BEDFORD BOROUGH COUNCIL

A Further Assessment of Sulphur Dioxide in the Bedford Borough

A Consultation Document

January 2007

- Technical Services Group
- Environmental Health Service
- Pollution Control Section

PRIDE IN BEDFORD

YOUR AIR QUALITY

Bedford Borough Council

Introduction

Clean air is essential for a good quality of life and progress has been made since the smogs of the 1950s by regulating industry and introducing smoke control areas. However, there are still problems with certain pollutants, particularly from vehicles. In July 1995, the Environment Act 1995 received Royal assent. Part IV of the Act established a new framework for improving air quality, embracing the National Air Quality Strategy, and incorporating health based standards and systems for the management of air quality.

In keeping with the objectives of the Environment Act and as part of a commitment to sustainable development, Bedford Borough Council approved a Local Air Quality Strategy. A corner stone of this Strategy is the Review and Assessment of Bedford's air quality. The objective is to undertake monitoring and evaluation of air quality throughout the borough in a staged process in order to reduce pollution hot spots and integrate air quality into strategic decision making and policies on a local basis. Review and Assessments of local air quality are required every three years and, if necessary, Air Quality Management Areas (AQMA) declared where pollution levels are found likely to exceed national standards. This continual need to review air quality is because of the consequence of changing circumstances including new and expanding industry and increasing vehicular use which could all potentially impact on local air quality.

Air Quality Review & Assessment (2004-2005)

Two Detailed Assessments carried out as part of the second round of Review and Assessment confirmed that emissions of Nitrogen Dioxide from the traffic within three locations in Bedford (High Street, Prebend Street and the A421 running through the village of Great Barford) were such that the annual mean National Standard for Nitrogen Dioxide was likely to be exceeded by the objective date of 31st December 2005. In addition, it was concluded that the emissions from the Stewartby Brickworks were such that all three National Standards for Sulphur Dioxide were likely to be exceeded by their respective objective dates, the earliest being 31st of December 2004.

In 2005 the Borough Council declared four AQMA's and commenced two Further Assessments with which to inform the two Action Plans that will be needed to bring about the improvements in air quality necessary to ensure the National Standards are met. A Progress Report in 2005 provided further confirmation of the highlighted exceedences and also identified a need to expand the Nitrogen Dioxide passive air quality monitoring resources, particularly for those sites in London Road and Dame Alice Street. A commitment was also

made to install new, more accurate, real time air quality monitoring stations in key locations to monitor both Sulphur Dioxide and Nitrogen Dioxide.

Air Quality Update and Screening Assessment (2006)

As part of it's continuing obligations under the Environment Act 1995, Bedford Borough Council commenced the third round of Review and Assessment in 2006 with an Update and Screening Assessment. The purpose being to re-examine the local air quality within the whole Borough to establish if there had been any changes since the second round of Review and Assessment which could threaten air quality elsewhere in the Borough other than those areas where AQMA's had been previously declared. This report incorporated the results of the newly expanded passive air quality monitoring resources for Nitrogen Dioxide. It concluded that, as a consequence of emissions from traffic, there may be a need to expand the existing AQMA's on the High Street and Prebend Street, Bedford. In addition, concerns were raised over the air quality on part of Goldington Road and Ampthill Road Bedford where again, emissions from traffic could threaten achievement of the annual mean National Standard for Nitrogen Dioxide.

Air Quality Further Assessment (2006)

Bedford Borough Council has now completed two Further Assessments in respect of the air quality situation in the previously declared AQMA's. These in depth studies have been conducted to characterise the sources of pollution so as to enable effective targeting within the Action Plans. The Further Assessment for Sulphur Dioxide has shown that the National Standards are still being exceeded in and around the Stewartby area. The existing AQMA incorporates the area of exceedance which the Action Plan will work towards improving in the future. Bedford Borough Council plan to continue to monitor the emissions from Stewartby brickworks so as to monitor their progress and keep in close liaison with the Environment Agency.

Moving Forward - Improving Local Air Quality

At the time of writing Bedford Borough Council is now in the process of finalising the two Action Plans which, when implemented, will work towards achievement of the currently exceeded National Standards for both Nitrogen Dioxide and Sulphur Dioxide. Improving air quality requires a multidisciplinary approach and as such an Air Quality Working Group has been established to oversee the development and progression of these Action Plans.

To inform the Detailed Assessment, Further Assessment and Action Plan processes, the real time air quality monitoring resources are to be expanded further. The Borough Council currently only operates one real time air quality monitoring station measuring Sulphur Dioxide in Stewartby though this has recently been upgraded and modernized to improve the quality of the data obtained. Funding has been secured to install three more stations. These will be placed in the existing AQMA's and will monitor Sulphur Dioxide or Nitrogen Dioxide as appropriate. In addition, a local company who operates a station in Kempston, is now supplying the Borough Council with their Sulphur Dioxide data. There are also the two stations measuring Sulphur Dioxide operated by the owners of the Brickworks which are based in Stewartby and Kempston Hardwick. Therefore, in total there will be five monitoring

stations measuring sulphur Dioxide and two stations measuring Nitrogen Dioxide within the Borough. This is a significant achievement and will ensure a good spread of accurate air quality monitoring data be continually obtained for years to come.

Our Commitment to You

Bedford Borough Council's Corporate Plan identifies 6 key priorities to which the Council is fully committed, one of these is to provide a "Clean and Green Borough". As part of this commitment the Council strives for a continuing improvement of air quality within the Borough making it a safe and clean place to live, work, visit and enjoy. With this is mind the Council will use its best endeavours to secure the achievement of the National Standards.

David Logan
Head of Service (Environmental Health, Bedford Borough Council)

Further Assessment of Sulphur Dioxide for the Bedford Borough Council

(as required by s.84(1) of the Environment Act 1995)

October 2006

ERG,
King's College London
4th Floor Franklin Wilkins Building
150 Stamford Street, London
SE1 9NH

Acknowledgement

The assistance of the Barry Williams and Rob Jamieson from Bedford Borough Council is gratefully acknowledged.

Executive Summary

Section 84(1) of the Environment Act 1995 requires the Council to undertake a Further Assessment of air quality following the designation of its air quality management areas (AQMAs). This Further Assessment of sulphur dioxide report for the Bedford Borough Council ("the Council") thus fulfils this next step of the Local Air Quality Management (LAQM) process.

The earlier Detailed Assessment report identified areas within the Council's area where sulphur dioxide concentrations exceeded government objectives. Public exposure was also identified in these areas and the Council consequently designated an AQMA in the south west of its area around the Stewartby brickworks, encompassing in whole, or part the parishes of Elstow, Stewartby, Wilstead and Wooton.

This report follows the guidance produced by the Department of Environment, Food and Rural Affairs (DEFRA). It updates monitoring information and refines knowledge of the sources of pollution. This has been undertaken using further modelling predictions, incorporating new emissions information.

The updated monitoring results confirm that the 15-minute mean air quality objective for sulphur dioxide has been exceeded at the Council's monitoring site in Stewartby. This objective has been exceeded for all years since 2003, including the current year (to 30 September). The number of periods exceeding the objective has reduced from over one hundred periods in 2003 and 2004 to less than 45 in 2005 and 2006. This reduction can be partly explained by reduced data capture during the summer periods of 2005 and 2006 when episodes mostly arise. The one-hour and 24 hour mean objectives were not exceeded over this period from 2003 to 2006.

Additional monitoring results outlined in the Alternative Options report for Stewartby brickworks, produced for the brickworks operator (Hanson building Products Ltd.) indicate that the 15-minute mean objective was also exceeded at site at Broadmead during 2005. This site is close to the brickworks and is run by the brickworks operator; it was set up in 2005. The equivalent percentiles for the one hour and 24 hour objectives were also reported, and these just met the objectives.

The brickworks operator also runs another monitoring site at Kempston Hardwick. The results for 2005 indicate that the 15-minute mean objective was not exceeded. No results for 2004 were reported. Earlier reports indicate that the 15-minute mean objective was exceeded at this site over the period from 2000 to 2003 inclusive.

During the period leading to the permitting of the brickworks and the period since, the brickworks operator has undertaken a series of changes to reduce sulphur dioxide concentrations. A Kiln Management Procedure was incorporated into operations at the brickworks during 2005 to specifically reduce peak concentrations. However precise details of the changes in emissions are not presented in the report to confirm the impact of these changes.

The revised modelling predictions use updated emissions rates from the Alternative Options report for Stewartby brickworks report. The modelling compares the updated averaged emission rates from the brickworks with the method used for determining the Council's

AQMA, which used a factor derived from the Environment Agency to determine peak emissions. The results confirm for both methods indicate that the 15-minute mean objective for sulphur dioxide is exceeded in areas with relevant public exposure.

The brickworks operator has outlined a series of options to reduce sulphur dioxide concentrations in the Alternative Options report. These are required as part of the Improvement Conditions of its IPPC permit issued by the Environment Agency for the brickworks. There are insufficient details in the report to permit a modelling assessment to be undertaken.

Despite this, indicative scenarios are modelled in the report. All of these scenarios are designed to show a reduction in concentrations, through either reduced emissions or through improved dispersion. The latter scenarios are highly simplified. The modelled predictions all indicate reduced concentrations, with the modelling of individual kilns showing the greatest reduction in concentrations. The scenario with the greatest reduction in concentrations is the modelling prediction for kiln ck3 only, which indicates that the 15-minute mean objective slightly exceeds the objective at the Council's Stewartby monitoring site and a small area that exceeds the objective approximately 2 km diameter and centred on the brickworks and including the village of Stewartby.

In summary, the results from this Further Assessment indicate that the sulphur dioxide air quality objectives are still exceeded in the area around Stewartby and that further measures and information are required to reduce concentrations. As a result the Council should maintain its AQMA as originally designated.

The Council is recommended to undertake the following actions, in respect of the findings for the statutory objectives relating to sulphur dioxide:

1. Retain its existing AQMA and undertake consultation on the findings arising from this report with the statutory and other consultees as required.

2. Maintain its monitor capability at its two monitoring sites in BF1 (in Stewartby) and BF3 (in Kempston).

3. Continue to liaise with the Environment Agency, who are the regulatory authority for industrial emissions and responsible for enforcement of the conditions incorporated into IPPC Permit issued to Hanson Building Products Limited for the Stewartby brickworks

Table of Contents

List of Figures

List of Tables

1 Introduction to the further assessment of sulphur dioxide

1.1 Overview

This report provides the further assessment of air quality for the Bedford Borough Council ("the Council"). This forms part of the Council's duties under Local Air Quality Management (LAQM) process of the Environment Act 1995.

The report includes updated information on the Council's Air Quality Management Area (AQMA) for sulphur dioxide (SO_2) in the south west of the Council's area, close to the Hansons Brickworks in Stewartby.

The Council also designated other AQMAs for nitrogen dioxide (please note these are the subject of a separate Further Assessment report).

1.2 Background

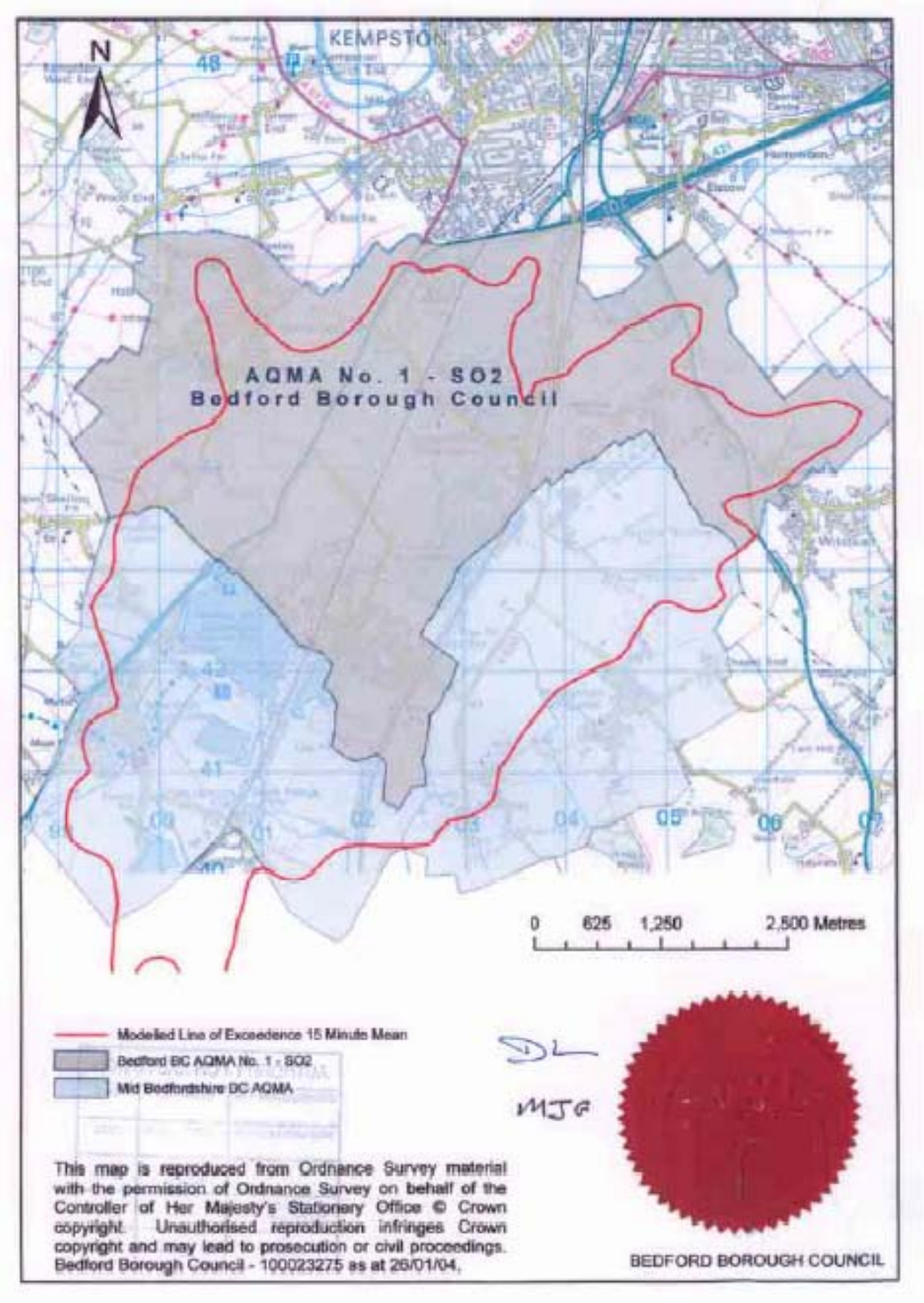
Local air quality management forms a key part of the Government's strategies to achieve the air quality objectives under the Air Quality (England) Regulations 2000 and 2002. As part of its duties the Council completed its second round Updating and Screening Assessment of the seven LAQM pollutants and concluded that a Detailed Assessment was necessary for SO_2.

The Detailed Assessment for SO_2 identified the likelihood that the SO_2 objectives (see Table 1) would be exceeded after 2005. To further aid the process, an additional report (Supplementary Assessment) was also produced by the Council, upon receipt of new information from the Environment Agency and Hanson (the brickworks operator). As a result the Council designated an AQMA in the south west of its area, encompassing in whole, or part the parishes of Elstow, Stewartby, Wilstead and Wooton (as shown in Figure 1).

Table 1 Sulphur dioxide air quality objectives relevant to this Further Assessment

Concentration	Measured as	Date to be achieved by
266µg m^{-3} not be exceeded more than 35 times a year	15 minute mean	31-Dec-05
350µg m^{-3} not be exceeded more than 24 times a year	1 hour mean	31-Dec-04
125µg m^{-3} not be exceeded more than 3 times a year	24 hour mean	31-Dec-04

Figure 1 Bedford AQMA No. 1 around the village of Stewartby



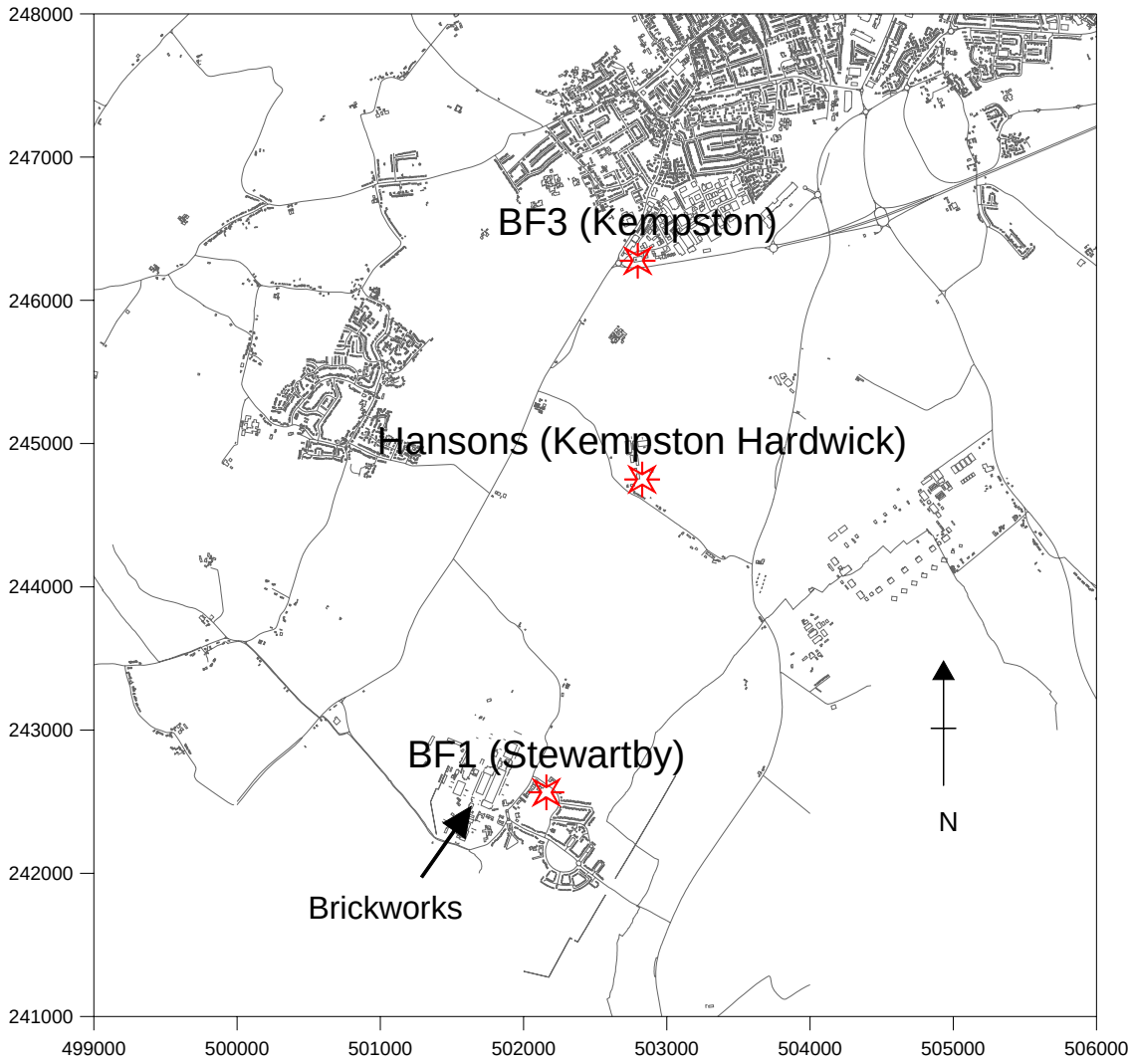
2 Air Pollution Measurements

2.1 Continuous SO_2 monitoring in the Bedford AQMA

The Council monitors SO_2 using an automatic analyser at its permanent site in Stewartby (BF1). This site opened in November 2000 and is located at a background site in a playing field; as such it is representative of relevant public exposure. The site is part of the Herts and Beds Air Pollution Monitoring Network (HBAPMN). It is operated to standards of QA/QC similar to the government's AURN and therefore it meets those of the TG 03 guidance.

The Council has also very recently opened a new site in Kempston (BF3) at a background location, close to the southern edge of the urban area. As a consequence there is very little data to report and the forthcoming monitoring results will be reported in subsequent Council reports. One of the sites operated by the brickworks operator; at Kempston Hardwick, along with the two Bedford operated sites, are shown in Figure 2.

Figure 2 Continuous monitoring sites near Bedford AQMA No.1



2.2 Summary of BF1 monitoring results (2001 to 2006)

The updated results for the BF1 site at Stewartby are reported below, these include the current year, 2006, up to 30 September, although it should be noted that these most recent results are still provisional. Details of data capture are also included for each year.

Table 2 Number of periods exceeding SO_2 objective standards at BF1 (2001 – 2006)

Objective	2001	2002	2003	2004	2005	2006 (part)
15min mean	25	26	***118***	***135***	***43***	***37***
Hourly mean	1	2	*4*	*8*	*3*	*0*
24hr mean	0	0	*0*	*0*	*0*	*0*
Data capture %	90	93	*89*	*88*	*76*	*83**
Max 15 min (µg m^{-3})	763	836	*1622*	*1355*	*1065*	*843*
Annual Mean (µg m^{-3})	11	10	*12*	*18*	*12*	*11*

(Note – bold indicates exceeds objective; * relates to period to 1 January to 30 September 2006 only; italics indicates < 90% data capture for year)

For all years shown the hourly and 24 hour mean SO_2 objectives have not been exceeded at the monitoring site. However since the new kiln was commissioned in 2002 (replacing ck22), the 15-minute SO_2 objective has been easily exceeded. There is also a marked reduction in the number of periods that exceeded the standards in both 2005 and 2006, as compared to the 2003 and 2004 totals. Possible reasons for this are discussed later in the report. It should be noted too, there was reduced data capture for both 2005 and 2006 (which relates to the period from the 1st January to 30th September only). This also provides a partial explanation for this reduction and it is further discussed below.

2.3 Analysis of temporal distribution of episodes

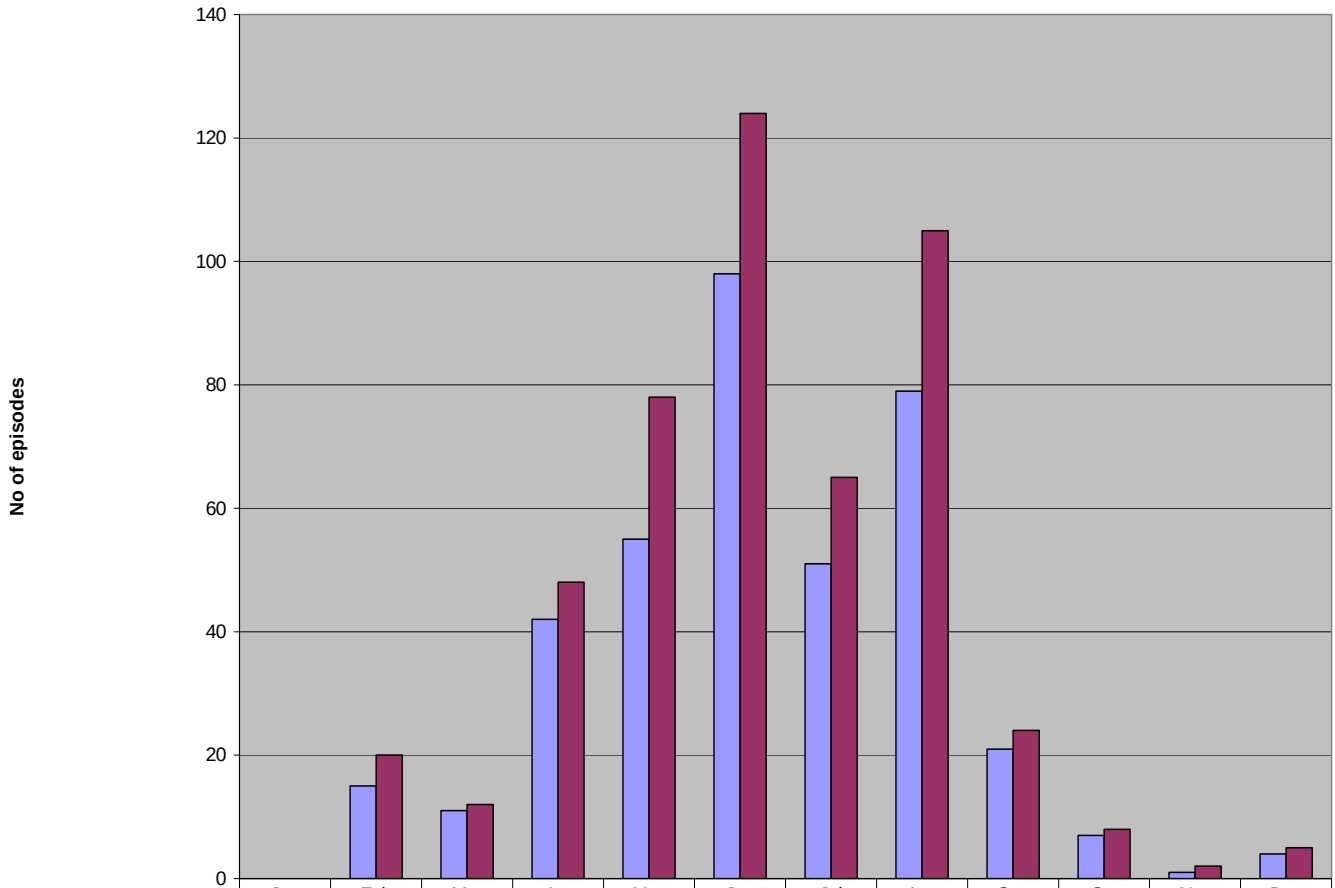
Previous Council reports (Detailed Assessment 2004 and Supplementary Assessment 2004) have indicated the wind conditions when episodes arise at the BF1 monitoring site. These are typically during the day from 10.00 hours to 16.00 hours as increased vertical mixing of the atmosphere takes place. At these times the wind speed is broadly from the west and the wind speed is lower than average. An update of the diurnal distribution of episodes presented in the Supplementary report is given in Appendix B (see Figure 9). This confirms that there has been no change in this understanding of episodes.

An analysis of the monthly distribution of episodes has now been undertaken. Figure 3 shows this distribution of peak episodes for the period of monitoring above, based on 15-minute episodes greater than 266 µg m^{-3} and also for 239 µg m^{-3} to increase sample data. (The latter is based on a 10% monitoring uncertainty).

The analysis confirms that very few episodes (slightly less than 10%) arise in the winter months from October to March, whilst the vast majority (slightly more than 90%) arise at this site during the period April to September, with the highest number of

occurrences in June and August. This is as expected since the typical conditions described above mostly arise during the warmer months.

Figure 3 Monthly distributions of episodes at BF1 (2001 to 2006)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Episodes > 266 ugm3	0	15	11	42	55	98	51	79	21	7	1	4
Episodes > 239 ug m3	0	20	12	48	78	124	65	105	24	8	2	5

As already commented on, for both 2005 and 2006, the data capture for the site was reduced below that of the 90% recommended in TG 03. Examination of the monitoring results for these two years reveals that there were lengthy periods during the summer periods when the analyser was not functioning.

The 15-minute mean results for 2005 and 2006 are shown in Appendix B (see Figure 10 and Figure 11) and the monthly data capture is shown in Table 3. For 2005, monitoring data are missing for periods of April, May, July and August. For 2006 data are missing for the whole of the period from the end of June to the middle of August.

Table 3 Monthly percentage data capture (2001 to 2006)

Month	2001	2002	2003	2004	2005	2006
Jan	*43.5*	94.6	*72.6*	97.7	*81.0*	97.1
Feb	99.9	98.7	92.7	*74.8*	97.6	97.7
Mar	99.6	98.8	97.6	97.2	*20.1*	97.8
Apr	99.8	97.9	96.4	97.5	*36.9*	96.9
May	*71.8*	95.5	*87.4*	97.7	*45.3*	97.2
Jun	97.6	97.7	*75.6*	97.6	97.7	*87.6*
Jul	100.0	96.0	97.3	94.0	*74.0*	*0.0*
Aug	99.7	91.6	*77.1*	94.7	*74.0*	*71.6*
Sep	98.7	97.7	*82.4*	97.7	97.3	99.7
Oct	96.3	*69.6*	96.6	93.7	97.8	-
Nov	*84.4*	97.5	93.8	*63.8*	97.6	-
Dec	95.2	*86.6*	97.7	*53.4*	97.1	-

(Note - italics indicate less than 90% data capture)

The monthly distribution shown in Figure 3 represents the aggregated results for all years and obviously there are no data for the missing periods. Hence the missing data for July of each the two years may indicate why the total number of episodes for July is comparatively lower than both June and August. The percentage distribution of episodes for the previous years (where the overall annual data capture exceeded 88% for all years) is given in Table 4.

Table 4 Monthly % distributions of episodes (2001 to 2004)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.0	3.9	3.3	13.5	16.1	15.5	15.8	23.4	4.6	2.3	0.3	1.3

The monthly distribution for these years indicates that proportion of episodes for July is equivalent to that for June and May.

During the four years (2001 to 2004 inclusive) there was a minimum of 94% data capture during the month of July in each year and for these years there were between 6 and 17 episodes recorded for the month of July alone. This provides further evidence that the total number of episodes for 2005 and 2006 are underestimates of the likely total for years with at least 90% data capture.

2.4 Other continuous monitoring in the area – Kempston Hardwick

As reported previously, the brickworks operator undertakes monitoring at Kempston Hardwick monitoring site, which is to the northeast of the brickworks. A summary of this monitoring is given below (the data are derived from the Alternative Options Report for Stewartby Brickworks, April 2006). Details of data capture and QA/QC for the site were however not reported.

Table 5 Number of periods exceeding SO_2 objective standards at Kempston Hardwick (2005)

Objective	2005
15min mean	11
Hourly mean	0
24hr mean	0

These results indicate that the SO_2 objectives were not exceeded at this site. The results for the period 2000 to 2003 inclusive were reported in earlier Council reports and these are reproduced in Table 6. These also indicated that the 24-hour objective was not exceeded. The 15-minute objective was however easily exceeded and there were also periods when the hourly standard was exceeded. As with the Council's site at Stewartby, there has been a large reduction in the number of periods exceeding the 15-minute mean standard, over the period from 2000 to 2005. No data however were available for 2004. The data capture for these sites exceeded 90%, apart from 2002 when data capture was 57% (the site was vandalised during the summer).

Table 6 Number of periods exceeding SO_2 objective standards at Kempston Hardwick (2000 - 2003)

Objective	2000	2001	2002	2003
15min mean	**64**	**70**	**153**	**36**
Hourly mean	3	5	4	1
24hr mean	0	0	0	0

(Note – bold indicates exceeds objective)

The operational changes undertaken at the brickworks during 2001 and 2002 when one kiln was closed and replaced by another (referred to above), changed the configuration of the chimneys and this helps explain the reduction in episodes at the monitoring site since 2002. Additional changes have been made since that time and these are reported in section 2.5 below.

2.5 Other continuous monitoring in the area – Broadmead

The brickworks operator has also opened a new site at Broadmead, which is close to the northeast of the brickworks. The site is located at the site of the maximum predicted hourly ground level concentration (based on dispersion modelling). This site opened in January 2005 and the results are summarised (from the Alternative Options Report for Stewartby Brickworks, April 2006). The details relating to data capture and QA/QC for the site were not reported.

Table 7 Number of periods exceeding SO_2 objective standards at Broadmead (2005)

Objective	2005
15min mean	**348**

(Note – bold indicates exceeds objective)

For this site the government's 15-minute mean objective of less than 35 periods less than 266 µg m^{-3} was easily exceeded.

The numbers of periods that the one hour and 24 hour standards were exceeded were not provided. The equivalent percentiles for these objectives however were reported, as follows:

99.2% ile for the 24 hour objective	117 µg m^{-3}
99.7% ile for the one hour objective	345 µg m^{-3}

Both these equivalent percentiles are just below the objectives of 125 and 350 µg m^{-3} respectively. The Alternative Options Report for the Stewartby Brickworks (AOS) also advises that whilst there is public exposure at the site, it is very limited.

2.6 Commentary on changes at the brickworks since 2002

The above monitoring results need to be considered in the light of the changes that have been tried and implemented at the brickworks. These have arisen in the period leading to the Environment Agency issuing a permit for the brickworks on 24th November 2004 (ref. BX1616IU) and the period since. A requirement of the permit is the reduction in ground level concentrations of SO_2.

The two brick kilns that currently operate at the brickworks are ck3 and ck1 (the latter replaced ck 22 in 2002) and to reduce SO_2, a series of control options have been tested. These are summarised from those outlined in the AOS report and include:

- Coal feeding sequence – to minimise dark smoke the sequence of coal feeding was changed.

- Staggered coal feeding – to minimise short-term SO_2 peaks the burner instructions for the kilns were modified.

- Louvers – to try to respond to peak SO_2 episodes louvers were installed at the base of the stack of ck3 and are now supplemented by fans. These now are operated using a computerised link to the Broadmead monitoring as part of the Kiln Management Procedure. (Note - these are the most recent changes referred to and they follow extensive trial testing).

- Third fire – to reduce peak emissions a third fire using reduced numbers of chambers was tried. It was halted as it reduced production efficiency.

- Alternative coal – coal is used as a supplementary fuel and anthracite was tried as an alternative to the exiting coal type to reduce levels of SO_2 emissions. It however was found to create high levels of dust and halted on health and safety grounds.

- Split chambers – this was trialled as a follow up to the third fire and again halted on health and safety grounds.

- Use of gas burners at end chambers – to reduce peak emissions as the fires round the end chambers, supplementary gas burners were tried and found not to provide any overall benefit.

During 2005, the AOS report confirms that the Kiln Management Procedure, based on the louvered option above, was used to reduce periods exceeding the SO_2 standards. From the monitoring information available to the Council this procedure appears to have had some success in reducing the number of periods exceeding the objective at the Stewartby and Kempston Hardwick sites. Although as already outlined some care is needed with this interpretation for the Stewartby site in view of the missing data for the summer periods. It is not possible to confirm whether or not there has been a change at the Broadmead monitoring site, as it only opened in 2005. However based on the above 2005 monitoring result, of 348 periods exceeding the 15-minute mean standard, it is clear that the changes during the year were not sufficient to reduce concentrations below the objective of not more than 35 such periods.

3 Predictions of Sulphur Dioxide (SO_2) for the Bedford area

3.1 Outline of previous modelling developments

The Environment Agency, the brickworks operator and the Council have all previously undertaken modelling of the brickworks to support the permitting and local air quality management processes. In each instance it has been fully recognised that the modelling has been difficult to complete with full confidence. Confounding issues include:

- The short term nature of the AQS objectives to be modelled;
- Limitations to understanding process emissions and specifically in relation to peak emissions;
- Model limitations;
- The changing nature of the process, specifically in relation to measures aimed at reducing SO_2 concentrations.

To try and overcome each of these, various assumptions have been used, however despite this, it remains very difficult to verify the modelling outcomes with the monitored results from the area.

The Council's AQMA was declared based on modelling approaches adapted from the assumptions used by the Environment Agency and it represented the best understanding of the dispersion of emissions from the brickworks at that time.

3.2 Update of recent changes

To help satisfy one of the Improvement conditions of the PPC Permit for the brickworks, the operator (Hanson Building Products Ltd.) commissioned an Alternative Options report for Stewartby brickworks (AOS) in April 2006. The principal focus of this report was to determine an appropriate control option (or options) for compliance with the government's air quality objectives.

To do this the AOS report considered the options previously used (see section 2.5) and also introduced new options. The new options are described below (see section 3.4).

The report also presents modelled 2005 emissions, which were derived from an average of the results from extractive emission tests during 2005. It further stated that although the kilns are equipped with a continuous emissions monitoring system (CEMS), it was not possible to undertake detailed modelling using hourly emissions data as these data were not fully validated.

In summary, the modelling in AOS report was undertaken 1) using 2003 meteorological data and compared to 2003 measurements and 2) using 2005 meteorological data and compared to 2005 measurements. In both instances 2005 emissions data were used. The modelling methodology used in the AOS report also did not include a factor to represent peak emissions, as was used for the Council's modelling.

Overall the modelling results in the AOS report predicted areas where the government's objectives were exceeded for both years modelled. For 2003 the results indicated a

reasonable comparison between modelled and monitored results (with agreement of +/- 20%), with better agreement at the Kempston Hardwick site than the Stewartby monitoring site. The model also under predicted concentrations expressed as a 99.9th percentile of 15-minute means.

The comparison for 2005 predictions was however problematic. This is because the Kiln Management Procedure used is considered to have affected the monitoring results at both the Broadmead and Kempston Hardwick sites. This was intentional as the purpose of the Kiln Management Procedure was to reduce peak episodes at these sites. There was also the reduced data capture at the Stewartby site discussed earlier. The AOS report indicates that the modelling for 2005 over predicted the 99.9th percentile at the Stewartby monitoring site. The 99.9th percentile quoted however is incorrect; instead of the value quoted, the correct value is 320 µg m^{-3}. This indicates that the model used for the AOS report under predicted concentrations at this site.

A comparison between 2003 and 2005 predictions showed higher results for 2003, than 2005 at all sites. This is consistent with the monitored results for these years and measurements from other sites across the U.K.

3.3 Comparison using revised emission data

A comparison has been undertaken of previous modelling by the Council with the emission inputs from the AOS report. To enable this, 2005 emissions data from the report have been modelled i) with the methodology outlined in the AOS report and ii) with the assumptions used in the previous modelling. The assumptions used previously for the Council's modelling, recognised that the averaged emissions data did not reflect the peak episodes adequately and instead adjustment factors were used, presenting a conservative approach to determine the peak concentrations.

For exact comparison purposes the 2001 meteorological data from Cardington were also used as these data were previously used in the Council's Detailed and Supplementary reports. The scenarios have also been modelled for the 15-minute objective only as this objective is the most stringent of the SO_2 objectives.

The resultant plot indicating the equivalent 99.9th percentile to represent the 15-minute mean objective for the above scenarios is shown in Figure 4, with that from the scenario used for the Council's AQMA. The 2005 emissions data using the AOS methodology is shown in red; the 2005 AOS emissions data using the peak adjusted assumptions based on the previous modelling are shown in green and the results used to determine the AQMA in dark blue.

The plot shows that the area exceeding the 15-minute objective is smaller for the revised 2005 emission scenario (in red), than the previous AQMA modelling (in blue) and the adjusted revised emissions scenario (in green). There is little difference between the previous modelling and the adjusted revised emissions scenario, with the area exceeding the 15-minute objective for the adjusted scenario being slightly more than the previous modelling.

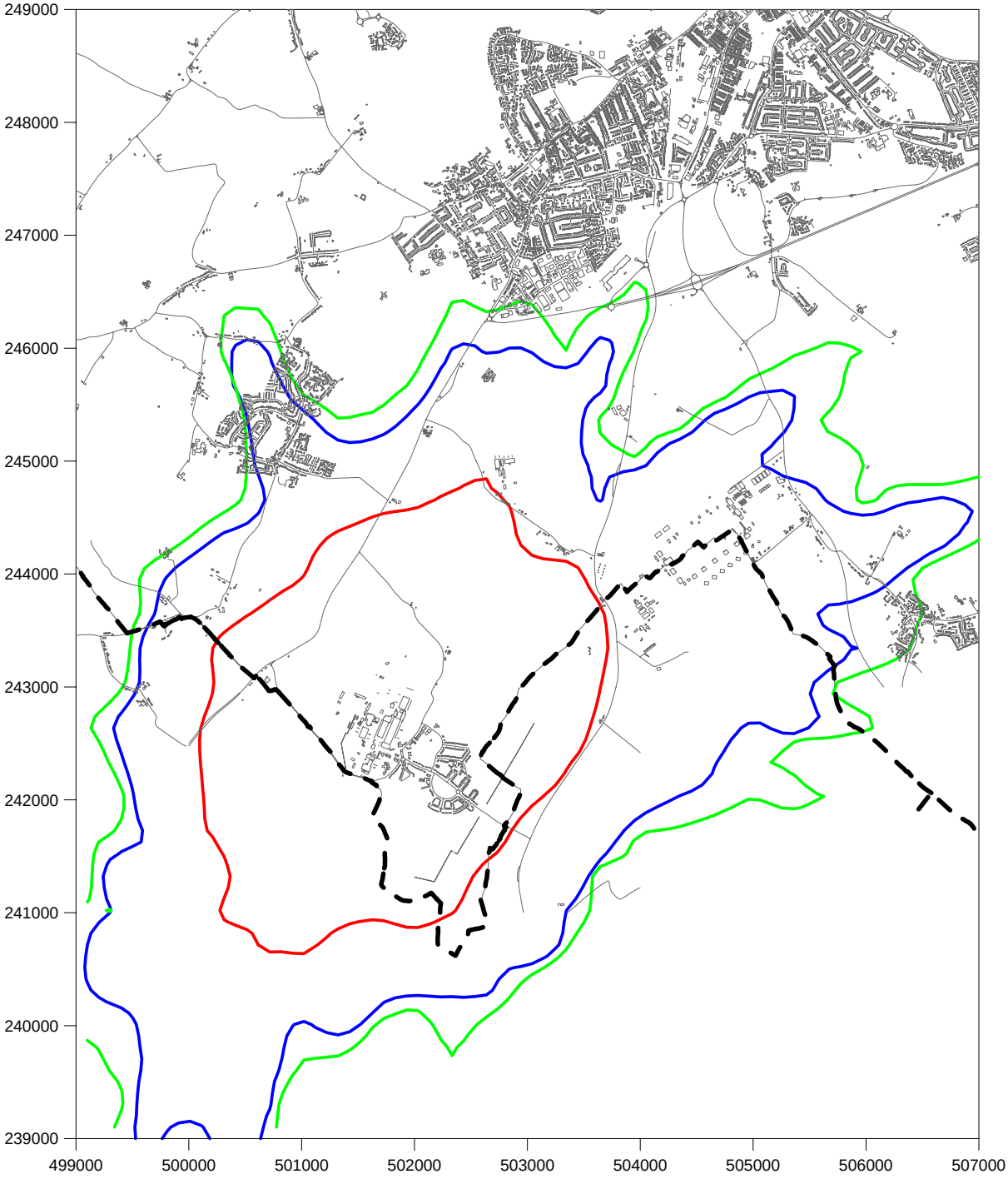
In conclusion the results based on the revised emissions are little changed from those previously modelled, with the main changes between the modelled scenarios, relating

to the different methods applied and specifically the use of the adjustment factor to represent peak emissions, as compared to an averaged emission rate.

The Environment Agency originally devised the adjustment factor from more detailed emissions data than that available to the Council. The approach adopted was to model a constant emissions scenario where the results were conservative but not overtly so e.g. not a scenario based on the brickworks operating at its operating limit or maximum rate. The factor that was derived took into account the periodicity of the brick production operation and was finally determined from a comparison of modelled results. The Council has not received any further information to indicate that this approach need be altered and hence it is still considered that this approach provides the best understanding for modelling emissions from the brickworks.

If it can be confirmed that the Kiln Management Procedure introduced at the brickworks reduces peak emissions then it may be appropriate to reconsider the adjustment factors and their use.

Figure 4 Modelled 99.9th percentile of 15-minute mean SO_2 concentrations using revised emission limits



Notes:
Red line – based on averaged emissions from the AOS report
Green line - based on peak adjusted averaged emissions from AOS report
Blue line – based on previous modelling from the Council's Supplementary Assessment
Dotted black line – Bedford Borough Council boundary

3.4 New proposed options for the brickworks

The AOS report outlines a series of new options for improving air quality and each of these has been assessed in a qualitative way in that report, and all are subject to one major proviso. This is that Hanson has decided not to operate its permitted installation (under permit BX1616IU) from the end of 2008, unless it can demonstrate, to the satisfaction of the Environment Agency, that it will achieve full compliance with the government's 15-minute air quality objective for SO_2.

The new options considered in the AOS report are extrapolated from a Best Available Techniques (BAT) assessment for the Whittlesey brickworks in the Fenland District Council's area. The options considered are as follows:

- Option A - existing emissions
- Option B – single new chimney for each kiln
- Option C – the addition of inert material
- Option D – an inductor to improve dispersion and dilute emissions
- Option E – dry or wet abatement
- Option F – kiln management procedure

The feasibility of each option are summarised in the AOS report, with a view on the applicability as an option under BAT (Best Available Technology).

In summary, option A is considered a candidate BAT option, although it is recognised that the 15-minute objective will not be complied with.

Options B, C and E are not considered candidate options: due to high costs (for options B and E), limited SO_2 reduction and other factors (for option C) and cannot be completed by the end of 2008 (for options B, C and E).

Options D (if used together with F) and F are considered candidate BAT options.

4 Scenario modelling of Bedford AQMA

4.1 Scenario selection

To further aid the Council a series of scenarios have been modelled. Regrettably no engineering details are provided for any of the options proposed in the AOS report and therefore it is not possible to model any of the options with complete certainty. Despite this the scenarios modelled are intended to provide an understanding of possible changes to concentrations in the AQMA and are in addition to the scenario modelled previously in the Supplementary report.

For the scenarios modelled in this report the latest emissions rates from the AOS report have been used. Otherwise the same methodology (based on the Council's previous reports and outlined earlier) has been used i.e. using peak adjustment factors. Once again for exact comparison purposes, 2001 meteorology has been used.

The scenarios modelled below are as follows:

1) Individual modelling of the separate brickwork kilns. This scenario will determine the influence of each kiln in isolation from the other, thus providing source apportionment information.

2) Increased chimney height. This option has been ruled out by the AOS report appraisal; it is however nonetheless useful for the Council to appreciate the impact of such as measure.

3) Increased efflux velocity of emission. This scenario is based on one proposed by the brickwork operator at another of its brickworks (Air Quality Management Plan for Whittlesey Brickworks 2004).

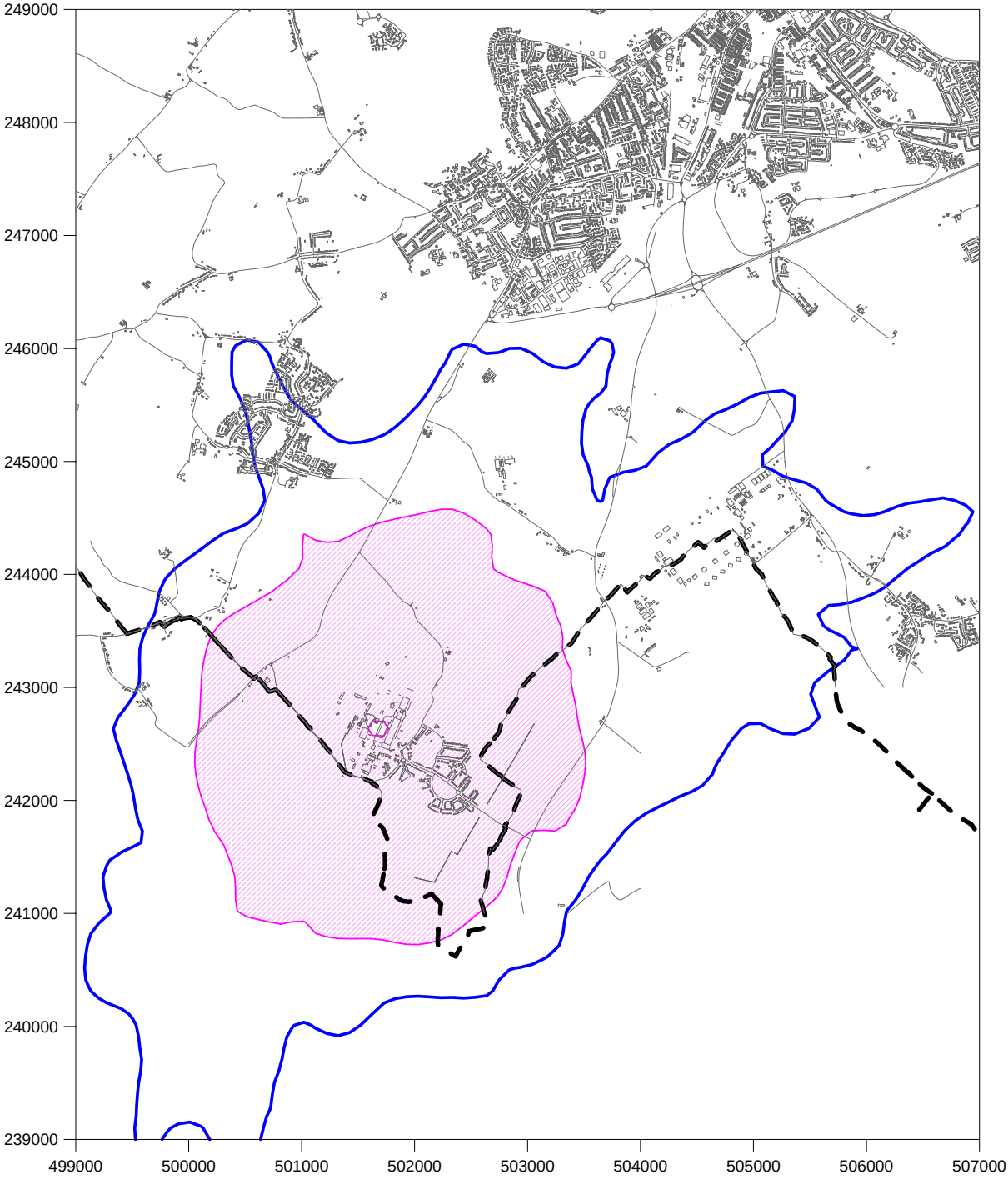
All these scenarios are designed to show a reduction in concentrations. Scenario 1 through reduced emissions and scenarios 2 and 3 through improved dispersion.

4.2 Results of modelled individual kilns

As outlined earlier there are two separate but closely located kilns in operation at the brickworks: ck 1 and ck 3. Both kilns are Hoffman kilns and each operates using the same raw materials and supplementary fuel. Notable differences between the kilns are that ck 1 has 48 chambers and discharges its emissions through two chimneystacks. Kiln ck 3 is smaller and has 36 chambers with one stack. The chimneystacks are all of similar height (approximately 70m), with similar discharges conditions and emission rates (see Appendix A). The stacks are all aligned in a roughly southwest to northeast axis (see Figure 8).

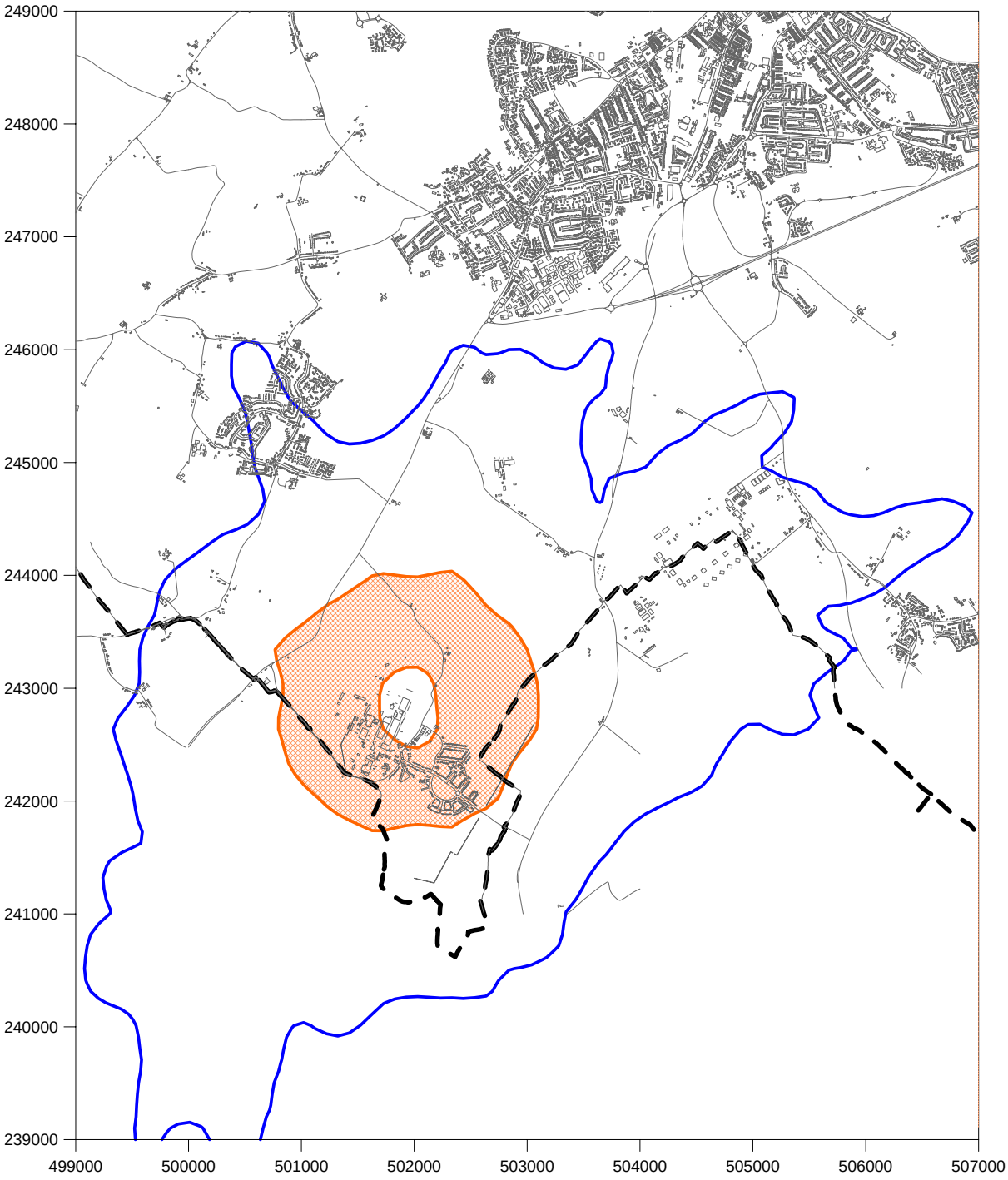
The modelling has been undertaken for each kiln in isolation and the results are presented below. Each figure is presented with the 99.9^{th} percentile used to determine the AQMA, for comparison purposes.

Figure 5 Modelled 99.9th percentile of 15-minute mean SO_2 concentrations using revised emission limits for kiln ck 1 emissions only



Notes:
Pink line – based on averaged AOS emission rate for ck 1 only
Blue line – based on previous modelling from the Council's Supplementary Assessment
Dotted black line – Bedford Borough Council boundary

Figure 6 Modelled 99.9th percentile of 15-minute mean SO_2 concentrations using revised emission limits for kiln ck 3 emissions only



Notes:
Orange line – based on averaged AOS emission rate for ck 3 only
Blue line – based on previous modelling from the Council's Supplementary Assessment
Dotted black line – Bedford Borough Council boundary

The predictions for both kilns include areas with relevant public exposure that exceed the 15-minute mean objective. Both of the areas predicted to exceed are roughly circular, with the ck1 plot having a diameter of approximately 3km and the ck3 plot approximately 2km. The areas predicted to exceed for the individual kilns reflect the difference in size between the two kilns; with the larger kiln ck1 having a greater area that exceeds the 15-minute mean objective than the ck3 kiln. Kiln ck 1 is one third larger than kiln ck3 and hence the emission rate is also approximately one third larger.

It should be noted that modelling the kilns individually gives an indication of the impact of reducing the throughput of the brickworks, by closing one of the kilns at the brickworks. This option has not been included within the AOS report, but it is clearly a BAT option for the brickworks operator to consider.

The predicted concentrations at the Stewartby and Kempston Hardwick monitoring sites are given in Table 8, with that based on the AQMA scenario. This comparison indicates the reduction for the individual kiln modelling.

Table 8 Predicted 99.9th percentile 15-minute mean concentration (µg m^{-3})

Site	Kiln ck1 only	Kiln ck3 only	Based on AQMA
Kempston Hardwick	229	201	**351**
BF1 (Stewartby)	**574**	**272**	**687**

(Note - bold indicates exceeds objective)

The predicted results for these scenarios indicate that concentrations are substantially reduced from the AQMA scenario. The objective is met at the Kempston Hardwick site for both the individual kiln modelling scenarios with a predicted reduction of 35 to 45% at the site. The objective is still exceeded at the BF1 site in Stewartby for the kiln ck3 scenario, albeit the objective is only just exceeded (and is within the range of 10% monitoring uncertainty).

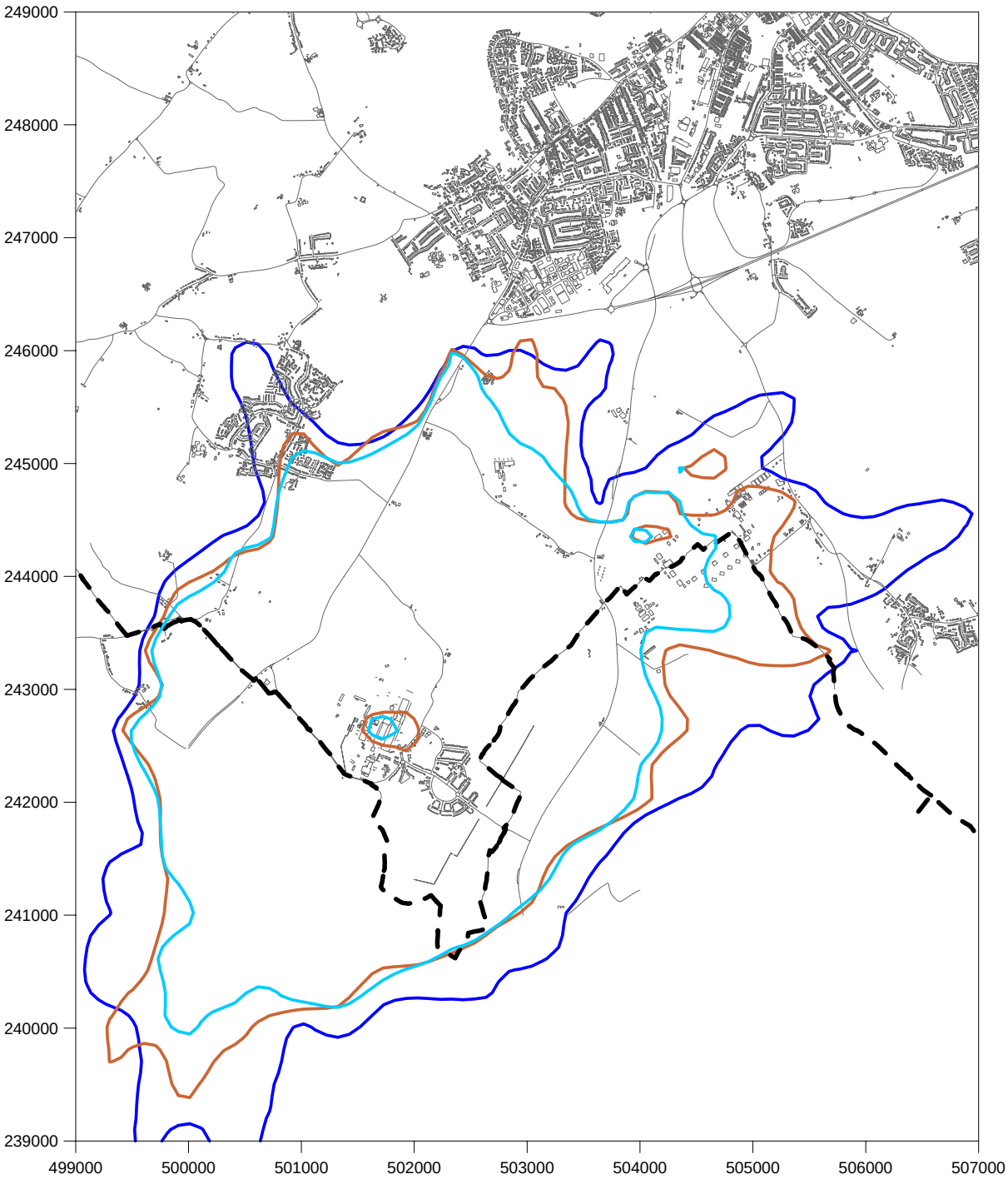
4.3 Results of increased chimneystack height

This scenario is based on an increased chimneystack height of 100m, with no other changes to the discharge parameters. Whilst it is most unlikely in practice that the other parameters would be unchanged, the scenario nevertheless gives the Council some understanding of the effect of an increased stack height. In this scenario all three stacks are increased to the same height. The results for this scenario and the scenario below are shown in Figure 7.

4.4 Results of changed efflux velocity

This scenario has been developed from the report on the Whittlesey brickworks and uses an increased efflux velocity of 15 m s^{-1} (from less than 10 m s^{-1} for the base case). It recognises that the efflux velocity from the stacks is currently low, although it does not change other the discharge parameters. The Whittlesey report suggests that reducing the stack diameter could increase the velocity; this however has not been replicated for modelling the Stewartby brickworks. In this scenario all three stacks have increased efflux velocity.

Figure 7 Modelled 99.9th percentile of 15-minute mean SO_2 concentrations using changed discharge parameters for both kilns.



Notes:
Brown line – based on increased stack height only
Light blue line – based on increased efflux velocity only
Blue line – based on previous modelling from the Council's Supplementary Assessment
Dotted black line – Bedford Borough Council boundary

The results shown in Figure 7 indicate that the 15-minute mean objective is exceeded for the scenarios. For both there is a smaller area that exceeds the objective compared to the AQMA modelling, confirming that the changes have reduced concentrations. The increased efflux velocity has a marginally reduced area from that of the increased chimney height. The predicted concentrations at the Stewartby and Kempston Hardwick monitoring results are shown in Table 9.

Table 9 Predicted 99.9th percentile at monitoring sites (μg m^{-3})

Site	Increased stack height	Increased efflux velocity	Based on AQMA
Kempston Hardwick	**316**	**300**	**351**
BF1 (Stewartby)	**360**	**415**	**687**

(Bold indicates exceeds objective)

These confirm the reduced concentrations at the sites, although the changes are not sufficient for the concentrations to be below the objective at both sites for both scenarios. Larger reductions are observed at the Stewartby site than the Kempston Hardwick site due to the changes in the plume emissions and their dispersion. (Note - the results also confirm that the concentration gradients between sites change for the different scenarios).

Important note – as discussed earlier for all the scenarios modelled above, peak adjustment factors have been used. If as indicated in the AOS report there have been reductions in the number of peak episodes at the sites then it is likely that the peak adjustment factor will tend to over predict concentrations. Some understanding of the effect that this has on the modelled concentrations can be gained from the comparison in Figure 4. This figure shows the difference between the unadjusted emissions (red line) and the adjusted emissions (green line). If the peak adjustment factor were decreased it would approach the concentration plot for the unadjusted emissions ((i.e. the red line), which can be considered to have an adjustment factor of 1. As previously noted, even with this reduced adjustment factor the 15-minute mean objective is exceeded.

5 Conclusion

This report fulfils the requirements of the DEFRA guidance for the Further Assessment and addresses relevant issues pertinent to the continuing LAQM process. The Further Assessment incorporates recent monitoring results and updated modelling input information from the Alternative Options report for Stewartby brickworks (AOS).

The monitoring results at the Kempston Hardwick site (operated by Hanson brickworks) for 2005 were all in compliance with the government's air quality objectives for SO_2, having in previous years exceeded the 15-minute mean objective. The objective however has been exceeded at the Council's site in Stewartby for all years since 2003 (including 2006). The objective was also exceeded in 2005 at the brickworks operator run site at Broadmead. This site started operating in 2005 and it recorded 348 periods greater than the 266 µg m^{-3} 15-minute mean standard (data were reported for 2006).

Episodes at Stewartby still arise under the same meteorological conditions, although there has been a recent drop in the number of episodes per year since 2004. In part this reduction can be explained by missing data. The AOS report also outlines that measures to reduce pollution from the brickworks have been undertaken. This includes a Kiln Management Procedure, which seeks to reduce peak episodes by providing a rapid response to adverse conditions at the Broadmead monitoring site. Further information is required to fully confirm the impact of this measure on SO_2 concentrations.

Modelling of the brickworks remains difficult, as does verifying the results, especially in view of the changing nature of the process. Despite this, this report has used new information from the AOS report relating to emissions from the brickworks. The modelling predictions based on the AOS report have been compared with the previous method used to determine the AQMA. The AOS report modelled averaged constant emissions without applying a factor to take into account the nature of peak episodes. The results show a smaller area of exceedence for the unadjusted scenario than the peak adjusted scenario. These results confirm that the main difference between scenarios relates to the use of the peak adjustment factor to determine concentrations. This factor was derived from the Environment Agency and used to provide realistic peak emissions.

Regardless of the method used all the modelling results show areas of predicted concentrations that exceed the 15-minute mean objective. The predicted results based on the revised information using the peak adjustment factor are little changed from the Council's previous modelling for the AQMA.

The report also considers the options proposed in the AOS report to reduce SO_2 concentrations. These measures are required by the Environment Agency to meet its permit conditions in respect of not exceeding the air quality objectives. However as part of its response to the Environment Agency, the brickworks operator, Hanson, has decided not to operate its permitted installation (under permit BX1616IU) from the end of 2008, unless it can demonstrate, to the satisfaction of the Environment Agency, that it will achieve full compliance with the government's 15-minute air quality objective for SO_2.

The precise measures in the above options however cannot be modelled due to lack of information on the pollutant emissions. Despite this, other scenarios have been modelled exploring ways of reducing ground level concentrations using the peak adjustment factor; these include: an increase in stack height only; an increase in efflux velocity only; and scenarios based on the individual emissions from the kilns. The results for all scenarios indicate that the 15-minute mean objective will still be exceeded, with a slight reduction for both stack height and changed efflux velocity scenarios from the previous AQMA result. The individual kiln modelling produces the greatest reduction in concentrations, with results from the smaller kiln (ck3) having the smallest area of the modelled scenarios that is predicted to exceed. For this ck3 scenario the predicted concentrations just exceed the objective at the Council's Stewartby site.

The modelling has highlighted that the use of the peak adjustment factor increases emissions and hence predicts increased concentrations. The applicability of this factor may have changed as a result of changes at the brickworks, although further evidence of the emissions is required before this can be confirmed. Despite this additional uncertainty, modelling of the brickworks without the factor still indicates that the 15-minute mean objective is exceeded in areas with relevant public exposure.

In summary, the results from this Further Assessment indicate that the sulphur dioxide air quality objectives are still exceeded in the area around Stewartby and that further measures and information are required to reduce concentrations. As a result the Council should maintain its AQMA as originally designated.

6 Recommendation

The Council is recommended to undertake the following actions, in respect of the findings for the statutory objectives relating to sulphur dioxide:

1. Retain its existing AQMA and undertake consultation on the findings arising from this report with the statutory and other consultees as required.

2. Maintain its monitor capability at its two monitoring sites in BF1 (in Stewartby) and BF3 (in Kempston).

3. Continue to liaise with the Environment Agency, who are the regulatory authority for industrial emissions and responsible for enforcement of the conditions incorporated into IPPC Permit issued to Hanson Building Products Limited for the Stewartby brickworks.

References:

Bedford Borough Council, 2004. Detailed Assessment of Sulphur Dioxide for the Bedford Borough Council.

Bedford Borough Council, 2004. Supplementary Assessment of Sulphur Dioxide for the Bedford Borough Council.

Bedford Borough Council, 2005. Air Quality Progress Report 2005.

DEFRA, 2003. Local Air Quality Management Technical Guidance. LAQM.TG3 (03) London: The Stationery Office.

DETR, 2000. Air Quality Strategy for England, Scotland, Wales and Northern Ireland. London: The Stationery Office. ISBN 010 145482 1.

Environment Agency, 2004. Air quality modelling and assessment of emissions from Fletton Brickworks at Stewartby (Hanson Building Products). Air Quality Modelling and Assessment Unit.

GAIR Consulting Ltd, 2004. Air Quality Management Plan: Whittlesey Brickworks. (December 2004).

GAIR Consulting Ltd., 2006. Alternative Options Report for the Stewartby Brickworks (April 2006).

Herts & Beds Air Quality Monitoring Network website. See http://www.hertsbedsair.org.uk/hertsbeds/asp/Home.asp

Appendix A

Modelling Approach

The overall objective of the air pollution dispersion modelling in this report is to produce a sound method whereby concentrations of SO_2 can be determined and developed in conjunction with the continuous monitoring results to produce percentile values that can be compared to the AQS objectives. In summary the main aims are to:

1) Use a dispersion model to make predictions of SO_2 over the time scales relevant to the AQS objectives
2) Undertake modelling of the releases of SO_2 over the area of interest and compare the model performance against air pollution measurements.
3) To make predictions of the possible future releases for the AQS objectives.
4) To use locally available meteorological data over recent years to take into account year to year variation.

Area of interest

The area of interest was limited to the southwest corner of the Council's area and the immediate surrounding area surrounding the Stewartby brickworks. This was based on the previous Council reports.

Dispersion model and parameters used

The dispersion model used was ADMS 3.1. This is a well-established dispersion model that meets the requirements of TG03 for point sources. It has also been well validated for use with point sources.

The surface roughness (s.r) length used was 0.2m (in line with the earlier reports). Sensitivity tests undertaken in the previous reports showed that a higher roughness length produced higher concentrations.

The model was set up to produce percentile values in long-term mode, since these were the output required.

The effects of buildings were not considered due to their relatively low height compared to the stacks. Terrain effects were also not been included within the model set up.

The development of emissions information used for modelling the area is dealt with separately below.

Treatment of background SO_2

The background concentrations of SO_2 in the previous reports were derived from the St. Albans monitoring site and found to be low. For the predictions made in this report a mean background of 4 µg m^{-3} was used. This was derived from previous reports and is broadly in line with the findings for the St. Albans site.

Assumptions used in the report

1) All SO_2 emissions are calculated on the basis of grammes emitted per second (g/s), as required by dispersion models.

2) The emissions are discharged from the 3 different chimneystacks at the brickworks. Specific details of the stacks are given in the table below.

Table 10 Details of Stewartby stacks from Alternative Options for Stewartby Report

Stacks	Easting	Northing	Height (m)	Diameter (m)	Exit temp (°C)	Exit velocity (m/s)
ck3	501909	242858	69.4	3.33	92.3	8.8
ck1b	501726	242642	70.3	2.35	113.8	9.5
ck1c	501673	242514	67.7	2.67	111.0	7.0

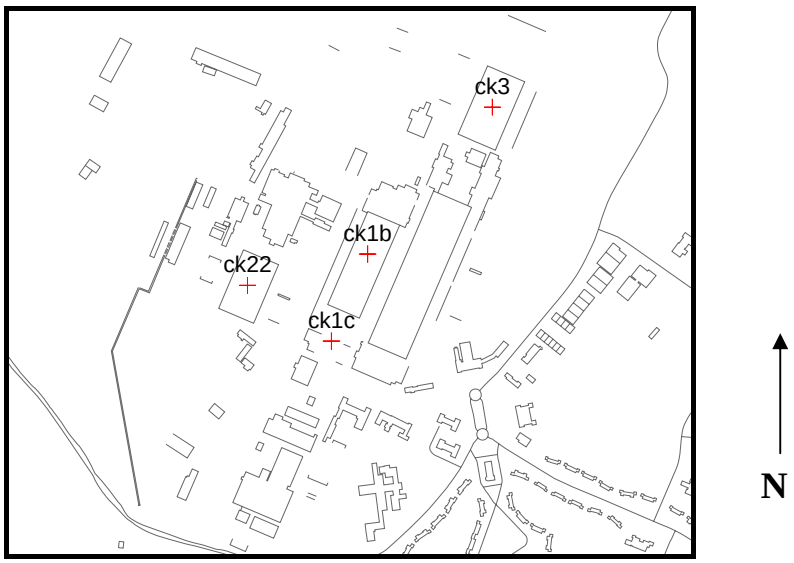
3) To try to reproduce the effects of changing emissions, the Environment Agency introduced a series of factors for each of the different objectives. These factors were derived from a representation of the firing cycles within each kiln and are based on peak emissions arising within an 18-hour cycle. This has been added to another cycle, representing changing emissions within the kiln, specifically as fires move from chamber to chamber around the kiln leading to changing exhaust conditions. This cycle is based on a 17-day period. From this understanding, sinusoidal signals were produced and these were randomly distorted to represent activities within the brickworks. Twenty such models runs were produced along with a model run based on a constant emission rate. From an inter comparison of the test runs with the constant emission rate a series of ratios were produced. The median of these was run again separately and from this continuous emission data factors of 1.4, 1.3 and 1.2 were obtained for the 15-minute, hourly and 24-hour mean objectives respectively.

Table 11 Mean emission rates used for modelling (with no adjustment)

Parameter	ck1b	ck1c	ck3
15 minute	78.2	75.3	113.3

4) The modelled estimates were derived from the modelled 99.9^{th} percentile of one-hour outputs. The equivalent percentile for the 15-minute mean objective however is the 99.9^{th} percentile for the 15-minute mean. Hence a factor of 1.36 based on for the Environment Agency report was used for the modelling within this report.

Figure 8 Location of the chimneys to the kilns used at Stewartby brickworks

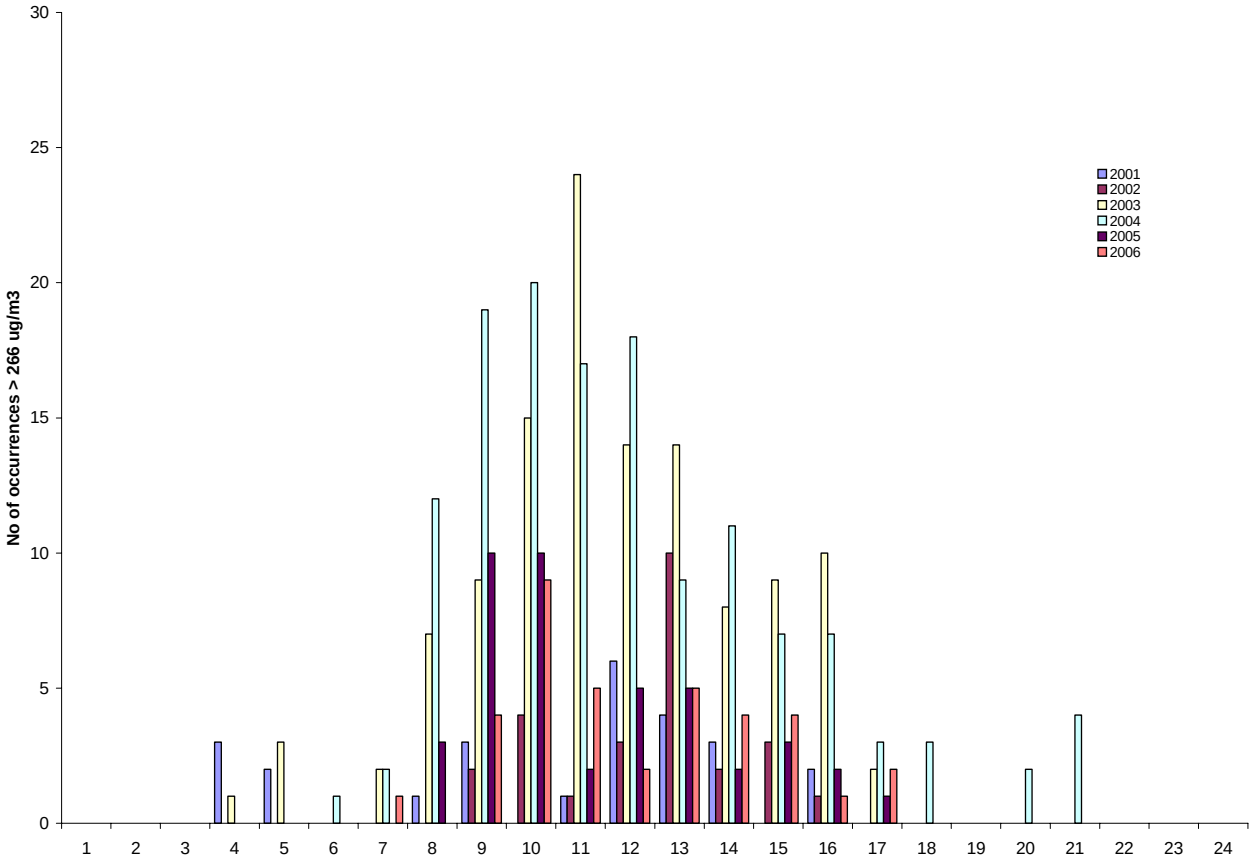


(Notes: the points are marked to represent the approximate position of the chimneystacks)

Appendix B

Temporal Distribution of episodes at the BF1 site

Figure 9 Distribution of episodes throughout the day at the BF1 site (2001 to 2006)



Sulphur dioxide monitoring at the BF1 site

Figure 10 Monitoring results for 2005 (ppb)

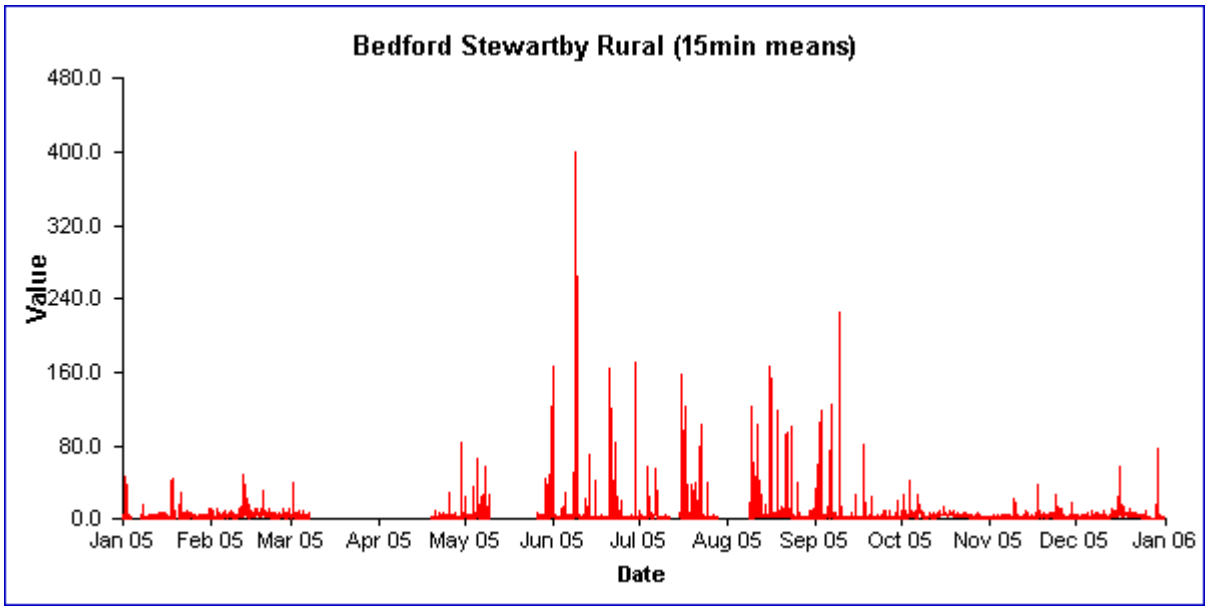
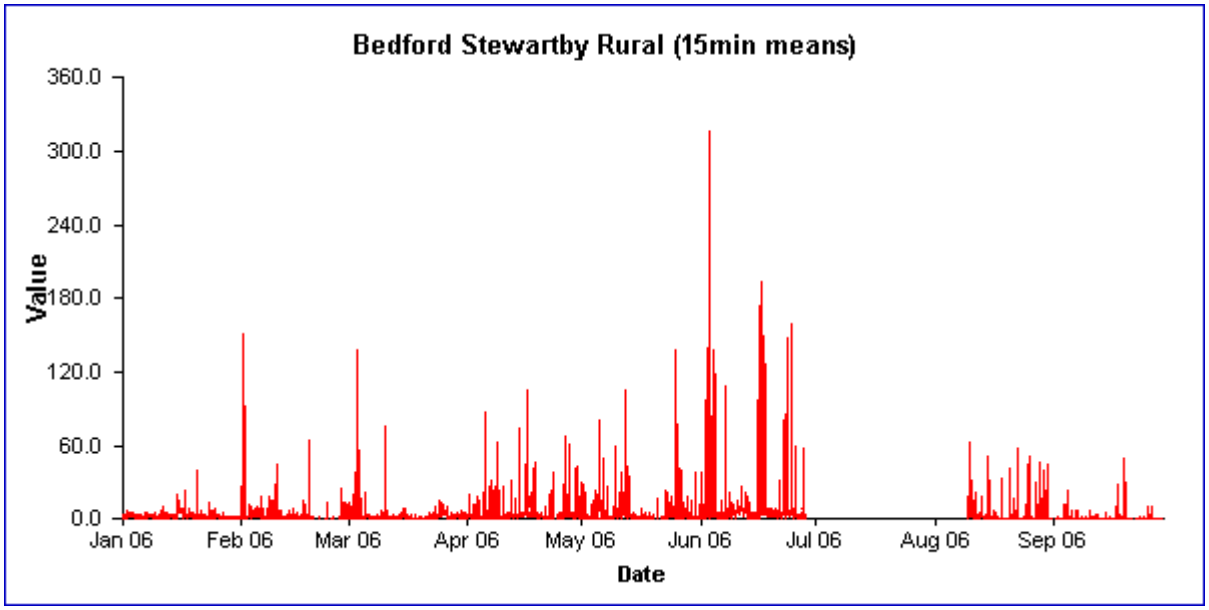


Figure 11 Monitoring results for 2006 to 30 September (ppb)



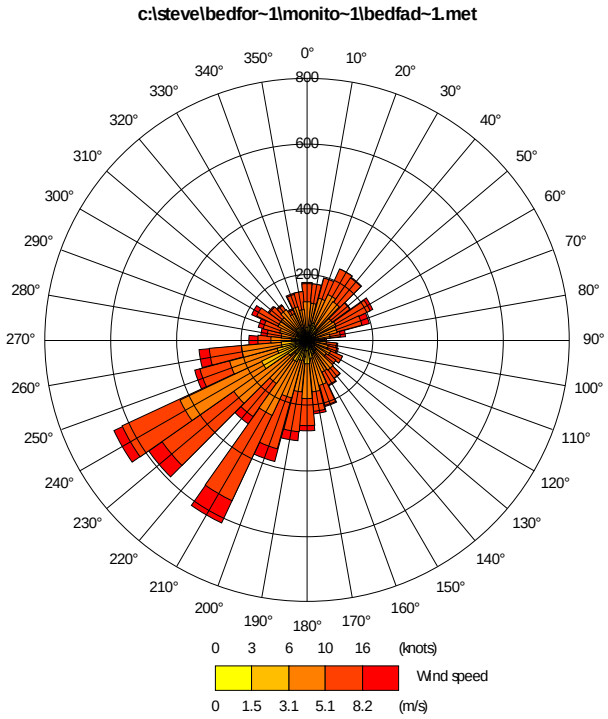
(N.B Includes data that are not fully ratified)

Appendix C

Meteorological information used in the report

The report uses 2001 meteorological data from the Bedford site at Cardington, with data provided by the Met. Office.

Figure 12 Wind rose for Bedford 2001



For 2001 the number of hours that wind data are lacking is 175 (representing just under 2% of the years measurements)

The following table presents a comparison of the winds from the identified sector for 2001, based on the number of hours for each wind sector. The sectors have been derived from the analysis of episodes in the monitoring chapter of the report.

Table 12 Analysis of wind sectors based on the monitoring sites

Wind sector (°)	2001 (hours)
270-360	2144
Total (hours)	8585

From the above table it can be seen that the frequency of winds from the sector identified for the BF1 site is approximately 25 % of the total.