Guidance Note

Dealing with coal tar bound arisings

Prepared for

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CH2M

Dealing with coal tar bound arisings

Contents

Appendices

i. Executive Summary

Until the mid-1980s coal tar based materials were used in carriageway construction; and locally their use may have continued after this period due to their resistance to diesel. Road tar is a complex mixture of hydrocarbons, derived from coal tar; some of which are carcinogenic and highly toxic to aquatic life. Bitumen is used in present-day construction and it is important to distinguish it from road tars, because although derived from crude oil, bitumen contains a lower proportion of PAHs. It therefore presents a far lower risk to the environment and human health. However, it is possible for bitumen to be contaminated by coal tar, as over time tar products can migrate.

Current guidance indicates that where the concentration of potentially carcinogenic hazardous substances is below 0.1% waste does not need to be classified carcinogenic. Benzo(a)pyrene (BaP) is used as a marker compound for carcinogenicity of certain coal tar entries. The assertion is that 50mg/kg (0.005%) concentration of BaP correlates to around 1000mg/kg (0.1%) coal tar. Thus, where BaP is less than 0.005%, the amount of coal tar is considered low enough for the material to be considered Non-Hazardous.

Several factors control the chemistry of coal tar; therefore because of its variability no single test is currently available which directly measures its concentration. Current methods range from visual identification only, through to identification and quantification by chemical analysis to assist in apportioning coal tar as the contributing source. Despite this, however, a definitive result is not produced. At best, by undertaking a combination of tests in a staged approach, the field of possibilities is narrowed. However, where other coal tar derived products are also present, these may mask the results or create false positives. The likelihood of other products being present must therefore be assessed to determine the accuracy of the results. As such, after extensive and costly testing, there remains in the results an element of uncertainty which cannot be eliminated. Information regarding the constituents of coal tar in various forms is provide in Appendix A

Under the Construction (Design and Management) Regulations 2015 it is the Designer’s responsibility to minimise construction hazards and to inform the Contractor of any remaining hazards on site. Therefore, due to the risk to human health and the environment, coal tar must be assumed to be present within the carriageway construction until proven otherwise.

Presently within Scotland coal tar cannot be reused in highway construction, it can only be disposed of. With rising disposal costs and an aging network, it is important that the presence of coal tar is established prior to disposal, not only to ascertain the level of risk to human health and the environment, but also to prevent unnecessary disposal.

This guidance note offers a safe method of working when dealing with potentially coal tar bound arisings; and is based on current guideline documents with regards to sampling and handling. Guidance is given with regards to assessing the potential for coal tar to be present within the carriageway construction in Appendix B as a series of flow charts. Guidance in scheduling the laboratory testing is presented in Appendix C. Guidance in assessing and reducing the risks during operations to construction workers, local residents and the wider environment is presented in Appendix D.

ii. Introduction

Background information

Coal tar is a by-product of coal carbonisation and historically was used as a source of organic chemicals until the massive expansion of the petrochemical industry after the Second World War. The process involves heating coal in the absence of air to produce coal gas, coke, tar and ammoniacal liquor. The coal tar produced was then subjected to fractional distillation and chemical processing, resulting in a range of mixed hydrocarbons and other products such as creosote, pitch and road tar. In its raw state coal tar is a viscous brown/black liquid with a distinct 'organic' pungent odour, which may make it identifiable even when mixed with other materials (ref. Department of the Environment Industry Profile – "Gas works, coke works and other coal carbonisation plants", 1995).

Bitumen-based surfacing materials predominate in present-day road construction in the UK, but coal tar pitch based materials could have been used in all pavement layers, including surface dressings up until the mid-1980s. Isolated materials may also be found in later road construction schemes where it may have been used due to its resistance to diesel. Road tar is a complex mixture of hydrocarbons derived from the high temperature treatment of coal tar; some of these have been shown to be carcinogenic, others are highly toxic to aquatic life, whilst some are both. A number of marker compounds (e.g. Benzo[a]pyrene, phenols and cresols) are used to identify the presence of these potentially hazardous and toxic aromatic hydrocarbons. However, some phenols and cresols are also toxic to aquatic organisms, and some are carcinogenic. Phenols are also relatively soluble in water and therefore can leach easily (ref. ADEPT 2016).

ADEPT (2016) states that as road tar is processed from coal tar it does not contain all the chemicals that are present in unrefined coal tar. In particular, there will be few volatile organic compounds (VOC), as it was usual for most of the Phenols and Cresols to be removed, to make other products. Despite this, road tar still contains carcinogenic compounds. Furthermore, as road tar and bitumen are both miscible, *"over time it is possible for some tar products to migrate into the adjacent bituminous layers, and vice versa"* (ref. ADEPT, 2016)

It is important that road tar is distinguished from bitumen. Typically, bitumen is derived from crude oil, and contains a lower proportion of polycyclic aromatic hydrocarbons (PAHs), by several orders of magnitude, than coal tar and therefore presents a far lesser risk to the environment and human health. As such, milled uncontaminated bituminous asphalt road planings can be used with the same environmental precautions as would be applied for virgin material (ref. Quarry Products Association and SEPA – Guidance on the Production of Fully Recovered Asphalt Road Planings). The issue of coal tar bound arisings therefore potentially presents a long-term and widespread challenge, especially with an ageing road network where there are ongoing maintenance requirements.

Further information of the chemical composition of coal tar, including human health effects and environmental impact are given in Appendix A of this document.

Existing waste classification and re-use

The definition of waste, as given in the Waste Frameworks Directive (2008/98/EEC) is:

"Any substance or object which the holder discards or intends or is required to discard". The holder being the person who produces or is in possession of the waste. Hazardous waste *'means waste which displays one or more of the hazardous properties listed in Annex III'.*

With reference to Annex III of the Waste Framework Directive, coal tar is deemed to be hazardous as it is considered to be an irritant (H 4), harmful (H 5), toxic (H 6), carcinogenic (H 7) and ecotoxic (H 14);

with components of coal-tar considered to be toxic for reproduction (H 10) and mutagenic (H 11) (see Appendix A).

With reference to the SEPA document, “Is it Waste?” (2005), regulatory controls apply to waste until it is fully recovered, thereby ceasing to be waste. Whether the waste has a value i.e. scrap metal or that the holder may have a use for it, does not necessarily mean that it is not being discarded nor that is has been fully recovered; therefore, it is still considered waste. Road planings, regardless of composition are therefore considered waste.

In the UK, the three Environment Agencies (Environment Agency (EA), Scottish Environmental Protection Agency (SEPA) and Natural Resources Wales (NRW (formerly the Environment Agency Wales)) take the view that road planings, regardless of composition are considered to be waste. In addition to those stored with no identifiable end use this also includes recycled asphalt produced to a relevant specification; and as such, this material will be subject to regulatory waste controls. Anyone producing, managing, importing or transporting these materials must comply with the requirements of the relevant Duty of Care regulations (including CDM Regulations 2015) and possess all appropriate permits and licences (ref. ADEPT, 2016). All UK waste regulations are based on European legislation, with the classification of waste road planings containing bituminous mixtures (including coal tar) driven namely by the Hazardous Waste Directive (1991). As a result, there are only small differences in the approach to dealing with waste, between Scotland, England, Wales and Northern Ireland.

The Hazardous Waste Directive (1991) provides a definition of waste and the framework for the correct management and regulation of hazardous waste throughout Europe. The European Waste Catalogue (EWC) is a catalogue of wastes and with regard to bituminous road planings; there are three associated waste codes:

For Asphalt material classified in the List of Wastes:

- 17 03 01* bituminous mixtures containing coal tar
- 17 03 02 bituminous mixtures other than those mentioned in 17 03 01
- 17 03 03* coal tar and tarred products

17 03 03* is an absolute hazardous waste code that is used to classify waste tar, including coal tar.

The guidance document “Guidance on the classification and assessment of waste (1st edition 2015) Technical Guidance WM3”, published by NRW, SEPA, NIEA and EA states that:

“If the concentration of potentially carcinogenic hazardous substances is at or above 0.1% the waste possesses the hazardous property HP7 carcinogen. Coal tar is a complex mix of hydrocarbon compounds which have to be added together to determine the concentration of coal tar. Therefore, the 0.1% concentration must be applied to all fractions of the coal tar. Assessments based on PAH’s alone are not consistent with the legislation and cannot be used to classify a waste as non-hazardous.”

“However, if the concentration of coal tar is known, Table 3.1 of the CLP Regulations (Classification, Labelling and Packaging of Substances Regulations; EC 1272/2008) uses Benzo[a]pyrene as a marker compound for carcinogenicity for certain coal tar entries. Where the concentration of Benzo[a]pyrene is less than 0.005% of the coal tar (rather than the waste as a whole), the coal tar is not carcinogenic and does not need to be considered for HP7”.

The following applies only to Asphalt material classified in the List of Wastes as:

- 17 03 01* bituminous mixtures containing coal tar

- 17 03 02 bituminous mixtures other than those mentioned in 17 03 01

Where the concentration of Benzo[a]pyrene is at or above 50 ppm (mg/kg) in the black top alone (excluding other material) then the amount of coal tar should be considered to be sufficient (0.1% or more) for the material to be hazardous and thus coded 17 03 01*. The assertion is that 50mg/kg (0.005%) correlates to around 1000mg/kg (0.1%) road tar (ref. ADEPT 2016). Subsequently where concentrations of Benzo[a]pyrene are below 50 ppm, then the amount of coal tar is considered sufficiently low enough for the material to be considered non-hazardous and thus coded 17 03 02.

As such when sampling the black top care is needed to ensure that if there are multiple layers that each is sub-samples in order to identify if there are layers with different concentrations of Benzo[a]pyrene.

For the above, the asterix (*) identifies which wastes are classified as Hazardous Waste, termed Special Waste in Scotland. Its noted that in both cases bituminous mixtures containing road tar are only classed as Hazardous Waste/Special Waste; if threshold concentrations are exceeded (referred as a "mirror entry" in the EWC).

'Mirror' entries refer to waste considered Hazardous Waste/Special Waste if the hazardous substance(s) it contains are above a specified threshold concentration(s). Alternatively, waste that is always Hazardous Waste/Special Waste, regardless of the concentration of the dangerous substance(s) in it are termed 'Absolute' entries and are denoted by an asterix *. As such whilst 17 03 01* is an Absolute entry, the Mirror entry is 17 03 02 (ref. www.netregs.org.uk and EWC).

With reference to WM3 '*the mixing of different types of hazardous waste, and of hazardous waste with other waste, substances or materials is prohibited by article 18 of the Waste Framework Directive, unless carried out at a suitably licensed facility that meets certain conditions*'. An exception to this being mixed municipal waste from domestic households.

Furthermore in Scotland each waste present must be described and the '*multi-coding of mixed wastes is not allowed and you should classify the waste, on the Special Waste Consignment Note, using a LoW* (List of Waste) *code that reflects the processes that produced the waste and ensures that the most appropriate disposal route is followed'*. Regulation 17A of the Special Waste Amendment (Scotland) Regulations 2004 imposes a duty on those who transport, recover or dispose of Hazardous Waste/Special Waste mixed with other waste, substances or materials, to separate it. This requirement applies where it is technically and economically feasible, and necessary in order to ensure that the waste is recovered or disposed of without endangering human health and without using processes or methods, which could harm the environment (ref. Special Waste Amendment (Scotland) Regulations 2004 – frequently asked questions)

Within England, the approach of the EA enables waste classified as 17 03 01* (i.e. hazardous) to be recovered wherever possible, as detailed within the regulatory position statement "The use of treated asphalt waste containing tar in construction operations" (number 075; March 2014). The regulatory position statement only applies to the final use of the treated material in construction operations; i.e. the material, as do all road planings, will remain "waste" up until the point of use. Further details regarding re-use are provided within the research documents produced by CH2M Hill "Dealing with Tar Bound Arisings and Producing a Safe System of Work" (March 2015).

SEPA and the Quarry Products Association (QPA) have issued "Guidance on the production of fully recovered asphalt road planings". However, as stated in the document the guidance applies solely to source segregated asphalt road planings covered by the European Waste Catalogue Code 17 03 02 (i.e. non-hazardous). It does not cover bituminous mixtures containing coal tar (17 03 01*) or coal tar and tarred products i.e. 17 03 01* and 17 03 03*. These are classed as Special Waste (Hazardous Waste). As such, currently there is no regulatory position for the reuse of planings containing tar within Scotland. All wastes containing tar are therefore treated as Special Waste (Hazardous Waste) within Scotland.

As waste disposal costs continue to rise it is important that the presence of coal tar within arisings is established prior to disposal or reuse. Not only to ascertain the level of risk to human health and the environment, but also to prevent unnecessary disposal and the associated costs incurred.

iii. Scope

This document is part of the second phase of a two-phase scope of works regarding the legacy of coal tar bound road arisings. Following on from stage 1, the objective of stage 2 is the development of guidance documentation suitable for use by all appropriate stakeholders; which makes the process of assessing and dealing with coal tar bound arisings easier and more transparent. The purpose of this document therefore is to provide practical guidance on the planning and preparation for investigation; sampling and testing protocols; the interpretation of laboratory test results and the safe handling, transportation, storage, reuse and disposal of coal tar bound road arisings. Included within this document is information regarding the currently available laboratory testing and its ability and reliability in the identification and quantification of coal tar. This document also includes guidance on handing; transportation and storage for road planings should laboratory testing identify the presence of coal tar bound arisings on site.

Guidance Note

1 Sampling protocol

1.1 Planning/preparation

1.1.1 Construction (Design and Management) Regulations 2015

It is the Designer's responsibility under the Construction (Design and Management) Regulations 2015 (CDM 2015) to minimise construction hazards and to inform the Contractor of any remaining hazards on site. Where excavations through the carriageway are planned, it is the Designer's responsibility to inform the Contractor, should records exist that indicate the likely presence of coal tar within the carriageway construction. The absence of any records should not be taken as proof that coal tar is not present within the carriageway construction and therefore it should be assumed to be present until proven otherwise.

For small scale schemes such as patching works it may be cost effective to assume that the pavement layers contain coal-tar bound arisings when there is uncertainty to its presence. One disadvantage of this is that under CDM Regulations (2015) the Designer will need to inform the Contractor that coal tar may be present on site. This may in turn require unnecessary mitigation measures to be adopted to prevent risk to human health and the environment. Secondly, uncontaminated material could be unnecessarily disposed of, resulting in unnecessary associated costs (ref. Construction Manager, May 2013). Disposal to landfill is however unsustainable and costly; therefore this may not be an option in the future.

Any available evidence confirming the absence, or presence, of coal tar within the carriageway should be made available to the Contractor prior to undertaking any works. This information should also be provided to any others who may be involved in handling, storing and/or processing any arisings (ADEPT, 2016). For further guidance, reference should be made to Flow Chart A, which is located within Appendix B of this document.

1.1.2 Third party companies

In order to ensure the safety of third party companies who intend to undertaken works requiring excavation through the carriageway construction; for example utility providers; it is the Designer's responsibility under CDM Regulations (2015) to inform site operatives of any hazards on site. Under the New Roads and Street Works Act 1991, Section 50 a 'Street Works License' (ref. New Roads and Street Works Act; 1991) is to be obtained from the relative authority before digging up the public highway to repair or place new service apparatus. Although essentially the same licence, different authorities have different conditions concerning the requirements and limitations covered by the licence, and the length of notice required. It is therefore recommended that the relevant authority be contacted a minimum of six weeks ahead of any proposed works to ensure sufficient time in which to process the application.

It is the responsibility of the Designer of any third party works to establish whether coal tar bound, arisings are present on site. It should be assumed to be present until proven otherwise. As such, the Designer should request as built and historical laboratory records during the planning stage.

For small schemes, less than 30m^2 in size, where no existing information is available, it may be more cost-effective to assume that coal tar bound arisings are present within the carriageway. However, in doing so Safe Working Practices must be adopted, with regards to excavation, handling, transportation, storage and disposal of materials. In all instances where coal-tar bound arisings are unknown, suspected or have previously been proven, the Designer should consult with the land owner before proceeding with any works, in order to agree the proposed course of action. The results of any laboratory testing; be it confirming the presence or absence of coal-tar bound arisings within the pavement construction must be sent to the relevant Local Authority for their records and future reference.

It should be noted that historically coal tar has been used as a protective coating to some utilities, therefore the risk of coal tar may remain on site despite coal-tar bound arisings being absent from the pavement construction (ref. HSG47, 2014). This is however outside the scope of this report.

1.1.3 Determining the carriageway construction

The first step in determining whether coal tar is likely to be present is by identifying the date of construction. As-built records, where available, will provide information on the original construction design and may be available from the relevant authority's Pavement Management Systems. These records alone are however, unlikely to give the level of detail required to remove the need for investigation.

Generally, coal tar based materials were used in layers of pavement construction; including the surface dressing up until the mid-1980s. Although the use of coal tar may have continued in isolated areas after this date, it is generally assumed, that for roads constructed after the mid-1980s the presence of coal tar is unlikely. Not all surfacing prior to this date contained coal tar and therefore, there is the risk that coal tar and bitumen were used interchangeably in the same construction course. Consequently, the location of tar bound materials could be unpredictable (ADEPT, 2016).

It is important that the extent and depth of any coal tar affected layers be identified. Road cores provide an effective means of sampling and should be used for identification purposes. Alternatively small pits may be excavated, however this is a much slower and a more expensive method in comparison to coring and therefore should not be used unless unavoidable.

It is recommended that cores of the road be taken ahead of any works as this will aid in determining whether coal tar containing materials can be left undisturbed, and allows the removal process to be designed. In addition testing of arisings ahead of the works, preventing delays on site.

Rigid pavements are constructed from slabs of steel reinforced cement concrete. Unlike flexible pavements, their construction does not involve the use of coal tar products and as such, these roads do not normally require investigation. However, should as-built records indicate, or it is suspected, that the rigid pavement overlies an earlier flexible pavement, cores should be undertaken to allow for sampling and testing to confirm the absence of coal tar layers.

Coring through any carriageway must be carried out in accordance with current Health and Safety legislation and with the appropriate traffic management in accordance with the Traffic Signs Manual, Chapter 8 (2006) (ref HD29/08 – Section 7.3) or equivalent local standard. In locations where there may be buried services, the public utility organisations must be contacted for details of the locations of their plant. The location of buried services should be confirmed before undertaking any works. At each borehole location, a Cable Avoidance Tool (CAT) should be used to confirm the absence of buried services prior to commencing works. A competent and qualified person, to ensure that the survey is undertaken correctly, must use the CAT. In situations of doubt, the Designer should be informed so that the position of the borehole may be reassessed. This is an occasion where a hand-excavated pit may be required.

1.2 Geophysical Surveying

1.2.1 Ground-Penetrating Radar

Where the thickness of the pavement has been identified to be or is suspected to be variable, a Ground Penetrating Radar (GPR) survey may be undertaken to identify where changes in thickness occur. This can be a useful tool to identify the edges of former road widening schemes, which can form the limit of coal tar affected layers.

Reference is made to HD29/08 Data for Pavement Assessment, Section 6, which provides guidance on the use of GPR as a non-destructive tool to obtain information about the pavement construction. GPR surveys may also be undertaken ahead of any works in order to identify the presence of buried services beneath the site.

1.3 Sampling methodology

1.3.1 Sampling plan

With reference to WM3, a sampling plan will need to be prepared before any sampling is undertaken. This is to ensure that all relevant factors are considered and that sufficient representative samples are taken. This will ensure that the works are properly planned and executed, ensuring accurate and reliable results and confidence in their interpretation (ref. WM3, 2015).

The sampling plan should identify the sample locations, restrictions to access and any problems, which occurred during the works, which may have affected the quality of the sample.

For further guidance, reference should be made to Flow Chart B, located within Appendix B of this document.

1.3.2 Core diameter

Typical core barrel diameters are 100mm, 150mm and 200mm although some Contractors may be able to cater to cores of up to 300mm diameter. Typically, the sample sizes required by laboratories ranges from 50g to 100g, although some may require samples of up to 250g. This should be confirmed prior to coring to ensure sufficient samples will be obtained, and may need amending on site if multiple thin layers are identified. The core size and uniformity of the core should be periodically reviewed throughout the process, to ensure that sufficiently large samples are obtained. The requirement for a potential switch to larger core barrels should be communicated to the appointed Contractor prior to mobilising to site

Core barrels of a minimum diameter of 150mm should be used where the condition of the carriageway construction is poor to increase the likelihood of good recovery (ref. HD29/08 – Section 7.4).

1.3.3 Number and location of cores

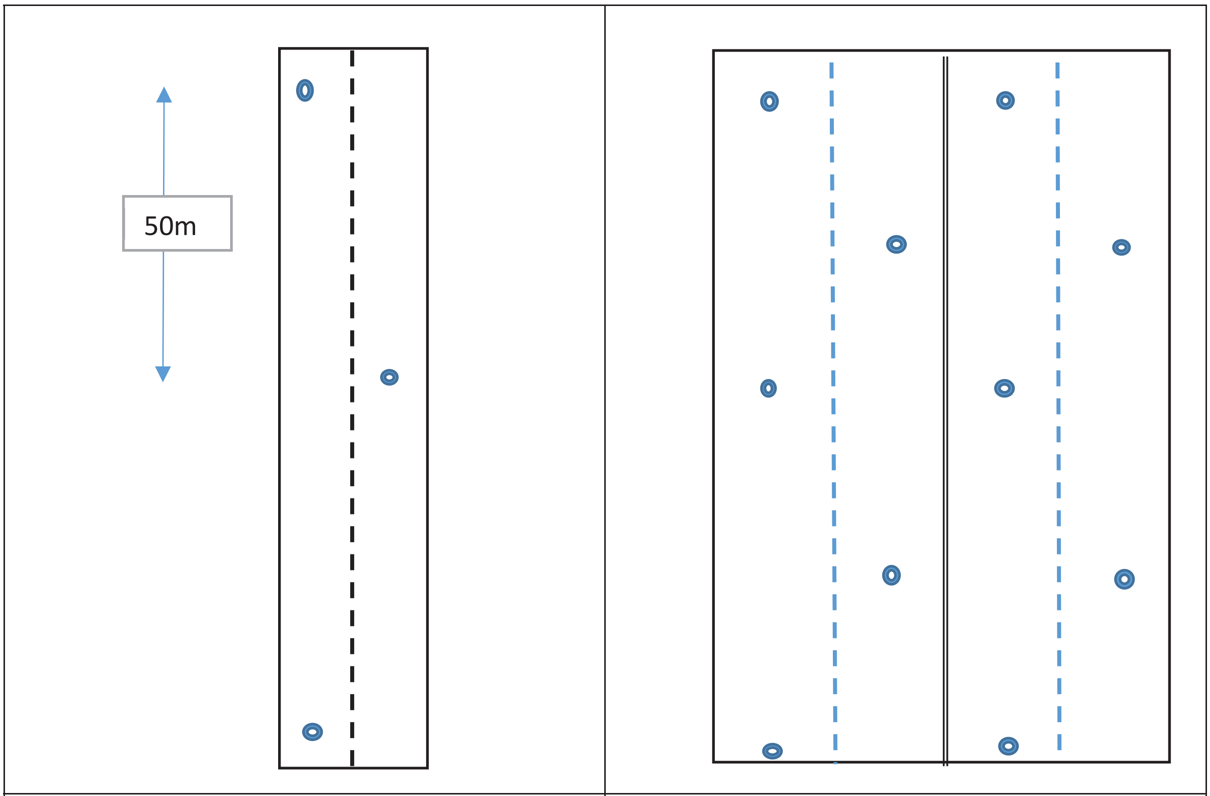
Road cores will provide information of the composition and condition of the carriageway. The number of cores taken will depend on the extent of the scheme, existing knowledge of the carriageway construction and the variability of its composition. The number of cores taken should be sufficient to confidently determine the structure of the road and the extent of any layers containing coal tar. If information exists, that is sufficient to enable the road construction to be identified and the binders can be definitively established, then the extent of the investigation and the frequency of sampling may be reduced (ADEPT, 2016)

1.3.3.1 Unknown carriageway construction or areas with inadequate existing information

Where no previous testing has been undertaken; or existing records are inadequate, and coal tar layers are believed to be laterally extensive; as a minimum one core every 50m length should be taken for single lane carriageways (ref Figure 1A). For dual carriageways, the cores should be staggered between the lanes so that as a minimum one core shall be taken every 25m between lane 1 and lane 2 (ref. Figure 1B). For roads of three lanes or greater a similar sampling frequency should be adopted to ensure that as a minimum the spacing between cores within each individual lane does not exceed 50m, with an interval of 25m between cores in adjacent lanes. Where hard shoulder pavement exists, cores should be undertaken at the same frequency and arrangement as outlined above (ADEPT, 2016). It is recommended that a minimum of three cores should be taken unless a site is less than 30m² then one core is considered adequate (ADEPT, 2016).

Where the carriageway construction is unknown and there is potential for coal tar layers to be, laterally variable it will be necessary to characterise the carriageway construction. This may be done by undertaking a GPR survey and/or by undertaking coring in stages. The extent of the variability of the pavement construction along a section will govern the location and number of cores taken. As a minimum, the frequency shall reflect the guidance given above for single, dual, hard shoulder and roads of three lanes or greater, where the carriageway construction is unknown but coal tar layers are believed to be laterally extensive. If however the construction is found to be significantly variable once planed, justification will need to be given if the number of cores taken does not meet the minimum frequency outlined. Further cores may then be required.

Figures 1A and 1B - Indicative core spacing



1A: Indicative sampling layout for single carriageway or single track road	1B: Indicative sampling layout for dual carriageway.

1.3.3.2 Known carriageway construction and/or areas with adequate existing information

In areas where the road has been found to be of uniform construction and testing has previously been undertaken; the records of which have been confirmed as being adequate and complete by a suitably qualified professional, additional testing is recommended to confirm the initial results. The sampling frequency outlined above may however be reduced to avoid taking unnecessary samples. For single lane carriageways, a minimum of one core every 200m should be taken (ref. Figure 1A but increase from 100m to 200m spacing's). For dual carriageways, the cores should again be staggered between lanes so that as a minimum one core is taken every 100m between lane 1 and lane 2 (ref. Figure 1B but increase from 50m to 100m spacing's). For roads of three lanes or greater a similar sampling frequency may be adopted, however as a minimum the spacing between cores within each individual lane should not exceed 100m in adjacent lanes. Where hard shoulder pavement also exists, a similar frequency is recommended. It is however, still recommended that a minimum of three cores be taken unless the site is less than 30m$^{2;}$ then one core is considered adequate (ADEPT, 2016).

1.3.3.3 Localised coal tar bound arisings

Where records indicate that coal tar may be localised, the position and frequency of the cores should reflect this.

1.3.3.4 Confirming longitudinal extent of coal tar layers

Where it is necessary to confirm the longitudinal extent of coal tar layers, cores should be take outside the known or suspected limits of the material. These samples shall also be tested in order to confirm the absence of coal tar bound arisings.

1.3.3.5 Location of cores

The cores shall be located within the centre of each lane to avoid the running track, unless the centre cannot be accessed due to health and safety requirements, or available records indicate that coal tar layers may not be spread beneath the entire carriageway. This is a potential restriction where roads have been widened in the past.

Alternative positions shall be agreed with the Designer and any changes to the planned locations accurately recorded.

1.3.4 Coring

1.3.4.1 Dust suppression and handling

Until proven otherwise it should be assumed that all cores contain coal tar layers and as such the core should be handled using disposable or PVC gloves to avoid dermal contact.

To avoid the generation of dust and thus avoid the inhalation of potentially coal tar contaminated material the Contractor shall employ an appropriate dust suppression system when coring through the carriageway. Potentially contaminated surface water run-off should not be allow to enter the drainage system or the environment. The use of task-specific facemasks should also be considered.

1.3.4.2 Depth

The core should be extended through the full thickness of the carriageway construction to determine the total thickness and to sample the deeper and subsequently older layers, this is normally around 0.5m, but could be greater. Typically, rigs are capable of drilling to a depth of 1m, although some Contractors may have extension rods allowing greater depths to be achieved if necessary.

As-built information, if it is available, will provide an indication of typical anticipated thickness. It is unlikely that pavement construction will exceed a thickness of 1m in most cases and such thicknesses will typically be localised, often associated with repeated patching.

The core axis shall be within 5° of the normal axis to the pavement (ref. BS EN 12697-36:2003)

1.3.5 Sampling – sub-base, made ground and superficial deposits

Sampling of the sub-base and underlying made ground or superficial deposits is not required for the analysis of coal tar. If however, the proposed works could involve the excavation of sub-base/ capping, consideration should be given to obtaining samples of the sub-base for laboratory testing. The sample container used should not cause contamination of the sample, nor should is absorb any sample components or allow volatile organic to be lost (ref. BS 10175:2011+A1:2013). The headspace should also be kept to a minimum to limit the loss of volatile contaminants. Each of the samples shall be clearly marked as potentially containing coal tar.

1.4 Sample preservation

1.4.1 Intact core

Where the full thickness of the pavement construction is recovered as a complete core, the core should be wrapped in multiple layers of cling film and sealed. The core should be clearly labelled (including top and bottom), and securely stored to prevent damage.

1.4.2 Fragmented core

Where the core is fragmented, care should be taken to prevent cross-contamination of the layers. Each disintegrated layer should be placed within its own glass jar with the headspace kept to a minimum to limit the loss of volatile contaminants. Each sample should be clearly labelled to prevent samples from being lost. As with an intact core, the fragmented sample should be carefully sub-sampled to segregate layers of construction. The sample container used should not cause contamination of the sample, nor should is absorb any sample components or allow volatile organic compounds to be lost (ref. BS 10175:2011+A1:2013). It is recommended that the Contractor discuss appropriate sample containers and storage with the intended laboratory ahead of mobilising to site to prevent degradation of samples. Further guidance is given is BS 10175:2011+A1:2013, Section 8.5.

1.4.3 Planings derived from any source

Guidance is provided in BS EN 932-1 (1997) and ADEPT (2016) Guidance Document, Appendix B2.3 with regards to sampling and testing of this material.

1.4.4 Groundwater samples

It is not recommended that water encountered within the core holes be sampled. This is because it will have been contaminated by the water flush used to aid coring and therefore is unlikely to be representative of the groundwater composition.

1.4.5 Labelling of samples

Each core, sample and/or container should be clearly labelled and include the following information

1. Contract/project number
2. Location
3. Sample reference number
4. Date and time of sampling
5. Method of sampling
6. Contractor

Each of the samples shall be clearly marked as potentially containing coal tar.

Each of the samples shall be suitably packaged so that no contamination or damage to the sampled materials takes place.

1.5 Reinstatement of boreholes

Reinstatement shall be undertaken in accordance with the local or national standard.

1.6 Surveying of boreholes

On completion of the works, the location of each core hole must be referenced against network sections to an accuracy of +/- 1m longitudinally and +/- 0.1m transversely from the nearside lane (Ref HD29/08 Section 7.1).

1.7 Sample transportation and storage

1.7.1 Responsibilities

The Principal Contractor shall take full responsibility for the care and storage of the core obtained from the investigation.

The Principal Contractor shall provide, in written format the details of how the samples are to be shipped from the site to the laboratory. This information is to be forwarded to the Designer for approval in a timely manner prior to the works commencing.

1.7.2 Sample temperature during transportation and storage

Samples are only representative of the material and area they were taken from for a specific length of time. This is termed the holding time, and will vary depending on the chemical. Samples and extracted compounds must be kept in the dark and at a cool temperature to ensure preservation (ref. BS 10175:2011+A1:2013).

Before being dispatched to the laboratory the internal temperature of the storage box is to be recorded on the appropriate chain of custody form. The maximum temperature during transportation is also to be recorded. The maximum temperature during storage and transportation should be no more than 4°C, and it is the responsibility of the Principal Contractor and subsequent subcontractors to ensure that this temperature is not exceeded at any point up to the point of testing.

2 Logging the core

2.1 Cleaning the core

The core should not be washed to remove dirt or grit accumulated by the drilling process as this could encourage the leaching of contaminants. However should dirt or grit obscure the surface preventing inspection and photographing, the material should be lightly brushed from the surface. For further guidance, reference should be made to Flow Chart B, located within Appendix B of this document.

2.2 Photographing the core

Natural lighting usually produces the best detail in photographs and is therefore preferred over artificial lighting that may mask features. Flash photography should be avoided, particularly when the core is wet as this too may obscure details. The core may require some support during logging and photographing. These should be strategically placed so they are out of camera shot.

2.3 Core log

2.3.1 Main description

It is recommended that for each core a full record of the core details be made in the form of a Core Log. An example of this is provided within HD29/08 – Section 7.7. Such detailed logging may assist in the identification of coal tar contaminated layers within subsequent cores, and provide information on the condition of the carriageway for future reference. The log shall include a good quality colour photograph with a scale strip and the core reference clearly visible. The core shall be logged and photographed within 24hours of the borehole having been completed. It shall be suitably re-sealed after photographing to limit the loss of volatiles.

The top and bottom faces of the core may not always be at 90° to the sides due to the condition of the pavement and relevant position of the rig at the time of coring. It therefore may be beneficial to the photograph to rotate the core along its axis until the body runs as parallel to the scale as possible.

Reference is made to HD29/08 Section 7.8 and 7.9, concerning the minimum details required for inclusion within the Core Log of each core.

Each layer within the core should be distinguishable by its interfaces, and may be discerned through the alignment of the aggregate. The thickness of these layers shall be determined following the guidance provide in EN12697-36:2003, “Bituminous mixtures – test methods for hot mix asphalt – Part 36: Determination of the thickness of a bituminous pavement”. By measuring the thickness of the layers identified as potentially containing coal tar, the potential overall content of the arisings may be calculated for any planed depth (ref. ADEPT 2016).

The material and layer type along with the nominal aggregate type should be recorded on the core log.

2.3.2 Cracking

Details of any cracking observed within the core will need to be recorded on the Core Log (e.g. longitudinal crack 150mm deep). Differentiation should be made between surface cracking and cracking which penetrates the core, similarly cracks that begin within a layer rather than at the surface shall also be differentiated (e.g. vertical crack from 15mm to 65mm deep). Cracking should also be detailed on the photograph, with any disintegration of the core also displayed to show the full drilled depth. The drilling depth can be confirmed by measuring the depth of the borehole and comparing this with the recovered core length. A variation of up to +/-15mm is considered acceptable (ref. HD29/08). Cores that are extracted in pieces from the core barrel will need to be pieced together. To avoid mixing the sequence of the fragments chalk/wax marks should be placed on the upper end of each part by the drillers, indicating the sequence in which the parts were extracted.

Guidance on the description and severity of cracking is given in Sections 6.9 to 6.25, HD30/08; ‘Maintenance Assessment Procedure’, with specific reference made to Table 6.2.

2.3.3 Missing or undistinguishable layers

Details of missing or undistinguishable layers should be included in the drill log with a valid reason if known. The term “Partially Disintegrated” shall be used when some of the layer is damaged but the majority is still intact and “Disintegrated” when the majority of the layer is damaged and remains in its component parts with bond destroyed. The position of damage within a layer may be referenced to the interface e.g. “at upper interface” or “at lower interface” where necessary.

2.3.4 De-bonding of layers

De-bonding at the interfaces between layers and layer segregation shall be highlighted and recorded on the Core Log.

2.3.5 Voids

The presence of voids in a layer shall also be reported and the frequency of voids should be described as High, Low, Medium or None. A High number of voids should be defined as where voids are all around the layer or there are two or more clusters of voids >5mm in diameter. A Low number of voids is defined as where the voids are less frequently positioned around the layer or in a cluster <5mm in diameter. The layer, location relative to the interfaces and the frequency shall be reported on the Core Log.

3 Sampling

3.1 Introduction

Reference should be made to the site's sampling plan ahead of undertaking sampling. Further guidance is given in Appendix D of WM3 (2015) and within Flow Chart B, located within Appendix B of this document.

3.2 Core preparation

Once layers for testing have been identified, the core should be cut and sampled for testing, dividing the core into sections for each construction layer, based on visual assessment. This should be as early as possible, ideally the same day and the samples stored in suitable containers that are clearly labelled. This task may be undertaken by the lab and must be determined before undertaking the works to ensure that there is no delay in testing.

The visual identification of samples for testing may be determined following guidance in the following section below; 'Test method; Visual identification only for sample selection'. This may be done on site or by the laboratory and must be determined before undertaking the works to ensure that there is no delay in testing.

Sample preparation for testing will be undertaken by the lab and will vary depending on the type of testing undertaken. Until proven otherwise it should be assumed that all cores contain coal tar layers and as such the core should be handled using disposable or PVC gloves to avoid dermal contact. The use of task-specific facemasks should also be considered when sub-sample to avoid inhalation of dust and/or vapours.

Guidance on correct sample preparation is given within the ADEPT 2016 Guidance document, which makes reference to BS EN 932-1:1997, BS EN 932-2:1999, BS EN 12697-28:2001 and BS EN 12697-6:2012.

3.3 Planings derived from any source

Guidance is provided in BS EN 932-1 (1997) and ADEPT (2016) Guidance Document, Appendix B2.3 with regards to sampling and testing of this material.

4 Testing protocols

4.1 Overview

The exact composition of coal tar is varied and depends on the source conditions, age of the material and processes used to produce the coal tar. Due to its chemical composition, there is no single test, which directly measures the concentration of coal tar.

Care should be taken when selecting a laboratory for testing as the test methods of laboratories varies significant from simply identifying the potential presence of coal tar to quantifying the amount of coal tar, and the concentrations of different components. The type of testing should be relevant to the scheme design and to the end use of the potentially coal tar bound arisings.

4.1.1 Testing timescale

Testing must be undertaken within a maximum of 10 days of sampling to prevent inaccurate results due to sample degradation.

4.1.2 UKAS accredited laboratory

In order to ensure that testing is adequately controlled in the laboratory, the sample preparation and testing laboratory must be UKAS (United Kingdom Accreditation Service) accredited as a minimum, to ensure confidence in the results. The accreditation of the laboratory must be determined before undertaking the works to avoid any delays in testing.

4.2 Handling of samples

Until proven otherwise it should be assumed that all cores contain coal tar layers and as such disposable or PVC gloves should be used when handling the core. Although the presence of PAHs may be detected by their odour, this is not recommended as one of the risks to human health is through inhalation of vapours/fumes; in addition to prolonged or repeated contact with skin; inhalation of excessive quantities of dust during cutting, drilling, planing or surface treatment of hardened asphalt.

4.3 Confidence and limitations of testing

Written confirmation should be obtained from the intended laboratory prior to scheduling any testing of samples for coal tar to ensure that, the results obtained are representative and that the degree of confidence in the results is clearly understood.

Tests based on detecting the presence of PAH (EPA 16) alone are unable to state whether concentrations of Benzo[a]pyrene are caused by other contaminates such as diesel. The presence of coal tar is therefore ascertained by also testing for phenol; and is based on the premise that coal tar does not contain very much phenol. This methodology is based on guidance given within the publication by ADEPT (2016).

Testing to determine the total % coal tar by means of gravimetric determination of toluene extractable matter are also unable to differentiate between coal tar and other hydrocarbon sources such as diesel, creosote, lube oil etc. This test is simply a means of determining if the gross level exceeds the threshold of 0.1%, at which concentration coal tar is classified to be Hazardous Waste/Special Waste. If the sample contain less than 0.1%, whether it contains coal tar or not becomes irrelevant with regards to waste disposal. However, should the sample contain greater than 0.1% further testing is required to determine if a concentration greater than 0.1% can be attributed to coal tar.

As discussed above testing to determine PAH concentration, in particular Benzo[a]pyrene by solvent extraction and analysis by Gas Chromatography-Mass Spectrometry (GC-MS) is also unable to definitively identify coal tar from other sources of contamination such as diesel.

Test methods based on extraction of contaminants at different pH levels to determine potential concentrations of both the acid and basic components of coal tar are also unable to definitively determine coal tar as the source of the contaminant. Instead, the presence and absence of certain compounds can assist in the apportioning of coal tar as the contributing source. This methodology is based on identifying components, which are less common in most routinely encountered hydrocarbon sources. However, these are not unique to coal tar and as such, samples containing products derived from coal tars (e.g. coal tar creosote) will display a positive result for coal tar.

These test methods use the more polar compounds as confirmation of coal tar, this is complicated by these being typically more water soluble/volatile than their PAH counterpart. Heavily weathered samples are therefore likely to have lost these key markers, potentially limiting the reliability of the results and the procedure.

By undertaking a combination of these tests in a staged approach, the field of possibilities is narrowed and it becomes increasingly likely that contamination can be accurately attributed to coal tar.

There is a possibility that, where other coal tar derived products may also be present, that the results could be masked, or false positives may occur (e.g. high levels of phenol could mask the fact that coal tar bound arisings are present, similarly the presence of coal tar creosote, could indicate coal tar is present when it is not). As such, the results should not be reviewed in isolation and the likelihood of these other products being present should be assessed to determine the accuracy of the results.

A further limitation is that some test methodologies can result in the loss of highly volatile hydrocarbons, causing optimistically low results for coal tar. In order to overcome this it is recommended that a variety of different tests be carried out in order to reduce uncertainty in the results.

4.5 Test methods

4.5.1 Introduction

The tests methods below outline the different analyses currently available to assist in identify the presence of coal tar bound materials. These range from visual identification only, through to identification and quantification in order to assist in apportioning coal tar as the contributing source. The type of analysis undertaken will depend on the nature and extent of the proposed scheme and the test results themselves. For further guidance, reference should be made to Flow Chart C, located within Appendix B of this document. An example specification is also included as Appendix C to this document.

4.5.2 Visual Identification only for sample selection

4.5.2.1 White acrylic paint

This method must be checked for accuracy before use, to avoid false negatives, especially with a new paint product.

Once logging and photographing of the core has been completed, the presence of coal tar bound materials should be determined. The paint (there are specific spray paint products on the market that are targeted at this function) should be applied to each layer of the core, one layer at a time to avoid confusion of the results. The paint and core should both be at room temperature when undertaking this test (ref. Impact Test Equipment), and should be left to dry once applied. The paint will appear white initially and turns yellow/light brown when in the presence of Polyaromatic Compounds (PACs; =PAH) at levels exceeding 125mg/kg, with a greater level of certainty above 150mg/kg (ref. ADEPT, 2016 and Impact Test Equipment). Where the reaction is not clear, an ultraviolet (UV) lamp can be used for clarification. Under UV light, the discoloured spray lightens and becomes yellow/green if PACs are present. PAC's are typically found in tar but also exist in other road construction materials such as bitumen, kerosene and diesel, but at lower concentrations, usually insufficient to affect the paint. The probability of obtaining a "false positive" result with the paint test with such materials is low, so a positive result should be seen as a strong, although not definitive indicator of the presence of coal tar.

Layers identified as containing possible coal tar should be recorded on the Core Log. The Designer should then identify sub samples for further testing for confirmation. Further guidance on this method is provided in Section C2.0 of the ADEPT 2016 Guidance Note 'Managing Reclaimed Asphalt – Highways and Pavements' – version 2016.1.

If the paint test identifies the presence of PACs at levels exceeding 125mg/kg but at depths below the intended planing depth, further testing is recommended to confirm the accuracy of the results. Consideration should also be given to further testing, as a safeguard should the proposed design change. This will avoid the need to return to site to take additional samples for testing, preventing delays and additional costs.

Should no reaction occur following application of the paint then the UV lamp must be used for clarification. Should this also produced a negative result further testing is still recommended to confirm these results.

4.5.3 For ongoing works

4.5.3.1 White acrylic paint

The methodology outline above is also suitable for use on site during ongoing works to confirm the absence of coal-tar bound arisings, or where suspected coal-tar bound arisings have been unexpectedly encountered. For small schemes <30m² in size, this method may be a cost-effective means of identifying possible coal-tar bound arisings, where further, extensive testing is costly in comparison to transportation and disposal costs for Category 17 03 01* waste.

Where coal-tar bound arisings are suspected it is recommended that the core is logged and photographed ahead of testing with the paint, to provide details of depth, thickness, composition and condition. As outlined above, layers identified as containing possible coal tar must be recorded on the Core Log. It is recommended that sub-samples are identified by the Designer for further testing, so to confirm the presence of coal tar, and if necessary inform for appropriate reuse or disposal. Further guidance on this method is provided in Section C2.0 of the ADEPT 2016 Guidance Note ‘Managing Reclaimed Asphalt – Highways and Pavements’ – version 2016.1.

4.5.4 Visual Identification only

4.5.4.1 Methylene Chloride

Methylene chloride, also known as dichloromethane is a colourless, volatile liquid and as such evaporates easily, producing high concentrations of vapour, particularly in confined or poorly ventilated spaces. Breathing in these vapours can produce narcotic effects and exposure to skin and eyes may cause irritation. Methylene chloride has therefore been classified as a Category 3 carcinogen in the European Community under the Chemicals (Hazard Information and Packaging) (CHIRP) Regulations and in Great Britain has a work place exposure limit for an 8 hour time weighted average of 100 ppm (ref. HSE – ‘Real time measurements of dichloromethane containing mixtures’, 2013).

Due to the potential human health risks, it is recommended that this method not be used as a means of visually identifying coal tar.

4.5.5 Laboratory identification only – no quantification

4.5.5.1 Methodology A – PAH analysis and phenol concentration only

This laboratory methods tests only for PAHs (EPA 16) concentrations, including Coronene using gas chromatography and mass spectrometry. Whilst this can identify concentrations of Benzo[a]pyrene this test is unable to determine whether the concentrations are caused by another source. Samples are therefore also tested for their Phenol concentration. This is based on the understanding that coal tars do not contain much Phenol.

This is not a definitive test for coal tar and provides no quantification. The test identifies concentrations of Benzo[a]pyrene, and if accompanied by low concentrations of Phenol, it is considered likely to be derived from coal tar.

4.5.5.2 Methodology B – PAH analysis and fingerprint analysis

Testing comprises the following:

- Determination of PAH’s by GC-MS (gas chromatography and mass spectrometry)
- Determination of biomarkers Hopane and Dibenzothiphenes by GC-MS*
- Determination of speciated phenols by GC-MS.
- Double ratio plot of PAH profile to determine likely source id.*
- Fingerprint analysis of GC-FID (Gas Chromatography-Flame Ionization Detector) chromatogram to identify hydrocarbon type.*

* this type of analysis is not part of every laboratories methodology (see Methodology A).

The above analysis is performed on an extract of chemically dried ‘as recovered’ fraction of the supplied material.

Fingerprint analysis of GC-FID chromatogram to identify hydrocarbon type is required to identify the presence of possible interfering compounds such as diesel. This can also be confirmed from further biomarker analysis for components such as Prystane and Phytane, which will also show the presence of diesel. This testing is important to confirm that a “positive” result is not caused by the presence of other materials such as diesel, which is used as a solvent during the laying phase.

Note that the method outline above identifies but does not accurately quantify the amount of coal tar present. An approximation is determined using the PAH values, principally Benzo[a]pyrene.

4.5.5.3 Methodology C – PAH, SARA, SVOC analysis

As an alternative to Methodology B laboratories may provide the following methodology:

- Extraction using DCM by soxhlet for SEM (Scanning Electron Microscope).
- Portion analysed for PAHs (GCMS)
- Portion analysed for SARA (Scanning Analysis Response and Assessment)
- Portion analysed for SVOC (Semivolatile Organic Compounds) GCMS for Coal Tar/Biomarkers etc.

The solvent extract is analysed by GCMS. The acquired GCMS data is examined for the presence of coal tar related compounds that are integrated accordingly. Any diesel, kerosene or other petroleum-related compounds that are present in the solvent extract are NOT integrated, as they are not considered coal tar related. This approach minimises the risk of ‘false positives of coal tar’ from being reported.

Some quantification may be derived by this methodology, as the Limits of Detection for this analysis is 0.1%.

WM3 states that *“coal tar is a complex mix of hydrocarbon compounds which have to be added together to determine the concentration of coal tar. Therefore, 0.1% concentration must be applied to all fractions of the coal tar. Assessments based on PAH’s alone are not consistent with legislation and cannot be used to classify waste as non-hazardous”.*

However, if the coal tar concentration is known Benzo[a]pyrene may be used as a marker compound for certain coal tar entries (ref. WM3, 2015). The assertion is that 50mg/kg (0.005%) of Benzo[a]pyrene correlates to around 1000mg/kg (0.1%) road tar (ref. ADEPT 2016). Therefore *“where the concentration of Benzo[a]pyrene is less than 0.005% of the concentration of coal tar (rather than the waste as a whole), the coal tar is not carcinogenic”* (ref. WM3, 2015).

4.5.5.4 Methodology D – gravimetric determination of toluene extractable matter

This test may be offered as the first stage of a three-stage testing methodology.

Gravimetric determination of toluene extractable matter in order to determine the total percentage coal tar in the sample. This is done as a means of determining whether the gross levels exceed the threshold of 0.1% coal tar. Where concentrations exceed 0.1% additional testing is required to determine the PAH concentration, particularly Benzo[a]pyrene.

The assertion is that 50mg/kg (0.005%) of Benzo[a]pyrene correlates to around 1000mg/kg (0.1%) road tar (ref. ADEPT 2016).

This method is positively biased for other hydrocarbon sources e.g. diesel, creosote, lube oil and as such false positives may be possible.

If it is suspected that the results are false positives, an assessment of all available records is recommended. This will need to be undertaken by a suitably qualified person. Sufficient supporting evidence will be required to justify that the results are from an alternative source and that the material should not be classified 17 03 01*. Should any doubt exist it should be assumed that the results are attributed to coal tar until proven otherwise.

4.5.6 Identification and quantification

4.5.6.1 Methodology E – PAH concentration analysis

This test may be undertaken where the gross levels of coal tar have been identified as exceeding 0.1% by the gravimetric determination of toluene extractable matter. It is the second stage of a three-stage testing methodology (see Methodology D and F above and below).

The PAH concentrations of the sample are analysed, with particular focus made on the concentration of Benzo[a]pyrene. Analysis is made by solvent extraction of the sample and subsequent analysis by GC-MS in full scan mode. The use of deuterated PAHs (coving 2-6 rings structures) aides in the accurate qualification of analytes well as their quantification.

This method is positively biased for other sources of PAHs but may be able to identify false positives derived from other analysis (specifically Methodology D)

Samples containing concentrations of Benzo[a]pyrene exceeding the threshold of 0.005% are classified as Hazardous Waste/Special Waste and coded 17 03 01*. This is based on the assertion that 50mg/kg (0.005%) of Benzo[a]pyrene correlates to around 1000mg/kg (0.1%) road tar (ref. ADEPT 2016) and the worst-case assumption that all the Benzo[a]pyrene may be attributed to coal tar. These samples should be subjected to further testing as outlined below.

4.5.6.2 Methodology F – detailed analysis of components

Contaminants are extracted at several different pH levels to determine the potential concentrations of both the acidic and basic components of coal tar. The tests focus primarily on the phenolics and heterocyclics, analysis is by either full scan GC-MS or, if required, GC-MS/MS. The list of determinands is as follows:

- Tar acids / phenolics, including phenols, cresols, xylenols, and naphthols
- Tar bases / nitrogen-containing heterocycles, including pyridines, quinolines, benzoquinolines, acridines, indolines, and carbazoles.
- Aromatic amines, such as aniline, aminonaphthalenes, diphenyl amines, aminofluorenes, and aminophenanthrenes as well as cyano-PAHs, benz acridine, and its methylsubstituted congeners.
- Sulphur - containing heterocycles, including benzothiophenes and their derivatives
- Oxygen-containing heterocycles, including dibenzofurans.

The presence/absence of these compounds can assist in the apportioning of coal tar as the contributing source. This is the third stage of a three-stage testing methodology (see Methodology D and E above)

This method is less susceptible to false positives as it is more selective and analyses the minor components of coal tar, which are less common in most routinely encountered hydrocarbon

sources, but they are not unique. Samples that contain products derived from coal tars (e.g. coal tar creosote) will be expressed a positive for coal tar but one would need to look at the likelihood and frequency of this potential contamination occurring.

This method is also susceptible to weathering and leaching. The more polar compounds of coal tar are more water soluble/volatile than their PAH counterparts. Heavily weathered samples can result in the loss of these key marker compounds, limiting the reliability of the results. If heavily weathered samples are encountered (and this can be gauged based on the analysis of PAH concentrations with specific focus on Benzo[a]pyrene) the laboratory should provide commentary in their report explaining the potential limitations of the procedure.

4.6 Frequency of testing

It is recommended that frequency of testing following guidance given in Section B2.1 of the ADEPT 2016 Guidance Note – 'Managing reclaimed asphalt – highways and pavements' – Version 2016.1. Further guidance is also provided within Sections B2.2, B8.2 and B7.0 of the document.

Consideration may be given to historical test results to avoid repetition and unnecessary testing. The historical results must however be reviewed by a suitably qualified professional, prior to undertaking the investigation works, to ensure that the testing methodology undertaken is still suitable and that the results are still applicable; with regards to current standards.

4.7 Costs

The cost of testing will vary depending on the complexity of analysis. Basic laboratory identification testing ranges from approximately £15 to £35 per sample, with more complex testing in the order of £70 to £120 (dated August 2015).

4.8 Turnaround times for testing

The turnaround time for testing will depend on the type of testing specified. Tests have a turnaround time of 5 to 10 days, although some testing may be expedited at an additional cost. This will however depend on the laboratory, type of testing scheduled, frequency of testing and existing laboratory workload. As such should rapid turnaround times be required this should be discussed and agreed with the laboratory before samples are scheduled so that deadlines can be met and additional associated costs can be taken into consideration.

4.9 No testing option

Whilst the option to proceed with a scheme without undertaking any prior sampling and testing is a possibility, it does come with some limitations. Where the presence of coal-tar bound arisings is unknown or unclear coal tar must be assumed to be present. Under CDM Regulations (2015), the Designer is therefore legally required to inform the Contractor of the possible presence of coal tar. Secondly, this option gives no opportunity to determine whether coal tar bound, arisings can be left undisturbed, resulting in unnecessary removal and disposal; and with it associated, and ever-increasing costs (ref. Construction Manager, May 2013). Thirdly, the removal process cannot be designed in advance to separate contaminated and non-contaminated arisings. This may result in the generation of larger quantities of contaminated materials requiring testing and/or disposal. Furthermore, arisings will need testing anyway following excavation, before a decision can be made on re-use, which runs the risk of delays (ref. Construction Manager, May 2013). Subsequently material may be unsuitable for their intended use; requiring storage and resulting in additional costs.

Hazardous Waste/Special Waste, if it is stored with no identifiable end use, will be subject to regulatory waste controls. In Scotland, a waste management licence or pollution prevention and control permit is required if you store more than 80 cubic meters of non-liquid Special Waste (Hazardous Waste) in a secure container, or 50 cubic meters in a secure place, or up to these volumes of material but for a period greater than 12 months, whilst awaiting collection (ref. www.netreg.org.uk).

5 Safe working practices

5.1 Introduction

Within Scotland, SEPA have issued guidance on the production of fully recovered asphalt road planings. However, as stated in the document the guidance applies solely to source segregated asphalt road planings covered by the European Waste Catalogue Code 17 03 02 (i.e. non-hazardous). It does not cover tar pitches that are derived from coal and are classed as Special Waste (Hazardous Waste), European Waste Catalogue Code 17 03 03*, nor 17 03 01*. Furthermore, the SEPA guidance states, *"where a road has a tar content it is the responsibility of the road owner/operator to identify and quantify this and make arrangements for its treatment/disposal at a suitably licensed facility"*. Furthermore, the document does not cover asphalt and asphalt road planings contaminated with any other substances including, though not restricted to, plastics, glass, metals and spilled liquids, nor asphalt removed/processed by any other methods other than by a road planer. These are not covered by this Guidance Note.

Coal tar bound arisings are likely to be found within both the urban environment and rural countryside, with each setting potentially having different pathways and receptors. Table 4 below presents an outline risk register, which should be considered for each site and any additional, site specific risks added for the urban environment and rural countryside, identifying the potential pathways and receptors. As the hazardous contaminants contained within coal tar have been identified as potentially carcinogenic, and are toxic to the environment the effect they pose to human health and the environment is therefore considered to be very high.

The following pages include risk assessments, which should be reviewed and updated to reflect each site's or working areas specific conditions.

Table 1 – scale of 23likelihood

Likelihood (L)	Scale
Very likely	4
Likely	3
Unlikely	2
Negligible	1

Table 2 – scale of effect

Effect (E)	Scale
Very high	4
High	3
Low	2
Very low	1

Table 3 – risk level

Degree of risk	Risk level	Recommended response
1 to 4	Trivial	None
5 to 8	Significant	Consider attention
9 to 12	Substantial	Attention required
13 to 16	Intolerable	Risk must be reduced

Table 4 - Example risk assessment for urban environment

Urban environment Risk Assessment					
Name of assessor and data		*Example: John Simpson, 28 June 2015*			
Highway name/chainage/length		*Example: Wellgate Street, Larkhall*			
Proposed scheme		*Example: Resurfacing full width, full length*			
Pathway	Receptor	Probability	Severity	Risk	Notes/ mitigation measures
Inhalation of contaminated dust.	Site operatives and maintenance staff	4	4	16	Risk can be reduced through the use of appropriate PPE i.e. appropriate face fitted mask or respirator Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*
	Members of the public - passers by	2	4	8	Keep members of the public outside the working area; consider the use barriers to prevent members of the public using seating areas directly adjacent to the working area. *(See notes 1 to 3)*
	Members of the public – neighbouring sites	3	4	8	Assumes build-up of dust within adjacent sites so greater risk of exposure to neighbours than people passing by the site. *(See notes 1 to 3)*
Ingestion of contaminated dust.	Site operatives and maintenance staff	3	4	12	Risk can be reduced with appropriate PPE and good hygiene standards i.e. gloves and respirator or face fitted mask Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*

	Members of the public - passers by	1	4	4	Keep members of the public outside the working area; consider the use barriers to prevent members of the public using seating areas directly adjacent to the working area. *(See notes 1 to 3)*
	Members of the public – neighbouring sites	2	4	8	Assumes build-up of dust within adjacent sites so greater risk of exposure than people passing by the site. *(See notes 1 to 3)*
Dermal contact with contaminated dust.	Site operative and maintenance staff	4	4	16	Risk can be reduced through the use of appropriate PPE i.e. task specific gloves. Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 3)*
	Members of the public - passers by	1	4	4	Unlikely to come into direct contact. See above *(See notes 1 to 3)*
	Members of the public – neighbouring sites	2	4	8	Assumes a build-up of contaminated dust. See above *(See notes 1 to 3)*
Dermal contact with, or ingestion of contaminated surface water and groundwater	Site operative and maintenance staff	2	4	8	Risk can be reduced through the use of appropriate PPE i.e. task specific gloves *(See notes 2 and 3)*
	Members of the public	1	4	4	*(See notes 2 and 3)*
Ingestion of contaminated	Animals and birds	2	4	8	Prevent run-off from the works area. Avoid undertaking works in wet weather.

surface water and groundwater	Fish	1	4	8	Prevent run-off from the works area. Avoid undertaking works in wet weather. Consider blocking drains or flushing drains afterwards and passing water through oil interceptor.
Inhalation of fumes / vapours	Site operatives and maintenance staff	2	4	8	Consideration should be given to the working area and whether surrounding structures create a 'confined' working area where fumes are not easily dissipated. Planing of road surface should not directly heat asphalt sufficiently to generate fumes. When working in hot weather consider the use of fans to increase air flow in confined areas. *(See notes 2 to 4)*
	Members of the public – passers by	1	4	4	Keep members of the public outside the working area; consider the use barriers to prevent members of the public using seating areas directly adjacent to the working area. When working in hot weather consider the use of fans to increase air flow in confined areas
	Members of the public – neighbouring sites	1	4	4	When working in hot weather consider the use of fans to increase air flow in confined areas
Contaminated surface water run-off into waterbody	Water environment - surface water bodies	3	4	12	Will depend on location of the coal tar bound arisings within the carriageway construction and the condition of the overlying and underlying layers. Assumes worst case; that coal tar bound arisings are at the surface or carriageway is in poor condition.
	Water environment - groundwater	2	4	8	
Seepage of leachate into waterbody	Water environment - groundwater	2	4	8	
	Water environment - surface water bodies	1	4	4	
Uptake of contaminated groundwater	Plants	2	4	8	
Inhalation of vapours and dust	*School children in adjacent playground for up to an hour, possibly eating/picnicking*	*2*	*4*	*8*	*Avoid working outside the school during play times, contact school ahead of works to check times…..*

Notes

1 - Whilst water has traditionally been used as a means of dust suppression the Contractor needs to consider that an appropriate collection system will need to be employed to prevent contaminated surface water run-off entering the environment. Further guidance on the management of construction dust is given on the HSE website – www.hse.gov.uk/construction/faq-dust.htm

2 - Further guidance is given in the HSE documents HSG150 2006 'Protecting the public; your next move' and 'Health and Safety in Construction' 3rd Edition.

3 – Further guidance is given in the HSE documents HSG151 2009 'Health and Safety in Construction'2nd Edition.

4 – Guidance on using Respiratory Protective Equipment is given in the HSE document HSG53 2013 'Respiratory protective equipment at work: a practical guide' 4th Edition

Table 5 –Example risk assessment for rural setting

Rural countryside					
Name of assessor and data		*Example John Simpson, 28 June 2015*			
Highway name/chainage/length		*Example A70 Glespin*			
Proposed scheme		*Example Resurfacing full width, full length*			
Pathway	Receptor	Probability	Severity	Risk	Notes
Inhalation of contaminated dust.	Site operatives and maintenance staff	4	4	16	Risk can be reduced through the use of appropriate PPE i.e. respirator Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*
	Members of the public - passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment. *(See notes 1 to 3)*
	Members of the public – neighbouring sites	1	4	4	Whilst there is an opportunity for dust to build up neighbouring, buildings are likely to be a located further from the site in comparison to the urban environment. *(See notes 1 to 3)*
Ingestion of contaminated dust.	Site operatives and maintenance staff	3	4	12	Risk can be reduced with appropriate PPE and good hygiene standards i.e. gloves and respirator Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*
	Members of the public - passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment

					(See notes 2 and 3)
	Members of the public – neighbouring sites	1	4	4	Whilst there is an opportunity for dust to build up neighbouring, buildings are likely to be a located further from the site in comparison to the urban environment. *(See notes 2 and 3)*
Dermal contact with contaminated dust.	Site operative and maintenance staff	4	4	16	Assumes use of appropriate PPE when handling potentially contaminated materials. Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 3)*
	Members of the public - passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment. *(See notes 1 to 3)*
	Members of the public – neighbouring sites	2	4	4	Neighbours are likely to be a significant distance from site in comparison to urban environment. *(See notes 1 to 3)*
Dermal contact with contaminated surface water and groundwater	Site operative and maintenance staff	3	4	12	Prevent run-off from the works area. Avoid undertaking works in wet weather. *(See notes 2 and 3)*
	Members of the public	1	4	12	Prevent run-off from the works area. Avoid undertaking works in wet weather. *(See notes 2 and 3)*

	Animals and birds	3	4	12	Prevent run-off from the works area. Avoid undertaking works in wet weather. Consider blocking drains or flushing drains afterwards and passing water through oil interceptor.
	Fish	4	4	16	Prevent run-off from the works area. Avoid undertaking works in wet weather.
Inhalation of fumes	Site operatives and maintenance staff	3	4	12	Open spaces, so less likely that there will be structures, which create a 'confined' working area. *(See notes 2 to 4)*
	Members of the public – passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment. *(See notes 2 and 3)*
	Members of the public – neighbouring sites	1	4	4	Neighbours are likely to be a significant distance from site in comparison to urban environment. *(See notes 2 and 3)*
Ingestion of contaminated groundwater and surface water	Site operatives and maintenance staff	1	4	4	Risk can be reduced through the use of appropriate PPE i.e. task specific gloves *(See notes 2 and 3)*
	Members of the public - passers by	1	4	4	
	Members of the public – neighbouring sites	2	4	8	Will depend how potable water supplies are obtained at neighbouring sites
	Animals and birds	3	4	12	Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.
	Fish	4	4	16	Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.

Contaminated surface water run-off into waterbody	Water environment	4	4	16	Fewer impermeable surfaces and water capture systems. Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.
Seepage of leachate into waterbody	Water environment	4	4	16	Fewer impermeable surfaces to inhibit seepage. Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.
Uptake of contaminated groundwater	Plants	4	4	16	Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.

Notes

1 - Whilst water has traditionally been used as a means of dust suppression the Contractor needs to consider that an appropriate collection system will need to be employed to prevent contaminated surface water run-off entering the environment. Further guidance on the management of construction dust is given on the HSE website – www.hse.gov.uk/construction/faq-dust.htm

2 - Further guidance is given in the HSE documents HSG150 2006 ‘Protecting the public; your next move’ and ‘Health and Safety in Construction’ 3rd Edition.

3 – Further guidance is given in the HSE documents HSG151 2009 ‘Health and Safety in Construction’2nd Edition.

4 – Guidance on using Respiratory Protective Equipment is given in the HSE document HSG53 2013 ‘Respiratory protective equipment at work: a practical guide’ 4th Edition

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5.1.1 Urban environment - risk commentary

5.1.1.1 Site operatives

Health Risks to site operatives are considered to be through dermal contact, and the inhalation of contaminated dust and vapours. The likelihood of dermal contact by site operatives is considered comparable with inhalation due to the nature of the work. This is a worst case and is based on the assumption that task specific PPE will not be worn. The risk of ingesting contaminated dust by site operatives is considered to be lower than inhalation, but would be increase by poor hygiene standards. Risks to site operatives can be considerably reduced with the use of task specific PPE.

It is unlikely that the arisings will be heated sufficiently during the planing process to result in the release of fumes. Should fumes however be released they are likely to pose a lower risk when undertaking works within open-air or rural situations. There may however, be a risk in situations where high vapour concentrations are allowed to build, such as in poorly vented, confined or semi-confined spaces. Semi and confined spaces may include areas beneath bridges and where high-rise buildings and/or narrow width roads prevent the free flow of air. Suitable respiratory protection is therefore recomented in poorly ventilated or enclosed areas to ensure exposure is below the workplace exposure levels (WEL). In confined areas, consider the use of fans to increase airflow.

Site operatives are likely to come into contact with contaminated waters. However, the risk is considered to be lower than for the inhalation of, or dermal contact with, contaminated dust, because there are likely to be fewer opportunities to come into contact with contaminated water.

- Wear task specific PPE
- Use artificial air circulation techniques (fans)
- Consider use of vacuum enhanced planing to minimise dust

5.1.1.2 Pedestrians and those in neighbouring properties

Health risks to members of the public/ passers-by from inhalation of contaminated dust is considered to be lower than the risk posed to those living directly adjacent to sites. Whilst passers-by are likely to be exposed to a higher concentration, because they are likely to pass closer to the site, this will only be for a very short period of time. Occupants of adjacent properties may be subject to a build-up of contaminated dust. This means that exposure could be ongoing even after completion of the site works.

The risk from fumes/vapours to people passing by the site is considered to be low because of the short exposure times. Similarly, fumes are likely to have dispersed before reaching neighbouring sites. Care should be taken however to minimise the chance of pedestrians remaining in the immediate vicinity of the works, where coal tar is present, such as restricting the use of seating areas.

The risk from fumes/vapours to neighbouring sites is considered to be greater than the risk posed to people passing by the site, they are however likely to disperse beyond 10 to 20m. Particular care should be taken in areas where shops or houses are immediately adjacent to the highway. All doors and windows should be closed during the works if coal tar is present.

The likelihood that contaminated dust will be ingested by members of the public, is considered to be greater than for site operatives. However, the likelihood is still low.

- Use artificial air circulation techniques (fans)
- Use barriers to segregate the public from the works
- Where buildings (shops or houses) are very close to the works, ensure doors and windows are closed.

- Discourage pedestrians from remaining in the vicinity of works by cordoning off seating areas in close proximity to the works.
- Consider the use of vacuum enhanced planing to reduce dust.
- Prevent any surface run-off from the site during the works if coal tar is present.

5.1.1.3 Animals, birds and aquatic life

Animals and birds may utilise contaminated surface waters for drinking, particularly if run-off from the works is not controlled. In the urban environment, the likelihood of aquatic life (particularly fish), being directly impacted by short-term run-off is relatively low. Should accumulations of dust or planing debris accumulate in the drainage system, this could lead to leachate persistently entering watercourses.

The risk of contaminating surface and groundwater bodies with contaminated surface water run-off depends on the condition of the road and the location of the coal tar bound arisings within its construction. This is assuming a worst-case scenario, that the materials are exposed at the surface/the road is in poor condition and works are undertaken in wet weather.

- Avoid working in wet weather if possible.
- Block gullies prior to starting the works and pump any accumulated water through an oil interceptor.
- Take care to remove all planing debris from the site.

5.1.2 Rural countryside - risk commentary

5.1.2.1 Site operatives

Health risks to site operatives are considered to be through dermal contact, and the inhalation of contaminated dust and vapours. The likelihood of dermal contact by site operatives is considered to be comparable with inhalation due to the nature of the work. This is a worst case and is based on the assumption that task specific PPE will not be worn. The risk of ingesting contaminated dust by site operatives is considered lower than inhalation, but would be increase by poor hygiene standards. Risks to site workers can be considerable reduced with the use of task specific PPE.

It is unlikely that the arisings will be heated sufficiently during the planing process to result in the release of fumes. Should fumes however be released they are likely to pose a lower risk when undertaking works within open-air situations. Suitable respiratory protection is required in poorly ventilated or enclosed areas to ensure exposure is below the workplace exposure levels (WEL).

Site operatives are likely to come into contact with contaminated waters. However, the risk is considered to be lower than for the inhalation or dermal contact with contaminated dust, because there are likely to be fewer opportunities to come into contact with contaminated water.

- Wear task specific PPE
- Consider use of vacuum enhanced planing to minimise dust

5.1.2.2 Pedestrians and those in nearby properties

Health risks to members of the public/ passers-by from inhalation of contaminated dust is considered low. It is considered unlikely that buildings and confined spaces will occur adjacent to the works.

The risk from fumes/vapours to people passing by the site is considered to be low because of the short exposure times and clear air flow. Similarly, fumes are likely to have dispersed before reaching nearby properties. Care should still be taken however to minimise the chance of pedestrians remaining in the immediate vicinity of the works, where coal tar is present, such as restricting the use of any seating areas.

The likelihood that contaminated water will be ingested by members of the public in nearby sites is considered to be greater than for site operatives because contaminated waters located off-site are likely to be unknown and local supplies may rely on local sources. However, this risk is still considered to be minor.

- Use barriers to segregate the public from the works, where there are footpaths and farms etc.
- Discourage pedestrians from remaining in the vicinity of works by cordoning off seating areas in close proximity to the works.
- Take steps where possible to prevent members of the public entering or crossing the working area when coal tar is exposed
- Consider the use of vacuum enhanced planing to reduce dust.

5.1.2.3 Animals, birds and aquatic life

Animals and birds may utilise contaminated surface waters for drinking, particularly if run-off from the works is not controlled. In the rural environment, the likelihood of aquatic life (particularly fish), being directly impacted by short-term run-off is moderate. Should accumulations of dust or planing debris accumulate in the drainage system, this could lead to leachate persistently entering watercourses. Animals and birds may utilise contaminated surface waters for drinking and bathing. The risk to aquatic life is considered higher than to birds and animals due to the potential proximity to the works, and the increase likelihood of highway drainage being uncontrolled, or discharging directly into watercourses.

The risk of contaminating surface and groundwater bodies with contaminated surface water run-off depends on the condition of the road and the location of the coal tar bound arisings within its construction. This is assuming a worst-case scenario, that the materials are exposed at the surface/the road is in poor condition and works are undertaken in wet weather.

- Avoid working in wet weather if possible.
- Block any gullies prior to starting the works and pump any accumulated water through an oil interceptor.
- Block any grips, ditches at the side of the carriageway and pump any accumulated water through an oil interceptor.
- Take care to remove all planing debris from the site.

6 Record keeping

Prior to undertaking any intrusive work on any highway, review the records in the national highway database to determine if coal tar is known to be present.

- Chainage/marker post/street name/ extents
- Affected lanes*
- Depth to top of layer
- Thickness
- Typical condition

* It is important to note the affected lanes if widening has been undertaken in the past as the older "affected" carriageway may now reside under only part of the current carriageway.

Whenever coal tar is identified in investigative works, the extent of it must be entered into the national highway database, including the depth (or depths) of the affected layers. This data must be made available to all operatives working on affected sections of carriageway, in particular utility companies.

Populating the national highway database will in the long term reduce the need to undertake chemical testing prior to works and may enable resurfacing works to be planned to avoid disturbing the affected horizon(s).

Where coal tar bound layers are removed from the carriageway, this must also be recorded in the national highway database such that it is clear if the risk remains.

7 Classification as waste

Reference should be made to the ADEPT Guidance note (2016) "Managing Reclaimed Asphalt – Highways and Pavements" Appendix B, with regards to the current classification of coal tar bound arisings as Hazardous/Special/Non-hazardous waste. Further information is given in Flow Chart D, located within Appendix B of this document. Landfill Waste Acceptance Criteria (WAC) testing and analysis are not to be used to determine waste classification nor for hazardous waste assessment purposes

8 Producing hazardous/special waste

You do not need to register as a producer of Special Waste (Hazardous Waste) in Scotland (ref. SEPA website). For further information see section on 'Safe storage'.

9 Safe handling and storage of coal tar bound arisings

9.1 Safe handling

The "Special Waste Regulations", 1996 and their amendments; "Special Waste Amendments (Scotland) 2004", set out procedures to be followed when disposing of, carrying and receiving Hazardous Waste/Special Waste. The assessment and classification of waste is based on a combination of chemical legislations and waste legislation, Guidance on the consignment of Special Waste in Scotland is given in the SEPA document "A guide to Consigning Special Waste" (June 2006).

An assessment of the hazards associated with the handling of coal tar bound arisings should be carried out ahead of any works and should include a full COSHH (Control of Substances Hazardous to Health) assessment (ref. ADEPT, 2016). The main pathways, as identified above are through inhalation, digestion and dermal contact with contaminated dust and to a lesser extent through the ingestion of contaminated dust. Whilst guidance exists for measuring airborne PAH concentrations by personal sampling (ref. MDHS 72 and MDHS 96), this is not recommended at it does not help to limit or prevent exposure, only provides a guide to assess ongoing exposure.

The contaminants contained within coal tar have the potential to be carcinogenic. Site operatives, laboratory staff, and anyone involved in the handing of coal tar bound arisings therefore must not handle these materials without the use of appropriate PPE, unless the material has been proven to be non-hazardous. PPE should include, but not limited to coveralls, eye protection, gloves and respiratory protection, with gloves suitable for the intended work. This should be in addition to any site/task specific PPE requirements. Dust caused by cutting, coring or planing of asphalt classified as hazardous must be controlled by containment, suppression and extraction/ filtration where possible to avoid its spread. Not only is this important to prevent the spread of dust contaminated with coal tar, but to also prevent the spread of silica dust which is a respiratory irritant. This is not only important when undertaking works within urban environments, but also in rural settings to avoid contaminating adjacent sites and the environment. When using water-based suppression systems, consideration will need to be given to the safe collection and disposal of contaminated water.

9.2 Safe transportation

Producers and holders of Hazardous Waste/Special Waste have a duty of care to ensure that the waste does not cause harm or damage (ref. Hazardous Waste - https://www.gov.uk/dispose-hazardous-waste/overview). This includes during handling, transportation and storage, from production through to safe disposal of the waste.

Hazardous Waste/Special Waste must be transported by a registered waste carrier under the Control of Pollution (Amendment) Act 1989, and the Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulation 1991; and be accompanied by a consignment note (ref. The Environmental Protection (Duty of Care) (Scotland) Regulations 2014). This is to ensure is properly and legally disposed of. It must also be sent to a facility that holds suitable pollution prevention and control permits and waste management licences. Within Scotland SEPA have an online database listing the details of all registered waste carriers and brokers (ref. Registered Waste Carriers and Brokers (SEPA) http://apps.sepa.org.uk/rocas/). For cross-border transport in the UK you only need to register once with one regulator for any movement between England, Wales and Scotland. For transport to and from Northern Ireland, you will need to register with Northern Ireland in addition to the other part of the UK. Further information on waste carriers and brokers in Scotland can be found on the SEPA website (ref. www.sepa.org.uk).

It is currently a requirement in Scotland that SEPA be notified prior to Special Waste (Hazardous Waste) leaving site, if it is a single movement or the first in a series of movements, at least 72 hours and not one month before the material is moved, or imported (ref. www.netregs.org.uk). All Hazardous Waste/Special Waste must be consigned using a SEPA-issued consignment note or code, regardless of its final destination within the UK. Special Waste Consignment Notes (SWCN) can be purchased online from the SEPA website. When exporting Hazardous Waste/Special Waste to England, Wales or Northern Ireland for treatment, disposal or recovery, the consignee who receives the waste is required to send a copy of the completed deposit note to SEPA (ref. www.sepa.org.uk).

Copies of consignment notes must be retained for a period of three years. Further guidance is given the in the SEPA document ‘A guide to Consigning Special Waste’ (June 2006) (ref. www.sepa.org.uk).

When transporting Hazardous Waste/Special Waste it must be:

- Separated from other wastes,
- In sealed and clearly labelled containers

- Transferred to a secure facility, which is authorised to receive it

Waste must be transported in a safe and secure manner to prevent the release of contaminated material en-route. This should include using enclosed or covered vehicles to prevent the spread of dust, and generation of leachate from precipitation.

The transportation of Hazardous Waste/Special Waste must comply with the controls on the carriage of dangerous goods, which are outlined in the HSE document ‘Carriage of dangerous good” (ref. HSE www.hse.gov.uk/cdg/index.htm).

With reference to the section on “Existing waste classification and re-use” under current guidelines coal tar bound arisings are only classified as hazardous waste if threshold concentrations are exceeded. Current guidance on the requirements for the safe handling of non-hazardous waste in Scotland can be found on the SEPA website and are not discussed within this document.

9.3 Safe storage

Waste categorised as 17 03 01* or 17 03 03* is classified as Hazardous Waste/Special Waste. A waste management licence and pollution prevention and control permit may therefore be required for storing these materials.

There are no specific guidelines for the safe temporary storage of coal tar bound arisings within the UK, nor specific to Scotland. However, all businesses producing controlled waste have a legal responsibility to ensure that it is produced, stored, transported and disposed of without causing harm to the environment or human health. This is termed ‘Duty of Care’ (ref. www.netregs.org.uk), and this has no time limit. Businesses are responsible for their waste up until it has been transferred to an authorised person; and are subsequently responsible for ensuring it is managed and disposed of correctly. Within Scotland businesses, which normally and regularly transport construction or demolition, waste may need to register with SEPA as a waste carrier, broker or dealer. If in doubt as to whether registration is required, SEPA should be contacted (ref. www.sepa.org.uk).

Under current guidelines within Scotland, England (since 1 April 2016) and Northern Ireland a business which produces Hazardous Waste/Special Waste, holds or stores Hazardous Waste/Special Waste and/or has Hazardous Waste/Special Waste removed from its premises is not required to register the premises regardless of the volume of waste produced (ref. www.gov.uk and SEPA). Businesses in Wales producing more than 500kg in a 12-month period are however still required to register with NRW (ref. www.naturalresources.wales). Changes to the consignment note code format have been made to accommodate the new legislation within England (ref. ‘Hazardous waste: consignment note guidance’).

In Scotland, a waste management licence or pollution prevention and control permit is not required if you store Special Waste (Hazardous Waste) on the site it was produced for up to 12 months whilst awaiting collection. The maximum amount that can be stored is:

- 23,000 litres of liquid waste stored in a secure container
- Either 80 cubic meters (m^3) of any other type of waste stored in a secure container, or 50 cubic meters (m^3) stored in a secure place.

If these conditions cannot be met, a waste management licence or a pollution prevention and control permit is required (ref. www.netreg.org.uk).

Special Waste (Hazardous Waste) must be stored separately from all other waste materials, within containers that are:

- Sealed,
- Labelled,

- Covered,
- Waterproof,

Special Waste (Hazardous Waste) containment areas must be:

- In separate designated areas,
- Secure,
- Clearly signed
- On impermeable surfaces

Special Waste (Hazardous Waste) should be stored separately from Non-Hazardous Waste; with each different type of Special Waste (Hazardous Waste) also segregated. Where there is a possibility that fumes may be generated, and allowed to build up, this should be clearly signposted, with adequate ventilation provided to encourage dispersal.

An environmental permit may be required for the storage of coal tar bound arisings and must be applied for in advance of any works to ensure that permission has been obtained. Further guidance on the separating and mixing of Hazardous Waste/ Special Waste is given in the document “Technical Guidance WM3: Waste Classification - Guidance on the classification and assessment of waste” (July 2015)

In addition to being potentially carcinogenic, some PAH are also known to be highly toxic to aquatic life. Some phenols and cresols contained within coal tar are toxic to aquatic organisms, whilst phenols are relatively soluble in water and can leach easily (ref. ADEPT, 2016). These contaminants can be picked up by rainwater passing through planings stockpiles or can seep out of the stockpiles as leachate and into the ground; or flow as surface water runoff into nearby watercourses. For these reasons coal tar bound arisings should be appropriately managed including covering and storing on an impermeable surface, with a surface water collection system in place to allow run-off to be captured, tested and if necessary treated before disposal.

9.4 Re-use

9.4.1 Legislation

Further information is given in Flow Chart E, located within Appendix B of the document.

In Scotland, there is currently no regulatory position for the re-use of planings containing tar, with all wastes containing above threshold concentrations classified as Special Waste (Hazardous Waste) (codes 17 03 01* and 17 03 03*) requiring disposal.

Presently within England arisings classified at Category 17 03 01* can only be re-used in cold mix processes (ref. Modern Asphalts, August 2011). This is a precautionary measure until sufficient investigation has been undertaken into the effects of re-heating road tar to higher temperatures (ref. ADEPT 2016). The ADEPT 2016 guidance document refers to BS EN 13108-8:2005 for guidance in the preparation of arisings for re-use. Since the document was issued BS EN 13108-8:2005 has been superseded by BS EN 13108-8:2016. Whilst BS EN 13108-8:2016 is specific to reclaimed asphalt with bituminous binders only, the preparation of samples of coal-tar bound arisings for testing should follow a similar path, provided procedures are put in place to prevent risk to human health and the environment.

Coal tar bound arisings (Category 17 03 01* waste), often alternatively referred to as Asphalt Waste Containing Coal Tar (AWCCT) in construction are commonly treated by crushing, grinding and screening, processes which requires an environmental permit in England and Wales. The re-use of this material is considered a waste recovery operation, therefore requiring a permit under the "Environmental Permitting (England and Wales) Regulations 2010" within England and Wales (ref. Regulatory Position Statement 075). However, as the EA consider the environmental risk of the activity to be *'low and capable of being adequately controlled by means of suitable general rules'* the re-use of AWCCT in construction can be undertaken provided that a number of criteria are met (ref. Regulatory Position Statement 075). This includes that that material not be used in surface applications.

The re-use of coal tar bound arisings (Category 17 03 01* waste) is currently not permitted in Scotland, therefore an equivalent standard does not currently exist. Re-use of asphalt classified to be 17 03 02 (non-hazardous waste) is however allowed. Guidance on this is given in the SEPA and QPA document 'Guidance on the production of fully recovered asphalt road planings". The re-use of arisings classified as 17 03 02 (non-hazardous waste) is outside the scope of this document and therefore is not discussed further.

9.4.2 Methods of re-use (currently outside Scotland)

It should be noted that there are no treatment options that are licensed to remediate coal-tar bound arisings in situ (ref. ADEPT, 2016). Furthermore, if coal-tar bound arisings remain competent and there is no need to remove them, they should not be disturbed (ref. ADEPT, 2016).

When re-using coal tar contaminated arisings (outside Scotland), a binder must be used to encapsulate the material, ensuring that the arisings are made into a dense, non-permeable, material that has suitable properties for the purpose intended. This may include the use of a suitable hydraulic binder such as Portland cement, or cold bitumen foam mixes which coat the contaminated aggregates (ref. ADEPT, 2016). This is termed Structural Road Recycling. Alternatively, other options include the removal of coal tar using biological agents or by pyrolysis before reusing arisings.

The RSTA "Code of Practice for In-situ Structural Road Recycling" (2012) identifies re-use as being the preferred method for dealing with coal tar contaminated arisings. This is because the method results in the total encapsulation of the hazardous contaminants, making them harmless to the environment and human health. In many cases, this removes the need for excavation and expensive off-site disposal within a licensed hazardous waste facility. However, when coal tar concentrations are found to be particularly high, incineration or off-site disposal may be the only options available (ref. RSTA 2012).

The process produces a recycled road-base/binder course layer comparable to a traditional bituminous or hydraulically bound road-base/binder course materials and is often considered as a more cost effective and environmentally friendlier alternative to traditional full or partial reconstruction of an existing road pavement (ref. RSTA, 2012). Where space is limited this method may also be undertaken ex-situ, however a suitable working area and safe access and egress for vehicles is required. The process also requires large volumes of water in order to hydrate the hydraulic binder and provisions of up to 60,000 litres per shift should be considered as part of the design of the works.

Guidance on the process of re-using coal tar contaminated arisings is given in the RSTA 'Code of Practice for In-situ Structural Road Recycling' (2012). Structural Road Recycling is covered in the "Specification for Highway Works", Clauses 947 and 978 and in the "Specification Guidelines for Structural Road Recycling" within published documents TRL 386 and TRL 611 (ref. RSTA 2012).

It is noted that all Structural Road Recycling schemes require the application of a least a new final surface course; a requirement also of RPS075 and this, with a degree of bulking caused by the process will result in an excess of material on site, which will require off-site disposal. This will need to be considered as part of the planning stage.

Where testing of cores has identified the presence of coal tar, bound arisings within the carriageway construction further investigation is required in order to ensure suitability for Structural Road Recycling. As a guideline (ref. RSTA, 2012) guidance recommended trial pits be excavated at a maximum frequency of one per 800-1000m², providing that the materials and depth of construction are broadly similar. These should be at least 450mm deep and large enough to facilitate the recovery of representative samples to enable proper inspection and assessment of the foundation platform and sub-grade where possible. Further trial pits may be required for verification should inconsistencies be found. Where possible samples should weight up to a safe lifting weight of 20kg of each excavated layer recovered, with the samples retained in clear polythene bags. These should be closed and sealed tightly with nylon cable ties to prevent moisture loss or spillage in transit. Should all trial pits reveal materials of a similar type, depth and consistency then it is recommended that a combined minimum weight of material samples of 160kg be recovered from the exact layer range appropriate to the anticipated treatment depth (RSTA, 2012).

It is recommended that expert evaluation be undertaken when considering the option of reuse. This is to ensure that arisings are suitable for reuse; and that the material is correctly encapsulated and resultant product fit for use.

9.4.3 Suitability for reuse (currently outside Scotland)

When coal tar concentrations are found to be particularly high re-use of coal-tar bound arisings may not be feasible leaving, incineration or off-site disposal as the only options. Structural Road Recycling may also not be possible where there is a risk to existing buried utilities. Such problems should be identified early during a scheme by reviewing current utility plans and undertaking GPR surveys, allowing sufficient time for a solution or alternative plan to develop (ref. RSTA, 2012).

9.5 Recycling

With reference to the ADEPT (2016) guidance note, planings identified, as Hazardous Waste/Special Waste Category 17 03 01* cannot be recycled, only reused as above.

9.6 Safe transportation of coal tar bound arisings

It should be noted that not all companies will transport and accept Hazardous Waste/Special Waste Classified as Category 17 03 01*, therefore finding a company may add significant costs to a project. As such, it is recommended that a transport company be sourced ahead of any works to avoid time delays on site.

9.7 Safe disposal of coal tar bound arisings

Only those sites and companies authorised to treat of or dispose of Hazardous Waste/Special Waste are allowed to do so. In Scotland, (ref. www.gov.uk – Authorisation to mix special waste (Scotland)) such sites and companies must have the following:

- a Waste Management Licence,
- authorisation under Part 1 of the Environmental Protection Act 1990
- a Pollution Prevention and Control Permit

Diluting Special Waste (Hazardous Waste) by mixing it with Non-Hazardous materials does not qualify as treatment. Therefore, if Special Waste (Hazardous Waste) is mixed with a consignment of Non-Hazardous waste, this will result in the whole consignment being classified as Special Waste (Hazardous Waste). Furthermore Regulation 17A of the Special Waste Amendment (Scotland) Regulations 2004 imposes a duty on those who transport, recover or dispose of Special Waste (Hazardous Waste) mixed with other waste, substances or materials to separate it. This requirement applies where it is technically and economically feasible, and necessary in order to ensure that the waste is recovered or disposed of without endangering human health and the environment (ref. SEPA - Special Waste Amendment (Scotland) Regulations 2004).

It should be noted that not all Hazardous Waste/Special Waste landfill sites are authorised to accept all types of Hazardous Waste/Special Waste, and that a series of requirements must be met before, a site will accept waste. This includes ensuring that the sites Waste Acceptance Criteria (WAC) testing is met.

As an alternative coal tar bound arisings may also be disposed of by incineration (ref. ADEPT, 2016)

10 Recommendations for further work

In order to make disposal to landfill no longer a necessary option, research is needed to create a more cost-effective testing, capable of quantifying coal tar concentrations accurately, quickly and most importantly without any room for uncertainty. Importantly such testing needs to be a cost-effective option for even the smallest scheme. A review of current test methodologies has found them to be limited by their inability to definitively quantify coal tar concentrations, the vulnerability of the test results to false positives and the limited value of the results in isolation. Consequently, this makes testing time consuming, costly; and therefore, potentially impractical for many situations. As such for some small scale schemes it is more cost-effective to assume that coal-tar is present within road planings and for the material to be treated as a Category 17 03 01* Hazardous Waste/Special Waste with regards to reuse and disposal, than undertaking testing to prove the material is in fact Category 17 03 02 (Non-Hazardous). Whilst increasing transportation and disposal costs are likely to make disposal to landfill increasingly uneconomical for some schemes, it is likely to remain a cost effective means of dealing with arisings generated by small-scale schemes until an alternative is provided.

At present within England coal tar bound arisings can only be re-used in cold bitumen mixes or hydraulic binders, whilst in Scotland re-use of Category 17 03 01* arisings is not permitted, requiring such materials to be disposed of. Given increasing transportation and disposal costs, pressures to reduce carbon emissions and the risk of aggregate shortages predicted in the future, re-use of Category 17 03 01* arisings provides a solution to each of these issues. Currently extensive testing is needed to apportion coal tar as being the likely contributing source, therefore more re-use and recycling solutions need to be developed to remove the need for such testing.

It is understood that the Waste and Resources Action Programme (WRAP) were investigating an End of Waste Protocol for AWCCT (ref. Construction Manager, May 2013). However a Quality Protocol would only be accepted *'if demonstrated that the use of bound AWCCT provides no adverse impact on the environment'* (ref. 'Beyond Regulations', March 2011). Subsequently AWCCT would no longer be considered a waste and therefore not subject to current regulatory requirements, thereby reducing costs, the volume of material sent to landfill, carbon emissions and use of virgin materials; and increasing the materials potential for re-use (ref. 'Beyond Regulations', March 2011). Given the potential advantages, re-using coal tar bound arisings it is recommended that further investigation be undertaken into the practicalities of adopting an End of Waste Protocol for this material.

11 Acronyms

ADEPT – Association of Directors of Environment, Economy, Planning and Transport

AWCCT – Asphalt Waste Containing coal Tar

BMGV – Biological Monitoring Guidance Value

CAS – Chemical Abstracts Service Registry Number

CAT – Cable Avoidance Tool

Carc – Capable of causing cancer and/or heritable genetic damage

CDM – Construction, Design and Management (Regulations)

CHIRP – Chemical Hazard Information and Packaging Regulations

CLP Regulations – Classification, Labelling and Packaging of Substances Regulations

COSHH – Control of Substances Hazardous to Health

DoE – Department of the Environment

EWC – European Waste Catalogue

EA – Environment Agency (England)

EPA – Environmental Protection Agency (USA)

GC-MS - Gas Chromatography-Mass Spectrometry

GCMS – see GC-MS

GC-FID – Gas Chromatography-Flame Ionization Detector

GPR – Ground-Penetrating Radar

HSE – Health and Safety Executive

IRMM – Institute of Reference Materials and Measurements

LoW code – List of Waste codes

MS – Mass Spectrometry

NIA – No information available

NLM – US National Library of Medicine

NJDH – New Jersey Department of Health

NRW – Natural Resources Wales

PAH – Polyaromatic Hydrocarbons

PAC – See PAH

PHE – Public Health England

PPE – Personal Protective Equipment

PVC – Poly vinyl chloride

QPA – Quarry Products Association

RfD – Reference Dose

RfC – Reference concentration

RSTA – Road Surface Treatment Association

RPS075 – Regulatory Position Statement 075

SARA – Scanning Analysis Response and Assessment model

SEPA – Scottish Environmental Protection Agency

SEM – Scanning Electron Microscope

Sen – capable of causing occupational asthma

Sk – can be absorbed through the skin (dermal contact)

SVOC – Semi Volatile Organic Compounds

SWCN – Special Waste Consignment Note

TDI – Tolerable Daily Intake

TDSI – Tolerable Daily

TWA – Time Weight Average

TPHCWGS – Total Petroleum Hydrocarbons Criteria Working Group

UKAS – United Kingdom Accreditation Service

USEPA – see EPA

UV – Ultraviolet

WAC – Waste Acceptance Criteria

WM3 – Waste Classification – Guidance on the classification and assessment of waste – Technical Guidance Revision 3 (1st edition 2015)

WEL – Workplace Exposure Limits

WRAP – Waste and Resource Action Programme

12 Glossary

Absolute entry – waste that is always hazardous regardless of the concentration of the dangerous substance(s).

CAS Number – Chemical Abstracts Service Registry Number; a unique numerical identifier assigned by the Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature.

Designer – Person responsible for the design of the ground investigation.

False positive – a test result that wrong indicates that a particular contaminant is present.

Mirror entry – waste considered hazardous/special waste if the hazardous substance(s) it contains are above a specified threshold concentration(s).

Principal Contractor – appointed by the client to control any project involving more than one Contractor. The term is not applied where only one Contractor is on site; therefore, the responsibilities of the Principal Contractor therefore become the responsibilities of the Contractor.

Soxhlet – laboratory equipment used for extraction of material.

13 References

13.1 Articles

‘Contaminants recycled with care’: Eurovia Roadstone – Modern Asphalts, August 2011

“Continuing Professional Development: Coal Tar” – Construction Manager Magazine, May 2013

13.2 Government Agencies – United Kingdom

Environment Agency – www.environment-agency.gov.uk

Health and Safety Executive – www.hse.gov.uk

Natural Resources Wales – https://naturalresources.wales/

NetRegs - “Environmental Guidance for Your Business in Northern Ireland and Scotland” - www.netregs.org.uk

Northern Ireland Environment Agency – www.daera-ni.gov.uk

Scottish Environmental Protection Agency – www.sepa.org.uk

Public Health England – https://www.gov.uk/government/organisations/public-health-england

13.3 Government Agencies - International

European Commission – http://ec.europa.eu

New Jersey Department of Health – www.nj.gov/health

United States Environmental Protection Agency – www.epa.gov

13.4 Guidelines

“Guidance on the Production of Fully Recovered Asphalt Road Planings” - Quarry Products Association and Scottish Environment Protection Agency (undated)

‘Gas works, coke works and other coal carbonisation plants‘- Department of the Environment Industry Profile (1995)

“Hazardous waste: consignment note guidance” - https://www.gov.uk/guidance/hazardous-waste-consignment-note-supplementary-guidance

“Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWGS)”

– Volume 1 - Analysis of Petroleum Hydrocarbons in Environmental Media – March 1998

– Volume 2 – Composition of Petroleum Mixtures - 1998; Amherst Scientific Publishers

– Volume 3 – Selection of Representative Total Petroleum Hydrocarbons (TPH) Fractions Based on Fate and Transport considerations – 1997; Amherst Scientific Publishers

– Volume 4 – Development of Fraction-Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH) – 1997; Amherst Scientific Publishers

- Volume 5 – Human Health Risk-Based Evaluation of Petroleum Contaminated Sites: Implementation of the Working Group Approach – 1998; Amherst Scientific Publishers

“Special Waste Amendment (Scotland) Regulations 2004 – Frequently Asked Questions” – SEPA www.sepa.org.uk/media/35347/special-waste-amendment-scotland-regulations-2004-faqs.pdf

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"A guide to consigning special waste"– Scottish Environment Protection Agency (June 2006)

HSG151 2nd Edition - "Protecting the Public: Your next move" – Health and Safety Executive, 2009

"Traffic Safety Measures and Signs for Road Works and Temporary Situations" – Chapter 8, Traffic Signs Manual (2009)

"RSTA Code of Practice for In-situ Structural Road Recycling" – RSTA and ADEPT (2012)

HSE53 4th Edition – "Respiratory protective equipment at work: A practical guide" – Health and Safety Executive, 2013

"Waste Sampling and Testing for Disposal to Landfill" – EBPRI 11507B (March 2013); Environment Agency

HSG47 3rd Edition - "Avoiding danger from underground services" – Health and Safety Executive, 2014

"Guidance on the classification and assessment of waste (1st edition 2015) Technical guidance WM3"– (July 2015) Scottish Environment Protection Agency, Natural Resources Wales, Environment Agency and Northern Ireland Environment Agency

"Managing Reclaimed Asphalt – Highways and Pavements" - ADEPT Guidance Note - version 2016.1 (January 2016)

13.5 Legislation and Regulations

"Authorisation to mix special waste (Scotland)" – www.gov.uk/authorisation-to-mix-special-waste-scotland

"Carriage of dangerous goods" – Health and Safety Executive – www.hse.gov.uk/cdg/index.htm

CLP Regulations - Classification, Labelling and Packaging of Substances Regulations; EC 1272/2008

Construction (Design and Management) Regulations, 2015

"Control of Pollution (Amendment) Act 1989" - www.legislation.gov.uk/ukpga/1989/14/contents

"Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations 1991 - www.legislation.gov.uk/uksi/1991/1624/contents/made

Hazardous Waste Directive (Council Directive 91/689/EEC of 12 December 1991 on hazardous waste) 1991

"EH40/2005 Workplace Exposure Limits" – Health and Safety Executive – UK Workplace Exposure Limits (2005) - http://www.hse.gov.uk/pubns/priced/eh40.pdf

"Environmental Permitting (England and Wales) Regulations 2010" - http://www.legislation.gov.uk/ukdsi/2010/9780111491423/contents

"New Roads and Street Works Act 1991" – www.legislation.gov.uk/ukpga/1991/22/section/50

Public Health England – www.gov.uk/government/organisations/public-health-england

- "Aniline Incident Management" – 2011
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- "Cyclohexane: Incident Management" – 2011
- "Hydrazine: Incident Management" – 2011
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- "n-Hexane: Incident Management" – 2011
- "Phenol: health effects, incident management and toxicology" – July 2014
- "Phthalates: Incident Management" – October 2015
- "Pyridine: Incident Management" – 2010
- "Toluene: Incident Management" – March 2012
- "Xylene: health effects and incident Management" – October 2015

"Special Waste Regulations 1996" – www.legislation.gov.uk/uksi/1996/972/contents/made

"Special Waste Amendment (Scotland) Regulations 2004" – www.gov.scot/Publications/2003/11/18527/29047

The European Waste Catalogue (EWC) – 2002

"The Environmental Protection (Duty of Care) (Scotland) Regulations 2014 - www.legislation.gov.uk/ssi/2014/4/regulation/4/made

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Waste Frameworks Directive 2008/98/EEC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives – Official Journal of the European Union L 312/3 – http://eur-europa.eu

13.6 Research Papers and Reports

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USEAP, 1989 - “Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual” (EPA/540/1-89/002)

USEPA, 1994 – “Review Draft Guidelines for Reproductive Toxicity Risk Assessment” (EPA600.AP.94.001)

13.7 Standards

13.7.1 Standards for Highways

HD29/08 - Data for Pavement Assessment; Part 3 (2008) - www.standardsforhighways.co.uk

HD30/08 - Maintenance Assessment Procedure; Section 4 Pavement Maintenance (2008) - www.standardsforhighways.co.uk

HD35/04 – ‘Conservation and the Use of Secondary and Recycled Materials’ (2004) – DMRB Volume 7 Section 1 Part 2 – www.standardsforhighways.co.uk

Manual of Contract Documents for Highway Works – Volume 1 Specification for Highway Works – Series 900 Road Pavements – “Road Pavements - Bituminous Bound Materials” – www.standardsforhighways.co.uk

13.7.2 UK version of European Standards

BS EN 932-1:1997 – Tests for general properties of aggregates. Methods for sampling

BS EN 932-2:1999 – Tests for general properties of aggregates. Methods of reducing laboratory samples.

BS EN 12697-6:2012 – Bituminous mixtures – Test methods for hot mix asphalt. Determination of bulk density of bituminous specimens.

BS EN 12697-28:2001 – Bituminous mixtures – Test methods for hot mix asphalt. Preparation of samples for determining binder content, water content and grading.

BS EN 12697-36:2003 - Bituminous mixtures – test methods for hot mix asphalt – Part 36: Determination of the thickness of a bituminous pavement

BS EN 13108-8:2016 – “Bituminous mixtures. Material specification. Reclaimed asphalt”

13.7.3 British Standards

BS 10175:2011+A1:2013 – Investigation of potentially contaminated sites – Code of practice, March 2011

13.8 Web sources and databases

Alfa Aesar – www.alfa.com

Fisher Scientific UK – www.fishersci.co.uk

Hazardous Waste - https://www.gov.uk/dispose-hazardous-waste/overview

“Dust” – Frequently asked questions – Health and Safety Executive
http://www.hse.gov.uk/construction/faq-dust.htm

Impact Test Equipment – PAK – Polycyclic Aromatic Hydrocarbon Detection - http://www.impact-test.co.uk/products/5280-pak-marker-spray-can-400ml/

Institute of Reference Materials and Measurements (IRMM) – JRC Science Hub – European Commission – http://ec.europa.eu/jrc/en/irmm

Look Chem – www.lookchem.com

PAK-MARKER – Interlab – www.interlab.bv.nl

PAN Pesticide Database – www.pesticideinfo.org

Registered Waste Carriers and Brokers (SEPA) - http://apps.sepa.org.uk/rocas/

Sigma Aldrich – www.sigmaaldrich.com

Spectrum Chemical – www.spectrumchemical.com

Termium Plus – www.termiumplus.gc.ca

US National Library of Medicine - http://toxnet.nlm.nih.gov/index.html

13.9 Other sources of information

Details of currently available laboratory testing details provided by:

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- DETS
- I2 Analytical
- Jones Environmental
- SAL Ltd

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www.soci.org/~/media/Files/Conference%20Downloads/2011/Recycling%20and%20Re%20using%20Asphalt%20Mar%2011/Martin_Brocklehurst_Presentation.ashx

Appendix A

Chemical composition of coal tar

Appendix A

Chemical composition of coal tar

With reference to the Department of Environment Industry (DoE) profile for Gas works, coke works and other coal carbonisation plants the principal components of coal tar are:

- Aromatic hydrocarbons – e.g. benzene, toluene and xylenes
- Polycyclic Aromatic Hydrocarbons – e.g. naphthalene and anthracene
- Hydroxy substituted phenyls – e.g. phenols, cresol, xylenols and related compounds, sodium phenoxide
- Heterocyclic nitrogen compounds – e.g. pyridine
- Organo-sulphur compounds e.g. thiophene
- Nitrogen compounds e.g. hydrazine, triethanolamine
- 2-mercaptobenzothiazole

This is consistent with information from the NLM which describes coal tar as containing *"a variable mix of organic compounds which include benzene, toluene, xylenes, cumenes, coumarone, indene, benzofuran, naphthalene, acenaphthene, methylnaphthalenes, fluorene, phenol, cresols, pyridine, picolines, phenanthrene, anthracene, carbazole, quinolines, fluoranthene, and pyrene"*.

A document by the US Department of Health and Human Services on the "toxicological profile for wood creosote, coal tar creosote, coal tar, coal tar pitch and coal tar pitch volatiles"(Sept 2002) lists the PAH components of coal tar pitch (Table 4-7 within the document) as determined by a study by Guillen, M.D. et al (1992). These are listed in Table A below. In the paper by Jiang, J. et al (2007) the composition of coal tar was produced by pyrolysis of coal obtained from central China. The coal tar was analysed by GC/MS techniques. The results are listed as aliphatic, aromatic, ester and polar group components of the coal tar, with the overall composition of the substance presented as Table 8 within the paper. These are listed in tables B to F below. Other chemicals listed within the DoE Industry profile are listed as Table G.

The chemicals listed in Tables A to G have been compared against UK Workplace Exposure Limits (WEL) (EH40/2005 Workplace exposure limits – HSE) Table H. However only approximately 500 substances have WEL's and as such where no WEL exists, guidance on human health and environmental risk have been obtained from laboratory health and safety datasheets to give some indication of the hazards posed. In some instances no information may be available for the substance.

Public Health England (www.gov.uk/government/organisations/public-health-england) have produced guidance on Polycyclic Aromatic Hydrocarbons with specific focus on Benzo(a)pyrene. Other documents relevant to coal tar include Aniline, Benzene, Cyclohexane, Hydrazine, Naphthalene, n-Hexane, Phenol, Phthalate, Pyridine, Toluene and Xylene. Information on exposure limits are included within Tables A to G

Where no WEL exist information on Reference Doses/Reference Concentrations (RfD)/(RfC) have been obtained from work undertaken by the Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWGS). An RfD is "an estimate (with uncertainty spanning perhaps an order of magnitude) of daily exposure to the human population, including sensitive subgroups that is likely to be without appreciable risk of deleterious effects during a lifetime" (USEPA, 1989). An RfC is "an estimate (with uncertainty spanning perhaps an order of magnitude) of continuous inhalation exposure to the human population, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a lifetime (USEPA, 1994).

Table A -- Summary of PAH components of coal tar pitch (derived from "Toxicological profile for wood creosote, coal tar creosote, coal tar, coal tar pitch and coal tar pitch volatiles" US Department of Health and Human Services

PAH component	**CAS number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
naphthalene	91-20-3*	X	X	X	X	PHE	No WEL Tolerable Daily Intake (oral) = 20ug kg^{-1} bw day^{-1} Tolerable Daily Intake (oral) = 7 ug kg^{-1} bw day^{-1} TDSI (oral) Adult = 20 ug kg^{-1} bw day^{-1} TDSI (oral) Child = 20 ug kg^{-1} bw day^{-1} Tolerable Daily Intake (inhale) = 0.86ug kg^{-1} bw day^{-1} Mean daily intake (inhale) = 2.8 ug day^{-1} TDSI (inhale) Adult = 0.82 ug kg^{-1} bw day^{-1} TDSI (inhale) Child = 0.79 ug kg^{-1} bw day^{-1}
benzo(b)thiophene							NIA on WEL
quinoline	91-22-5	X	X	X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
2-methylnaphthalene	91-57-6		X	X	X	Sigma Aldrich TPHCWGS	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure
							NIA on WEL RfD (oral) 0.03mg/kg/day~
1-methylnaphthalene	90-12-0	X	X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Respiratory sensitization, Carcinogenicity, Mutagenicity Aspiration hazard
						TPHCWGS	NIA on WEL RfD (oral) 0.06mg/kg/day
biphenyl	92-52-4*		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure
						TPHCWGS	NIA on WEL RfD = 0.05 mg/kg/day

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
2-ethylnaphthalene						Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
dimethylnaphthalene			X	X	X	Sigma Aldrich	Depends on type, worst case given: Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure
methylbiphenyl						Alfa Aesar	May depend on type. Causes skin irritation, eye irritation and may cause respiratory irritation NIA on WEL
acenaphthene	83-32-9		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
azaacenaphthylene							NIA on WEL
dibenzofuran	132-64-9		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
fluorene	86-73-7			X	X	Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling.
						TPHCWGS	NIA on WEL RfD = 0.04 mg/kg/day
methylacenaphthene	36541-21-6						NIA on WEL
9,10-dihydroanthracene	613-31-0			X	X	Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
9,10-dihydrophenanthrene	776-35-2			X	X	Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
Methylfluorene (1-methylfluorene is suggested by Sigma Aldrich website)	- 1730-37-6					Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
1,2,3,4-tetrahydroanthracene	2141-42-6						NIA on WEL
phenanthrene	85-01-8		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
anthracene	120-12-7*					TPHCWGS	NIA on WEL RfD = 0.3 mg/kg/day
acridine	260-94-6		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
phenanthridine	229-87-8		X			Sigma Aldrich	Corrosive to metals, Skin corrosion, serious eye damage NIA on WEL
carbazole	86-74-8	X				Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL
methylphenanthrene, -anthracene		X				NLM	Carcinogen as benzene soluble aerosol

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
4H-cyclopenta(def)phenanthrene	203-64-5						NIA on WEL
Methylcarbazole (9-Methylcarbazole is suggested by Sigma Aldrich website)	- 1484-12-4		X	X	X	Sigma Aldrich	Will depend on type, not all have been determined. Corrosive to metals, Skin corrosion, Serious eye damage, Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
2-phenylnaphthalene	612-94-2					Fisher Scientific	NIA on WEL
azafluoranthene	206-56-4						NIA on WEL
phenanthro(4,5-bcd)thiophene	30796-92-0						NIA on WEL
pyrene	129-00-0	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard
						THPCWGS	NIA on WEL RfD (oral) = 0.03 mg/kg/day
Benzonaphthofuran	243-42-5 205-39-0					Sigma Aldrich	NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
(Benzon(b)naphtha(1,2-d)furan is suggested by Sigma Aldrich website)							
benzacenaphthene or isomer	-	Proven carcinogen in animal testing				NLM	Carcinogen as benzene soluble aerosol
(Fluoranthene?)	206-44-0*		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure
						TPHCWGS	NIA on WEL RfD = 0.04 mg/kg/day
benzo(lmn)phenanthridine	194-03-6						NIA on WEL
benzo(kl)xanthene	200-23-7						NIA on WEL
methylfluoranthene, -pyrene							NIA on WEL
4H-benzo(def)carbazole	203-65-6					Sigma Aldrich	No information available NIA on WEL
azafluoranthene, -pyrene							NIA on WEL
benzo(a)fluorene (11-H benzo(a)fluorine is suggested by Sigma Aldrich website)	238-84-6 -					Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling.

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							NIA on WEL
benzo(c)fluorene (7H-benzo(c)fluorene is suggested by Sigma Aldrich website)	205-12-9 -	x				Sigma Aldrich	Carcinogen NIA on WEL
Methylbenzacenaphthene							NIA on WEL
Methylpyrene							
(1- methylpyrene is suggested by Sigma Aldrich website)	2381-21-7		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
(2- methylpyrene is suggested by pesticideinfo.org)	3442-78-2			May be toxic to molluscs		pesticideinfo.org	
methylazapyrene							NIA on WEL
methylbenzofluorene							NIA on WEL
dihydrochrysene							NIA on WEL
Dimethylfluoranthene							NIA on WEL
trimethylfluoranthene							NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
benzo(b)naphtho(2,1-d)thiophene	239-35-0						NIA on WEL
benzo(c)phenanthrene	195-19-7		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
benzo(ghi)fluoranthene	203-12-3					Sigma Aldrich	Information not available
			Possibly	Possibly		NLM	Occupational exposure limits have not been established. May be toxic through inhalation. NIA on WEL
dimethylbenzonaphthofuran							NIA on WEL
benzo(b)naphtho(1,2-d)thiophene	205-43-6					Sigma Aldrich	Information not available NIA on WEL
Dibenzoquinoline (dibenzo(f,h)quinolone is suggested by Sigma Aldrich website)	85495-86-9 217-65-2					Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
tetrahydrochrysene							NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
benzo(a)naphtho(2,3-d)thiophene							NIA on WEL
benz(a)anthracene	56-55-3	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL
chrysene	218-01-9	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL
11H-benzo(a)carbazole	239-01-0		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
naphthacene	92-24-0	Not available	x			Spectrumchemical.com	Acute toxicity. There are no known effects from chronic exposure NIA on WEL
methylbenzonaphthothiophene							NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
tetramethylfluoranthene							NIA on WEL
Methylbenz(a)anthracene (1-Methylbenz(a)anthracene is suggested by Sigma Aldrich website)	- 2498-77-3					Sigma Aldrich	No information available NIA on WEL
Tetramethylfluoranthene	71277-99-1						NIA on WEL
7H-benzo(c)carbazole	205-25-4	X				Lookchem.com NLM	Possible mutagen? Possible carcinogen NIA on WEL
5H-benzo(b)carbazole	243-28-7						NIA on WEL
methylbenzophenanthridine	140206-47-9						NIA on WEL
dimethylbenzo(cdf)carbazole							NIA on WEL
Methylchrysene (6-Methylchrysene is suggested by Sigma Aldrich website)	- 1705-85-7		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
11H-benz(bc)aceanthrylene	202-94-8						NIA on WEL
4H-cyclopenta(def)chrysene	202-98-2						NIA on WEL
Binaphthalene (rac-BINAP)	-						

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
	76189-55-4 (R) 76189-56-5 (S)						No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
4H-cyclopenta(def)triphenylene	23992-32-7						NIA on WEL
Phenylphenanthrene (9-phenyl phenanthrene suggested)	- 844-20-2						NIA on WEL
Dihydrobenzofluoranthene							NIA on WEL
Dimethylchrysene							NIA on WEL
dibenzophenanthridine	140206-63-9						NIA on WEL
Biquinoline (2,2'-Biquinoline is suggested by Sigma Aldrich website)	- 119-91-5		X				Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
benzo(j)fluoranthene	205-82-3*	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							NIA on WEL
benzo(b)fluoranthene	205-99-2*	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL
						NJHD	OSHA – airborne permissible exposure limit 0.2mg/m3 over 8 hours NIOSH – airborne exposure limit of 0.1mg/m3 averaged over a 10 hour shift ACGIH – airborne exposure limit of 0.2mg/m3 averaged over 8 hour shift
benzo(k)fluoranthene	207-08-9	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL
dibenzonaphthofuran	133248-55-2						NIA on WEL
azabenzopyrene	109489-32-9						NIA on WEL
benzophenanthrothiophene	80819-45-0	Possibly					Possible carcinogen NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
benzo(e)pyrene	192-97-2	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL
perylene	198-55-0					Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
						NLM	Average daily intake 0.76ng/day/man based on avg daily intake of perylene in ambient air samples collected from Osaka, Japan
benzo(a)pyrene	50-32-8	X				HSE	Index dose - inhalation - 0.7×10^{-3} ug kg^{-1} bw day^{-1} Index dose – oral - 0.02 ug kg^{-1} bw day^{-1}
methylbenzofluoranthene							NIA on WEL
4H-naphtho(1,2,3,4-def)carbazole							NIA on WEL
dibenzofluorene	238-84-6						NIA on WEL
dihydroindenopyrene							NIA on WEL
Methylbenzopyrene							NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
(1-Methylbenzo(a)pyrene suggested)	40568-90-9						
dibenzo(cg)phenanthrene							NIA on WEL
11H-cyclopenta(ghi)perylene	83899-23-4						NIA on WEL
Dimethylbenzopyrene (7,10-dimethylbenzo(a)pyrene suggested)	 63104-33-6						NIA on WEL
11H-indeno(2,1,7-cde)pyrene	59004-71-6						NIA on WEL
dinaphthothiophene	71012-24-3						NIA on WEL
dibenzonaphthothiophene							NIA on WEL
Dibenzocarbazole (7H-Dibenzo(c,g,)carbazole suggested by NLM)	- 194-59-2	Possibly				NLM	Possible human carcinogen based on animal lab studies NIA on WEL
dibenzo(bg)phenanthrene							NIA on WEL
benzo(g)chrysene	196-78-1						NIA on WEL
dimethylbenzofluoranthene							NIA on WEL
Dibenzoacridine (dibenzo(aj)acridine suggested)	- 224-42-0	Possibly				Termium Plus	NIA on WEL
benzo(c)chrysene	194-69-4	Suspected carcinogen				Sigma Aldrich	No information available NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
dibenz(aj)anthracene	224-41-9		X			Sigma Aldrich	Acute toxicity (oral, dermal and inhalation) NIA on WEL
indenopyrene	193-39-5						NIA on WEL
methyldibenzophenanthrene							NIA on WEL
methyldibenzophenanthracene							NIA on WEL
methylbenzophenanthrothiophene							NIA on WEL
dibenz(ac)anthracene	215-58-7		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal and inhalation) NIA on WEL
dibenz(ah)anthracene	53-70-3	X		X	X	IRMM Safety datasheet	
						NJDH	Acute and chronic health effects are associated with this contaminant NIA on WEL
trimethylbenzofluoranthene	140206-45-7						NIA on WEL
dimethyldibenzophenanthrene							NIA on WEL
dimethyldibenzophenanthracene							NIA on WEL

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
benzo(b)chrysene	214-17-5					Sigma Aldrich	No information available NIA on WEL
picene	213-46-7					Sigma Aldrich	No human health risk classification listed. NIA on WEL
benzo(ghi)perylene	191-24-2			X	X	Sigma Aldrich	NIA on WEL
		Possible carcinogen				SEPA	
benzo(a)naphthacene	226-88-0						NIA on WEL
anthanthrene	191-26-4	X				IRMM datasheet	
			X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
methyl indenopyrene	140206-70-8						NIA on WEL
Notes							

PAH component	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
NIA on WEL	No information available on Workplace Exposure Limits		NLM		US National Library of Medicine	IRMM	Institute of Reference Materials and Measurements
SEPA	Scottish Environmental Protection Agency		Sigma Aldrich		www.sigmaaldrich.com (chemical supply company)	HSE	Health and Safety Executive
PHE	Public Health England		NJDH		New Jersey Department of Health - USA	Spectrumchemical.com	Chemical supply company
pesticideinfo.org	Pesticide Database - USA		Fisher Scientific		Chemical supply company	Alfa Aesar	Supplier of materials and reagents
Termium Plus	Chemical Database - Canada						

Table B –Compositions analysis results of aliphatics group in coal tar (derived from "GC/MS Analysis of coal tar composition produced from coal pyrolysis", Jiang, J., et al (2007)

Substance	**CAS number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
Butane,2,2-dimethyl	75-83-2	X	X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization, Mutagenicity, Carcinogenicity, Reproductive toxicity, Specific target organ toxicity – repeat exposure, Aspiration hazard NIA on WEL
1-Pentene,2,4,4-trimethyl	107-39-1			X	X	Sigma Aldrich	NIA on WEL
Hexanaphthene Also known as Cyclohexane	110-82-7	X	X	X	X	PHE	LTEL (8 hour reference period): 100ppm (350mg m^{-3}) STEL (15 min reference period): 300 ppm (1050mg m^{-3})
1,3,5-Cycloheptatriene (Cycloheptatriene suggested by Sigma Aldrich website)	544-25-2 544-25-2	X	X			Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL
3,4-Heptene (1-Heptene suggested by Sigma Aldrich website)	- 592-76-7	X	X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization, Mutagenicity, Carcinogenicity, Reproductive

Substance	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							toxicity, Specific target organ toxicity – repeat exposure, Aspiration hazard NIA on WEL
1,3,5,7-Cyclooctatetraene (1,3,5,7-Cyclooctatetraene-1,2-dicarboxylic acid suggested by Sigma Aldrich website)	629-20-9 -					Sigma Aldrich	No information available NIA on WEL
Dicyclooctane,1,3,5-triene							NIA on WEL
1-Heptene	592-76-7	X	X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
2-Hexene,3-ethyl	Not available						NIA on WEL
Octane	111-65-9	X	X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL

Substance	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
Octane,2-methyl	3221-61-2						NIA on WEL
Octane,4-ethyl	2216-34-4						NIA on WEL
1-Octene	111-66-0	X	X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
1-Nonene,3-methyl	2980-71-4					Sigma Aldrich	Skin corrosion, serious eye damage NIA on WEL
Undecane	1120-21-4	X				Sigma Aldrich	Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
Undecane,2,6-dimethyl	17301-23-4						NIA on WEL
Decane,3-methyl	13151-34-3						NIA on WEL
Undecane,2,3-dimethyl							NIA on WEL
1-Undecene,4-methyl	74630-39-0						NIA on WEL

Substance	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
Dodecane	112-40-3	X				Sigma Aldrich	Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
1,12-Tridecdiene							NIA on WEL
1-Tridecene	2437-56-1		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Tridecane	629-50-5	X				Sigma Aldrich	Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
1-Tetradecene	1120-36-1	X				Sigma Aldrich	Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
1-Pentadecene	13360-61-7					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling.

Substance	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							NIA on WEL
Eicosane,7-hexyl	55333-99-8						NIA on WEL
Phenanthrene,9-dodecyltetradecahydro							NIA on WEL
Heptadecane,9-hexyl	55124-79-3						NIA on WEL
Octadecane,3-ethyl-5-(2-ethyl butyl)	55282-12-7						NIA on WEL
Nonadecane	629-92-5					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling. NIA on WEL
7-Pentacosene	96313-98-3						NIA on WEL
Nonadecane,3-methyl-5-(2-ethyl butyl)	6418-45-7						NIA on WEL
Docosane,7-hexyl	55373-86-9						NIA on WEL
Indene,methyl (2-Methylindene suggested by Sigma Aldrich website)	- 2177-47-1					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling. NIA on WEL

Substance	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
Naphthalene,2-methyl	91-57-6	X	X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Specific target organ toxicity – single exposure, Respiratory sensitization, Mutagenicity, Carcinogenicity, Reproductive Toxicity, Specific Target Organ Toxicity – repeated exposure, Aspiration Hazard.
						TPHCWGS	NIA on WEL RfD = 0.06 mg/kg/day
Naphthalene,1-methyl	90-12-0		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure
						TPHCWGS	NIA on WEL RfD = 0.03 mg/kg/day
Indole	120-72-9		X	X	X	Sigma Aldrich	Skin corrosion, Serious eye damage NIA on WEL
Indole,1-methyl (1-methylindole-3-carboxylic acid suggested by sigma Aldrich website)	32387-21-6		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation. Eye irritation, Skin sensitization, Specific Target Organ Toxicity NIA on WEL
Naphthalene,2,6-dimethyl	581-42-0			X	X	Sigma Aldrich	
Naphthalene,1,4-dimethyl	571-58-4					Sigma Aldrich	No human health risk classification listed.

Substance	**CAS number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
							Eye shield, gloves and respirator recommended when handling.
Biphenylene	259-79-0					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling. NIA on WEL
11-Heneicosanone	19781-72-7					Sigma Aldrich	No information available NIA on WEL
Benzyl Benzoate	120-51-4		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, NIA on WEL
Phenanthrene	85-01-8		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, NIA on WEL
Benzo[k]fluoranthrene	207-08-9	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
Benzo[ghi]perylene	191-24-2			X	X	Sigma Aldrich	NIA on WEL

Substance	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
9,10-Dimethylanthracene	781-43-1	X	X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
Pyrene,1-methyl	2381-21-7		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, NIA on WEL
Benzo[b]naphtha[2,1-d]thiophene		Possible mutagen?					NIA on WEL
Triphenylene	217-59-4			X	X	Sigma Aldrich	Skin corrosion, Serious eye damage NIA on WEL
Notes							

NIA on WEL	No information available on Workplace Exposure Limits	NLM	US National Library of Medicine	IRMM	Institute of Reference Materials and Measurements
SEPA	Scottish Environmental Protection Agency	Sigma Aldrich	www.sigmaaldrich.com (chemical supply company)	HSE	Health and Safety Executive
PHE	Public Health England	NJDH	New Jersey Department of Health - USA	Spectrumchemical.com	Chemical supply company

Substance	CAS number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes

pesticideinfo.org	Pesticide Database - USA	Fisher Scientific	Chemical supply company	Alfa Aesar	Supplier of materials and reagents

Table C - Based on the compositions analysis results of aromatics group in coal tar (derived from "GC/MS Analysis of coal tar composition produced from coal pyrolysis", Jiang, J., et al (2007)

Substance		**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
Phenylmethane (Toulene)	- 108-88-3	X	X			PHE	LTEL (8 hour reference period): 50ppm (191 mg m^{-3}) STEL (15min reference period: 100 ppm (384 mg m^{-3})
p-Xylene	106-42-3		X			PHE	LTEL (8 hour reference period): 50ppm (220 mg m^{-3}) STEL (15min reference period: 100 ppm (441 mg m^{-3})
						TPHCWGS	RfD = 2 mg/kg/day
Pyridine	110-86-1		X			PHE	LTEL (8 hour reference period): 5ppm (16 mg m^{-3}) STEL (15min reference period: 10 ppm (33 mg m^{-3})
Xylene	1330-20-7		X			PHE	LTEL (8 hour reference period): 50ppm (220 mg m^{-3}) STEL (15min reference period: 100 ppm (441 mg m^{-3})
						TPHCWGS	RfD = 2 mg/kg/day
Indene	95-13-6					HSE	LTEL (8 hour reference period): 10ppm (48 mg m^{-3}) STEL (15min reference period: 15 ppm (72 mg m^{-3})
Quinoline	91-22-5	X	X	X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard

Substance		Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							NIA on WEL
Indene,methyl (2-Methylindene suggested by Sigma Aldrich website)	- 2177-47-1					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling. NIA on WEL
Naphthalene	91-20-3	X	X	X	X	PHE	No WEL Tolerable Daily Intake (oral) = 20ug kg^{-1} bw day^{-1} Tolerable Daily Intake (oral) = 7 ug kg^{-1} bw day^{-1} TDSI (oral) Adult = 20 ug kg^{-1} bw day^{-1} TDSI (oral) Child = 20 ug kg^{-1} bw day^{-1} Tolerable Daily Intake (inhale) = 0.86ug kg^{-1} bw day^{-1} Mean daily intake (inhale) = 2.8 ug day^{-1} TDSI (inhale) Adult = 0.82 ug kg^{-1} bw day^{-1} TDSI (inhale) Child = 0.79 ug kg^{-1} bw day^{-1}
Naphthalene,2-methyl	9157-6		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure

Substance		Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
						TPHCWGS	NIA on WEL RfD = 0.06 mg/kg/day
Naphthalene,1-methyl	90-12-0		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure
						TPHCWGS	NIA on WEL RfD = 0.06 mg/kg/day
Indole	204-420-7		X	X	X	Sigma Aldrich	Skin corrosion, Serious eye damage, Acute toxicity (oral, dermal, inhalation) NIA on WEL
biphenyl	92-52-4		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure
						TPHCWGS	NIA on WEL RfD = 0.05 mg/kg/day
Indole,1-methyl	603-76-9					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling. NIA on WEL
Naphthalene,2,6-dimethyl	581-42-0			X	X	Sigma Aldrich	NIA on WEL

Substance		Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
Naphthalene,1,4-dimethyl	571-58-4					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling. NIA on WEL
Biphenylene	259-79-0					Sigma Aldrich	No human health risk classification listed. Eye shield, gloves and respirator recommended when handling. NIA on WEL
1-Isopropenyl naphthalene							NIA on WEL
Dibenzo furan	132-64-9						NIA on WEL
Naphthalene,1,6,7-trimethyl	2245-38-7						NIA on WEL
Fluorene	86-73-7			X	X	Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling.
						TPHCWGS	NIA on WEL RfD = 0.04 mg/kg/day
1,1-Biphenyl,4-methyl							NIA on WEL
6H-Dibenzo[b,d]-pyran							NIA on WEL
11-Heneicosanone	19781-72-7					Sigma Aldrich	No information available NIA on WEL
9H-Fluorene,2-methyl	1430-97-3						NIA on WEL
Benzyl Benzoate	120-51-4		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ

Substance		Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							toxicity – single exposure, Respiratory sensitization
4-Phenanthrenol,1,2,3,4-tetrahydro-4-methyl	77536-58-4						NIA on WEL
Phenanthrene	85-01-8		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization NIA on WEL
Phenol,4-(2-phenyl ethenyl)	6554-98-9						NIA on WEL
Phenyl-pyridin	1008-89-5						NIA on WEL
Benzo[b]quinolone Also known as Acridine	260-94-6		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Benzenamine,4,4-methylenebis							NIA on WEL
Anthracene,2-methyl	613-12-7						NIA on WEL
9H-Fluorene-2-carbonitrile							NIA on WEL
Naphthalene,2-phenyl	612-94-2						NIA on WEL
Phenanthrene,1,7-dimethyl							NIA on WEL
9,10-Dimethy anthracene	781-43-1	X	X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target

Substance		Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
Pyrene	129-00-0	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard
						THPCWGS	NIA on WEL RfD (oral) = 0.03 mg/kg/day
Fluoranthrene	206-44-0		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Pyrene,1-methyl	2381-21-7		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure, NIA on WEL
Benzo[kl]xanthrene	200-23-7						NIA on WEL
benzo(c)fluorene (7H-benzo(c)fluorene is suggested by Sigma Aldrich website)	205-12-9 -	x				Sigma Aldrich	Carcinogen NIA on WEL
Pyrene,1,3-dimethyl	64401-21-4						NIA on WEL

Substance		**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
Benzo[b]naphtha[2,1-d]thiophene	239-35-0	Possible mutagen?					NIA on WEL
Benzo[a]phenazine,12-oxide	18636-87-8						NIA on WEL
Triphenylene	217-59-4			X	X		Skin corrosion, Serious eye damage NIA on WEL
Naphthacene	92-24-0	Not available	x			Spectrumchemical.com	Acute toxicity. There are no known effects from chronic exposure NIA on WEL
Benzo[c]phenanthrene,5-methyl	652-04-0						NIA on WEL
benzo(a)pyrene	50-32-8	X				HSE	Index dose - inhalation - 0.7x10^{-3} ug kg^{-1} bw day^{-1} Index dose – oral - 0.02 ug kg^{-1} bw day^{-1}
Benzo[k]fluoranthrene	207-08-9	X		X	X	Sigma Aldrich	Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
Benzo[ghi]perylene	191-24-2			X	X	Sigma Aldrich	NIA on WEL

Notes

NIA on WEL	No information available on Workplace Exposure Limits	NLM	US National Library of Medicine	IRMM	Institute of Reference Materials and Measurements
SEPA	Scottish Environmental Protection Agency	Sigma Aldrich	www.sigmaaldrich.com (chemical supply company)	HSE	Health and Safety Executive
PHE	Public Health England	NJDH	New Jersey Department of Health - USA	Spectrumchemical.com	Chemical supply company

Substance		**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**

pesticideinfo.org	Pesticide Database - USA	Fisher Scientific	Chemical supply company	Alfa Aesar	Supplier of materials and reagents

Table D - Based on the compositions analysis results of ester group in coal tar (derived from "GC/MS Analysis of coal tar composition produced from coal pyrolysis", Jiang, J., et al (2007)

Substances	**CAS Number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Sources**	**Notes**
o-Acetyl-L-serine	66638-22-0						NIA on WEL
1-Deoxy-d-mannitol	-						NIA on WEL
2-Cyclopentanone (Cyclopentanone is suggested by Sigma Aldrich website)	- 120-92-3		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
2,5-Dimethyl furan	625-86-5		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
2-Furanketon	-						NIA on WEL
2-Methylpropyl acetate Also known as Isobutyl acetate	- 110-19-0		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Carbamicacid,phenylester Also known as Phenyl carbamate	- 622-46-8					Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
Propionic acid 2-methylbenzyl ester Also known as Isobutyric acid	- 79-31-2		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL

Substances	**CAS Number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Sources**	**Notes**
Cyclohexane-3-nitrile (3-Cyclohexene-1-carboxylic acid suggested by Sigma Aldrich website)	- 4771-80-6		X			Sigma Aldrich	Skin corrosion, Serious eye damage, Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Phenol,2,3-dimethyl (2,3-Dimethylphenol)	526-75-0		X	X	X	Sigma Aldrich	Corrosive to metals, Skin corrosion, Serious eye damage, Acute toxicity (oral, dermal, inhalation), NIA on WEL
3,4-Dimethyl benzyl alcohol	6966-10-5					Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
Methyl-nitro carbonate acid athyl ester	-						NIA on WEL
4-Hydroxy benzene sulfonic acid	98-67-9					Sigma Aldrich	Corrosive to metals, Skin corrosion, Serious eye damage NIA on WEL
Butylated Hydroxytoluene	128-37-0				X	Sigma Aldrich	No human health risk classification listed. Eye-shield, gloves and respirator recommended when handling. NIA on WEL
dl-5-Methyltryptophan	951-55-3					Sigma Aldrich Fisher Science	Eye-shield, gloves and respirator recommended when handling. May cause eye and skin irritation and respiratory and digestive tract irritation. Toxicology properties have not been fully investigated

Substances	**CAS Number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Sources**	**Notes**
							NIA on WEL
Dibenzofuran	132-64-9		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Acridine	260-94-6		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
1,2-Benzedicarboxylic acid, bis(2-methlpropyl) ester	18699-48-4						NIA on WEL
Dibutylphthalate	84-74-2	X		X	X	Sigma Aldrich EPA	Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard Animal tests show moderate toxicity from inhalation and low toxicity from oral exposure. No human test results. No information on carcinogenicity. NIA on WEL
1,2-Benzenedicarboxylic acid,disooctyl ester	27554-26-3		X			LookChem.com	Moderately toxic by ingestion, mildly by skin contact. Skin irritant. Possible risk of impaired fertility and possible risk of harm to unborn child. NIA on WEL

Substances	**CAS Number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Sources**	**Notes**

Notes

NIA on WEL	No information available on Workplace Exposure Limits	NLM	US National Library of Medicine	IRMM	Institute of Reference Materials and Measurements
SEPA	Scottish Environmental Protection Agency	Sigma Aldrich	www.sigmaaldrich.com (chemical supply company)	HSE	Health and Safety Executive
PHE	Public Health England	NJDH	New Jersey Department of Health - USA	Spectrumchemical.com	Chemical supply company
pesticideinfo.org	Pesticide Database - USA	Fisher Scientific	Chemical supply company	Alfa Aesar	Supplier of materials and reagents

Table E - Based on the compositions analysis results of polar group in coal tar (derived from "GC/MS Analysis of coal tar composition produced from coal pyrolysis", Jiang, J., et al (2007)

Substance	**CAS Number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
2-Cyclopentanone (Cyclopentanone is suggested by Sigma Aldrich website)	- 120-92-3		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Cyclopentanone,2-methyl	1120-72-5					Sigma Aldrich	No human health risks records NIA on WEL
Pyridine,2-methyl	109-06-8		X			Sigma Aldrich	Acute toxicity (oral, dermal and inhalation) NIA on WEL
Pyridine,3-methyl	108-99-6		X			Sigma Aldrich	Acute toxicity (oral, dermal and inhalation) Corrosive to metals, Skin corrosion, Serious eye damage NIA on WEL
2,6-dimethylpyridine	108-48-5		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Aniline	62-53-3*	X	X	X	X	PHE	LTEL (8 hour reference period): 1ppm (4 mg m^{-3}) STEL – NONE SPECIFIED
Phenol	108-95-2*	x	x			PHE	LTEL (8 hour reference period): 2ppm (7.8 mg m^{-3}) STEL – NONE SPECIFIED
1,2-benzyl diol Also known as 1,2-Dihydroxybenzene	- 120-80-9	X	X			Sigma Aldrich	Skin corrosion, Serious eye damage, actuate toxicity (oral, dermal and inhalation), skin irritation, eye irritation, skin sensitisation, specific target organ toxicity – single exposure NIA on WEL
Phenol,2-methyl	95-48-7	Possibly				EPA	

Substance	CAS Number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
			X	X	X	Sigma Aldrich	Skin corrosion, Serious eye damage, actuate toxicity (oral, dermal and inhalation) NIA on WEL
Phenol,3-methyl	108-39-4	Possibly	X	X	X	EPA Sigma Aldrich	Skin corrosion, Serious eye damage, actuate toxicity (oral, dermal and inhalation) NIA on WEL
Phenol,3,5-dimethyl Also known as –m-Xylenol	108-68-9		X	X	X	Sigma Aldrich	Skin corrosion, Serious eye damage, actuate toxicity (oral, dermal and inhalation) NIA on WEL
Phenol,1,2-dimethyl (2,3-dimethylphenol suggested by Sigma Aldrich website)	526-75-0		X	X	X	Sigma Aldrich	Skin corrosion, Serious eye damage, actuate toxicity (oral, dermal and inhalation) NIA on WEL
Phenol,3,4-dimethyl	95-65-8		X	X	X	Sigma Aldrich	Skin corrosion, Serious eye damage, actuate toxicity (oral, dermal and inhalation) NIA on WEL
Isoquinoline	119-65-3	X	X			Sigma Aldrich	Actuate toxicity (oral, dermal and inhalation), Respiratory sensitization, Carcinogen, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration Hazard NIA on WEL
Indole,2-methyl	95-20-5					Sigma Aldrich	Skin corrosion, Serious eye damage NIA on WEL
phenol,1,2-diphene,4-ethyl	-						NIA on WEL
Quinoline,7-methyl	612-60-2					Sigma Aldrich	Skin corrosion, Serious eye damage, Acute toxicity (oral, dermal, inhalation), Skin

Substance	CAS Number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
							irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure Possible mutagen NIA on WEL
1H-Indole,2-methyl Also known as 2-Methylindole	95-20-5					Sigma Aldrich	Skin corrosion, Serious eye damage NIA on WEL
Propanenitrile,3,3-thiobis Also known as 3,3'-Thiodipropionitrile	111-97-7		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
2-Naphthalenol Also known as 2-Naphthol	135-19-3		X	X	X	Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Diethyl Phthalate	84-66-2*						LTEL (8 hour reference period): 5mg m^{-3} STEL (15 min reference period): 10mg m^{-3}
Isoquinoline,2-oxide (Isoquinoline, N-oxide suggested by Sigma Aldrich website)	- 1532-72-5					Sigma Aldrich	No human health risks recorded NIA on WEL
Acridine	260-94-6		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL
Carbazole	86-74-8	X				Sigma Aldrich	Respiratory sensitization, Carcinogenicity, Mutagenicity, Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard NIA on WEL

Substance	**CAS Number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
3,4-Biphenyldicarbonitrile	-						NIA on WEL
3,4-Phenanthroline	-						NIA on WEL

Notes					
NIA on WEL	No information available on Workplace Exposure Limits	NLM	US National Library of Medicine	IRMM	Institute of Reference Materials and Measurements
SEPA	Scottish Environmental Protection Agency	Sigma Aldrich	www.sigmaaldrich.com (chemical supply company)	HSE	Health and Safety Executive
PHE	Public Health England	NJDH	New Jersey Department of Health - USA	Spectrumchemical.com	Chemical supply company
pesticideinfo.org	Pesticide Database - USA	Fisher Scientific	Chemical supply company	Alfa Aesar	Supplier of materials and reagents
EPA	United States Environmental Protection Agency				

Table F – Summary of analysis of coal tar (derived from "GC/MS Analysis of coal tar composition produced from coal pyrolysis", Jiang, J., et al (2007)

Categories	**Compositions**	**Kinds count**	**Content (%)**
Aliphatics	Paraffin hydrocarbons	19	9.988
Alkene		14	7.341
Aromatics	Benzene and its derivatives	7	7.997
	Naphthalene and its derivatives	10	10.738
	Phenanthrene, anthracene and their derivatives	11	6.963
	Indene and its derivatives	2	0.755
	Fluorene and its derivatives	3	0.461
	Pyrene and its derivatives	4	0.492
Oxygenic compounds	Alcohols	2	0.774
	Phenols	13	8.493
	Aldehyde, ketone	5	1.589
	Acid, ester	12	2.754
	Furan and its derivatives	3	0.809
	Pyran and its derivatives	1	0.041
Nitrogenous compounds	Priding and its derivatives	5	1.015
	Indole and its derivatives	4	0.409
	Quinoline and its derivatives	5	1.053
	Aniline and its derivatives	2	0.503
	Nitrile and its derivatives	4	0.431
	Phenazine and its derivatives	1	0.089
	Carbazole and its derivatives	1	0.094
Sulfuric compounds	Thiophene and its derivatives	1	0.01
Unknown		9	0.929
Total		138	63.728

Table G – Summary of other substances contained within coal tar as identified by DoE Industry Profile

Substance	CAS Number	Carcinogen	Acute toxicity	Acute hazard to aquatic environment	Chronic hazard to aquatic environment	Source	Notes
Cresol *p*-cresol m-cresol *o*-cresol*	 106-44-5 108-39-4 95-48-7		X	X*	X*	Sigma Aldrich	Skin corrosion, Serious eye damage, acute toxicity (oral, dermal and inhalation) NIA on WEL – previous limits withdrawn
Sodium phenoxide	139-02-6		X			Sigma Aldrich	Skin corrosion, Serious eye damage NIA on WEL
						NLM	Toxic if ingested
Toluene	108-88-3*		X			PHE	LTEL (8 hour reference period: 50ppm (191 mg m^{-3}) STEL (15 min reference period): 100ppm (384 mg $m\text{-}^{3}$) Reproductive toxicity, Specific target organ toxicity – single exposure, Specific target organ toxicity – repeated exposure, Aspiration hazard, Skin irritation
						TPHCWGS	RfD = 0.2mg/kg/day
Triethanolamine	102-71-6					Sigma Aldrich	No human health risk listed. Eye-shield, gloves and respirator recommended when handling

Substance	**CAS Number**	**Carcinogen**	**Acute toxicity**	**Acute hazard to aquatic environment**	**Chronic hazard to aquatic environment**	**Source**	**Notes**
							NIA on WEL
2-mercaptobenzothiazole	149-30-4		X			Sigma Aldrich	Acute toxicity (oral, dermal, inhalation), Skin irritation, Eye irritation, Skin sensitization, Specific target organ toxicity – single exposure NIA on WEL

Notes

NIA on WEL	No information available of Workplace Exposure Limits	Sigma Aldrich	Chemical supply company	NLM	US National Library of Medicine

Table H – EH40/2005 Workplace Exposure Limits

Substance	**Workplace exposure limit**				**Comments**
	Long term exposure limit (8hr TWA reference period)		**Short term exposure limit (15 minute reference period)**		
	ppm	**mg.m^{-3}**	**ppm**	**mg.m^{-3}**	
Aniline CAS 62-53-3	1	4	-	-	Sk
Asphalt, petroleum fumes CAS number 8052-42-4	-	5	-	10	
Benzene CAS 71-43-2	1	3.25	-	-	Carc, Sk
Butane CAS 106-97-8	600	1450	750	1810	Carc (only applies if Butane contains more than 0.1% of buta-1,3-diene)
Cyclohexane CAS 110-82-7	100	350	300	1050	
Dibutyl phthalate CAS 84-74-2	-	5	-	10	
Diethyl phthalate CAS 84-66-2	-	5	-	10	
Hydrazine CAS 302-01-2	0.02	0.03	0.1	0.13	Carc, Sk
Indene CAS 95-13-6	10	48	15	72	
Phenol	2	7.8	4	16	Sk

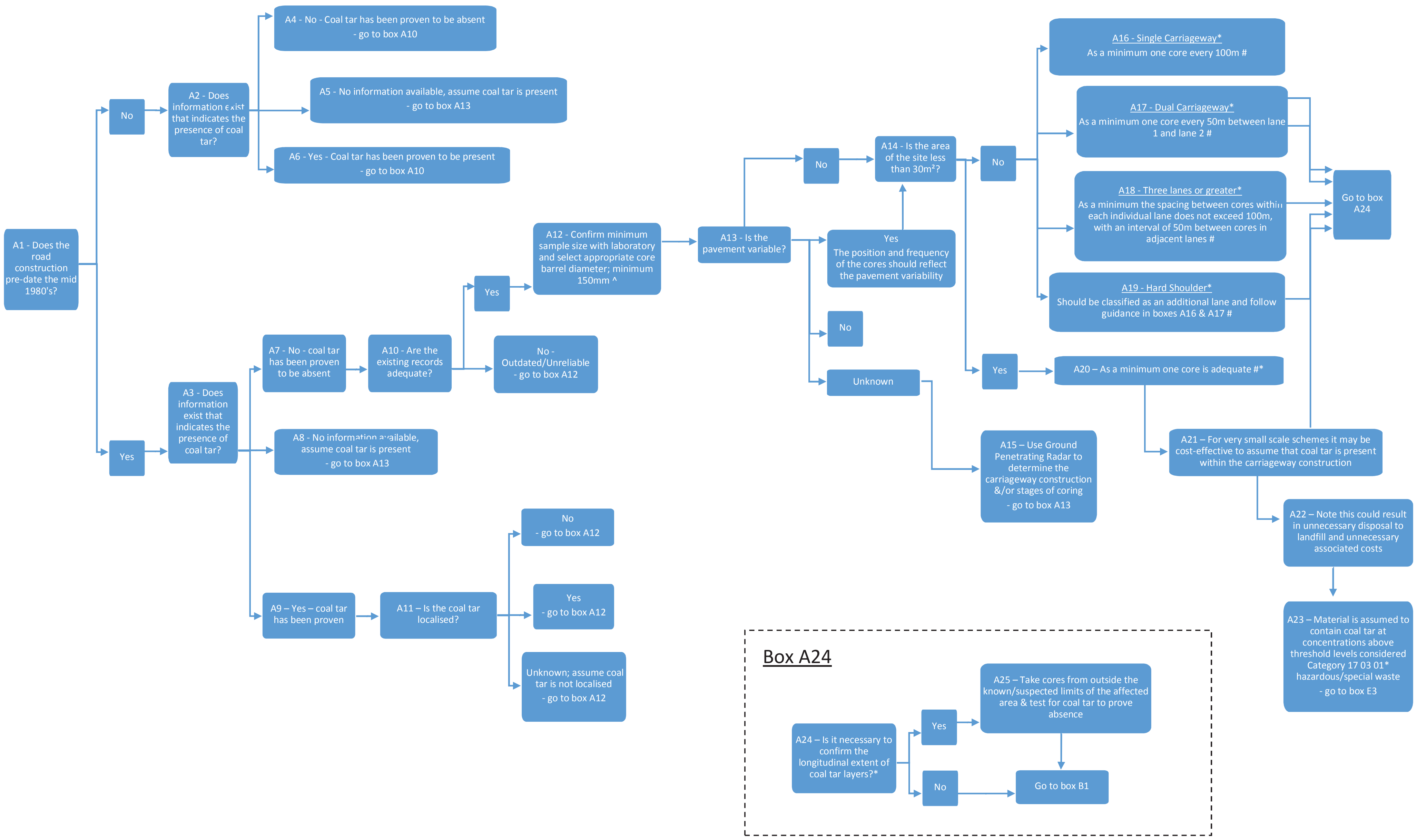
Substance	Workplace exposure limit				Comments
	Long term exposure limit (8hr TWA reference period)		Short term exposure limit (15 minute reference period)		
	ppm	mg.m^{-3}	ppm	mg.m^{-3}	
CAS 108-95-2					
Propionic acid CAS 79-09-4	10	31	15	46	
Pyridine CAS 110-86-1	5	16	10	33	
Toulene CAS 108-88-3	50	191	100	381	Sk
Xylene, o-, m-, p- or mixed isomers CAS 1330-20-7	50	220	100	441	Sk, BMGV

Notes

Carc	capable of causing cancer and/or heritable genetic damage	Sen	capable of causing occupational asthma	Sk	can be absorbed through the skin
TWA	Time Weight Average	BMGV	Biological Monitoring Guidance Value		

Appendix B
Flow Charts

Chart A – Step-by-step guide to positioning cores

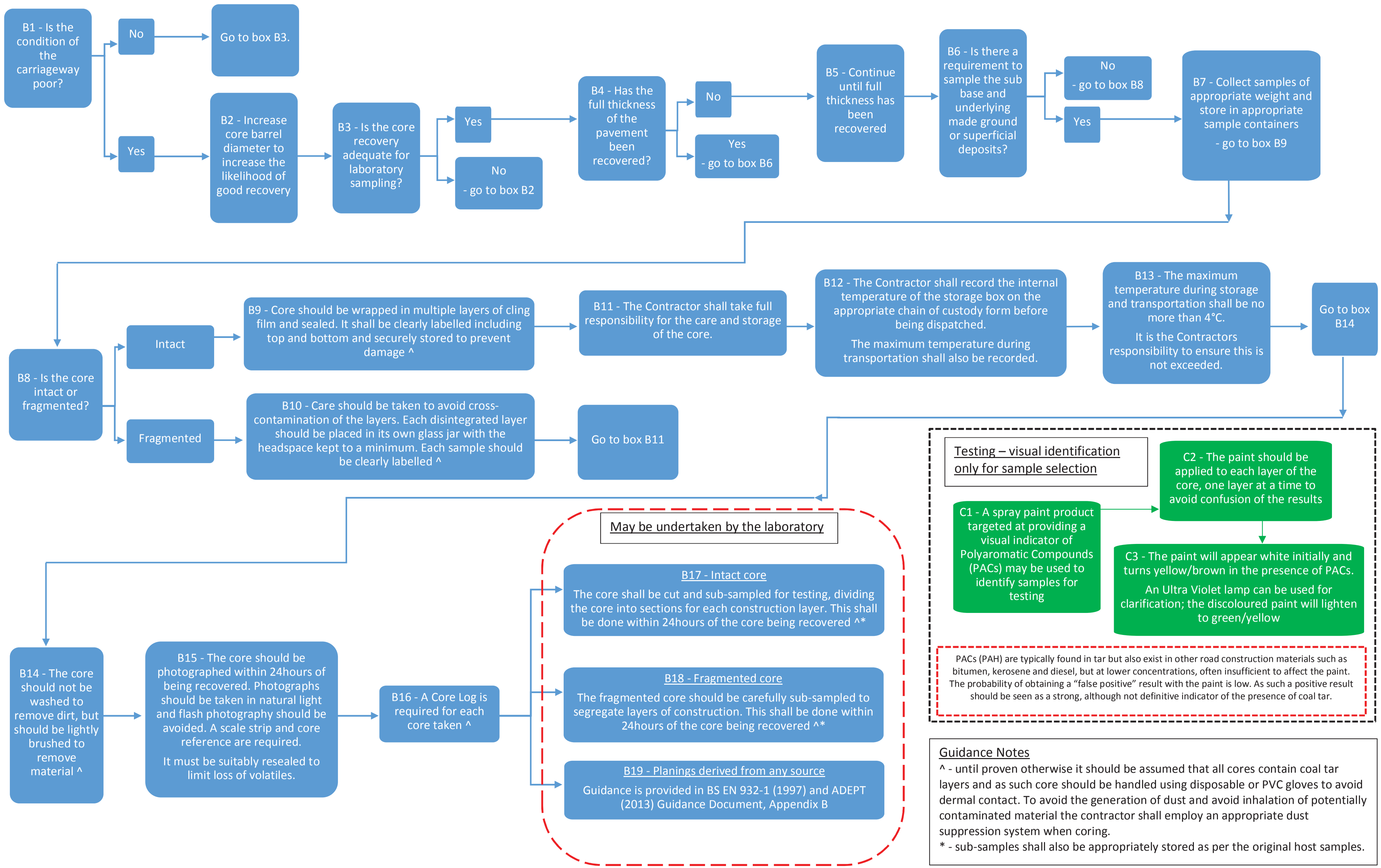


Guidance Notes

- cores shall be located within the centre of each lane to avoid the running track unless the centre cannot be accessed due to health and safety requirement, or available records indicate that coal tar layers may not be spread beneath the entire carriageway. This is a potential restriction where roads have been widened in the past. Alternative positions shall be agreed with the supervisor and any changes to the planned locations accurately recorded.

* - a sampling plan is required before any sampling is undertaken.

Chart B – Step by step guide to coring, logging and sub-sampling cores



B1 - Is the condition of the carriageway poor?

No → Go to box B3.

Yes → B2 - Increase core barrel diameter to increase the likelihood of good recovery

B3 - Is the core recovery adequate for laboratory sampling?

Yes → B4

No - go to box B2

B4 - Has the full thickness of the pavement been recovered?

No → B5

Yes - go to box B6

B5 - Continue until full thickness has been recovered

B6 - Is there a requirement to sample the sub base and underlying made ground or superficial deposits?

No - go to box B8

Yes → B7

B7 - Collect samples of appropriate weight and store in appropriate sample containers - go to box B9

B8 - Is the core intact or fragmented?

Intact → B9 - Core should be wrapped in multiple layers of cling film and sealed. It shall be clearly labelled including top and bottom and securely stored to prevent damage ^

Fragmented → B10 - Care should be taken to avoid cross-contamination of the layers. Each disintegrated layer should be placed in its own glass jar with the headspace kept to a minimum. Each sample should be clearly labelled ^ → Go to box B11

B11 - The Contractor shall take full responsibility for the care and storage of the core.

B12 - The Contractor shall record the internal temperature of the storage box on the appropriate chain of custody form before being dispatched.

The maximum temperature during transportation shall also be recorded.

B13 - The maximum temperature during storage and transportation shall be no more than 4°C.

It is the Contractors responsibility to ensure this is not exceeded.

Go to box B14

B14 - The core should not be washed to remove dirt, but should be lightly brushed to remove material ^

B15 - The core should be photographed within 24hours of being recovered. Photographs should be taken in natural light and flash photography should be avoided. A scale strip and core reference are required.

It must be suitably resealed to limit loss of volatiles.

B16 - A Core Log is required for each core taken ^

May be undertaken by the laboratory

B17 - Intact core

The core shall be cut and sub-sampled for testing, dividing the core into sections for each construction layer. This shall be done within 24hours of the core being recovered ^*

B18 - Fragmented core

The fragmented core should be carefully sub-sampled to segregate layers of construction. This shall be done within 24hours of the core being recovered ^*

B19 - Planings derived from any source

Guidance is provided in BS EN 932-1 (1997) and ADEPT (2013) Guidance Document, Appendix B

Testing – visual identification only for sample selection

C1 - A spray paint product targeted at providing a visual indicator of Polyaromatic Compounds (PACs) may be used to identify samples for testing

C2 - The paint should be applied to each layer of the core, one layer at a time to avoid confusion of the results

C3 - The paint will appear white initially and turns yellow/brown in the presence of PACs.

An Ultra Violet lamp can be used for clarification; the discoloured paint will lighten to green/yellow

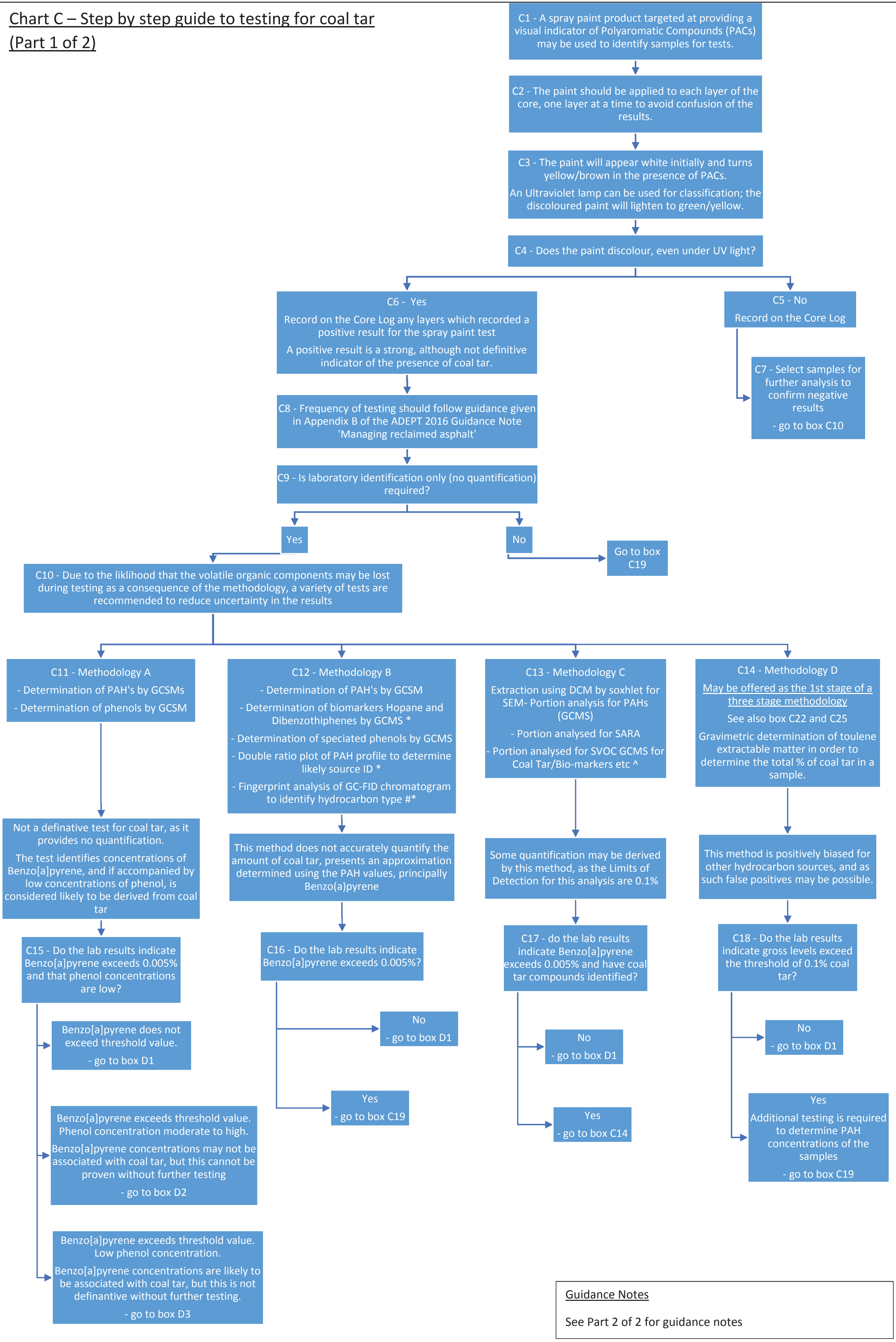
PACs (PAH) are typically found in tar but also exist in other road construction materials such as bitumen, kerosene and diesel, but at lower concentrations, often insufficient to affect the paint. The probability of obtaining a “false positive” result with the paint is low. As such a positive result should be seen as a strong, although not definitive indicator of the presence of coal tar.

Guidance Notes

^ - until proven otherwise it should be assumed that all cores contain coal tar layers and as such core should be handled using disposable or PVC gloves to avoid dermal contact. To avoid the generation of dust and avoid inhalation of potentially contaminated material the contractor shall employ an appropriate dust suppression system when coring.

* - sub-samples shall also be appropriately stored as per the original host samples.

Chart C – Step by step guide to testing for coal tar (Part 1 of 2)



C1 - A spray paint product targeted at providing a visual indicator of Polyaromatic Compounds (PACs) may be used to identify samples for tests.

C2 - The paint should be applied to each layer of the core, one layer at a time to avoid confusion of the results.

C3 - The paint will appear white initially and turns yellow/brown in the presence of PACs.

An Ultraviolet lamp can be used for classification; the discoloured paint will lighten to green/yellow.

C4 - Does the paint discolour, even under UV light?

C6 - Yes

Record on the Core Log any layers which recorded a positive result for the spray paint test

A positive result is a strong, although not definitive indicator of the presence of coal tar.

C5 - No

Record on the Core Log

C7 - Select samples for further analysis to confirm negative results

- go to box C10

C8 - Frequency of testing should follow guidance given in Appendix B of the ADEPT 2016 Guidance Note 'Managing reclaimed asphalt'

C9 - Is laboratory identification only (no quantification) required?

Yes

No

Go to box C19

C10 - Due to the liklihood that the volatile organic components may be lost during testing as a consequence of the methodology, a variety of tests are recommended to reduce uncertainty in the results

C11 - Methodology A

- Determination of PAH's by GCSMs
- Determination of phenols by GCSM

C12 - Methodology B

- Determination of PAH's by GCSM
- Determination of biomarkers Hopane and Dibenzothiphenes by GCMS *
- Determination of speciated phenols by GCMS
- Double ratio plot of PAH profile to determine likely source ID *
- Fingerprint analysis of GC-FID chromatogram to identify hydrocarbon type #*

C13 - Methodology C

Extraction using DCM by soxhlet for SEM- Portion analysis for PAHs (GCMS)

- Portion analysed for SARA
- Portion analysed for SVOC GCMS for Coal Tar/Bio-markers etc ^

C14 - Methodology D

May be offered as the 1st stage of a three stage methodology

See also box C22 and C25

Gravimetric determination of toulene extractable matter in order to determine the total % of coal tar in a sample.

Not a definative test for coal tar, as it provides no quantification.

The test identifies concentrations of Benzo[a]pyrene, and if accompanied by low concentrations of phenol, is considered likely to be derived from coal tar

This method does not accurately quantify the amount of coal tar, presents an approximation determined using the PAH values, principally Benzo(a)pyrene

Some quantification may be derived by this method, as the Limits of Detection for this analysis are 0.1%

This method is positively biased for other hydrocarbon sources, and as such false positives may be possible.

C15 - Do the lab results indicate Benzo[a]pyrene exceeds 0.005% and that phenol concentrations are low?

Benzo[a]pyrene does not exceed threshold value.

- go to box D1

Benzo[a]pyrene exceeds threshold value. Phenol concentration moderate to high.

Benzo[a]pyrene concentrations may not be associated with coal tar, but this cannot be proven without further testing

- go to box D2

Benzo[a]pyrene exceeds threshold value. Low phenol concentration.

Benzo[a]pyrene concentrations are likely to be associated with coal tar, but this is not definantive without further testing.

- go to box D3

C16 - Do the lab results indicate Benzo[a]pyrene exceeds 0.005%?

No

- go to box D1

Yes

- go to box C19

C17 - do the lab results indicate Benzo[a]pyrene exceeds 0.005% and have coal tar compounds identified?

No

- go to box D1

Yes

- go to box C14

C18 - Do the lab results indicate gross levels exceed the threshold of 0.1% coal tar?

No

- go to box D1

Yes

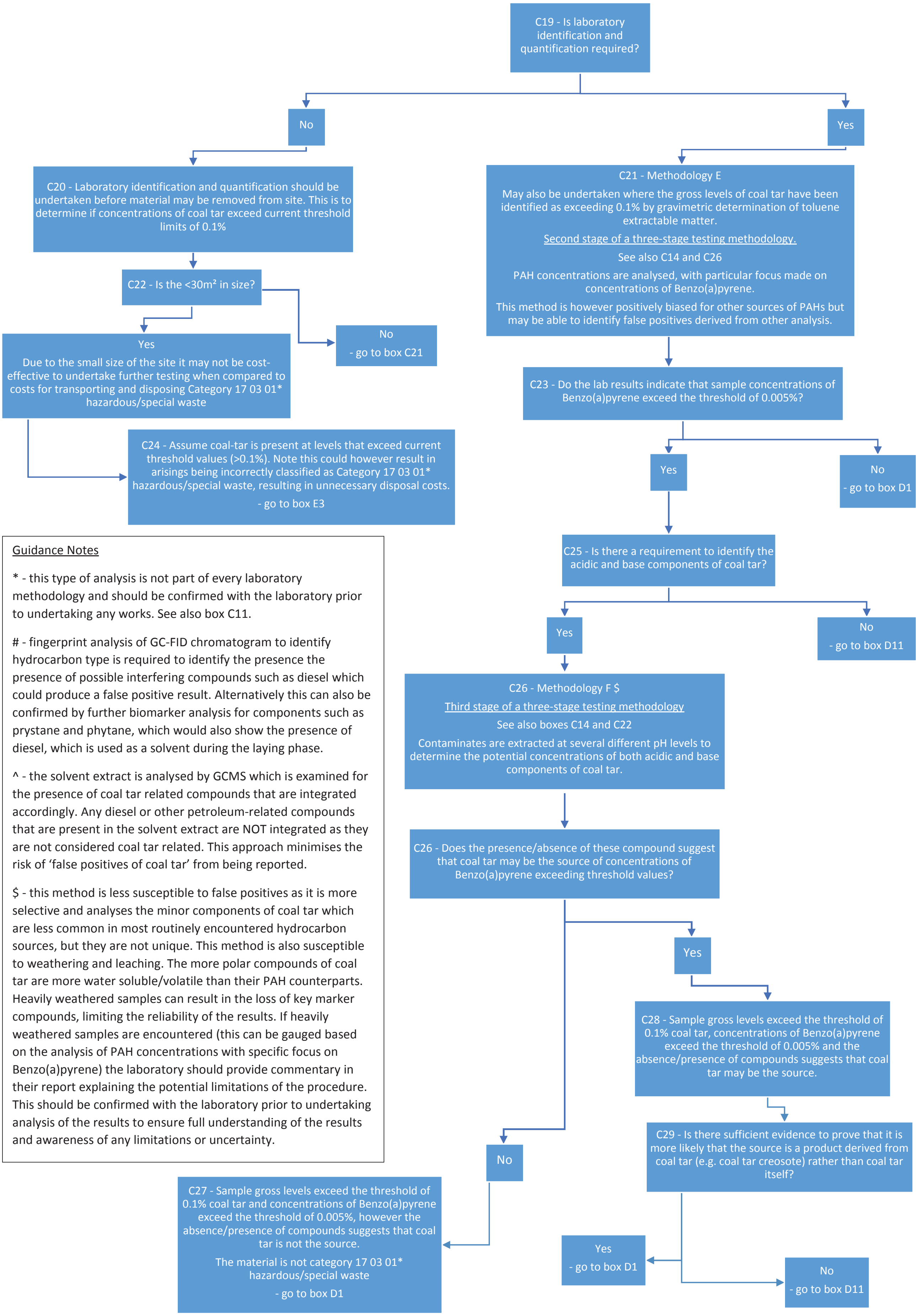
Additional testing is required to determine PAH concentrations of the samples

- go to box C19

Guidance Notes

See Part 2 of 2 for guidance notes

Chart C – Step by step guide to testing for coal tar (Part 2 of 2)



C19 - Is laboratory identification and quantification required?

No

C20 - Laboratory identification and quantification should be undertaken before material may be removed from site. This is to determine if concentrations of coal tar exceed current threshold limits of 0.1%

C22 - Is the <30m² in size?

Yes

Due to the small size of the site it may not be cost-effective to undertake further testing when compared to costs for transporting and disposing Category 17 03 01* hazardous/special waste

No

- go to box C21

C24 - Assume coal-tar is present at levels that exceed current threshold values (>0.1%). Note this could however result in arisings being incorrectly classified as Category 17 03 01* hazardous/special waste, resulting in unnecessary disposal costs.

- go to box E3

Yes

C21 - Methodology E

May also be undertaken where the gross levels of coal tar have been identified as exceeding 0.1% by gravimetric determination of toluene extractable matter.

Second stage of a three-stage testing methodology.

See also C14 and C26

PAH concentrations are analysed, with particular focus made on concentrations of Benzo(a)pyrene.

This method is however positively biased for other sources of PAHs but may be able to identify false positives derived from other analysis.

C23 - Do the lab results indicate that sample concentrations of Benzo(a)pyrene exceed the threshold of 0.005%?

Yes

No

- go to box D1

C25 - Is there a requirement to identify the acidic and base components of coal tar?

Yes

No

- go to box D11

C26 - Methodology F $

Third stage of a three-stage testing methodology

See also boxes C14 and C22

Contaminates are extracted at several different pH levels to determine the potential concentrations of both acidic and base components of coal tar.

C26 - Does the presence/absence of these compound suggest that coal tar may be the source of concentrations of Benzo(a)pyrene exceeding threshold values?

Yes

C28 - Sample gross levels exceed the threshold of 0.1% coal tar, concentrations of Benzo(a)pyrene exceed the threshold of 0.005% and the absence/presence of compounds suggests that coal tar may be the source.

C29 - Is there sufficient evidence to prove that it is more likely that the source is a product derived from coal tar (e.g. coal tar creosote) rather than coal tar itself?

Yes

- go to box D1

No

- go to box D11

No

C27 - Sample gross levels exceed the threshold of 0.1% coal tar and concentrations of Benzo(a)pyrene exceed the threshold of 0.005%, however the absence/presence of compounds suggests that coal tar is not the source.

The material is not category 17 03 01* hazardous/special waste

- go to box D1

Guidance Notes

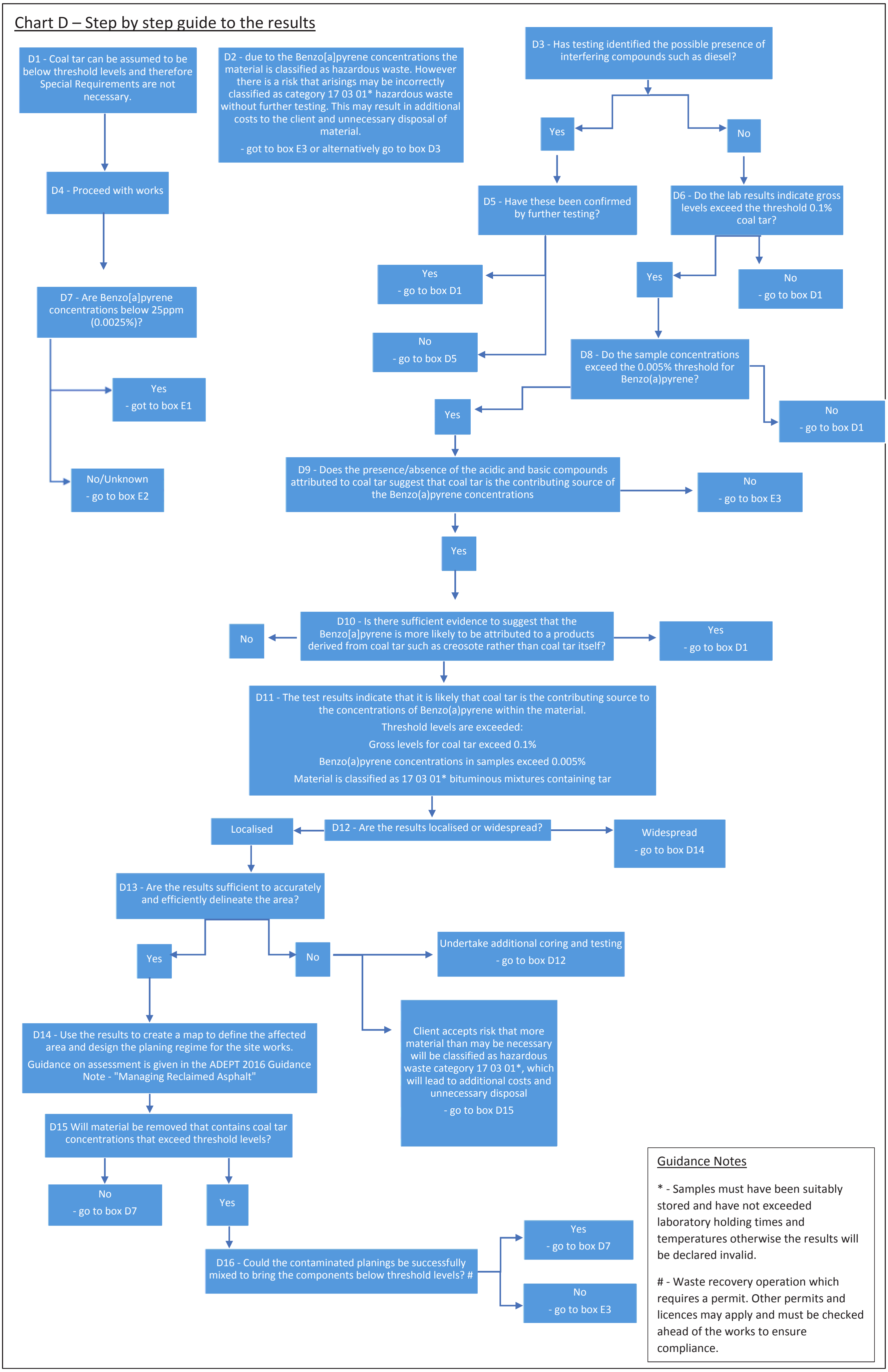
* - this type of analysis is not part of every laboratory methodology and should be confirmed with the laboratory prior to undertaking any works. See also box C11.

- fingerprint analysis of GC-FID chromatogram to identify hydrocarbon type is required to identify the presence the presence of possible interfering compounds such as diesel which could produce a false positive result. Alternatively this can also be confirmed by further biomarker analysis for components such as prystane and phytane, which would also show the presence of diesel, which is used as a solvent during the laying phase.

^ - the solvent extract is analysed by GCMS which is examined for the presence of coal tar related compounds that are integrated accordingly. Any diesel or other petroleum-related compounds that are present in the solvent extract are NOT integrated as they are not considered coal tar related. This approach minimises the risk of 'false positives of coal tar' from being reported.

$ - this method is less susceptible to false positives as it is more selective and analyses the minor components of coal tar which are less common in most routinely encountered hydrocarbon sources, but they are not unique. This method is also susceptible to weathering and leaching. The more polar compounds of coal tar are more water soluble/volatile than their PAH counterparts. Heavily weathered samples can result in the loss of key marker compounds, limiting the reliability of the results. If heavily weathered samples are encountered (this can be gauged based on the analysis of PAH concentrations with specific focus on Benzo(a)pyrene) the laboratory should provide commentary in their report explaining the potential limitations of the procedure. This should be confirmed with the laboratory prior to undertaking analysis of the results to ensure full understanding of the results and awareness of any limitations or uncertainty.

Chart D – Step by step guide to the results



D1 - Coal tar can be assumed to be below threshold levels and therefore Special Requirements are not necessary.

D4 - Proceed with works

D7 - Are Benzo[a]pyrene concentrations below 25ppm (0.0025%)?

Yes - got to box E1

No/Unknown - go to box E2

D2 - due to the Benzo[a]pyrene concentrations the material is classified as hazardous waste. However there is a risk that arisings may be incorrectly classified as category 17 03 01* hazardous waste without further testing. This may result in additional costs to the client and unnecessary disposal of material.

- got to box E3 or alternatively go to box D3

D3 - Has testing identified the possible presence of interfering compounds such as diesel?

Yes

No

D5 - Have these been confirmed by further testing?

Yes - go to box D1

No - go to box D5

D6 - Do the lab results indicate gross levels exceed the threshold 0.1% coal tar?

Yes

No - go to box D1

D8 - Do the sample concentrations exceed the 0.005% threshold for Benzo(a)pyrene?

Yes

No - go to box D1

D9 - Does the presence/absence of the acidic and basic compounds attributed to coal tar suggest that coal tar is the contributing source of the Benzo(a)pyrene concentrations

No - go to box E3

Yes

D10 - Is there sufficient evidence to suggest that the Benzo[a]pyrene is more likely to be attributed to a products derived from coal tar such as creosote rather than coal tar itself?

No

Yes - go to box D1

D11 - The test results indicate that it is likely that coal tar is the contributing source to the concentrations of Benzo(a)pyrene within the material.

Threshold levels are exceeded:

Gross levels for coal tar exceed 0.1%

Benzo(a)pyrene concentrations in samples exceed 0.005%

Material is classified as 17 03 01* bituminous mixtures containing tar

D12 - Are the results localised or widespread?

Localised

Widespread - go to box D14

D13 - Are the results sufficient to accurately and efficiently delineate the area?

Yes

No

Undertake additional coring and testing - go to box D12

Client accepts risk that more material than may be necessary will be classified as hazardous waste category 17 03 01*, which will lead to additional costs and unnecessary disposal

- go to box D15

D14 - Use the results to create a map to define the affected area and design the planing regime for the site works.

Guidance on assessment is given in the ADEPT 2016 Guidance Note - "Managing Reclaimed Asphalt"

D15 Will material be removed that contains coal tar concentrations that exceed threshold levels?

No - go to box D7

Yes

D16 - Could the contaminated planings be successfully mixed to bring the components below threshold levels? #

Yes - go to box D7

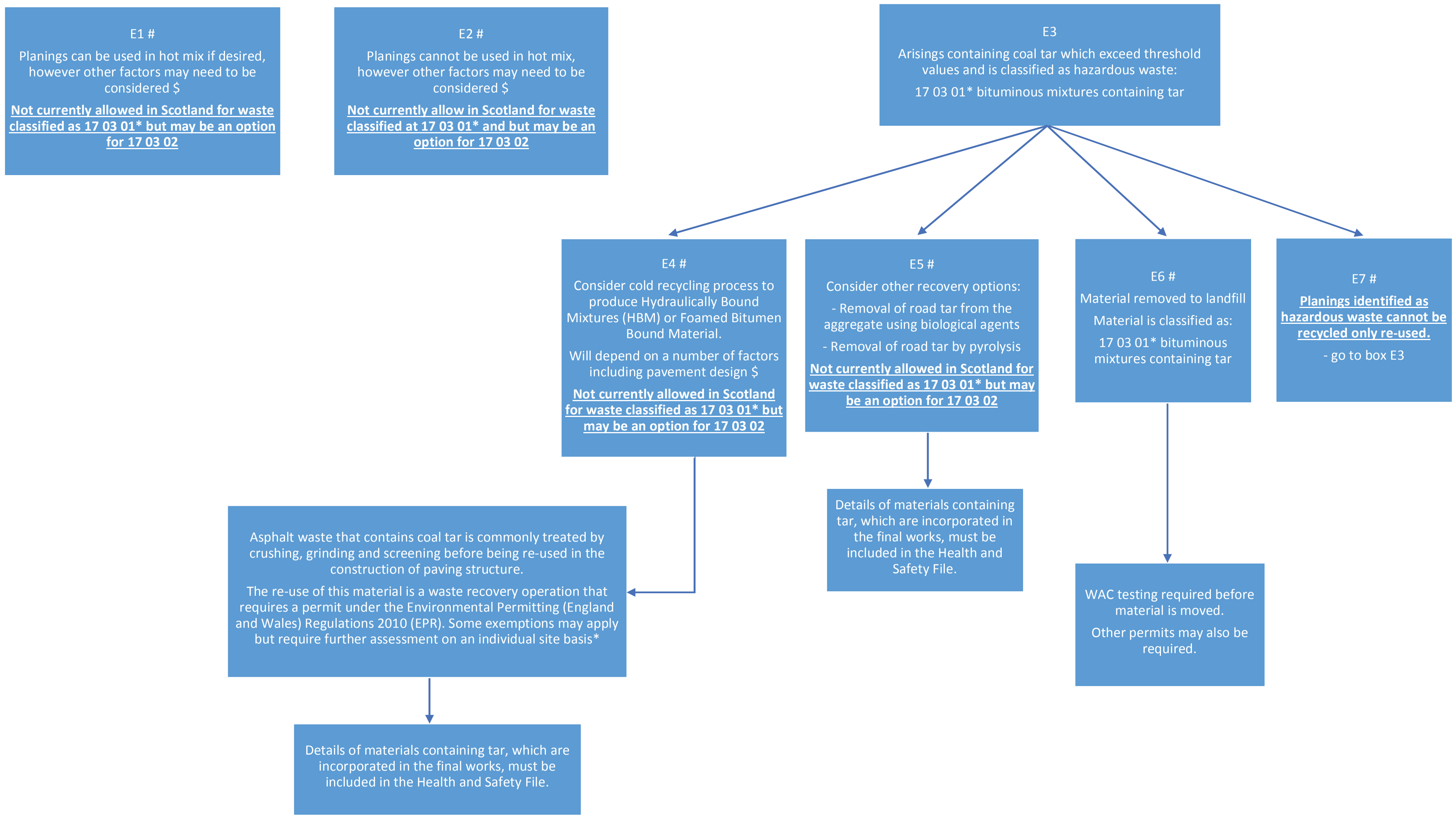
No - go to box E3

Guidance Notes

* - Samples must have been suitably stored and have not exceeded laboratory holding times and temperatures otherwise the results will be declared invalid.

- Waste recovery operation which requires a permit. Other permits and licences may apply and must be checked ahead of the works to ensure compliance.

Chart E – What to do next – options (based on current practices within England)



E1 #

Planings can be used in hot mix if desired, however other factors may need to be considered $

Not currently allowed in Scotland for waste classified as 17 03 01* but may be an option for 17 03 02

E2 #

Planings cannot be used in hot mix, however other factors may need to be considered $

Not currently allow in Scotland for waste classified at 17 03 01* and but may be an option for 17 03 02

E3

Arisings containing coal tar which exceed threshold values and is classified as hazardous waste:

17 03 01* bituminous mixtures containing tar

E4 #

Consider cold recycling process to produce Hydraulically Bound Mixtures (HBM) or Foamed Bitumen Bound Material.

Will depend on a number of factors including pavement design $

Not currently allowed in Scotland for waste classified as 17 03 01* but may be an option for 17 03 02

E5 #

Consider other recovery options:

- Removal of road tar from the aggregate using biological agents
- Removal of road tar by pyrolysis

Not currently allowed in Scotland for waste classified as 17 03 01* but may be an option for 17 03 02

E6 #

Material removed to landfill

Material is classified as:

17 03 01* bituminous mixtures containing tar

E7 #

Planings identified as hazardous waste cannot be recycled only re-used.

- go to box E3

Asphalt waste that contains coal tar is commonly treated by crushing, grinding and screening before being re-used in the construction of paving structure.

The re-use of this material is a waste recovery operation that requires a permit under the Environmental Permitting (England and Wales) Regulations 2010 (EPR). Some exemptions may apply but require further assessment on an individual site basis*

Details of materials containing tar, which are incorporated in the final works, must be included in the Health and Safety File.

Details of materials containing tar, which are incorporated in the final works, must be included in the Health and Safety File.

WAC testing required before material is moved.

Other permits may also be required.

Guidance Notes

* - Reference is made to the Environment Agency's Regulatory position statement 075 – "The movement and use of treated asphalt waste containing coal tar" – MWRP RPS 075 Version 4; issued September 2014.

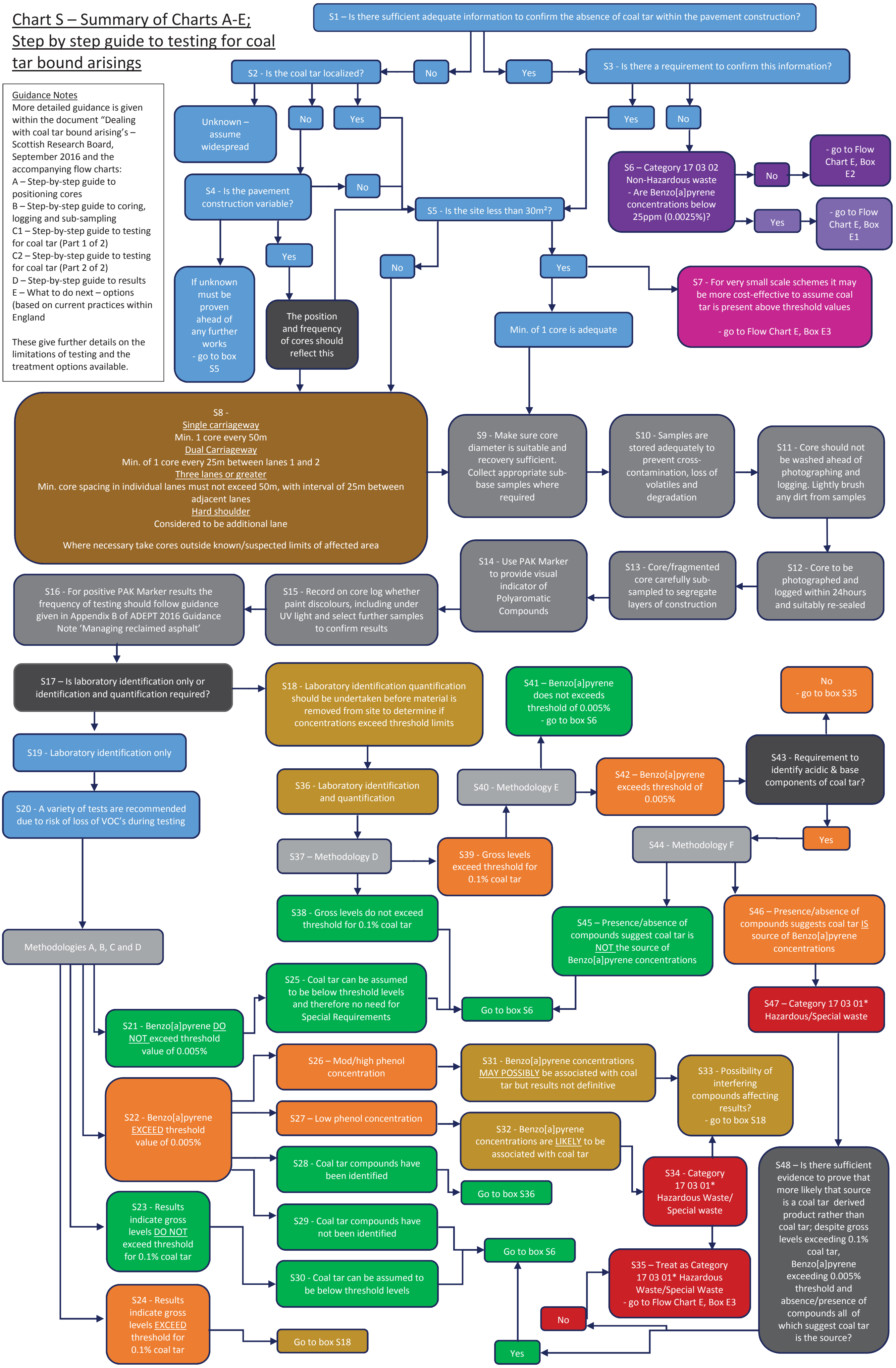
\# - Reference is made to the ADEPT Guidance Note "Managing Reclaimed Asphalt – highways and pavements"; Version 1; issued January 2016

$ - Reference is made to HD35/04 – "Conservation and the use of secondary and recycled materials"

Chart S – Summary of Charts A-E; Step by step guide to testing for coal tar bound arisings

Guidance Notes
More detailed guidance is given within the document "Dealing with coal tar bound arising's – Scottish Research Board, September 2016 and the accompanying flow charts:
A – Step-by-step guide to positioning cores
B – Step-by-step guide to coring, logging and sub-sampling
C1 – Step-by-step guide to testing for coal tar (Part 1 of 2)
C2 – Step-by-step guide to testing for coal tar (Part 2 of 2)
D – Step-by-step guide to results
E – What to do next – options (based on current practices within England

These give further details on the limitations of testing and the treatment options available.



S1 – Is there sufficient adequate information to confirm the absence of coal tar within the pavement construction?

No

Yes

S2 - Is the coal tar localized?

Unknown – assume widespread

No

Yes

S3 - Is there a requirement to confirm this information?

Yes

No

S4 - Is the pavement construction variable?

No

Yes

If unknown must be proven ahead of any further works - go to box S5

The position and frequency of cores should reflect this

S5 - Is the site less than 30m²?

No

Yes

S6 – Category 17 03 02 Non-Hazardous waste - Are Benzo[a]pyrene concentrations below 25ppm (0.0025%)?

No

- go to Flow Chart E, Box E2

Yes

- go to Flow Chart E, Box E1

S7 - For very small scale schemes it may be more cost-effective to assume coal tar is present above threshold values

- go to Flow Chart E, Box E3

Min. of 1 core is adequate

S8 -
Single carriageway
Min. 1 core every 50m
Dual Carriageway
Min. of 1 core every 25m between lanes 1 and 2
Three lanes or greater
Min. core spacing in individual lanes must not exceed 50m, with interval of 25m between adjacent lanes
Hard shoulder
Considered to be additional lane

Where necessary take cores outside known/suspected limits of affected area

S9 - Make sure core diameter is suitable and recovery sufficient. Collect appropriate sub-base samples where required

S10 - Samples are stored adequately to prevent cross-contamination, loss of volatiles and degradation

S11 - Core should not be washed ahead of photographing and logging. Lightly brush any dirt from samples

S12 - Core to be photographed and logged within 24hours and suitably re-sealed

S13 - Core/fragmented core carefully sub-sampled to segregate layers of construction

S14 - Use PAK Marker to provide visual indicator of Polyaromatic Compounds

S15 - Record on core log whether paint discolours, including under UV light and select further samples to confirm results

S16 - For positive PAK Marker results the frequency of testing should follow guidance given in Appendix B of ADEPT 2016 Guidance Note 'Managing reclaimed asphalt'

S17 – Is laboratory identification only or identification and quantification required?

S18 - Laboratory identification quantification should be undertaken before material is removed from site to determine if concentrations exceed threshold limits

S19 - Laboratory identification only

S20 - A variety of tests are recommended due to risk of loss of VOC's during testing

Methodologies A, B, C and D

S21 - Benzo[a]pyrene DO NOT exceed threshold value of 0.005%

S22 - Benzo[a]pyrene EXCEED threshold value of 0.005%

S23 - Results indicate gross levels DO NOT exceed threshold for 0.1% coal tar

S24 - Results indicate gross levels EXCEED threshold for 0.1% coal tar

Go to box S18

S25 - Coal tar can be assumed to be below threshold levels and therefore no need for Special Requirements

S26 – Mod/high phenol concentration

S27 – Low phenol concentration

S28 - Coal tar compounds have been identified

S29 - Coal tar compounds have not been identified

S30 - Coal tar can be assumed to be below threshold levels

Go to box S6

S31 - Benzo[a]pyrene concentrations MAY POSSIBLY be associated with coal tar but results not definitive

S32 - Benzo[a]pyrene concentrations are LIKELY to be associated with coal tar

Go to box S36

S33 - Possibility of interfering compounds affecting results? - go to box S18

S34 - Category 17 03 01* Hazardous Waste/ Special waste

S35 – Treat as Category 17 03 01* Hazardous Waste/Special Waste - go to Flow Chart E, Box E3

No

Yes

Go to box S6

S36 - Laboratory identification and quantification

S37 – Methodology D

S38 - Gross levels do not exceed threshold for 0.1% coal tar

Go to box S6

S39 - Gross levels exceed threshold for 0.1% coal tar

S40 - Methodology E

S41 – Benzo[a]pyrene does not exceeds threshold of 0.005% - go to box S6

S42 – Benzo[a]pyrene exceeds threshold of 0.005%

S43 - Requirement to identify acidic & base components of coal tar?

No - go to box S35

Yes

S44 - Methodology F

S45 – Presence/absence of compounds suggest coal tar is NOT the source of Benzo[a]pyrene concentrations

S46 – Presence/absence of compounds suggests coal tar IS source of Benzo[a]pyrene concentrations

S47 – Category 17 03 01* Hazardous/Special waste

S48 – Is there sufficient evidence to prove that more likely that source is a coal tar derived product rather than coal tar; despite gross levels exceeding 0.1% coal tar, Benzo[a]pyrene exceeding 0.005% threshold and absence/presence of compounds all of which suggest coal tar is the source?

Appendix C
Example coal tar testing specification

PLEASE READ BEFORE SCHEDULING TO AVOID UNNECESSARY OR INSUFFICIENT TESTING

Notes	General
1	Frequency of testing should follow guidance given in Appendix B of the ADEPT 2016 Guidance Note 'Managing reclaimed asphalt'
2	The type of testing undertaken will be reflected in the intended end use of the arisings, which will be governed by coal tar concentrations

Notes	Use of PAK Marker
1	Should be used to identify potential samples for testing. Neither positive or negative results should be taken to be conclusive proof without further laboratory testing. In the absence of further laboratory testing coal tar should be assumed to be present at concentrations exceeding current threshold values.

Notes	Laboratory identification only
1	There is a risk that arisings may be incorrectly classified as Category 17 03 01* Hazardous/Special Waste, resulting in unnecessary disposal and costs. For small sites it may however be cost-effective to assume that coal-tar exists at concentrations exceeding current threshold values.

Notes	Laboratory identification leading to quantification
1	Due to the likelihood that VOC may be lost during testing as a consequence of the testing methodology, a variety of tests are recommended to reduce the uncertainty in the results. Tests available include Methodology A, B, C and D. further details are given within the main text 'Dealing with coal tar bound arisings' and Flow Chart C - Part 1 of 2.

		Advantages	Disadvantages	Outcome	
Do Methodology A, B, C or D; or a combination of them all to reduce uncertainty	**Methodology A**	Identifies concentrations of Benzo[a]pyrene and if accompanied by low concentrations of Phenol, source is considered LIKELY to be derived from coal tar. .	Not a definitive test for coal tar as it provides no quantification only whether Benzo[a]pyrene exceeds 0.005% and if Phenol concentrations are deemed 'Low'. Is possible that test results are corrupted by interfering compounds creating a 'false positive'.	Benzo[a]pyrene concentrations exceed 0.005% and Phenol concentrations are medium to high.	Material is classified Category 17 03 01* Hazardous/Special Waste. Further testing required to confirm source is coal tar and not interfering compounds to avoid possibly unnecessary disposal and associated costs. **Suggest Methodology C or D**
				Benzo[a]pyrene concentrations exceed 0.005% and Phenol concentrations are low.	
				Benzo[a]pyrene concentrations don't exceed 0.005% and Phenol concentrations are low.	Coal tar can be assumed to be below threshold value. he material is not category 17 03 01* Hazardous/Special Waste. No further testing required
				Benzo[a]pyrene concentrations don't exceed 0.005% and Phenol concentrations are medium to high.	
	Methodology B	Identifies concentration of Benzo[a]pyrene. Fingerprint analysis of GC-FID chromatogram of hydrocarbon type is used to help identify possible interfering compounds which could produce a 'false positive'. Similarly use of biomarker analysis for components such as prystane and phytane will show the presence of diesel which is an interfering component	Does not accurately quantify the amount of coal tar, only presents an approximation determined using PAH values, principally Benzo[a]pyrene. Is possible that the test results are corrupted by interfering compounds creating a 'false positive'. Determination of biomarkers Hopane and Dibenzothiphenes by GCMS, double ratio plot of PAH profile to determine likely source ID, and fingerprint analysis of GC-FID chromatogram to identify hydrocarbon type is not offered by every laboratory.	Benzo[a]pyrene concentrations exceed 0.005%.	Material is classified as Category 17 03 01* Hazardous/Special Waste. Additional testing require to confirm source is coal tar and not interfering compounds to avoid possibly unnecessary disposal and associated costs. **Suggest Methodology C or D**
				Benzo[a]pyrene concentrations don't exceed 0.005%.	Coal tar can be assumed to be below threshold value. The material is not category 17 03 01* Hazardous/Special Waste. No further testing required.
	Methodology C	Some quantification of coal tar derived from this method as the Limits of Detection for this are 0.1%. Technique minimises the risk of 'false positives' as any diesel or other petroleum-related compounds that are present in the solvent extract are NOT integrated as they are not considered coal tar related.	Not an accurate quantification of coal tar concentration.	Benzo[a]pyrene concentrations don't exceed 0.005% and coal tar compounds have not been identified	Coal tar can be assumed to be below threshold value. The material is not category 17 03 01* Hazardous/Special Waste. No further testing required.
				Benzo[a]pyrene concentrations don't exceed 0.005% but coal tar compounds have been identified	Impossible scenario, additional testing required as results possibly corrupt
				Benzo[a]pyrene concentrations exceed 0.005% but coal tar compounds have not been identified	Possible that coal tar is below threshold concentrations, but additional testing required to confirm source of Benzo[a]pyrene is not coal tar related. **Suggest Methodology D**
				Benzo[a]pyrene concentrations exceed 0.005% and coal tar compounds have been identified	Material classified as Category 17 03 01* Hazardous Waste/Special Waste. Additional testing required to determine % of coal tar in sample and avoid possibly unnecessary disposal and associated costs. **Suggest Methodology D**
	Methodology D	Determines the total % of coal tar in sample	Method is positively biased for other hydrocarbon sources, and as such 'false positives' may be possible. Less uncertainty when undertaken as part of the full three stage test (see Methodology E and F)	Gross levels do not exceed threshold of 0.1% tar.	Coal tar can be assumed to be below threshold value. The material is not category 17 03 01* Hazardous/Special Waste. No further testing required.
				Gross levels exceed threshold of 0.1% tar.	Additional testing required to determine PAH concentrations of samples. **Suggest Methodology E or F**

	Laboratory identification leading to quantification
1	Methodology E and F may be undertaken without undertaking Methodology D, however there may be financial implications of undertaking these tests when Benzo[a]pyrene concentrations have not been determined as concentrations may be below the 0.005% threshold for Benzo[a]pyrene.

		Advantages	Disadvantages	Outcome	
Do either Methodology E or F or a combination of the both	**Methodology E**	Focuses on Benzo[a]pyrene concentrations within PAH concentrations so as to determine whether Benzo[a]pyrene exceeds 0.005%	Method is positively biased for other hydrocarbon sources, and as such 'false positives' may be possible. Less uncertainty when Methodology F also undertaken.	Benzo[a]pyrene concentrations don't exceed 0.005%.	Coal tar can be assumed to be below threshold value. The material is not Category 17 03 01* Hazardous/Special Waste. No further testing required.
				Benzo[a]pyrene concentrations exceed 0.005%.	Material classified as Category 17 03 01* Hazardous Waste/Special Waste. However still possible that results reflect a 'false positive' due to interfering compounds. Additional testing required to determine if source is from coal tar and so avoid possibly unnecessary disposal and associated costs. **Methodology F**
	Methodology F	This method is less susceptible to false positives as it is more selective and analyses the minor components of coal tar which are less common in most routinely encountered hydrocarbon sources, but they are not unique.	Whilst the minor components of coal tar analysed are less common in most routinely encountered hydrocarbon sources, they are not unique. This method is susceptible to weathering and leaching so not recommended for heavily weathered pavement layers as key marker compounds are likely to have been lost, limiting the reliability of the results.	Gross levels exceed threshold 0.1% coal tar, and Benzo[a]pyrene concentrations exceed 0.005%. Furthermore the absence/presence of compounds suggests that coal tar is the likely source.	If there is sufficient evidence to prove that it is more likely that the source is a product derived from coal tar rather than coal tar itself the material is not Category 17 03 01* Hazardous/Special Waste.
					No evidence to prove that the source is likely to be a product derived from coal tar rather than coal tar. Material is classified as Category 17 03 01* Hazardous/Special Waste
				Gross levels exceed threshold 0.1% coal tar, and Benzo[a]pyrene concentrations exceed 0.005%. However the absence/presence of compounds suggests that coal tar is not the likely source.	Coal tar can be assumed to be below threshold value. The material is not Category 17 03 01* Hazardous/Special Waste. No further testing required.

Test methodology	Results	Explanation	Action	Further information and guidance
PAK Marker	PAK Marker remains white and no discolouration is detected under Ultra Violet light.	PAH may be present, but at concentrations less than 125mg/kg.	Coal tar assumed to be present below threshold levels and therefore Special Requirements are not necessary. Select sub-samples for further testing to confirm negative results.	Flow Chart D, Box D1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Uncertainty over discolouration	If there is any uncertainty over whether paint discolours it should be assumed that PAH are present at concentrations greater than 150mg/kg.	Further testing required, however for sites of an area less than 30m^2 it may be more economical to assume coal tar is present at concentrations greater than 0.1% (1000mg/kg).	Flow Chart C1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	PAK Marker discolours to yellow/brown but does not change to yellow/green under Ultra Violet light.	PAK Marker discolours to yellow/brown when in the presence of PAH at concentrations exceeding 125mg/kg, with a greater level of certainty above 150mg/kg.	PAH are typically found in coal tar but also exist in other road construction materials such as bitumen, kerosene and diesel, but at lower concentrations, usually insufficient to affect the PAK Marker. The probability of obtaining a 'false positive' result with the paint test with such materials is low, so a positive result should be seen as a strong, although not definitive indicator of the presence of coal tar. Further testing required to confirm coal tar is the source of the PAH (see Methodologies A to F). However it may be more economical to assume coal tar is present at concentrations greater than 0.1% (1000mg/kg), particularly for sites of an area less than 30m^2.	Flow Chart C1, Box C6 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	PAK Marker discolours to yellow/brown and change to yellow/green under Ultra Violet light.	PAHs are present at concentrations greater than 125mg/kg, and most likely at concentrations exceeding 150mg/kg.		Flow Chart C1, Box C6 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
Methodology A	Results indicate Benzo(a)pyrene does not exceed exceeds threshold value of 0.005% (50mg/kg).	Coal tar may be present, but can be assumed to be at concentrations less than threshold levels. Special Requirements are therefore not necessary.	No further action	Flow Chart D, Box D1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg) and phenol concentrations are low	Benzo(a)pyrene concentrations are likely to be associated with coal tar, but this is not definitive without further testing.	Further testing required to aid in quantification of coal tar concentrations. Undertake further testing using an alternative methodology; Methodology C, D and F (results of Methodology B and E are similar to Methodology A). However it may be more economical to assume coal tar is present at concentrations greater than 0.1% (1000mg/kg), particularly for sites of an area less than 30m^2.	Flow Chart D, Box D3 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg) and phenol concentrations are moderate to high	Benzo(a)pyrene concentrations may not be associated with coal tar, but this is not definitive without further testing.		Flow Chart C1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
Methodology B	Results indicate Benzo(a)pyrene concentrations do not exceed threshold value of 0.005% (50mg/kg).	Coal tar may be present, but can be assumed to be at concentrations less than threshold levels. Special Requirements are therefore not necessary.	No further action	Flow Chart D, Box D1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg).	Benzo(a)pyrene concentrations may be associated with coal tar, but this is not definitive without further testing.	Undertake further testing using an alternative methodology; Methodology C, D and F available (results of Methodology A and E are similar to Methodology B). However it may be more economical to assume coal tar is present at concentrations greater than 0.1% (1000mg/kg), particularly for sites of an area less than 30m^2.	Flow Chart C1 and D - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
Methodology C	Results indicate Benzo(a)pyrene concentrations do not exceed threshold value of 0.005% (50mg/kg) and coal tar compounds have not been identified.	Coal tar may still be present but it is at concentrations less than threshold levels. Special Requirements are therefore not necessary.	No further action	Flow Chart D, Box D1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg) but coal tar compounds have not been identified.	Benzo(a)pyrene concentrations may not be associated with coal tar, but this is not definitive without further testing.	Further testing required to aid in quantification of coal tar concentrations. Undertake further testing using an alternative methodology; Methodology A, and D to F available (results of Methodology B will be similar to Methodology C) However it may be more economical to assume coal tar is present at concentrations greater than 0.1% (1000mg/kg), particularly for sites of an area less than 30m^2 .	Flow Chart D, Box D3 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg) and coal tar compounds have been identified.	Benzo(a)pyrene concentrations are likely to be associated with coal tar, but this is not definitive without further testing.		Flow Chart C1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
Methodology D	Results indicate gross levels do not exceed the threshold of 0.1% (1000mg/kg) coal tar	Coal tar may be present, but can be assumed to be at concentrations less than threshold levels. Special Requirements are therefore not necessary.	No further action	Flow Chart D, Box D1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Results indicate gross levels exceed the threshold of 0.1% (1000mg/kg) coal tar	Concentrations may be associated with coal tar, but this is not definitive without further testing.	Undertake further testing using Methodology E and/or Methodology F. However it may be more economical to assume coal tar is present at concentrations greater than 0.1% (1000mg/kg), particularly for sites of an area less than 30m^2.	Flow Chart C2 and D - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
Methodology E	Results indicate Benzo(a)pyrene concentrations do not exceed threshold value of 0.005% (50mg/kg).	Coal tar may be present, but can be assumed to be at concentrations less than threshold levels. Special Requirements are therefore not necessary.	No further action	Flow Chart D, Box D1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg).	Benzo(a)pyrene concentrations may or may not be associated with coal tar, but this is not definitive without further testing.	Undertake further testing using Methodology F if there is a requirement to identify the acidic and base components of coal tar.	Flow Chart C2, Box C26 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
Methodology F	Previous results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg) and specific acidic and basic components of coal tar are present.	Although sample gross levels exceed the threshold of 0.1% coal tar and concentrations of Benzo(a)pyrene exceed the threshold of 0.005%, the absence/presence of compounds suggests that coal tar may not be the source.	No further action	Flow Chart D, Box D1 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016
	Previous results indicate Benzo(a)pyrene concentrations exceed threshold value of 0.005% (50mg/kg) but specific acidic and basic components of coal tar are absent.	Sample gross levels exceed the threshold of 0.1% coal tar, concentrations of Benzo(a)pyrene exceed the threshold of 0.005% and the absence/presence of compounds suggests that coal tar may be the likely source.	Material is classified as being 17 03 01* bituminous mixtures containing tar. The extent of this material needs to be established	Flow Chart D, Box D13 - 'Dealing with coal tar bound arisings'; CH2M Nov 2016

Notes	Options for reuse and disposal
1	Options based on current practices within England are given in Chart E - 'Dealing with coal tar bound arisings'; CH2M Nov 2016

Project name	E.g. vA1 Junction 62 upgrade scheme	Turnaround	Samples to be tested within maximum of 10 days of sampling	Comments
Client	E.g. Aone+			
Project Number	E.g. 563456			
Date of sampling	01/05/2014			

Date testing scheduled				Visual identification only	Laboratory; identification only													Laboratory identification and quantification																					^ - undertake test if gross levels of toulene exceed 0.1%.
Scheduled by				PAK Marker Spray Paint	Methodology A ~		Methodology B ~							Methodology C ~			Methodology D ~ #	Methodology E ~#		Methodology F ~#																			* To be undertaken only if positive results obtained from PAK Marker
Test type											Tests to identify potential interfering compounds - choose Option 1 or Option 2									Extraction										GCMS or GC-MS/MS analysis?									
											1	2								Define pH value below for contaminants to be extracted at																			
Core reference	Layer reference	Sample reference	Sample depth		PAH (EPA16) *	Phenol	PAH (EPA16) * $	Speciated phenol *	Hopane *	Dibenzothiphenes *	Fingerprint analysis of GC-FID chromatogram to identify hydrocarbon type	Prystane	Prystane	Extraction using DCM by soxhlet for SEM	Analysis for SARA *	Analysis for SVOC for coal tar/biomarkers *	Gravimetric determination of toulene extractable matter	Solvent extraction of sample	PAH (EPA16) analysis; specific focus Benzo[a]pyrene *	1	2	3	4	5	6	7	8	9	10	GSMS	GCMS/MS	Tar acids/phenolics	Tar bases/nitrogen-containing heterocycles	Aromatic amines	Cyano-PAHs	Methylsubstituted congeners	Sulphur-containing heterocycles	Sulphur-containing heterocycles	Notes
Eg. RC-01	L1	S1	0.05-0.1	X																																			x - inform engineer of any positive results.
Eg. RC-01	L1	S2	0.05-0.1														X	^	^																				
Eg. RC-02	L1	S2	0.05-0.1																				x	x					x		x				x				Undertake test if Benzo[a]pyrene exceeds 0.005% threshold concentration
Running total				1													1	1	1				1	1					1		1				1				

Key
~ reference is made to the Guidance Note 'Dealing with coal tar bound arising's - CH2M, September 2016
# - 1st part of 3 part test. Method E and F may be undertaken before Method D. Not all three stages may be required
* by GCMC method
$ results to be plotted as double ratio plot of PAH profile to determine likely source

Appendix D
Example site risk assessments

Risk assessment for sites where coal tar bound surfacing may be present in rural environments.

Rural / countryside					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes
Inhalation of contaminated dust.	Site operatives and maintenance staff	4	4	16	Risk can be reduced through the use of appropriate PPE i.e. respirator Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*
	Members of the public - passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment. *(See notes 1 to 3)*
	Members of the public – neighbouring sites	1	4	4	Whilst there is an opportunity for dust to build up neighbouring, buildings are likely to be a located further from the site in comparison to the urban environment. *(See notes 1 to 3)*
Ingestion of contaminated dust.	Site operatives and maintenance staff	3	4	12	Risk can be reduced with appropriate PPE and good hygiene standards i.e. gloves and respirator Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*
	Members of the public - passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment *(See notes 2 and 3)*

Risk assessment for sites where coal tar bound surfacing may be present in rural environments.

Rural / countryside					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes
	Members of the public – neighbouring sites	1	4	4	Whilst there is an opportunity for dust to build up neighbouring, buildings are likely to be a located further from the site in comparison to the urban environment. *(See notes 2 and 3)*
Dermal contact with contaminated dust.	Site operative and maintenance staff	4	4	16	Assumes use of appropriate PPE when handling potentially contaminated materials. Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 3)*
	Members of the public - passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment. *(See notes 1 to 3)*
	Members of the public – neighbouring sites	2	4	4	Neighbours are likely to be a significant distance from site in comparison to urban environment. *(See notes 1 to 3)*
Dermal contact with contaminated surface water and groundwater	Site operative and maintenance staff	3	4	12	Prevent run-off from the works area. Avoid undertaking works in wet weather. *(See notes 2 and 3)*
	Members of the public	1	4	12	Prevent run-off from the works area. Avoid undertaking works in wet weather.

Risk assessment for sites where coal tar bound surfacing may be present in rural environments.

Rural / countryside					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes
					(See notes 2 and 3)
	Animals and birds	3	4	12	Prevent run-off from the works area. Avoid undertaking works in wet weather. Consider blocking drains or flushing drains afterwards and passing water through oil interceptor.
	Fish	4	4	16	Prevent run-off from the works area. Avoid undertaking works in wet weather.
Inhalation of fumes	Site operatives and maintenance staff	3	4	12	Open spaces, so less likely that there will be structures, which create a ‘confined’ working area. *(See notes 2 to 4)*
	Members of the public – passers by	1	4	4	Passers-by are less likely in a rural countryside setting in comparison to an urban environment. *(See notes 2 and 3)*
	Members of the public – neighbouring sites	1	4	4	Neighbours are likely to be a significant distance from site in comparison to urban environment. *(See notes 2 and 3)*
Ingestion of contaminated groundwater and surface water	Site operatives and maintenance staff	1	4	4	Risk can be reduced through the use of appropriate PPE i.e. task specific gloves *(See notes 2 and 3)*

Risk assessment for sites where coal tar bound surfacing may be present in rural environments.

Rural / countryside					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes
	Members of the public - passers by	1	4	4	
	Members of the public – neighbouring sites	2	4	8	Will depend how potable water supplies are obtained at neighbouring sites
	Animals and birds	3	4	12	Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.
	Fish	4	4	16	Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.
Contaminated surface water run-off into waterbody	Water environment	4	4	16	Fewer impermeable surfaces and water capture systems. Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.
Seepage of leachate into waterbody	Water environment	4	4	16	Fewer impermeable surfaces to inhibit seepage. Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.
Uptake of contaminated groundwater	Plants	4	4	16	Consider blocking drain inlets and/or flushing drains and passing water through oil interceptor.

Risk assessment for sites where coal tar bound surfacing may be present in rural environments.

Rural / countryside					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes

Notes

1 - Whilst water has traditionally been used as a means of dust suppression the Contractor needs to consider that an appropriate collection system will need to be employed to prevent contaminated surface water run-off entering the environment. Further guidance on the management of construction dust is given on the HSE website – www.hse.gov.uk/construction/faq-dust.htm

2 - Further guidance is given in the HSE documents HSG150 2006 ‘Protecting the public; your next move’ and ‘Health and Safety in Construction’ 3rd Edition.

3 – Further guidance is given in the HSE documents HSG151 2009 ‘Health and Safety in Construction’ 2nd Edition.

4 – Guidance on using Respiratory Protective Equipment is given in the HSE document HSG53 2013 ‘Respiratory protective equipment at work: a practical guide’ 4th Edition

Risk assessment for sites where coal tar bound surfacing may be present in urban environments.

Urban environment Risk Assessment					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes/ mitigation measures
Inhalation of contaminated dust.	Site operatives and maintenance staff	4	4	16	Risk can be reduced through the use of appropriate PPE i.e. appropriate face fitted mask or respirator Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*
	Members of the public - passers by	2	4	8	Keep members of the public outside the working area; consider the use barriers to prevent members of the public using seating areas directly adjacent to the working area. *(See notes 1 to 3)*
	Members of the public – neighbouring sites	3	4	8	Assumes build-up of dust within adjacent sites so greater risk of exposure to neighbours than people passing by the site. *(See notes 1 to 3)*
Ingestion of contaminated dust.	Site operatives and maintenance staff	3	4	12	Risk can be reduced with appropriate PPE and good hygiene standards i.e. gloves and respirator or face fitted mask Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 4)*
	Members of the public - passers by	1	4	4	Keep members of the public outside the working area; consider the use barriers to prevent members of the public using seating areas directly adjacent to the working area. *(See notes 1 to 3)*

Risk assessment for sites where coal tar bound surfacing may be present in urban environments.

Urban environment Risk Assessment					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes/ mitigation measures
	Members of the public – neighbouring sites	2	4	8	Assumes build-up of dust within adjacent sites so greater risk of exposure than people passing by the site. *(See notes 1 to 3)*
Dermal contact with contaminated dust.	Site operative and maintenance staff	4	4	16	Risk can be reduced through the use of appropriate PPE i.e. task specific gloves. Consider the use of vacuum enhanced planing to minimise dust and ensure that all residue is removed. *(See notes 1 to 3)*
	Members of the public - passers by	1	4	4	Unlikely to come into direct contact. See above *(See notes 1 to 3)*
	Members of the public – neighbouring sites	2	4	8	Assumes a build-up of contaminated dust. See above *(See notes 1 to 3)*
Dermal contact with, or ingestion of contaminated surface water and groundwater	Site operative and maintenance staff	2	4	8	Risk can be reduced through the use of appropriate PPE i.e. task specific gloves *(See notes 2 and 3)*
	Members of the public	1	4	4	*(See notes 2 and 3)*
Ingestion of contaminated	Animals and birds	2	4	8	Prevent run-off from the works area. Avoid undertaking works in wet weather.

Risk assessment for sites where coal tar bound surfacing may be present in urban environments.

Urban environment Risk Assessment					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes/ mitigation measures
surface water and groundwater	Fish	1	4	8	Prevent run-off from the works area. Avoid undertaking works in wet weather. Consider blocking drains or flushing drains afterwards and passing water through oil interceptor.
Inhalation of fumes / vapours	Site operatives and maintenance staff	2	4	8	Consideration should be given to the working area and whether surrounding structures create a 'confined' working area where fumes are not easily dissipated. Planing of road surface should not directly heat asphalt sufficiently to generate fumes. When working in hot weather consider the use of fans to increase air flow in confined areas. *(See notes 2 to 4)*
	Members of the public – passers by	1	4	4	Keep members of the public outside the working area; consider the use barriers to prevent members of the public using seating areas directly adjacent to the working area. When working in hot weather consider the use of fans to increase air flow in confined areas
	Members of the public – neighbouring sites	1	4	4	When working in hot weather consider the use of fans to increase air flow in confined areas
Contaminated surface water run-off into waterbody	Water environment - surface water bodies	3	4	12	Will depend on location of the coal tar bound arisings within the carriageway construction and the condition of the overlying and underlying layers. Assumes worst case; that coal tar bound arisings are at the surface or carriageway is in poor condition.
	Water environment - groundwater	2	4	8	
Seepage of leachate into waterbody	Water environment - groundwater	2	4	8	
	Water environment - surface water bodies	1	4	4	
Uptake of contaminated groundwater	Plants	2	4	8	

Risk assessment for sites where coal tar bound surfacing may be present in urban environments.

Urban environment Risk Assessment					
Name of assessor and date					
Highway name/chainage/length					
Proposed scheme					
Pathway	Receptor	Probability	Severity	Risk	Notes/ mitigation measures

Notes

1 - Whilst water has traditionally been used as a means of dust suppression the Contractor needs to consider that an appropriate collection system will need to be employed to prevent contaminated surface water run-off entering the environment. Further guidance on the management of construction dust is given on the HSE website – www.hse.gov.uk/construction/faq-dust.htm

2 - Further guidance is given in the HSE documents HSG150 2006 'Protecting the public; your next move' and 'Health and Safety in Construction' 3rd Edition.

3 – Further guidance is given in the HSE documents HSG151 2009 'Health and Safety in Construction '2nd Edition.

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