NOISE BARRIERS

CERC

In this document 'ADMS' refers to ADMS-Roads 5.0, ADMS-Urban 5.0 and ADMS-Airport 5.0. Where information refers to a subset of the listed models, the model name is given in full.

1. INTRODUCTION

The effect of noise barriers on air quality close to roads is of interest, particularly in mainland Europe. Investigations using wind tunnels and dispersion models show that ground level concentrations are reduced immediately downstream of a noise barrier, due to the fact that emissions are effectively elevated by the barrier. In ADMS, this reduction in ground level concentration has been represented by modelling a road with a noise barrier as an elevated road source. The model is able to take into account noise barriers on either or both sides of a road, parallel to the road.

Noise barriers are also modelled in the TNO traffic model used in the Netherlands, and results from the TNO model (shown for example in [1]), are consistent with those from ADMS.

The relationship between the height of the noise barrier and the increase in elevation of the modelled road source is given in Section 2. Details of model restrictions and assumptions are also given in this section. The Appendix details the methodology used to derive the relationship between the height of the noise barrier and the increase in road elevation.

2. CALCULATION OF THE ELEVATED ROAD SOURCE HEIGHT

The relationship between the noise barrier height, H_{NB}, and the height of the elevated road source, $\hat{z}_s$, is

$$\hat{z}_s = A \times H_{NB} + z_{s\_road} \quad (1)$$

where z_{s_road} is the height at which the line representing the road without a noise barrier is modelled, and $A = 0.4943$ is a constant. Recall from the road source Technical Specification (P31/01) that z_{s_road} is given by

$$z_{s\_road} = z_s + h_0, \quad (2)$$

where $h_0 = 1$ m is the initial mixing height and z_s is the road height as entered by the user.

2.1 Region of influence

When ADMS models a road source, the source is divided up into a number of wind-aligned segments. For each segment, a conservative region of influence is defined outside which the source has a negligible effect (for further details please refer to the Technical Specification, P25/03).

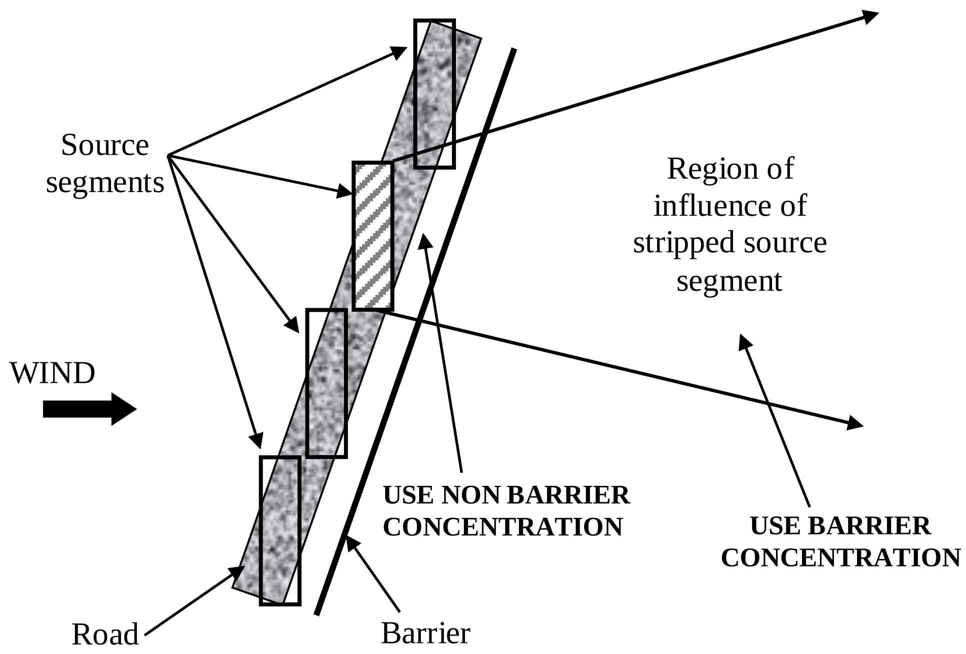

Figure 1 – Diagram showing where the barrier and non-barrier concentrations are used downstream of a road source segment

Figure 1 shows a diagram of a road source, with the wind coming from the left of the figure. A noise barrier is located to the right of the road. The road source is divided up into four wind-aligned source segments, and the region of influence of one of the segments is shown. Between the road and the noise barrier, the unadjusted concentration values are used, and downwind of the barrier, the concentration due to the elevated road source is used, in order to represent the effect of the barrier on concentrations.

2.2 Assumptions and restrictions

The main restriction of this module is that adjustments to concentrations are only made outside the noise barrier, when clearly the presence of the barrier will affect concentrations within the road. To also consider concentrations within the road, where there are noise barriers of similar heights on both sides of the road, the road should be treated as a basic street canyon, refer to Technical specification document P28/01. Alternatively, for a more advanced treatment, especially in cases where the barrier heights are asymmetric, the advanced street canyon module can be used in place of the noise barrier and basic canyon modules. The advanced street canyon module calculates the effect of noise barriers on concentrations both inside and outside the canyon, please refer to Technical Specification document P28/02 for further details on the advanced street canyon module.

Assumptions made during the derivation of the algorithm given by equation (1) above include:

- Only neutral meteorological conditions were considered.
- The emission was considered to be at ambient temperature.
- Barrier heights of up to 10 m were investigated.

3. REFERENCES

[1] Wesseling, J. and Visser, G. (2003) Measuring and modelling of the A13 motorway near Overschie. *Arena Magazine*, no.**8**.

APPENDIX DERIVATION OF THE ELEVATED ROAD SOURCE HEIGHT ALGORITHM

This Appendix describes the method of investigation used to derive the algorithm given by (1), which relates a given noise barrier height to the height of the corresponding elevated road that can be used to represent the decrease in concentrations downwind of the barrier. The industrial source model ADMS 3 was used for this investigation in order to be able to model the effect of explicitly defined buildings on concentrations.

Note that:

- As road sources are not modelled in ADMS 3, this investigation was conducted using a line source (for details of the differences between line sources and road sources in ADMS please refer to P31/01). The relative difference between concentrations due to line and road sources was investigated to ensure that it was correct to apply the derived methodology for road sources (see Section A.2 below).

- Non-point sources cannot be modelled with buildings in ADMS 3. However, a line source can be accurately represented by a series of point sources; if sufficient points sources are modelled, the difference between modelled concentrations is negligible.

- The investigations described are effectively two-dimensional i.e. a building relatively long in the crosswind direction was modelled and end effects were not considered. The along-wind solution at the building centre has been applied more generally in three dimensions to roads, which are modelled as crosswind source segments. Barrier edge effects on concentrations are therefore neglected.

A.1 Representing the barrier in ADMS 3

Figure 2 shows a vertical cross section of the ADMS 3 model set up. The crosswind width of the noise barrier is 500 m and the along wind width is 0.2 m. Barrier heights of up to 10 m and ‘road’ centreline to barrier distances of up to 40 m are considered, the latter accounting for road widths of up to 80 m. Figure 3 shows an example set of results for a source-barrier distance of 10 m. Here, the thick black line gives the concentrations in the absence of a barrier, and results for barrier heights of 2 m, 3 m, 4 m, 6 m, 8 m and 10 m are also shown.

As would be expected, as the barrier height increases, the initial concentration downstream of the barrier decreases, due to the fact that the source is effectively elevated. For the lower barrier heights (2 m and 3 m), the downstream concentrations are predicted to exceed the concentrations in the absence of a barrier, whereas for barrier heights 4-10 m, the concentrations initially remain lower.

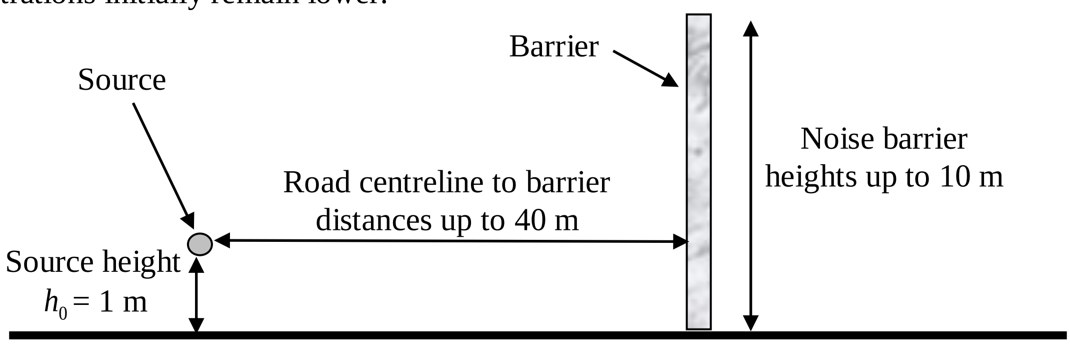

Figure 2 – Vertical cross section of the ADMS 3 model set up

When a building is modelled, the flow field is divided into different regions (for further details of the various regions, please refer to Technical Specification paper P16/01). One very apparent part of the flow field is the cavity region immediately downstream of the building. Due to this region, there is a slight discontinuity in the concentration gradient downstream of a building, and this has been indicated in Figure 3 for each of the cases where the barrier has been modelled. The length of the cavity region is related to the barrier height, with the cavity region being longer for higher barriers.

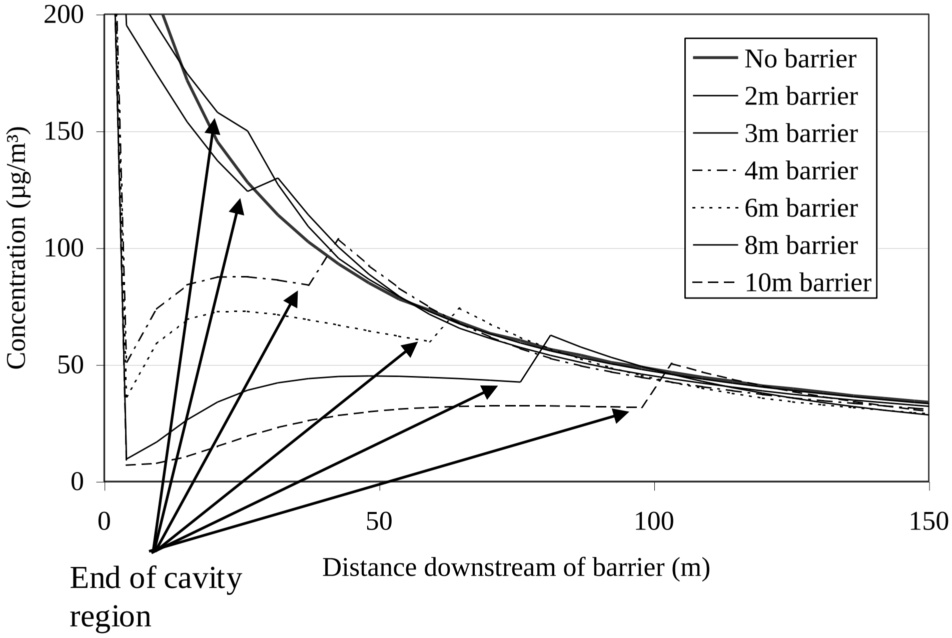

Figure 3 – Concentrations downwind of a barrier as modelled in ADMS 3, for source-barrier distance 10 m and barrier heights 2 m, 3 m, 4 m, 6 m, 8 m and 10 m; end of cavity region indicated by arrows; concentrations in the absence of a barrier also shown.

A model attempting to represent the behaviour of the concentration decay downstream of a noise barrier should, in the limit of the noise barrier height tending to zero, tend to the profile given in the absence of a barrier. For this reason, it was decided to ignore

- the behaviour predicted by the low level barriers at 2 m and 3 m, and
- the unphysical discontinuity in concentration gradient at the edge of the cavity region.

By consideration of the first downwind maximum concentrations shown in Figure 3, it is possible to approximate the concentration downwind of a noise barrier by an elevated line source using the expression given by equation (1) above. Full details are omitted in this document, but Figure 4 compares the line source approximations to the explicitly modelled barrier, for barrier heights 4m, 6m, 8m and 10m and a road centerline to barrier distance of 10m. Note that the vertical scale on this plot has been magnified to show more detail than in Figure 3. Conclusions of the full investigation include:

- the approximations show good agreement close to the barrier, in particular for the lower barrier heights, and
- results for shorter road centreline to barrier distances (less than 20 m say) are better than for larger distances (20-40 m, say).

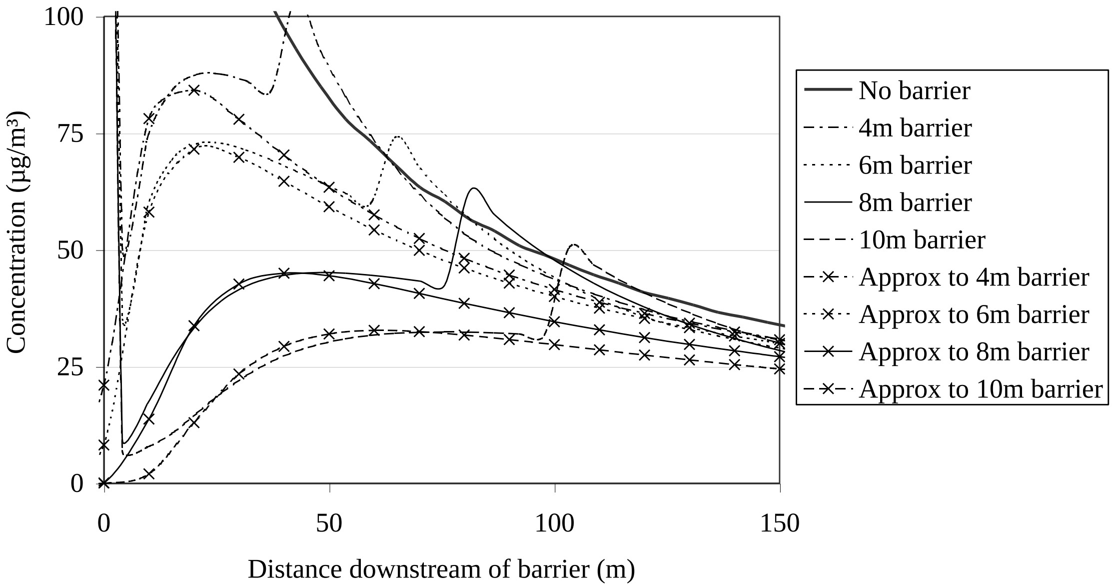

Figure 4 – Comparisons of line source approximations to concentrations downstream of a barrier in ADMS 3, for source-barrier distance 10 m and barrier heights 4 m, 6 m, 8 m and 10 m; concentrations in the absence of a barrier also shown.

A.2 Extension to from line sources in ADMS 3 to road sources

As outlined in document P31/01, ADMS models roads as line sources, with:

- a minimum height of $h_0 = 1$ m, and
- an increased vertical plume spread.

It is important to check if the source height predicted by (1) gives similar concentrations for the line and road sources, relative to the maximum concentrations ‘in the absence of a barrier’ for both source types.

Maximum concentrations downstream of a road source are both lower and closer to the source than for a line source of the same emission and elevation. This is as expected due to the increased vertical plume spread for road sources. However, maximum concentrations for elevated sources relative to the maximum concentration of a source at a height of h_0 for road sources were found to be within 10% of the same ratio for line sources, so the expression relating barrier height and source elevation derived using ADMS 3 line sources is valid for modelling road sources in ADMS.