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Grenfell Investigation into Potential Land Contamination Impacts

Stage 1 Overarching Report

Royal Borough of Kensington and Chelsea

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		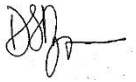	
Shehu Saleh and Simon Cole	Simon Cole	David Dyson	Liz Philp

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Prepared for:

Royal Borough of Kensington and Chelsea

Prepared by:

AECOM Infrastructure & Environment UK Limited
Sunley House
4 Bedford Park, Surrey
Croydon CRO 2AP
United Kingdom

T: +44 20 8639 3500
aecom.com

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Acronyms

ATSDR	US Agency for Toxic Substances and Disease Registry
BaP	Benzo-a-Pyrene
BFR	Brominated Fire Retardants
bgl	Below ground level
BGS	British Geological Survey
BS	British Standard
CLR11	Contaminated Land Report No. 11
COC/ COT	UK Department of Health Committees on Carcinogenicity and Toxicity
COPC	Chemicals of Potential Concern
Defra	Department for Environment, Food & Rural Affairs
EA	Environment Agency
EFSA	European Food Safety Authority
FSA	UK Food Standards Agency
GSMT	Grenfell Site Management Team
HSL	Health and Safety Laboratory
ISO	International Organization for Standardization
LBHF	London Borough of Hammersmith & Fulham
MAP	Multi-Agency Partnership
MHCLG	Ministry of Housing, Communities and Local Government
NAME	Numerical Atmospheric-Dispersion Modelling Environment
NBC	Normal Background Concentration
NMQS	National Quality Mark Scheme
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCE	Perchloroethylene (also called tetrachloroethene)
PCLs	Potential Contaminant Linkages
PM10	Particulate Matter (10 µm in diameter)
POSH	Possibility of Significant Harm
PRA	Preliminary risk assessment
PU	Polyurethane
QA	Quality Assurance
RBKC	Royal Borough of Kensington and Chelsea
SAG	Science Advisory Group
SQP	Suitably Qualified Person
SVFs	Synthetic Vitreous Fibres
SVOCs	Semi-Volatile Organic Compounds
TICs	Tentatively Identified Compounds
TN	Technical Notes
TPH	Total Petroleum Hydrocarbon
UKAS	United Kingdom Accreditation Service
USEPA	US Environmental Protection Agency
VOCs	Volatile Organic Compounds
WHO	World Health Organisation

Executive Summary

AECOM has undertaken Stage 1 of the soil investigation into potential land contamination caused by the Grenfell Tower fire. This investigation has been carried out under Part 2A of the Environmental Protection Act 1990, and in accordance with the statutory guidance for Part 2A. The objectives of the investigation were to collate relevant background information, carry out site reconnaissance, and undertake some exploratory soil sampling, with the purpose of informing a preliminary assessment of risk and the design of Stage 2 of the investigation.

Information regarding chemicals likely to have been released from the fire, as well as the possible background concentrations in soil before the fire, was gathered through a series of desk-based evidence reviews.

Consultations were held with the community to better understand where debris and smoke had fallen during and in the immediate aftermath of the fire, and where best to take the exploratory soil samples. These consultations included a site cordon reconnaissance visit in April 2019, two community events held in April 2019 and a site walkover of proposed exploratory sample locations (over two days) in May 2019.

Soil samples were collected from 21 areas within 1km of Grenfell Tower of soil, (including from within the cordon around the Tower). These areas were selected on the basis of a number of factors (described in **TN03**, and including community feedback, practical accessibility, smoke plume direction) and all were areas of open space (majority were grassed areas in residential estates and public parks). This included a small-scale pilot study implemented at Waynflete Square where more soil samples were taken than in the other areas, and the data from those samples assessed in more detail to support the design of Stage 2 along with the data from the exploratory samples. Whilst schools and private gardens have not been included in the Stage 1 sampling exercise, the selected sampling locations are considered to provide a good indication of the level of contamination that may be present in nearby residential gardens and schools in the context of the specific purpose of Stage 1.

The purpose of the exploratory sampling was to understand what contaminants might be present in soil, what sampling and analytical techniques were needed, and help identify whether contaminant linkages – a combination of a source (i.e. a contaminant in soil), a pathway (i.e. a mechanism by which exposure to that contaminant could occur), and a receptor (e.g. people or property) – could be present. The pilot study allowed more data to be collected from one area and the Part 2A risk assessment process to be progressed in more detail as an example of how it might be progressed at Stage 2 of the investigation.

The contaminants (or chemicals of potential concern (COPC)) tested for in soil samples fall in to seven groups; metals (for example lead), volatile organic compounds (VOCs) such as benzene, polycyclic aromatic hydrocarbons (PAHs), dioxins, furans and PCBs, cyanide and isocyanate, phosphate ester flame retardants, brominated flame retardants, and asbestos and synthetic vitreous fibres. The results of the laboratory analysis of the soil samples did not reveal obvious patterns in the spread or concentration of the chemicals assessed to suggest that they might have originated from the Grenfell Tower fire, rather than being from historic (pre-fire) land uses. Chemicals associated with flame retardants used in some household products and building materials (for example, sofas) were only rarely detected. Where they were detected, they were reported at concentrations that are several hundred to several thousand times lower than the relevant values for protection of human health. Other chemicals such as lead and polycyclic aromatic hydrocarbons (PAHs), were sometimes detected at elevated concentrations (i.e. above the screening values); however, these chemicals are commonplace in the urban environment and the levels detected are below the maximum concentrations observed during pre-fire local ground investigations and could also be within the normal background range expected for London. Low levels of asbestos and synthetic vitreous fibres were sporadically detected in some soil samples, with the identified presence considered to represent a low risk to health. It is not clear whether these substances originated from the fire or from other urban sources given their common use in buildings.

The contaminants have been grouped and ranked based on a methodology that has been developed for the preliminary risk assessment (PRA) that enables contaminant linkages to be prioritised on the basis of a number of evidence factors (such as whether the contaminant has been detected, whether its concentration exceeds health based screening criteria, or whether the concentration exceeds

typical background levels). The methodology is described in detail in **TN16** and is designed to be consistent with the Part 2A statutory requirement that investigation should only continue if there is a "reasonable possibility of a significant contaminant linkage" or that there is sufficient evidence to conclude whether the land meets the statutory definition of contaminated land.

This prioritisation process has identified human-health contaminant linkages associated with lead and PAHs as those that most warrant further investigation at Stage 2, as they represent reasonably possible significant contaminant linkages. Additional human-health contaminant linkages associated with asbestos and dioxins and furans were identified for further investigation on the basis of having relatively high uncertainty following the Stage 1 assessment, with the intention of improving the level of confidence in the characterisation of those linkages.

The assessment of risk to human health carried out in accordance with the statutory guidance for Part 2A for the pilot study area points to the land meeting the definition of Category 4 (i.e. the health risk posed by the identified levels of chemicals in the soil is "no, or low risk" (low as defined in the statutory guidance for Part 2A)).

The recommended design for Stage 2 incorporates recommendations that target single areas of land and investigate that land in a systematic way to assess the potential risks under Part 2A. Thirty-four (34) specific areas of land have been recommended in **TN18** based on the following selection criteria:

- Schools and community kitchen gardens located within 500m of the Tower in any direction.
- Schools and community kitchen gardens located up to 1,000m from the Tower in a north-westerly direction.
- Public open spaces to fill notable gaps in spatial coverage (once schools and community gardens have been identified) using the same distance criteria (i.e. 500m from Tower in any direction and up to 1,000m from the Tower in a north-westerly direction).
- Schools and other public areas predominantly identified based on requests for testing, or concerns about impacts, raised during community engagement prior to or during the Stage 1 assessment (reported in **TN14**).

It is recommended that testing includes soil and produce grown in community kitchen gardens and allotments for lead; PAHs; asbestos; and dioxins, furans and dioxin-like PCBs.

1. Introduction

This report presents a summary of the findings of Stage 1 of the Grenfell Investigation into Potential Land Contamination Impacts. AECOM was appointed in March 2019 to carry out this work on behalf of the Multi-Agency Partnership which was established by the UK Government to oversee and advise on the further environmental checks for the Grenfell site that were announced by the UK Government on the 26th October 2018. The investigation is taking a phased approach and comprises two stages:

Stage 1 – the collation of relevant background information to be able to design Stage 2.

Stage 2 – the main stage of investigation and assessment.

Further information on the programme for the environmental checks can be found online at https://www.gov.uk/guidance/soil-and-environmental-checks.

The investigation into potential land contamination impacts is being carried out under Part 2A of the Environmental Protection Act 1990 and the associated statutory guidance (Defra, 2012). This statutory guidance sets out specific requirements on how the investigation should be undertaken and how the results from that investigation should be interpreted.

The objective of Part 2A is to provide a means of dealing with unacceptable risks to human health and the environment posed by land contamination. Through the identification of land that poses an unacceptable risk, making that land suitable for use by removing that risk, and doing so in such a way that the burdens faced by individuals, companies and society as a whole are proportionate, manageable and compatible with the principles of sustainable development.

The primary focus of this investigation is on the risk to human health, and therefore the Part 2A definition of unacceptable risk to human health is of direct relevance. This definition is that "significant harm" is occurring, or there is "a significant possibility of significant harm". The statutory guidance for Part 2A additionally defines four categories of land:

- Category 1 – land where a significant possibility of significant harm exists. Defined as an unacceptably high probability that significant harm would occur if no action is taken to stop it.
- Category 2 – land where there is a strong case for considering that the risks are of sufficient concern and for taking action under Part 2A on a precautionary basis.
- Category 3 – land where there isn't a strong case for action and the legal test for significant possibility of significant harm (unacceptable risk) is not met. This can include land where the identified risk is not low but regulatory intervention is not warranted. The strength of the case is measured by the predicted level of risk and the benefits and impacts of intervention.
- Category 4 – land where there is no risk, or the risk is low. This includes land where:
    - no contaminant linkage has been identified.
    - only normal levels of contaminants in soil are present.
    - soil concentrations do not exceed relevant GAC.
    - estimated levels of exposure from soil are likely to form only a small proportion of exposure from other sources.

The work that AECOM has undertaken has been overseen and reviewed by the Multi-Agency Partnership, the Science Advisory Group, and the National Quality Mark Scheme (NQMS) Suitably Qualified Person (SQP) Paul Nathanail. Full details of the Stage 1 investigation are presented in a series of Technical Notes (TN) included as appendices to this report.

1.1 Aims, objectives and scope of Stage 1

The primary aim of Stage 1 was to develop an initial conceptual model for the potential land area affected by the Grenfell Tower fire.

The objectives of Stage 1 were to collate relevant background information, carry out site reconnaissance, and undertake some exploratory sampling, with the purpose of informing a preliminary assessment of risk and the design of Stage 2.

The scope of work was developed in accordance with the approach described in the Model Procedures for the Management of Land Contamination (CLR11) (EA, 2004)[1], and comprised the following tasks:

- Information gathering and evidence reviews: Desk-based research, site reconnaissance, and community engagement.
- Exploratory soil sampling and analytical laboratory testing.
- More detailed sampling in one area – termed "pilot study").
- Data interpretation and preliminary risk assessment.
- Design of Stage 2.

The outcomes from these tasks are summarised in the following sections of this overarching report. The detailed output from each task is provided in a series of Technical Notes - each technical note detailing a specific task or component of a task. These Technical Notes are listed as described in **Table 1**:

Table 1. Listing of Technical Notes

Number	Abbreviated Title	Purpose
TN01	Stage 1 Final Specification	Agreed final specification for the Stage 1 contract (Stage 1 works to be undertaken by AECOM).
TN02	Evidence Review Protocol	Proposed method for how AECOM will research and report background literature information.
TN03	Sampling Plan	Agreed protocol for how AECOM will undertake the exploratory and pilot study soil sampling and what laboratory testing will be done.
TN04	Evidence review for chemicals released from fires	Identification of fire effluents (subsequently referred to as chemicals of potential concern (COPC)) that might have been released during the fire and therefore should be considered as part of Stage 1.
TN05	Fate of debris after the fire	Identifying where debris fell as a result of the fire and what clean-up efforts were undertaken.
TN06	Review of smoke plume modelling	Review of the smoke plume air dispersion modelling undertaken by the Met Office to help understand where smoke particles may have been deposited on the ground.
TN07	Environmental fate of fire effluents	Review of published information on what might happen to fire effluents once they are released into the environment.
TN08	Toxicity of fire effluents	Review of published information on the possible adverse health effects associated with the chemicals that may have been released from the fire.
TN09	Urban background soil contaminants	Review of published studies on the range of chemical concentrations found in urbans soils in the UK.
TN10	Historical land use	Review of historical land uses in the study area that could have resulted in soil contamination.
TN11	* now unused but kept in for consistency [Originally intended to research statistical methods for data comparison. No longer required as part of final specification for Stage 1].	
TN12	Local background soil concentrations	Review of ground investigations in the local area before the fire to determine what range of chemical concentrations could have been present in the soil before the fire.
TN13	Sources of urban soil	Review of published studies on the sources of chemicals found in urban

[1] The Environment Agency has recently released a revised online version of CLR 11 (termed Land contamination: risk management (LC:RM) that is available via https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks. The scope, framework and purpose of the LC:RM guidance remains the same as that of CLR 11.

Number	Abbreviated Title	Purpose
	contaminants	soils.
TN14	Community Engagement	Record of information provided to AECOM either directly via the community engagement events held in April or indirectly via community contact with the MHCLG Grenfell community liaison team.
TN15	Factual data from soil sampling	Factual record of the soil sampling exercise; what was done and what was observed during the work.
TN16	Preliminary risk assessment	The initial understanding (the conceptual model) of the land and the potential risk it might pose. This is presented in accordance with the staged procedures set out in CLR11 and therefore does not include an interpretation of the soil data acquired from the exploratory sampling.
TN17	Pilot study Part 2A risk assessment	A more in-depth risk assessment for the pilot study area (Waynflete Square) using the soil concentration data acquired from the soil sampling.
TN18	Stage 2 design proposal	The proposed design for Stage 2, taking into consideration the statutory requirements of Part 2A and the evidence provided by the information gathering and exploratory sampling.

The detailed specification and methodology for the work is set out in Technical Notes **TN01-TN03** which are appended to this report.

The study area for Stage 1 was limited to a radial distance of 1km from Grenfell Tower – a limit that represented an area most likely to have been affected by fire emissions – most notably falling debris. One of the objectives of Stage 1 was to identify potential spatial distributions of fire-related impacts so that any requirement for extending the investigation area to distances beyond the initial 1km radius could be taken forward to Stage 2.

The work for Stage 1 was undertaken during the period of March through to August 2019, with the following key milestones:

- Community engagement events (April 2019).
- Soil sampling within the Tower cordon (April 2019).
- Site reconnaissance (May 2019).
- Exploratory and pilot study sampling (June 2019).
- Final laboratory results received (July 2019).
- Community meeting to present initial findings (July 2019).
- Final report issued (September 2019).

2. Information gathering: site reconnaissance and community engagement activities

To help inform the selection of appropriate locations from which to collect soil samples for laboratory analyses, there was a site cordon reconnaissance visit, two community engagement workshops, and a site walkover of proposed exploratory sample locations (over two days).

The meeting for the site reconnaissance took place within the Tower cordon with the Grenfell Site Management Team (GSMT) on 2nd April 2019. The visit and subsequent discussion helped to establish the type, nature, size and spread of debris originating from the Grenfell Tower fire. The debris was reported to have comprised of metal and glass fragments, as well as pieces of cladding and insulation material ranging up to 1m in dimension. The metal and glass fragments fell vertically within 20m from the base of the Tower, whereas the lighter cladding and insulation material were distributed farther away from the Tower, to distances of up to 50m (for larger debris around 30cm in size) and 150m for smaller debris (below 30cm in size) (debris has occasionally been reported at farther distances to the northwest of the Tower). Debris in the cordoned area around the Tower was

cleared by the Police and Fire Brigade in the days following the fire. RBKC provided additional information of locations where debris has been found (information was from Council staff and the public), and of road sweepings and refuse collection by its contractor during the period immediately after the fire. Members of the local community also engaged with project personnel during the site reconnaissance, providing further information regarding locations where debris has been found and locations where the soil has been changed or turned-over since the fire. Further information on the information gathered is provided in **TN05** which is appended to this report.

Following the site cordon visit, two community engagement workshops were held on the 25th and 27th April, attended by members of the local community, and representatives of AECOM, MAP and SAG. The sessions were hosted by the Ministry of Housing, Communities and Local Government (MHCLG). Attendees at the events shared their concerns, observations and requests. This included identification of locations on maps where debris from the fire have been found and locations where ash and strong odours were noted during or after the fire. The farthest location from which ash and odours were observed is an allotment located approximately 3.7km to the north-west in the London Borough of Brent. The MHCLG also set up an email account for members of the public to provide further feedback after the sessions.

The output from the two community sessions identified that debris was deposited within a few hundred metres around the Tower; with debris also deposited to the northwest of the Tower to at least 1km distance. Details of concerns expressed by the public and requests for the inclusion of specific locations in the planned exploratory soil sampling submitted by members of the community were collated.

A site walkover of the proposed exploratory sampling areas took place on the 23rd and 24th May, when additional feedback from the community was provided on where debris had fallen.

An account of the site cordon reconnaissance visit, community engagement workshops, site walkovers, and the discussions with RBKC, MHCLG and other stakeholders is presented in **TN14** which is appended to this report. This information was used to inform the soil sampling design. Reports of fallen debris inside the exploratory area were taken in to account in the design of the Stage 1 sampling. Reports of debris outside of the exploratory area have been taken forward to Stage 2 design considerations.

3. Evidence review: collation and review of background information on contaminants potentially released from the fire and their distribution in the environment

3.1 Chemicals of potential concern (COPC)

To focus the efforts of the Stage 1 investigation on those contaminants likely to have been generated by the Grenfell Tower fire and which may have been deposited on soils surrounding the site, a review of available evidence was carried out. The review was aimed at identifying and summarising available evidence on the range of chemical substances emitted during building fires, and the potential long-term soil contamination and associated human health risks. The main objective of the review was to identify the COPC likely to have been emitted during the Grenfell Tower fire, from a public health perspective, focussing on chemicals associated with building materials that are likely to remain in debris or in particulate or residue form. Some of the key COPC identified from the evidence reviewed are summarised in **Table 2**.

Table 2. Classes of COPC expected to be released from building fires

Class of COPC	Description
Metals	Including lead, aluminium, antimony, arsenic, barium, chromium, manganese, nickel, mercury and thallium. These metals are present in building materials and may therefore be released in the event of fires or collapse of buildings (Landrigan, et al., 2004).
Polycyclic aromatic hydrocarbons (PAHs)	A large group (over 100) of organic compounds formed from the incomplete combustion of organic materials (Wakefield, 2010). Elevated levels of PAHs in the soil close to Grenfell Tower were previously reported by (Stec, et al., 2019).

Class of COPC	Description
Dioxins and furans	A group of toxic substances formed mainly during the incomplete combustion of materials containing carbon, oxygen and chlorine or bromine, and are therefore commonly found as emissions in most fire effluents (Wakefield, 2010). Elevated concentrations of dioxins and furans were found in the soil samples collected within 140m of Grenfell Tower (Stec, et al., 2019).
Isocyanates	A family of highly reactive chemicals generated from the thermal degradation of polyurethane (PU) foams (Bengtström, et al., 2016). (Stec, et al., 2019) identified the presence of isocyanates in soil samples collected close to Grenfell Tower.
Volatile organic compounds (VOC).	VOCs are products of the combustion of organic materials. (BSI, 2017) identified benzene, formaldehyde and perchloroethylene (PCE) as amongst the VOCs that have been found in surface water, groundwater and soil following fires. Benzene levels in the soil around Grenfell Tower were reported in (Stec, et al., 2019) to be 40 times greater than the reference soil.
Organo-phosphorous compounds	Organo-phosphorous compounds (specifically phosphate esters) are common constituents of fire retardants used in foams and electrical equipment. (Hewitt, et al., 2017) detected these compounds only in fires where the fuel included a sofa and conclude that they are volatilised in their original form. Members of this class of compounds were detected in soils collected close to the Grenfell Tower (Stec, et al., 2019).
Brominated compounds	A wide range of brominated fire retardants (BFRs) are either currently or historically in use, and those with greatest application include: polybrominated biphenyls (PBB, no longer on the market), tetrabromobisphenol A (TBBP-A, still in use), polybrominated diphenyl ethers (PBDEs, including decaBDE, presently being voluntarily phased out by industry), and hexabromocyclododecane (HBCDD, still in use). BRFs were not found to be present in significant quantities on the exterior face of façade materials in the study of McKenna, et al., 2019 and how much BFR might have been released from products containing BFRs (such as furniture) during the fire is not clear (Stec, et al., 2019).
Asbestos	Asbestos was commonly used in buildings until its ban in 1999. Studies of fire events involving asbestos materials indicate that exposures during and in the immediate aftermath of the fire are expected to be minimal (Smith & Saunders, 2007).
Synthetic Vitreous Fibres (SVF)	SVFs are associated with glass wool used as part of the insulation foam panels in buildings and were found in soil and debris samples found close to the Grenfell Tower (Stec, et al., 2019).

The above list is not exhaustive; the full list of COPC included in the evidence review can be found in **TN04** which is appended to this report. Further to the identification of the COPC, a review of the potential toxicity and environmental fate of the COPC was undertaken.

3.2 COPC Toxicity and Guidelines

Published reviews of COPC toxicity and development of guideline values by authoritative public health organisations have been reviewed, and this review has identified that the majority of the COPC have been the subject of detailed reviews by one or more of these organisations in the last two decades. This is important as these studies are an important part of a risk assessment into potential health risk. The organisations included in the review include the World Health Organisation (WHO), the US Agency for Toxic Substances and Disease Registry (ATSDR), the US Environmental Protection Agency (USEPA), and the UK Department of Health Committees on Carcinogenicity and Toxicity (COC and COT). **Table 3** summarises the available information for each COPC group:

Table 3. Summary of available toxicity guidelines for COPC

COPC Group	Toxicological Evaluation Available?	Health-Based Guidance Value Available?	Health-Based Soil Screening Criteria Available?	Information on Population Exposures Available?
Metals (specifically lead)	Yes	Yes	Yes	Yes
Chlorinated dioxins and furans and PCBs	Yes	Yes	Yes	Yes

COPC Group	Toxicological Evaluation Available?	Health-Based Guidance Value Available?	Health-Based Soil Screening Criteria Available?	Information on Population Exposures Available?
Brominated dioxins and furans	No	No	No	Yes
PAHs	Yes	Yes	Yes	Yes
VOCs (specifically benzene)	Yes	Yes	Yes	Yes
Non-dioxin-like PCBs	Yes	Yes	Yes	Yes
Cyanides	Yes	Yes	Yes	Yes
Isocyanates	Yes	Yes	No	No
Asbestos	Yes	Yes	Yes	No
Synthetic vitreous fibres	Yes	Yes	No	No
Phosphate Esters	Yes	Yes (not all)	Yes (not all)	No
Brominated Diphenyl Ethers	Yes	Yes (not all)	Yes (not all)	Yes
Polybrominated Biphenyls	Yes	No	No	Yes
Tetrabromobisphenol A	Yes	Yes	No	Yes
Hexabromocyclododecane	Yes	Yes	No	Yes

Further details on the information found on COPC toxicity are provided in **TN08** which is appended to this report.

3.3 COPC Environmental Fate

The environmental fate of COPC describes what happens to the chemicals once they are released to the environment. Often chemicals, once released to the environment, do not stay in the form they were released in. Those that do tend to stay the same are termed “persistent” and these include some of the COPC – particularly dioxins and furans. Other chemicals may volatise into the air or dissolve in water. Others may bind strongly to soil particles. Chemicals can also degrade in the environment, often either by reactions triggered by exposure to sunlight, or by microorganisms in the soil. A summary of the likely environmental fate of the COPC is provided in **Table 4**, and further information on the evidence review for the environmental fate of COPC is provided in **TN07** which is appended to this report.

Table 4. Environmental fate of the COPC

Class of COPC	Overview of generic environmental fate
Metals (e.g. lead)	Following deposition, lead attaches to soil particles to form stable compounds with low solubility. It is largely retained in the upper layer (2-5 cm) of soil, especially in soils with at least 5% organic matter or a pH 5 or above. Lead may transform from one compound to another, but it is not degraded in the environment.
Polycyclic aromatic hydrocarbons (PAHs)	Once deposited, PAHs may attach to soil material or seep into groundwater or surface water; lighter PAHs such as naphthalene may evaporate back into the air. PAHs are generally resistant to degradation by microorganisms and can persist in the environment for relatively long periods of time. There are gaps in the current understanding of how PAHs breakdown in soils.
Dioxins and furans	Dioxins and furans are highly persistent compounds and have been detected in air, water, soil, sediments, animals and foods. They have low solubility in water and attach strongly to the organic matter in soils and sediments. This group of compounds are relatively immobile and are removed from soil surfaces largely through soil erosion processes. There is some evidence of limited degradation in the presence of sunlight.
Isocyanates	Isocyanates are volatile substances that generally return to the atmosphere within a short period of time following their deposition onto soil. Members of this group of

Class of COPC	Overview of generic environmental fate
	compounds are highly susceptible to degradation in the presence of sunlight and water.
Volatile organic compounds (VOC).	VOCs have considerable solubility in water. They are generally mobile and likely to leach to groundwater following deposition onto soil. Lighter VOCs such as benzene have high volatility and are easily transferred from the surface of soils with loose particles (such as sand and gravel) to air. VOCs readily undergo degradation by microorganisms and are generally not persistent in soils and groundwater.
Brominated Fire Retardants (BFR)	BFRs are reported to have limited solubility and to strongly attach to soils and sediments. They are therefore not readily mobile in soil. BFRs are persistent in the environment and will not generally biodegrade, although adapted microorganisms may degrade the compounds. Some members of this class of COPCs are reported to degrade in the presence of sunlight.
Asbestos	Asbestos fibres do not volatilise or degrade in soil or water, and only move through soil during runoff or erosion. Asbestos fibres in soil may be resuspended in air by ground disturbances such as human activity and wind erosion and can persist in the environment.
Synthetic Vitreous Fibres (SVF)	SVFs are reported to settle out of air and water, depositing in soil or sediment where they remain. They are non-volatile, insoluble and do not degrade under environmental conditions.

3.4 UK Met Office's atmospheric dispersion modelling

A review of a report published by the Met Office on the atmospheric dispersion of the plume smoke emitted during the Grenfell Tower fire and its impact on air quality in terms of airborne particulate matter (Kendall, et al., 2019)[2] has been performed to further inform the exploratory sampling design. The report was based on modelling carried out using the Met Office's Numerical Atmospheric-Dispersion Modelling Environment (NAME) model, meteorological data from weather stations and the Met Office's UK weather forecast, and information about heat and particulate emissions based on analysis of the fire carried out by the Health and Safety Laboratory (HSL). The modelling focussed on the dispersion of small soot and particulate matter (10µm and 100µm) emitted during the first 15 hours of the fire (corresponding to the main fire event); larger particles or embers from the fire are considered to be subject to gravitational settlement close to the Tower and were not modelled.

Throughout the simulation, the direction of plume dispersion was to the northwest of Grenfell Tower. During the most intense part of the fire (first 4 hours), the plume of smoke initially rose upwards in a pillar of smoke to a height of a few hundred metres, before spreading horizontally in a north-westerly direction, reaching the ground 3-4km kilometres downwind of the Tower. During the latter half of the modelled period (corresponding to after sunrise), the plume was more evenly spread vertically, and reached ground level within a kilometre of the Tower. The modelled dispersion of the plume of smoke from the fire was found to be broadly in agreement with available photographic evidence (and is consistent with anecdotal accounts from the community engagement events described earlier).

The report acknowledged the model overestimated ground level windspeeds compared to measurements taken at the nearest monitoring station at Kew Gardens (7km away); but concluded that, overall, the simulation provides a better representation of the event than would meteorological data from a single site (when windspeeds at greater heights above ground level are considered).

The Met Office produced a number of model outputs for varying particle sizes and densities that provide an indication of the area over which smoke particles may have been deposited. What the modelling does not provide is absolute values for the deposited mass of particles in any one area, because of the uncertainties and limitations in the approach. The modelling suggests that particles were deposited up to 5km away (the limit of the images provided in the report), and that deposition may have been heaviest within a relatively narrow area up to 1-2km of the Tower and then a much broader area from 2km onwards.

[2] The report is publicly available at https://www.metoffice.gov.uk/research/library-and-archive/publications/science/weather-science-technical-reports

Figure 1. Copy of Figure 9f and 10f from Met Office report FRTR 637

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

- It doesn't consider particles larger than 100µm (0.1mm), and therefore does not attempt to model the dispersal and deposition of debris emitted during the fire.
- 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.

The modelling therefore helps in identifying where investigation might be appropriate but does not provide any information on the difference in deposition between debris and small particles, nor provide information on what deposition rate might be of concern.

AECOM's review of FRTR 637 is provided in **TN06** appended to this report.

3.5 Urban Sources of COPC

The COPC that could be present in soil as a result of the fire could also be present from other historic urban sources. Most of the COPC are present in the urban environment as a result of human activity. A review of urban sources of COPC was undertaken and two broad categories of potential sources of COPC were identified:

- Natural sources: contamination due to the presence of parent geological materials in the ground. This could be an important source of metals in soils.
- Man-made sources: associated with dust deposition from industrial emissions including combustion of fuels; emissions from road or rail transportation; deposition from flooding or utility networks; and sources associated with management of vegetated areas.

Transportation is considered a likely source of contaminants in the study given the presence of transport infrastructure including railways and roads such as the A40 Westway and A3220 West Cross Route within the area of interest. Contaminant sources related to road transportation include emissions from vehicle exhausts, plus tyre abrasion, followed by deposition of atmospheric particulates. Other sources include the release of fuel, lubricants or de-icing salts to ground.

Soil is also not the only source of exposure to these chemicals. The use and release of these substances into the environment means that they can be present in air, water, and in our diet from sources unrelated to those under investigation (in this case the Grenfell Tower fire). The European Food Safety Authority (EFSA) and the UK Food Standards Agency (FSA) monitor the presence of many of the COPC in diet for example. This is a relevant consideration under Part 2A where the

contribution to overall exposure may be higher from sources other than soil and it might have relatively little health benefit to try and reduce exposure from soil sources if exposure through diet or background air quality is significantly higher.

Further details of this review are provided in **TN12** appended to this report.

3.6 Background levels of contaminants in soil

The statutory guidance for Part 2A requires the consideration of normal background concentrations when interpreting soil sample results, taking into account both local concentrations and regional and national ones. This is because Part 2A is not intended to apply to land with levels of contaminants in soil that are commonplace and widespread across England, and normal levels of contaminants should not be considered to cause land to qualify as contaminated land unless there is a particular reason for doing so.

A comparison of exploratory sample and pilot study sample concentrations with background levels in soil could provide one line of evidence of where fire-related impacts might exist if reported concentrations from Stage 1 sampling exceed typical background levels.

A review of evidence on the background concentrations of COPC in soils was carried out to understand the range in reported concentrations in urban soils. The review covered background concentrations in soils which account for both geogenic (i.e. natural) and diffuse pollution. It involved evaluation of published UK surveys or open source data from UK government organisations or institutions such as the British Geological Survey (BGS), Defra and the Environment Agency, as well as online literature surveys using keyword searches at sites such as google scholar and ResearchGate. The review concentrated on data from 2000 onward and included published reports such as the UK Soil and Herbage Survey (Creaser, et al., 2007). Full details of this review are provided in **TN09** appended to this report

The review was extended to reviews of reports of contaminated land investigations (undertaken close to Grenfell Tower) submitted to RBKC and LBHF as part of the planning process for development proposals before the fire, as well as assessments of historical and current land uses that could give rise to enhanced concentrations of COPC due to anthropogenic activities. COPC were found in many samples collected within 500m of Grenfell Tower; selected examples have been summarised in **Table 5**.

Table 5. Summary of background concentration of selected COPC near Grenfell Tower

Chemical / Chemical Group	Concentration range in local soils (mg/kg)	Description of local data	Published Normal Background Concentration for Urban Areas in England (mg/kg)[3]
Lead (Pb)	99 mg/kg to 12000 mg/kg (from 18 submitted reports)	Highest reported concentration associated with Phase 2 Geo-Environmental Assessment (2012) for an academy and leisure centre immediately adjacent to Grenfell Tower.	820 mg/kg
Benzo(a)pyrene	0.7 mg/kg to 98 mg/kg (from 13 submitted reports)	Highest reported concentration associated with Geo-environmental Site Investigation (2016) carried out as part of a proposed redevelopment of Avondale Park Primary School approximately 300m south from Grenfell Tower.	3.6 mg/kg
Polycyclic aromatic hydrocarbons (PAHs)	130 mg/kg to 217 mg/kg (from 3 submitted reports)	Highest reported concentration associated with a Report on Ground Investigation (2006) carried out as part of the redevelopment of the Land adjacent to Kingsnorth House on Kingsdown Close, 120m to the north of Grenfell Tower.	Not published

[3] (Johnson, et al., 2012)

Asbestos	Not stated in reports	Detected at a few of the sites investigated.	Not published

Table 6 summarised what background soil data that has been identified by the evidence review for each group of COPC.

Table 6. Summary of available background soil information for COPC

COPC Group	Defra NBC Available?	Included in UKSHS?	Other regional surveys identified?	Included in local reports
Metals	For arsenic, cadmium, copper, lead, mercury and nickel	Yes	Part of BGS GBASE and LondonEarth	Yes
Chlorinated dioxins and furans and PCBs	No	Yes	No	No
Brominated dioxins and furans	No	No	No	No
PAHs	Benzo(a)pyrene only	Yes	Yes (Vane et al)	Yes
VOCs (specifically benzene)	No	No	No	Yes
Non-dioxin-like PCBs	No	Yes	Yes (Vane et al)	No
Cyanides	No	No	No	Not often
Isocyanates	No	No	No	No
Asbestos	No	No	No	Yes
Synthetic vitreous fibres	No	No	No	No
Phosphate Esters	No	No	No	No
Brominated Diphenyl Ethers	No	No	Yes (Drage et al)	No
Polybrominated Biphenyls	No	No	No	No
Tetrabromobisphenol A	No	No	No	No
Hexabromocyclododecane	No	No	No	No

Evaluation of historical maps of the areas within 500m of Grenfell Tower was carried out to identify any past land-use activities that could have impacted the land quality of the area. The review indicated a range of land uses in the areas of interest, including iron works, garages and railway lines and stations. These land uses could potentially be historical sources of land contamination in the areas of interest.

The London County Council Bomb Damage Maps 1939-1945 book indicates that the area within 100m to the east, south east, and south of the Tower suffered extensive bomb damage during the Second World War. Additional serious bomb damage is shown further to the south east and south west of the Tower, whereas to the north east, north and north west only isolated patches of ‘clearance areas’ and a single house showing non-structural blast damage are shown. Fires associated with the bombing, and the subsequent clearance of damaged buildings has the potential to have also impacted the land quality of the area, and it may be that material from that damage remains beneath land and buildings rebuilt in those areas.

This review of potential local background factors in soil contamination is provided in full in the combined **TN10** and **TN12** appended to this report.

4. Exploratory soil sampling and laboratory analyses

4.1 Choice of location and soil sampling approach

The sampling for the Stage 1 investigation was designed to reflect guidance contained in relevant British Standards, including:

- BS 10175:2011+A2:2017. Investigation of potentially contaminated sites – Code of practice, British Standards Institution Publication. (British Standards Institute, 2017).
- BS ISO 18400-101:2017. Soil quality – Sampling. Part 101: Framework for the preparation and application of a sampling plan, British Standards Institution Publication, 2017 (British Standards Institute, 2017a).
- BS ISO 26367-1:2017. Guidelines for assessing the adverse environmental impact of fire effluents. Part 1: General, British Standards Institution Publication, 2017 (British Standards Institute, 2017b).
- BS ISO 26367-2:2017. Guidelines for assessing the adverse environmental impact of fire effluents. Part 2: Methodology for compiling data on environmentally significant emissions from fires, British Standards Institution Publication, 2017 (British Standards Institute, 2017c).

These Standards, together with information gathered during the site walkover surveys and community engagement workshops, as well as evidence collected from the information reviews, were used to identify appropriate locations for the collection of soil samples. Other factors that influenced the selection of sampling locations include:

- The two predominant wind directions observed on the day of the fire (south easterly wind blowing in a north westerly direction from the Tower) and the day after (westerly blowing in an easterly direction from the Tower).
- Areas where debris has been reported to have fallen during the fire.
- Areas within the Met Office modelled plume deposition.
- Areas of concern identified by the public during community engagement events or via community communication channels with MHCLG (refer to **TN14**).
- Ease of access to sampling locations.

The full rationale for the design of the Stage 1 exploratory soil sampling and testing is provided in **TN03** which is appended to this report.

4.2 Exploratory sampling

Based on the above factors, 21 areas within 1km radius of the Tower (including the cordoned area and the pilot study area) were chosen as Stage 1 exploratory sampling locations. These locations represent areas of accessible space where it is understood that the soil has not been significantly disturbed or altered since the fire and are shown in **Figure 2**. Whilst schools and private gardens have not been included in the Stage 1 sampling exercise, the selected sampling locations are considered to provide a good indication of the level of contamination that may be present in nearby residential gardens and schools. Two soil samples were collected (at random) within each sampling area to provide some evidence of spatial variability in soil concentrations. Duplicate samples were also taken in accordance with the requirements of British Standard BS10175 (BSI, 2017).

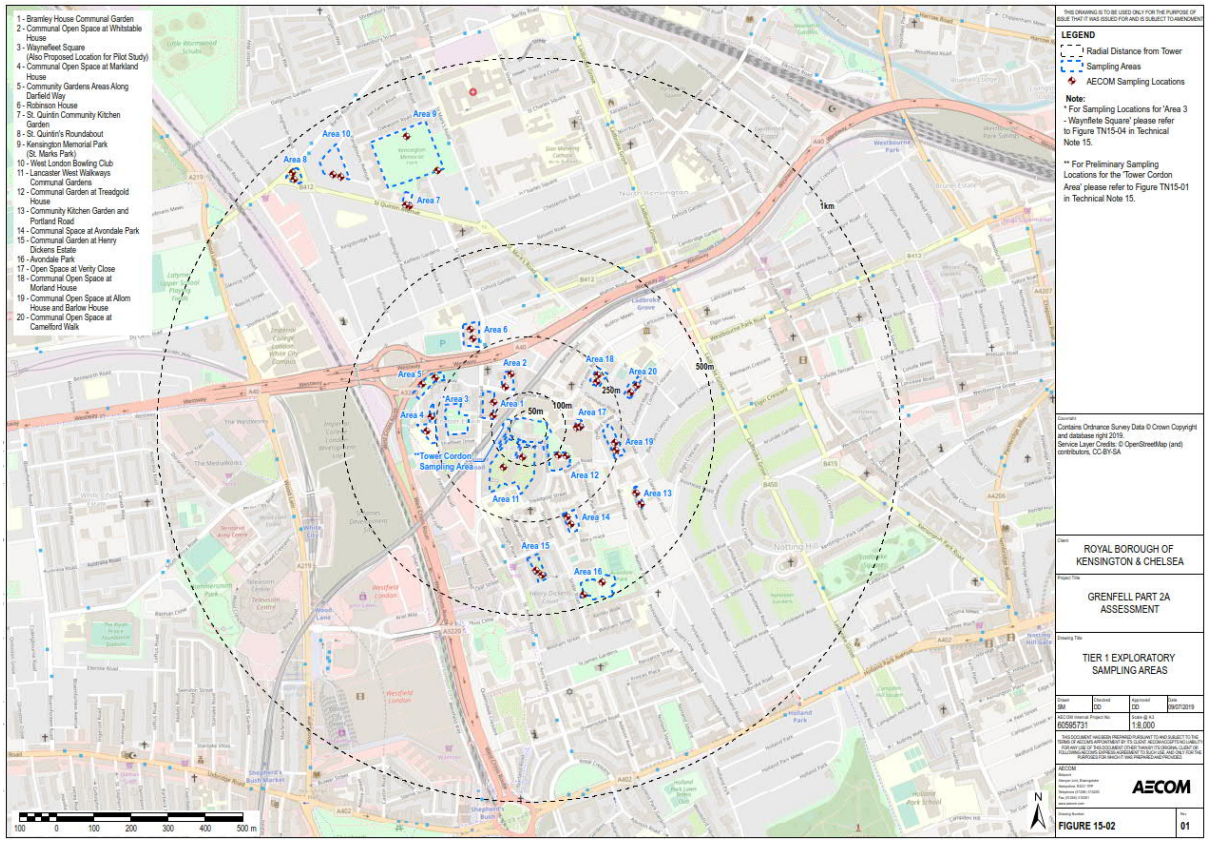


Figure 2. Stage 1 exploratory sampling locations (based on TN15-02)

In deciding the sampling approach to adopt, a review of the sampling strategies described in various publications including those by the Environment Agency (Creaser, et al., 2007) and Defra (Johnson, et al., 2012) was undertaken, in addition to the Standards described earlier. The specific circumstance of the site (in terms of the time since the fire took place and chemistry of the COPC expected – e.g. their low solubility in water and/or strong attachment to soil particles) was also considered. On the basis of these factors, it was concluded that a sampling approach that targets the top 5cm of undisturbed soil is appropriate for identifying whether contaminants from the fire are present in the soils.

Soil samples were taken at four locations within the site cordon on 10th April 2019 to inform the final design of the sampling and analytical methods. The remaining exploratory samples across the study area were taken on the 4th-7th June 2019.

Field notes including ground conditions, soil logs and visual observations of anthropogenic inclusions in the soil (such as the presence of ash, coal, clinker and potential cladding) were taken by field staff. Standard Quality Assurance (QA) procedures consistent with relevant guidance and national and international Standards were applied for both sample collection and laboratory analysis.

Further information on how the sampling was undertaken and what was found is provided in Technical Note **TN15** which is appended to this report.

4.3 Pilot study

A small-scale pilot study involving more detailed sampling in a single area was implemented, separate from the wider exploratory sampling exercise. The study was aimed at investigating local variability in the concentration of COPC in a small area and illustrating the quantitative risk assessment process under Part 2A and informing the PRA and design of Stage 2. Waynflete Square, an area of public open space within a residential setting where debris from the fire was reported to have fallen, was selected for the pilot study because it meets the selection factors mentioned in Section 4.1. This area is located around 200m to the northwest of the Tower, consistent with the predominant wind direction during the fire.

Soil samples were collected from nine locations along 20m sampling grids, at depths of 0-5cm and 10-15cm to explore the variation of COPC concentrations with depth. Eight additional samples (2.5m apart) were collected at one grid location in a radial pattern from the central sample, to explore the possibility of variation in COPC concentration on a smaller scale. The sampling locations within Waynflete Square are shown on **Figure 3**.

Further information on how the sampling was undertaken and what was found is provided in Technical Note **TN15** which is appended to this report.

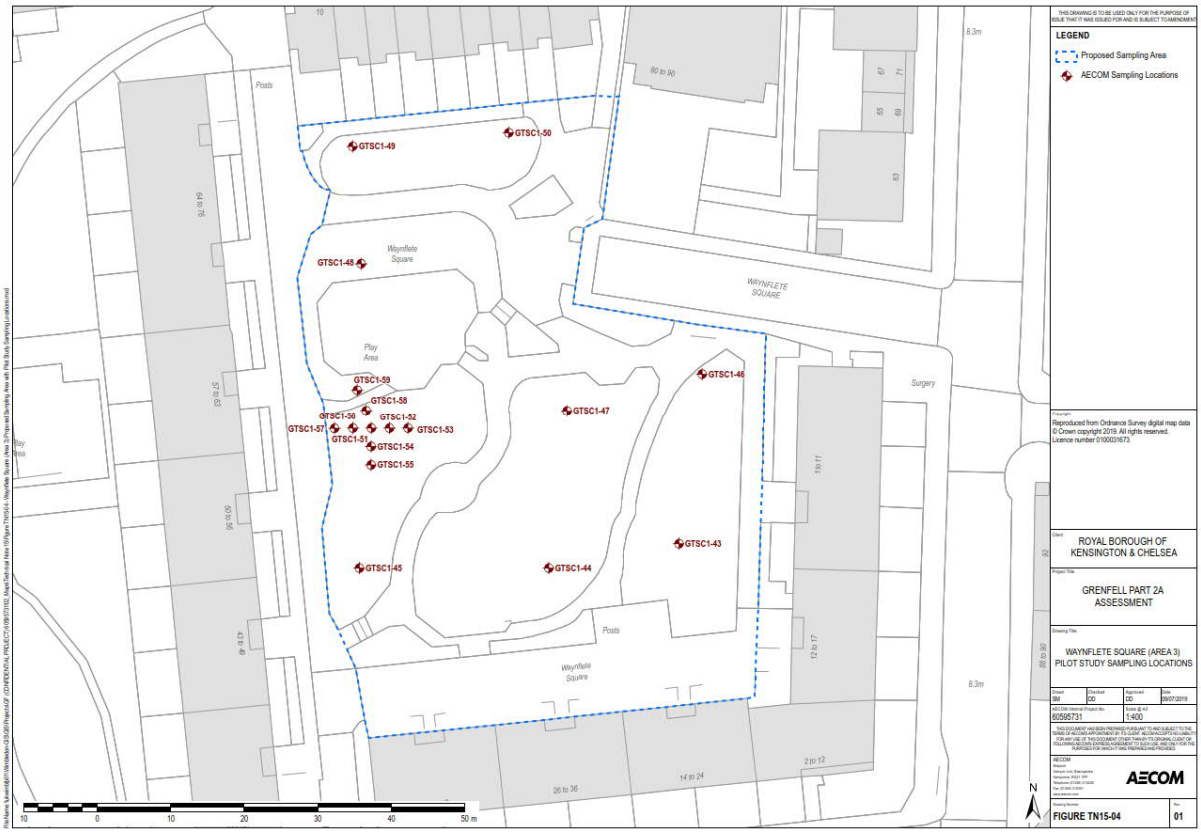


Figure 3. Pilot study sampling locations (based on TN17-01)

4.4 Laboratory testing

Analyses of the COPC present in the soil samples collected were performed by Element Materials Technology (formerly Exova Jones Environmental Ltd), a laboratory that specialises in the testing of soil samples for environmental contaminants. The laboratory is accredited by the United Kingdom Accreditation Service (UKAS). Element was supported by two subcontractor laboratories for COPC that they could not analyse themselves. These were RPS Mountainheath for organophosphate and brominated flame retardants and Marchwood Scientific Services for chlorinated and brominated dioxins, furans and dioxin-like polybiphenyls.

Details of the testing schedule, analytical methods, detection limits and method accreditation status are presented in **TN03** and **TN15** which are appended to this report. The analytical results from the testing of the soil samples are included in **TN15**.

5. Evaluation of soil contamination results

5.1 Contaminant distribution patterns

Results of laboratory analysis of soil collected as part of the exploratory sampling exercise did not show obvious patterns in terms of geographical spread or concentration distribution that might be expected as a result of the initial conceptual model for spread and distribution from the fire, as demonstrated by the charts in **Figure 4** and **Figure 5** for PAHs and brominated dioxins and furans – two of the COPC associated with emissions from building fires. These Figures indicate varying concentrations of COPC with distance from the Tower and in all directions with no clear trend. This is different to the outcome of a recent study which observed a decrease in the concentration of COPC with distance from the Tower (Stec, et al., 2019). The results also challenge the assumption that the concentration of COPC will be highest to the northwest of the Tower, the direction of the predominant wind direction during the fire, where the deposition of particulate matter would be expected to be highest. COPC concentrations were low within the site cordon, suggesting that either the fallen debris did not result in soil contamination – either as a result of the subsequent clean-up of the debris and/or because of the effect of the fire water in washing the finer debris off the surface of the soil.

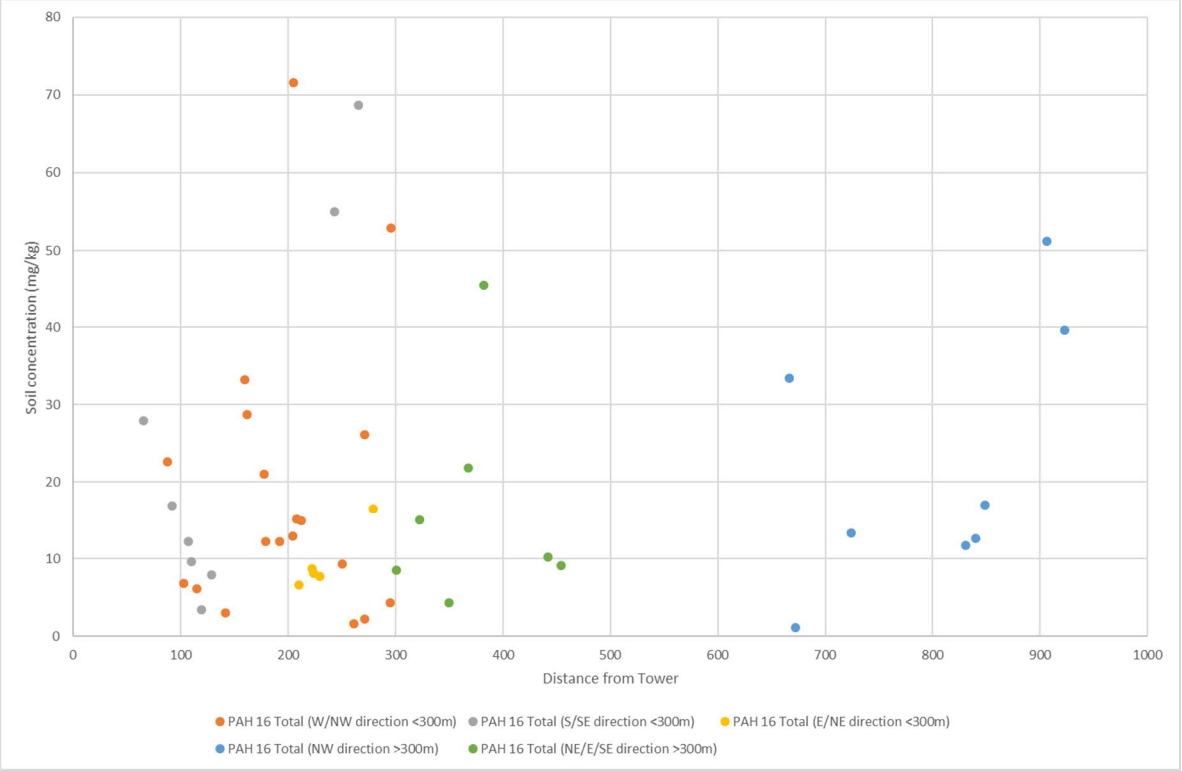


Figure 4. Plot of PAH 16 total soil concentrations against distance from Tower (based on TN18-4)

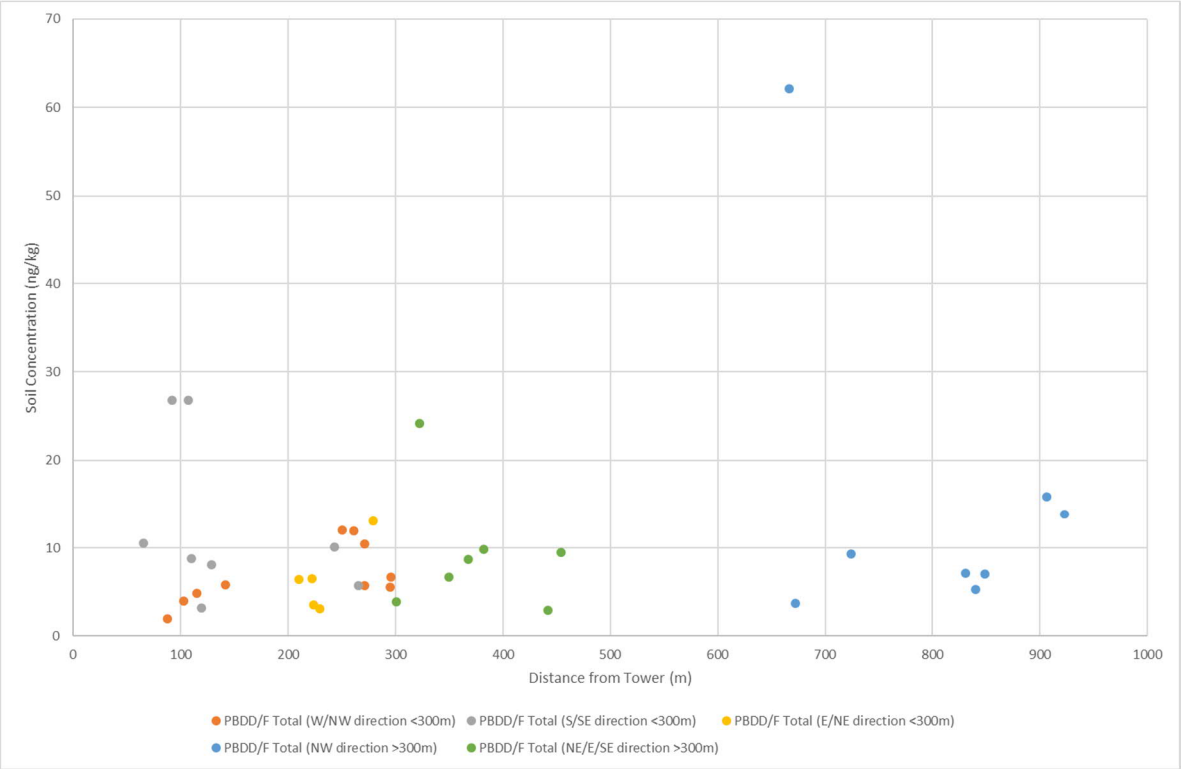


Figure 5. Plot of brominated dioxins and furans (total) soil concentrations against distance from Tower (based on TN18-5).

COPC associated with brominated flame retardants were not detected in any soil sample. Detectable concentrations of organophosphate ester flame retardants and isocyanate compounds (compounds associated with the combustion of foam materials), were detected in very few (1 to 4) sample locations and were reported at concentrations several hundred to several thousand times lower than the relevant soil screening values for protection of human health identified in **TN08**.

Asbestos and synthetic vitreous fibres (SVF) were identified in a number of soil samples, with the identified presence considered to represent a low risk to health in the Waynflete Square pilot study (**TN17**). No samples from the exploratory sampling were identified with asbestos concentrations higher than those reported at Waynflete Square. It is not clear whether these have resulted from the fire or from other potential urban sources given their common use in buildings. The highest asbestos concentration was detected in Waynflete Square. In general, the detection of asbestos was sporadic in other exploratory areas, with it not typically being detected in duplicate samples from the sample location or in both samples from one area.

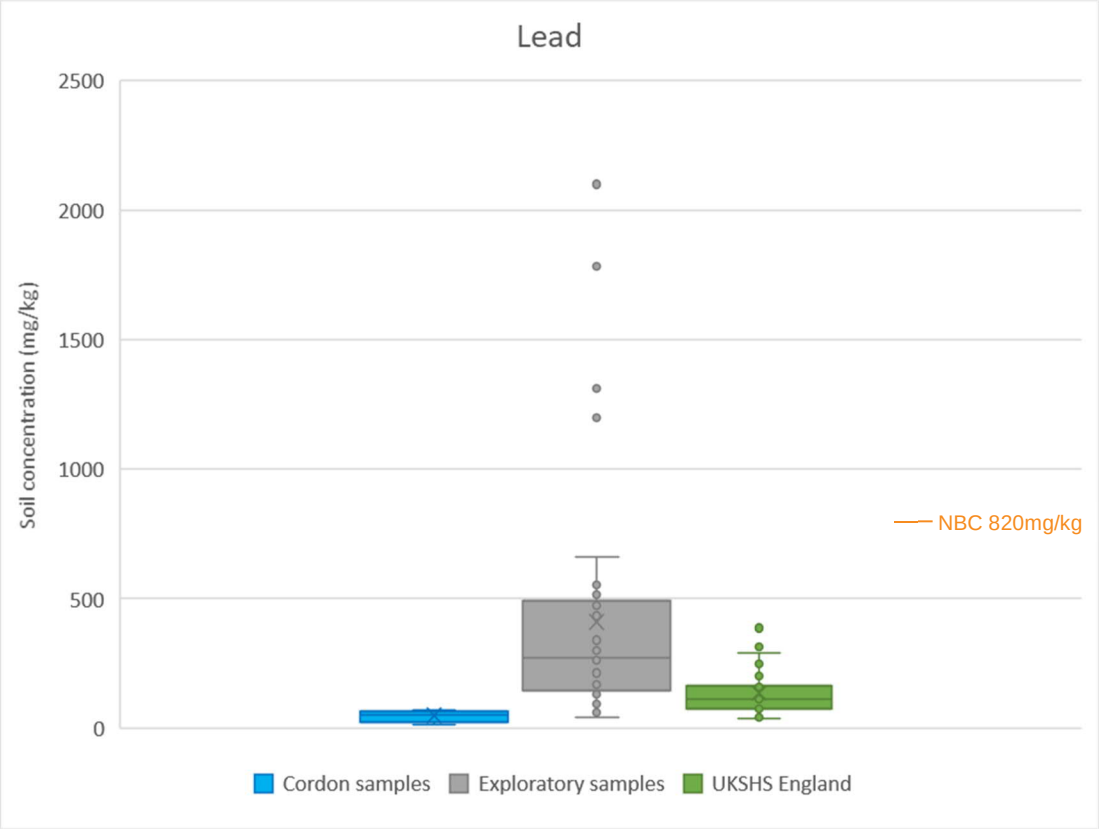
5.2 Comparison with background concentrations

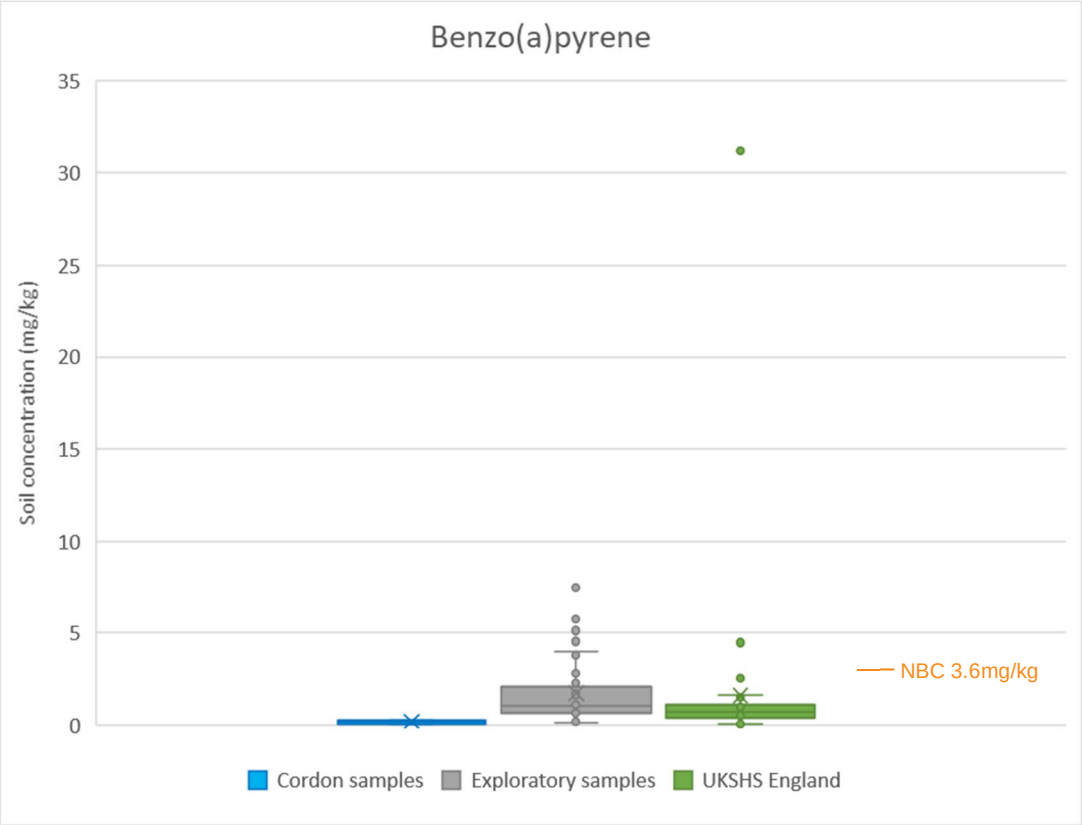
Concentrations of PAHs and dioxins and furans were broadly comparable to those reported in published surveys of urban soils such as (Vane, et al., 2014), which reported PAH (sum of US EPA 16) concentrations ranging from 4 to 67mg/kg with a mean of 18mg/kg from an area in east London. Reported benzo(a)pyrene concentrations were however often higher than the normal background concentration for urban areas of England of 3.6mg/kg (Johnson, et al., 2012).

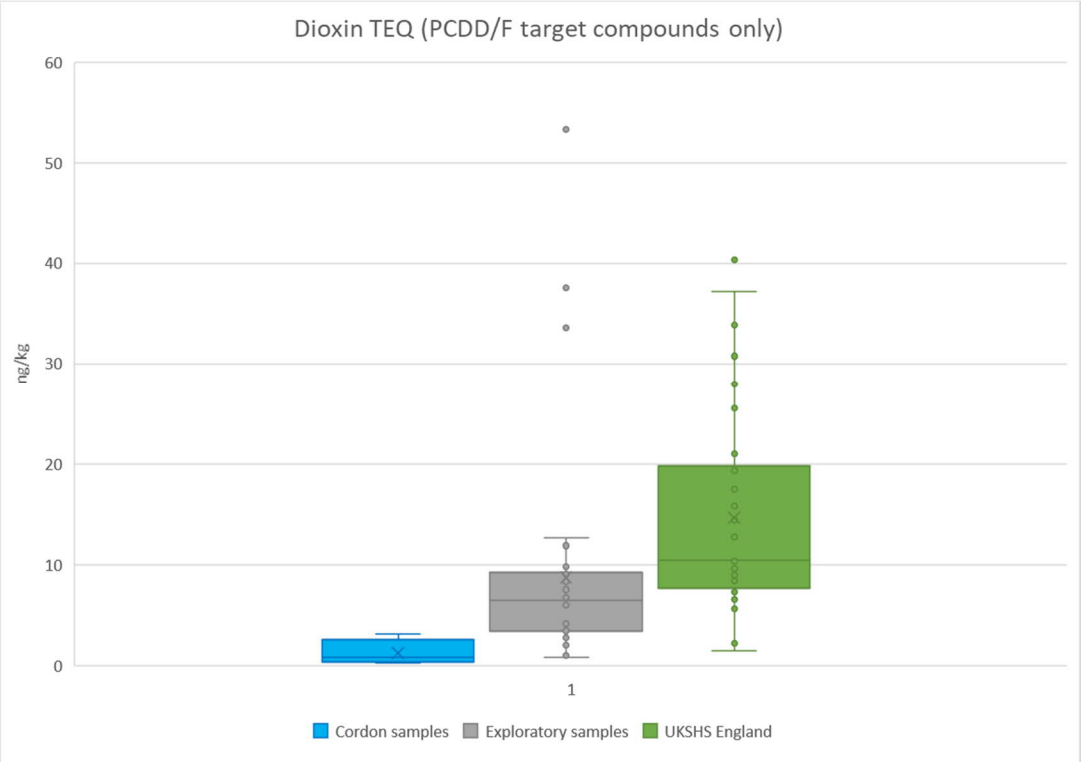
The normal background concentration for urban areas of England for lead is 820mg/kg and a small number of reported results exceed this. The concentration of lead in north Kensington is interpolated to be 260-665mg/kg (Lark & Scheib, 2013), which compares to a concentration range of around 50-2100mg/kg in the exploratory and pilot study samples. The concentrations of these COPC in the exploratory samples were, however, well below the maximum concentrations observed during site investigations carried out to support various planning applications in areas close to Grenfell Tower prior to the fire (see **Table 5**), and there is no direct evidence that lead was released as a result of the Grenfell Tower fire (it was included as a COPC based on assessments made for the World Trade Center collapse – refer to **TN04**). Direct comparison of individual sample results to the Lark & Schieb

range is not appropriate due to the way in which the Lark & Scheib concentrations have been estimated.

Figure 6 shows a comparison of the measured soil concentrations in the exploratory samples compared to those measured in regional surveys published by the Environment Agency (UKSHS) and Defra (SP1008) for lead, benzo(a)pyrene and chlorinated dioxins and furans.







Key for data presentation in “box and whisker” plots

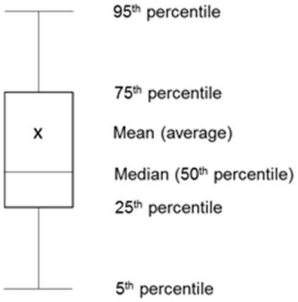


Figure 6. Exploratory soil sample concentrations distributions (based on TN18-7).

The “box and whisker” plots provide a simplified visual comparison of the data and indicate that dioxin concentrations in the exploratory samples tend to correspond to the lower concentrations reported in regional surveys, benzo(a)pyrene concentrations may be a little higher and lead concentrations higher than those in the regional surveys. A number of reported concentrations of benzo(a)pyrene and lead exceed the normal background concentration for urban soils, although the average concentrations do not. However, more detailed data analysis is required to provide greater certainty in these observations.

Background concentrations of other COPC, for example flame retardant chemicals, are uncertain as studies into urban soil concentrations of these chemicals are not as extensive as those for metals, PAHs and dioxins, or have not been found by the evidence review reported in **TN09**.

6. Preliminary risk assessment

A Preliminary Risk Assessment (PRA) has been carried out to qualitatively evaluate the source-pathway-receptor Contaminant Linkages (CLs) for the study area, with the purpose of identifying those linkages that don’t require further investigation and those that do. The PRA was performed using information gathered from the desk studies, community engagement and soil sampling and analysis activities described in the preceding sections. A summary of the PRA is provided in the following sub-sections of this report; the full PRA is provided in **TN16** which is appended to this report.

6.1 Source, pathways and receptors assessed

A summary of the range of COPC, and an indication of background concentrations and potential sources is presented in Section 3. These COPC have been categorised into groups of soil contaminants including heavy metals, PAHs, dioxins and furans, isocyanates, PCBs, VOCs and SVOCs, asbestos and SVFs, and flame retardants.

The range of receptors that could be exposed to identified COPC were categorised into four main groups in accordance with Statutory Guidance (Defra, 2012), and have been summarised in **Table 7** below.

Table 7. Receptors considered for PRA

Group	Sub-group	Description
Human health	Nearby Residents (R1)	This group includes residents living in properties with private gardens where cultivation of produce is a possibility, those living in properties with no private outdoor space without any possibility of growing produce, those with raised bed plots in community kitchen gardens, and those with larger typical allotment plots.
	Visitors (R2)	This group includes visitors to the area either to visit local residents, use local parks and leisure services, or use commercial services (e.g. shops).
	Commercial workers (R3)	This group includes workers in local businesses or other services (e.g. schools) that are not resident in the local area

Group	Sub-group	Description
	Maintenance workers (R4)	This group includes workers that are not resident in the local area but who work in the area carrying out regular maintenance jobs that involve more disturbance of the soil/ground (such as tending park areas) than workers in a commercial business such as a shop.
Property	Pets (R5).	
	Homegrown produce (R6).	
	Buildings (R7).	
Controlled water	Groundwater (R8)	Groundwater in Kempton Park Gravel (Secondary-A aquifer) (R8).
	Surface waters: (R9)	River Thames located approximately 2.9km to the south southwest. The Grand Union Canal located approximately 1.4km to the north. Lakes in Kensington Gardens and Hyde Park located approximately 2.3km to the east southeast.
Ecological	Brent Reservoir	A Site of Special Scientific Interest (SSSI) located approximately 6.3km to the north northwest of the Tower. It is situated beyond the area of significant impact from the plume and has not been considered any further.
	Barn Elms Wetland Centre	A Site of Special Scientific Interest (SSSI) located approximately 3.8km to the south southwest of the Tower. It is not expected to have been affected by particle deposition or debris. As such it has not been considered.

Potential pathways associated with the exposure of the receptors identified above were assessed. The likely exposure pathways for humans were based on the land-uses and the activities pursued by members of the public in the areas close to the Tower, which are likely to result in their exposure. The pathways that have been assessed are:

- Human health:
    - Ingestion of soil and soil derived indoor dust (P1).
    - Inhalation of soil-derived dust (indoor and outdoor) (P2i and P2o).
    - Dermal contact with soil (P3).
    - Dermal contact with soil derived dust (indoor) (P4).
    - Consumption of produce and attached soil (P5).
    - Inhalation of vapours (indoor and outdoor) (P6i and P6o).
- Controlled Waters:
    - Leaching of contaminants from surface soils (P7).
    - Vertical migration in the unsaturated zone (P8).
    - Lateral migration in the groundwater (P9).
    - Run-off to surface water (P10).
- Pets – as per humans.
- Homegrown produce (a receptor that is covered both by P5 for human health and as a receptor, with the statutory requirement that it is fit for purpose (i.e. complies with the provisions of the Food Safety Act 1990).
- Buildings:
    - Leaching and migration in unsaturated zone (P7 – P9) to sub-surface structure (e.g. foundations).

- Chemical Interaction with structural building materials causing corrosion, weakening or other effect that could cause structural failure, substantial damage or substantial interference with right of occupation (P14)[4].

6.2 Evaluation of Contaminant Linkages

A contaminant linkage is identified when there is a source and a pathway and a receptor, such that there is possibility of significant harm or significant pollution to that receptor.

Pets, property and controlled waters (groundwater and surface water regulated by the Environment Agency) have not been identified as critical receptors for the following reasons:

- The human health risk assessment process focuses on sensitive land-uses and the most sensitive receptors that characterise these land-uses. This critical receptor is children aged 0-6 years old. It is reasonable to conclude that, in the absence of any Part 2A guidance on the assessment of risks to pets, if 0-6 year old children are not at risk of significant harm, then pets are not at risk of significant harm either.
- The COPC being considered in this assessment are very unlikely to damage buildings.
- The Environment Agency has confirmed that it does not consider controlled waters to be at risk because of the geology in the area and the distance to relevant receptors.
- Risks to homegrown produce intended for personal consumption are directly accounted for in the assessment of human health.

The focus of the PRA has therefore been on risk to human health and what the information collected in Stage 1 suggests that risk might be. The Statutory Guidance for Part 2A justifies continuation of the investigation of land if there is a reasonable possibility of a significant contaminant linkage (that is a contaminant linkage that could result in the land being determined as contaminated land). The Statutory Guidance states that local authorities should stop the investigation of land if there is not a reasonable possibility of a significant contaminant linkage, or if information already obtained is sufficient for the local authority to decide whether the land is contaminated land or not. The reasonable possibility of a significant contaminant linkage being present has been assessed on the basis of the following considerations, which are described in detail in the EA/PHE methodology referred to in **TN16**:

- Frequency and spatial distribution of COPC detection in soil samples i.e. is there any evidence of COPC being present in soil that could be clearly attributed to deposition from the fire as opposed to normal background or other localised historic sources.
- Proportion of COPC concentrations that exceed generic screening criteria, and magnitudes of exceedance.
- Comparison of reported COPC soil concentrations with local, regional and national background levels.
- The level of confidence in the available data (what uncertainties or data gaps remain).

The COPC considered at this point in the PRA were:

- S1 – Metals, specifically lead and aluminium.
- S2 – PAHs and related SVOC compounds.
- S3 - dioxins, furans and dioxin-like PCBs.
- S4 – non-dioxin-like PCBs.
- S5 – VOCs (benzene).
- S6 – Organophosphorous compounds (specifically TEHP).
- S7 – Cyanides.

[4] The statutory guidance for Part 2A explicitly excludes buried services such as sewers, water pipes or electricity cables as receptors under the definition of property.

- S8 – Fibres (asbestos and SVF).

Contaminant linkages associated with these contaminants were evaluated and those that potentially warranted further investigation were identified as follows:

Table 8. Contaminant Linkages that warrant further assessment based on PRA

Sources		Pathways		Receptors	
S1	Lead	P1	Ingestion of soil and indoor dust	R1	Residents
		P5	Consumption of produce and attached soil		
S2	Polycyclic Aromatic Hydrocarbons and associated SVOCs (represented by BaP as a surrogate marker)	P1	Ingestion of soil and indoor dust	R1	Residents
		P3	Dermal contact with soil (outdoor)		
		P4	Dermal contact with soil derived dust (indoor)		
		P5	Consumption of produce and attached soil		
S8	Asbestos	P2	Inhalation of soil derived dust (indoor and outdoor)	R1	Residents

[Those linkages that are greyed out are included on the basis of reducing uncertainty as opposed to the reasonable possibility of a SCL because of detected concentrations exceeding generic screening criteria and normal background concentrations]

7. Pilot Study

A pilot study was carried out in one area close to Grenfell Tower (Waynflete Square) to trial the Part 2A risk assessment process prior to the expected expansion of the risk assessment to a wider area, or a larger number of areas, as part of the Stage 2 investigation.

The pilot study involved taking a greater number of samples from one area (Waynflete Square) and assessing that data in accordance with the requirements of the Part 2A statutory guidance. The soil data were compared against local and regional background concentrations, and soil screening levels designed to be protective of human health.

This process identified reported concentrations of lead, chloromethane, and PCBs (non-dioxin-like), and the identification of asbestos, as warranting further consideration. All other identified soil contaminants were screened out as not being of concern.

Following further investigation of screening criteria for asbestos, the concentrations of asbestos detected are unlikely to pose a significant possibility of significant harm to health as they do not exceed screening criteria designed to be protective of human health.

More detailed evaluation for the other COPC included calculation of potential representative average concentrations, review and comparison with typical background concentrations, and consideration of exposure from other non-soil (and non-fire related) sources (e.g. dietary intake). The assessment concluded that this area of land meets the statutory definition of “Category Four” and therefore does not meet the statutory definition of contaminated land.

Other relevant considerations in the assessment are that lead is not necessarily a contaminant directly associated with the fire, and the reported concentrations in the pilot study area may result from other pre-existing urban sources. Asbestos may have been released during the fire, but it is not possible to directly attribute the asbestos that has been detected to the fire.

Overall the risk assessment undertaken suggests that the health risk posed by the identified levels of contaminants in the soil in this pilot study area is low and therefore does not warrant further action under Part 2A. Further investigation should only be justified on the basis of minimising uncertainty so far as is relevant, reasonable and practicable.

Full details of the risk assessment are provided in **TN17** which is appended to this report.

8. Conclusions and Recommendations for Stage 2

AECOM has carried out exploratory soil sampling, informed by a desk-based evidence review and the local community's experience, in areas of public open space and community kitchen gardens within a 1km radius of the Grenfell Tower with the primary objective of identifying the nature and potential extent of soil contamination that has resulted from the debris and particulate fallout from the Tower fire in June 2017.

The desk-based evidence review has established a list of chemicals that may have been released from the fire, the potential toxicity and environmental fate of those chemicals, and the other potential sources of those chemicals that result in them being detected in soil and in people being exposed to them. The valuable information from the community has identified that there was an area around the Tower that extends to less than 500m to the south and east of the Tower within which debris fell during and immediately after the fire. The Met Office modelling and community information also suggests that the fallout area extends in a north-westerly direction to beyond 1km, with one reported observation of ash in the air close to ground level over 3km to the northwest in an allotment in the London Borough of Brent. Small fragments of debris that could have originated from fires were observed in soil sampled during the exploratory sampling exercise. It cannot be determined whether the material originated from the Grenfell Tower fire or is material related to other historic fires.

The analytical results from the testing of the exploratory soil samples did not detect the presence of chemicals such as brominated flame retardants, which could be associated with emissions from building fires; whilst chemicals of potential concern such as polycyclic aromatic hydrocarbons (PAHs) and lead that were measured at elevated concentrations are commonplace in urban environments and could have originated from historic sources. No clear spatial pattern in the results has been seen, providing no obvious evidence of a difference in soil concentrations clearly affected or likely to be less affected by the fire.

Because of the lack of a clear pattern in the data, and the fact that chemicals were either not detected or are at concentrations that are not clearly different to background, the exploratory sampling has not established clear evidence for land contamination from the fire, nor established that further investigation would likely identify soil contaminant concentrations that could result in the land being determined as contaminated land under Part 2A. The objective of Stage 1 was not however to provide concrete conclusions, rather assist in the planning and design of Stage 2.

A methodology was developed for the preliminary risk assessment that enabled contaminant linkages to be prioritised on the basis of a number of evidence factors. The Stage 1 information was additionally considered in **TN18** and the COPC placed into the priority groups available for them.

Table 9. COPC classification

Prioritisation	Priority Group Description			COPC
Lowest	Most if not all results less than suitable method detection limits (MDL) and/or sample depth and location inconsistent with potential exposure pathways			Brominated flame retardants, phosphate ester flame retardants, isocyanates, VOCs (excluding chloromethane), asbestos and SVF, non dioxin like PCBs
Low	Most results above MDL and sample depth and location consistent with potential exposure pathways, but no indication of spatial patterns or hot spot consistent with fire emissions	All results at or below a relevant GSC	All results considered to be within typical background levels	Cyanides, metals (other than lead), chloromethane, dioxins, furans & dioxin-like PCBs, cresols
Medium	Most results above MDL and sample depth and location consistent with potential exposure pathways, but no indication of spatial patterns or hot spot consistent with fire emissions	Some results well-above a relevant GSC	Some results above typical background levels	Lead, PAHs (with BaP as a surrogate marker)
High	Results above MDL and	Majority of results	Majority of results	None

Prioritisation	Priority Group Description			COPC
	sample depth and location consistent with potential exposure pathways. Results indicate a strong spatial pattern and/or hot spot(s) that are consistent with fire emissions	above relevant GSC and many results well-above a relevant GSC	above typical background levels	
Highest	Results above MDL and sample depth and location consistent with potential exposure pathways. Results indicate of a strong spatial pattern or hot spot that is consistent with fire emissions	Majority of results well-above a relevant GSC	Majority of results well-above typical background levels	None

Even though it has not been determined that the detected concentrations of lead and PAHs have resulted from the fire, the contaminant linkages associated with these two COPC have been identified as those with the greatest justification for further investigation because of the number of sample concentrations reported above generic screening criteria and normal urban background concentrations.

As noted in Section 6.2 above, Part 2A justifies continuation of the investigation of land if there is a reasonable possibility of a significant contaminant linkage (that is a contaminant linkage that could result in the land being determined as contaminated land). The Statutory Guidance states that local authorities should stop the investigation of land if there is not a reasonable possibility of a significant contaminant linkage, or if information already obtained is sufficient for the local authority to decide whether the land is contaminated land or not.

Uncertainty is an important consideration in the risk assessment process under Part 2A and local authorities are required to minimise uncertainty in the assessment where it is relevant, reasonable and practicable to do so. In view of this, it is considered appropriate to include asbestos and dioxins, furans and dioxin-like PCBs in the analytical scope for Stage 2. They have been identified as potential fire effluents and have been commonly (in the case of dioxins) or erratically (in the case of asbestos) detected in soil. The absence of detectable concentrations of other possible fire effluents such as the flame retardants and isocyanates does not justify their inclusion in Stage 2.

In view of the outcome of the PRA, and the objectives and scope of the exploratory investigation, it is considered that a further, targeted investigation at Stage 2 is justified in accordance with Part 2A to collect sufficient information so that all required stages of risk assessment can be completed to allow the Local Authority to make an informed decision with regard to the Part 2A status of the land under investigation. .

It is recommended that the Stage 2 investigation should target single areas of land and investigate that land in a systematic way to assess the potential risks under Part 2A. 34 specific areas of land have been recommended in **TN18** based on the following selection criteria:

- Schools and community kitchen gardens located within 500m of the Tower in any direction.
- Schools and community kitchen gardens located up to 1,000m from the Tower in a north-westerly direction.
- Public open spaces to fill notable gaps in spatial coverage (once schools and community gardens have been identified) using the same distance criteria (i.e. 500m from Tower in any direction and up to 1,000m from the Tower in a north-westerly direction).
- Schools and other public areas predominantly identified based on requests for testing, or concerns about impacts, raised during community engagement prior to or during the Stage 1 assessment (reported in **TN14**).

It is recommended that testing includes soil and produce grown in community kitchen gardens and allotments for lead; PAHs; asbestos; and dioxins, furans and dioxin-like PCBs.

Full details and justifications of the design for Stage 2 are provided in **TN18** which is appended to this report.

9. References

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Appendix 1. Technical Note 01 – Final Specification for the Stage 1 Investigation

Appendix 2. Technical Note 02 – Proposed Protocol for Desk-based Evidence Reviews

Appendix 3. Technical Note 03 – Protocol for Initial Soil Sampling

Appendix 4. Technical Note 04 – Fire Chemistry and Identification of COPC

Appendix 5. Technical Note 05 – Fate of Debris – Deposition, Spread and Clean-up

Appendix 6. Technical Note 06 – Review of Met Office Air Dispersion Modelling

Appendix 7. Technical Note 07 – Review of Fire Effluent Environmental Fate and Transport

Appendix 8. Technical Note 08 – COPC Toxicity

Appendix 9. Technical Note 09 – Published Data on National and Regional Urban Background Concentrations

Appendix 10. Technical Note 10 (including TN12) – Potentially Contaminative Land Uses and Local Background Soil Concentrations

Appendix 11. Technical Note 13 – Potential Source Contributions to Urban Soil Pollution

Appendix 12. Technical Note 14 – Collated Community Information

Appendix 13. Technical Note 15 – Factual Data from Exploratory Sampling and Pilot Study

Appendix 14. Technical Note 16 – Preliminary Risk Assessment

Appendix 15. Technical Note 17 – Pilot Study Part 2A Risk Assessment

Appendix 16. Technical Note 18 – Stage 2 Design

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