



UPDATED ASBESTOS RISK ASSESSMENT REPORT FOR SYMMETRY PARK, HUYTON, MERSEYSIDE

TE1163-TE-00-XX-RP-GE-001-V01

VERSION 1

19 APRIL 2022

FINAL

Prepared for:

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DOCUMENT CONTROL

Report No. :	TE1163-TE-00-XX-RP-GE-001-V01
Report Status:	FINAL
Version No.:	1
Project Engineer:	Adrian Read
Date of Issue:	19/04/2022

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Version No.	Description of Issue / Revision	Date of Issue	Author	Reviewed By	Approved By
1	FINAL	19/04/2022	Adrian Read	Sean Lee	Sean Lee



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1. INTRODUCTION

Tier Environmental was commissioned by Tritax Symmetry Ltd to undertake an updated detailed quantitative asbestos risk assessment for the Symmetry Park development located off Fox's Bank Lane, Cronton, L3 5SU.

Tier Environmental have previously produced an Asbestos Risk Assessment Report for Symmetry Park, Huyton, Merseyside (report reference: TE1163ARA1.0, dated 22nd October 2020) and have subsequently been in receipt of a letter response from Knowsley Council (reference: 20/00494/HYB, dated 14th April 2022) which includes comments pertaining to a number of Tier Environmental documents including the previous Asbestos Risk Assessment Report.

The aim of this report is to provide a revised asbestos risk assessment that addresses the items raised in the Knowsley Council response letter and incorporates the use of the SoBRA 'Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021) which has been released since the production of the original Asbestos Risk Assessment Report.

1.1. Proposed Development

The redevelopment is to comprise 4 No. industrial warehouses each with associated car parking areas, surface water attenuation ponds and areas of soft landscaping. In the south and eastern areas of the Site it is proposed that the site will be redeveloped into a country park, comprising woodland, ephemeral lakes and footpaths. A large scale earthworks exercise (approximately 450,000m³ of cut/fill) is proposed to provide the appropriate development platforms and highway gradients.

The proposed layout of the Site is presented in UMC Architects Drawing No. 18128-F0006 Rev F, which is included within Appendix A to this report. At the time of writing the four proposed units are as follows:

- Unit 03 – located in the north-western part of the Site – 238,565ft² – approximate proposed final floor level – 33.00m AOD;
- Unit 04 – located in the south-western part of the Site – 290,500ft² - approximate proposed final floor level – 36.50m AOD;
- Unit 02 – located in the northern part of the Site – 204,600ft² - approximate proposed final floor level – 37.50m AOD; and,
- Unit 01 – located in the eastern part of the site – 164,400ft² - approximate proposed final floor level – 41.200m AOD.

1.2. Objectives

The objectives of this report are:

- To update the previously issued asbestos risk assessment in order to determine whether any residual risk remains for future land users;
- To provide a robust and clear response to the queries raised in letter response from Knowsley Council (reference: 20/00494/HYB, dated 14th April 2022);
- To incorporate the SoBRA 'Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021) which has been released since the production of the original Asbestos Risk Assessment Report.

1.3. Assumptions

The following assumptions are made in this report:



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- It is assumed that ground levels will not change significantly from those described in this report or as shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The previous ground investigations have been conducted with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to visual observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.
- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- There may be other conditions prevailing on the Site which have not been revealed by this investigation and which have not been taken into account by this report.
- Responsibility cannot be accepted for any conditions not revealed by previous investigations. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

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2. SITE DETAILS AND DESCRIPTION

2.1. Overview

Table 2.1 Current Site Overview.

Site name	Former Cronton Colliery
Site address	Halsneads Farm Livery Stables, Fox's Bank Lane, Cronton, L353SU. A site location plan is included as Drawing No. TE1163GIR1 within Appendix A.
National Grid Reference	SJ 47493 89537
Location description	The Site is located south of the M62 in a predominantly agricultural area. The closest town is Whiston which is 2.3 km North of the Site.
Approximate Site area	28.96ha
Site shape	Irregular with the longest axis in the east to west direction and the shortest axis being in the north to south direction.
General topography and ground levels	The Site is generally undulating with ground levels in the north of the site ranging from 44m AOD in the east to 24m AOD in the west.
Current land use	The southern area of the site is a plateau at 34m AOD with a steep slope towards the south to 25m AOD.
Existing structures	Ground levels in the eastern area of the site generally decrease from 48m AOD in the centre to 40m AOD in the west and 34m AOD in the east and south.
Site ground surfaces	The Site is currently unoccupied with no above ground structures. The northern area of the Site is currently occupied by grazing and agricultural land. The southern and eastern areas of the Site are currently occupied by immature woodland on the regraded colliery spoil slopes.
Sub-surface structures	The area of the southern access road is covered with concrete hardstanding with bridge/embankment structure.
Invasive plant species	There are 3 No. methane vent pipes located within the centre of the site overlying the 3 No. old mine shafts used by the former colliery



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3. ASBESTOS DETAILED QUANTITATIVE RISK ASSESSMENT

3.1. Knowsley Council Comments and Responses

Tier Environmental have produced this document to update the previously issued asbestos risk assessment in such a manner that incorporates the SoBRA 'Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021), and systematically addresses the items raised in the Knowsley Council (reference: 20/00494/HYB, dated 14th April 2022) that pertain to the previously issued Asbestos Risk Assessment Report for Symmetry Park, Huyton, Merseyside (report reference: TE1163ARA1.0, dated 22nd October 2020).

For ease, the table below has been prepared which has reproduced the pertinent Knowsley Council comments and Tier Environmental corresponding responses and clarifications have been presented.



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Table 3.1 Summary of Knowsley Council ARA Report Comments and Tier Environmental Responses

Knowsley Council Comment (letter reference: 20/00494/HYB, 14 th April 2022)	Tier Environmental Response (19 th April 2022)
The proposed acceptable concentration for chrysotile asbestos of 0.029% w/w is presented within the Asbestos Risk Assessment Report (ARA). It is noted that any chrysotile asbestos concentrations reported from future testing in excess of those encountered in the recent site investigation works, or any different types of asbestos (e.g. crocidolite or amosite) will require further risk assessments.	Agreed, Tier Environmental acknowledge this requirement.
In view of the amendments to the SRA, a further detailed review of the ARA has been undertaken which has identified a number of queries which need to be addressed. A revised version of ARA should be provided to support the current proposals.	This Updated Asbestos Risk Assessment report has been prepared to address the comments raised.
The estimation of dust levels at exposure has been taken from the example in Box 13.3 in CIRIA C733 for gardening activities in dry and dusty conditions (based on ambient urban dust levels and ART modelling of shovelling of dry powders). Confirmation is required whether this is representative of the exposure scenarios adopted for (i) the proposed commercial end use and (ii) the country park end use. Further observation is provided below in relation to the critical receptors and exposure scenarios adopted for the proposed land uses.	Tier Environmental have provided further justification in Section 3.5, below; however in summary Tier Environmental consider that activities that involve digging / shovelling represent the most reasonable 'violent' agitation of the soils that may be anticipated during maintenance and recreational activities for both (i) the proposed commercial end use and (ii) the country park end use. CIRIA C733 identify that consideration of asbestos fibres at the surface becoming airborne due to wind is usually a minor consideration, as is the case here.
When estimating the normalised airborne respirable fibre concentration (f/ml) for chrysotile asbestos, reference is also made to amosite asbestos (MEAS suspect this is a typographical error). It should be made clear that the estimated normalised fibre concentration of 0.13 f/ml per mg/m ³ (derived assuming a sand soil type and the maximum reported asbestos concentration in soil at the Site (0.029% w/w) is based on chrysotile asbestos only and must not be applied to any other type of asbestos.	Agreed, clarification on this is provided in the updated assessment, below. Section 3.5 now states: <i>"It should be noted that in the event that other forms of asbestos are identified in the future on this site (e.g. crocidolite or amosite), then this risk assessment should be appropriately updated to take account of these additional types of asbestos."</i>
The exposure scenario and critical receptor adopted for the Commercial/Industrial Land Use scenario need to be clarified. The critical receptor is stated to be a working adult female aged 16 to 65 where outdoor activity has been limited to 1 hour per day (what is the nature of the activity that would bring about exposure?). Reference is then made to landscape maintenance workers who are assumed to conduct activities in landscaped areas under dry and dusty conditions for an average of 1 hour per day for 81 days per year.	Tier Environmental have adopted an alternative assumption for this; subsequent to the October 2020 report SoBRA have released Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021). Tier Environmental have therefore adjusted the critical receptor age ranges in line with this calculation sheet as described in the assessments below. In addition, further justification for the selection of the frequency and exposure durations are provided in the assessments below.
The exposure scenario and critical receptor adopted for the Public Open Space Land Use scenario also need to be more clarified. The critical receptor is stated to be a female child aged zero to 6 years. Outdoor activity limited to 2 hours per day. Reference is then made to landscape maintenance workers who are assumed to conduct activities in landscaped areas under dry and dusty conditions for an average of 1 hour per day for 81 days per year.	Tier Environmental have clarified that for the Public Open Space Land Use, an assumption has been made for outdoor activities to be 2 hours a day in accordance with SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination (Final Project Report (Revision 2), dated: 24 th September 2014) for a public open space park land use.
It is assumed that the adoption of 81 days per year in the annual exposure calculation for both land uses is based on the estimated number of dry days each year where the ground surface may be dry enough to allow fibre release? This needs to be clarified.	This is correct. Tier Environmental have considered local Met Office precipitation data within this calculation as detailed in the sections below. For the avoidance of any doubt, the site-specific number of dry days each year the ground surface may be dry enough to allow fibre release in an outdoor environment has been calculated as 81 days a year.



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Knowsley Council Comment (letter reference: 20/00494/HYB, 14 th April 2022)	Tier Environmental Response (19 th April 2022)
The age adjustment factors for mesothelioma risk appear to have been incorrectly applied to the predicted cumulative exposures rather than the estimated lifetime risk. This has the effect of increasing the predicted cumulative exposures which are then used to estimate mesothelioma risks. This and the subsequent parts of the risk estimation and evaluation needs to be revised.	Age adjustment factors are now applied within the SoBRA Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021). Age adjustment and application is detailed on the calculation sheets appended to this report.
In the final part of the Risk Evaluation, an adjustment has been made to the estimated lifetime mesothelioma and lung cancer risks to account for soil moisture content. MEAS do not believe that this adjustment is appropriate. In addition, the effects of soil moisture have been considered earlier in the risk assessment through estimation of the number of dry days each year the ground surface may be dry enough to allow fibre release in an outdoor environment.	Tier Environmental consider there is a distinction between the estimation of the number of dry and dusty days per year and then the effect that any residual moisture content within the soils on these dry and dusty days has to the fibre release potential. Nevertheless, and to provide additional confidence in the conclusions, Tier Environmental has removed (within this updated assessment) any further adjustment to account for soil moisture content.



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3.2. Asbestos Risk Assessment

The presence of asbestos within the Made Ground soils presents a problem in that there is a risk of site users coming into contact with these soils during the proposed uses of the Site as commercial warehouses and a publicly accessible country park. It should be pointed out that, based upon current information; it is considered that the levels of asbestos are low and that the proposed landscaping areas will likely be covered by grass or shrub vegetation, which would reduce the exposure risk to a low level. Nevertheless, there must be a decision as to what must be done in order to ensure the safety of the future site users. The potential issues are highlighted below:

1. The site users must be protected, or it must be demonstrated that they are not at risk.
2. It must be ensured that Tritax Symmetry has been diligent in terms of their liabilities and cannot have been seen to be negligent.
3. Any work must be communicated in such a way that does not cause undue alarm to neighbouring site users or future site users.

In total, when the results of the laboratory testing on the imported topsoil materials are combined, asbestos has been reported in 8 No. of the 45 No. samples obtained (17.7% of the samples).

Tier Environmental consider that, on balance, it is appropriate to conduct further detailed risk assessment in accordance with CIRIA C733 to determine whether excavation and off-site disposal of the soils is required or whether it is possible to confirm that there is a minimal/tolerable risk and justification to retain the soils on Site. Justification for this is provided below:

- 82.3% of the samples have returned 'no asbestos detected' results;
- It is considered that the materials do not have gross contamination in that that no visual evidence of asbestos lagging, coating or fibres bundles were encountered during the soil sampling;
- Where detected the concentrations are consistently low (generally <0.005% w/w with one isolated concentration of 0.029% w/w)

Whilst in some cases, a qualitative argument relating to the absence of asbestos (or only sporadic presence of very low concentrations of low risk ACMs), pathway or receptors may be sufficient to demonstrate that remediation is not required. In other cases, the decision to remediate may not require quantitative risk assessment, if, for example a site exhibits gross contamination at the surface. It is considered that this site does not have gross contamination; such that no visual evidence of asbestos lagging, coating or free fibres was encountered during the site investigations to date.

As asbestos fibre bundles have been reported in 17.7% of Made Ground from the samples obtained on Site it is considered that a site-specific assessment in accordance with CIRIA C733 is required in this instance.

3.3. Objectives and Approach

Taking into account the planned future use of the Site, the objectives of this appraisal were:

- To undertake an updated site specific human health risk assessment with regard to the concentration of identified asbestos, in line with the principals stated in C733 in order to determine whether any residual risk remains for future land users;
- To provide a robust and clear response to the queries raised in letter response from Knowsley Council (reference: 20/00494/HYB, dated 14th April 2022);
- To incorporate the SoBRA 'Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021) which has been released since the production of the original Asbestos Risk Assessment Report.



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As no robust method of producing an asbestos GAC is available or possible at present, quantitative risk assessments for asbestos-related soils need to characterise the nature and extent of asbestos contamination in soils. For this Site, this is achieved through a clear evaluation of the future land use, including likely receptors and the type, form, condition, and concentrations of asbestos in soils. From the characteristic value, it will be possible to estimate potential airborne fibre concentrations that may arise from such contamination and then use a range of risk assessment techniques which will enable lines of evidence to develop a realistic exposure scenario for the future commercial / industrial and public open space / park land use. The exposure scenarios will also utilise in-built conservatism and predict likely cumulative exposures for the maximum periods of time a working female adult, aged fifteen to sixty years working at the warehouse unit (regarded here as the critical receptor for a commercial land use and in accordance with SoBRA's calculation sheet assumptions) or a female child, aged zero to 6 years visiting the country park (regarded here as the critical receptor for a public open space land use) are likely to spend at the site. This exposure will finally allow us to evaluate the significance of the associated risks and whether the worst case occurrences of asbestos represent anything other than a minimal / tolerable risk to the site users. In doing, so, it is considered that such an assessment will be protective of a future maintenance workers whose exposure would be less than that of the critical receptor in this instance.

3.4. Asbestos Quantification Testing

In order to attempt to quantify the percentage of asbestos in any given soil sample, the following method is followed. The whole sample is tipped into a tray, weighed, dried, and weighed again. The sample is inspected under a x40 stereomicroscope, and any visible ACM or clumps of fibres are removed and weighed.

These fibres are inspected under a Polarising Light Microscope to confirm the presence and type of asbestos in the sample (a bulk ID). This will be reported even if only a small number of fibres are found, and if this goes on to the full quantification method, the amount of asbestos may well be <0.001%.

For fibre quantification the residual sample is sieved and the <5mm fraction is dispersed in water for an hour. Replicate aliquots (at least four) are then removed, filtered, and the filters mounted onto microscope slides for counting and measuring using Phase Contrast Optical Microscopy. These results are then converted to a % by weight and added to the % of ACM found in the initial part of the method.

3.5. Concentration of Asbestos in Soils and Potential Fibre Release

Asbestos quantification testing has demonstrated that all of the samples where asbestos quantification has been conducted are <0.005% w/w with the exception of a single reported concentration of 0.029% w/w of bitumen products / chrysotile fibre bundles. The aim of this section of the risk assessment is to predict realistic airborne concentrations from the measured soil concentrations, backed up from published fibre release potential tests. The assessment has taken into account the potential for a future increase in fibre release as ACMs degrade in order to determine whether the measured concentrations are representative of the range of possible weather conditions and activities that could occur. Overall, the risk of the aforementioned further physical and chemical degradation of the chrysotile and microscopic chrysotile bitumen products is considered to be unlikely given the land use; however, the potential for fibre release given the pre-existing nature of the fibre bundles shall be considered.

Current risk models are based on airborne fibre concentrations and, in order to predict the potential fibre release from the soils at the site, information has been taken from the published literature. Addison et al. (1988) measured the release of airborne fibres from 'spiked' dry soils ("sandy", "intermediate" and "clay") containing between 0.001, 0.01, 0.1 and 1% free fibrous asbestos (3 types). The experiment used rotating drums to generate dust from dry soils and measured the dust concentrations in mg/m³ and asbestos fibre concentrations in f/ml. The effects of soil moisture were also assessed. The soil type at the site varies comprising:



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- Generally – a black, dark grey sandy clayey angular to rounded, fine to coarse gravel of mudstone, coal and mixed anthropogenics.
- Grey sandy, gravelly clay. The gravel is angular to rounded, fine to coarse of mixed natural and anthropogenics.
- Dark brown/black slightly sandy, gravelly LOAM

As a precautionary / conservative approach, the fibre release prediction has been taken to be sand. Further conservatism is built into these numbers, given that the laboratory experiments were very violent and produced much more dust/airborne fibre than would be expected from normal or anticipated site activities (particularly when the commentary provided in the 'Asbestos Risk Assessment' Section above is taken into consideration). When the correlation between normalised fibre concentrations in air and % of asbestos in soil is studied, it appears that the model also over predicts the concentrations of fibre release at low concentrations.

With respect to deriving soil-dust in air concentrations Section 13.4.2 in CIRIA C733 states the following:

"The Addison et al (1988) data was reported relative to respirable dust concentrations (i.e. f/ml per mg/m³ dust). So, the concentration of airborne soil dust (e.g. PM10) used in the predictive modelling will have a direct effect on the estimated airborne concentrations of asbestos fibres. Great care needs to be taken in selecting, and justifying, an appropriate value of airborne dust that is consistent with the exposure scenario as an overly cautious value will result in unrealistically high predictions of airborne asbestos fibres. However, the difficulty in identifying a defensible value should not be underestimated.

Respirable dust concentrations can be measured on-site (under relevant conditions), based on literature values for activities similar to those being considered, or based on measurement at other similar sites. In addition, predictive models such as the ART model (an occupational dust exposure tool) can give indicative concentrations of soil dust in air for some activities.

While the ART user guide points out that the model is not calibrated for asbestos fibres per se, it can be used to predict levels of dusts generated from soils. Robertson et al (2011) used both site measurements and ART predictions in estimating the likely concentrations of soil dust in air during activities in domestic gardens."

CIRIA C733 acknowledges that free asbestos fibres at the surface can become airborne due to wind (usually a minor consideration, as described in CIRIA C733) or by or site use (e.g. gardening and children playing).

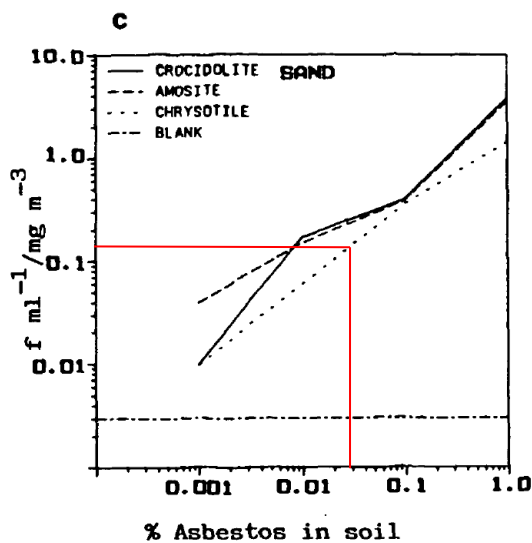
Taking into account that background urban dust (PM10) is generally taken to be at concentrations of around 20 µg/m³; however, in line with example 13.3 in CIRIA C733, the concentration of soil dust during gardening activities in dry and dusty conditions was estimated to be 100 µg/m³ (0.1 mg/m³) based on ambient urban dust levels and ART modelling of shovelling of dry powders. Tier Environmental note that example 13.3 in CIRIA C733 is for a residential land-use scenario; however, it is considered that this selected worst-case activity of 'shovelling' (representing the most reasonable violent agitation of the soils that may release asbestos fibres) is justifiably used for the proposed land uses as listed below:

- landscape maintenance works involving shovelling / digging activities that may take place on Site in the commercial / industrial areas;
And also is appropriately conservative for;
- a scenario where either landscape maintenance works involving shovelling / digging activities are conducted in areas of the publicly accessible country park;
And is also appropriately conservative for;
- a situation where a park user digs a hole / shovels into the underlying soil whilst playing within the publicly accessible country park land use.

Figure 7 from Addison et al (1988) has been used to estimate the normalised airborne respirable fibre concentration (f/ml) for chrysotile asbestos (based on the asbestos screen results) assuming a sand soil type. Taking the maximum reported asbestos concentration in soil at the Site (0.029%

w/w) the graph indicates a normalised fibre concentration of 0.13 f/ml per mg/m³ for chrysotile. As such, when the value derived for chrysotile is taken and the concentration of soil dust is taken into consideration then an airborne fibre concentration during such activities in a dry and dusty conditions has been estimated to be 0.013 f/ml (Ci) and assumed to be insignificant at other times. It should be noted that in the event that other forms of asbestos are identified in the future on this site (e.g. crocidolite or amosite), then this risk assessment should be appropriately updated to take account of these additional types of asbestos.

Figure 3.1 Normalised airborne respirable fibre concentration (adapted from Figure 7 from Addison et al (1988))



3.6. Exposure Scenario for the Critical Receptor

It has been assumed that as the samples have been obtained from shallow soils that exposure may occur during general use, digging and landscape maintenance activities.

Hawarden weather station lies around 29 miles from the Site and is considered to be a relatively accurate representation of the average amount of days (24h) with precipitation during a month. The number of days when precipitation has surpassed 1mm per day (24h) it is defined as a day with precipitation. A review of Met Office data over a mean period of between 1981 and 2010, states the average number of dry days per year is 230. Data from the last year (2019, obtained from Hawarden weather station) states that the number of dry days for 2019 was 168. The data from 1981 – 2010 has been used as it accounts for more dry days per year and is taken from a larger data set therefore is the more conservative value to use.

Airborne asbestos fibres are only likely to be released when the ground conditions are dry and dusty. The number of dry days per year is used as an indicator for potential fibre release, however, although there was less than 1mm of rain reported on 230 days of the year this does not reflect the soil moisture content. It is estimated based on industry practice, that on 35% of the dry days each year the ground surface may be dry enough to allow fibre release in an outdoor environment therefore, a total of 81 days a year has been calculated for this Site.

As stated above the detailed risk assessment will be undertaken twice for each of the two proposed land uses (commercial and public open space – park). A conservative approach with regards to sample locations has been applied as earthworks conducted on site may mean that low level asbestos impacted materials presently located within one area of the site ultimately reside within another area post-earthworks. All samples obtained from



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across the entire site area have been reviewed for both end site uses disregarding sample locations or final material locations post earthworks. This approach is considered to build further conservatism and confidence into the model.

Commercial/Industrial End Land Use

The most critical receptor of a commercial/industrial land use is considered to be a working adult female (aged fifteen to sixty years) where outdoor activity has, conservatively, been limited to one hour per day in accordance with Box 3.6 of the Updated technical background to the CLEA model (SR3, January 2009); however, this assumes that all respiration periods are engaged in passive activities which is not necessarily considered to be the case for landscape maintenance workers. In addition, Box 3.6 of the Updated technical background to the CLEA model (SR3, January 2009) also calculates a weighted average as the worker does not spend time outside for 60 days a year – Tier Environmental have conservatively *not applied* the weighted average as it is considered that a landscape maintenance worker may still work outside for these days. Tier Environmental considers that an average 1 hour of non-passive digging / shovelling activities for a landscape maintenance worker (working adult female (aged fifteen to sixty years)) represents a reasonable critical receptor scenario for the commercial / industrial end land use.

Example 13.3 in CIRIA C733 demonstrates that E_i should be calculated taking into consideration only those days where dry and dusty conditions prevail. As such, Tier Environmental have determined above that the ground surface may be dry enough to allow fibre release in an outdoor environment, a total of 81 days a year, based on local Met Office precipitation data.

Landscape maintenance workers are assumed, very conservatively, to conduct digging / shovelling activities in landscaped areas under dry and dusty conditions for an average of 1 hour per day for 81 days per year ($F_i T_i$) consistent with the calculation approach in example 13.3 in CIRIA C733 and using the values justified above for the critical receptor scenario for a commercial / industrial end land use.

Annual exposure is calculated in accordance with CIRIA C733:

$$E_i = C_i \times F_i \times T_i$$

Where E_i is annual exposure, C_i is the estimated concentration (f/ml) for the event, F_i is the frequency of the event per year, T_i is the period of time that the event lasts in hours.

Tier Environmental have at this point of the risk assessment adopted a different approach to that provided in the original Asbestos Risk Assessment Report for Symmetry Park, Huyton, Merseyside (report reference: TE1163ARA1.0, dated 22nd October 2020). Since October 2020, when that original report was produced, SoBRA have produced a 'Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021) and a copy of the sheet and the assumptions made is appended to this report.

A worst-case assumption has been made that all available 5 year age tranches have been applied for the number of days and hours and summarised above for a commercial worker from 15 years of age.

Cumulative Exposure for the Described Worst Case Exposure Scenario

Mesothelioma Risk

The cumulative risk for mesothelioma is calculated as 0.017 per 100,000 over a lifetime of 80 years.



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Engineer: Adrian Read
Date: 19/04/2022

Lung Cancer Risk

The cumulative risk for lung cancer is calculated as 0.0056 per 100,000 over a lifetime of 80 years.

Total Risk and Conclusion

This exposure-risk model can be used to investigate the significance of potential exposures in terms of likely ELCR. The ELCR of 1:100,000 is generally considered the limit of minimal risk; however, uncertainties need to be treated carefully if unrealistically cautious assessments are to be avoided.

The above mesothelioma and lung cancer risk calculations provides a total risk of 0.023 per 100,000 over a lifetime of 80 years with significant conservatism built into the model.

On this basis, it is considered that the reported concentrations of chrysotile asbestos within the Made Ground materials will present a minimal / tolerable risk for the proposed commercial / industrial land use, including soft landscaped areas and are therefore suitable for use.

Public Open Space End Land Use

The most critical receptor of the public open space land use is considered to be a female child, aged zero to 6 years visiting the country park where the worst-case exposure scenario is regarded as being shovelling / digging. This outdoor activity has, conservatively, been assessed for two hours per day in accordance with assumptions included in SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination (Final Project Report (Revision 2), dated: 24th September 2014) for a public open space park land use. Tier Environmental considers that an average 2 hour of non-passive digging / shovelling activities during recreation represents a reasonable worst-case critical receptor scenario for the public open space land use.

Example 13.3 in CIRIA C733 demonstrates that E_i should be calculated taking into consideration only those days where dry and dusty conditions prevail. As such, Tier Environmental have determined above that the ground surface may be dry enough to allow fibre release in an outdoor environment, a total of 81 days a year, based on local Met Office precipitation data.

Critical public open space users are assumed, very conservatively, to conduct digging / shovelling activities under dry and dusty conditions for an average of 2 hour per day for 81 days per year ($F_i T_i$) consistent with the *calculation approach* in example 13.3 in CIRIA C733 and using the values justified above for the critical receptor scenario for a public open space near park land use.

Annual exposure is calculated in accordance with CIRIA C733:

$$E_i = C_i \times F_i \times T_i$$

Where E_i is annual exposure, C_i is the estimated concentration (f/ml) for the event, F_i is the frequency of the event per year, T_i is the period of time that the event lasts in hours.

As per the assessment for commercial / industrial land use, Tier Environmental have at this point of the risk assessment adopted a different approach to that provided in the original Asbestos Risk Assessment Report for Symmetry Park, Huyton, Merseyside (report reference: TE1163ARA1.0, dated 22nd October 2020). Since October 2020, when that original report was produced, SoBRA have produced a 'Calculation Sheet for risk from cumulative exposure to asbestos in air' (SoBRA 2021) and a copy of the sheet and the assumptions made is appended to this report.



UPDATED ASBESTOS RISK ASSESSMENT REPORT FOR SYMMETRY PARK, HUYTON, MERSEYSIDE

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Tier Environmental have, in addition, assumed a worst-case scenario that all available 5 year age tranches have been applied for the number of days and hours and summarised above.

Cumulative Exposure for the Described Worst Case Exposure Scenario

Mesothelioma Risk

The cumulative risk for mesothelioma is calculated as 0.094 per 100,000 over a lifetime of 80 years.

Lung Cancer Risk

The cumulative risk for lung cancer is calculated as 0.021 per 100,000 over a lifetime of 80 years.

Total Risk and Conclusion

This exposure-risk model can be used to investigate the significance of potential exposures in terms of likely ELCR. The ELCR of 1:100,000 is generally considered the limit of minimal risk; however, uncertainties need to be treated carefully if unrealistically cautious assessments are to be avoided.

The above mesothelioma and lung cancer risk calculations provides a total risk of 0.12 per 100,000 over a lifetime of 80 years with significant conservatism built into the model.

On this basis, it is considered that the reported concentrations of chrysotile asbestos within the Made Ground materials will present a minimal / tolerable risk for the proposed public open space land use and are therefore suitable for use.

3.7. Proposed Acceptable Concentrations For Forthcoming Earthworks

To create suitable development platforms and highways gradients a large scale earthworks (approximately 450,00m³) is proposed for the development. It is considered that any chrysotile asbestos concentrations reported from future verification testing in excess of those encountered in the recent site investigation works, **or any different types of asbestos (e.g. crocidolite or amosite)** will require further risk assessments to be undertaken to assess suitability for use. Therefore, any future chrysotile values at or below 0.029% w/w should be considered to acceptable concentrations that would result in a minimal/tolerable risk for materials to be re-used at the Site. It is proposed that, for the planned earthworks a sampling regime will be undertaken to suitably characterise the material throughout the works. If concentrations of asbestos are encountered above this value, they should be identified and further assessed before re-use of the material is undertaken.



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4. REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the conclusions of the Asbestos Quantitative Risk Assessment. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisations for their comment and approval.



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Date: 19/04/2022

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6. GLOSSARY OF TERMS

ACEC	Aggressive Chemical Environment for Concrete (classification)
aOD	Above Ordnance Datum
bgl	Below ground level
BGS	British Geological Survey
BRE	Building Research Establishment
CBR	California Bearing Ratio (test)
COMAH	Control of Major Accident Hazards (regulations)
Designated location	Site (and the ecosystem on that site) protected under national or international legislation. A potential ecological receptor to be considered as part of the assessment of land contamination. Example designated locations include SSSIs (q.v.), SACs (q.v.), national nature reserves, Ramsar sites and bird special protection areas.
DQA	Data Quality Assessment
DQO	Data Quality Objective
DQRA	Detailed Quantitative Risk Assessment
DWS	Drinking Water Standard
EQS	Environmental Quality Standard
GAC	Generic Assessment Criterion
GQA	General Quality Assessment (Environment Agency)
GSV	Gas Screening Value
HCV	Health Criteria Value
IPPC	Integrated Pollution Prevention and Control (regulations)
K _{ow}	Octanol-water partition coefficient
LEL	Lower Explosive Limit
LL	Liquid Limit
LoD	Limit of Detection (analytical)
LoQ	Limit of Quantification (analytical)
Mean Value Test	Statistical test (described in the CIEH Guidance) to estimate the mean value of a normally distributed population of data at a given level of confidence. Normally for contaminated land assessment, the 95th percentile (referred to as the 95%UCL or US95) is applied as a reasonable but conservative estimate of the mean concentration for comparison with the relevant assessment criteria.
Maximum Value Test	Statistical test (described in the CIEH Guidance) to identify whether an elevated concentration within a normally distributed data set forms part of the underlying population from which it has been sampled or whether it is an outlier (such as a localised area of contamination) that merits further consideration.
MC	Moisture Content
NGR	National Grid Reference
NIHHS	Notification of Installations Handling Hazardous Substances (regulations)
OS	Ordnance Survey
PI	Plasticity Index
PID	Photoionisation Detector
PL	Plastic Limit
ppm	Parts per million
ppmv	Parts per million by volume
QA	Quality Assurance
QC	Quality Control
SAC	Special Area of Conservation
SOM	Soil Organic Matter



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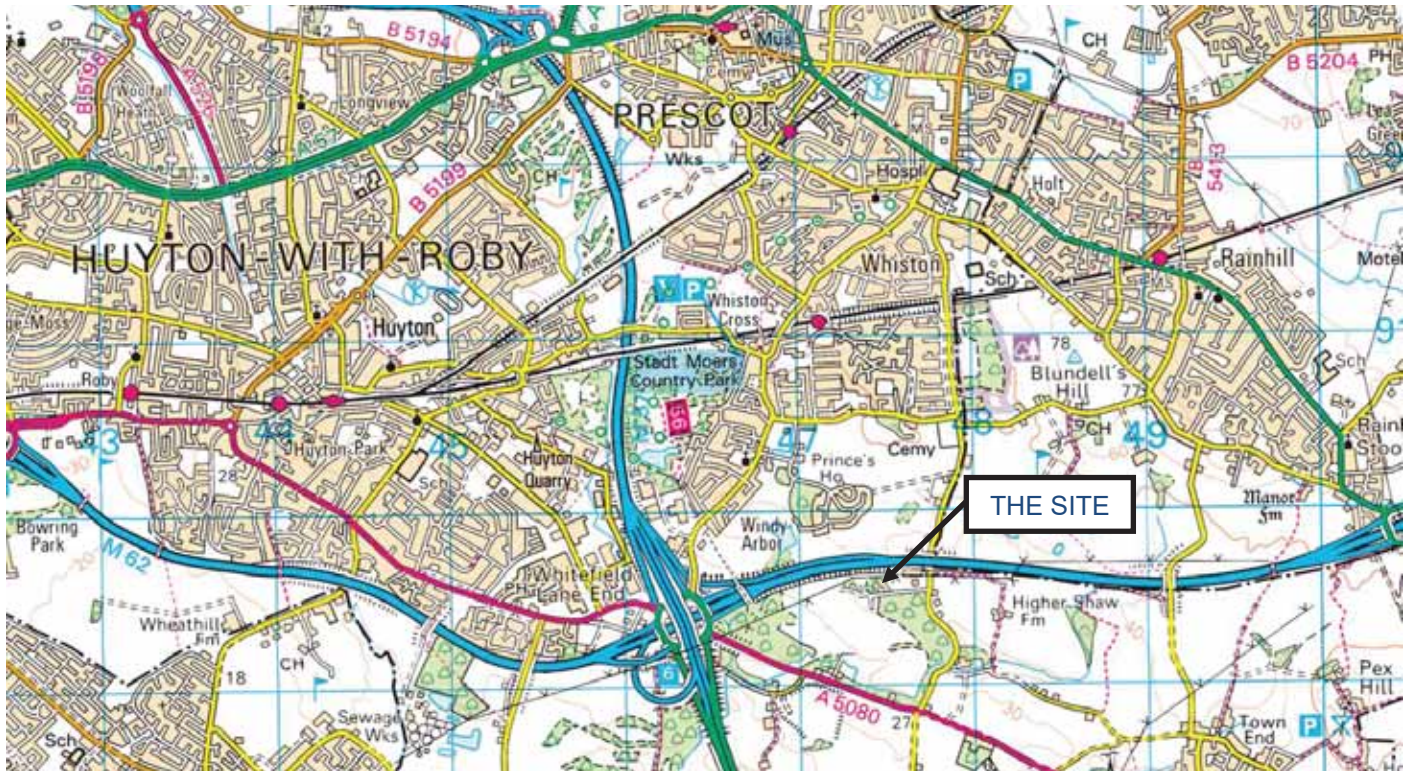
SPT	Standard Penetration Test
SPZ	Source Protection Zone
SSAC	Site-Specific Assessment Criterion
SSSI	Site of Special Scientific Interest
SVOC	Semi-Volatile Organic Compound
TEF	Toxicity Equivalent Factor
TPH	Total Petroleum Hydrocarbons
TWA	Time Weighted Average
US95	95 th percentile estimate of the true mean value of a data population (also known as 95%UCL).
VOC	Volatile Organic Compound

APPENDIX A - DRAWINGS



Contract Number	TE1163
Contract	Former Cronton Colliery Site
Client	DB Symmetry

Site Location Plan



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Scale	NTS		
Drawn by	JC	Approved	SL
Drawing Number	TE1163GIR1		



DO NOT SCALE

GENERAL NOTES:

- This drawing is to be read in conjunction with all other Architect's, Engineer's and Specialist's drawings, together with the appropriate specifications.
- It is the Contractor's responsibility to check all dimensions on site. Dimensions MUST NOT be scaled from this drawing. Any discrepancies to be brought to the immediate attention of the Architect in writing.
- All dimensions are in millimetres unless noted otherwise.
- All levels are in metres, unless noted otherwise.

LEGEND

- Proposed Retaining Wall
- (Retaining wall heights shown indicate the retained height. Design of retaining walls to be carried out by a specialist designer.)
- × ???m Existing Spot Level
- × ???m Proposed Spot Level
- E1=???m E1: Top of Wall Elevation
E2=???m E2: Bottom of Wall Elevation
H=???m H: Height of Wall
- Major Contour (0.500m intervals)
- Minor Contours (0.100m intervals)
- Extent of 1 in 3 slope
- Existing Overhead Electricity Pylons

2020 Locations:

- TP Trial Pit Location
- RB Rotary Borehole Location
- WS Window Sample Location
- CP Cable Percussive Location

2019 Locations:

- TP Trial Pit Location
- WS Window Sample Location

P1	24.08.20	MB	Planning Issue	PJB	PJB
REV	DATE	BY	DESCRIPTION	CHK	APD

DRAWING STATUS:	PLANNING
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CLIENT: TRITAX SYMMETRY HUYTON LIMITED

ARCHITECT: UMC ARCHITECTS

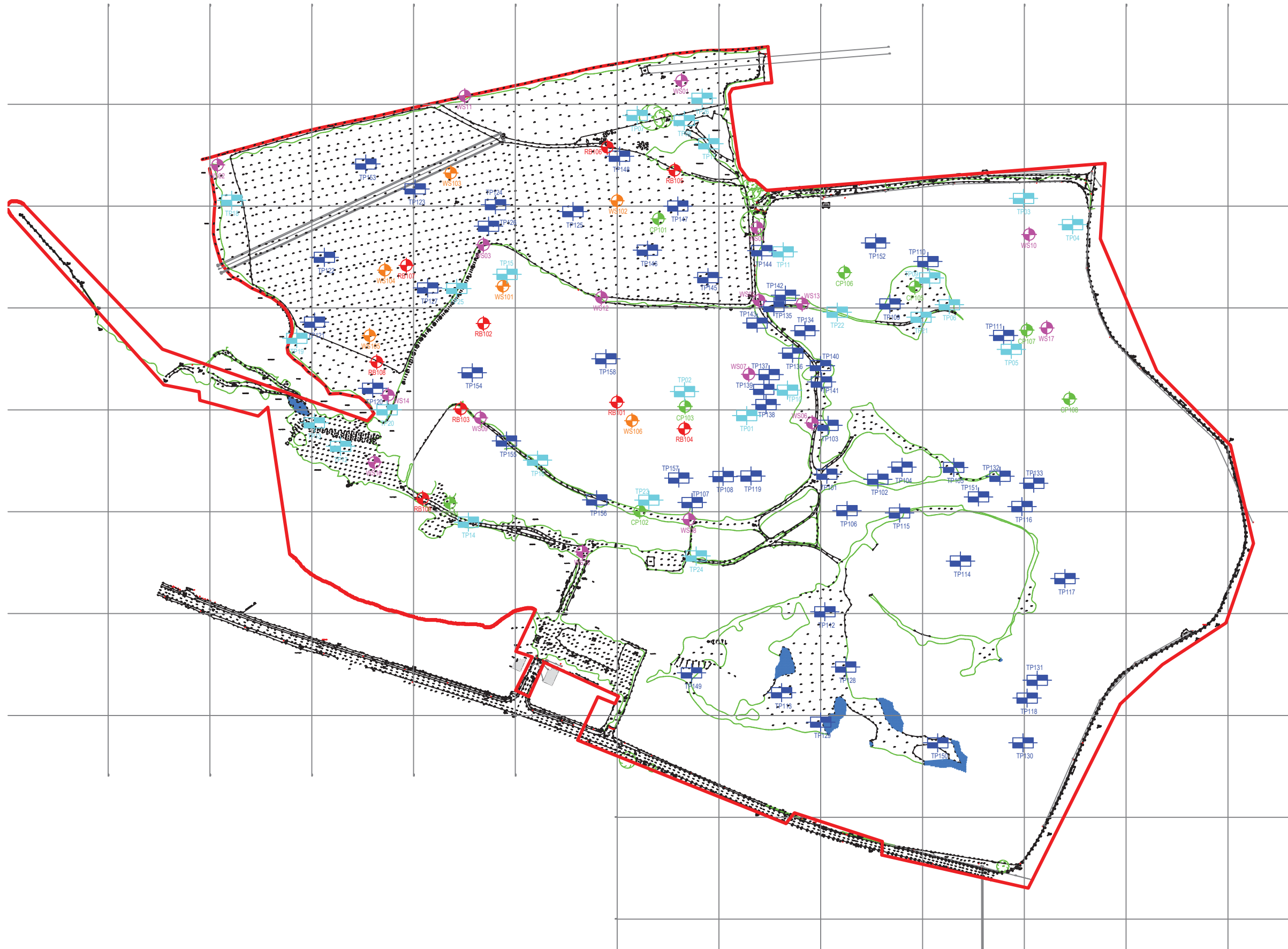
PROJECT: SYMMETRY PARK HUYTON

TITLE: Exploratory Hole Location Plan & Earthworks Proposal

SCALE @ SIZE: 1:1250 CHECKED: P. J. Barlow APPROVED: P. J. Barlow

CAD FILE: CADFILELON DESIGN/DRAWN: MB DATE: 22.10.20

PROJECT No: TE1163 DRAWING No: TE1163GIR3 REV: P1



Notes

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ARCHITECTS, ENGINEERS AND SPECIALISTS DRAWINGS TOGETHER WITH THE APPROPRIATE SPECIFICATIONS.

IT IS THE CONTRACTORS RESPONSIBILITY TO CHECK ALL DIMENSIONS ON SITE. DIMENSIONS MUST NOT BE SCALED FROM THIS DRAWING. ANY DISCREPANCIES TO BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE ARCHITECT IN WRITING.

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

ALL LEVELS ARE IN METRES, UNLESS NOTED OTHERWISE.

2020 Locations:

- Trial Pit Location
- Rotary Borehole Location
- Window Sample Location
- Cable Percussive Location

2019 Locations:

- Trial Pit Location
- Window Sample Location

A	AUG 2020	JR	EHLP	SL
Rev	Date	By	Description	Appd
Revisions				
Status				
FINAL				



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Client

DB SYMMETRY

Architect

NA

Project

Former Cronton Colliery Site (Huyton)

Title

EXPLORATORY HOLE LOCATION PLAN

Scale	Drawn	Revision
NTS	JR	
Date	Checked	A
OCT2020	ap	

Job No.	Drawing No.
TE1163	TE1163EHLP

APPENDIX B - CHEMICAL TEST SAMPLING

Samples were selected by a representative of Tier Environmental during the site investigation works in accordance with the sampling approach described elsewhere in this report.

Samples for chemical analysis

All samples for chemical analysis were placed into clean new containers as summarised in Table 1. Unless explicitly stated elsewhere in this report, no preservatives were used to eliminate the risk that preservatives cause contaminant dissolution or analytical interference. Containers for VOC analysis were fully filled to exclude headspace.

Soil samples were dispensed as soon as possible after collection using reusable stainless steel spatulas, trowels or similar implements.

Ground water samples were collected from boreholes using single-use Teflon bailers or dedicated Waterra tubing with foot valves, except as otherwise noted within this report. Caution was taken to avoid excessive agitation during collection

New disposable gloves were used by the engineer for the collection of each sample.

Reusable equipment was washed down with distilled or deionised water between samples, except where tarry or similarly sticky materials were present. In such cases specific cleaning procedures were adopted as specifically described elsewhere in this report.

All sub-samples taken for chemical analysis were placed into refrigerators or cool boxes containing frozen ice packs immediately after aliquoting. All samples were transferred in cool boxes containing frozen ice packs to the relevant UKAS/MCERTS accredited laboratory as soon as possible. Recommended maximum holding times before analysis are summarised in Table 1.

Table 1. Sample containers and holding times.

Analysis	Container/special requirements	Max. holding time at 4°C before analysis
Soil and sediment samples		
VOCs	30-60 g brown or green glass jar with VOC-resistant cap and inert cap liner. Must be fully filled.	14 days
TPHCWG	30-60 g brown or green glass jar with VOC-resistant cap and inert cap liner PLUS 250-500 g brown or green glass jar with unwaxed cap liner. ¹ The former must be fully filled.	14 days
All other organics	250-500 g brown or green glass jar with unwaxed cap liner.	7 days
Inorganics	Air-tight 0.5-2.0 kg plastic container (250-500 g brown or green glass jar may also be used).	14 days ²
Water samples		
VOCs	40-50 ml glass vial with VOC resistant screw cap and inert liner. Must be fully filled.	14 days
TPHCWG	40-50 ml glass vial with VOC resistant screw cap and inert liner PLUS 500-1000 ml brown or green glass bottle with screw cap and unwaxed liner. ¹ The former must be fully filled, the latter should be filled if possible.	14 days
All other organics	500-1000 ml brown or green glass bottle with screw cap. Fill if possible.	7 days
Inorganics	500-1000 ml translucent or opaque screw cap plastic <i>or</i> brown or green glass bottles. Fill if possible.	14 days ³

¹ The smaller vessel is used for analysis of the volatile components within the TPH mixture and the larger one is for the non-volatile components.

² 14 days is set as a reasonable limit for all routine analyses of soil for those inorganic components vulnerable to chemical and/or biological breakdown. Samples for sulphate analysis are vulnerable to biological sulphate-reduction but can be held for up to 28 days. For total metals, a holding period of up to 6 months is acceptable.

³ 14 days applies for all routine analyses of most inorganic components that may be vulnerable to chemical and/or biological reactions. In the specific cases of sulphide, nitrite, nitrate and phosphate analyses, storage time must not exceed 48 hours. For total metals, a holding time of up to 6 months is acceptable.

Tier Environmental standard analytical suites

The analyses included with Tier Environmental's standard analytical suites for soil, soil leachate and water samples are presented in Table 2. Other individual analyses were specified as described within this report.

Table 2. Tier Environmental Standard Analytical Suites.

Parameter	Sample type					
	Soil		Leachate ¹		Water	
		LoD ² (mg/kg or as stated)		LoD (µg/l or as stated)		LoD (µg/l or as stated)
Metals and metalloids						
Arsenic	✓	1	✓	10	✓	10
Cadmium	✓	1	✓	5	✓	5
Chromium	✓	1	✓	5	✓	5
Mercury	✓	1	✓	1	✓	1
Lead	✓	1	✓	4	✓	4
Selenium	✓	2	✓	10	✓	10
Copper	✓	1	✓	1	✓	1
Nickel	✓	1	✓	50	✓	50
Zinc	✓	1	✓	8	✓	8
Other inorganics						
Ammonia (as NH ₄ -N)					✓	15
Total sulphate	✓	100			✓	50 mg/l
Water-soluble sulphate	✓	0.1 g/l				
Hardness (as CaCO ₃)					✓	1 mg/l
Organics						
Monohydric phenol	✓	1	✓	0.5	✓	0.5
Speciated PAHs (USEPA 16)	✓	0.1	✓	0.01	✓	0.01
Total Organic Carbon	✓	0.1 wt%				
Others						
Electrical conductivity					✓	NA
pH	✓	NA	✓	NA	✓	NA

NA - Not applicable

1 Leachate preparation according to NRA (1994), 10:1 liquid to solid ratio.

2 The table presents the desired limit of detection for the analysis. Higher LoDs may be reported on analytical data sheets due to interference between analytes within specific samples or if the laboratory needed to dilute samples to achieve results within the calibrated range for that instrument.

Analytical QA procedures

Introduction

Quality Assurance (QA) is a system of review and audit that assesses the effectiveness of that product and assures the producer and user that defined standards of quality have been met. If we consider site investigation and chemical analysis, QA is the management system that ensures these measures are in place and working as intended.

QA within the laboratory form part of relevant certification programmes (such as UKAS and MCERTS) and, indeed, will be undertaken in some form by any reputable analyst, whether for a certified technique or not. Laboratory QA/QC is beyond the control of Tier Environmental and will not be considered further in this document, although the relevant laboratory documentation can be obtained upon request. QA must also form part of the design and execution of a site investigation.

Two parameters often used to assess measurement quality objectives are bias and precision. Bias is a systematic deviation in the data. For example, a positive bias (concentrations higher than in reality) would be introduced if sampling bottles were a source of the analyte, and this fact was unknown. Precision is the variation in the measurements around a central 'expected' value. This could be due both to real variability in the environmental medium being measured and random errors in the analytical process. Both precision and bias can be assessed by the use of appropriate blanks and replicates within the site investigation programme.

The objectives of the QA activities undertaken in this present site investigation were to recognise and quantify systematic bias within the analytical dataset and to obtain an indication of precision. In environmental samples, much of the observed variability is likely to result from heterogeneity in the sampled medium, particularly for soil and sediment samples.

Such QA practice within the sampling programme is required by current guidance (e.g., Environment Agency report P5-065/TR (2000); Environment Agency LFTGN02 (2002); BS 10175:2001).

Alternative QA procedures to the generic approach presented in this appendix may be specified for a project, provided case-specific justification is given.

QA checking procedure (data validation)

The responsible Engineer and Project Reviewer are required to undertake data validation and provide comment on data quality within the main body of the report(s) issued, when noteworthy matters arise. This QA checking should involve:

Confirming that data reported by the laboratory have achieved the standards specified by the certification scheme (MCERTS or UKAS). This will be indicated on the analytical certificates issued by the laboratory.

Checking that the limit of detection (LoD) and limit of quantification (LoQ) achieved by the laboratory for an individual analyte is appropriate for the purposes of the report. LoD and LoQ will vary dependent upon analyte concentrations, sample matrix properties and interference from co-contaminants.

A check that the reported range of concentrations are reasonable for the analyte. For example, the dissolved concentration of an analyte in a water sample should not exceed saturation. If it does, then this merits further consideration (e.g., was colloidal organic matter or other solid-phase material present or could there have been unobserved free-phase organic liquid?) and explicit comment. At its simplest, there may be a unit error.

Where analysis involves reporting of Tentatively Identified Compounds (TICs; normally by mass spectrometry), the reviewers should check that these might reasonably be expected at the site under consideration. The uncertainties in identification by MS mean that it is not uncommon that TICs are incorrectly assigned. In cases of doubt, the analytical laboratory can re-check the raw data and confirm.

A review of the analytical precision by comparing data obtained for duplicate samples. There is no absolute threshold - variability is entirely dependent upon the sample matrix and manner in which the contaminant has entered the sample. Variability that cannot reasonably be assigned to such factors (for example a very high apparent variability in data for sediment-free water samples) should be reviewed with the laboratory. Variability that is attributable to the sample matrix can nevertheless provide important pointers to improve understanding of contaminant transport pathways and the risks posed by pollutant linkages (e.g., soil heterogeneity, the association of contamination with particular soil fractions, the presence of residual NAPL within soil pores or the role of suspended sediments in contaminant transport).

Confirmation that no errors have been introduced by data transcription, unit conversion or corrections between preliminary and certificates issued by the laboratory. The reviewer should audit a proportion (typically 5-10%) of all data from the original (final) certificates of analysis through to the equivalent values in the report for those specific samples.

It is important to consult the analytical laboratory if apparent QA issues arise. Many apparent concerns can be adequately resolved on the basis of revisiting the raw analytical data or by obtaining a better understanding of the inherent limitations of the analysis for a particular matrix or sample type.

APPENDIX C - SOBRA CALCULATION SHEETS FOR RISK FROM CUMULATIVE EXPOSURE TO ASBESTOS IN AIR OUTPUT

This workbook has been developed by and is made freely available as a beta version by SoBRA's Asbestos Subgroup. It is part of the current workstream of the group, the aim of which is to advocate the understanding and use of good risk assessment practice when it comes to assessing the potential health risk from exposure to asbestos in soil. SoBRA specifically and gratefully acknowledges the principal author of this spreadsheet - Barry Mitcheson - and the assistance of Andrew Darnton.

The purpose of this workbook is to provide a freely available common approach to calculating the potential mortality risk from exposure to airborne asbestos fibres, based on the epidemiological models published by Hodgson & Darnton in 2000. Importantly the spreadsheet permits the calculation of mortality risk using either the non-linear or linear versions of the H&D model. Whilst the non-linear model has been the one traditionally used to date in the calculation of risk from exposure to asbestos in soil, it has become evident more recently that for lower exposures (compared to the occupational exposures on which the model is based) the linear model is the more appropriate option for calculating the risk from mesothelioma. The accompanying SoBRA discussion paper on the calculation of guidelines for asbestos fibres in ambient air (SoBRA, 2021) provides a comparison of the H&D model options together with risk estimates from other international published models. It is recommended that this paper is read in conjunction with the use of this workbook. There are other published risk models and methods for estimating health risk from exposure to asbestos.

Calculation Sheet for risk from cumulative exposure to asbestos in air

Based on The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure, John T. Hodgson and Andrew Darnton, Ann Occup Hyg (2000) 44 (8): 565-601, and personal communication with Andrew Darnton and should be read in conjunction with SoBRA's Discussion Paper on Guidelines for Airborne Concentrations of Asbestos Fibres in Ambient Air: Implications for Quantitative Risk Assessment (SoBRA, 2021)
© SoBRA, 2021

Default parameters

Asbestos type	Chrysotile
Mesothelioma model	Linear
Lung cancer model	Non-Linear
Lung cancer base risk population	All - population average
Receptor expected lifetime	Lifetime 80 years
Lung cancer age adjustment	Age adjustment based on Latency

Concentration in air

Assumes exposure to constant average asbestos exposure

Chrysotile

Concentration in air f/ml

1.30E-02

Exposure over five year tranches

Age	Concentration in air f/ml	Exposure Days per year	Hours per day	Years (Actual)	Exposure time hrs per year hrs/year	Exposure over each 5 year tranche (Includes adjustment to occupational years (equal to 2000hrs of exposure per year)) f/ml.yr	X - Cumulative exposure in f/ml.yr = Concentration in air x Exposure time hrs per year x Time period / 2000 (hrs in an occupational year) to top of age group
0							
1	0-5	1.30E-02			0.00E+00	0.00E+00	0.00E+00
2	5-10	1.30E-02			0.00E+00	0.00E+00	0.00E+00
3	10-15	1.30E-02			0.00E+00	0.00E+00	0.00E+00
4	15-20	1.30E-02	81	5	8.10E+01	2.63E-03	2.63E-03
5	20-25	1.30E-02	81	5	8.10E+01	2.63E-03	5.27E-03
6	25-30	1.30E-02	81	5	8.10E+01	2.63E-03	7.90E-03
7	30-35	1.30E-02	81	5	8.10E+01	2.63E-03	1.05E-02
8	35-40	1.30E-02	81	5	8.10E+01	2.63E-03	1.32E-02
9	40-45	1.30E-02	81	5	8.10E+01	2.63E-03	1.58E-02
10	45-50	1.30E-02	81	5	8.10E+01	2.63E-03	1.84E-02
11	50-55	1.30E-02	81	5	8.10E+01	2.63E-03	2.11E-02
12	55-60	1.30E-02	81	5	8.10E+01	2.63E-03	2.37E-02

Mesothelioma Risk

$$P_M = A_{pr} X^r + A_{pt} X^t$$

P_M Percent excess mortality from Mesothelioma (in percent)
 A_{pr} Constant of proportionality for Pleural risk
 A_{pt} Constant of proportionality for peritoneal risk
 X Cumulative exposure in f/ml.yr
 r Pleural slope of exposure response (on a log-log scale)
 t Peritoneal slope of exposure response (on a log-log scale)

$$\hat{O}_M = \frac{(A_{pr} X^r + A_{pt} X^t) E_{adj}}{100}$$

O_M the observed meso deaths
 E_{adj} the expected mortality from all causes adjusted to an age at start of exposure of 30.

Risk estimate based on a 30 year old worker exposed for a five year period with cumulative exposure above.
Reference: Developing risk estimates consistent with Table 11 for extended exposures, Hodgson and Darnton 2000

Best Estimate	Chrysotile	Reference
Asbestos type		
A_{pr}	0.001	H&D 2000 Table 1 Mesothelioma risk expressed as percentage total expected mortality per f/ml.yr - Adjusted for age at first exposure.
r_{meso}	1	Linear model
A_{pt}	1E-20	H&D 2000 Table 8 Best estimate slope (r=0.75, t=2.1)
t	2.1	H&D 2000 Table 8 Best estimate slope (r=0.75, t=2.1)
Expected mortality from all causes adjusted to an age at start of exposure of 30	0.7	H&D 2000 p. 584 "Absolute risk estimates can therefore be derived from the PM value for a given exposure by multiplying by a factor of 0.7."

Age	Age adjustment Factor for mesothelioma risk Lifetime 80 years	Reference	P_M (%) *	Risk	Risk age adjusted assuming Lifetime 80 years
0					
1	0-5		0.0E+00	0.0E+00	0.0E+00
2	5-10		0.0E+00	0.0E+00	0.0E+00
3	10-15		0.0E+00	0.0E+00	0.0E+00
4	15-20		2.6E-06	1.8E-08	5.5E-08
5	20-25		2.6E-06	1.8E-08	3.9E-08
6	25-30		2.6E-06	1.8E-08	2.8E-08
7	30-35		2.6E-06	1.8E-08	1.8E-08
8	35-40		2.6E-06	1.8E-08	1.1E-08
9	40-45		2.6E-06	1.8E-08	7.4E-09
10	45-50		2.6E-06	1.8E-08	5.5E-09
11	50-55		2.6E-06	1.8E-08	3.7E-09
12	55-60		2.6E-06	1.8E-08	1.8E-09

* To get the contribution to the risk for the second period alone the risk due to the cumulative dose from the first period is subtracted... and so on.
Developing risk estimates consistent with Table 11 for extended periods, Hodgson and Darnton 2000

Cumulative risk	Chrysotile	Lifetime 80 years
		1.7E-07

Lung Cancer

$$P_L = A_L X^r$$

P_L Percentage excess of expected lung cancer mortality
 A_L Constant of proportionality for lung cancer risk
 r Lung cancer slope of exposure response (on a log-log scale)
 X Cumulative exposure in f/ml.yr

$$\text{Predicted excess risk} = O_L - E_L = \frac{A_L X^r E_L}{100}$$

E_L Proportion of the specific population that will die of lung cancer between age 40-79

Risk estimate based on a 30 year old worker exposed for a five year period with cumulative exposure above.
 Reference: Developing risk estimates consistent with Table 11 for extended exposures, Hodgson and Darnton 2000

Best Estimate	Chrysotile	Reference
A_L	0.028	H&D 2000 Table 10 Best (p=1.3)
r_{lung}	1.3	H&D 2000 Table 10 Best (p=1.3)
Proportion of the specific population that will die of lung cancer between age 40-79	0.033	Based on Average 2016-2018 populations statistics

Age	Age adjustment	Age adjustment reference	P_L (%)	Risk (age adjusted)
0-5	1	Developing risk estimates consistent with Table 11 for extended exposures, Hodgson and Darnton 2000	0.0E+00	0.0E+00
5-10	1		0.0E+00	0.0E+00
10-15	1		0.0E+00	0.0E+00
15-20	1		1.2E-05	4.1E-09
20-25	1		1.8E-05	5.9E-09
25-30	1		2.1E-05	6.9E-09
30-35	1		2.3E-05	7.7E-09
35-40	1		2.5E-05	8.3E-09
40-45	1		2.7E-05	8.8E-09
45-50	0.75		2.8E-05	6.9E-09
50-55	0.5		3.0E-05	4.8E-09
55-60	0.25		3.1E-05	2.5E-09

Cumulative risk	Chrysotile	5.6E-08
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Cumulative lifetime Risk Estimate

Asbestos type	Chrysotile		
Risk from Mesothelioma	Lifetime 80 years	Linear	1.7E-07
Risk from Lung Cancer	All - population average	Non-Linear	5.6E-08
TOTAL			2.3E-07

Limitations

This spreadsheet is offered as a free available resource by SoBRA to improve the consistency in, and adoption of, the use of the Hodgson and Darnton algorithms for estimating lifetime cancer risk for low level environmental exposures to airborne asbestos fibres. It has been developed by members of the SoBRA Asbestos-in-soil sub-group acting in a voluntary capacity, and constitutes the work of the individual authors, not those of their employers. Users of this spreadsheet must satisfy themselves that the content is appropriate for the intended use and no guarantee of suitability is made.

Feedback on this spreadsheet is welcome and should be sent to info@sobra.org.uk

Calculation Sheet for risk from cumulative exposure to asbestos in air

Based on The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure, John T. Hodgson and Andrew Darnton, Ann Occup Hyg (2000) 44 (8): 565-601, and personal communication with Andrew Darnton and should be read in conjunction with SoBRA's Discussion Paper on Guidelines for Airborne Concentrations of Asbestos Fibres in Ambient Air: Implications for Quantitative Risk Assessment (SoBRA, 2021)
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Default parameters

Asbestos type	Chrysotile
Mesothelioma model	Linear
Lung cancer model	Non-Linear
Lung cancer base risk population	All - population average
Receptor expected lifetime	Lifetime 80 years
Lung cancer age adjustment	Age adjustment based on Latency

Concentration in air

Assumes exposure to constant average asbestos exposure

Chrysotile

Concentration in air f/ml

1.30E-02

Exposure over five year tranches

Age	Concentration in air f/ml	Exposure Days per year	Hours per day	Years (Actual)	Exposure time hrs per year hrs/year	Exposure over each 5 year tranche (Includes adjustment to occupational years (equal to 2000hrs of exposure per year)) f/ml.yr	X - Cumulative exposure in f/ml.yr =Concentration in air x Exposure time hrs per year x Time period /2000 (hrs in an occupational year) to top of age group
0							
1	0-5	1.30E-02	81	2	5	1.62E+02	5.27E-03
2	5-10	1.30E-02	81	2	5	1.62E+02	5.27E-03
3	10-15	1.30E-02	81	2	5	1.62E+02	5.27E-03
4	15-20	1.30E-02	81	2	5	1.62E+02	5.27E-03
5	20-25	1.30E-02	81	2	5	1.62E+02	5.27E-03
6	25-30	1.30E-02	81	2	5	1.62E+02	5.27E-03
7	30-35	1.30E-02	81	2	5	1.62E+02	5.27E-03
8	35-40	1.30E-02	81	2	5	1.62E+02	5.27E-03
9	40-45	1.30E-02	81	2	5	1.62E+02	5.27E-03
10	45-50	1.30E-02	81	2	5	1.62E+02	5.27E-03
11	50-55	1.30E-02	81	2	5	1.62E+02	5.27E-03
12	55-60	1.30E-02	81	2	5	1.62E+02	5.27E-03

Mesothelioma Risk

$$P_M = A_{pr} X^r + A_{pt} X^t$$

P_M Percent excess mortality from Mesothelioma (in percent)

A_{pr} Constant of proportionality for Pleural risk

A_{pt} Constant of proportionality for peritoneal risk

X Cumulative exposure in f/ml.yr

r Pleural slope of exposure response (on a log-log scale)

t Peritoneal slope of exposure response (on a log-log scale)

$$\hat{O}_M = \frac{(A_{pr} X^r + A_{pt} X^t) E_{adj}}{100}$$

O_M the observed meso deaths

E_{adj} the expected mortality from all causes adjusted to an age at start of exposure of 30.

Risk estimate based on a 30 year old worker exposed for a five year period with cumulative exposure above.
Reference: Developing risk estimates consistent with Table 11 for extended exposures, Hodgson and Darnton 2000

Best Estimate	Chrysotile	Reference
Asbestos type		
A_{pr}	0.001	H&D 2000 Table 1 Mesothelioma risk expressed as percentage total expected mortality per f/ml.yr - Adjusted for age at first exposure.
r_{meso}	1	Linear model
A_{pt}	1E-20	H&D 2000 Table 8 Best estimate slope (r=0.75, t=2.1)
t	2.1	H&D 2000 Table 8 Best estimate slope (r=0.75, t=2.1)
Expected mortality from all causes adjusted to an age at start of exposure of 30	0.7	H&D 2000 p. 584 "Absolute risk estimates can therefore be derived from the PM value for a given exposure by multiplying by a factor of 0.7."

Age	Age adjustment Factor for mesothelioma risk Lifetime 80 years	Reference	P_M (%)*	Risk	Risk age adjusted assuming Lifetime 80 years
0					
1	0-5		5.3E-06	3.7E-08	2.6E-07
2	5-10		5.3E-06	3.7E-08	2.0E-07
3	10-15		5.3E-06	3.7E-08	1.5E-07
4	15-20		5.3E-06	3.7E-08	1.1E-07
5	20-25		5.3E-06	3.7E-08	7.7E-08
6	25-30		5.3E-06	3.7E-08	5.5E-08
7	30-35		5.3E-06	3.7E-08	3.7E-08
8	35-40		5.3E-06	3.7E-08	2.2E-08
9	40-45		5.3E-06	3.7E-08	1.5E-08
10	45-50		5.3E-06	3.7E-08	1.1E-08
11	50-55		5.3E-06	3.7E-08	7.4E-09
12	55-60		5.3E-06	3.7E-08	3.7E-09

* To get the contribution to the risk for the second period alone the risk due to the cumulative dose from the first period is subtracted... and so on.
Developing risk estimates consistent with Table 11 for extended periods, Hodgson and Darnton 2000

Cumulative risk	Chrysotile	Lifetime 80 years
		9.4E-07

Lung Cancer

$$P_L = A_L X^r$$

P_L Percentage excess of expected lung cancer mortality
 A_L Constant of proportionality for lung cancer risk
 r Lung cancer slope of exposure response (on a log-log scale)
 X Cumulative exposure in f/ml.yr

$$\text{Predicted excess risk} = O_L - E_L = \frac{A_L X^r E_L}{100}$$

E_L Proportion of the specific population that will die of lung cancer between age 40-79

Risk estimate based on a 30 year old worker exposed for a five year period with cumulative exposure above.
 Reference: Developing risk estimates consistent with Table 11 for extended exposures, Hodgson and Darnton 2000

Best Estimate	Chrysotile	Reference
A_L	0.028	H&D 2000 Table 10 Best (r=1.3)
r_{lung}	1.3	H&D 2000 Table 10 Best (r=1.3)
Proportion of the specific population that will die of lung cancer between age 40-79	0.033	Based on Average 2016-2018 populations statistics

Age	Age adjustment	Age adjustment reference	P_L (%)	Risk (age adjusted)
0-5	1	Developing risk estimates consistent with Table 11 for extended exposures, Hodgson and Darnton 2000	3.1E-05	1.0E-08
5-10	1		4.5E-05	1.5E-08
10-15	1		5.2E-05	1.7E-08
15-20	1		5.8E-05	1.9E-08
20-25	1		6.2E-05	2.0E-08
25-30	1		6.6E-05	2.2E-08
30-35	1		7.0E-05	2.3E-08
35-40	1		7.3E-05	2.4E-08
40-45	1		7.5E-05	2.5E-08
45-50	0.75		7.8E-05	1.9E-08
50-55	0.5		8.0E-05	1.3E-08
55-60	0.25		8.3E-05	6.8E-09

Cumulative risk	Chrysotile	2.1E-07
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Cumulative lifetime Risk Estimate

Asbestos type	Chrysotile		
Risk from Mesothelioma	Lifetime 80 years	Linear	9.4E-07
Risk from Lung Cancer	All - population average	Non-Linear	2.1E-07
TOTAL			1.2E-06

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This spreadsheet is offered as a free available resource by SoBRA to improve the consistency in, and adoption of, the use of the Hodgson and Darnton algorithms for estimating lifetime cancer risk for low level environmental exposures to airborne asbestos fibres. It has been developed by members of the SoBRA Asbestos-in-soil sub-group acting in a voluntary capacity, and constitutes the work of the individual authors, not those of their employers. Users of this spreadsheet must satisfy themselves that the content is appropriate for the intended use and no guarantee of suitability is made.

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