Grenfell Investigation into Potential Land Contamination Impacts

Technical Note 06: Review of Met Office Air Dispersion Modelling

Royal Borough of Kensington and Chelsea

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Quality information

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1. Introduction

This technical note presents AECOM's review of the Met Office's report "*Grenfell Tower fire: modelling deposition of smoke particulates using NAME",* Forecasting Research Technical Report No. 637, April 2019. The report is publicly available at https://www.metoffice.gov.uk/research/library-and-archive/publications/science/weather-science-technical-reports at the time of writing.

2. Objective

The objective of this review is to identify and summarise the information contained within the report that is most relevant to the design of the Stage 1 exploratory sampling and the design of the Stage 2 investigation. Specifically:

- Identify the smoke plume deposition areas that might require soil sampling.
- Identify whether there were substantial differences in deposition rates in different areas.
- Identify whether the modelling results could be used to infer potential soil concentrations of smoke particle contaminants.

3. Review of Modelling Methodology

Table TN06-01 summarises the key elements of the modelling approach and the implications for model interpretation.

TN06-01: Summary of method related information

Comment number	Details	Comment
1	The model approach is a Lagrangian particle method, capable of representing the movement of air pollutants in 3 dimensions, over long periods of time and over long distances. These techniques have been used within regulatory models for more than 30 years.	The model is suitable for the task it has been used for. The study area is at the shorter end of what the NAME model can model, and the method does not report results within 300m of the tower.
2	The model includes 'a maximum deposition height' which represents a height above ground level where there is limited mixing of the air above or below that height, in effect a boundary layer.	If the plume rises through the boundary layer, then lighter particles remain above the boundary layer and therefore are not available to undergo deposition onto the ground. This phenomenon is visible in the photographs included in the report (page 15 of the report) as a plume with a flat base. The above text uses 'boundary layer' as a common English description for a dividing point. Within the technical terminology used for modelling, the "maximum deposition height" in the model is not the same as the "boundary layer height"
3	Heavy particles are able to move through the boundary layer representing the maximum deposition height, due to the action of gravity. This is represented in the model.	Heavier particles can be deposited before the air carrying lighter particles has been mixed back into air below the boundary layer. Potentially the point of maximum impact may be different for heavier and lighter particles.
4	The model considers how the shape of a particle will affect the rate at which it would fall under the action of gravity. A flatter profile (like the particle in	The model only considers the extremes of spherical and flat profiles and not the actual profiles of particulates present in the fire. It

Comment number	Details	Comment
	Figure 4a of the report) providing more resistance to the air compared to a spherical profile and results in flat particles falling more slowly and being deposited further from the source of emissions.	provides output representing the range of answers within which the values for the real-world situation will sit.
5	The model considers in turn the distribution of deposited material for particles of different combinations of size, density and profile.	The model does not report the actual amount of particulate deposition in any one area, or the concentration of any associated chemical that may be bound to the particulate, but instead provides results that identify the relative mass of particulate material likely to have deposited in one location compared to other locations.

4. Review of Model Findings

Table TN06-02 provides a summary of the findings of the air dispersion modelling exercise that are most relevant to Stage 1.

TN06-02: Summary the findings of the modelling study

Comment number	Details	Comment
6	The modelling reports that during the period of the early stages of the fire when mass release rates are highest, there is little deposition of lighter particles because they are held above a boundary layer well above ground level.	This will limit the mass concentration of fire effluents found in deposited dusts or soil across the impacted area, including the location predicted to experience relatively high levels of deposition. As material is mixed back into air below the boundary layer it will be deposited over a wide area and at lower concentrations than would have been the case if the plume had grounded within a small number of kilometres from the tower. These lower more dispersed concentrations will be harder to distinguish from the variation likely in baseline conditions.
7	Results should be interpreted as relative quantities	It is not appropriate to attempt to factor a chemical concentration value for specific air pollutants from the total deposition map results, but the results are suitable for considering where material is likely to have deposited in perceptible amounts and where no perceptible impact is likely to have occurred.
8	The report sets out the rationale behind the sensitivity testing and which factors are likely to exert a more dominant influence on the reported results.	This adds confidence to the report’s conclusions but does not provide additional information that is likely to materially change the way the total deposition maps are used in further studies.
9	Within 300 m of the tower the model is reported to be outside the performance window for the modelling method.	It would be reasonable to assume that local turbulence could have resulted in dispersion of airborne material in any direction within that 300m zone around the tower.
10	Met data from Kew (Figure 13 in the report) indicates that after the period of the main fire, wind directions changed, and any residual emissions are most likely to have deposited to the East, but this time period is outside of the dispersion model study scope.	While the main areas affected by modelled particle sizes are likely to be 3km to 5km to the north west of the tower, there may be perceptible impacts to the east resulting from lower residual emission rates over a longer period of time.

5. Conclusions

The model has looked at the dispersion and deposition of two sizes of particles during the main period of the fire (3.5 hours) and the subsequent 12 hours; and particle sizes of 10µm and 100µm to represent soot and larger particles respectively. The particle emission rate and the convective heat release rate from the fire were based on estimates provided to the Met Office by the Health and Safety Laboratory, and meteorological conditions were based on data from the Met Office's Numerical Weather Prediction analysis. Because particle shape can have a big influence on dispersion and deposition, two extremes of particle shape were modelled – one a perfect sphere, and one a disc.

The authors make clear the limitations of the modelling; namely:

- It doesn't consider particles larger than 100µm (0.1mm).
- The model cannot reliably predict deposition within 300m of the Tower.
- There is a lack of knowledge on the nature of the particles emitted (size, density, and shape).
- There are uncertainties in the meteorological conditions and the source emission estimates.

Consequently, the authors caution that the focus of the study was on simulating the spatial distribution and relative quantity of particle deposition, and that the results should be used as indicative rather than absolute quantitative deposition values. Because only two extremes of particle shape have been modelled, the plume maps need to be interpreted in the knowledge that the plume will have consisted of a wide range of particle sizes, shapes and densities and that the deposited material would have been spread across the deposition areas indicated.

Importantly by not modelling particles greater than 0.1mm in size, the modelling does not attempt to model the dispersal and deposition of debris emitted during the fire.

The modelling indicates that the smoke particle deposition extended beyond 5km distance from the Tower and the plume for larger (100µm) particles was wider than that for smaller (10µm) particles – the width of the deposition plume at a distance of 3km from the Tower being approximately 3 km for 10µm particles and almost 6km for 100µm particles. The deposition of spherical particles is modelled to be higher than that for non-spherical particles – the maximum deposition for spherical particles being 3.2g/m^2, compared to <0.32 g/m^2 for non-spherical particles.

For the smaller 10µm particles the highest deposition rate was modelled at <0.032g/m^2 and this was limited to within 1km of the Tower, 100x lower than the highest modelled deposition for dense 100µm particles of 3.2g/m^2 that is modelled to have occurred in an area greater than 3km form the Tower.

To put the reported deposition rates in to context (and noting the modelling uncertainty in these values as commented in Table 2), if 3.2g of soot was deposited over one square metre of soil and mixed within just the upper 1cm of soil, the dilution of the deposited particles in the soil is a factor of at least 3,750, if we assume a soil bulk density of 1200kg/m^3. The dilution factor increases linearly with the depth of soil mixing assumed. At 20cm, the dilution factor is 75,000 if that soil thickness is uniformly mixed.

The higher rates of deposition are predicted to be in a zone to the northwest of the Tower approximately 0.5km wide and within 1km of the Tower, and in a much larger zone that extends northwest approximately 2 km from the Tower and approximately 2.5km wide. The highest zone of deposition modelled is an oval area on the southern boundary of the London Borough of Brent with the London Borough of Ealing where deposition is modelled to be 100x higher than that in the 0.5km wide zone identified above that is within 1km of the Tower.

Because of the differences in the predicted deposition rates between spherical and non-spherical particles, the chemical composition of the more spherical particles could exert a greater influence over observed soil concentrations, however, this is also dependent on the relative concentrations of the chemical components of the particles. Both these factors are unknown.

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