COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

STATEMENT ON THE EVIDENCE FOR HEALTH EFFECTS IN THE TRAVELLING PUBLIC ASSOCIATED WITH EXPOSURE TO PARTICULATE MATTER IN THE LONDON UNDERGROUND

Summary

1 COMEAP last reviewed the evidence for health risks associated with exposure to particulate matter (PM) in the air of the London Underground in 1998. Since that time, new evidence has emerged, suggesting that a reassessment would be appropriate. Most of this new research has been focused on the physical and chemical properties of PM in the air of underground subway systems. In general, these studies have reported underground particles to be larger in diameter and with higher mass concentrations than those in ambient air (ie outdoors, above ground). Studies have also found the time spent commuting in the underground to contribute substantially to daily personal exposure to PM mass. However, PM emission sources in underground subway systems are very different from those above ground. Due to the different contributing sources, the chemical and physical properties of PM in the underground differ from those typical of outdoor PM. These differences in physical and chemical properties, as well as the different exposure patterns (ie primarily episodic exposures over short-periods of time) and age distribution profile (smaller proportion of elderly and young persons) of the underground-travelling population compared to the overall population, might be expected to lead to effects on health different from those caused by exposure to ambient air pollution.

2 In 2003, the Institute of Occupational Medicine (IOM)[1] made several recommendations regarding the need for studies on the health effects of exposure to pollution in underground subway systems. Unfortunately, there has been little progress in this area over the last fifteen years. Few studies have examined the potential effects of inhalation exposure to underground PM on human health, and those that did reported inconsistent results.

3 The lack of available studies assessing the human health effects of exposure to underground particles, and the differences between underground PM and that found in ambient air, mean that it is not possible to determine the nature and extent of any health risk to those travelling on the London Underground. We cannot, rule out the possibility that there is a health risk from exposure to underground PM. Given that there is strong evidence that both long- and short-term exposure to particle pollutants in ambient air are harmful to health, it is likely that there is some health risk associated with exposure to underground PM. With regards to toxicity of

[1] Institute of Occupational Medicine Report TM/03/024. Assessment of health effects of long-term exposure to tunnel dust in the London Underground

underground PM, the evidence is limited and there is no strong suggestion that underground PM is significantly different to ambient PM. Given the absence of any consistent evidence on the relative toxicity per unit mass exposure of underground PM and that in ambient air, there is insufficient evidence to provide quantitative comment on the risk associated with inhalation of particles on the London Underground. We would encourage Transport for London (TfL) to continue to find practicable ways of reducing PM levels on the Underground network.

Background

4 An average of 4.8 million journeys are made on the London Underground every day.

5 Exposure to ambient air pollution – notably PM – increases mortality and morbidity risk. Underground transport systems have elevated airborne PM mass concentrations compared with ambient air, raising concerns about the potential health impact of such particles. However, PM emission sources in the London Underground are different from those in ambient air, such that the physical and chemical properties (particle size distribution and chemical composition) of PM in the London Underground differ from those found in ambient air.

6 COMEAP last reviewed the evidence for health risks associated with exposure to PM in the London Underground in 1998. A statement was produced: this is attached as Appendix A. On the basis of the Committee's recommendations in that statement, TfL commissioned the IOM to conduct research into the likely health effects from exposure to underground PM. The 2003 IOM report concluded, based on the limited available evidence, "*We do not think that the travelling public is at any serious or substantial risk from travelling underground… However, the in vitro tests show that tunnel dust is not inert… We encourage management and unions in the Underground to continue to work together to find practicable ways of keeping dust levels low*"[2]. Moreover, the authors suggested that their conclusions should be re-evaluated from time to time as new information became available.

7 Since 2003 there have been increasing efforts to understand the physical and chemical characteristics of PM that modulate toxicity. While it seems likely that the adverse health effects from particulate air pollution are not related to particle mass concentrations alone, knowledge of which specific characteristics of PM are responsible for adverse effects is currently incomplete. In a 2015 statement[3], COMEAP stated that *"It is unlikely that all components of particulate matter have the same potency in causing health effects…..However, we consider that, overall, the current evidence is mixed and remains insufficient to draw reliable conclusions about which are the most health-damaging components".* COMEAP's statement is based on evidence of health effects associated with ambient PM and was intended for application to questions relating to the possible effects on health of exposure to

[2] Institute of Occupational Medicine Report TM/02/04. Assessment of health effects of long-term exposure to tunnel dust in the London Underground

[3] COMEAP 2015 Statement on the evidence for differential health effects of particulate matter according to source or components https://www.gov.uk/government/publications/particulate-air-pollution-health-effects-of-exposure

ambient particles. It was not drafted with environments such as the London Underground in mind.

8 Since 2003, there have been advances in the understanding of the physical properties and chemical composition of PM in the London Underground, and other subway systems around the world. In addition, there has been increasing media attention on subway pollution and its potential public health impact. Consequently, TfL asked COMEAP to re-assess health risks to the travelling public associated with PM exposure in the London Underground.

The approach adopted by COMEAP

9 The Committee discussed and approved the terms of reference for its work on this topic at a meeting held in June 2017. The terms of reference are attached as Appendix B. A COMEAP Sub-group, made up of Members and co-opted experts, was set up to review the available evidence (Appendix C).

10 To assist the Committee with preparing a statement, TfL commissioned Professor Mark Nieuwenhuijsen (Institute for Global Health, Barcelona) to undertake a literature review to identify and summarise relevant studies and evidence. Summaries of these studies are included in Working Paper 1. The key questions to be addressed in the review were discussed at a COMEAP Sub-group meeting in July 2017.

11 In addition, the Committee and its Sub-group considered other data sources, and drew on their own expertise, in coming to the conclusions set out in this statement. These sources included:

a) Concentrations of PM and its components in the London Underground, measured by King's College, London. The evidence is summarised in Working Paper 2
b) Information from TfL on routine London Underground worker dust-exposure levels and PM sampling results, pre- and post-clean-up. The evidence is summarised in Working Paper 3
c) Report by the Air Quality Expert Group (AQEG) Understanding PM_{10} in Port Talbot[4]
d) Health Effect Institute's National Particle Component Toxicity (NPACT) studies[5]
e) Guidelines and exposure limits for inhalation of airborne metals The evidence is summarised in Working Paper 6

12 Draft versions of the statement were discussed at the March 2018 and June 2018 Committee meetings. Points raised during our discussions can be found in the minutes of our meetings. We agreed a revised version by correspondence in October 2018. This statement sets out the Committee's current thinking with regard to the potential health effects associated with exposure to PM in the London Underground. We also make several recommendations for future research, which we think would help to resolve some of the difficulties we encountered during our work.

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[4] https://uk-air.defra.gov.uk/assets/documents/110322_AQEG_Port_Talbot_Advice_Note.pdf
[5] https://www.healtheffects.org/publication/national-particle-component-toxicity-npact-initiative-integrated-epidemiologic-and

13 A number of Working Papers were developed by Members of the Sub-group, and other experts, to support discussion of various aspects of the work and explore the evidence in this statement in more detail. These are listed below, and are available from the COMEAP website[6]. The views expressed in the working papers are those of the author(s) and do not necessarily reflect those of the Committee.

Working Paper 1	Literature searches commissioned by TfL Mark Nieuwenhuijsen
Working Paper 2	Subway $PM_{2.5}$ characterisation John Stedman and David Green
Working Paper 3	Monitoring of London Underground workers exposure to respirable dust between 2005 and 2017 Olivia Carlton and Nick Wilson
Working Paper 4	Mechanistic evidence for health effects of PM in the London Underground Matthew Loxham
Working Paper 5	Personal exposure to $PM_{2.5}$ while commuting on the London Underground Christina Mitsakou
Working Paper 6	Comparison of published health-based exposure limits (occupational and population) with PM concentrations in the London Underground Sarah Robertson and Kerry Foxall

Summary of the evidence and Members' views

PM in the London Underground

14 Mass concentrations of PM at the platforms on London Underground lines are typically much higher than in ambient air. Based on the 2003 IOM report, Seaton et al. (2005)[7] reported platform $PM_{2.5}$[8] concentrations of 270–480 µg/m^3 (average over three days) at Hampstead station. More recent work (Smith et al., 2018)[9] at the same location has reported a mean $PM_{2.5}$ concentration of 492 µg/m^3 (over a 10 day period). For comparison, the ambient $PM_{2.5}$ annual mean concentration measured at national network monitoring sites in the UK in 2016 was 10 µg/m^3, with a range from 3 µg/m^3 in rural Scotland to 16 µg/m^3 at a roadside monitoring site close to a busy road in London[10]. Elevated $PM_{2.5}$ concentrations have been reported in other subway[11] systems but have been, in general, lower than observed in the London

[6] Working papers referred to in this statement are available from the COMEAP website: https://www.gov.uk/government/groups/committee-on-the-medical-effects-of-air-pollutants-comeap

[7] A.Seaton, J. Cherrie, M.Dennekamp, K. Donaldson, J.F. Hurley, C.L. Tran (2005). The London Underground: dust and hazard to health. Occup. Environ. Med., **62**(6): 355-362

[8] $PM_{2.5}$ includes particles that have an aerodynamic diameter less than or equal to 2.5 µm

[9] J.D. Smith, B. Saunders, D. C. Green, M. Priestman, A. H. Tremper, I. Mudway, G. W. Fuller, E. Nicolosi, T. Smith and B. M. Barratt (2018). Public health risks from respirable particles on the 'London Underground' metro network; should we be concerned? (In Press)

[10] https://uk-air.defra.gov.uk/

[11] Subway, also called underground, tube, or metro, is used to describe an underground rail network used for public, mass rapid transit. Note that some of the track in an underground system may be above ground, as in London Underground

Underground. The higher PM concentrations measured in the London Underground are likely due to the system's age (it is the world's oldest subway system) and the fact that large parts of the network are in deep, poorly ventilated tunnels. However, monitoring results are not always directly comparable because of differences in the measurement techniques used. In studies in which optical particle counters were used to infer PM mass, it was not always clear whether a conversion factor[12] was used to account for the difference between ambient particle density and the higher density of particles found in subway systems due to the high metallic content. This makes comparison of results difficult. Similarly, where a size distribution is based on optical or electrical mobility diameter, it should be converted to aerodynamic diameter to allow comparison with ambient particles.

15 Measurements across the London Underground (Smith et al., 2018) have shown that $PM_{2.5}$ concentrations are generally highest at stations of deep tube lines and at stations furthest from sections of above-ground track[13]. The latest measurements report average $PM_{2.5}$ mass concentrations of 250 µg/m^3 on the Northern line, one of the deep tube lines (unpublished data from King's College London).

16 Routine monitoring in the London Underground by TfL over many years has shown that concentrations of total inhalable and respirable dust (8 hour time-weighted averages) to which train operators and station staff are exposed are all >4-fold lower than workplace exposure limits of 4 mg/m^3 (respirable dust, time-weighted average over 8 hours) published by the Health and Safety Executive (HSE)[14].

17 An expanded cleaning regime was introduced by TfL in 2017, with increased cleaning of the London Underground network's tunnels and stations. Over the summer, 46 stations and five tunnel sections were cleaned with industrial vacuums and "magnetic wands". Cleaning whole tunnel sections was found to be more effective at reducing respirable dust concentrations (44% reduction) on station platforms than cleaning only stations and platform approach tunnels (8% reduction). However, it is currently unknown if, and how quickly, dust concentrations return toward baseline levels after cessation of the cleaning. Based on the outcome of this cleaning and preliminary recommendations and input from the COMEAP Sub-group, TfL are currently cleaning one London Underground line (including walls and subway tunnels) and taking PM measurements before, during and following the clean to understand the short- and medium-term impacts of this cleaning regime on the concentrations of tunnel dust.

18 The sources of $PM_{2.5}$ in subway systems are very different from the sources of ambient $PM_{2.5}$. Ambient concentrations in the UK typically consist of up to 50% from secondary aerosol formed by chemical reactions in the atmosphere (from gaseous precursors, such as nitrogen oxides (NOx) or sulphur dioxide (SO_2) and ammonia (NH_3)), one third from primary emission sources, including combustion emissions, with the remainder consisting of sea salt and mineral dusts[15].

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[12] For example, Smith et al. (2018) used a conversion factor of 2 to obtain $PM_{2.5}$ mass concentrations in the London Underground
[13] See Figure 4 in Working Paper 2
[14] See Appendix 1 of Working Paper 3
[15] See Table 3 in Working Paper 3

19 The sources of $PM_{2.5}$ in the London Underground include a contribution from ambient air drawn into the system through tunnel and station entrances. The elevated concentrations are caused by additional sources within the network, principally the mechanical wear of train components, including wheels, current collector shoes and brake blocks, and non-rolling stock sources, including rail wear, biological particles and textile fibres associated with passengers. These are emitted as primary sources and then re-suspended by the train movements. Borgese (2018, personal communication, 26th January 2018) has estimated that wheel and collector shoe sources contribute about half of the emissions associated with train movements, with brake blocks and rail wear each contributing about a quarter[16].

20 Smith et al. (2018) have reported a comparison of the measured particle mass and particle number concentrations in the London Underground with ambient particle measurements for central London. $PM_{2.5}$ mass concentration on the Jubilee Line (302 µg/m^3) was approximately 16 and 11 times higher than $PM_{2.5}$ filter samples taken at a roadside environment (26 µg/m^3) and urban background (18 µg/m^3) site in London, respectively. Particle number concentrations were lower (15,070 particles per cm^3) than at the roadside (26,810 particles per cm^3) but higher than the ambient background (6,521 particles per cm^3)[17].

21 Smith et al. (2018) collected $PM_{2.5}$ filter samples every 4 hours over a period of 48 hours at Hampstead underground station in November 2015. Subsequent laboratory analysis quantified the chemical composition as 47% iron oxide, 14% other metallic and mineral oxides, 11% organic carbon, and 7% elemental carbon. 21% of the mass remained unidentified by comparison to the direct mass measurement and this was likely made up of silicates[18]. Seaton et al. (2005) reported 67% iron oxide at the same location. The large contribution from Fe oxide in the London Underground is consistent with a similar study of subway air undertaken in Barcelona by Querol et al. (2012)[19]. The bulk chemical composition of $PM_{2.5}$ measured underground is clearly very different to that measured in ambient air, with a much greater contribution from iron, principally in the form of iron oxide, and a much smaller relative contribution from secondary aerosols.

22 While this statement focuses on PM, a small number of studies have measured gaseous pollutants in subway air. The results show that for gaseous pollutants such as nitrogen dioxide (NO_2) and volatile organic compounds (VOCs), concentrations in subway systems are typically similar to those in the outdoor air. None of these studies, however, have been conducted in the London Underground. We would not expect, particularly for the deep tube lines, combustion-related sources to be a major contributor to the pollutant concentrations in subway systems.

Evidence on health effects of subway PM

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[16] See Figure 2 in Working Paper 2
[17] See Figure 6 in Working Paper 2
[18] See Figure 7 in Working Paper 2
[19] X. Querol, T. Moreno, A. Karanasiou, C. Reche, A. Alastuey, M. Viana, O. Font, J. Gil, E. de Miguel and M. Capdevila (2012). Variability of levels and composition of PM_{10} and $PM_{2.5}$ in the Barcelona metro system. Atmospheric Chemistry and Physics **12**(11): 5055-5076.

23 A review of the experimental studies (human, animal and cellular) conducted to assess the effects of exposure to airborne particulates in subway systems and adverse effects is given below. Further details of the individual studies are reported in Working Papers 1 and 4.

24 Four studies have assessed the health effects in humans from exposure to a subway environment using a quasi-experimental design, mainly in young volunteers (healthy individuals or patients with mild asthma). None of these studies have been conducted on the London Underground and all have examined effects following relatively short exposure periods (as short as 2 hours) in sample sizes ranging from 16 to 120. Three out of the four studies report research that has been conducted in the Stockholm subway system. The chemical composition of PM in this subway is similar to that in the London Underground, but the concentrations are 2-3 fold lower. The fourth study was conducted in Taipei, where the underground PM concentration is also lower than those in the London Underground. As such, it is not clear how applicable the results from these studies are to exposures in the London Underground.

25 Markers of cardiovascular (eg heart rate variability (HRV)), respiratory (eg lung function) and/or immune system (eg lipid mediators) health have been investigated, with little overlap in the measures used among the four studies. Some studies have indicated that short-term exposure to underground PM may cause small changes in markers of inflammation and HRV; but whether these small changes have short- or long-term clinical significance remains unclear. Moreover, the heterogeneous mix of outcomes studied, combined with the inter-individual variability across studies and paucity of work on the subject, has made it difficult to draw clear conclusions, especially regarding anything other than acute one-off exposures.

26 We also considered studies on the health effects of occupational exposure to underground PM. Health data on occupationally exposed workers can provide some insight into the nature of toxicity or lack of toxicity in the general population but are of limited use because of an innate bias called the “healthy worker effect”[20]. Six studies have examined potential subway-worker health risks from exposure to a subway environment. None of the studies were conducted in the UK; 4 out of the 6 studies took place in Stockholm. Most studies showed no or minor effects of exposure on markers of inflammation and cardiovascular disease (CVD) and no effect on the incidence of lung cancer. Drawing clear evidence-based conclusions regarding short- and long-term health effects from these studies is problematic owing to the small number and the lack of power (most used small sample sizes). The use of different study designs and outcome measures (cardiovascular, respiratory and cancer outcomes) also makes it difficult to compare results across studies.

27 Similar to the human studies, the data from animal studies is too sparse to draw any conclusions regarding the toxicity of subway PM in animal models. In contrast, the evidence on *in vitro* biological effects of subway PM is more extensive. One of the most consistent findings is that exposure to particles from subway

[20] R. Chowdhury, D. Shah, A. R. Payal (2017). Healthy worker effect phenomenon: revisited with emphasis on statistical methods – a review. J. Occup. Environ. Med., **21**(1):2-8

systems, including the London Underground, can induce inflammatory responses and oxidative stress in cultured human lung cells. However, these cell exposure studies *in vitro* have tended to use somewhat higher exposures of PM than are likely to occur in the airways based on airborne PM concentrations in subway systems and the total airway surface area, possibly around two orders of magnitude higher (Jimenez et al., 2000)[21]. Nonetheless, airway PM deposition is not uniform, and there is evidence that PM deposition may be greatly increased at airway bifurcation points and areas of altered lung geometry and anatomy (which may be a result of disease), as well as with ventilation increases during exercise (Phalen et al., 2006)[22]. Therefore, it is possible that localised areas of the airways could be exposed to PM at concentrations not dissimilar to those which show effects in *in vitro* studies. Several *in vitro* studies have repeatedly shown that transition metal ions, such as iron, copper, nickel and others, exhibit the ability to generate oxidative stress (an imbalance in the cell's ability to control highly reactive forms of oxygen), and that metals in lower oxidation states stimulate greater oxidative stress. However, the airways generally present a somewhat reducing environment, and so the oxidation state of the metal inhaled may change upon contact with lung lining fluid.

28 Subway particles are known to be enriched in iron, principally in the form of iron oxide. An important question is whether the iron component of underground PM, which represents a major fraction of total mass, is responsible for the observed toxicity. Although some *in vitro* studies showed iron chelation to be capable of suppressing, at least partially, the toxicity associated with underground PM, other studies have indicated that PM-induced reactive oxygen species generation is better correlated with non-ferrous elements, such as copper and barium[23]. Furthermore, it has been demonstrated that PM from the Stockholm subway has greater genotoxic and oxidative stress potential than pure iron oxide particles (such as haematite and magnetite). These observations suggest that there may be other important components, perhaps "working" synergistically with iron-containing species. It may also be that it is not simply the elemental composition of the metals which is important, but its bioavailability, determined by water solubility. The proportion of the insoluble fraction is generally higher in underground systems compared to ambient PM and, at least in terms of acute effects, this may reduce the relative toxicity.

29 Where studies have directly compared the effects of underground PM to particles from other modes of transportation, there is evidence that, in human lung cells, underground PM exhibits more potent inflammatory effects than tyre and road wear particles and negative control particles (eg carbon black and titanium dioxide). However, there is generally, but not always, a higher pro-inflammatory potential of ambient particles collected in urban settings compared to those collected underground. One reason for this may be the presence of the higher concentrations of endotoxin (ipopolysaccharide) in urban PM[24] . It is also possible that the greater

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[21] L. A. Jiménez, J.Thompson, D. A. Brown, I. Rahman, F. Antonicelli, R. Duffin, E. M. Drost, R.T. Hay, K. Donaldson, W. MacNee (2000). Activation of NF-kappaB by PM(10) occurs via an iron-mediated mechanism in the absence of IkappaB degradation. Toxicol Appl Pharmacol., 166(2):101-10
[22] R. F. Phalen, M. J. Oldham, A. E. Nel (2006). Tracheobronchial particle dose considerations for in vitro toxicology studies. Toxicol Sci., **92**(1):126-32
[23] See Working Paper 4 for details of individual studies
[24] Endotoxins are cell membrane components of Gram-negative bacteria and released from lysed bacterial cells

particle number concentration of urban PM compared with underground PM plays a role in this effect. In contrast to the inflammatory response, subway particles have generally been reported to induce greater oxidative stress than an equal mass of urban airborne particles.

Exposure in the London Underground

30 We used information on the amount of time spent in the London Underground to estimate the extent of exposure to underground PM. The London Travel Demand Survey (LTDS) is a continuous survey of households in the Greater London area (covering the 33 London boroughs including the City of London). Around 8,000 households take part in the LTDS each year, with every member of the household (aged over 5 years old) providing information on trips taken in a 24-hour period. Using data from the LTDS 2005-2010 (45,079 people) the average time spent underground by users of the London Underground aged 30-59 years was 60 minutes per day (sum of platform wait time, time spent in carriage and time moving between platforms) [25]. Although this accounts for only a small proportion of time per day (4%), we estimate that a 1-hour exposure during to $PM_{2.5}$ in the London Underground is equivalent to a 24-hour exposure to ambient $PM_{2.5}$ (assuming $PM_{2.5}$ concentrations of 250 µg/m^3 in the London Underground and 13.6 µg/m^3 outdoors).

31 To compare the exposure of a commuter travelling by the London Underground or bus, we assumed that the same journey would take approximately 1-hour by underground and about 2.5-hours by bus (hypothetical scenario) and assumed a mean $PM_{2.5}$ concentration of 14.5 µg/m^3 whilst on the bus[26]. We estimated that exposure to (ambient/traffic-related) $PM_{2.5}$ whilst travelling by bus would be equivalent to approximately one third of the exposure to $PM_{2.5}$ that would have been experienced on the London Underground.

32 We also undertook sensitivity calculations, over a range of underground $PM_{2.5}$ concentrations from 94 to 300 µg/m^3. Details of the methods and results are included in Working Paper 5.

33 This is not unique in being an indoor environment with elevated concentrations of $PM_{2.5}$. Individuals will also be exposed to high concentrations of $PM_{2.5}$ in their home, such as during cooking. In indoor microenvironments, average $PM_{2.5}$ concentrations can be appreciably higher than those in the outdoor air because of indoor sources; model simulations of $PM_{2.5}$ concentrations in London dwellings showed that in non-smoking households the average person indoors is exposed to annual average concentrations of 28.4 µg/m^3 (over twice the outdoor concentrations), and that most of the PM from indoor sources is from cooking-related activities (peak concentrations around 400 µg/m^3 in houses with gas cooking)[27].

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[25] See https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/consultations-and-surveys/london-travel-demand-survey and Table 1 in Working Paper 5.

[26] D. Smith, C. Mitsakou, N. Kitwiroon, B. Barratt, H. Walton, J. Taylor, H.R. Anderson, F. Kelly, S. Beevers (2016). London Hybrid Exposure Model: improving human exposure estimates to NO_2 and $PM_{2.5}$ in an urban setting. Env Sci Technol.

[27] C. Shrubsole, R. Ridley, P. Biddulph, J. Milner, S. Vardoulakis, M. Ucci, P. Wilkinson, Z. Chalabi (2012). Indoor $PM_{2.5}$ exposure in London's domestic stock: modelling current and future exposures following energy efficient refurbishment. Atmos. Environ., **52**:335-343

$PM_{2.5}$ from indoor sources will also be of different composition and particle size distribution from ambient $PM_{2.5}$.

Susceptibility of the exposed population in the London Underground

34 The data provided by TfL from its LTDS for the period 2015-16 suggest that the age distribution for customers of the London Underground is broadly similar to that of a working population, and is not representative of the general population. For the period 2015-2016, 68% of those travelling on the London Underground one or more days each week were between the ages of 25 and 59 years; less than 7% were either under 16 or over 65 years of age[28]. Therefore, it seems probable that those more susceptible to the effects of air pollution, namely children and elderly persons, are markedly under-represented among regular uses of the Underground. Moreover, whilst no data are available, it is also likely that individuals with serious medical conditions are under-represented relative to their numbers in the general population.

Individual chemical components

35 Metal concentrations in PM were available from measurements performed in one station on the London Underground[29]. Smith et al. (2018) collected $PM_{2.5}$ filter samples from Hampstead underground station in November 2015, the deepest station below street level on the London Underground (58.5 m). It is therefore likely that PM from Hampstead station represents a relatively "pure" underground PM, with little contribution from outside sources. Of the metals measured, we considered several to be potentially relevant to health: chromium, copper, iron, manganese, nickel, vanadium, arsenic, cadmium, cobalt and zinc. We drew on published health-based assessments (eg workplace exposure limits (WELs), World Health Organization (WHO) Air Quality Guidelines, EU Target Values, recommendations from the Expert Panel on Air Quality Standards (EPAQS) etc.) in order to assess whether the reported concentrations of these metals in the London Underground samples were of public health concern.

36 Metal concentrations in the $PM_{2.5}$ samples collected from Hampstead underground station were all several orders of magnitude below the current UK Health and Safety Executive WELs[30]. For comparison with concentrations in air that are considered tolerable for the general public, we made a number of adjustments to the measured concentrations. First, we needed to account for the fact that the measurements in the London Underground were of concentrations in the $PM_{2.5}$ fraction, while many of the health-based recommendations are for metal concentrations in the PM_{10}[31] fraction. The mean daytime (8 am to 8 pm) measured London Underground $PM_{2.5}$ were therefore converted to concentrations in the PM_{10} fraction using an approximate conversion factor of 2 (based on a study by Gustafsson et al. (2006) that found the $PM_{2.5}$ proportion in the Stockholm

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[28] Personal correspondence from TfL, 24th October 2017
[29] See Table 2 in Working Paper 2
[30] http://www.hse.gov.uk/pubns/books/eh40.htm
[31] PM_{10} includes particles that have an aerodynamic diameter less than or equal to 10 µm

underground railway to be approximately 50% of PM_{10})[32]. After this conversion, we also needed to take into account that health-based guidance values for the general population are derived to be protective over continuous lifetime exposure, while users of the London Underground would only be exposed for a short time, during their journey (eg 1 hour per day). To do this, exposure to subway PM_{10} concentrations for 1 hour per day was converted into a 24-hour time-weighted exposure. For details, see Table 1 in Working Paper 6.

37 We concluded that levels of copper, vanadium, cadmium, cobalt and zinc were not of toxicological concern for the general population. We also concluded that arsenic, iron, manganese and nickel were unlikely to be of toxicological concern for the general population. However, given the uncertainties and the range of sampling and analysis, we felt that more data are needed to obtain better estimates of any potential risk that these metals pose to public health. Adjusted total chromium concentrations (using the assumptions set out above) were much higher than the available guidance value, which is for hexavalent chromium, the most toxic form of the element. They were also much higher than the concentrations of total chromium in ambient air. Again, we concluded that there is insufficient information on total chromium levels and the form of chromium present in underground air to estimate the potential risk from this metal, though we note that very little of the total chromium concentration would need to be in the form of hexavalent chromium to pose a potential risk to health. It will be important that future measurements confirm both the concentrations and oxidation state of chromium present in underground air.

38 Long-term occupational exposure to high levels of respirable crystalline silica can cause silicosis and lung cancer. Crystalline silica levels in the London Underground are routinely measured by TfL. All samples taken in the last 10 years, except one, which was still well below the workplace exposure limit, were below the limit of detection (0.01 mg/m^3). Hence, we do not consider crystalline silica exposure concentrations in the Underground likely to pose a risk to public health.

Other potentially relevant comparators

39 Given that iron is the major component of PM in the London Underground, we considered the risks of other settings in which specific emissions are likely to result in exposure to iron-rich PM, namely the iron and steel industry (eg welders, iron foundry and steel workers). There was also some discussion of this topic at the COMEAP meeting in November 2017. Points raised during the meeting are captured in the minutes of the meeting.

40 Several epidemiological and experimental studies have reported adverse health effects from occupational exposures to iron dust or fumes. The most commonly reported adverse effects include acute and chronic inflammation of the respiratory tract and pneumonia. Occupational exposure during iron and steel founding has been classified by the International Agency for Research on Cancer (IARC) as carcinogenic to humans, but there was insufficient evidence to conclude

[32] This factor is numerically consistent with the method used by WHO to convert guidelines in ambient air for PM_{10} to $PM_{2.5}$ by application of a $PM_{10}/PM_{2.5}$ ratio of 0.5 (WHO Air Quality Guideline 2005)

carcinogenic potential in animals or humans for iron oxides. However, respirable dust levels and iron levels in the London Underground are well below current long-term (8 h time weighted average (TWA)) and short-term (15 min reference period) WELs[33].

41 Studies have also linked the reductions in PM_{10} to improvements in several population health outcomes during the temporary closure of the Utah valley steel mill that took place between August 1986 and September 1987. However, it is unclear from these studies whether this was due to decreases in iron-rich or combustion-related emissions, as both would have been expected. Nonetheless, a number of subsequent studies have shown that metals appeared to be the major cause of the toxicity of Utah PM, manifesting as lung injury and neutrophilic inflammation with increased rates of airway hyperresponsiveness in rats exposed to PM collected when the steel mill was operational (Dye et al, 2001)[34]. Importantly, effects on cell injury and intracellular signalling *in vitro* caused by Utah steel mill PM could be recreated by treating cells with simple mixtures of the most common metals in the PM samples (Pagan et al, 2012)[35]. However, no clear picture has emerged as to which metal is most likely to be particularly relevant to health or if interactions between metals play a role. Indeed, Pagan et al. (2012) suggest that it is the combination of metals, rather than their individual presence, which is of critical importance in determining outcome.

42 In addition, relevance to the London Underground is not clear as, across the studies reviewed, iron appeared to account for a smaller proportion of the total PM mass (eg <0.1%) than in subway PM. We also note that the consequences of inhaling iron may differ according to its chemical form (eg metallic, oxide, chloride) or oxidation state.

Interpretation of epidemiological studies on ambient PM

43 As explained in paragraph 3, the lack of available studies assessing the human health effects of exposure to underground particles, and the differences between underground PM and that found in ambient air, mean that it is not possible to determine the nature and extent of any health risk to those travelling on the London Underground. We had some discussion about the personal exposure to all sources of particles, personal exposure to particular sources of particles, ambient particulate concentrations, particulate concentrations in the underground and the relationships between these parameters. We considered going into this in detail but concluded that the simplest summary was that while personal exposure studies tell us that particles from sources other than outdoor air affect our overall personal exposure, this is not reflected in the results of the time series and cohort studies, which are influenced predominantly by exposures to outdoor air (including that which infiltrates into the indoor environment). Further carefully designed research is

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[33] See Table 1 in Working Paper 3 and Appendix 1 of Working Paper 3

[34] J. A. Dye, J. R. Lehmann, J. K. McGee, D. W. Winsett, A. D. Ledbetter, J. I. Everitt, A. J. Ghio, D. L. Costa (2001). Acute pulmonary toxicity of particulate matter filter extracts in rats: coherence with epidemiology studies in Utah Valley resident. Environ Health Perspect., **101**(3):395-403.

[35] I. Pagan, D. L. Costa, J. K. McGee, J. H. Richards, J. A. Dye (2012). Metals mimic airway epithelial injury induced by in vitro exposure to Utah Valley ambient particulate matter extracts. J Toxicol Environ Health A., **66**(12):1087-112.

needed to quantify the effects of exposures to sources such as cooking aerosol and subway tunnel particles.

44 For effects associated with long-term exposure, the extent of the contribution to the overall effect estimate of effects arising from short-term exposure to peaks of high concentrations is unclear. This may have important implications in the application of ambient PM coefficients to underground settings. During the time spent in the underground, individuals are exposed to PM mass concentrations substantially higher than to annual ambient concentrations. It has been suggested that the relationship between ambient $PM_{2.5}$ exposure and health outcomes may be linear in the lower exposure portion of the relationship, followed by a flattening out at higher exposures, suggesting relatively lower effects of incremental exposure increases at higher exposures (Burnett et al., 2014) [36]. This might suggest that the coefficient usually used for quantifying mortality associated with $PM_{2.5}$ concentrations (COMEAP, 2009)[37] is not appropriate at the concentrations experienced in the London Underground.

45 The subway is also a unique environment in terms of the composition and sources of PM and it is not clear whether subway PM is more or less toxic than outdoor PM. This raises questions about the validity of extrapolating epidemiological results from ambient air to underground settings.

46 There has been interest in quantifying the health effects of ambient pollution on the basis of reported associations with black carbon (BC), a component of the $PM_{2.5}$ arising from combustion sources such as diesel engines. In outdoor air, BC is likely to act both as a carrier of toxic products of combustion, and as a marker of exposure to a mixture of pollutants arising from combustion. When used in the London Underground, optical measurement techniques (eg use of Aethalometer) produce mass concentration of BC results which are not comparable with those of ambient air, due to the different optical properties of the London Underground particles. In the underground subway microenvironment, the sources of light-absorbing particles are very different (carbon and oxidised metallic wear products) and the measurements from these techniques should therefore be interpreted with caution, as the concentrations reported and the composition of the particles measured are not comparable to those for outdoor air. In addition, because it arises from different sources underground, in subways BC does not act as a marker of the same pollutants as it does above ground.

Overview of the sources, nature and impact of the individual uncertainties on using the coefficient of ambient $PM_{2.5}$ concentration to estimate risk associated with exposure to $PM_{2.5}$ in the London Underground

[36] R.T. Burnett, A. Pope, M. Ezzati, C. Olives, S. S. Lim, S. Mehta, H. H. Shin, G. Shing, B. Habbell, Hubbell, M. Brauer, R. Anderson, K. R. Smith, J. R. Balmes, N. G. Bruce, H. Kan, F. Laden, A. Prüss-Ustün, M C. Turner, S. M. Gapstur, R. Diver, A. Cohen (2014). An integrated risk function for estimating the global burden of disease attributable to ambient fine particulate matter. Environ Health Perspect **122**: 397-403.

[37] COMEAP 2009 Long-term exposure to air pollution: effect on mortality. Committee on the Medical Effects of Air Pollutants. https://www.gov.uk/government/publications/comeap-long-term-exposure-to-air-pollution-effect-on-mortality

47 The Committee agreed that it was important to understand the uncertainties associated with using a summary coefficient from cohort studies of mortality associated with ambient $PM_{2.5}$ to estimate potential mortality effects of exposure to $PM_{2.5}$ in the London Underground. Table 1 provides a description of multiple lines of evidence and assesses their potential impact (eg leading to an underestimate, overestimate, or unknown) on the appropriateness of using coefficients linking ambient $PM_{2.5}$ concentrations with health effects to estimate risk associated with exposure to $PM_{2.5}$ in the London Underground. Symbols (plus or minus) indicate whether the lines of evidence suggest that using the coefficient would be likely to over- or underestimate any risk. In coming to these views, the Committee has taken into consideration how much time people spend in the London Underground, and how this relates to annual exposures. Limited data were available; so it was not possible to provide a quantitative measure of uncertainty.

Table 1: Characterisation of the uncertainties if a summary coefficient from cohort studies of mortality associated with ambient $PM_{2.5}$ was used to estimate potential mortality effects of exposure to $PM_{2.5}$ in the London Underground*

Lines of evidence considered	Would using $PM_{2.5}$ mortality risk coefficients of ambient origin over- or underestimate the mortality risk per 10 µg/m^3 increase in subway $PM_{2.5}$
Physical and chemical properties	
Distribution of particle number concentration: Particle number size distribution and total particle number concentration of subway particles are typically dominated by larger particles than those of PM above ground. The general consensus is that smaller particles may be more harmful to health than larger particles per unit mass, and therefore applying the coefficient for ambient air is likely to overestimate risk	**+**
Chemical composition: Metals comprise a much larger component of subway PM than ambient PM. In particular, underground particles are rich in iron (principally in the form of iron oxide) and other metals such as arsenic, manganese, nickel and chromium. Subway PM may be less rich in some other health-relevant components present in ambient and combustion-related PM. Although it might be expected that some components are more harmful than others to health, the evidence available does not give a consistent view of their relative toxicity.	**Unknown**
Water solubility of metals in PM: The toxicity of metals in PM has been linked to their water solubility. Risk would likely be overestimated since the proportion of the insoluble fraction is generally higher in PM from underground systems than in ambient PM and, at least in terms of acute effects, may reduce the relative toxicity.	**+**
Studies on the effects of subway PM on human health	
Occupational studies: There is very little information on the potential health effects following inhalation exposure to underground particles from studies in workers, and results are difficult to interpret as studies have used a variety of different outcome measures for assessing health effects.	**Unknown**

Human volunteer studies: There is very little information on the potential health effects following inhalation exposure to underground particles from studies in humans and none in London; and generally, the available studies were of short-term exposure to underground PM in relatively small numbers of human subjects.	**Unknown**
Mechanistic particle toxicology both *in vitro* and *in vivo* **Oxidative stress:** In general, studies that have directly compared PM collected from different locations have indicated greater PM oxidative stress potential from samples collected at underground subway stations than at urban locations. Therefore, applying the coefficient of ambient air is likely to underestimate risk. **Inflammation:** In general, studies that have directly compared PM collected from different locations, have demonstrated lower PM inflammatory potential from samples collected at underground subway stations than at urban locations. Therefore, applying the coefficient of ambient air is likely to overestimate risk.	**-** **+**
Interpretation of epidemiological studies on ambient PM **Relationship between measured concentration and overall exposure:** While personal exposure studies tell us that particles from sources other than outdoor air affect our overall personal exposure, this is not reflected in the results of the time series and cohort studies, which are influenced predominantly by exposures to outdoor air (including that which infiltrates into the indoor environment). Further carefully designed research is needed to quantify the effects of exposures to sources such as subway tunnel particles. **Long-term versus short-term contributions:** For effects associated with long-term exposure, the extent of the contribution of effects arising from short-term exposure to peaks of high concentrations to the overall effect estimate is unclear. This may have important implications in the application of ambient PM coefficients to underground settings.	**Unknown** **Unknown**

* in coming to these views, the Committee has taken into consideration how much time people spend in the London Underground, and how this relates to annual exposures.

Key: + = overestimate the risk; - = underestimate the risk

Conclusions

48 We have examined various strands of evidence regarding possible effects on health arising from exposure to PM, both in underground transport systems and in other environments. None of this evidence is directly transferable to assessing the health risks to the travelling public from exposure to PM in the London Underground.

Few studies have examined the potential effects of inhalation exposure to underground PM on human health, and none of these have been conducted on the London Underground. The majority (3 out of 4 studies) have been performed in Stockholm, where the subway system is different to the underground system in London in terms of its design and air quality. Nonetheless, from our consideration of the available evidence we have reached the following conclusions for each of the questions set out in the terms of reference (Appendix B):

> *a. The relevance of results of epidemiological studies linking ambient air pollution with health outcomes in informing views on the likely health effects of exposure to PM and its components in the London Underground.*
>
> PM emission sources in the London Underground are different from those contributing PM to ambient air; the physical and chemical properties of the emitted particles are also different. It is likely that the adverse health effects of particles in ambient air are not related to particle mass concentrations alone, but which components are most toxic is not known. Nor is it known which sources emit the most toxic particles. While personal exposure studies tell us that particles from sources other than outdoor air affect our overall personal exposure, this is not reflected in the results of the time series and cohort studies, which are influenced predominantly by exposures to outdoor air (including that which infiltrates into the indoor environment). We therefore concluded that it is not appropriate to apply the coefficients from epidemiological studies based on ambient PM concentrations to concentrations measured in a subway microenvironment to quantify risk.
>
> *b. The relevance of results of any available studies of health effects of exposure (including occupational exposure) to particulate air pollution in other underground railway networks to informing the views on the health risks to the travelling public from exposures in the London Underground.*
>
> While knowledge of the sources, chemical composition and physical properties of subway PM has improved, very little new information on the health effects of inhalation exposure to underground PM has emerged from studies in humans. In general, the available studies are of short-term exposures to underground PM in relatively small numbers of human subjects. Some studies have indicated that such exposures may cause small changes in markers of inflammation and HRV; but whether these small changes have short- or long-term clinical significance remains unclear. Moreover, methodological variations, including different types of outcome measures, make comparison and synthesis of findings across studies difficult. There is, however growing evidence of effects of subway particles on oxidative stress and inflammatory responses *in vitro* but these

studies present many challenges in their interpretation and extrapolation to humans.

c. How useful is the available information on health effects of other occupational, environmental or experimental exposures to iron-rich particles in informing views on the health risks to the travelling public from exposures in the London Underground?

Health risks identified from exposure to iron-rich PM in other settings are not a good guide to predicting risks to the travelling public from exposure to underground PM. This is because the iron may be in a different form from that found in the underground (eg its oxidation state and/or combination with other elements), and may be associated with different types of emissions with differential toxicities.

d. A view on whether the latest evidence supports the reasoning and conclusions of the 2003 IOM report.

The 2003 IOM report concluded: "*We do not think that the travelling public is at any serious or substantial risk from travelling underground… However, the in vitro tests show that tunnel dust is not inert… We encourage management and unions in the Underground to continue to work together to find practicable ways of keeping dust levels low*."

Since 2003 there have been a number of studies examining the characteristics of inhalable particles from subway systems around the world, including the London Underground, and these indicate that the chemical composition of subway PM might be more complex than previously thought. Recent measurements suggest a smaller contribution of iron to the overall mass of PM in subway environments with substantial contributions of organic and elemental carbon and the presence of other non-ferrous metals with potential biological effects. However, the majority of the new scientific evidence presented in the statement (eg susceptibility of the population exposed, and the nature and size distribution of the particles) supports the conclusions of the 2003 IOM report.

e. A view on the public health risk from exposure to particulate air pollutants in the London Underground, taking into account factors that may influence the health effects related to exposure.

The lack of available studies assessing the human health effects of exposure to underground particles, and the differences between underground PM and that found in ambient air, mean that it is not possible to determine the nature or extent of any health risk to those travelling on the London Underground. We cannot rule out the possibility that there is a health risk from exposure to underground PM. Given that there is strong evidence that both long- and short-term exposure to particle pollutants in ambient air are harmful to health, it is likely that there is some health risk associated with exposure to underground PM. With regards to toxicity of underground PM, the evidence is limited and there is no strong suggestion that underground PM is significantly different to ambient PM. Given the absence of any consistent evidence on the relative toxicity per unit mass exposure of underground

PM and that in ambient air, there is insufficient evidence to provide quantitative comment on the risk associated with inhalation of particles on the London Underground. We would encourage TfL to continue to find practicable ways of reducing PM levels on the Underground network.

It is important that the decision to travel above or below ground should not be influenced only by consideration of health risks from PM inhalation. PM concentrations are only one factor that should be considered when comparing the potential health impact of different transport modes. Although other modes of transport may mean exposure to lower PM concentrations, they may involve longer travel times. In addition, other modes of transport (eg car) may involve a reduction in the benefits to health conferred by physical exercise. Further, individuals are exposed to similarly high PM concentrations through activities such as cooking in their homes.

Recommendations

49 To improve risk assessment and to best advice on risk management a deeper and more comprehensive understanding is needed of: 1) the concentrations and properties of subway PM; 2) the exposed population (including age profile and health status) and the nature and level of exposure (individual and population); and 3) the health effects of exposure to subway PM.

Recommendations to TfL

50 Our recommendations to TfL are:

i. To enable London Underground PM to be included in wider toxicity studies at low cost, physiologically relevant fractions (eg PM_{10} and $PM_{2.5}$) should be collected and made available to researchers.

ii. To conduct additional measurements of metal concentrations (particularly chromium, arsenic, iron, manganese and nickel) in a number of locations and determine the speciation of chromium (levels of hexavalent chromium).

iii. To continue PM monitoring to allow better understanding of concentrations as well as factors affecting PM concentrations and exposure, including but not limited to, passenger numbers, ventilation, train piston effect and station design.

Research recommendations

51 Much work is still needed to understand the relationship between subway PM exposure and any health effects. To ensure that this is not still the position when we next review the topic, we have considered what further studies might reduce uncertainties in the understanding around subway PM and its effects on human health for those exposed while using the London Underground. Our research recommendations are outlined below and will require collaboration across disciplines, including epidemiology, toxicology and atmospheric chemistry:

i. Investigation of ways to increase the usefulness of employment health records of those working in the underground to assess potential adverse health effects of underground exposures.

ii. Well-conducted human exposure studies in volunteers, similar to the studies investigating the health effects of Oxford Street air pollution[38] and epidemiological studies, if power calculations suggest these could provide valuable additional understanding.

iii. Well-designed mechanistic studies (*in vivo* and *in vitro*) to better understand the relative toxicity of subway particle components and the molecular pathways involved.

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December 2018

[38] R.Sinharay, J. Gong, P. Ohman-Strickland, S. Ernst, F.J. Kelly, J.J. Zhang, P. Collins, P. Cullinan, K.F. Chung (2018). Respiratory and cardiovascular responses to walking down a traffic-polluted road compared with walking in a traffic-free area in participants aged 60 years and older with chronic lung or heart disease and age-matched healthy controls: a randomised, crossover study. Lancet **339**: 339-349.

COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

STATEMENT ON THE EVIDENCE FOR THE HEALTH EFFECTS ASSOCIATED WITH EXPOSURE TO DUST PARTICLES IN THE LONDON UNDERGROUND

APPENDIX A

COMEAP's 1998 statement: Dust on the London Underground

1 COMEAP has examined the report of a study of dust concentrations on the London Underground undertaken by Professor Nick Priest and colleagues of Middlesex University. The authors found that peak levels of dust, measured as PM_{10}, were high and argued that people using the Underground might acquire a large proportion of their daily exposure to particles whilst travelling by this means. The authors also suggested that, extrapolating from the findings of epidemiological studies relating daily average concentrations of PM_{10} to effects on health, such exposure might have significant adverse health effects.

2 Members were also provided with a study on the toxicological properties of dust from the London Underground undertaken by the Institute of Occupational Medicine (Edinburgh) between 1991 and 1993. This study showed that a large proportion of the dust was made up of quartz but that this was of comparatively low toxicity. It was suggested that the high iron content of the dust reduced the inherent toxicity of the quartz.

3 Members concluded:

a) that the study reported by Professor Priest and colleagues had been done well, though there were concerns about the technical details of how the dust levels had been monitored and the lack of controls using other forms of transport in London.

b) that the concentrations of dust were indisputably high but it was recognised that this was not unexpected and had been known for some time.

c) that using published epidemiological studies to predict the effects of exposure to dust on the Underground on health was unwise in that:

i) the epidemiological studies quoted dealt with 24 hour average and not peak concentrations;
ii) the epidemiological studies dealt with the effects of the general ambient aerosol which was different in terms of chemical composition and, possibly, in terms of particle size distribution from that found in the Underground;
iii) those people likely to be most at risk from effects of exposure to particles, for example the elderly suffering from chronic cardio-respiratory disease, were not likely to use the Underground to the same extent as younger and healthier people. This view was supported by an analysis of the age

distribution of Underground passengers provided by London Underground.

f) that the risk posed to health by the quartz content of Underground dust was likely to be low.

g) that there was a case for more work to be done on the composition and particle-size distribution of Underground dust.

h) that there was a case for an epidemiological study of the effects on health of exposure to Underground dust.

4 It was agreed that these conclusions and recommendations should be made available to London Underground.

COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

STATEMENT ON THE EVIDENCE FOR THE HEALTH EFFECTS ASSOCIATED WITH EXPOSURE TO PARTICULATE MATTER IN THE LONDON UNDERGROUND

APPENDIX B

DRAFT Terms of reference for the COMEAP Sub-group on the health effects associated with exposure to dust particles in the London Underground

Background

1. COMEAP last reviewed the evidence on the health risks associated with exposure to dust particles in the London Underground in 1998 and 2003.

2. Recently, the Head of Occupational Health, Transport for London (TfL; Dr Olivia Carlton) has asked for the Committee to review whether the currently available evidence supports its earlier statement.

Proposed terms of reference and questions to be addressed

3. Members' views will be invited upon:

I. The relevance of results of epidemiological studies linking ambient air pollution with health outcomes in informing views on the likely health effects of exposure to particulate matter (PM) and its components (for example, black carbon (BC) and elemental carbon (EC)) in the London Underground.

II. The relevance of results of any available studies of health effects of exposure (including occupational exposure) to particulate air pollution in other underground railway networks to informing views on the health risks to the travelling public from exposures in the London Underground

III. How useful is the available information on health effects of other occupational, environmental or experimental exposures to iron-rich particles in informing views on the health risks to the travelling public from exposures in the London Underground?

IV. A view on whether the latest evidence supports the reasoning and conclusions of the 2003 IOM report.

V. A view on the public health risk from exposure to particulate air pollutants in the London Underground, taking into account factors that may influence the health effects related to exposure (including composition, concentration, exposure duration/frequency and vulnerability).

VI. To identify knowledge gaps and advise as to whether further research is required.

Scope of the work

4. It is suggested that the Committee's considerations are largely based on a literature review to be commissioned by TfL. The COMEAP Sub-group (see below) will be fully involved at all stages of the commissioning review process, including developing the scope of the work and details of the literature search (for example, search terms and criteria for inclusion and exclusion) as well as monitoring progress and providing a steer if there are decision points for the researcher during the review.

5. It is also anticipated that the results of a study undertaken by King's College London on concentrations of pollution on the London Underground will be available to the Sub-group.

6. The Committee may make a request to TfL for further information (for example, more measurement data) if it would make an important difference to the Committee's ability to reach an informed opinion.

Resources

7. It is proposed that a COMEAP Sub-group be formed. This will largely comprise current COMEAP Members, but additional Members may be co-opted for particular expertise if the Committee considers it necessary.

8. COMEAP Secretariat support will be led by Dr Sarah Robertson, with support from Ms. Alison Gowers.

Timescales

9. The COMEAP Sub-group on the health effects of exposure to airborne PM in the London Underground will be established during June 2017. Regular follow-up meetings of the group will be organised (the frequency of meeting will be decided at the first Sub-group meeting).

10. The Sub-group should aim to bring an initial view on the evidence, and a draft of the statement, for discussion at the COMEAP meeting in November 2017 or February 2018. The exact project completion date is largely dependent on when the review is commissioned.

Proposed outputs

11. A COMEAP statement to advise Transport for London on points 3(I) – 3(VI) above.

COMEAP Secretariat
August 2017

COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

STATEMENT ON THE EVIDENCE FOR THE HEALTH EFFECTS ASSOCIATED WITH EXPOSURE TO DUST PARTICLES IN THE LONDON UNDERGROUND

APPENDIX C

Membership list of the COMEAP TfL sub-group on the health effects associated with exposure to dust particles in the London Underground

Chair	Dr Nicola Carslaw BSc MSc PhD
Members	Professor Alan Boobis OBE PhD CBiol FSB FBTS
	Professor Paul Cullinan MB MSc MD FRCP FFOM (co-opted)
	Dr David Green BSc MSc PhD (co-opted)
	Professor Deborah Jarvis MBBS MRCP MD FFPH
	Dr David Green BSc MSc PhD (co-opted)
	Dr Matthew Loxham BSc MSc PhD (co-opted)
	Mr John Stedman BA
Secretariat:	Dr Sarah Robertson BSc MSc PhD
	Ms Alison Gowers BSc MSc
	Dr Christina Mitsakou BSc MSc PhD

We would also like to acknowledge:

Dr Olivia Carlton (TfL)
Miss Kerry Foxall (PHE)
Dr Donna Morgans (TfL)
Mr Nick Wilson (TfL)