3 DISPERSION MODELLING OF EXISTING ACTIVITIES

3.1 METHODOLOGY

3.1.1 AERMOD Prime

The United States Environmental Protection Agency (US EPA) atmospheric dispersion model AERMOD has been used historically to predict the impact of the Whittlesey Works on air quality. Therefore, the current version of AERMOD (AERMOD Prime, *Version 4.1.1*) has been adopted for use in this assessment.

AERMOD is a new generation dispersion model that has been developed by the US American Meteorological Society and Environmental Protection Agency Regulatory Model Improvement Committee which incorporates the latest understanding of the atmospheric boundary layer and is able to predict ground level concentrations arising from emissions to atmosphere from elevated point sources (i.e. chimneys).

3.1.2 Area Covered by the Model

Two grids have been used to predict the impact of the Works on air quality. A coarse grid with a grid spacing of 500 m covered an area of 20 by 20 km centred between the two brickwork sites. A finer grid is used to provide more detailed predictions immediately surrounding the two brickworks and has a grid spacing of 100 m and covers an area of 4 by 4 km again centred between the two brickwork sites.

3.1.3 Climate

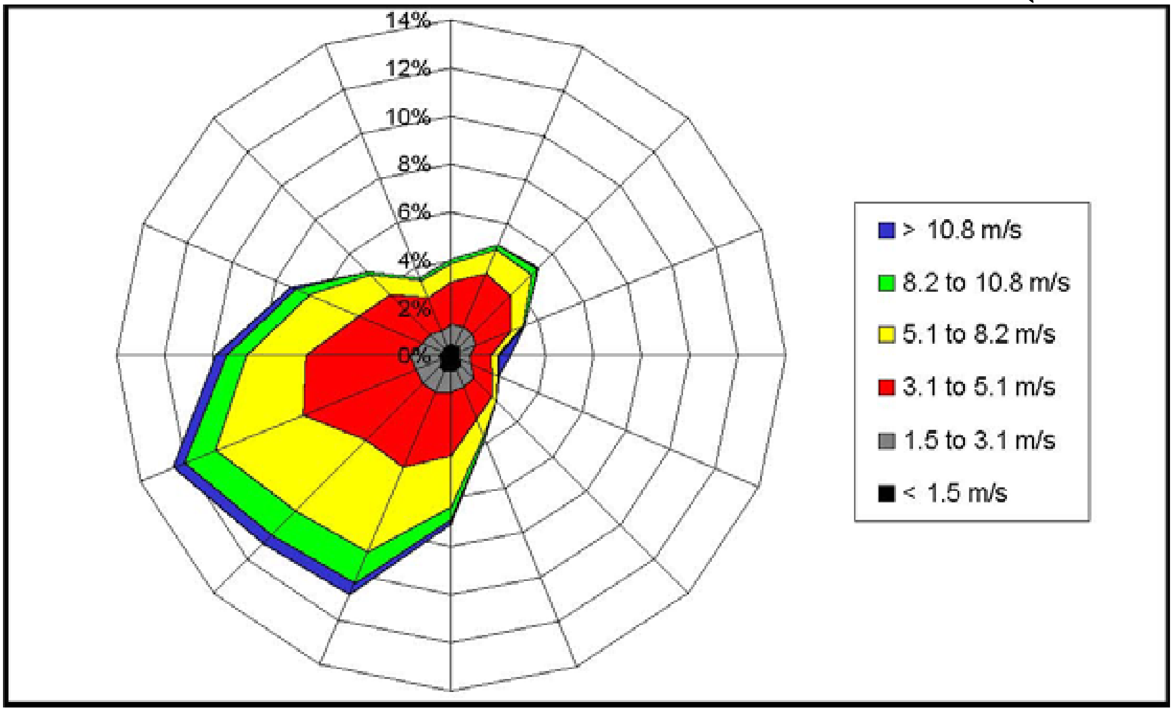
The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind direction, wind speed, and atmospheric stability:

- Wind direction determines the direction of travel of the plume.
- Wind speed affects dispersion by increasing initial dilution of pollutants and inhibiting plume rise.
- Atmospheric stability is a measure of the turbulence of the air, particularly of the vertical motions present. AERMOD uses a parameter known as the Monin-Obukhov length which, together with the wind speed, describes the stability of the atmosphere.

For meteorological data to be suitable for dispersion modelling purposes a number of meteorological parameters need to be measured on an hourly basis. Parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of sites where the required meteorological measurements are made. In the UK, all of these sites are quality controlled by the Meteorological (Met) Office.

The most representative Met Office observing station to Whittlesey is RAF Wittering. This is the nearest observing station where wind speed, wind direction, temperature and cloud cover are recorded. The wind rose for Wittering observing station for 1997 to 2000 (the most recent four years available) is presented in *Figure 3.1*. It indicates the percentage wind direction and wind speed and shows the prevailing wind direction is from the southwest.

FIGURE 3.1 WINDROSE FOR RAF WITTERING METEOROLOGICAL DATA (1997 TO 2000)



3.1.4 Terrain

Terrain features for the area should be included if slopes are greater than 1 in 10. The area immediately surrounding the Works is very flat and there are no significant terrain features. Consequently, the inclusion of terrain is not necessary. However, all of the chimneys are located within quarries at heights below the surrounding terrain and this will effectively reduce the height of the chimneys compared to surrounding areas.

Therefore, flat terrain has been assumed for the modelling but the chimney heights input to the dispersion model are the heights above the upper level of the quarry rather than from the base.

3.2 ACTERISATION OF CURRENT EMISSIONS

3.2.1 Emmisions Data

Average emissions data for the two Saxon chimneys and three Kings Dyke chimneys are presented in *Table 3.1* and *Table 3.2*, respectively. These parameters are the same as were used for the PPC permit application submitted for the Works. Continuous emission monitoring systems (CEMS) data for the Saxon 2 chimney (S2) is available from mid July 2003 and CEMS for S1 and KD2 will be provided by the end of 2004. However, for S2 there is limited CEMS data available due to problems with the flow data and removal of the CEMS for cleaning of the chimney. In addition, data that are available require validation before it can be assumed with confidence that the monitoring data generated are representative of the emissions from this kiln. Consequently, annual average emissions for all chimney stacks have been derived from regular six monthly sampling surveys of all sources rather than using the CEMS data for the single chimney on Kiln S2. However, the accuracy and validity of CEMS data will be investigated and this will include recalibration (flow rate, gas concentration, etc.). It is recommended that the emissions data is revised at the end of 2005 when the data set for S2 is more robust and monitoring data for S1 and KD2 (to be installed later this year) will also be available.

TABLE 3.1 AVERAGE EMISSIONS DATA FOR THE SAXON KILN EMISSIONS

Parameter	Kiln S1	Kiln S2
Number of Chimneys	1 (S1)	1 (S1)
Number of Chambers Served	34	34
Number of Fires	2	2
Chimney Height (m) (a)	70.5	70.5
Internal Diameter (m)	2.59	2.59
Exit Velocity (m s^{-1})	11.0	11.0
Temperature of Exit Gas (°C)	118	118
Actual Flow Rate (Am^3 s^{-1})	58.0	58.0
Normal Flow Rate (N m^3 s^{-1}) (a)	40.6	40.6
Sulphur Dioxide Emission Rate (g s^{-1})	63	63
(a) Height of chimneys above the upper edge of the quarry in which they are located (b) Flow is corrected to 273 K, 101.3 kPa, dry gas basis		

TABLE 3.2 AVERAGE EMISSIONS DATA FOR THE KINGS DYKE KILN EMISSIONS

Parameter	Kiln KD1	Kiln KD2	Kiln KD3/4
Number of Chimneys	1 (KD1)	1 (KD2)	1 (KD3/4)
Number of Chambers Served	34	34	68
Number of Fires	2	2	4
Chimney Height (m) (a)	71.2	78.8	109.3
Internal Diameter (m)	2.89	2.59	3.65
Exit Velocity (m s^{-1})	8.8	11.0	11.1
Temperature of Exit Gas (°C)	118	118	118
Actual Flow Rate (Am^3 s^{-1})	57.7	58.0	116.1
Normal Flow Rate (Nm^3 s^{-1}) (a)	40.3	40.6	81.3
Sulphur Dioxide Emission Rate (g s^{-1})	63	55	126
(a) Height of chimneys above the upper edge of the quarry in which they are located (b) Flow is corrected to 273 K, 101.3 kPa, dry gas basis			

3.22 Variability Factors

Data provided in *Table 3.1* and *Table 3.2* are the average emissions data for each chimney. However, emissions from the kilns are known to vary significantly and the use of average emissions data may underestimate the impact of the Works on off-site SO_2 concentrations. However, there is limited data to provide a comparison of the effect of the variability of the emissions on predicted ground level concentrations for the Whittlesey Works. At the Stewartby Works where there is a reasonable data set of emission concentrations, modelling of fixed average and hourly variable emissions data for the PPC permit application indicated that the use of average emissions data will result in a small underestimation of predicted ground level concentrations, particularly for the short term air quality objectives. The variability factors for Kilns CK1 and CK3 at the Stewartby Works have been calculated as [3]:

$$\frac{\textit{Predicted concentration using variable hourly emissions data}}{\textit{Predicted concentration for fixed average emissions data}}$$

The average variability factors were estimated to be as follows:

- 1.12 for the 99.9th percentile of 1-hour mean concentrations;
- 1.07 for the 99.7th percentile of 1-hour mean concentrations; and
- 1.03 for the 99.2nd percentile of 24-hour mean concentrations.

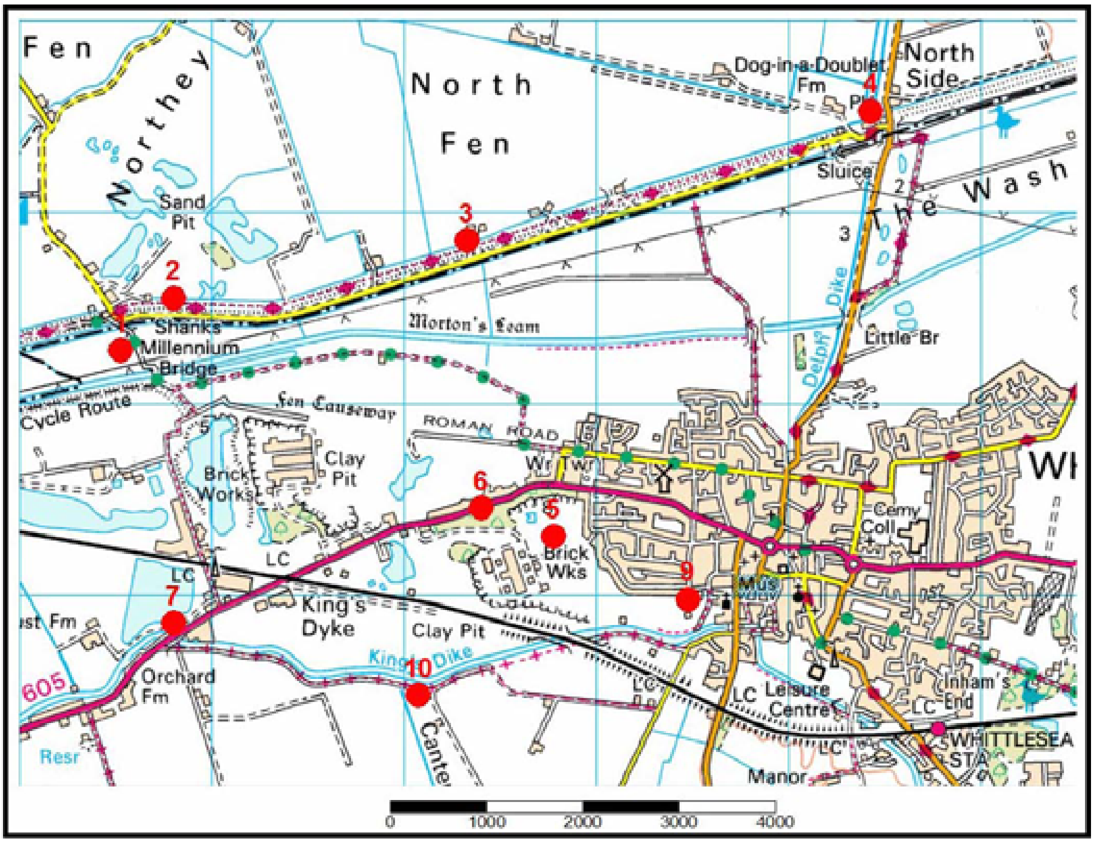
When modelling with fixed average emission concentrations these factors have been applied to the modelling results to allow for the variability in the emissions. The variability factors are based on emissions from three chimneys. An estimate of the variability factors for a single chimney for the Stewartby Kiln CK3 indicates that the variability factor increases with fewer emission sources. For the Whittlesey Works with five emission sources the variability in total emissions from the Works is likely to be less particularly when high emissions from one kiln are balanced by lower emissions from another.

3.2.3 Sensitive Receptors

The nearest highly populated residential properties to the Works are located within Whittlesey with a number of additional residential properties to the north of the Kings Dyke Works and properties located in Kings Dyke between the two brickwork sites. A number of discrete receptors have been included in the modelling to assess the potential impact on air quality of the Works. The locations of the receptors considered are presented in *Figure 3.2*.

3 PPC Permit Application for the Whittlesey Brickworks (Application Reference BX1632) (March 2004)

FIGURE 3.2 LOCATION OF SENSITIVE RECEPTORS CONSIDERED FOR THE ASSESSMENT



3.3 PREDICTED GROUND LEVEL CONCENTRATIONS

Predicted ground level SO_2 concentrations for the existing operations at the Whittlesey Brickworks are presented in *Tables 3.3* to *3.6* for the meteorological years 1997 to 2000. These have been predicted using fixed average emissions data (as presented in *Table 3.1* and *Table 3.2*) but the variability of the emissions has been accounted for by applying the average variability factors provided in *Section 3.2.2*. The 99.9th percentile of hourly mean concentrations have also been multiplied by a factor of 1.31 to provide an estimate of the 99.9th percentile of 15-minute averages based on monitoring data recorded at Hanson's air quality monitoring station and Bedford Borough Council's monitoring station. The locations of the sensitive receptors considered for the assessment are presented in *Figure 3.2* (see *Section 3.2.3*).

Contour plots of predicted SO_2 concentrations as the annual mean for 1997, 24-hour for 1998, 1-hour for 1999 and 15-minute for 2000 are presented in *Figures 3.3* to *3.6*, respectively.