerals (UK) Limited.	SLR Consulting Limited	A. Dawson	M. Denning	Sep-21

Originator's Name:	SLR Consulting Limited	**Proposed Date:**	Sep-21
Proposal: *Briefly describe what is the intended change*			
To review document TWL-CP-PA-EN-006.3.24.1 original doc number 412-01939-00003 Emissions to airH1 Screening and Atmospheric Dispersion Modelling prepared and submitted by SLR Consulting Limited. The document is to be reviewed by a person deemed competent by Tungsten West Limited to ensure that all information contained in the review document is still valid for the purpose based upon the current operational status of the Hemerdon Tungsten Mine (Quarry).			

Reason for Change: *Choose an option(s) below and give a brief reason*	
Safety Improvement	
Cost Reduction	
Sustain Production	
Increase Production	
Compliance	To ensure integration with TWL business management systems and satisfy requirements for bespoke installation permit application guidance
Other	
Temporary	
Permanent	
Estimated Start Date:	Sep-21
Estimated Cost:	

Change Assessment: *Identify all the type of changes required*	
Type of Change	**Brief Detail**
Statuary Approval or Notice	
Equipment Design or Construction	
Equipment operating parameters	
Operating Environment	
People Training	
Procedures etc	Integration of legacy documentation and procedures within TWL business management system
Maintenance	
Supply/Stocked Item	
HSE or Emergency Response	

Change Review:

I have reviewed the changes that have taken place and they are in line with the original proposal, and in my opinion do not create any Health, Safety or Environmental hazards.

Originator Name: SLR Consulting Limited

Reviewer's Name: Alex Dawson (PIEMA)
Manager Signature: Max Denning Date: Sep-21

Drakelands Mine

Emissions to Air

H1 Screening and Atmospheric Dispersion Modelling

SLR Ref: 412-01939-00003

January 2014

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1.0 INTRODUCTION

Wolf Minerals (UK) Limited (Wolf) seek planning permission for the inclusion of a 'Reduction Kiln' and other changes to the Mineral Processing Facility (MPF) at its wolframite and cassiterite mine at Drakelands. The Drakelands Mine is located 10km north east of Plymouth in Devon.

The MPF will include a Reduction Kiln in order to reduce haematite to magnetite. The reduction kiln will be fired on diesel or liquid petroleum gas and will be equipped with an off-gas scrubbing system. The emission to air will comprise both typical combustion products associated with the fuel source and off-gas from the processing of the ore in a reducing atmosphere i.e. nitrogen oxides, sulphur dioxide, carbon monoxide and particulate potentially containing low levels of arsenic after scrubbing.

This report presents the air quality risk assessment in support of the Environmental Permit application.

1.1 Scope of Assessment

The scope of this assessment is limited to consideration of the emissions to air. The assessment of Reduction Kiln process emissions has been undertaken in combination with other emissions to air from the MPF installation and Directly Associated Activities including:

- from two Dryer Plants (that also use diesel as their fuel source) and may also include entrained particulate; and
- the Primary Crusher bag house particulate emissions.

The scope includes an assessment of potential cumulative (or in-combination) impacts with the Mine Waste Facility (MWF) regulated by the Environment Agency and other emissions from mine activities.

The report considers potential risk as a result of airborne emissions and assesses potential impacts by comparison to Air Quality Standards and regulatory benchmarks (Environmental Assessment Levels) for the protection of human health and the environment.

1.2 Objectives

The objective of this report is to undertake an assessment of potential impacts using Environment Agency (the Agency) H1 Environmental Risk Assessment guidance (specifically it is Annex f[1] of this guidance that applies to air emissions).

1.3 Report Structure

The remainder of the report is structured as follows:

- Section 2 details the relevant guidance and environmental quality standards/benchmarks;
- Section 3 describes the baseline environment with regard to sensitive receptors and prevailing meteorological conditions;
- Section 4 describes the methodology applied in screening and assessment;
- Section 5 details the H1 Screening Assessment; and
- Section 6 details the results of the dispersion modelling.

[1] Environment Agency H1 Environmental Risk Assessment – annex f v2.1.

2.0 GUIDANCE AND ENVIRONMENTAL BENCHMARKS

2.1 Environmental Permitting Regulations and Guidance

Emissions to air from the installation will be controlled under the Environmental Permitting (England and Wales) Regulations by the Environment Agency (the Agency). Guidance has been produced by the Agency to assist operators to assess risks to the environment and human health when applying for a permit under the EP Regulations, these include both over arching 'horizontal' guidance and sector specific guidance. Guidance that has been consulting in undertaking this assessment includes:

- *Horizontal Guidance Note H1 - Environmental risk assessment for permits*[2]. Annex F[3] of the H1 Guidance Note is specifically concerned with emissions to air and the process of carrying out a bespoke risk assessment. Included in Annex F of the H1 Guidance Note are Environmental Assessment Levels (EALs) for protection of human health and the environment.
- Sector Guidance Note - *Non-Ferrous Metals and the Production of Carbon and Graphite (EPR 2.03)*[4]*.* This guidance describes the standards and measures that businesses are expected to take in order to control the risk of pollution. Included in this guidance are benchmarks for emissions to air for pollutants of concern.

2.2 Local Air Quality Management

Part IV of the Environment Act 1995 requires local authorities to review and assess existing and predict future air quality in their areas as part of a rolling 'review & assessment' process. In areas where exceedences of one or more of the air quality objectives are predicted the local authority must designate an Air Quality Management Area (AQMA). Once designated; the local authority must then draw up an Air Quality Action Plan (AQAP) setting out the measures it intends to take in pursuit of achieving the air quality objectives in the AQMA.

The core guidance documents for use by persons involved in Local Air Quality Management (LAQM), or considering the impacts of a development with the potential to impact on air quality as covered by LAQM, are LAQM.TG(09)[5] and LAQM.PG(09)[6].

An Agency position statement[7] clarified the role of the Agency in relation to Local Air Quality management, stating:

> *'In discharging its pollution control functions, the Agency has a statutory responsibility under the Environment Act 1995 to have regard to the Government's Air Quality Strategy, including the achievement of the air quality standards and objectives'*
>
> *'The Agency has an important role to play in this process ……… through the provision of information and the regulation of emissions to air from processes it regulates'.*

[2] Environment Agency, Horizontal Guidance Note H1 - Environmental risk assessment for permits v2.1 (April 2010).

[3] Environment Agency, Horizontal Guidance Note H1 - Annex (f) Air Emissions (February 2012).

[4] Environment Agency, How to comply with your environmental permit Additional guidance for: Non - Ferrous Metals and the Production of Carbon and Graphite (EPR 2.03) (March 2009)

[5] DEFRA, Local Air Quality Management Technical Guidance LAQM.TG(09), (February 2009).

[6] DEFRA, Local Air Quality Management Policy Guidance, LAQM.PG(09) (February 2009).

[7] Position statement (July 2003) setting out the Environment Agency's policy position on air quality.

2.3 The Air Quality Strategy

The UK Air Quality Strategy[8] (UK AQS) sets out a comprehensive strategic framework within which air quality policy will be taken forward in the short to medium term, and the roles that Government, industry, the Environment Agency, local government, business, individuals and transport have in protecting and improving air quality.

The UK AQS contains air quality objectives based on the protection of both human health and vegetation (ecosystems) and have been set taking into account the air quality standards defined in the Air Quality Standards Regulations 2010[9] (the '2010 Regulations').

The 2010 Regulations are in turn are defined by 'limit values' contained in the following Directives of the European Parliament and of the Council:

- Directive 2008/50/EC on ambient air quality and cleaner air for Europe; and
- Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.

The UKAQS includes more exacting objectives for some pollutants than those required by EC legislation. This air quality assessment refers only to UK Air Quality Standards, as compliance with these standards will also ensure that the less demanding European Air Quality limit values would also be met.

A summary of the air quality standards relevant to this assessment is provided in the Section 2.4 *Environmental Quality Standards*.

2.4 Environmental Quality Standards

The Environmental Quality Standards applied in this assessment, on the basis of the policy, legislation and guidance described in this section are presented in the sections below.

2.4.1 Air Quality Standards and Objectives

The AQS objectives and standards relevant to this assessment are presented in Table 2-1 below.

Table 2-1
AQS Objectives and Air Quality Standards

Pollutant	Limit Value	Measured as
Carbon monoxide (CO)	10 mg/m^3	Maximum daily running 8 hour mean
Nitrogen dioxide (NO_2)	200 µg/m^3	1 hour mean (18 exceedences per year 99.79%ile of hourly averages)
	40 µg/m^3	Annual mean
Sulphur dioxide (SO_2)	266 µg/m^3	15 minute mean (35 exceedences per year; 99.90%ile of 15-min averages)
	350 µg/m^3	1 hour mean (24 exceedences per year; 99.73%ile of hourly averages)
	125 µg/m^3	24 hour mean (3 exceedences per year; 99.18%ile of 24-hr averages)
Particulate matter	40 µg/m^3	Annual mean

[8] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, DEFRA. July 2007
[9] Statutory Instrument 2010 No. 1001, 11th June 2010

Pollutant	Limit Value	Measured as
(PM_{10}) (gravimetric)	50 µg/m^3	24 hour mean (35 exceedences per year ; 90.4%ile of 24-hr averages)

In addition to these AQS objectives, the following additional 'target values' defined within the Air Quality Standard Regulations 2010 are of relevance to this assessment.

Table 2-2
Additional Air Quality 'Target Values'

Pollutant	Concentration	Measured as
Particulate matter ($PM_{2.5}$) (gravimetric)	25 µg/m^3 [(a)]	Annual mean
Arsenic	6 ηg/m^3	Annual mean

Table Notes:
a) AQ Regs 2010 includes an exposure reduction in accordance with Part 4.

2.4.2 Environmental Assessment Levels

For many substances which are released to air, 'standards' or 'objectives' have not been defined within the AQS. Where the necessary criteria are absent, the EA has adopted interim values known as Environmental Assessment Levels (EALs).

EAL's for Air (for the protection of human health)

The EAL's for the pollutants of concern in this assessment are taken from the AQS objectives and standards. Although for arsenic the EAL value is more stringent than the Air Quality Standard Regulations 'target' value at 3ηg/m^3 as an annual mean in PM_{10}.

EALs for Deposition

The EALs also include a suite of maximum deposition rates (MDRs) that are intended to be protective of soils. For arsenic the MDR is 0.02mg/m^2/day. The MDR's are derived from Soil Quality Criteria that are taken from '*Code of Practice for Agriculture Use of Sewage Sludge*'[10] and therefore protective of soils for agricultural use. The MDR in H1 is defined as '*the quantity of pollutant which can be added to the soil daily over 50 years before the selected soil quality criteria is exceeded*'. For a process that is not operating for 50 years, such as the proposed reduction kiln (that will operate for approximately 15 years), the MDR can be adjusted. An MDR based on 15 years deposition would be 0.07mg/m^2/day before the soil quality criteria is exceeded.

2.4.3 Critical Levels and Critical Loads

There are many areas in the UK which have been designated by a variety of UK and International bodies as being worthy of protection. These sites will contain species, communities or other receptors which will be sensitive to pollution for which indicative exposure thresholds for their protection have been defined. These thresholds are known as Critical Levels (for airborne concentrations) and Critical Loads (for deposition rates).

[10] Department of the Environment, Code of Practice for Agricultural Use of Sewage Sludge (1989).

Critical Levels

Critical levels are a quantitative estimate of exposure to one or more airborne pollutants in gaseous form, below which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge. Critical levels for the protection of vegetation and ecosystems are specified within relevant European air quality directives and corresponding UK air quality regulations (see Table 2-3).

Table 2-3
Critical Levels for the Protection of Vegetation and Ecosystems

Pollutant	Concentration (µg/m^3)	Measured as
Sulphur dioxide	10	Annual mean for sensitive lichen communities & bryophytes and ecosystems where lichens & bryophytes are an important part of the ecosystem's integrity
	20	Annual mean for all higher plants (all other ecosystems)
Nitrogen Oxides	30	Annual mean
	75	Daily mean

Critical Loads

Critical loads are a quantitative estimate of exposure to deposition of one or more pollutants, below which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge. Critical loads are set for the deposition of various substances to sensitive ecosystems. In relation to combustion emissions critical loads for eutrophication and acidification are relevant which can occur via both wet and dry deposition; however on a local scale only dry (direct deposition) is considered significant.

Empirical critical loads for eutrophication (derived from a range of experimental studies) are assigned based for different habitats, including grassland ecosystems, mire, bog and fen habitats, freshwaters, heathland ecosystems, coastal and marine habitats, and forest habitats and can be obtained from the UK Air Pollution Information System (APIS) website (www.apis.ac.uk/). The critical loads for nitrogen and acid deposition are presented in Section 11).

The development of effects-based critical loads for heavy metals in soils and freshwaters is currently subject to research. As a result the assessment of potential risks has been undertaken on the basis of a literature review for published critical load ranges. A report produced in response to a Convention of Long-Range Transboundary Air Pollution initiative titled, '*Critical Loads of copper, nickel, zinc, arsenic, chromium and selenium for terrestrial ecosystems at a European scale*[11]' provides a critical load for arsenic of 0.0822mg/m^2/day.

[11] G.J. Reinds J.E. Groenenberg W. de Vries. *Critical Loads of copper, nickel, zinc, arsenic, chromium and selenium for terrestrial ecosystems at a European scale.* Alterra-rapport 1355 Alterra, Wageningen, (2006)

3.0 BASELINE ENVIRONMENT

3.1 Site Setting and Sensitive Receptors

The proposed Reduction Kiln operations are located within an area characterised by historic and current quarrying and mining operations, in particular on land to the north and north east. The proposed MWF at Drakelands Mine is located approximately 60m to the north of the plant.

The city centre of Plymouth is located approximately 10km to the south west of the application site, with the suburban towns of Plympton, Chaddlewood, Woodford, Longbridge and Leigham extending to within approximately 2km south west of the site boundary.

The land surrounding Drakelands Mine is rural with isolated residential properties and farm buildings. The 'currently' residential properties within approximately 500m of the Drakelands Mine site boundary are subject to a Section 52 Agreement[12] and as such cannot be used for residential purposes. Some areas of the surrounding moors and woods are protected habitats and include Special Areas of Conservation, Ancient Woodlands and County Wildlife Sites.

The sections below describe the receptor locations included in the assessment on the basis of H1 and other regulatory guidance.

3.1.1 Human Receptor Locations

Human receptor locations have been characterised with reference to LAQM.TG(09) Box 1.4. According to LAQM.TG(09) air quality standards should only apply to locations where *'members of the public are likely to be regularly present and are likely to be exposed for a period of time appropriate to the averaging period of the objective. Authorities should not consider exceedences of the objectives at any location where relevant public exposure would not be realistic'*. Thus short term standards such as the 1-hour standard for NO_2 should apply to footpaths and other areas which may be regularly frequented by the public even for a short period of time. Longer term standards such as daily means, or annual means, should apply at houses or other locations which the public can be expected to occupy on a continuous basis. These standards do not apply to exposure at the workplace.

On this basis the receptors in Table 3-1 have been assessed against all averaging periods; as a precautionary approach all land surrounding the boundary (whether footpaths are present or not) has been considered as short term receptors only (i.e. for 15-minute means and 1-hour means). A drawing showing receptor locations is included as Drawing AQ1.

Table 3-1
Sensitive Human Receptor Locations

ID	Receptor	X	Y	Type
DR1	Scrap Yard	256181	58639	Work Place
DR2	Mumford Cottage	257798	60758	Residential
DR3	Portworthy	255470	60195	Residential
DR4	Heath Farm/ The Rambles	254901	59213	Residential
DR5	Animal Welfare Centre / Heathdown Cottage	254808	59385	Residential
DR6	Lobb Shippon	255938	58212	Work Place

[12] Pursuant to planning references: 9/42/49/0542/85/3, granted 1986 and 9/490405/91/3, granted 1991 and the subsequent Modification Order (Planning reference JS/SKC/A0577, issued 2010).

ID	Receptor	X	Y	Type
DR7	Galva House	256558	58084	Residential
DR8	Golden Clay Shoot	255682	58949	Work Place
DR9	WindWhistle/The Barn	256131	57788	Residential
DR10	Newnham Home Farm	255669	58020	Residential
DR11	Elfordleigh Country Club	254644	58651	Residential
DR12	Truelove	255219	60713	Residential
DR13	Wotter Farm	256005	61640	Residential
DR14	Broadoak Cottages	256779	61322	Residential
DR15	Lee Moor (Village)	257120	61691	Residential
DR16	Goodamoor Cottage	258038	58646	Residential
DR17	Headon Gate	258654	59223	Residential
DR18	Houndall Farm	258622	58977	Residential
DR19	Birchland	257918	58313	Residential
DR20	Sparkwell Farm	257838	57924	Residential
DR21	Hemerdon House	257282	57570	Residential

Table Note: Properties subject to the Section 52 planning agreement have been excluded as they will no longer be occupied by residents.

3.1.2 Ecological Receptors

The H1 Guidance Note[13] states that ecological habitats should be screened against relevant standards if they are located within the following set distances from the facility:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs) or Ramsar sites within 10km of the installation; and
- Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNR), Local Nature Reserves (LNR), local wildlife sites (LWS) and ancient woodland (AW) within 2km of the installation.

Designated nature conservation sites within the screening distances from the Drakelands Mine Planning boundary are presented in Table 3-2. The designated nature conservation sites will be at a greater distance from the proposed Reduction Kiln and therefore this presents a precautionary assessment.

Table 3-2
Nature Conservation Sites

Receptor Name	Type of Receptor	Minimum Distance from Drakelands Mine Boundary	Direction from Site Boundary
European / International Designated ecological Receptors within 10km			
The Tamar Estuaries Complex	(SPA)	9500m	North West
South Dartmoor Woods	(SAC)	3900m	North West
Dartmoor	(SAC)	3050m	North East
Plymouth Sound and Estuaries (two areas within 10km)	Special Area of Conservation (SAC)	8500m	South West and South
Ecological Receptors within 2km			

[13] Horizontal Guidance Note H1 – Annex (f), Environment Agency, 2010.

• Brockhole & Binicliff Woods • Truelove • Crownhill Down • Higher Lee • Hooksbury Wood • Blackalder Tor • The Ruts • Smallhanger Waste • Knowle Wood • Shaugh Moor • Ridding Down • Headon Down • Great Shaugh & Cann Woods	Local Wildlife Sites (LWS) (Previously known as County Wildlife Sites)	Within 2km	West, South West, North and East
• Three unnamed areas of ancient and semi natural woodland • Hatshill / Holt Woods • Brockhole / Binicliff Woods • Fernhill Wood • Hooksbury Wood – Ancient replanted • Higher Lee Woods – Ancient and Semi-Natural • Coleland – Ancient Replanted	Ancient Woodland	Within 2km	West, North, and South West

The dispersion modelling has specifically included the ecological receptors in Table 3-2. In accordance with AQTAG06[14], either discrete or array receptor grids at 100m resolution have been used to represent sensitive ecological receptors.

In addition to the ecological receptors above, Priority Habitats that do not have a statutory designation and are not included in the above areas have also been included, as follows:

- part of Lower Hooksbury Wood contains lichens including 3 Red Data Book, 2 Nationally Rare and 8 Nationally Scarce species;
- Bottle Hill contains deciduous woodland (Priority Habitat); and
- Drakeland Mine Area contains deciduous woodland (Priority Habitat).

3.2 Meteorological Conditions

The most important meteorological parameters governing the atmospheric dispersion of pollutants are as follows:

- wind direction determines the broad transport of the emission and the sector of the compass into which the emission is dispersed;
- wind speed will affect ground level concentrations of emissions by increasing the initial dilution of pollutants in the emission; and
- atmospheric stability; a measure of the turbulence, particularly of the vertical motions present.

The meteorological data provider was consulted for the most appropriate data set for the area. The closest meteorological station with detailed wind data is at Plymouth, 10km to the

[14] AQTAG06 – Technical Guidance on detailed modelling approach for an appropriate assessment for emissions to air. Environment Agency, working Draft version 9, 12/05/06.

south west. Data covering the period 2004 to 2008 (inclusive) is presented in the windrose below, showing the frequency of wind speed and direction.

It can be seen that there is a strong south westerly component with winds from this sector accounting for approximately 40% of hours in the year. Winds from the north western quarter account for approximately 19% of total winds with winds from the south east being the least frequent to occur.

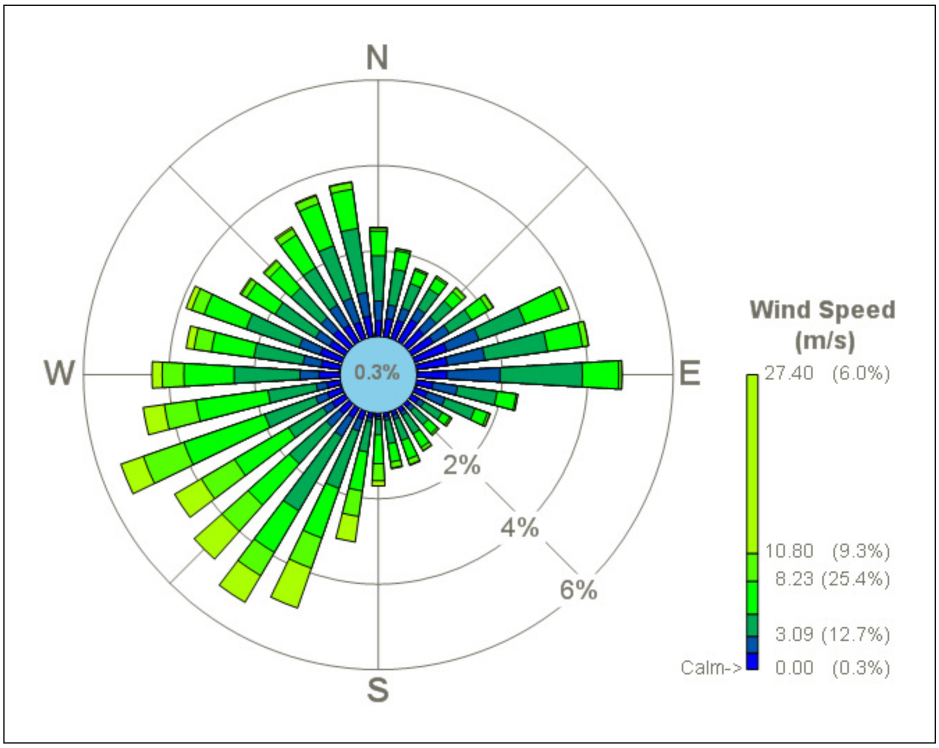

Figure 3-1
Windrose for Plymouth Mountbatten Meteorological Station (2004 – 2008)

3.3 Topography

The presence of elevated terrain can significantly affect the dispersion of pollutants and the resulting ground level concentration in a number of ways. Elevated terrain reduces the distance between the plume centre line and the ground level, thereby increasing ground level concentrations. Elevated terrain can also increase turbulence and, hence, plume mixing with the effect of increasing concentrations near to a source and reducing concentrations further away.

The installation is located at an elevation of approximately 171m above ordnance datum (AOD) on the north side of a shallow river valley. Within 250m south the elevation is 148m AOD which then rises again to 200m within approximately 750m. The valley feature descends to the south west to approximately 90m within 1km and rises to the north east to approximately 200m within 1km.

3.4 Baseline Air Quality Conditions

This sub-section reviews the existing baseline air quality and deposition in the vicinity of the installation according to monitoring and/or modelling from South Hams District Council, Defra, and the Air Pollution Information System.

3.4.1 Monitoring Data

The UK Automatic Urban and Rural Network (AURN) is a country-wide network of air quality monitoring stations operated on behalf of Defra. The closest monitoring station is located at Plymouth Centre. This monitor is classified as an 'urban background' and therefore will not be representative of the application site given its rural setting.

The majority of monitoring undertaken by South Hams District Council (SHDC) is concentrated about the population centres of Kingsbridge, Totnes, Ivybridge and Dean Prior (on the A38). Due to the distance from the installation these stations are not suitable for use to characterise the local air quality in the vicinity of the installation. However, automated (real-time) and non-automated (diffusion tube) monitors have recently been located to the south and east of the installation to monitor combustion emissions from the Langage Combined Cycle Gas Turbine Power station.

The most recent published[15] results from the real-time monitor located in Sparkwell (which is approximately 1.4km to the south east) are presented in Table 3-3. Concentrations of NO_2 PM_{10} and SO_2 concentrations are considered low.

Table 3-3
Sparkwell Automated Monitor (µg/m^3)

	2011 Annual Mean	Comparison to short-term Objectives
PM_{10}	21.3	8 exceedences of 50µg/m^3 24-hour mean
NO_2	6.7	No exceedences of AQS Objectives
SO_2	0.8	No exceedences of any AQS Objectives

Monitoring of NO_2 by diffusion tube is undertaken in the villages of Lutton and Cornwood, (approximately 2.4km east and 3.6km east respectively) as well as in a rural location on the moor (approximately 4.6km north east). The 2011 data is presented in Table 3-4 below.

Table 3-4
Diffusion Tube Annual Mean Background NO_2 Concentrations (µg/m^3)

Location ID	x	y	2011
(PS) Moor	260504	61478	4.3
(PS) Cornwood	260583	59596	7.9
(PS) Lutton	259320	58955	7.9

3.4.2 Defra Background Maps

Background pollutant concentration data on a 1km x 1km spatial resolution is provided by Defra[16] and is routinely used in assessing background pollutant concentrations where monitoring has not taken place for the purposes of Local Air Quality Management. The annual mean background concentrations for the grid squares containing the site and discrete receptors are presented in Table 3-5.

Predicted concentrations for NO_2, NO_X and PM_{10} are based on 2010 emissions data. Projection factors for SO_2 are not provided in LAQM.TG(09) since 2001 therefore values are

[15] 2012 Air Quality Updating and Screening Assessment for South Hams District Council (May 2012)

[16] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

likely to be an over prediction (for example APIS 3 year average from 2006 to 2008 are approximately half the Defra value).

Table 3-5
Estimated Annual Mean Background Concentrations (µg/m^3)

Pollutant	256500,59500	257500,59500	256500,58500	257500,58500
PM_{10}	14.3	14.5	12.2	12.4
$PM_{2.5}$	8.2	8.2	7.9	7.9
NO_2	7.8	7.4	8.6	8.0
SO_2	1.61	1.57	1.66	1.62
CO	110	122	101	110

Baseline concentrations for other averaging periods have been based on the Defra predictions and converted in accordance with Table 2.1 of Horizontal Guidance Note H1 (see Table 3-6).

Table 3-6
Calculated Background Concentrations for other Averaging Periods

Pollutant	Averaging Period	Concentration (µg/m^3)
PM_{10}	24-hour	17.1
CO	8-hour	170.8
NO_2	1-hour	17.2
SO_2	15-minute	4.4
	1-hour	3.3
	24-hour	2.0

3.4.3 UK Heavy Metals Monitoring Network

The Centre for Ecology & Hydrology (CEH) operates a national monitoring network for heavy metals. The closest monitoring site to the installation is located at Yarner Wood approximately 30km to the north east. The most recent data set states 0.44ng/m^3 as an annual average.

3.4.4 Critical Levels and Critical Loads

The Air Pollution Information System (APIS) is a support tool for assessment of potential effects of air pollutants on habitats and species developed in partnership by the UK conservation agencies and regulatory agencies and the Centre for Ecology and Hydrology. APIS has been used to provide information on:

- identification of whether the habitats present are sensitive to effects caused by potential emissions;
- critical levels (Table 2-3) and current baseline concentrations (Table 3-7); and
- critical loads and current deposition rates (Table 3-8 and Table 3-9).

Table 3-7
Background NO_x and SO_2 Concentrations

Name / Type	NO_x	SO_2
South Dartmoor Woods (SAC)	6.36	0.66
Dartmoor (SAC)	6.04	0.67
Plymouth Sound and Estuaries (SAC)	14.71	0.46
Tamar Estuary (SPA)	9.45	0.45

Name / Type	NO_x	SO_2
Fernhill Wood (AW)	14.12	0.68
Hooksbury Wood(AW+LWS)	14.12	0.68
Coleland Wood (AW)	9.19	0.67
Brockhole & Bincliffe Wood (AW)	11.12	0.45
Knowle Wood (AW +CWS)	7.16	0.45
Hatshill Holt (AW)	14.71	0.46
Headon Down (LWS)	14.12	0.68
Small Hanger Waste (LWS)	14.12	0.68
Crown Hill Down (LWS)	14.12	0.68
Lower Hooksbury (PH) (Moss)	11.12	0.45
Bottle Hill (PH)	11.12	0.45
Drakeland/Hemerdon Mine Area (PH)	11.12	0.45
The Ruts (CWS)	7.16	0.45
Truelove (CWS)	7.16	0.45
ShaughMoor (CWS)	7.16	0.45
Blackadder Tor (CWS)	7.16	0.45
Ridding Down (CWS)	7.16	0.45
Great Shaugh & Cann Woods (CWS)	14.71	0.46

Table 3-8
Nitrogen Critical Loads and Current Loads (kg N/ha/yr)

Name / Type	Terrestrial Habitat Information	Critical Load Range	Current Load
South Dartmoor Woods (SAC)	Old sessile oak woods with Ilex and Blechnum	10-15	41.44
	European Dry Heaths	10-20	26.32
Dartmoor (SAC)	Northern Atlantic wet heaths with Erica tetralix	10-20	18.13
	European Dry Heaths	10-20	18.13
	Blanket Bogs	5-10	18.13
	Old sessile oak woods with Ilex and Blechnum	10-15	32.65
Plymouth Sound and estuaries (SAC)	Suppralittoral Rock (Shore Dock)	10-20	16.06
	Atlantic Salt Meadows	20-30	16.06
	Estuaries (Saltmarsh)	20-30	16.06
Tamar Estuary (SPA)	Littoral Sediment	20-30	20.16
Fernhill Wood (AW)	Broad-leaved deciduous woodland	10-20	32.62
Hooksbury Wood(AW+LWS)	Broad-leaved deciduous woodland	10-20	32.62
Coleland Wood (AW)	Broad-leaved deciduous woodland	10-20	31.22
Brockhole & Bincliffe Wood (AW)	Broad-leaved deciduous woodland	10-20	31.22
Knowle Wood (AW +CWS)	Broad-leaved deciduous woodland	10-20	27.86
Hatshill Holt (AW)	Broad-leaved deciduous woodland	10-20	26.88
Headon Down (LWS)	Dwarf Shrub Heath	10-20	18.76
Small Hanger Waste (LWS)	Dwarf Shrub Heath	10-20	18.76
Crown Hill Down (LWS)	Dwarf Shrub Heath	10-20	18.76
Lower Hooksbury (PH) (Moss)	Broad-leaved deciduous woodland	10-20	31.22
Bottle Hill (PH)	Broad-leaved deciduous woodland	10-20	31.22
Drakeland/Hemerdon Mine Area (PH)	Broad-leaved deciduous woodland	10-20	31.22
The Ruts (CWS)	Dwarf Shrub Heath	10-20	14.98
Truelove (CWS)	Dwarf Shrub Heath	10-20	14.98
ShaughMoor (CWS)	Dwarf Shrub Heath	10-20	14.98
Blackadder Tor (CWS)	Dwarf Shrub Heath	10-20	14.98
Ridding Down (CWS)	Dwarf Shrub Heath	10-20	14.98
Great Shaugh & Cann Woods (CWS)	Broad-leaved deciduous woodland	10-20	26.88

Table Note: Only habitats sensitive to nitrogen with are shown.

Table 3-9
Acid Critical Load Functions and Current Loads (kg_{eq}/ha/yr)

Name / Type	Terrestrial Habitat Information	Critical Load Function	N Dep	S Dep
South Dartmoor Woods (SAC)	Old sessile oak woods with Ilex and Blechnum	MaxCLminN: 0.5 MaxCLMaxN: 3.263 MaxCLMaxS: 2.763 MinCLminN: 0.142 MinCLMaxN: 1.536 MinCLMaxS: 1.251	2.960	0.700
	European Dry Heaths	MaxCLminN: 1.035 MaxCLMaxN: 1.852 MaxCLMaxS: 0.96 MinCLminN: 0.642 MinCLMaxN: 1.202 MinCLMaxS: 0.45	1.880	0.570
Dartmoor (SAC)	Northern Atlantic wet heaths with Erica tetralix	MaxCLminN: 1.035 MaxCLMaxN: 4.832 MaxCLMaxS: 4.19 MinCLminN: 0.642 MinCLMaxN: 1.122 MinCLMaxS: 0.46	1.295	0.363
	European Dry Heaths	MaxCLminN: 1.035 MaxCLMaxN: 4.832 MaxCLMaxS: 4.19 MinCLminN: 0.642 MinCLMaxN: 1.122 MinCLMaxS: 0.46	1.295	0.363
	Blanket Bogs	MaxCLminN: 0.321 MaxCLMaxN: 1.306 MaxCLMaxS: 0.985 MinCLminN: 0.321 MinCLMaxN: 0.83 MinCLMaxS: 0.509	1.295	0.363
	Old sessile oak woods with Ilex and Blechnum	MaxCLminN: 0.5 MaxCLMaxN: 4.555 MaxCLMaxS: 4.27 MinCLminN: 0.142 MinCLMaxN: 0.939 MinCLMaxS: 0.654	2.332	0.512
Fernhill Wood (AW)	Broad-leaved deciduous woodland	CLmaxS: 1.15 CLminN: 0.28 CLmaxN: 1.43	2.330	0.350
Hooksbury Wood (AW)	Broad-leaved deciduous woodland	CLmaxS: 1.15 CLminN: 0.28 CLmaxN: 1.43	2.330	0.350
Coleland Wood (AW)	Broad-leaved deciduous woodland	CLmaxS: 1.47 CLminN: 0.5 CLmaxN: 1.97	2.230	0.430
Brockhole & Bincliffe Wood (AW)	Broad-leaved deciduous woodland	CLmaxS: 1.75 CLminN: 0.14 CLmaxN: 1.9	2.230	0.220
Knowle Wood (AW +CWS)	Broad-leaved deciduous woodland	CLmaxS: 1.5 CLminN: 0.5 CLmaxN: 2	1.990	0.270
Hatshill Holt (AW)	Broad-leaved deciduous woodland	CLmaxS: 1.09 CLminN: 0.28 CLmaxN: 1.38	1.920	0.180
Headon Down (LWS)	Dwarf Shrub Heath	CLmaxS: 0.56 CLminN: 1.04 CLmaxN: 1.61	1.340	0.280
Small Hanger Waste (LWS)	Dwarf Shrub Heath	CLmaxS: 0.56 CLminN: 1.04 CLmaxN: 1.61	1.340	0.280
Crown Hill Down (LWS)	Dwarf Shrub Heath	CLmaxS: 0.56 CLminN: 1.04 CLmaxN: 1.61	1.340	0.280
Lower Hooksbury (PH) (Moss)	Broad-leaved deciduous woodland	CLmaxS: 1.76 CLminN: 0.14 CLmaxN: 1.9	2.230	0.220
Bottle Hill (PH)	Broad-leaved deciduous woodland	CLmaxS: 1.77 CLminN: 0.14 CLmaxN: 1.91	2.230	0.220
Drakeland/Hemerdon Mine Area (PH)	Broad-leaved deciduous woodland	CLmaxS: 1.51 CLminN: 0.36 CLmaxN: 1.88	2.230	0.220
The Ruts (CWS)	Dwarf Shrub Heath	CLmaxS: 0.87 CLminN: 1.25 CLmaxN: 2.12	1.070	0.180
Truelove (CWS)	Dwarf Shrub Heath	CLmaxS: 0.87 CLminN: 1.25 CLmaxN: 2.12	1.070	0.180
ShaughMoor (CWS)	Dwarf Shrub Heath	CLmaxS: 0.87 CLminN: 1.25 CLmaxN: 2.12	1.070	0.180
Blackadder Tor (CWS)	Dwarf Shrub Heath	CLmaxS: 0.63 CLminN: 1.01 CLmaxN: 1.64	1.070	0.180
Ridding Down (CWS)	Dwarf Shrub Heath	CLmaxS: 0.47 CLminN: 0.86 CLmaxN: 1.33	1.070	0.180
Great Shaugh & Cann Woods (CWS)	Broad-leaved deciduous woodland	CLmaxS: 1.09 CLminN: 0.28 CLmaxN: 1.38	1.920	0.180

Table Note: Only habitats with acidity critical load functions are shown.

4.0 ASSESSMENT METHODOLOGY

4.1 H1 Screening Method

The principal of the H1 screening technique is based on dispersion factors for differing stack heights derived from atmospheric dispersion modelling (described in detail within the H1 guidance document). The method requires details of the pollutant emissions rate, stack release height and details of receptors. The predicted ground level concentration is then compared to EALs to determine if emissions are insignificant or whether detailed modelling is required.

In accordance with H1 guidance, emissions to air are considered to be insignificant if:

- the long term process contribution is <1% of the long term environmental standard; and
- the short term process contribution is <10% of the short term environmental standard

For process contributions that cannot be considered insignificant the need for detailed modelling is determined against the following threshold criteria:

- [Maximum Process Contribution (long term) + background concentration] > 70% of the Environmental Assessment Level; or
- Maximum Process Contribution (short term) > 20% of the difference between the short term environmental benchmark minus twice the long term background concentration.

4.2 Atmospheric Dispersion Modelling

Dispersion modelling of emissions has been undertaken using the US American Meteorological Society and Environmental Protection Agency Regulatory Model (BREEZE AERMOD v7) dispersion model.

This model is commonly used for assessments of this kind and has been accepted as suitable for use by the EA on similar projects, including the Permit Application for the Drakelands Mine Waste Facility.

4.2.1 Model Domain / Receptors

In addition to the discreet human and ecological receptor locations listed in Table 3-1 and Table 3-2, the modelling has been undertaken using a receptor grid across an Ordnance Survey map of the study area. Pollutant exposure isopleths are generated by interpolation between receptor points and superimposed onto the map. This method allows the exposure at any receptor (long term or short term) in the study area to be determined and presented graphically. A 1km by 1km receptor grid with a 50m resolution and a 2km by 2km with a 100m resolution were applied. In addition discrete receptor locations were modelled for boundary receptors at 50m intervals.

SAC and Ancient Woodland habitats were entered into the model using GIS datasets downloaded from Natural England. Council Wildlife Sites were entered on the basis of map information (Easimap) provided by the EA. Receptors were entered as arrays using a 100m resolution.

4.2.2 Meteorological Data and Pre-processing

Following consultation with the meteorological data provider, it was concluded that the Meteorological Observation Station located at Plymouth (approximately 10km south west of the application site) would provide the most representative data set for purposes of this assessment. A five year data set for this station, covering the period 2004 – 2008 has been used for this assessment. This accounts for inter-year variability in meteorological conditions.

The meteorological data was obtained in '.met' format from the data supplier and converted to the required surface and profile formats for use in AERMOD using AERMET Pro meteorological pre-processor.

Details specific to the exact site location are required for the pre-processing of the meteorological data, such as latitude, longitude and surface characteristics. Given the varying nature of the surface features in the vicinity of the installation, the surface characteristics were divided into four sectors and applied as shown below in accordance with the latest guidance[17].

Table 4-1
Met Data Preparation – Applied Surface Characteristics

Zone (Start)	Zone (end)	Landscape Character	Albedo	Bowen[a]	Surface Roughness
084	146	Cultivated land and Woodland belts	0.2687	0.8806	0.14120
146	211	Cultivated land			0.07250
211	253	Cultivated land and Woodland belts			0.15314
253	084	Grasslands			0.04025

Table Notes: a) Bowen Ratio and albedo based upon assessment of land-use in 10x10km grid surrounding site being 9.5% Urban, 55% Cultivated Land, 25% Grassland, 4% Deciduous Forests, 1% Water and 5% Coniferous Forests.

4.2.3 Topography

AERMOD utilises digital elevation data to determine the impact of topography on dispersion from a source. Topographical data has been obtained in OS digital (.ntf) format. The model was run with OS 1:50,000 scale digital height contour data. Data was processed by the AERMAP function within AERMOD to calculate terrain heights, and interpolate data to calculate terrain heights for sources, buildings etc. The ground level elevations for proposed buildings have been entered on the basis of site survey and design data.

4.2.4 Special Treatment of Model Results

Nitric Oxide to NO_2 Conversion

Oxides of nitrogen (NO_x) emitted to atmosphere as a result of combustion will consist largely of nitric oxide (NO), a relatively innocuous substance. Once released into the atmosphere, NO is oxidised to NO_2. The proportion of NO converted to NO_2 depends on a number of factors including wind speed, distance from the source, solar radiation and the availability of oxidants, such as ozone (O_3).

[17] AERMOD Implementation guide. AERMOD implementation workgroup, USEPA. Last revised January 8, 2008.

Following the EA AQMAU guidance[18] on conversion ratio for NOx and NO_2 a worst case scenario has been applied for detailed modelling in that 35% of NOx is presented as NO_2 in relation to short term impacts and 70% of NOx is present as NO_2 in relation to long term impacts.

Sulphur Dioxide – 15 minute averaging period

As dispersion models utilise hourly average meteorological data, calculation of 15-minute averages, such as required for SO_2, requires the application of conversion factors. For the purposes of detailed modelling of SO_2, a conversion factor of 1.34 is applied to hourly average data as detailed in Section 3.3 of H1 Guidance Note.

4.2.5 Building Downwash

The integrated Building Profile Input Programme (BPIP) module within AERMOD was used to assess the potential impact of building downwash upon predicted dispersion characteristics.

Building downwash occurs when turbulence, induced by nearby structures, causes pollutants emitted from an elevated source to be displaced and dispersed rapidly towards the ground, resulting in elevated ground level concentrations. Building downwash should always be considered for buildings that have a maximum height equivalent to at least 40% of the emission height and which within a distance defined as five times the lesser of the height or maximum projected width of the building.

On this basis all buildings have been input to the model based on the site layout plans but only the buildings in Table 4-2 influence the stack dispersion.

Table 4-2
Buildings

Description	OSGR Y	OSGR X	Elev. (m AOD)	Height (m)	x-length (m)	y-length (m)	Angle
Main Building	256939.2	58901.7	169.35	28.8	20.4	50.1	-35
Main Building	256909.8	58942.8	169.35	23.8	20.8	76.8	-35
Primary Crusher	257044.0	58752.5	145.55	24.9	7.9	9.3	55.3
Primary Crusher	257055.7	58760.4	145.55	20.5	25	13.9	-124.6
Primary Crusher	257030.0	58773.4	145.55	6	9	9.7	-33.7

4.2.6 Arsenic Deposition Modelling

AERMOD has been used to provide deposition rates of arsenic. Particle deposition is determined mainly by the particle size (aerodynamic) and density, with the terminal velocity of a particle determining how far and soon it will deposit. AERMOD incorporates 2 methods for modelling deposition of particles:

- Method 1 is used when a significant fraction (> 10%) of the total particulate mass has a diameter greater than 10 microns and the particle size distribution is reasonably well known.
- Method 2 is used when the particle size distribution is not well known and when a small fraction (less than 10% of the mass) consists of particles with a diameter of 10 microns or larger.

[18] http://www.environment-agency.gov.uk/business/regulation/38791.aspx

For this assessment, as data relating to particle size and density is limited, Method 2 has been applied using published data[19] relating to particle size distribution for arsenic as below:

- Fine mass fraction: 0.75
- Mean Particle Diameter: 0.5µm

4.3 Assessment of Impacts on Habitats

4.3.1 Assessment for SACs, SPAs and SSSIs

In order to clarify the procedure for assessing the impact of Process Industries Regulation permissions under the Habitats Regulations[20]; the EA has prepared Operational Instructions. These operational instructions form Appendix 7[21] of the EA's guidance (the EU Habitats & Birds Directive Handbook) on how the EA implements the Habitats Regulations when they consider new consents and review old consents. They define a 4-stage assessment procedure as detailed below:

- Stage 1 – identification of relevant application by distance from designated site;
- Stage 2 – identification of permissions that are likely to be significant;
- Stage 3 – the 'appropriate assessment'; and
- Stage 4 – determination of the permission.

As part of the 'Stage 2' assessment, the significance of the long-term process contribution (PC) is assessed against the following criteria:

- If the PC is less than 1% of the relevant long-term benchmark (EAL, critical level or critical load), the emission is 'not likely to have a significant effect alone or in combination irrespective of the background levels'

Where this criterion is exceeded; consideration of the predicted environmental concentration (PEC) is required and the following criteria applied:

- If the PEC is less than 70% of the relevant long-term benchmark, the emission is 'not likely to have a significant effect'.

If on the basis of this Stage 2 assessment it cannot be concluded that the emission is not likely to have a significant effect, a Stage 3 'appropriate assessment' is required.

4.3.2 Assessment for NNR, LNR, LWS and AW

The EA's Operational Instruction 66_12 '*Simple assessment of the impact of aerial emissions from new or expanding IPPC regulated industry for impacts on nature conservation*' has been used for sites with designations such as National Nature Reserve (NNR), Local Nature Reserve (LNR), Local Wildlife Sites (LWS) and Ancient Woodlands (AW). This guidance provides risk based screening criteria to determine whether emissions are likely to result in 'significant pollution', for NNR, LNR, LWS and AW if the process contribution is less than 100% of the relevant critical level or load then it can be concluded there is 'no significant pollution'.

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[19] Deposition Parameterizations for the Industrial Source Complex (ISC3) Model. Environmental Research Division, Argonne National Laboratory on behalf of US Department of Energy, June 2002.

[20] Conservation of Habitats and Species Regulations 2010

[21] Appendix 7, Assessment of new PIR permissions under the Habitat Regulations, Operational Instruction. Environment agency, Version 2, 06/06/07.

4.3.3 Calculation of Contribution to Critical Loads

Deposition rates were calculated using empirical methods recommended by the EA (AQTAG06). Dry deposition flux was calculated using the following equation:

> Dry deposition flux (µg/m^2/s) = ground level concentration (µg/m^3) x deposition velocity (m/s)

The applied deposition velocities for the relevant chemical species are as shown in Table 4-3.

Table 4-3
Applied Deposition Velocities

Chemical Species	Recommended deposition velocity (m/s)	
NO_2	Grassland	0.0015
	Woodland	0.003
SO_2	Grassland	0.012
	Woodland	0.024

The units are then converted from µg/m^2/s to units of kg/ha/year by multiplying the dry deposition flux by standard conversion factors as summarised in Table 4-4.

Table 4-4
Applied Deposition Conversion Factors

Chemical Species	Conversion factor [µg/m^2/s to kg/ha/year]	
NO_2	of N:	96
SO_2	of S:	157.7

Wet deposition occurs via the incorporation of the pollutant into water droplets which are then removed in rain or snow, and is not considered significant over short distances (AQTAG06) compared with dry deposition and therefore for the purposes of this assessment, wet deposition has not been considered.

Critical Loads - Eutrophication

The contribution to critical loads for nitrogen deposition are recorded as KgN/ha/yr.

Critical Loads - Acidification

The predicted deposition rates are converted to units of equivalents (keq/ha/year), which is a measure of how acidifying the chemical species can be, by dividing the dry deposition flux (kg/ha/year) by standard conversion factors as presented in Table 4-5.

Table 4-5
Applied Acidification Conversion Factors

Chemical Species	Conversion factor [kg/ha/year to keq/ha/year]
of N:	multiply by 96
of S:	multiply by 157.7

4.3.4 Calculation of PC as a percentage of Acid Critical Load Function

The calculation of the process contribution of N and S to the critical load function has been carried out according to the guidance on APIS, which is as follows:

'The potential impacts of additional sulphur and/or nitrogen deposition from a source are partly determined by PEC, because only if PEC of nitrogen deposition is greater than CLminN will the additional nitrogen deposition from the source contribute to acidity. Consequently, if PEC is less that CLminN only the acidifying affects of sulphur from the process need to be considered:

Where PEC N Deposition < CLminN

*PC as % CL function = (PC S deposition/CLmaxS)*100*

Where PEC is greater than CLminN (the majority of cases), the combined inputs of sulphur and nitrogen need to be considered. In such cases, the total acidity input should be calculated as a proportion of the CLmaxN.

Where PEC N Deposition > CLminN

*PC as %CL function = ((PC of S+N deposition)/CLmaxN)*100'*

5.0 H1 SCREENING ASSESSMENT

5.1 Emission Parameters

5.1.1 Reduction Kiln

Information on emission parameters has been provided by Wolf's design team in collaboration with the off-gas scrubber manufacturer.

Emission benchmarks for NO_x, SO_2, CO and particulate have been based on EPR 2.03 Annex 1 Benchmarks; for the purposes of H1 screening the 'daily average' benchmarks have been applied as a worst case assessment, i.e. monthly average benchmarks are lower. For arsenic the emission benchmark has been provided by the 'scrubber' manufacturer.

Table 5-1
Reduction Kiln Emission Parameters

	Units	Reduction Kiln Stack
Emission Point ID		A3
Stack Location	OSGR x/y	256884.4 058977.4
Stack Height	m	30
Stack Diameter	m	0.2
Temperature	°C	72
Actual Efflux Velocity	m/s	17.7
Volume Flow	Nm^3/s	0.44
'Daily Average' benchmarks		
NOx Concentration	mg/Nm^3 (a)	500
SO_2 Concentration	mg/Nm^3 (a)	500
CO Concentration	mg/Nm^3 (a)	300
Particulate Concentration	mg/Nm^3 (a)	10
NOx Emission Rate	g/s	0.220
SO_2 Emission Rate	g/s	0.220
CO Emission Rate	g/s	0.132
Particulate Emission Rate	g/s	0.004
'Monthly average' benchmarks		
NOx Concentration	mg/Nm^3 (a)	300
SO_2 Concentration	mg/Nm^3 (a)	500
CO Concentration	mg/Nm^3 (a)	150
Particulate Concentration	mg/Nm^3 (a)	5
NOx Emission Rate	g/s	0.132
SO_2 Emission Rate	g/s	0.220
CO Emission Rate	g/s	0.066
Particulate Emission Rate	g/s	0.002
Manufacturers specification		
Arsenic Concentration	mg/Nm^3 (a)	1
Arsenic Emission Rate	g/s	0.00044

Table Note:
a) Reference conditions are in accordance with EPR2.03-Annex 1 Benchmarks: 0^oC (273k), 101.3 kPa, no correction for water vapour or oxygen.

5.1.2 Other Point Source Emission Input

The Processing Plant includes two additional combustion emission sources (the Wolframite Pre-Drier and the Product Drier) and one additional particulate emission source (the Primary Crusher Bag House). These emissions have been specifically included in the H1 screening and modelled as necessary to provide a cumulative (or in-combination) assessment. The emission parameters are presented in Table 5-2 below.

Table 5-2
Emission Parameters

	Units	Pre-Drier	Product Drier	Primary Crusher
Emission Point ID		A2	A4	A1
Stack Location	OSGR x/y	256882.5 58981.7	256872.0 59010.5	257025.7 58776.6
Stack Height	m	25	25	3
Stack Diameter	m	0.4	0.2	0.72
Temperature	°C	115	105	Ambient +5
Actual Efflux Velocity	m/s	15.7	10.6	15.2
Volume Flow	Nm^3/s [a]	1.39[a]	0.24[a]	6.3
NOx Emission Rate	g/s	0.045[b]	0.008[b]	n/a
SO_2 Emission Rate	g/s	0.032[a]	0.006[a]	n/a
CO Emission Rate	g/s	0.011[b]	0.002[b]	n/a
Particulate Emission Rate	g/s	0.069[a]	0.012[a]	0.29[c]

Table Note:
a) Reference conditions, particulate emission limits and sulphur content of fuel are in accordance with Process Guidance Note 3/18(12) Statutory guidance for mineral drying and cooling (September 2012)
b) Combustion released have been based on emissions factors (US-EPA: AP-42, Fifth Edition, Volume I Chapter 1: External Combustion Sources) and design fuel consumption.
c) Particulate emissions based on 'Process Guidance Note 3/08(12) Statutory guidance for quarry processes (September 2012)' of $50mg/m^3$.

5.2 Grouping of Air Emissions

5.2.1 Nitric Oxide to NO_2 Conversion

Following the Environment Agency AQMAU guidance[22] on conversion ratio for NOx and NO_2 a worst case scenario for screening assessments has been applied (which differs from detailed modelling) in that 50% of NOx is presented as NO_2 in relation to short term impacts and 100% of NOx is present as NO_2 in relation to long term impacts.

5.2.2 Particulate

There is limited particle size distribution analysis data available. On this basis a precautionary approach has been adopted and it has been assumed that all particulate is at the size fraction of interest, i.e. PM_{10} or $PM_{2.5}$.

5.3 Effective Release Height

The stack is 30m high located adjacent (within 1m) of the main building. The height of the main building is 25m.

H1 states that '*where the height of the release is greater than 3m above the ground or building on which it is located but less than 2.5 times the height of the tallest adjacent building, the effective height of release can be estimated from:*

*Ueff = (1.66*H)*(Uact/H-1)*

[22] http://www.environment-agency.gov.uk/business/regulation/38791.aspx

Where:

- *H is the height (m) of the tallest adjacent building within the distance 5L (where L is the lesser of the building height and the maximum projected width between two points at the same height in the building)*
- *Ueff is the effective stack height*
- *Uact is the actual (physical) stack height*

On the basis of a 30m stack (*Uact)* the effective release height (*Ueff)* has been assumed to be zero for all point sources as a worst case assessment.

5.4 Dispersion Factors

On the basis of the effective height of release the following dispersion factors have been applied:

- Long-term dispersion factor: 148 (µg/m^3 per g/s emitted); and
- Short-term dispersion factor: 3390 (µg/m^3 per g/s emitted) converted to appropriate averaging periods in accordance with H1 Table 2.1).

5.5 H1 Screening Results

The emission inputs used in the screening are presented in Table 5-1 and Table 5-2, backgrounds as presented in Table 3-5 to Table 3-7.

The results of the H1 screening are provided in Appendix A (Table A-1 and Table A-2). On the basis of the screening the following conclusions are reached:

- the following process contributions are insignificant and have been screened out of further assessment: carbon monoxide (8-hr mean) and arsenic (1-hr mean). The remaining process contributions are potentially significant and have progressed to the second stage of screening (i.e. inclusion of background concentrations) to identify if detailed modelling is required.
- the following emissions require detailed modelling: nitrogen dioxide (1-hr and annual mean), sulphur dioxide (15-min, 1-hr and 24-hr means), PM_{10} (24-hr mean and annual mean), $PM_{2.5}$ (annual mean) and arsenic (annual mean). Reduction Kiln emissions have been modelled using ‘daily average’ emission benchmarks.

Process contributions to nitrogen deposition and acid deposition cannot be screened out and have progressed to detailed modelling using ‘daily average’ emission benchmarks.

6.0 DISPERSION MODELLING RESULTS

6.1 Air Concentrations

6.1.1 Maximum Ground Level Concentration

The maximum ground level process contribution outside the installation boundary is presented in Table 6-1. The process contribution is less than 10% of short-term EALs and can therefore be considered insignificant for all pollutants with the exception of 15-minute mean SO_2 and 24-hour mean PM_{10} concentrations. The particulate (PM_{10} and $PM_{2.5}$) and arsenic process contribution is above the significance threshold (1% for long-term EALs). With the inclusion of current derived background concentrations the predicted environmental concentration remains below the EAL.

These maximum ground level concentrations occur at the site boundary which is not a location of relevance for human exposure in terms of AQS objectives according to Defra guidance (LAQM.TG(09)). Further investigation into the potential cumulative effects of particulates from the MWF and mine activities is provided in Section 6.1.2 and Section 6.2.

Figures in Appendix B present an illustration of the dispersion of pollutants for those in excess of 1% of long term EALs or 10% of short term EALs.

Table 6-1
Maximum Ground Level Concentrations Outside Boundary (µg/m³)

Pollutant	Averaging Period	PC	PC as % of EAL	PEC	PEC as % EAL
NO_2	Annual	0.9	2%	9.5	24%
NO_2	1-hr 99.8%ile	9.0	4%	26.2	13%
SO_2	15-min 99.9%ile	31.2	12%	35.6	13%
SO_2	1-hr 99.7%ile	23.3	7%	26.6	8%
SO_2	24-hr 99.2%ile	7.7	6%	9.7	8%
PM_{10}	24-hr 90.4%ile	13.0	26%	30.1	60%
PM_{10}	Annual	4.4	11%	18.9	47%
$PM_{2.5}$	Annual	4.4	18%	12.6	50%
Arsenic	Annual	0.0018	59%	0.0022	74%

6.1.2 Human Discrete Receptor Concentrations

Installation Process Contribution

The process contribution of NO_2 and SO_2 at human receptor locations is presented in Table 6-2. Tabulated process contributions for each model run are presented in Appendix C. The process contribution is less than 10% of short-term EALs and less than 1% of the long-term EALs and can therefore be considered insignificant.

Table 6-2
AQS (NO_2 and SO_2 Objectives) – Impact at Human Receptor Locations (µg/m³)

ID	NO_2 PC	PC as % of EAL	NO_2 PC	PC as % of EAL	SO_2 PC	PC as % of EAL	SO_2 PC	PC as % of EAL	SO_2 PC	PC as % of EAL
	1-hr 99.8%ile		Annual Mean		15-min 99.9%ile		1-hr 99.7%ile		24-hr 99.2%ile	
R1	4.0	2%	0.2	<1%	13.7	5%	10.3	3%	1.5	1%
R2	0.6	<1%	<0.1	<1%	1.6	1%	1.2	<1%	0.3	<1%
R3	0.5	<1%	<0.1	<1%	1.5	1%	1.1	<1%	0.2	<1%
R4	1.5	1%	<0.1	<1%	5.0	2%	3.7	1%	0.5	<1%

ID	NO_2 PC	PC as % of EAL	NO_2 PC	PC as % of EAL	SO_2 PC	PC as % of EAL	SO_2 PC	PC as % of EAL	SO_2 PC	PC as % of EAL
R5	1.2	1%	<0.1	<1%	3.9	1%	2.9	1%	0.4	<1%
R6	2.9	1%	0.1	<1%	9.9	4%	7.4	2%	0.9	1%
R7	2.9	1%	0.1	<1%	9.4	4%	7.0	2%	1.0	1%
R8	2.7	1%	0.1	<1%	9.2	3%	6.8	2%	1.2	1%
R9	2.2	1%	<0.1	<1%	7.2	3%	5.4	2%	0.6	<1%
R10	2.3	1%	<0.1	<1%	8.0	3%	5.9	2%	0.7	1%
R11	1.5	1%	<0.1	<1%	5.0	2%	3.8	1%	0.5	<1%
R12	0.3	<1%	<0.1	<1%	0.9	<1%	0.7	<1%	0.1	<1%
R13	0.3	<1%	<0.1	<1%	1.0	<1%	0.8	<1%	0.2	<1%
R14	0.2	<1%	<0.1	<1%	0.5	<1%	0.4	<1%	0.1	<1%
R15	0.2	<1%	<0.1	<1%	0.5	<1%	0.4	<1%	0.2	<1%
R16	1.8	1%	0.1	<1%	5.4	2%	4.0	1%	0.6	<1%
R17	0.6	<1%	<0.1	<1%	1.9	1%	1.4	<1%	0.3	<1%
R18	0.8	<1%	<0.1	<1%	2.5	1%	1.9	1%	0.4	<1%
R19	1.8	1%	0.1	<1%	5.7	2%	4.2	1%	0.5	<1%
R20	0.9	<1%	<0.1	<1%	2.9	1%	2.2	1%	0.3	<1%
R21	1.4	1%	<0.1	<1%	4.6	2%	3.4	1%	0.5	<1%

The process contribution of PM_{10} and $PM_{2.5}$ at receptor locations is presented in Table 6-3 below. The process contributions are low but above the significance criteria at a number of receptors so have progressed to an in-combination assessment reported in the following section.

Table 6-3
AQS (Particulate) – Impact at Human Receptor Locations (µg/m^3)

ID	PM_{10} PC	PC as % of EAL	PM_{10} PC	PC as % of EAL	$PM_{2.5}$ PC	PC as % of EAL	As PC	PC as % of EAL
	24-hour 90.4%ile		Annual		Annual		Annual	
R1	4.9	<10%	1.6	4%	1.6	6%	3.5E-04	12%
R2	0.1	<1%	<0.1	<1%	<0.1	<1%	5.4E-05	2%
R3	0.3	1%	0.1	<1%	0.1	<1%	2.6E-05	1%
R4	0.9	2%	0.3	1%	0.3	1%	9.7E-05	3%
R5	0.7	1%	0.2	1%	0.2	1%	7.0E-05	2%
R6	2.6	5%	0.7	2%	0.7	3%	1.5E-04	5%
R7	3.8	8%	1.1	3%	1.1	4%	1.7E-04	6%
R8	2.1	4%	0.6	2%	0.6	2%	2.4E-04	8%
R9	1.8	4%	0.5	1%	0.5	2%	1.2E-04	4%
R10	1.9	4%	0.5	1%	0.5	2%	1.1E-04	4%
R11	1.2	2%	0.4	1%	0.4	1%	8.4E-05	3%
R12	0.2	<1%	0.1	<1%	0.1	<1%	1.7E-05	1%
R13	<0.1	<1%	<0.1	<1%	<0.1	<1%	1.6E-05	1%
R14	<0.1	<1%	<0.1	<1%	<0.1	<1%	1.3E-05	<1%
R15	<0.1	<1%	<0.1	<1%	<0.1	<1%	2.6E-05	1%
R16	0.5	1%	0.2	<1%	0.2	1%	1.5E-04	5%
R17	0.1	<1%	0.1	<1%	0.1	<1%	5.8E-05	2%
R18	0.2	<1%	0.1	<1%	0.1	<1%	7.4E-05	2%
R19	0.7	1%	0.2	1%	0.2	1%	1.6E-04	5%
R20	1.4	3%	0.4	1%	0.4	2%	8.6E-05	3%
R21	2.3	5%	0.7	2%	0.7	3%	1.3E-04	4%

<u>In-Combination Effects (Installation + MWF + Mining activities)</u>

The Permit Application for the Mine Waste Facility included atmospheric dispersions modelling of particulate and arsenic emissions including a cumulative impact assessment with the Reduction Kiln emissions and mining activities. The assessment is included as Appendix D to this report. The assessment was accepted by the Environment Agency and Permit issued (Permit No. EPR/FB3639RK). Appendix D contains details on the source term and modelling methodology. It should be noted that the conclusions of the risk assessment are considered robust on the basis that the dust emission factors used have been developed for significantly higher risk climates (i.e. the arid regions of the USA and Australia), therefore the cumulative assessment is likely to over-predict the potential impacts. This cumulative impact assessment has been updated with the final design data for the Reduction Kiln as presented in this report.

The potential cumulative impacts due to particulate emissions from the installation in-combination with emissions from the MWF, mine and background are presented in Table 6-4. The maximum process contribution occurs along the eastern ownership boundary between the mine and the MWF as a result of the location and contribution of haul road dust emissions, however this is not a relevant exposure location for the averaging period. Again it should be noted that this is likely to be an over prediction given the emission factors used. The predicted environmental concentration at relevant sensitive receptor locations is below the relevant Air Quality Objectives and EALs.

Table 6-4
In-combination: AQS (Particulate) – Impact at Human Receptor Locations (µg/m^3)

ID	PM_{10} PC	PEC	PEC as % of EAL	PM_{10} PC	PEC	PEC as % of EAL	$PM_{2.5}$ PC	PEC	PEC as % of EAL
	24-hr 90.4%ile			Annual Mean			Annual Mean		
R1	16.98	34.08	68.2%	5.39	19.89	49.7%	5.39	13.59	54.3%
R2	0.61	17.71	35.4%	0.21	14.71	36.8%	0.21	8.41	33.6%
R3	1.98	19.08	38.2%	0.75	15.25	38.1%	0.75	8.95	35.8%
R4	5.09	22.19	44.4%	1.47	15.97	39.9%	1.47	9.67	38.7%
R5	4.11	21.21	42.4%	1.25	15.75	39.4%	1.25	9.45	37.8%
R6	9.70	26.80	53.6%	2.91	17.41	43.5%	2.91	11.11	44.4%
R7	12.11	29.21	58.4%	3.69	18.19	45.5%	3.69	11.89	47.6%
R8	12.12	29.22	58.4%	3.67	18.17	45.4%	3.67	11.87	47.5%
R9	7.94	25.04	50.1%	2.32	16.82	42.1%	2.32	10.52	42.1%
R10	7.78	24.88	49.8%	2.30	16.80	42.0%	2.30	10.50	42.0%
R11	5.50	22.60	45.2%	1.61	16.11	40.3%	1.61	9.81	39.2%
R12	1.11	18.21	36.4%	0.42	14.92	37.3%	0.42	8.62	34.5%
R13	0.29	17.39	34.8%	0.11	14.61	36.5%	0.11	8.31	33.2%
R14	0.73	17.83	35.7%	0.26	14.76	36.9%	0.26	8.46	33.9%
R15	0.27	17.37	34.7%	0.08	14.58	36.5%	0.08	8.28	33.1%
R16	4.08	21.18	42.4%	1.51	16.01	40.0%	1.51	9.71	38.9%
R17	1.44	18.54	37.1%	0.51	15.01	37.5%	0.51	8.71	34.8%
R18	1.74	18.84	37.7%	0.70	15.20	38.0%	0.70	8.90	35.6%
R19	5.61	22.71	45.4%	1.96	16.46	41.1%	1.96	10.16	40.6%
R20	5.52	22.62	45.2%	1.83	16.33	40.8%	1.83	10.03	40.1%
R21	8.06	25.16	50.3%	2.38	16.88	42.2%	2.38	10.58	42.3%

The in-combination process contribution of arsenic and predicted environmental concentration at human receptor locations is presented in Table 6-5. The results of the cumulative impact assessment show a maximum ground level concentration outside the site boundary of 0.0024µg/m^3 (including the 0.00044µg/m^3) which represents 82% of the long term EAL. It should be noted that this boundary location is not a relevant long-term human exposure location for this annual mean EAL. The predicted environmental concentration at all sensitive receptor locations is below the EAL.

Table 6-5
In-combination: Arsenic (Annual Mean) - Impact at Human Receptor Locations (μg/m^3)

ID	As PC	PEC	PEC as % of EAL
R1	3.7E-04	8.1E-04	27%
R2	4.9E-05	4.9E-04	16%
R3	2.5E-05	4.6E-04	15%
R4	9.2E-05	5.3E-04	18%
R5	6.4E-05	5.0E-04	17%
R6	1.6E-04	6.0E-04	20%
R7	1.6E-04	6.0E-04	20%
R8	2.5E-04	6.9E-04	23%
R9	1.1E-04	5.5E-04	18%
R10	1.2E-04	5.6E-04	19%
R11	9.6E-05	5.4E-04	18%
R12	1.5E-05	4.5E-04	15%
R13	1.9E-05	4.6E-04	15%
R14	1.5E-05	4.6E-04	15%
R15	2.5E-05	4.6E-04	15%
R16	1.4E-04	5.8E-04	19%
R17	6.0E-05	5.0E-04	17%
R18	7.1E-05	5.1E-04	17%
R19	1.3E-04	5.7E-04	19%
R20	7.3E-05	5.1E-04	17%
R21	1.1E-04	5.5E-04	18%

6.2 Arsenic Deposition Rate

The maximum process contribution to arsenic deposition outside the installation boundary is presented in Table 6-6 below. The deposition rate remains significantly below the MDR for protection of soils (based on agricultural use) and below the applied Critical Load for protection of habitats. At less than 1% of the EALs it can be concluded, according to EA guidance, that arsenic deposition is '*not likely to have a significant effect alone or in combination irrespective of the background levels*'.

Table 6-6
Maximum Arsenic Deposition Rate (mg/m^2/day)

Location	EAL (Reference) (mg/m^2/day)	Deposition Rate (mg/m^2/day)	Deposition Rate as % of EAL
Outside Boundary	0.07 (MDR (15years))	0.00032	0.5%
	0.083 (Critical Load (Reinds 2006))		0.4%

As described in the Section above, an update to the cumulative impact assessment of arsenic deposition with the MWF has been completed notwithstanding the fact that deposition as a result of the Reduction kiln emissions are insignificant. The assessment that accompanied the application for the MWF stated:

> *Notwithstanding the fact that the deposition of arsenic from the MWF can be considered insignificant, a sensitivity assessment to examine the potential cumulative effects as a result of a possible future 'reduction kiln' have been considered ....*

The maximum combined process contribution at a boundary location increases from $5.70E^{-04}$ mg/m^2/day to $5.74E^{-04}$ mg/m^2/day and therefore remains at less than 1% of the EAL. On this basis the potential cumulative effect of a possible roaster can be considered insignificant

The results of the updated cumulative impact assessment show a maximum ground level contribution of $5.79E^{-04}$ mg/m^2/day which is less than 1% of the EAL and can therefore be considered insignificant.

6.3 Nitrogen and Acid Deposition at Ecological Receptors

The process contribution to critical loads for nitrogen deposition is presented in Table 6-7 below. The contribution remains below 1% at all SAC's and below 100% at all AW's and LWSs and can therefore be considered insignificant and not likely to cause significant pollution respectively.

Table 6-7
Contribution to Nitrogen Critical Loads (kg N/ha/yr)

Name / Type	Terrestrial Habitat Information	PC	PC as % of Lower CLO
South Dartmoor Woods (SAC)	Old sessile oak woods with Ilex and Blechnum	0.002	<0.1%
	European Dry Heaths	0.001	<0.1%
Dartmoor (SAC)	Northern Atlantic wet heaths with Erica tetralix	0.001	<0.1%
	European Dry Heaths	0.001	<0.1%
	Blanket Bogs	0.001	<0.1%
	Old sessile oak woods with Ilex and Blechnum	0.002	<0.1%
Plymouth Sound and estuaries (SAC)	Suppralittoral Rock (Shore Dock)	0.001	<0.1%
	Atlantic Salt Meadows	0.001	<0.1%
	Estuaries (Saltmarsh)	0.001	<0.1%
Tamar Estuary (SPA)	Littoral Sediment	0.001	<0.1%
Fernhill Wood (AW)	Broad-leaved deciduous woodland	0.027	0.3%
Hooksbury Wood(AW+LWS)	Broad-leaved deciduous woodland	0.011	0.1%
Coleland Wood (AW)	Broad-leaved deciduous woodland	0.005	0.1%
Brockhole & Bincliffe Wood (AW)	Broad-leaved deciduous woodland	0.021	0.2%
Knowle Wood (AW +CWS)	Broad-leaved deciduous woodland	0.004	<0.1%
Hatshill Holt (AW)	Broad-leaved deciduous woodland	0.015	0.1%
Headon Down (LWS)	Dwarf Shrub Heath	0.012	0.1%
Small Hanger Waste (LWS)	Dwarf Shrub Heath	0.043	0.4%
Crown Hill Down (LWS)	Dwarf Shrub Heath	0.018	0.2%
Lower Hooksbury (PH) (Moss)	Broad-leaved deciduous woodland	0.049	0.5%
Bottle Hill (PH)	Broad-leaved deciduous woodland	0.143	1.4%
Drakeland/Hemerdon Mine Area (PH)	Broad-leaved deciduous woodland	0.076	0.8%
The Ruts (CWS)	Dwarf Shrub Heath	0.001	<0.1%
Truelove (CWS)	Dwarf Shrub Heath	0.001	<0.1%
ShaughMoor (CWS)	Dwarf Shrub Heath	0.001	<0.1%
Blackadder Tor (CWS)	Dwarf Shrub Heath	0.001	<0.1%
Ridding Down (CWS)	Dwarf Shrub Heath	0.003	<0.1%
Great Shaugh & Cann Woods (CWS)	Broad-leaved deciduous woodland	0.016	0.2%

The process contribution for nitrogen and sulphur deposition to acid critical load functions is presented in Table 6-8 below. The process contribution as a percentage of the critical load function has been calculated according to the formulae in Section 4.3.4. The contribution remains below 1% at all SAC's and below 100% at all AW's and LWS (CWSs) and can therefore be considered insignificant.

Table 6-8
Contribution to Acid Critical Loads (kg_{eq}/ha/yr)

Name / Type	Terrestrial Habitat Information	N PC	S PC	N PEC	S PEC	PC as % of CLO
South Dartmoor Woods (SAC)	Old sessile oak woods with Ilex and Blechnum	<0.001	0.002	2.960	0.702	0.1%
	European Dry Heaths	<0.001	0.001	1.880	0.571	0.1%
Dartmoor (SAC)	Northern Atlantic wet heaths with Erica tetralix	<0.001	0.001	1.295	0.364	<0.1%
	European Dry Heaths	<0.001	0.001	1.295	0.364	<0.1%
	Blanket Bogs	<0.001	0.001	1.295	0.364	0.1%
	Old sessile oak woods with Ilex and Blechnum	<0.001	0.001	2.333	0.513	<0.1%
Fernhill Wood (AW)	Broad-leaved deciduous woodland	0.002	0.021	2.332	0.371	1.6%
Hooksbury Wood(AW+LWS)	Broad-leaved deciduous woodland	0.001	0.008	2.331	0.358	0.6%
Coleland Wood (AW)	Broad-leaved deciduous woodland	<0.001	0.004	2.230	0.434	0.2%
Brockhole & Bincliffe Wood (AW)	Broad-leaved deciduous woodland	0.001	0.016	2.231	0.236	0.9%
Knowle Wood (AW +CWS)	Broad-leaved deciduous woodland	<0.001	0.003	1.990	0.273	0.2%
Hatshill Holt (AW)	Broad-leaved deciduous woodland	0.001	0.012	1.921	0.192	0.9%
Headon Down (CWS)	Dwarf Shrub Heath	0.001	0.009	1.341	0.289	0.6%
Small Hanger Waste (LWS)	Dwarf Shrub Heath	0.003	0.033	1.343	0.313	2.3%
Crown Hill Down (CWS)	Dwarf Shrub Heath	0.001	0.014	1.341	0.294	0.9%
Lower Hooksbury (PH) (Moss)	Broad-leaved deciduous woodland	0.003	0.038	2.233	0.258	2.2%
Bottle Hill (PH)	Broad-leaved deciduous woodland	0.010	0.111	2.240	0.331	6.4%
Drakeland/Hemerdon Mine Area (PH)	Broad-leaved deciduous woodland	0.005	0.059	2.235	0.279	3.4%
The Ruts (CWS)	Dwarf Shrub Heath	<0.001	0.001	1.070	0.181	0.1%
Truelove (CWS)	Dwarf Shrub Heath	<0.001	0.001	1.070	0.181	0.1%
ShaughMoor (CWS)	Dwarf Shrub Heath	<0.001	0.001	1.070	0.181	0.1%
Blackadder Tor (CWS)	Dwarf Shrub Heath	<0.001	0.001	1.070	0.181	0.1%
Ridding Down (CWS)	Dwarf Shrub Heath	<0.001	0.002	1.070	0.182	0.2%
Great Shaugh & Cann Woods (CWS)	Broad-leaved deciduous woodland	0.001	0.013	1.921	0.193	1.0%

The process contribution for nitrogen oxides and sulphur dioxide to critical levels is presented in Table 6-9 below. All process contributions are insignificant.

Table 6-9
Contribution to Critical Levels ($\mu g/m^3$)

Name / Type	NO_x Daily PC	PC as % of EAL	NO_x Annual PC	PC as % of EAL	SO_2 Annual PC	PC as % of EAL
South Dartmoor Woods (SAC)	0.58	0.8%	0.01	<0.1%	0.01	<0.1%
Dartmoor (SAC)	0.16	0.2%	<0.01	<0.1%	0.01	<0.1%
Plymouth Sound & Estuaries (SAC)	0.11	0.1%	<0.01	<0.1%	<0.01	<0.1%
Tamar Estuary (SPA)	0.10	0.1%	<0.01	<0.1%	<0.01	<0.1%
Fernhill Wood (AW)	1.64	2.2%	0.07	0.1%	0.09	0.1%
Hooksbury Wood(AW+LWS)	1.12	1.5%	0.03	<0.1%	0.04	<0.1%
Coleland Wood (AW)	0.51	0.7%	0.01	<0.1%	0.02	<0.1%
Brockhole & Bincliffe Wood (AW)	1.17	1.6%	0.05	0.1%	0.07	0.1%
Knowle Wood (AW +CWS)	0.56	0.7%	0.01	<0.1%	0.01	<0.1%
Hatshill Holt (AW)	1.12	1.5%	0.04	<0.1%	0.05	0.1%

Name / Type	NO_x Daily PC	PC as % of EAL	NO_x Annual PC	PC as % of EAL	SO_2 Annual PC	PC as % of EAL
Headon Down (LWS)	1.21	1.6%	0.06	0.1%	0.08	0.1%
Small Hanger Waste (LWS)	3.03	4.0%	0.21	0.3%	0.28	0.4%
Crown Hill Down (LWS)	2.11	2.8%	0.09	0.1%	0.12	0.2%
Lower Hooksbury (PH) (Moss)	2.33	3.1%	0.12	0.2%	0.16	0.2%
Bottle Hill (PH)	4.85	6.5%	0.35	0.5%	0.47	0.6%
Drakeland/Hemerdon Mine (PH)	2.28	3.0%	0.18	0.2%	0.25	0.3%
The Ruts (CWS)	0.30	0.4%	0.01	<0.1%	0.01	<0.1%
Truelove (CWS)	0.36	0.5%	0.01	<0.1%	0.01	<0.1%
ShaughMoor (CWS)	0.19	0.3%	<0.01	<0.1%	<0.01	<0.1%
Blackadder Tor (CWS)	0.21	0.3%	0.01	<0.1%	0.01	<0.1%
Ridding Down (CWS)	0.58	0.8%	0.01	<0.1%	0.02	<0.1%
Great Shaugh & Cann Woods(CWS)	1.29	1.7%	0.04	0.1%	0.05	0.1%

The process contribution to critical levels and critical loads remains below 1% at the SACs and SPAs and below 100% at the Ancient Woodlands and LWS, therefore in summary:

- potential effects at the SAC/SPAs can be concluded '*not likely to have a significant effect alone or in combination irrespective of the background levels*'; and
- it can be concluded there is '*no significant pollution*' at the LWSs and Ancient Woodlands.

7.0 CONCLUSIONS

The conclusion of this air quality impact assessment, undertaken using atmospheric dispersion modelling, is that there are no predicted exceedences of Environmental Quality Standards or Environmental Assessment Levels associated with emissions from the proposed MPF (i.e. Reduction Kiln, two Drier Plant and Primary Crusher Bag House) alone, or in-combination with emissions from the Mine Waste Facility and mine activities.

In particular:

- the in-combination process contribution of pollutants (NO_2, $PM_{10,}$ $PM_{2.5,}$ SO_2, CO) is not predicted to lead to exceedences of their respective Air Quality Objectives;
- the in-combination process contribution of arsenic is not predicted to lead to exceedences of the Air Quality Limit Value or more stringent EA Environmental Assessment Level;
- the in-combination process contribution to arsenic deposition is predicted to be less than 1% of the benchmark levels for the protection of soils and ecological receptors, i.e. the process contribution is predicted to be insignificant and therefore '*not likely to have a significant effect alone or in combination irrespective of the background levels'*; and
- the process contribution of nitrogen oxides and sulphur dioxide are less than 1% of the relevant Critical Levels and Critical Loads at all European Sites (Ramsar, SPA's and SAC's) and all nationally or locally designated sites (SSSI's and CWS (or LWS) respectively), therefore according to EA guidance leads to a conclusion of '*no significant pollution'.*

8.0 CLOSURE

This report has been prepared by SLR Consulting Limited with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Wolf Minerals; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

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

APPENDIX A – H1 SCREENING TABLES

Table A-1
H1 Screening Results – Airborne Concentration

Pollutant	Nitrogen Dioxide		Carbon Monoxide		Sulphur Dioxide				PM_{10}		$PM_{2.5}$	Arsenic	
	1-hour	Annual	8-hour	Annual	15-min	1-hr	24-hr	Annual	24-hr	Annual	Annual	1-hr	Annual
Process Contribution (PC)	531.6	40.3	396.1	21.5	1344.7	1003.5	592.1	38.1	867.8	55.8	55.8	1.20	0.07
EAL (ug/m³)	200	40	10000	350	266	350	50	50	50	40	25	48	0.006
PC (as %age of EAL)	265.8%	100.9%	4.0%	6.1%	505.5%	286.7%	1184.1%	76.2%	1735.5%	139.5%	223.3%	2.5%	1084.8%
PC Insignificant?	No	No	Yes	No	No	No	No	No	No	No	No	Yes	No
Background Concentration (B) (ug/m³)	17.2	8.6		122	4.4	3.3	2.0	1.7	17.1	14.5	8.2		0.00044
B+PC (ug/m³)		48.9		143.5			594.0	39.7		70.3	64.0		0.066
B+PC (as %age of LT EAL)		122%		41%			1188%	79%		176%	256%		1092%
ST EAL - 2*LT BG	182.8				262.9	346.7			21.0				
PC as % of (ST EAL - 2*LT BG)	290.8%				511.9%	289.5%			4132.2%				
Is detailed modelling required?	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes

Table Notes: ST = Short Term LT = Long Term
a) No ST EAL for arsenic therefore EAL for Arsine applied

Table A-2
H1 Screening Results - Deposition

Pollutant	Arsenic
	Annual
Process Contribution (PC)	0.07
Deposition (mg/m²/day)	0.17
EAL (mg/m²/day)	0.02
PC (as %age of EAL)	844%
PC Insignificant?	**No**
Is detailed modelling required?	**Yes**

APPENDIX B – FIGURES

Figure B-1 Nitrogen Dioxide Annual Mean

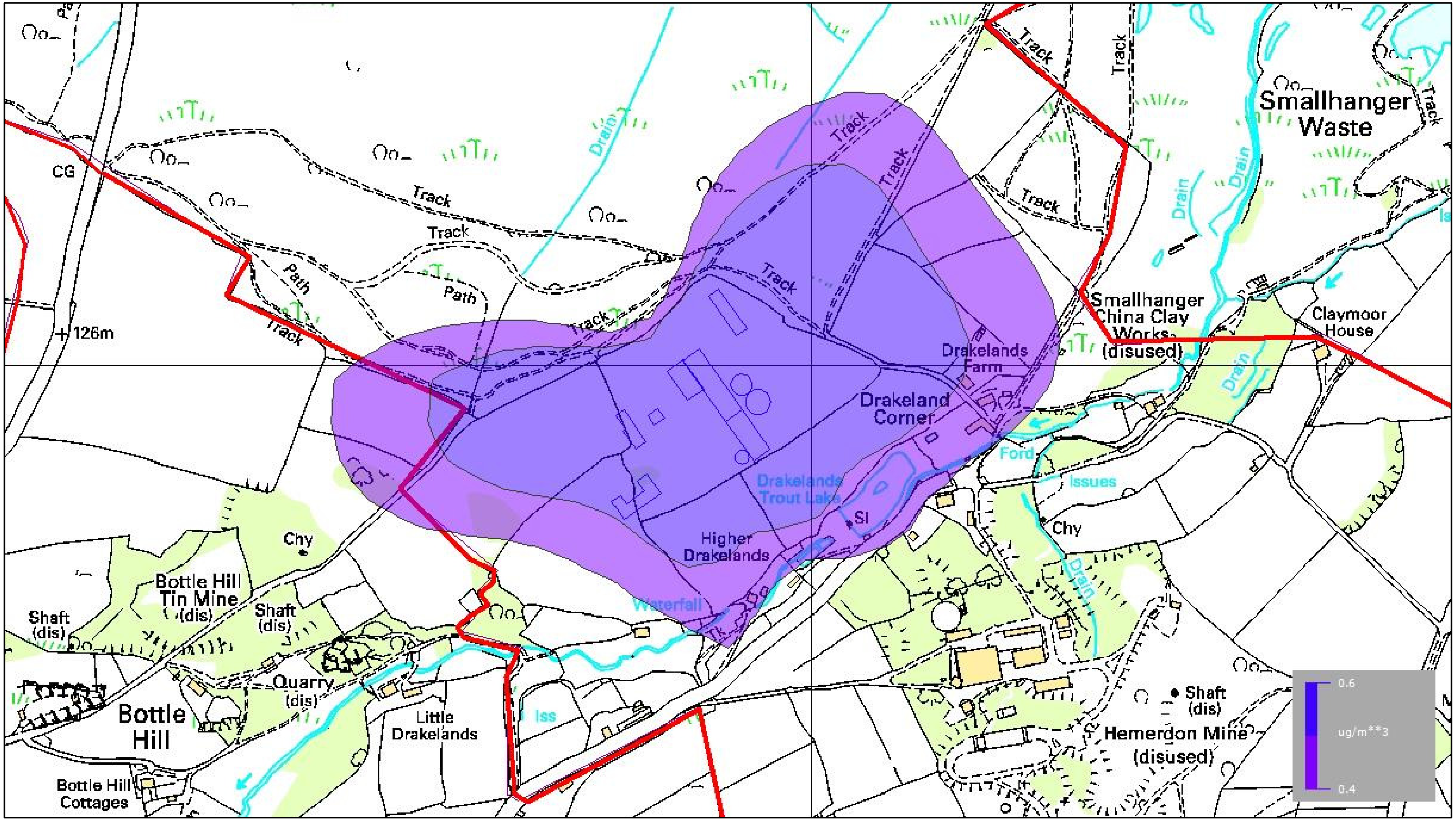


Figure B-2 Sulphur Dioxide 15-min mean (99.9%ile)

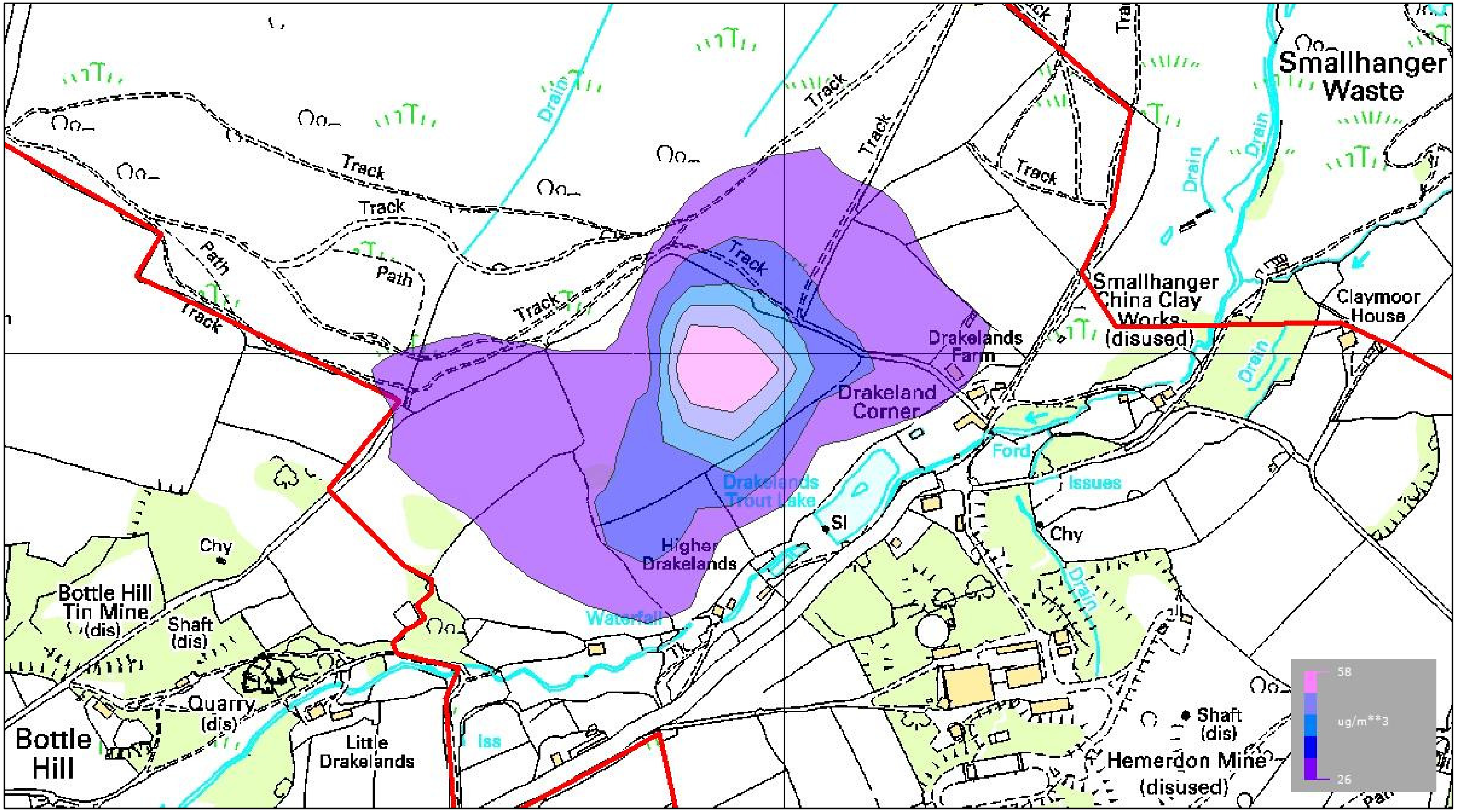


Figure B-3 PM_{10} / $PM_{2.5}$ Annual Mean

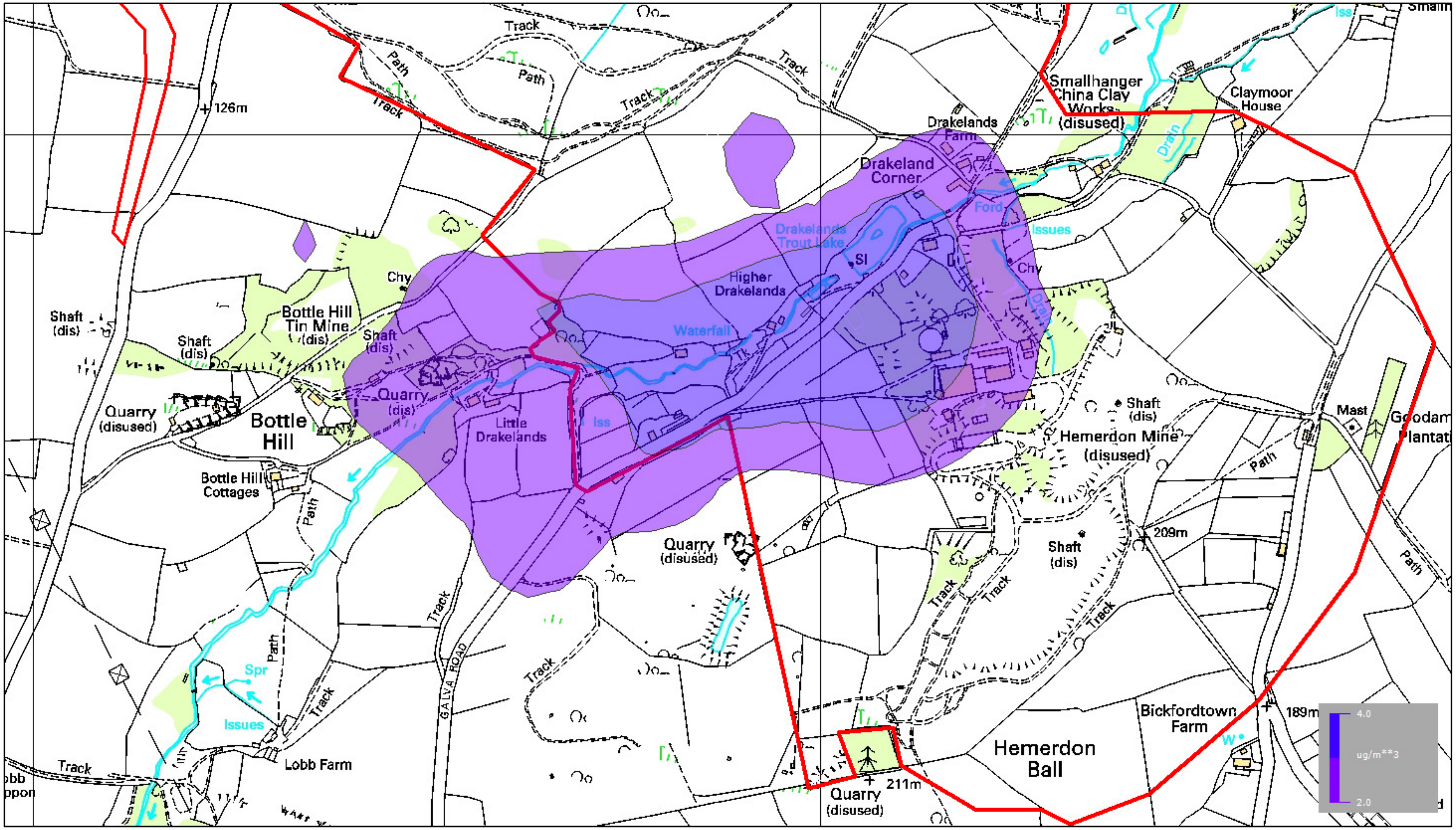


Figure B-4 PM_{10} 24-hour Mean (90.4%ile)

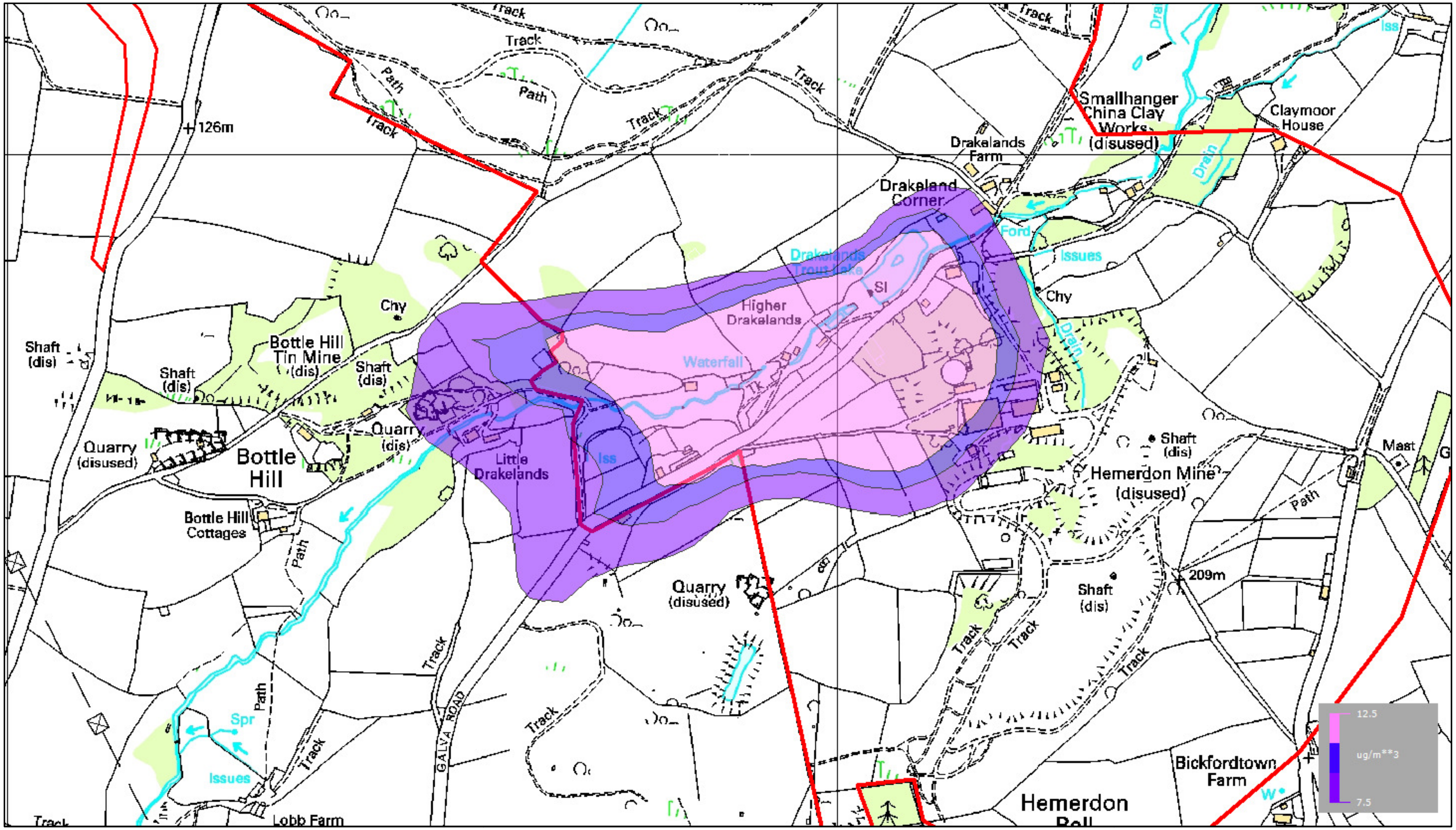
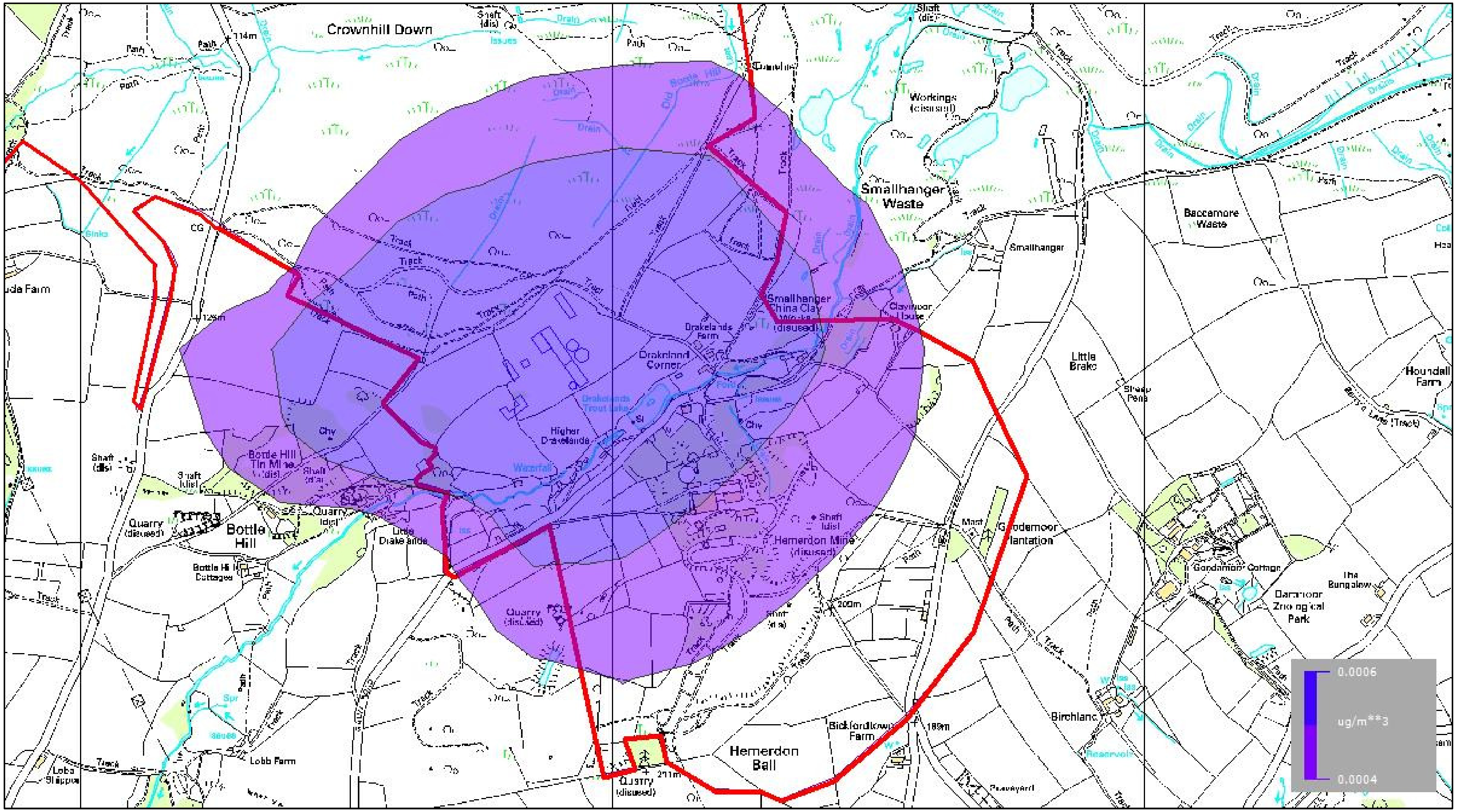


Figure B-5 Arsenic Annual Mean



APPENDIX C – TABULATED RESULTS

Table C-1
SO_2 15-minute Mean 99.9%ile (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	13.80	14.11	13.83	14.18	12.81
DR2	2.01	1.36	2.22	1.10	1.31
DR3	1.92	1.49	1.61	1.28	1.01
DR4	5.71	4.55	4.77	4.85	5.05
DR5	4.88	3.38	4.05	3.50	3.59
DR6	9.85	10.25	9.24	10.17	10.17
DR7	9.82	10.03	9.85	10.65	6.67
DR8	9.41	9.20	9.20	8.87	9.12
DR9	8.43	8.13	5.59	7.85	6.07
DR10	8.44	7.92	7.60	7.97	7.93
DR11	5.05	5.17	4.97	5.02	4.97
DR12	1.09	0.76	0.92	1.00	0.69
DR13	1.03	1.21	1.14	1.10	0.70
DR14	0.47	0.58	0.50	0.46	0.49
DR15	0.49	0.52	0.60	0.43	0.50
DR16	5.33	4.92	5.09	6.80	4.67
DR17	1.90	1.89	1.94	2.23	1.58
DR18	2.68	3.00	2.08	2.38	2.33
DR19	6.81	4.21	6.06	5.62	5.65
DR20	2.88	2.94	2.22	3.67	2.72
DR21	4.94	5.62	3.87	4.63	4.03

Table C-2
SO_2 1-hour Mean 99.73%ile (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	10.30	10.53	10.32	10.58	9.56
DR2	1.50	1.01	1.66	0.82	0.97
DR3	1.43	1.11	1.20	0.95	0.75
DR4	4.26	3.39	3.56	3.62	3.77
DR5	3.64	2.53	3.02	2.61	2.68
DR6	7.35	7.65	6.90	7.59	7.59
DR7	7.33	7.49	7.35	7.95	4.98
DR8	7.02	6.87	6.86	6.62	6.80
DR9	6.29	6.06	4.17	5.86	4.53
DR10	6.30	5.91	5.67	5.95	5.92
DR11	3.77	3.86	3.71	3.74	3.71
DR12	0.81	0.57	0.69	0.75	0.52
DR13	0.77	0.90	0.85	0.82	0.52
DR14	0.35	0.44	0.37	0.34	0.36
DR15	0.36	0.39	0.45	0.32	0.37
DR16	3.98	3.67	3.80	5.07	3.48
DR17	1.42	1.41	1.45	1.66	1.18
DR18	2.00	2.24	1.56	1.78	1.74
DR19	5.08	3.14	4.52	4.19	4.22
DR20	2.15	2.19	1.66	2.74	2.03
DR21	3.69	4.19	2.89	3.46	3.01

Table C-3
SO_2 24-hour Mean 99.18%ile (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	1.48	1.41	1.64	1.62	1.48
DR2	0.26	0.27	0.52	0.19	0.26
DR3	0.15	0.21	0.27	0.24	0.15
DR4	0.43	0.43	0.50	0.49	0.43
DR5	0.33	0.45	0.37	0.43	0.33
DR6	0.78	0.92	1.04	1.02	0.78
DR7	0.87	1.07	0.83	1.13	0.87
DR8	1.12	1.41	1.27	0.97	1.12
DR9	0.40	0.86	0.55	0.76	0.40
DR10	0.66	0.64	0.72	0.71	0.66
DR11	0.55	0.49	0.42	0.47	0.55
DR12	0.09	0.16	0.19	0.19	0.09
DR13	0.13	0.15	0.22	0.21	0.13
DR14	0.08	0.08	0.09	0.11	0.08
DR15	0.13	0.26	0.21	0.31	0.13
DR16	0.50	0.57	0.67	0.81	0.50
DR17	0.25	0.22	0.40	0.30	0.25
DR18	0.31	0.60	0.39	0.49	0.31
DR19	0.52	0.48	0.49	0.54	0.52
DR20	0.35	0.31	0.30	0.31	0.35
DR21	0.40	0.54	0.51	0.51	0.40

Table C-4
NO_2 1-hour Mean 99.8%ile (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	4.02	4.13	3.93	4.09	3.73
DR2	0.69	0.47	0.80	0.33	0.50
DR3	0.62	0.51	0.52	0.43	0.37
DR4	1.61	1.49	1.41	1.40	1.52
DR5	1.50	1.03	1.29	1.13	1.20
DR6	2.97	2.93	2.66	2.86	2.87
DR7	2.93	2.98	2.97	3.13	2.32
DR8	2.73	2.67	2.72	2.55	2.62
DR9	2.43	2.30	1.77	2.45	1.89
DR10	2.46	2.36	2.20	2.29	2.32
DR11	1.47	1.57	1.49	1.54	1.45
DR12	0.33	0.25	0.28	0.32	0.25
DR13	0.32	0.38	0.40	0.35	0.25
DR14	0.14	0.17	0.16	0.14	0.14
DR15	0.22	0.17	0.20	0.13	0.18
DR16	1.87	1.54	1.78	2.38	1.47
DR17	0.59	0.68	0.67	0.72	0.49
DR18	0.94	0.97	0.64	0.81	0.79
DR19	2.13	1.34	1.97	1.76	1.77
DR20	0.94	0.86	0.75	1.12	0.82
DR21	1.64	1.67	1.16	1.39	1.18

Table C-5
NO_2 Annual Mean (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	0.14	0.14	0.18	0.16	0.14
DR2	0.02	0.02	0.02	0.02	0.02
DR3	0.01	0.01	0.01	0.01	0.01
DR4	0.04	0.04	0.04	0.04	0.04
DR5	0.03	0.02	0.03	0.03	0.03
DR6	0.06	0.07	0.07	0.07	0.06
DR7	0.07	0.08	0.05	0.07	0.04
DR8	0.10	0.12	0.10	0.10	0.11
DR9	0.05	0.05	0.03	0.05	0.03
DR10	0.05	0.05	0.05	0.05	0.05
DR11	0.04	0.04	0.04	0.04	0.05
DR12	0.01	0.01	0.01	0.01	0.00
DR13	0.01	0.01	0.01	0.01	0.01
DR14	0.01	0.01	0.01	0.01	0.01
DR15	0.01	0.01	0.01	0.01	0.01
DR16	0.06	0.05	0.05	0.07	0.06
DR17	0.02	0.02	0.03	0.03	0.03
DR18	0.03	0.03	0.03	0.03	0.03
DR19	0.07	0.04	0.05	0.06	0.05
DR20	0.04	0.03	0.03	0.03	0.03
DR21	0.05	0.06	0.03	0.05	0.04

Table C-6
PM_{10} 24-hour Mean 90.4%ile (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	4.91	4.88	4.71	4.70	5.22
DR2	0.09	0.07	0.08	0.06	0.07
DR3	0.44	0.34	0.27	0.26	0.25
DR4	0.99	0.75	0.92	0.75	0.85
DR5	0.81	0.59	0.73	0.70	0.64
DR6	2.49	2.49	2.68	2.91	2.33
DR7	3.94	4.28	2.91	4.31	3.31
DR8	2.23	2.16	2.13	1.81	2.02
DR9	2.25	1.90	1.47	1.93	1.62
DR10	1.80	1.84	1.98	2.13	1.76
DR11	1.39	1.34	1.17	1.09	1.23
DR12	0.30	0.22	0.16	0.18	0.17
DR13	0.02	0.05	0.03	0.02	0.02
DR14	0.04	0.06	0.05	0.02	0.03
DR15	0.03	0.03	0.03	0.02	0.03
DR16	0.47	0.39	0.48	0.50	0.46
DR17	0.13	0.14	0.15	0.15	0.17
DR18	0.21	0.19	0.16	0.20	0.20
DR19	0.76	0.52	0.59	0.78	0.68
DR20	1.61	1.30	1.06	1.55	1.33
DR21	2.25	2.93	1.82	2.31	2.18

Table C-7
PM_{10} Annual Mean (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	1.58	1.59	1.50	1.47	1.64
DR2	0.03	0.02	0.03	0.02	0.02
DR3	0.15	0.13	0.11	0.11	0.10
DR4	0.32	0.25	0.25	0.25	0.26
DR5	0.26	0.20	0.21	0.22	0.22
DR6	0.76	0.72	0.76	0.80	0.68
DR7	1.21	1.33	0.89	1.24	0.90
DR8	0.74	0.63	0.59	0.56	0.61
DR9	0.60	0.61	0.45	0.54	0.46
DR10	0.56	0.55	0.57	0.58	0.48
DR11	0.39	0.39	0.34	0.32	0.38
DR12	0.10	0.08	0.07	0.07	0.07
DR13	0.01	0.02	0.01	0.01	0.01
DR14	0.02	0.02	0.02	0.02	0.02
DR15	0.01	0.01	0.01	0.01	0.01
DR16	0.17	0.15	0.17	0.18	0.17
DR17	0.05	0.04	0.05	0.05	0.06
DR18	0.07	0.06	0.07	0.08	0.08
DR19	0.27	0.17	0.19	0.27	0.24
DR20	0.52	0.44	0.35	0.46	0.46
DR21	0.73	0.84	0.55	0.67	0.62

Table C-8
$PM_{2.5}$ Annual Mean (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	1.58	1.59	1.50	1.47	1.64
DR2	0.03	0.02	0.03	0.02	0.02
DR3	0.15	0.13	0.11	0.11	0.10
DR4	0.32	0.25	0.25	0.25	0.26
DR5	0.26	0.20	0.21	0.22	0.22
DR6	0.76	0.72	0.76	0.80	0.68
DR7	1.21	1.33	0.89	1.24	0.90
DR8	0.74	0.63	0.59	0.56	0.61
DR9	0.60	0.61	0.45	0.54	0.46
DR10	0.56	0.55	0.57	0.58	0.48
DR11	0.39	0.39	0.34	0.32	0.38
DR12	0.10	0.08	0.07	0.07	0.07
DR13	0.01	0.02	0.01	0.01	0.01
DR14	0.02	0.02	0.02	0.02	0.02
DR15	0.01	0.01	0.01	0.01	0.01
DR16	0.17	0.15	0.17	0.18	0.17
DR17	0.05	0.04	0.05	0.05	0.06
DR18	0.07	0.06	0.07	0.08	0.08
DR19	0.27	0.17	0.19	0.27	0.24
DR20	0.52	0.44	0.35	0.46	0.46
DR21	0.73	0.84	0.55	0.67	0.62

Appendix D – Drakelands MWF Dust Dispersion Modelling

Hemerdon Mining Waste Facility Environmental Permit Application EPR/FB3639RK/A001
Dust Risk Assessment and Management Plan -Appendix 4B-4: Dust Dispersion Modelling

SLR

global environmental solutions

Hemerdon Mining Waste Facility

Environmental Permit Application
EPR/FB3639RK/A001

Dust Risk Assessment and Management Plan
Appendix 4B-4: Dust Dispersion Modelling

Document Reference: Section 4B

July 2013

WOLF Minerals

EXECUTIVE SUMMARY

This detailed atmospheric dispersion modelling report has been produced as an Appendix to the Dust Risk Assessment and Management Plan in response to a Schedule 5 notice issued by the Environment Agency (dated 05/07/2013).

The scope of this dust risk assessment encompasses all potential dust sources at the proposed Mine Waste Facility (MWF), i.e.:

- wind generated dust from the embankment and beached tailings;
- handling of materials in building the embankment; and
- haul roads transporting ROM and DMS Rejects to the embankment.

In addition, activities associated with the mining and processing of ore have also been included where necessary as they are not represented in the baseline. On this basis the source term also includes:

- drilling and blasting;
- materials handling (loading / unloading from trucks);
- vehicle entrainment of dust on haul roads;
- wind erosion/dust generation on exposed areas (mine pit, ROM storage pile);
- crushing and screening; and
- ore processing (‘possible reduction kiln).

In the absence of UK dust emissions factors for similar mine operations, emissions from the operations at the MWF and proposed mine operations at the adjacent Hemerdon Mine have been based on:

- Australian Government Department of the Environment and Heritage National Pollutant Inventory ‘Emission Estimation Technique Manual for Mining’; and where necessary
- United States Environmental Protection Agency (US-EPA) AP-42 ‘Compilation of Air Pollutant Emission Factors’.

The use of this approach is considered highly precautionary and considered very likely to over-estimate emissions given the climate (i.e. ‘arid/semi-arid’ climates within Australia and the USA) in which the emission factors were generated compared to the ‘temperate / moderate maritime’ climate of the UK.

The assessment considers potential risk as a result of airborne dust and dust deposition (including metals) in terms of Air Quality Standards and/or benchmarks for the protection of health, amenity and ecological receptors.

The conclusion of this dust impact assessment, undertaken using atmospheric dispersion modelling, is that there are no predicted exceedences of Environmental Quality Standards or Environmental Assessment Levels associated with dust emissions from the proposed MWF either alone or in combination with other foreseeable developments.

In particular:

- the Process Contribution of PM_{10} is not predicted to lead to exceedences of either the annual mean or 24-hour mean Air Quality Objectives;

- ambient metal concentrations are predicted to be less than 1% of the long term EAL at all sensitive receptor locations and less than 10% of short term EALs at any location outside the site boundary and can therefore be considered insignificant;
- metal deposition is predicted to be less than 1% at ecological receptors, i.e. the process contribution is predicted to be insignificant and therefore '*not likely to have a significant effect alone or in combination irrespective of the background levels'*;
- the process contribution of all dusts and metals are less than 1% of the relevant Critical Load at all European Sites (Ramsar, SPA's and SAC's), therefore according to Environment Agency guidance the emission is '*not likely to have a significant effect alone or in combination irrespective of the background levels'.*

The assessment has included a sensitivity analysis incorporating a scenario in which the possible cumulative effects of a possible 'reduction kiln' has been investigated where required. The result of the cumulative assessment do not change the conclusions detailed above.

The conclusions of the assessment support the conclusions of the qualitative assessment set out in the main report (Reference Section 4B – Dust Risk Assessment and Management Plan).

CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

This detailed atmospheric dispersion modelling report has been produced as an Appendix to the Dust Risk Assessment and Management Plan in response to a Schedule 5 notice issued by the Environment Agency (dated 05/07/2013).

The main report contains:

- background and description of the project as it relates to this assessment;
- legislation and guidance documents;
- site setting and receptors; and
- baseline air quality and ecological receptor information.

The main report should be referred to for details on these subjects, some details have been re-produced in this report where they are considered they may be of direct use to the reader.

1.1 Scope of Assessment

The scope of this dust risk assessment encompasses all potential dust sources at the proposed MWF, i.e.

- wind generated dust from the embankment and beached tailings;
- handling of materials in building the embankment; and
- haul roads transporting ROM and DMS Rejects to the embankment.

In addition, activities associated with the mining and processing of ore have also been included where necessary as they are not represented in the baseline. On this basis the source term also includes:

- drilling and blasting;
- materials handling (loading / unloading from trucks);
- vehicle entrainment of dust on haul roads;
- wind erosion on exposed areas (mine pit, ROM storage pile);
- crushing and screening; and
- ore processing (‘possible reduction kiln).

The assessment is based on dust emission factors developed by the environmental regulation authorities in the USA and Australia and utilises atmospheric dispersion modelling to predict the potential impacts on the environment.

The assessment considers potential risk as a result of airborne dust and dust deposition in terms of Air Quality Standards and/or benchmarks for the protection of health, amenity and ecological receptors.

2.0 ENVIRONMENTAL QUALITY STANDARDS

The sections below present the Environmental Quality Standards against which the potential impacts of the facility have been compared.

2.1 Air Quality Standards and Objectives

The 'Air Quality Strategy for England, Scotland, Wales and Northern Ireland' (AQS) 2007, contains air quality objectives based on the protection of both human health and vegetation (ecosystems). The AQS sets out a framework for reducing hazards to health from air pollution and ensuring that international commitments are met. These objectives were set taking into account the Air Quality Standards defined in the Air Quality Standards Regulations 2007 (now superseded by the Air Quality Standards Regulations 2010).

The Environment Agency's dust monitoring guidance M17[1] describes the hierarchy with regard to air quality criteria, stating that statutory limits (e.g. EC directive limits and national air quality standards and objectives) take precedence over Environmental Assessment Levels (addressed below).

In relation to dust the AQS includes objectives for particulate matter less than 10 microns in diameter (PM_{10}), presented in Table 2-1.

Table 2-1
UKAQS Air Quality Objectives and Standards

Pollutant	Concentration	Measured as
Particulate matter (PM_{10}) (gravimetric)	40 µg/m^3	Annual mean
	50 µg/m^3	24-hour mean (no more than 35 exceedences per year)

2.2 Environmental Assessment Levels

Horizontal Guidance Notes produced by the Environment Agency provide overarching guidance across sectors. *Horizontal Guidance Note H1 - Environmental risk assessment for permits*[2] is intended to assist operators to assess risks to the environment and human health when applying for a permit under the EP Regulations.

Annex F[3] of the H1 Guidance Note is specifically concerned with emissions to air and the process of carrying out a bespoke risk assessment. Included in the EPR Annex F H1 Guidance Note are Environmental Assessment Levels (EALs) for each pollutant in air against which impact may be assessed. A summary of the appropriate EALs for pollutants potentially contained in the tailings produced by the operation are presented in Table 2-2.

Table 2-2
Relevant EALs (µg/m^3)

Pollutant		Long Term EAL (Annual average)	Short Term (Hourly average) EAL
Arsenic	(As)	0.003	15[(a)]

[1] Environment Agency, Monitoring of particulate matter in ambient air around waste facilities. Technical Guidance Document (Monitoring) M17 (March 2004)

[2] Environment Agency, Horizontal Guidance Note H1 - Environmental risk assessment for permits v2.1 (April 2010).

[3] Environment Agency, Horizontal Guidance Note H1 - Annex (f) Air Emissions. (February 2012).

Pollutant		Long Term EAL (Annual average)	Short Term (Hourly average) EAL
Cadmium	(Cd)	0.005	1.5[(a)]
Chromium (II and III)	(Cr)	5	150
Copper	(Cu)	10	200
Lead	(Pb)	0.25	---
Mercury	(Hg)	0.25	7.5
Nickel	(Ni)	0.02	30[(a)]
Selenium	(SE)	1	30
Zinc	(Z)	50	1000

Table Note:
a) Where the H1 Guidance Note Table does not include an EAL previous H1 document has been applied.

In accordance with H1 guidance, emissions to air are considered to be insignificant if:

- the long term process contribution is <1% of the long term environmental standard; and
- the short term process contribution is <10% of the short term environmental standard

For process contributions that cannot be considered insignificant the need for detailed modelling is determined against the following threshold criteria:

- [Maximum Process Contribution (long term) + background concentration] > 70% of the Environmental Assessment Level; or
- Maximum Process Contribution (short term) > 20% of the difference between the short term environmental benchmark minus twice the long term background concentration.

2.3 Standards for Protection of Amenity

Larger airborne particles are resident in the atmosphere for short periods of time after release as they are heavy enough to fall out of suspension in the air relatively quickly. Therefore, they do not cause long-term or wide spread changes to local air quality but their deposition on property and cars can cause soiling and dis-colouration and may therefore result in complaints through amenity loss.

There are no statutory limit values for dust deposition above which ‘nuisance’ is deemed to exist – ‘nuisance’ is a subjective concept and its perception is highly dependent upon the existing conditions and the change which has occurred. The Environment Agency’s dust monitoring guidance M17[4] proposes limit values for protection against dust annoyance for different monitoring methods that are acknowledged as coming into use through ‘custom and practice’ rather than a robust study. A limit of 200mg/m^2/day is proposed for use with dust gauges and various complaint thresholds (e.g. ‘possible complaint’, ‘probable complaint’) for use with surface soiling measurement techniques.

[4] Environment Agency, Monitoring of particulate matter in ambient air around waste facilities. Technical Guidance Document (Monitoring) M17 (March 2004)

2.4 Standards for Protection of Ecological Receptors

2.4.1 Assessment under the Habitats Regulations

In order to clarify the procedure for assessing the impact of Process Industries Regulation permissions under the Habitat Regulations; the Environment Agency has prepared Operational Instructions. These operational instructions form Appendix 7[5] of the Agency's guidance (the EU Habitats & Birds Directive Handbook) on how the Agency implements the Habitats Regulations when they consider new consents and review old consents. They define a 4-stage assessment procedure as detailed below:

- Stage1 – identification of relevant application by distance from designated site;
- Stage 2 – identification of permissions that are likely to be significant;
- Stage 3 – the 'appropriate assessment'; and
- Stage 4 – determination of the permission.

The 'stage 1' assessment indicates that any EP application within 10km of a designated site and 15km for centrally dispatched coal or oil-fired power station is considered relevant. For this assessment a study area of 10km has been adopted.

As part of the 'stage 2' assessment, the significance of the long-term process contribution (PC) is assessed against the following criteria:

- If the PC is less than 1% of the relevant long-term benchmark (EAL, critical level or critical load), the emission is '*not likely to have a significant effect alone or in combination irrespective of the background levels'*

Where this criterion is exceeded; consideration of the predicted environmental concentration (PEC) is required and the following criteria applied:

- If the PEC is less than 70% of the relevant long-term benchmark, the emission is 'not likely to have a significant effect'.

If on the basis of this Stage 2 assessment it cannot be concluded that the emission is not likely to have a significant effect, a Stage 3 'appropriate assessment' is required.

Where it is identified that a Stage 3 'appropriate assessment' is required in relation to emissions to air, the results of detailed atmospheric dispersion modelling are used to predict impacts of various pollutants at the sensitive locations. The procedure for undertaking such an 'appropriate assessment' has been defined by the Agency in conjunction with Natural England in the AQTAG06[6] guidance document.

The AQTAG06 procedure defines the dispersion modelling approach in terms of receptor location and arrays, use of topographical and terrain data, the calculation of deposition fluxes, how these should be considered alongside the background conditions and relevant critical levels and loads.

Further information on assessing the impact of aerial emissions is provided in Operational instruction 66_12 '*Simple assessment of the impact of aerial emissions from new or*

[5] Appendix 7, Assessment of new PIR permissions under the Habitat Regulations, Operational Instruction. Environment agency, Version 2, 06/06/07.

[6] AQTAG06 – Technical Guidance on detailed modelling approach for an appropriate assessment for emissions to air. Environment Agency, working Draft version 10, 20/4/10.

expanding IPPC regulated industry for impacts on nature conservation'[7]. The screening criteria advised in this document are presented in Table 2-3.

Table 2-3
EA Screening Criteria

Screening criteria (c)	European sites	SSSIs*	NNR, LNR, LWS, ancient woodland*
X (km)	15[a] or 10[b]	2	2
Y (% threshold)	1	1	100
Z (% threshold)	70	70	not applicable

Table Note:
a) coal and oil fired power stations;
b) all other applications
c) X is a standard screening distance from the application; Y is the long term process contribution calculated (PC) as a percentage of the relevant critical level or critical load; Z is the long term predicted environmental concentration (PEC) calculated as a percentage of the relevant critical level.

2.4.2 Critical Loads

The 'critical load' is the concept used to assess the risk of impacts on sensitive ecosystems from aerial deposition. It is defined as '*a quantitative estimate of exposure to deposition of one or more pollutants, below which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge'*.

Empirical critical loads for eutrophication (nitrogen deposition) and acidification (due to sulphur and nitrogen oxide deposition) have been developed for a range of protected habitats. These are presented on the UK Air Pollution Information System (APIS) website (www.apis.ac.uk/). However, to date, no 'critical load' estimates for dust, or metal constituents of dust have been developed within a legislative context.

2.4.3 Metal Critical Loads

The development of effects-based critical loads for heavy metals in soils and freshwaters is currently subject to research. As a result the assessment of potential risks has been undertaken on the basis of a literature review for published critical load ranges. Two published reports have been used in the assessment, described below:

- The primary resource is a report for a project undertaken on behalf of Defra[8] to develop improved models and mapping procedures for critical loads in the UK. This report provides critical loads for cadmium, copper, lead and zinc on a 1km resolution map of the UK.
- The secondary resource, used for metals omitted in the above report[9], is a report produced in response to a Convention of Long-Range Transboundary Air Pollution initiative and provides critical loads based on a 50km resolution map.

[7] Operational instruction 66_12 'Simple assessment of the impact of aerial emissions from new or expanding IPPC regulated industry for impacts on nature conservation' (Issued 08/05/2012). Threshold applied are understood to be under review by NE and CCW.

[8] Ashmore et al. *Further Development of an Effects (Critical Loads) Based Approach for Cadmium, Copper, Lead and Zinc*. Final Report for Defra (EPG 1/3/188, November 2004)

[9] G.J. Reinds J.E. Groenenberg W. de Vries. *Critical Loads of copper, nickel, zinc, arsenic, chromium and selenium for terrestrial ecosystems at a European scale*. Alterra-rapport 1355 Alterra, Wageningen, (2006)

Table 2-4 presents the Critical Load ranges used in the assessment.

Table 2-4
Dust Deposition Thresholds

Metal	Critical Load (or range) (mg/m²/day)	Reference Source
Cd	0.0014 - 0.0027	Ashmore et al (2004)
Pb	0.0041 - 0.0082	Ashmore et al (2004)
Cu	0.0274 - 0.0685	Ashmore et al (2004)
Ni	0.0274 - 0.0685	Ashmore et al (2004)
Zn	0.0685 - 0.2740	Ashmore et al (2004)
Cr	0.0329	Reinds et al (2006)
As	0.0822	Reinds et al (2006)
Se	0.0014 - 0.0016	Reinds et al (2006)

2.4.4 Deposition Rate (smothering)

The physical effects of dust can be associated with blockage and damage to stomata (for small particle size 8-12μm), shading, and abrasion.

Interim Advice Note (IAN) prepared as a supplement to the Design Manual for Roads and Bridges[10] suggests that only dust deposition levels above 1000 mg/m^2/day are likely to affect sensitive ecological receptors. This level of dust deposition is approximately five times greater than the level at which most dust deposition may start to cause a perceptible nuisance to humans. Furthermore, it is stated that most species appear to be unaffected until dust deposition rates are at levels considerably higher than this[11].

2.5 Dust Deposition and Soil Quality Criteria

The H1 guidance includes maximum deposition rates (MDR – mg/m^2/day) that are intended to be protective of soils. The MDR's are derived from Soil Quality Criteria that are taken from '*Code of Practice for Agriculture Use of Sewage Sludge*'[12] and therefore protective of soils for agricultural use. The MDR in H1 is defined as '*the quantity of pollutant which can be added to the soil daily over 50 years before the selected soil quality criteria is exceeded*'.

The MWF is anticipated to be completed and restored within 15 years, on this basis the MDR's (which are based on a 50 years of deposition) have been modified in order to calculate a deposition threshold below which the Soil Quality Criteria will not be exceeded. The tailings metal content analysis has been used in the deposition rate threshold calculation. This is considered a precautionary approach on the basis that any dust deposited is highly unlikely to comprise solely tailings and would be diluted by other dusts.

Table 2-5
MDR Based on 15-years

Metal	H1 MDR (mg/m²/day) (based on 50yrs)	Adjusted MDR (mg/m²/day) (based on 15yrs)
Arsenic	0.02	0.07

[10] Volume 11, Section 3, part 1 of the Design Manual for Roads and Bridges (and now incorporated into HA207/07).
[11] Farmer A.M. (1991) *The Effects of Dust on Vegetation – A Review.* Environmental Pollution **79**. Pp 63-75
[12] Department of the Environment, Code of Practice for Agricultural Use of Sewage Sludge (1989).

Metal	H1 MDR ($mg/m^2/day$) (based on 50yrs)	Adjusted MDR ($mg/m^2/day$) (based on 15yrs)
Cadmium	0.009	0.03
Chromium	1.5	5.00
Copper	0.25	0.83
Lead	1.1	3.67
Mercury	0.004	0.01
Molybdenum	0.016	0.05
Nickel	0.11	0.37
Selenium	0.012	0.04
Zinc	0.48	1.60

3.0 METHODOLOGY

3.1 Source Term

In the absence of UK dust emissions factors for similar mine operations, emissions from the operations at the MWF and proposed mine operations at the adjacent Hemerdon Mine have been based on:

- Australian Government Department of the Environment and Heritage National Pollutant Inventory 'Emission Estimation Technique Manual for Mining'; and where necessary
- United States Environmental Protection Agency (US-EPA) AP-42 'Compilation of Air Pollutant Emission Factors'.

The emission factors are typically based on activity rate and account for characteristics of the mineral material and meteorological conditions. Size specific emission factors are provided for both PM_{10} and Total Suspended Particulate (TSP).

The use of this approach is considered highly precautionary and considered very likely to over-estimate emissions given the climate (i.e. 'arid/semi-arid' climates within Australia and the USA) in which the emission factors were generated compared to the 'temperate / moderate maritime' climate of the UK.

Section 4.0 of the main report provides a description of the operations and dust sources at the site, Section 5.2 of this report presents the details specific to the generation of an emissions rate for each activity.

3.2 Dispersion Model

Dispersion modelling of emissions has been undertaken using the US American Meteorological Society and Environmental Protection Agency Regulatory Model (BREEZE AERMOD v7) dispersion model.

This model is commonly used for assessments of this kind and has been used by a consortium from the Environment Agency and Health Protection Agency for estimating dust impacts from landfill APC cells.[13]

3.2.1 Meteorological Data and Pre-processing

Following consultation with the meteorological data provider, it was concluded that the Meteorological Observation Station located at Plymouth approximately 10km south west of the development site, would provide the most representative data set for purposes of this assessment. A 5 year data set for this station, covering the period 2004 – 2008 has been used for this assessment. This accounts for inter-year variability in meteorological conditions.

The meteorological data was obtained in .met format from the data supplier and converted to the required surface and profile formats for use in AERMOD using AERMET Pro meteorological pre-processor.

[13] '*Modeling human exposures to air pollution control (APC) residues released from landfills in England and Wales'* Christopher Macleod a, Raquel Duarte-Davidson b, Bernard Fisher c, Betty Ng d, David Willey d, Ji Ping Shi d, Ian Martin e, Gillian Drew f, Simon Pollard f, Environment International 32 (2006) 500–509.

Details specific to the exact site location are required for the pre-processing of the meteorological data, such as latitude, longitude and surface characteristics. Given the varying nature of the surface features in the vicinity of the site, the surface characteristics were divided into four sectors and applied as shown below in accordance with the latest guidance[14].

Table 3-1
Met Data Preparation – Applied Surface Characteristics

Zone (Start)	Zone (end)	Landscape Character	Albedo	Bowen[a]	Surface Roughness
170	250	Grassland / forest	0.2687	0.8806	0.422
250	280	Forest			0.900
280	330	Forest / cultivated land			0.487
330	170	Grassland/heathland			0.040

Table Notes: a) Bowen Ratio and albedo based upon assessment of land-use in 10x10km grid surrounding site being 9.5% Urban, 55% Cultivated Land, 25% Grassland, 4% Deciduous Forests, 1% Water and 5% Coniferous Forests.

3.2.2 Topography

AERMOD utilises digital elevation data to determine the impact of topography on dispersion from a source. Topographical data for the site has been obtained in OS digital (.ntf) format. The model was run with OS 1:50,000 scale digital height contour data. Data was processed by the AERMAP function within AERMOD to calculate terrain heights, and interpolate data to calculate terrain heights for sources, buildings etc. The ground level elevations for sources at the MWF and mine area have been entered on the basis of site survey and design data.

3.2.3 Deposition Modelling

Particle deposition is determined mainly by the particle size (aerodynamic) and density, with the terminal velocity of a particle determining how far and soon it will deposit. AERMOD incorporates 2 methods for modelling deposition of particles:

- Method 1 is used when a significant fraction (> 10%) of the total particulate mass has a diameter greater than 10 microns and the particle size distribution is reasonably well known.
- Method 2 is used when the particle size distribution is not well known and when a small fraction (less than 10% of the mass) consists of particles with a diameter of 10 microns or larger.

For this assessment, in the absence of site specific 'field tests' on particle size the approach adopted in by the US-EPA[15] to validate their modelling protocol for coal mines has been used. In the approach adopted by the US-EPA the composite distribution from four tests on haul roads was used to characterise all emissions from road and area sources because '*a) haul roads account for more than half of all emissions and b) various categories of fugitive dust sources have been shown to exhibit similar particle size profiles, as indicated by emissions factor data presented in AP-42 Section 11.2'*. The particle deposition parameters are presented in Table 3-2.

[14] AERMOD Implementation guide. AERMOD implementation workgroup, USEPA. Last revised January 8, 2008.

[15] US-EPA Modelling Fugitive Dust Impacts from Surface Coal Mining Operations – Phase II Model Evaluation Protocol (1994)

Table 3-2
Particle Deposition Parameters

Aerodynamic Diameter (µm)	Mass Fraction (%)	Particle Density (g/cm^3)
32	39%	1
25	20%	1
20	12%	1
15	8%	1
10	7%	1
5	5%	1
2.5	5%	1
1	4%	1

3.2.4 Wind Generated Emissions

Emissions from undisturbed areas of the MWF embankment, beached tailings, ROM pad, and Mine Pit will not occur when the wind speed is not sufficiently high to lift and disperse dust.

The NPI equation for storage piles (based on US-EPA AP-42) uses 5m/s as a threshold friction velocity to factor into the calculation of emission rates. The Department of the Environment (DoE) sponsored study published in 1995[16] provides threshold friction velocities for a variety of soil types – on a review of this information >5m/s appears an appropriate value.

On this basis emissions from area sources have been calculated only for wind speeds at 5m/s and above. Wind speeds at surface will be lower than at the 10m reference anemometer height, therefore the use of 5m/s is precautionary.

3.3 Potential Cumulative Effects

A review of the ROMP submission (2009) and the Devon County Minerals Plan (2004) in relation to Lee Moor, Headon and Shaugh Lake quarries has been undertaken. The environmental impact assessment undertaken in support of the ROMP submission does not predict significant dust deposition or PM_{10} impacts to occur from the continued operation of the quarries based on monitoring undertaken, i.e. continued operations are predicted to maintain the *status quo*.

Since the ROMP submission there may have been a reduction in point source emissions of PM_{10} from the kilns, the EIA states:

> *'The processing plants at Headon Quarry and the Herreschoff No.3 Kiln both operate under LAPPC permits issued by South Hams District Council. According to the Council the Headon plant is compliant in respect of emission levels, the Herreschoff No.3 Kiln is compliant at present, but the PM10 emissions limit will be revised downwards in 2009 from 100 mg/m3 to 50 mg/m3. This change will necessitate some improvements to the plant, identified as a change to the dry scrubbing system which is being actioned by Imerys'.*

[16] Department of Environment, The Environmental Effects of Dust from Surface Mineral Workings – Technical Report, Arup Environmental (1995)

The cumulative assessment has incorporated cumulative effects of future mine operations at Hemerdon and a possible ‘reduction kiln’ as emissions from these sources will not be incorporated into the baseline monitoring undertaken in the area to date.

4.0 BASELINE CONDITIONS AND SENSITIVE RECEPTORS

4.1 Sensitive Human Receptor Locations

Air quality objectives should apply to all locations where members of the public may be reasonably likely to be exposed to air pollution for the duration of the relevant objective. Longer term objectives such as the annual mean for PM_{10} should apply only at locations where people are likely to be present for long periods (examples given are residential properties, schools, hospitals and care homes). In the case of 24-hour objectives a relevant location would be one where the individuals may be exposed for eight hours or more in a day. These objectives do not apply to exposure at the workplace and should not apply to footpaths or other locations where members of the public are likely to be exposed for only a short period of time. Shorter term objectives, such as 1-hour objectives (and 1-hour EALs) would include any outdoor locations where members of the public might reasonably be expected to regularly spend 1 hour or more.

In relation to nuisance dust, locations with a high sensitivity to dust include hospitals and clinics, hi-tech industries, painting and furnishing and food processing. Locations classed as being moderately sensitive include schools, residential areas and food retailers. Table 4-1 below shows examples of dust sensitive facilities[17,18].

Table 4-1
Dust Sensitive Receptors

High Sensitivity	Medium Sensitivity	Low Sensitivity
Hospitals and clinics Retirement homes Hi-tech industries Painting and furnishing Food processing	Schools and residential areas Food retailers Greenhouses and nurseries Horticultural land Offices	Farms Light and heavy industry Outdoor storage

On the basis of the guidance described above, discrete receptors relevant for annual mean or 24-hour mean exposure have been used in the dispersion modelling report to assess potential impacts as presented in Table 4-2. Drawing H1a identifies those 'current' receptors that are subject to the Section 52 Agreement which therefore have been excluded from the dust risk assessment on the basis that they will not be present. Boundary receptors have been used in the model to assess potential short-term (1-hour) exposure.

Table 4-2
Sensitive Human Receptor Locations

ID	Receptor	X	Y	Type
DR1	Scrap Yard	256181	58639	Work Place
DR2	Mumford Cottage	257798	60758	Residential
DR3	Portworthy	255470	60195	Residential
DR4	Heath Farm/ The Rambles	254901	59213	Residential
DR5	Animal Welfare Centre / Heathdown Cottage	254808	59385	Residential
DR6	Lobb Shippon	255938	58212	Work Place
DR7	Glava House	256558	58084	Residential
DR8	Golden Clay Shoot	255682	58949	Work Place
DR9	WindWhistle/The Barn	256131	57788	Residential

[17] Ireland M. (1992) "Dust: Does the EPA go far enough?", Quarry Management, pp23-24.
[18] ARUP (1995). *The Environmental Effects of Dust from Surface Mineral Workings*. Report on behalf of DEFRA. (HMSO), Environmental/Ove Arup & Partners.

ID	Receptor	X	Y	Type
DR10	Newnham Home Farm	255669	58020	Residential
DR11	Elfordleigh Country Club	254644	58651	Residential
DR12	Truelove	255219	60713	Residential
DR13	Wotter Farm	256005	61640	Residential
DR14	Broadoak Cottages	256779	61322	Residential
DR15	Lee Moor (Village)	257120	61691	Residential
DR16	Goodamoor Cottage	258038	58646	Residential
DR17	Headon Gate	258654	59223	Residential
DR18	Houndall Farm	258622	58977	Residential
DR19	Birchland	257918	58313	Residential
DR20	Sparkwell Farm	257838	57924	Residential
DR21	Hemerdon House	257282	57570	Residential

4.2 Ecological Receptors

The H1 Guidance Note[19] states that ecological habitats should be screened against relevant standards if they are located within the following set distances from the facility:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs) or Ramsar sites within 10km of the installation; and
- Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNR), Local Nature Reserves (LNR), local wildlife sites and ancient woodland within 2km of the installation.

Designated sites within the set screening distance provided by the Environment Agency are presented in Table 4-3 and shown on Drawing H1b1 and H1b2.

Table 4-3
Environment Agency Screening for Nature Conservation Sites

Receptor Name	Type of Receptor	Minimum Distance from Boundary	Direction from Site Boundary
European / International Designated ecological Receptors within 10km as shown on Drawing H1b1			
The Tamar Estuaries Complex	(SPA)	9500m	North West
South Dartmoor Woods	(SAC)	3900m	North West
Dartmoor	(SAC)	3050m	North East
Plymouth Sound and Estuaries (two areas within 10km)	Special Area of Conservation (SAC)	8500m	South West and South
Ecological Receptors within 2km			
• Brockhole & Binicliff Woods • Truelove • Crownhill Down • Higher Lee • Hooksbury Wood • Blackalder Tor • The Ruts • Smallhanger Waste	Local Wildlife Sites (LWS) (Previously known as County Wildlife Sites)	Within 2km	West, South West, North and East

[19] Environment Agency, Horizontal Guidance Note H1 - Annex (f) Air Emissions. (February 2012).

• Knowle Wood • Shaugh Moor • Ridding Down • Headon Down • Great Shaugh & Cann Woods			
• Three unnamed areas of ancient and semi natural woodland • Hatshill / Holt Woods • Brockhole / Binicliff Woods • Fernhill Wood • Hooksbury Wood – Ancient replanted • Higher Lee Woods – Ancient and Semi-Natural • Coleland – Ancient Replanted	Ancient Woodland	Within 2km	West, North, and South West

The dispersion modelling has specifically included the ecological receptors in Table 4-3. Given the emissions at the site are from ground level diffuse sources impacts will be greatest at the closest receptors and lower at those further away. In accordance with AQTAG06[20], either discrete or array receptor grids at 100m resolution have been used to represent sensitive ecological receptors.

In addition to the ecological receptors above Priority Habitats, that do not have a statutory designation and are not included in the above areas have also been included, as follows:

- part of Lower Hooksbury Wood contains lichens including 3 Red Data Book, 2 Nationally Rare and 8 Nationally Scarce species;
- Bottle Hill contains deciduous woodland (Protected Habitat); and
- Drakeland/Hemerdon Mine Area contains deciduous woodland (Protected Habitat).

4.3 Baseline Air Quality

4.3.1 PM_{10}

Monitoring Data

The UK Automatic Urban and Rural Network (AURN) is a country-wide network of air quality monitoring stations operated on behalf of Defra. The closest monitoring station is located at Plymouth Centre. This monitor is classified as an ‘urban background’ and therefore will not be representative of the application site given its rural setting.

The majority of monitoring undertaken by South Hams District Council (SHDC) is concentrated about the population centres of Kingsbridge, Totnes, Ivybridge and Dean Prior (on the A38). Due to the distance from the installation these stations are not suitable for use to characterise the local air quality in the vicinity of the installation. However, automated (real-time) monitors have recently been located to the south and east of the MWF to monitor combustion emissions from the Langage Combined Cycle Gas Turbine Power station.

[20] AQTAG06 – Technical Guidance on detailed modelling approach for an appropriate assessment for emissions to air. Environment Agency, working Draft version 9, 12/05/06.

The most recent published[21] results from the real-time monitor located in Sparkwell (which is approximately 1.4km to the south east) are presented in Table 4-4. No exceedences of air quality objectives were reported in 2011.

Table 4-4
Sparkwell Automated Monitor (µg/m^3)

	Objective	2011 Monitoring Results
PM_{10}	Annual mean	21.3
	24-hr mean	8 exceedences of 50µg/m^3 24-hour mean

A 3-month monitoring survey for PM_{10} commissioned by Wolf Minerals was completed between 29th July and 3rd November 2011 at Birchlands Farm. The reported findings state: '*a mean value of 13µg/m^3 (micrograms per cubic metre) was recorded for the period within a range between 3µg/m^3 and 35µg/m^3. As such there were no exceedences of the daily NAQS Objective for PM_{10} during the 3 month duration of this phase*'[22]. The monitoring results show a fair agreement with the Defra background of 12.4µg/m^3 as detailed below.

Defra Backgrounds

Background pollutant concentrations have been obtained from Defra UK Background Air Pollution Maps. These 1km grid resolution maps are based upon a 2010 base year verified against monitored concentrations from a large number of automatic monitoring stations across the Country with projection factors provided for future years. The annual mean PM_{10} concentrations for the grid squares within 1km of the installation for 2013 are presented in Table 4-5 below.

Table 4-5
Estimated Annual Mean PM_{10} Concentrations (µg/m^3)

Y X	254500	255500	256500	257500	258500
61500	12.7	13.1	14.3	14.7	15.1
60500	12.8	12.9	14.2	17.5	15.0
59500	12.5	12.1	14.3	14.5	13.8
58500	12.7	12.4	12.2	12.4	12.3

4.3.2 UK Heavy Metals Monitoring Network

The Centre for Ecology & Hydrology (CEH) operates a national monitoring network for heavy metals. The closest monitoring site to the MWF is located at Yarner Wood approximately 30km to the north east. The most recent data set states 0.44ng/m^3 as an annual average.

4.3.3 Dust Deposition

Dust deposition monitoring was commissioned by Wolf Minerals at receptor locations in the vicinity of the installation. The monitoring programme ran between 12/08/2011 and 29/02/2012. A summary of reported[22] mean deposition levels is presented in Table 4-6.

[21] 2012 Air Quality Updating and Screening Assessment for South Hams District Council (May 2012)

[22] Advance Environmental, Assessment of baseline dust and particulate matter in the vicinity of Hemerdon Tungsten Mine for Wolf Minerals Limited (February 2012)

Table 4-6
Dust deposition Rate

Location	12/08/2011 – 29/02/2012 Mean ($mg/m^2/day$)
Old Newnham Farm	23
Bude Farm House	24
Birchlands Farm	24
Bottle Hill Cottage	40
Mumford Cottage	34

The measured dust deposition rates are relatively low and accord with typical levels reported for ‘open country’[23].

[23] Good Practice Guide: Control and Measurement of Nuisance Dust and PM_{10} from the Extractive Industries. Minerals Industry Research Organisation, (2011.)

5.0 SOURCE TERM

5.1 Source Term (Assessment) Scenario

The generation of the source term has incorporated the sources at the MWF facility i.e.

- wind generated dust from the embankment and beached tailings;
- handling of materials in building the embankment; and
- haul roads transporting ROM and DMS Rejects to the embankment.

In addition, activities associated with the mining and processing of ore have also been included as they are not represented in the baseline. On this basis the source term also includes:

- drilling and blasting;
- materials handling (loading / unloading from trucks);
- vehicle entrainment of dust on haul roads;
- wind erosion on exposed areas (mine pit, ROM storage pile);
- crushing and screening; and
- ore processing (‘possible reduction kiln).

The assessment has adopted a hypothetical worst case scenario for the generation of the source term in that:

- the MWF has been assumed to be at Stage 3 (Year 7) with the largest beached tailings area with the embankment only partially (i.e. lower slopes) restored; and
- mine activity (i.e. truck movements, blasting, material handlings as at Year 5, i.e. 10Mt/per annum).

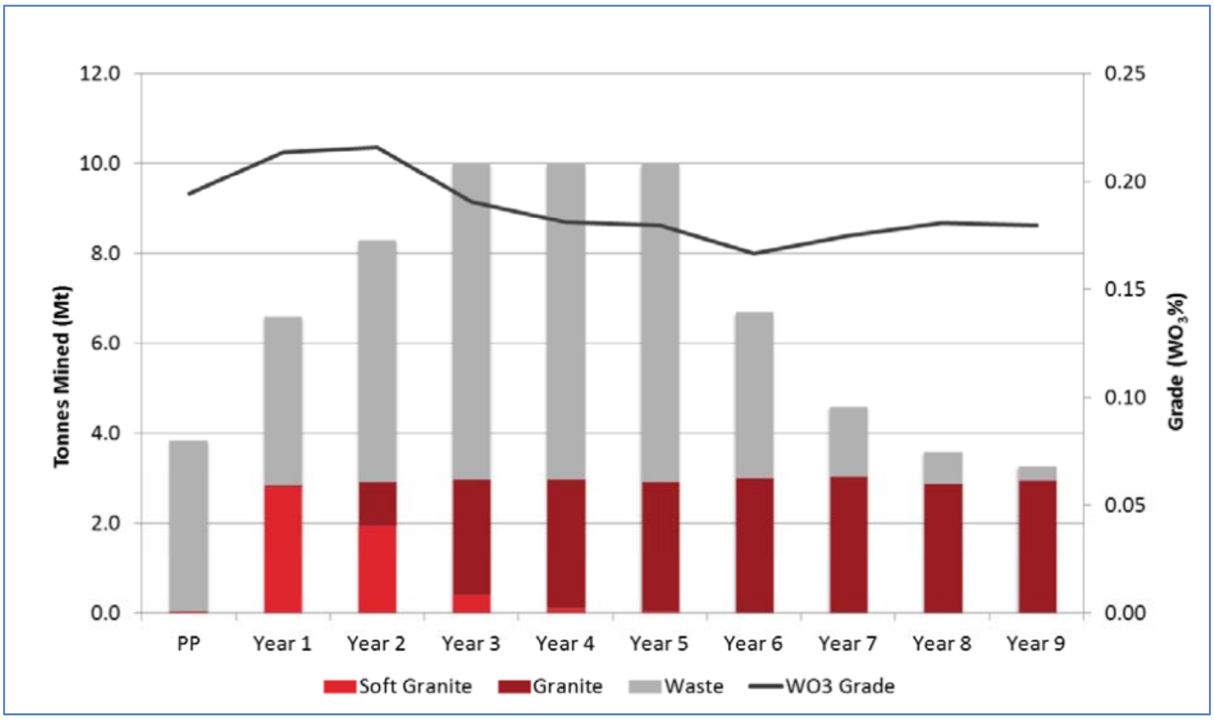


Figure 5-1
Tonnes Mined

5.2 Estimation of Emissions

5.2.1 Materials Handling

Dust may potentially be generated as a result of excavation, truck loading, and truck tipping of top-soils, overburden and ore materials. The amount of dust generated by these 'material handling' operations is a factor of the quantity of materials handled, it's moisture content, as well as climatic factors such as wind speed

The following AP-42 equation (AP-42 Section 13.2.4) has been used to estimate excavations, loading and unloading emissions:

E = k (0.0016)((U/2.2)^1.3(M/2)^-1.4)

where:

- E = particle size-specific emission factor (kg/t handled)
- U = mean wind speed (5.2 m/s from Met data)
- M = material moisture content (%)
- k = particle size multiplier (PM_{10} 0.35, TSP 0.74)

Moisture content has been estimated at 1% for the Ore body (granite) and 7% for the waste rock (i.e. mixture of clay, slate and kaolinised granite.)[24].

A control factor for the use of sprays when required of 0.5 has been applied following Australian NPI guidance (refer to Table 4 of NPI guidance).

Emissions have been factored up to reflect:

- pit and plant operations for 24 hours per day for 5.5days/week; and
- MWF operations (i.e. handling waste rock and DMS Rejects) 6am to 10pm for 5.5 days/week.

Table 5-1
Materials Handling

Source	Rate (k tpa)	Type	PM_{10} Emissions (g/s)	TSP Emissions (g/s)
In-pit excavation	10000	Ore 30%+Waste 70%	0.2987	0.6365
In-pit loading	10000	Ore 30%+Waste 70%	0.2987	0.6365
ROM tipping at Process Plant	3000	Waste	0.2591	0.5477
MWF tipping waste rock	7100	Ore	0.0603	0.1351

5.2.2 Drilling and Blasting

Drilling at the Hemerdon Mine will be undertaken with full dust suppression, i.e. bag filters and water sprays if necessary. Given the mitigation factors published in Australian NPI guidance (refer to Table 4 of NPI guidance) of 99% and 70% respectively, the cumulative

[24] SANTI, P. M. AND DOYLE, B. C., 1997, The locations and engineering characteristics of weak rock in the U.S. In Santi, P. M. and Shakoor, A. (Editors), Characterization of Weak and Weathered Rock Masses, Association of Engineering Geologists Special Publication #9: Association of Engineering Geologists, Denver, CO, pp. 1–22.

mitigation is anticipated to reduce dust to insignificant levels and drilling has not been modelled.

Blasting occurs intermittently for short durations (i.e. seconds). The ability of the model to simulate releases from blasting is limited by the minimum 1-hour time-step of the model. As such blasting has been accounted for in the modelling, simulated as if occurring for an hour with the mass release averaged over the hour. However given the relatively minor contribution to overall emissions from mining operations, it is considered that the limitations in modelling and general assumptions about drilling and blasting rates are of low significance.

The blasting emission equations from the AP-42 emission factor (Table 11-9-1 in AP-42) have been applied as follows (A = area):

- E kg PM_{10} / blast = 0.000014 * A^1.5 * (0.52); and
- E TSP / blast = 0.000014 * A^1.5.

The modelling has assumed 2 blast per week. The area requiring blasting has been calculated based on a volume of 3.7Mm^3 (10Mt at 2.65t/m^3) and a bench height of 10m, giving an area of 7257m^2 per week.

Table 5-2
Blasting

Source	PM_{10} Emissions (g/s) Per blast	TSP Emissions (g/s) Per blast
Blasting	0.00020	0.00038

5.2.3 Screening and Crushing

Planning Condition 31(d) states:

> *'The process plant shall be enclosed within buildings. The buildings housing the primary crusher, and those where dry material is handled shall be kept under negative air pressure and the extracted air shall be passed through an efficient dust collection plant'*.

As such the Primary and Secondary crushing plant (including screens) shall be housed within a building with air extracted to a dust collections plant. Following the guidance for Metalliferous Mines on control efficiencies (NPI Table 4) enclosure can be assumed to provide 100% control. On this basis Crushing and Screening have been excluded from the modelling.

5.2.4 Wind erosion

Dust emissions may be generated by wind erosion of exposed surfaces on the MWF (i.e. embankment and beached tailings), in the mine area, and ROM storage piles. The magnitude of dust emission is a factor of the total area and emission rate. The primary factors that affect the rate of emission of fugitive dust include the extent of surface compaction, moisture content, particle size distribution, wind speed and precipitation.

MWF

Emissions from the surface of the Tailings Management Facility have been estimated on the basis of US-AP42 emission factors for sand and gravel processing (Table 8.19.1-1 -EPA, 1985). This was considered most appropriate on the basis of the known particle size of the tailings (i.e. predominantly a medium to fine sand). The emission factors are:

- EF_{PM10} = 0.16 kg/ha/hour
- EF_{TSP} = 0.08 kg/ha/hour

According to AP-42 '*spray systems can also reduce loading and wind erosion emissions from storage piles of various materials 80 to 90 percent*'. On this basis and considering the Dust Management Plan in place that makes use of both water sprays and opening spigots to saturate drying areas, a 90% emission reduction has been applied.

The embankment is made up of coarse blasted rock and DMS rejects (a coarse de-slimed gravel that is handled wet and encased within the coarse rock). In the absence of emission factors in either the NPI or AP-42 for constructed embankments of this type the same emission factor as for the beached tailings was applied. Considering the nature of the surface of the embankment this is therefore considered a precautionary estimate.

Mine Area and ROM Pile

The emission rate has been calculated following the guidance in the Australian NPI for wind erosion from exposed areas. The default recommended is the same as for wind erosion from active coal piles, for which the NPI addresses the AP-42 equation and concludes the result are '*believed to be a high estimate for Australian conditions. It is recommended that the SPCC (1983) default values be used as follows*':

- EF_{TSP}(kg/ha/hr) = 0.4kg/ha/hr
- EF_{PM10}(kg/ha/hr) = 0.2kg/ha/hr

A control factor for the use of sprays when required of 0.5 has been applied following Australian NPI guidance (refer to Table 4 of NPI guidance).

The potential emission rates are higher than for the MWF. This is considered appropriate given the increased activity levels, most notably within the Pit and the potential for the pit to retain dusts and lead to a build up.

Modelling Information

The areas for each source have been entered on the basis of site plans and the following assumptions have been made:

- the embankment is fully developed with the lower slopes (approximately 50% restored);
- the Beached Tailings account for approximately 50% of the tailings area (i.e. 50% submerged or saturated);
- the ROM pile area is at capacity
- the Mine Pit is fully developed in terms of area and in Year 5 approximately 72% of its depth (144m).
- annual emissions calculated on the basis of the emissions factors have been apportioned equally across hours when winds are >5.1m/s (approximately 43% of the time) to calculate a specific emission rate ($g/m^2/s$).

The sources and emission rates modelled are presented in Table 5-3.

Table 5-3
Wind Erosion

Source	Type	Area (m2)	PM_{10} Emissions ($g/m^2/s$)	TSP Emissions ($g/m^2/s$)
Beached Tailing	Area Source	152339	5.11E-07	1.02E-06
Embankment	Area Source	387230	5.11E-07	1.02E-06
Pit	Open Pit	360000	6.46E-06	1.29E-05
ROM Pad	Area Source	17819	6.46E-06	1.29E-05

5.2.5 Vehicle Entrainment of Dust from Unpaved Haul Roads

Emission Estimation

Unpaved haul roads can lead to dust generation as a result of the pulverization of surface material caused by the wheels on the road surface, the particles are lifted into the air either by the rolling wheels or as a result of air currents from the turbulence cause by the passing of the vehicle.

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. The other primary factors that affect dust generation on unpaved haul roads on industrial sites as opposed to general traffic include, silt content and vehicle weight, thus for vehicles travelling on unpaved surfaces at industrial sites, emissions are estimated from the following equation:

$$EF = k\,(s/12)^a (W/3)^b (281.9)$$

where k, a, b, are empirical constants given below and:

- EF = size-specific emission factor (g/VKT)
- k = 1.5 for PM^{10} and 4.9 for TSP
- s = surface material silt content (%)
- a = 0.9 for PM^{10} and 0.7 for TSP
- W = mean vehicle weight (tons)
- b = 0.45 for PM10 and 0.45 for TSP
- 281.9 = g/VKT to lb/VMT

The silt content was based on AP-42 guidance. The AP-42 guidance states '*tests … show that road silt content is normally lower than in the surrounding parent soil, because the fines are continually removed by the vehicle traffic, leaving a higher percentage of coarse particles*'. On this basis use of the silt content of the surrounding soils would likely result in an overestimate of haul road emissions. In the absence of site specific road silt loading data a mean silt content of 8.4% was taken from AP-42 Table 13.2.2-1 '*Typical Silt Content Values Of Surface Material On Industrial Unpaved Roads*'. A value of 8.4% represents the highest mean value applied to 'haul road to/from pit' for either sand and gravel, stone quarrying, taconite mining or western surface coal mines. The emissions rate has then been adjusted for the total number of wet days (156) in the year to reflect natural mitigation (number of wet days / 365).

Vehicle distances travelled were determined for the following return transport routes: waste material to the MWF (2.9km), DMS Rejects to the MWF (1.9km), and ore to run of mine pad (0.8km). Route distances were measured using a site plan, and vehicle trips were calculated on the basis of waste/ore tonnes generated and vehicle capacity (80 tonne trucks). The assessment has assumed 80 Tonne Rear Dump Haul Trucks (120t loaded / 50t unloaded for return journey, i.e. a mean weight of 85t).

Emissions from the haul roads are minimised through:

- regular maintenance (including grading);
- limiting vehicle speeds; and
- use of watering systems (bowsers / water truck).

These methods are effective at minimising dust release from the site haul roads with the use of water likely to provide a substantial reduction in emissions of dust and PM_{10}. Estimates within AP42 (Chapter 13.2.2) indicate that a moisture content of 5% in surface material will provide a 95% control efficiency and monthly use of ‘treatments’ (e.g. resins) can provide 90% control efficiency. A 90% control efficiency is also claimed by manufacturers of road treatments such as Dustex, MidWest, Quattro Solutions, and GE’s Dust Treat. At Hemerdon an average allowance of 500 m³/day of water has been assumed for dry days when dust suppression may be required. In addition the Dust Management Plan includes use of chemical suppressants if dust monitoring indicates it is required. On this basis a 90% control efficiency has been applied.

The emission rates modelled are presented in Table 5-4.

Table 5-4
Unpaved Haul Road Emissions

	Haul Route	Tonnes of Material Moved/day	Approx. Distance (km/day)	g/VKM	Total g/s per route
PM_{10}	PIT-MWF	24,825	900	79	1.2
	Pit - Plant	10,140	241	79	0.2
	Plant to MWF	6,713	159	79	0.2
TSP	PIT-MWF	24,825	900	277	4.3
	Pit - Plant	10,140	241	277	0.8
	Plant to MWF	6,713	159	277	0.8

Modelling Information

The roads have been modelled using volume sources in accordance with AERMOD user guidance. A plume width of 20m has been applied (road width +6m) and a vehicle height of 5.2m used. The total emission has been divided across the volume sources used to represent the haul roads as follows:

- waste material to the MWF - 44 Volume Sources;
- DMS Rejects to the MWF - 22 Volume Sources; and
- ore to run of mine pad - 9 Volume Sources.

Some stretches of the haul road are trafficked by more than one haul route e.g. from the process plant DMS area to the MWF embankment is used by both trucks carrying DMS rejects and waste rock, in which case the emissions from each route are added to derive the volume source emission rate.

The roads have been assumed to be in use as follows:

- PIT-MWF: 6am to 10pm for 5.5 days/week
- Pit – Plant: 24 hours per day for 5.5days/week
- Plant to MWF: 6am to 10pm for 5.5 days/week

5.2.6 Ore Processing

There is the possibility that a reduction kiln may be required as part of the ore processing plant at Hemerdon. Consequently in order to investigate the potential cumulative effects on PM_{10} and arsenic concentrations and deposition of such a plant, emissions based on ore tonnage throughput and manufacturers' specifications have been included. Particulate emission benchmarks have been based on Sector Guidance Note - Non-Ferrous Metals and the Production of Carbon and Graphite (EPR 2.03)[25] and a $1000m^3$hr flow rate. Arsenic concentrations have been based on manufacturer's specification. Particulate emissions have been assumed to comprise 100% PM_{10}.

The most recent design proposals from GR Engineering Services Ltd for a possible reduction kiln indicate that the assumptions in this assessment are highly conservative in terms of both volume flow and arsenic concentration in flue gas. The gas scrubbing system used to remove the volatised arsenic would be subject to a BAT assessment at the time of any Permit Application, however it is likely to comprise a 3 stage process of quench cooling of the gas stream to sublime the arsenic, absorption of the arsenic into solution in a wet scrubber, followed by removal of any particulates in a baghouse. The assumptions in this assessment effectively double the volume flow and increase the arsenic concentration by a factor of 10 compared to the latest design proposal. Notwithstanding this, further sensitivity analysis has been undertaken with a further 50% uplift in concentration applied.

Table 5-5
Emission Parameters

	Units	Possible Reduction Kiln
Location	NGR m	x:256879, y:59009
Stack Height	m	30m
Stack Diameter	m	0.17
Temperature	°C	60
Actual Efflux Velocity	m/s	15.8
Volume Flow	Nm^3/s	0.28
'Daily Average' benchmarks		
Particulate Concentration	$mg/Nm^{3\ (a)}$	10
Particulate Emission Rate	g/s	0.0028
'Monthly average' benchmarks		
Particulate Concentration	$mg/Nm^{3\ (a)}$	5
Particulate Emission Rate	g/s	0.0014
Manufacturers specification		
Arsenic Concentration	$mg/Nm^{3\ (a)}$	1
Arsenic Emission Rate	g/s	0.00028

Table Note:
a) Reference conditions are in accordance with EPR2.03-Annex 1 Benchmarks: 0^oC (273k), 101.3 kPa, no correction for water vapour or oxygen.

For this assessment, as a small fraction (less than 10% of the mass) consists of particles with a diameter of 10 microns or larger, the Method 2 approach to modelling deposition has been applied using published data[26] relating to particle size distribution for arsenic as below:

- Fine mass fraction: 0.75

[25] Environment Agency, How to comply with your environmental permit Additional guidance for: Non - Ferrous Metals and the Production of Carbon and Graphite (EPR 2.03) (March 2009)

[26] Deposition Parameterizations for the Industrial Source Complex (ISC3) Model. Environmental Research Division, Argonne National Laboratory on behalf of US Department of Energy, June 2002.

- Mean Particle Diameter: 0.5μm

The integrated Building Profile Input Programme (BPIP) module within AERMOD was used to assess the potential impact of building downwash upon predicted dispersion characteristics. All site buildings (offices and processing plant) have been input to the model based on the site layout plans but only the buildings in Table 5-6 are of relevance given their height.

Table 5-6
Modelled Buildings

Description	OSGR Y	OSGR X	Elev. (m AOD)	Height (m)	x-length (m)	y-length (m)	Angle
Main Building	256936.2	58906.4	171	27.0	21.1	114.9	-34.7
Main Building	256893.0	58956.2	171	29.7	7.0	13.6	-34.6

5.3 Dust Composition - Metals

The main report details the composition of each waste stream. The waste materials used in embankment construction are coarse blasted non-mineralised waste rock and wet de-slimed DMS Rejects that constitutes a coarse gravel that is emplaced within the waste rock. Therefore as concluded in the main report the embankment does not represent a potential dust source with elevated metal concentrations. The processing tends to concentrate the arsenic into the slurried waste, the tailings, these will comprise predominantly the gravity rejects (accounting for approximately 90% by weight) but also include slimes reject, froth flotation rejects and magnetic reject. The gravity reject is kaolinised and fresh granite that has been ground to a size of 300μm, i.e. a fine to medium sand. There exists potential for a proportion of fines (i.e. silt sized) material to be entrained in the slurry.

Laboratory simulated test-work using composite granite samples obtained from the site has broadly produced the slurry waste (tailings) indicated at the end of the process. Subsequently, multi-elemental dry weight analyses of these tailings has been undertaken and produced by AMEC. Table 5-7 summarises the concentrations for the pollutants of concern, this composition has been applied to emissions from the beached tailings.

Table 5-7
Summary of Elemental Analyses (ppm)

Metal	Composite Tails
As	920
Cd	<1
Cr	90
Cu	98
Pb	4
Hg	<1
Mo	4
Ni	10
Se	2
Zn	34

6.0 DUST IMPACT ASSESSMENT

The results of the atmospheric dispersion modelling are presented in the sections below. In general the results present:

- the total deposition or concentration from all sources at the MWF;
- the contribution (deposition or concentration) from the beached tailings alone; and
- the cumulative deposition or concentration as a result of all sources at the MWF (including beached tailings) and mine operations (mining, processing, haulage).

Further analysis of source contributions is presented as necessary.

6.1 PM_{10}

The predicted annual mean PM_{10} concentrations at sensitive receptor locations are presented in Table 6-1 below. The cumulative predicted environmental concentration (PEC), i.e. background plus MWF process contribution (PC) plus mine PC, remains well below the EAL at all locations. Figure 6-1 illustrates the dispersion of PM_{10} representing the annual mean PM_{10} process contribution. The maximum process contribution occurs along the southern boundary as a result of the location and contribution of haul road dust emissions.

Table 6-1
Annual PM_{10} Concentration (µg/m^3)

ID	MWF PC	MWF PC % EAL	Cumulative PC	Cumulative PEC	Cumulative % EAL
DR1	1.4	4%	3.8	25.1	63%
DR2	0.1	<1%	0.2	21.5	54%
DR3	0.4	1%	0.6	21.9	55%
DR4	0.7	2%	1.2	22.5	56%
DR5	0.7	2%	1.0	22.3	56%
DR6	0.7	2%	2.2	23.5	59%
DR7	0.8	2%	2.6	23.9	60%
DR8	1.3	3%	3.0	24.3	61%
DR9	0.5	1%	1.8	23.1	58%
DR10	0.5	1%	1.8	23.1	58%
DR11	0.5	1%	1.2	22.5	56%
DR12	0.2	<1%	0.3	21.6	54%
DR13	0.0	<1%	0.1	21.4	53%
DR14	0.1	<1%	0.2	21.5	54%
DR15	<0.1	<1%	0.1	21.4	53%
DR16	0.2	1%	1.3	22.6	57%
DR17	0.1	<1%	0.5	21.8	54%
DR18	0.1	<1%	0.6	21.9	55%
DR19	0.2	1%	1.7	23.0	58%
DR20	0.2	1%	1.4	22.7	57%
DR21	0.4	1%	1.7	23.0	57%

The predicted 24-hour mean PM_{10} concentrations at sensitive receptor locations are presented in Table 6-1 below. The MWF process contribution is less than 10% of the EAL and the cumulative predicted environmental concentration remains below the EAL at all sensitive receptor locations. Figure 6-2 illustrates the dispersion of PM_{10} (24-hr mean as a

90.4%ile). The maximum process contribution occurs along the southern boundary as a result of the location and contribution of haul road dust emissions.

Table 6-2
24-hour Mean PM_{10} Concentration (µg/m^3)

ID	MWF PC	MWF PC % EAL	Cumulative PC	Cumulative PEC	Cumulative % EAL
DR1	5.1	10%	12.1	34.4	69%
DR2	0.3	1%	0.5	22.8	46%
DR3	1.0	2%	1.7	24.0	48%
DR4	2.7	5%	4.2	26.5	53%
DR5	2.2	4%	3.4	25.7	51%
DR6	2.5	5%	7.1	29.4	59%
DR7	2.5	5%	8.4	30.7	61%
DR8	4.6	9%	10.1	32.4	65%
DR9	1.7	3%	6.1	28.4	57%
DR10	1.9	4%	5.9	28.2	56%
DR11	1.6	3%	4.3	26.6	53%
DR12	0.5	1%	0.9	23.2	46%
DR13	0.1	<1%	0.3	22.6	45%
DR14	0.3	1%	0.7	23.0	46%
DR15	0.1	<1%	0.2	22.5	45%
DR16	0.5	1%	3.6	25.9	52%
DR17	0.3	1%	1.3	23.6	47%
DR18	0.4	1%	1.5	23.8	48%
DR19	0.6	1%	4.9	27.2	54%
DR20	0.8	2%	4.1	26.4	53%
DR21	1.3	3%	5.8	28.1	56%

Table Note: Background annual mean concentration applied for 24-hr PM_{10} following LAQM.TG(09) guidance Section A3.207.

6.2 Metal Concentrations in Air

6.2.1 MWF Contribution

The annual mean metal concentration at sensitive human receptor location is presented in Table 6-3 below. Table 6-4 presents the concentration as a percentage of the EAL. The concentration is predicted to be less than 1% at all human receptor locations and the site boundary and therefore considered insignificant. Notwithstanding this further consideration has been given to potential cumulative effects with a possible reduction kiln in the Section 6.2.2.

Table 6-3
Annual Mean Metal Concentration (µg/m^3)

ID	PM_{10}	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Se	Zn
DR1	2E-06	2E-09	2E-07	2E-07	1E-08	2E-09	1E-08	2E-08	5E-09	8E-08	2E-06
DR2	4E-06	4E-09	4E-07	4E-07	2E-08	4E-09	2E-08	4E-08	9E-09	2E-07	4E-06
DR3	2E-06	2E-09	2E-07	2E-07	9E-09	2E-09	9E-09	2E-08	5E-09	8E-08	2E-06
DR4	3E-06	3E-09	2E-07	3E-07	1E-08	3E-09	1E-08	3E-08	6E-09	9E-08	3E-06
DR5	2E-06	3E-09	2E-07	3E-07	1E-08	3E-09	1E-08	3E-08	5E-09	9E-08	2E-06
DR6	1E-06	1E-09	9E-08	1E-07	4E-09	1E-09	4E-09	1E-08	2E-09	4E-08	1E-06

ID	PM_{10}	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Se	Zn
DR7	2E-06	2E-09	2E-07	2E-07	9E-09	2E-09	9E-09	2E-08	4E-09	7E-08	2E-06
DR8	2E-06	2E-09	2E-07	2E-07	1E-08	2E-09	1E-08	2E-08	5E-09	8E-08	2E-06
DR9	9E-07	1E-09	9E-08	1E-07	4E-09	1E-09	4E-09	1E-08	2E-09	3E-08	9E-07
DR10	6E-07	7E-10	6E-08	7E-08	3E-09	7E-10	3E-09	7E-09	1E-09	2E-08	6E-07
DR11	1E-06	1E-09	1E-07	1E-07	5E-09	1E-09	5E-09	1E-08	2E-09	4E-08	1E-06
DR12	8E-07	9E-10	8E-08	8E-08	3E-09	9E-10	3E-09	9E-09	2E-09	3E-08	8E-07
DR13	1E-06	1E-09	1E-07	1E-07	5E-09	1E-09	5E-09	1E-08	3E-09	5E-08	1E-06
DR14	3E-06	3E-09	3E-07	3E-07	1E-08	3E-09	1E-08	3E-08	6E-09	1E-07	3E-06
DR15	2E-06	2E-09	2E-07	2E-07	9E-09	2E-09	9E-09	2E-08	4E-09	7E-08	2E-06
DR16	1E-06	1E-09	1E-07	1E-07	5E-09	1E-09	5E-09	1E-08	2E-09	4E-08	1E-06
DR17	1E-06	1E-09	1E-07	1E-07	5E-09	1E-09	5E-09	1E-08	3E-09	5E-08	1E-06
DR18	1E-06	1E-09	1E-07	1E-07	5E-09	1E-09	5E-09	1E-08	2E-09	4E-08	1E-06
DR19	8E-07	9E-10	8E-08	9E-08	4E-09	9E-10	4E-09	9E-09	2E-09	3E-08	8E-07
DR20	9E-07	9E-10	8E-08	9E-08	4E-09	9E-10	4E-09	9E-09	2E-09	3E-08	9E-07
DR21	1E-06	2E-09	1E-07	2E-07	6E-09	2E-09	6E-09	2E-08	3E-09	5E-08	1E-06
Max Bnd	2E-05	2E-08	2E-06	2E-06	1E-07	2E-08	1E-07	2E-07	5E-08	8E-07	2E-05

Table 6-4
Annual Mean Metal Concentration as % of EAL

ID	As	Cd	Cr	Cu	Pb	Hg	Ni	Se	Zn
DR1	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR2	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR3	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR4	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR5	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR6	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR7	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR8	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR9	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR10	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR11	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR12	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR13	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR14	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR15	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR16	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR17	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR18	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR19	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR20	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR21	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Max Bnd	0.7%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

The 1-hr mean metal concentration at sensitive human receptor location and maximum boundary location is presented in Table 6-5 below. Table 6-6 presents the concentration as a percentage of the EAL. The concentration is predicted to be less than 1% (significantly less than the 10% significance threshold) at all human receptor locations and therefore considered insignificant.

Table 6-5
1-hr Mean Metal Concentration (µg/m³)

ID	PM_{10}	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Se	Zn
DR1	7E-01	1E-04	1E-07	1E-05	1E-05	5E-07	1E-07	5E-07	1E-06	2E-07	4E-06
DR2	2E-01	3E-05	3E-08	3E-06	3E-06	1E-07	3E-08	1E-07	3E-07	7E-08	1E-06
DR3	5E-01	2E-05	2E-08	2E-06	2E-06	8E-08	2E-08	8E-08	2E-07	4E-08	7E-07
DR4	4E-01	3E-05	4E-08	3E-06	4E-06	1E-07	4E-08	1E-07	4E-07	7E-08	1E-06
DR5	4E-01	3E-05	4E-08	3E-06	4E-06	1E-07	4E-08	1E-07	4E-07	7E-08	1E-06
DR6	5E-01	6E-05	7E-08	6E-06	7E-06	3E-07	7E-08	3E-07	7E-07	1E-07	2E-06
DR7	6E-01	8E-05	8E-08	7E-06	8E-06	3E-07	8E-08	3E-07	8E-07	2E-07	3E-06
DR8	6E-01	6E-05	6E-08	6E-06	6E-06	3E-07	6E-08	3E-07	6E-07	1E-07	2E-06
DR9	4E-01	6E-05	7E-08	6E-06	7E-06	3E-07	7E-08	3E-07	7E-07	1E-07	2E-06
DR10	4E-01	5E-05	6E-08	5E-06	6E-06	2E-07	6E-08	2E-07	6E-07	1E-07	2E-06
DR11	3E-01	4E-05	4E-08	4E-06	4E-06	2E-07	4E-08	2E-07	4E-07	8E-08	1E-06
DR12	4E-01	1E-05	1E-08	1E-06	1E-06	6E-08	1E-08	6E-08	1E-07	3E-08	5E-07
DR13	5E-01	2E-05	2E-08	2E-06	2E-06	1E-07	2E-08	1E-07	2E-07	5E-08	8E-07
DR14	2E-01	1E-05	1E-08	1E-06	1E-06	5E-08	1E-08	5E-08	1E-07	2E-08	4E-07
DR15	2E-01	4E-05	4E-08	3E-06	4E-06	2E-07	4E-08	2E-07	4E-07	8E-08	1E-06
DR16	1E-01	4E-05	5E-08	4E-06	5E-06	2E-07	5E-08	2E-07	5E-07	1E-07	2E-06
DR17	1E-01	5E-05	5E-08	5E-06	5E-06	2E-07	5E-08	2E-07	5E-07	1E-07	2E-06
DR18	1E-01	4E-05	4E-08	4E-06	4E-06	2E-07	4E-08	2E-07	4E-07	9E-08	1E-06
DR19	1E-01	6E-05	6E-08	6E-06	6E-06	2E-07	6E-08	2E-07	6E-07	1E-07	2E-06
DR20	2E-01	4E-05	4E-08	4E-06	4E-06	2E-07	4E-08	2E-07	4E-07	8E-08	1E-06
DR21	4E-01	4E-05	5E-08	4E-06	5E-06	2E-07	5E-08	2E-07	5E-07	9E-08	2E-06
Max Bnd	1E+00	1E-04	1E-07	1E-05	1E-05	4E-07	1E-07	4E-07	1E-06	2E-07	4E-06

Table 6-6
1-hr Mean Metal Concentration as % of EAL

ID	As	Cd	Cr	Cu	Hg	Ni	Se	Zn
DR1	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR2	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR3	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR4	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR5	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR6	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR7	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR8	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR9	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR10	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR11	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR12	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR13	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR14	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR15	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR16	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR17	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR18	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR19	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR20	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
DR21	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Max Bnd	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

6.2.2 Cumulative Effects

The potential cumulative effects as a result of a possible future 'reduction kiln' and background concentrations have been considered. The maximum ground level concentration from a possible 'reduction kiln' emissions occurs within the site boundary, therefore the maximum concentration at the boundary is relevant.

The maximum combined process contribution at a boundary location is 0.0017µg/m^3 (including a background concentration of 0.00044µg/m^3). The PEC is therefore 55% of the EAL.

As a sensitivity assessment the concentration of the 'reduction kiln' emission have been increased by 50%. This results in a total combined PEC of 0.0023µg/m^3. The PEC is therefore 75% of the EAL.

On the basis of these results the arsenic EAL is not predicted to be exceeded.

6.3 Nuisance Dust

Table 6-7 presents the dust deposition rates predicted at sensitive human receptor locations and Figure 6-3 illustrates the dispersion of dust deposition around the MWF. The contribution from the MWF is predicted to be less than 1% of the 'custom and practice' EAL stated in Environment Agency M17 guidance of 200mg/m^2/day at all residential locations. The deposition is 1.3% and 1.1% respectively at the scrap yard and the Golden Clay Shoot which are considered low risk receptors. The risk of the MWF causing a dust nuisance is considered to be negligible.

Table 6-7
Dust Deposition Human Receptor Locations (mg/m^2/day)

ID	MWF PC	% EAL
DR1	2.6	1.3%
DR2	2.0	1.0%
DR3	0.8	0.4%
DR4	1.0	0.5%
DR5	0.9	0.5%
DR6	0.9	0.5%
DR7	1.4	0.7%
DR8	2.2	1.1%
DR9	0.6	0.3%
DR10	0.6	0.3%
DR11	0.6	0.3%
DR12	0.4	0.2%
DR13	0.3	0.1%
DR14	0.9	0.4%
DR15	0.8	0.4%
DR16	1.6	0.8%
DR17	1.1	0.5%
DR18	0.9	0.5%
DR19	1.2	0.6%
DR20	0.8	0.4%
DR21	0.9	0.4%

6.4 Dust Deposition and Soil Quality Criteria

The predicted dust deposition at sensitive human receptor locations and the maximum deposition at the site boundary is presented in Table 6-8 below.

Table 6-8
Metal Deposition (mg/m^2/day)

ID	Dust	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Se	Zn
DR1	0.02	2E-05	2E-08	2E-06	2E-06	7E-08	2E-08	7E-08	2E-07	3E-08	6E-07
DR2	0.11	1E-04	1E-07	1E-05	1E-05	4E-07	1E-07	4E-07	1E-06	2E-07	4E-06
DR3	0.02	1E-05	2E-08	1E-06	2E-06	6E-08	2E-08	6E-08	2E-07	3E-08	5E-07
DR4	0.02	2E-05	2E-08	2E-06	2E-06	8E-08	2E-08	8E-08	2E-07	4E-08	7E-07
DR5	0.02	2E-05	2E-08	2E-06	2E-06	7E-08	2E-08	7E-08	2E-07	4E-08	6E-07
DR6	0.01	7E-06	7E-09	6E-07	7E-07	3E-08	7E-09	3E-08	7E-08	1E-08	2E-07
DR7	0.01	1E-05	1E-08	1E-06	1E-06	6E-08	1E-08	6E-08	1E-07	3E-08	5E-07
DR8	0.02	2E-05	2E-08	2E-06	2E-06	7E-08	2E-08	7E-08	2E-07	4E-08	6E-07
DR9	0.01	6E-06	7E-09	6E-07	7E-07	3E-08	7E-09	3E-08	7E-08	1E-08	2E-07
DR10	<0.01	4E-06	5E-09	4E-07	5E-07	2E-08	5E-09	2E-08	5E-08	1E-08	2E-07
DR11	0.01	8E-06	8E-09	7E-07	8E-07	3E-08	8E-09	3E-08	8E-08	2E-08	3E-07
DR12	0.01	6E-06	6E-09	6E-07	6E-07	2E-08	6E-09	2E-08	6E-08	1E-08	2E-07
DR13	0.01	1E-05	1E-08	1E-06	1E-06	4E-08	1E-08	4E-08	1E-07	2E-08	4E-07
DR14	0.06	6E-05	6E-08	6E-06	6E-06	2E-07	6E-08	2E-07	6E-07	1E-07	2E-06
DR15	0.05	5E-05	5E-08	5E-06	5E-06	2E-07	5E-08	2E-07	5E-07	1E-07	2E-06
DR16	0.02	2E-05	2E-08	2E-06	2E-06	8E-08	2E-08	8E-08	2E-07	4E-08	7E-07
DR17	0.03	2E-05	3E-08	2E-06	3E-06	1E-07	3E-08	1E-07	3E-07	5E-08	9E-07
DR18	0.02	2E-05	2E-08	2E-06	2E-06	9E-08	2E-08	9E-08	2E-07	4E-08	8E-07
DR19	0.02	1E-05	2E-08	1E-06	2E-06	7E-08	2E-08	7E-08	2E-07	3E-08	6E-07
DR20	0.01	1E-05	1E-08	1E-06	1E-06	6E-08	1E-08	6E-08	1E-07	3E-08	5E-07
DR21	0.01	1E-05	1E-08	1E-06	1E-06	5E-08	1E-08	5E-08	1E-07	2E-08	4E-07
Max Bnd	0.62	6E-04	6E-07	6E-05	6E-05	2E-06	6E-07	2E-06	6E-06	1E-06	2E-05

The deposition rate as a percentage of the EAL (Maximum Deposition Rate for a 15-year operational period) is presented in Table 6-9. All deposition rates at sensitive receptors are predicted to be less that 1% of the EAL and therefore metal deposition from tailing dusts is not considered to be significant in terms of impact upon human health.

Table 6-9
Metal Deposition (% of MDR)

ID	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Se	Zn
DR1	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR2	0.2%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR3	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR4	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR5	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR6	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR7	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR8	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR9	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR10	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

ID	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Se	Zn
DR11	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR12	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR13	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR14	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR15	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR16	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR17	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR18	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR19	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR20	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
DR21	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Max Bnd	0.9%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Notwithstanding the fact that the deposition of arsenic from the MWF can be considered insignificant a sensitivity assessment to examine the potential cumulative effects as a result of a possible future ‘reduction kiln’ have been considered. The maximum ground level concentration from a possible ‘reduction kiln’ emissions occurs within the site boundary, therefore the maximum concentration at the boundary is relevant.

The maximum combined process contribution at a boundary location increases from $5.70E^{-04}$ mg/m2/day/m^3 to $5.74E^{-04}$ mg/m2/day/m^3 and therefore remains at less than 1% of the EAL. On this basis the potential cumulative effect of a possible roaster can be considered insignificant.

As a sensitivity assessment the concentration of the ‘reduction kiln’ emission have been increased by 50%. This results in a total combined PEC of $5.76E^{-04}$ mg/m2/day/m^3 and therefore remains at less than 1% of the EAL. On the basis of this sensitivity assessment the potential cumulative effect of a possible roaster can be considered insignificant.

6.5 Effects of Dust on Ecological Receptors

6.5.1 Dust Deposition

The predicted dust deposition rates at ecological receptors are presented in Table 6-10. The rates are slightly above 1% of the adopted EAL of 1000mg/m^2/day at Small Hanger Waste and Crownhill Down, but below 1% at all other locations.

Table 6-10
MWF Process Contribution to Dust Deposition at Ecological Receptors (mg/m^2/day)

ID	MWF PC (mg/m^2/day)	% EAL
Fernhill Wood AW	2.1	0.2%
Hooksbury Wood AW	2.7	0.3%
Coleland Wood AW CWS	3.2	0.3%
South Dartmoor Woods SAC	0.1	<0.1%
Dartmoor SAC	0.4	<0.1%
Plymouth Sound and Estuaries SAC	<0.1	<0.1%
Hooksbury Wood CWS	2.7	0.3%
Crownhill Down CWS	10.4	1.0%
Smallhanger Waste CWS	18.5	1.9%

ID	MWF PC (mg/m²/day)	% EAL
Headon Down CWS	3.2	0.3%
Lower Hooksbury PH (Moss)	2.6	0.3%
Bottle Hill PH	6.8	0.7%
Drakeland/Hemerdon Mine Area PH	7.6	0.8%
Truelove CWS	0.5	<0.1%
ShaughMoor CWS	0.2	<0.1%
Higher Lee Wood AW CWS	0.6	0.1%
Blackadder Tor CWS	1.0	0.1%
Knowle Wood AW CWS	1.3	0.1%
Ridding Down CWS	1.4	0.1%
Brockhole and Bincliffe Wood AW	0.8	0.1%
Great Shaugh & Cann Woods CWS	0.8	0.1%
Hatshill Holt AW	0.7	0.1%
Tamar Est SPA	0.0	<0.1%

The cumulative effects of dust deposition incorporating the process contribution from the mine operations and background (see Table 4-6) are presented in Table 6-11 below. It is predicted that deposition rates will remain significantly below the EAL at all receptors.

Table 6-11
Total Dust Deposition at Ecological Receptors (mg/m²/day)

ID	Cumulative PC	PEC (PC+BG)	% of EAL
Fernhill Wood AW	2.8	42.8	4.3%
Hooksbury Wood AW	3.3	43.3	4.3%
Coleland Wood AW CWS	4.0	44.0	4.4%
South Dartmoor Woods SAC	0.1	40.1	4.0%
Dartmoor SAC	1.2	41.2	4.1%
Plymouth Sound and Estuaries SAC	0.1	40.1	4.0%
Hooksbury Wood CWS	3.3	43.3	4.3%
Crownhill Down CWS	15.7	55.7	5.6%
Smallhanger Waste CWS	50.5	90.5	9.1%
Headon Down CWS	13.7	53.7	5.4%
Lower Hooksbury PH (Moss)	4.4	44.4	4.4%
Bottle Hill PH	17.1	57.1	5.7%
Drakeland/Hemerdon Mine Area PH	55.2	95.2	9.5%
Truelove CWS	0.7	40.7	4.1%
ShaughMoor CWS	0.4	40.4	4.0%
Higher Lee Wood AW CWS	1.0	41.0	4.1%
Blackadder Tor CWS	1.5	41.5	4.1%
Knowle Wood AW CWS	2.4	42.4	4.2%
Ridding Down CWS	3.1	43.1	4.3%
Brockhole and Bincliffe Wood AW	1.6	41.6	4.2%
Great Shaugh & Cann Woods CWS	1.3	41.3	4.1%
Hatshill Holt AW	1.1	41.1	4.1%
Tamar Est SPA	0.0	40.0	4.0%

6.5.2 Deposition of Metals

The predicted deposition of metals as a result of tailings dust deposition on ecological receptors is presented in Table 6-12 and the deposition as a percentage of the Critical Load in Table 6-13. It is predicted that metal deposition will be less than 1% of the Critical Load at all receptor locations.

Table 6-12
MWF Process Contribution to Metal Deposition at Ecological Receptors

ID	Dust	Cd	Pb	Cu	Ni	Zn	Cr	As	Se
	mg/m²/day								
Fernhill Wood AW	4E-02	4E-08	3E-07	4E-06	4E-06	1E-06	1E-05	4E-05	2E-07
Hooksbury Wood AW	5E-02	5E-08	4E-07	5E-06	6E-06	2E-06	1E-05	5E-05	2E-07
Coleland Wood AW CWS	3E-01	3E-07	2E-06	3E-05	3E-05	9E-06	8E-05	3E-04	1E-06
South Dartmoor Woods SAC	2E-03	2E-09	2E-08	2E-07	2E-07	7E-08	6E-07	2E-06	8E-09
Dartmoor SAC	2E-02	2E-08	2E-07	2E-06	2E-06	7E-07	6E-06	2E-05	8E-08
Plymouth Sound and Estuaries SAC	5E-04	5E-10	4E-09	5E-08	5E-08	2E-08	1E-07	4E-07	2E-09
Hooksbury Wood CWS	5E-02	5E-08	4E-07	5E-06	6E-06	2E-06	1E-05	5E-05	2E-07
Crownhill Down CWS	5E-01	5E-07	4E-06	5E-05	6E-05	2E-05	1E-04	5E-04	2E-06
Smallhanger Waste CWS	2E-01	2E-07	2E-06	2E-05	3E-05	8E-06	7E-05	2E-04	1E-06
Headon Down CWS	6E-02	6E-08	5E-07	6E-06	7E-06	2E-06	2E-05	6E-05	2E-07
Lower Hooksbury PH (Moss)	4E-02	4E-08	3E-07	3E-06	4E-06	1E-06	1E-05	3E-05	1E-07
Bottle Hill PH	4E-02	4E-08	3E-07	4E-06	4E-06	1E-06	1E-05	3E-05	1E-07
Drakeland/Hemerdon Mine Area PH	6E-02	6E-08	5E-07	6E-06	6E-06	2E-06	2E-05	5E-05	2E-07
Truelove CWS	1E-02	1E-08	8E-08	1E-06	1E-06	3E-07	3E-06	9E-06	4E-08
ShaughMoor CWS	7E-03	7E-09	6E-08	7E-07	8E-07	3E-07	2E-06	7E-06	3E-08
Higher Lee Wood AW CWS	4E-02	4E-08	3E-07	4E-06	4E-06	1E-06	1E-05	3E-05	1E-07
Blackadder Tor CWS	7E-02	7E-08	6E-07	7E-06	8E-06	2E-06	2E-05	7E-05	3E-07
Knowle Wood AW CWS	7E-02	7E-08	6E-07	7E-06	8E-06	2E-06	2E-05	7E-05	3E-07
Ridding Down CWS	8E-02	8E-08	6E-07	8E-06	9E-06	3E-06	2E-05	7E-05	3E-07
Brockhole &Bincliffe Wood AW	1E-02	1E-08	9E-08	1E-06	1E-06	4E-07	3E-06	1E-05	4E-08
Great Shaugh & Cann Woods CWS	2E-02	2E-08	1E-07	2E-06	2E-06	6E-07	5E-06	2E-05	7E-08
Hatshill Holt AW	1E-02	1E-08	1E-07	1E-06	1E-06	4E-07	4E-06	1E-05	5E-08
Tamar Est SPA	3E-04	3E-10	2E-09	3E-08	3E-08	9E-09	8E-08	3E-07	1E-09

Table 6-13
MWF Process Contribution to Metal Deposition at Ecological Receptors

ID	Cd	Pb	Cu	Ni	Zn	Cr	As	Se
Fernhill Wood AW	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Hooksbury Wood AW	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	<0.1%
Coleland Wood AW CWS	<0.1%	0.1%	0.1%	0.1%	<0.1%	0.2%	0.3%	0.1%
South Dartmoor Woods SAC	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Dartmoor SAC	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Plymouth Sound and Estuaries SAC	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Hooksbury Wood CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	<0.1%
Crownhill Down CWS	<0.1%	0.1%	0.2%	0.2%	<0.1%	0.5%	0.6%	0.1%
Smallhanger Waste CWS	<0.1%	<0.1%	0.1%	0.1%	<0.1%	0.2%	0.3%	0.1%
Headon Down CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	0.1%	<0.1%
Lower Hooksbury PH (Moss)	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

ID	Cd	Pb	Cu	Ni	Zn	Cr	As	Se
Bottle Hill PH	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Drakeland/Hemerdon Mine Area PH	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	<0.1%
Truelove CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
ShaughMoor CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Higher Lee Wood AW CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Blackadder Tor CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	0.1%	<0.1%
Knowle Wood AW CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	0.1%	<0.1%
Ridding Down CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	0.1%	<0.1%
Brockhole &Bincliffe Wood AW	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Great Shaugh & Cann Woods CWS	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Hatshill Holt AW	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Tamar Est SPA	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

The metal deposited in the greatest amounts in comparison to its Critical Load is arsenic. Notwithstanding the fact that deposition is predicted to be less than 1% of the critical load, the contribution from a possible 'reduction kiln' has been modelled. The maximum combined process contribution is predicted to be $4.78E^{-04}mg/m^2/day$, this is 0.6% of the EAL.

As a sensitivity assessment the concentration of the 'reduction kiln' emission have been increased by 50%. This results in a total combined PEC of $4.84E^{-04}mg/m^2/day$ and therefore remains at less than 1% of the EAL.

Therefore the predicted process contribution of arsenic from the MWF and possible 'reduction kiln' operation is significantly below the Critical Load, i.e. below the level at which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge.

6.5.3 Habitats Regulations Assessment Summary

The assessment concludes that the process contribution of all dusts and metals are less than 1% of the relevant Critical Load at all European Sites (Ramsar, SPA's and SAC's), therefore the emission is '*not likely to have a significant effect alone or in combination irrespective of the background levels'* according to Environment Agency guidance.

7.0 CONCLUSION

The conclusion of this dust impact assessment, undertaken using atmospheric dispersion modelling, is that there are no predicted exceedences of Environmental Quality Standards or Environmental Assessment Levels associated with dust emissions from the proposed Mine Waste Facility either alone or in combination with other foreseeable developments.

In particular:

- the Process Contribution of PM_{10} is not predicted to lead to exceedences of either the annual mean or 24-hour mean Air Quality Objectives;
- ambient metal concentrations are predicted to be less than 1% of the long term EAL at all sensitive receptor locations and less than 10% of short term EALs at any location outside the site boundary and can therefore be considered insignificant;
- metal deposition is predicted to be less than 1% at ecological receptors, i.e. the process contribution is predicted to be insignificant and therefore, according to Environment Agency guidance '*not likely to have a significant effect alone or in combination irrespective of the background levels'*;
- the process contribution of all dusts and metals are less than 1% of the relevant Critical Load at all European Sites (Ramsar, SPA's and SAC's), therefore according to Environment Agency guidance the emission is '*not likely to have a significant effect alone or in combination irrespective of the background levels'.*

The assessment has included a sensitivity analysis incorporating a scenario in which the possible cumulative effects of a possible 'reduction kiln' has been investigated where required. The result of the cumulative assessment do not change the conclusions detailed above.

The conclusions of the assessment are considered robust on the basis that the dust emission factors used have been developed for significantly higher risk climates (i.e. the arid regions of the USA and Australia), therefore the assessment is likely to over-predict the potential impacts.

The conclusions of the assessment support the conclusions of the main report (Reference Section 4B – Dust Risk Assessment and Management Plan).

8.0 CLOSURE

This report has been prepared by SLR Consulting Limited with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Wolf Minerals; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

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

Figure 6-1 Annual Mean PM_{10} – MWF Process Contribution

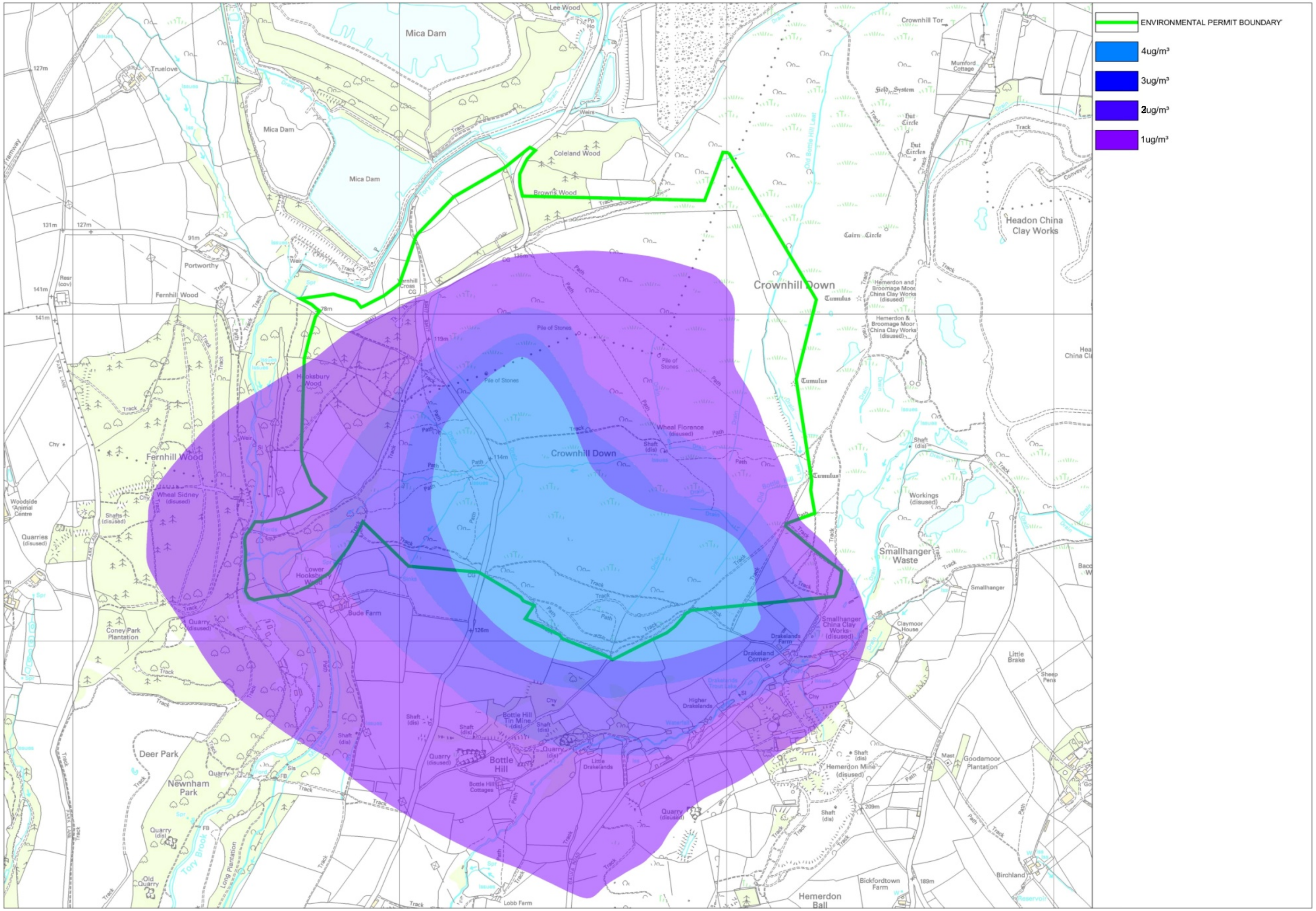


Figure 6-2 24-hour Mean PM_{10} (90.4%ile) – MWF Process Contribution

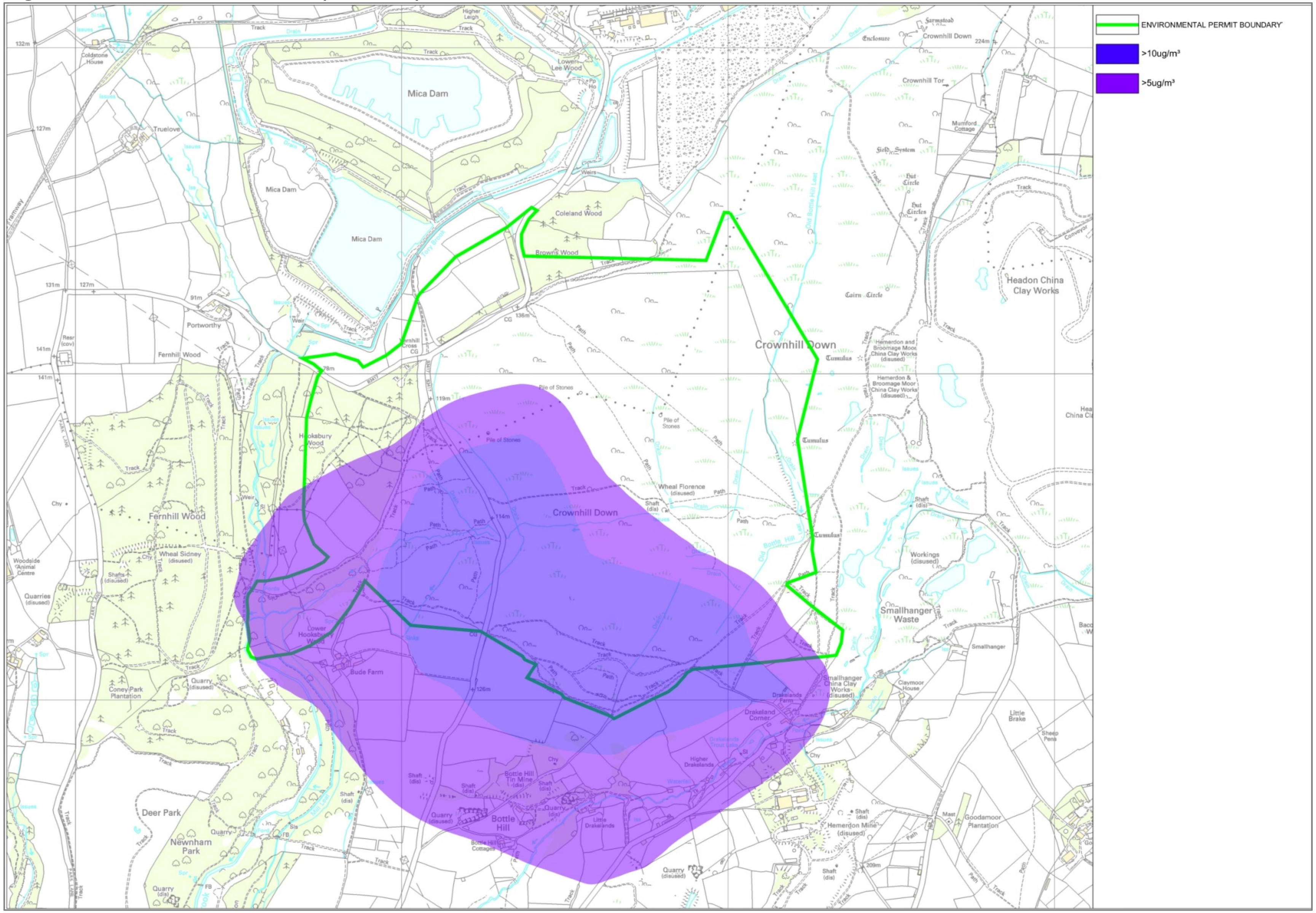
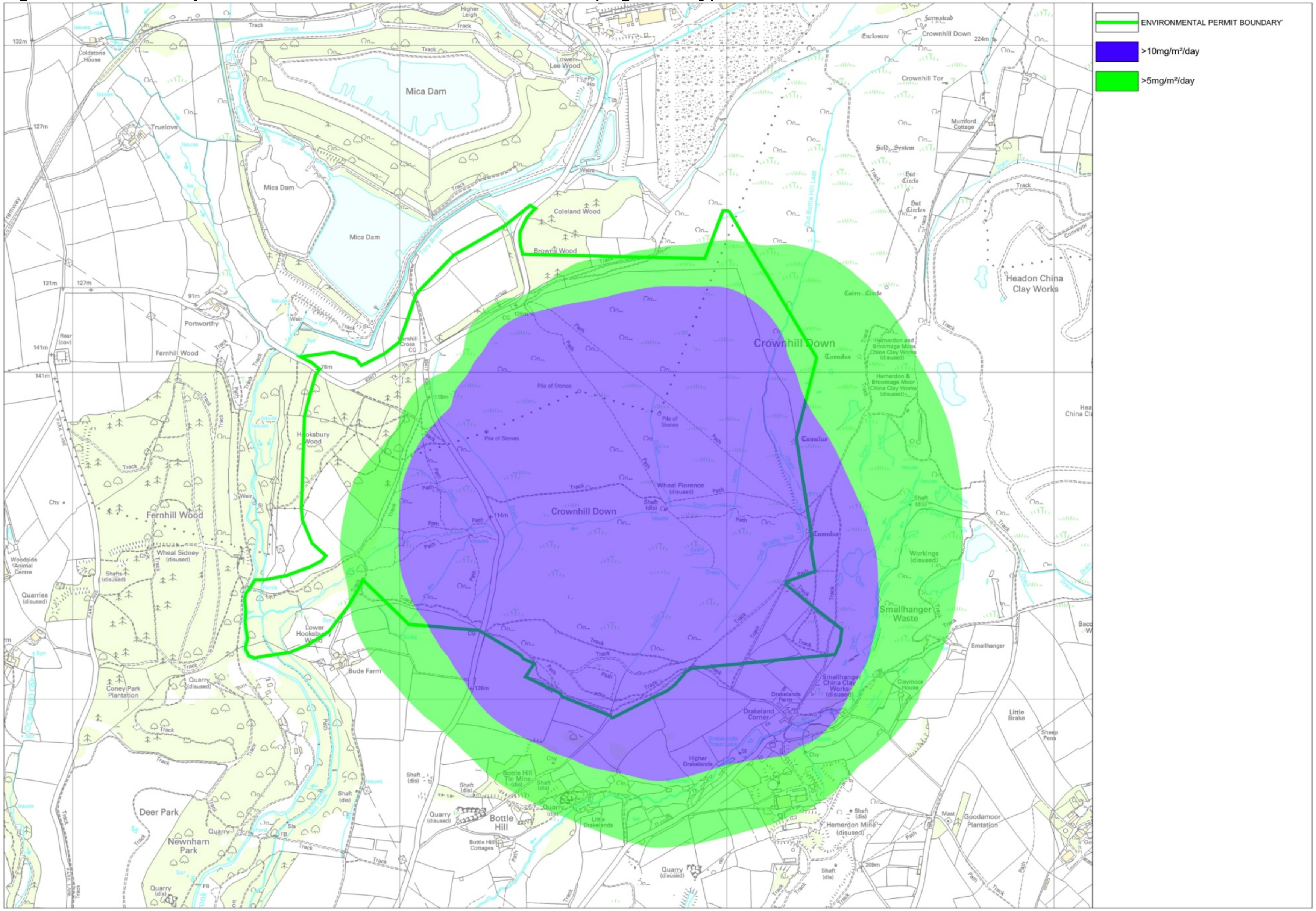


Figure 6-3 Dust Deposition – MWF Process Contribution (mg/m²/day)



APPENDIX A – TABULATED RESULTS

Table A-1
PM_{10} annual Mean – Total MWF Contribution (µg/m³)

ID	2004	2005	2006	2007	2008
DR1	1.47	1.69	1.23	1.54	1.11
DR2	0.08	0.09	0.11	0.09	0.09
DR3	0.44	0.44	0.40	0.38	0.32
DR4	0.72	0.71	0.78	0.71	0.73
DR5	0.68	0.61	0.67	0.65	0.64
DR6	0.71	0.84	0.56	0.76	0.52
DR7	0.86	1.02	0.56	0.84	0.63
DR8	1.31	1.37	1.38	1.33	1.28
DR9	0.53	0.63	0.36	0.52	0.34
DR10	0.51	0.62	0.43	0.57	0.40
DR11	0.48	0.46	0.52	0.46	0.46
DR12	0.25	0.22	0.19	0.17	0.13
DR13	0.05	0.05	0.04	0.04	0.04
DR14	0.15	0.11	0.11	0.11	0.12
DR15	0.04	0.04	0.04	0.03	0.04
DR16	0.26	0.15	0.18	0.23	0.24
DR17	0.12	0.10	0.09	0.12	0.12
DR18	0.16	0.13	0.12	0.17	0.15
DR19	0.30	0.18	0.21	0.28	0.26
DR20	0.28	0.21	0.18	0.28	0.24
DR21	0.44	0.47	0.29	0.40	0.38

Table A-2
PM_{10} 24-hr Mean 90.4%ile – Total MWF Contribution (µg/m³)

ID	2004	2005	2006	2007	2008
DR1	5.36	5.85	4.63	5.55	4.33
DR2	0.25	0.25	0.31	0.27	0.25
DR3	1.25	1.09	0.74	0.86	0.90
DR4	2.96	2.53	2.58	2.85	2.37
DR5	2.17	2.08	2.10	2.49	2.42
DR6	2.29	3.28	1.98	2.62	2.09
DR7	2.91	3.48	1.68	2.84	1.79
DR8	4.65	4.86	4.45	4.56	4.36
DR9	1.97	2.55	1.07	1.86	1.18
DR10	1.87	2.31	1.61	1.99	1.71
DR11	1.78	1.44	1.87	1.58	1.52
DR12	0.55	0.56	0.40	0.48	0.45
DR13	0.13	0.12	0.08	0.05	0.06
DR14	0.31	0.31	0.25	0.31	0.31
DR15	0.14	0.12	0.13	0.10	0.12
DR16	0.69	0.38	0.48	0.61	0.55
DR17	0.25	0.21	0.22	0.33	0.30

ID	2004	2005	2006	2007	2008
DR18	0.37	0.31	0.32	0.52	0.39
DR19	0.90	0.48	0.45	0.74	0.64
DR20	0.97	0.61	0.47	0.88	0.83
DR21	1.13	1.67	0.79	1.37	1.31

Table A-3
PM_{10} Annual Mean – Tailings Contribution (µg/m^3)

ID	2004	2005	2006	2007	2008
DR1	0.0028	0.0032	0.0015	0.0019	0.0028
DR2	0.0037	0.0039	0.0050	0.0045	0.0054
DR3	0.0017	0.0027	0.0026	0.0018	0.0024
DR4	0.0026	0.0018	0.0041	0.0022	0.0031
DR5	0.0022	0.0020	0.0035	0.0024	0.0032
DR6	0.0011	0.0013	0.0008	0.0007	0.0013
DR7	0.0020	0.0029	0.0009	0.0024	0.0027
DR8	0.0027	0.0020	0.0037	0.0023	0.0018
DR9	0.0012	0.0015	0.0004	0.0009	0.0011
DR10	0.0006	0.0009	0.0006	0.0005	0.0009
DR11	0.0015	0.0007	0.0021	0.0008	0.0010
DR12	0.0009	0.0009	0.0012	0.0005	0.0008
DR13	0.0008	0.0020	0.0023	0.0006	0.0012
DR14	0.0027	0.0035	0.0033	0.0026	0.0030
DR15	0.0022	0.0024	0.0022	0.0021	0.0021
DR16	0.0016	0.0011	0.0008	0.0011	0.0010
DR17	0.0017	0.0012	0.0011	0.0015	0.0012
DR18	0.0015	0.0011	0.0009	0.0014	0.0010
DR19	0.0011	0.0008	0.0008	0.0009	0.0009
DR20	0.0010	0.0008	0.0008	0.0011	0.0010
DR21	0.0016	0.0020	0.0010	0.0019	0.0015

Table Note: Annual mean metal concentrations are calculated from the PM_{10} concentration in this table and Table 5-7.

Table A-4
Dust Deposition – Total MWF Contribution (mg/m^2/day)

ID	2004	2005	2006	2007	2008
DR1	2.6	3.0	2.4	2.8	2.2
DR2	1.7	1.9	2.1	2.0	2.0
DR3	0.8	0.9	0.9	0.6	0.8
DR4	0.8	1.0	1.2	1.0	1.3
DR5	0.7	0.8	1.0	0.9	1.2
DR6	0.9	1.0	0.8	1.0	0.8
DR7	1.5	1.8	0.9	1.6	1.1
DR8	1.9	2.0	2.5	2.2	2.3
DR9	0.6	0.8	0.5	0.7	0.5
DR10	0.6	0.6	0.6	0.6	0.5
DR11	0.5	0.5	0.7	0.6	0.6
DR12	0.4	0.4	0.4	0.3	0.3

ID	2004	2005	2006	2007	2008
DR13	0.3	0.3	0.4	0.2	0.2
DR14	0.9	1.0	0.9	0.7	0.9
DR15	0.8	0.9	0.8	0.6	0.8
DR16	2.0	1.3	1.4	1.6	1.7
DR17	1.2	0.9	0.9	1.1	1.3
DR18	1.1	0.8	0.8	1.0	1.1
DR19	1.4	1.0	1.1	1.1	1.2
DR20	0.9	0.8	0.8	0.8	0.8
DR21	1.0	1.0	0.6	1.0	0.8

Table A-5
Dust Deposition – Tailings Contribution (mg/m^2/day)

ID	2004	2005	2006	2007	2008
DR1	0.020	0.022	0.011	0.013	0.019
DR2	0.089	0.094	0.122	0.116	0.130
DR3	0.013	0.019	0.018	0.011	0.018
DR4	0.019	0.013	0.029	0.015	0.022
DR5	0.016	0.014	0.024	0.016	0.022
DR6	0.008	0.009	0.006	0.005	0.009
DR7	0.014	0.019	0.006	0.017	0.018
DR8	0.020	0.014	0.025	0.017	0.013
DR9	0.008	0.010	0.003	0.006	0.007
DR10	0.004	0.006	0.004	0.004	0.006
DR11	0.010	0.005	0.014	0.005	0.007
DR12	0.007	0.006	0.008	0.003	0.006
DR13	0.007	0.016	0.018	0.005	0.010
DR14	0.056	0.073	0.068	0.053	0.060
DR15	0.052	0.059	0.051	0.047	0.051
DR16	0.028	0.022	0.015	0.021	0.019
DR17	0.033	0.024	0.019	0.032	0.026
DR18	0.028	0.022	0.015	0.027	0.020
DR19	0.020	0.014	0.014	0.017	0.016
DR20	0.015	0.012	0.012	0.016	0.015
DR21	0.012	0.015	0.008	0.014	0.011

Table Note: Annual mean metal concentrations are calculated from the dust deposition in this table and Table 5-7.

Table A-6
Dust Deposition – Total MWF Contribution (mg/m^2/day)

ID	2004	2005	2006	2007	2008
Maximum at Receptor					
Fernhill Wood AW	0.60	0.68	0.86	0.76	0.91
Hooksbury Wood AW	0.81	0.87	1.07	0.97	1.12
Coleland Wood AW CWS	1.21	1.26	1.26	1.01	1.14
South Dartmoor Woods SAC	0.02	0.03	0.03	0.02	0.02
Dartmoor SAC	0.13	0.15	0.16	0.16	0.16
Plymouth Sound and Estuaries SAC	0.01	0.02	0.01	0.01	0.01
Hooksbury Wood CWS	0.81	0.87	1.07	0.97	1.12

ID	2004	2005	2006	2007	2008
Crownhill Down CWS	3.59	3.60	3.79	3.88	4.11
Smallhanger Waste CWS	6.31	6.38	6.70	6.93	7.47
Headon Down CWS	1.21	1.00	1.02	1.15	1.40
Lower Hooksbury PH (Moss)	0.82	0.88	1.09	0.97	1.04
Bottle Hill PH	2.53	2.90	2.14	2.79	2.07
Drakeland/Hemerdon Mine Area PH	3.13	2.36	2.44	2.79	3.14
Truelove CWS	0.19	0.21	0.19	0.13	0.14
ShaughMoor CWS	0.07	0.09	0.09	0.06	0.06
Higher Lee Wood AW CWS	0.22	0.24	0.25	0.17	0.21
Blackadder Tor CWS	0.38	0.39	0.38	0.30	0.35
Knowle Wood AW CWS	0.47	0.48	0.51	0.46	0.47
Ridding Down CWS	0.48	0.50	0.56	0.52	0.53
Brockhole &Bincliffe Wood AW	0.23	0.24	0.34	0.27	0.32
Great Shaugh & Cann Woods CWS	0.23	0.28	0.34	0.31	0.39
Hatshill Holt AW	0.18	0.22	0.26	0.24	0.31
Tamar Est SPA	0.01	0.01	0.01	0.01	0.01

Table A-7
Dust Deposition – Tailings Contribution (mg/m^2/day)

ID	2004	2005	2006	2007	2008
Maximum at Receptor					
Fernhill Wood AW	0.013	0.014	0.019	0.012	0.017
Hooksbury Wood AW	0.016	0.018	0.024	0.015	0.023
Coleland Wood AW CWS	0.088	0.119	0.114	0.082	0.098
South Dartmoor Woods SAC	0.001	0.001	0.001	0.000	0.001
Dartmoor SAC	0.006	0.006	0.008	0.008	0.009
Plymouth Sound and Estuaries SAC	0.000	0.000	0.000	0.000	0.000
Hooksbury Wood CWS	0.016	0.018	0.024	0.015	0.023
Crownhill Down CWS	0.177	0.191	0.192	0.182	0.194
Smallhanger Waste CWS	0.098	0.075	0.067	0.096	0.103
Headon Down CWS	0.028	0.020	0.016	0.026	0.024
Lower Hooksbury PH (Moss)	0.014	0.008	0.020	0.010	0.013
Bottle Hill PH	0.014	0.019	0.007	0.015	0.015
Drakeland/Hemerdon Mine Area PH	0.028	0.022	0.016	0.023	0.020
Truelove CWS	0.003	0.006	0.004	0.002	0.003
ShaughMoor CWS	0.002	0.004	0.005	0.001	0.002
Higher Lee Wood AW CWS	0.010	0.017	0.018	0.009	0.013
Blackadder Tor CWS	0.024	0.031	0.028	0.023	0.026
Knowle Wood AW CWS	0.023	0.024	0.028	0.027	0.029
Ridding Down CWS	0.023	0.024	0.032	0.030	0.033
Brockhole &Bincliffe Wood AW	0.005	0.003	0.006	0.003	0.004
Great Shaugh & Cann Woods CWS	0.006	0.007	0.009	0.005	0.008
Hatshill Holt AW	0.004	0.004	0.007	0.004	0.006
Tamar Est SPA	<0.001	<0.001	<0.001	<0.001	<0.001

Table Note: Annual mean metal concentrations are calculated from the dust deposition in this table and Table 5-7.

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