REMEDIAL OPTIONS APPRAISAL, REMEDIATION STRATEGY AND VERIFICATION PLAN FOR PHASE 2A AREA, STOCKPORT INTERCHANGE

ISSUE 1.0

TE1438ROARS

21 DECEMBER 2020

FINAL

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DOCUMENT CONTROL

Project No. :	TE1438ROARS
Report Status:	FINAL
Issue No.:	1.0
Project Engineer:	Adrian Read
Date of Issue:	21/12/2020

Issue No.	Description of Issue / Revision	Date of Issue	Reviewed By	Author
1.0	FINAL	21/12/2020	SL	AR

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1. INTRODUCTION

Tier Environmental was commissioned by Willmott Dixon Construction Ltd to undertake a Remedial Options Appraisal and Remediation Strategy report for the Phase 2A Area of the Stockport Interchange (the "Site") located in a mixed commercial, industrial and residential setting of Stockport Town Centre near post code SK3 0EH.

It is understood the wider development will comprise:

- A new covered bus interchange (referred to as the 'Interchange'), to include a northern and southern concourse building and operator accommodation (permanent driver accommodation and facilities);
- A multi-storey residential block of approximately 196 residential units referred to as the 'Residential Block';
- External green areas and a hard-landscaped public park;
- Commercial units / offices on Exchange Street comprise of three office blocks;
- Construction of a pedestrian link bridge from the Interchange to the rail station;
- Swaine Street – consolidated arrangement which narrows the overall corridor;
- The external area of Heaton Lane Car Park is proposed to be used as a temporary bus station while the existing bus station is cleared and constructed (this area is not being considered by Tier Environmental within these fees); and
- Pedestrian / cycle routes via the proposed primary / secondary roads which will connect with the wider network.

For the avoidance of doubt, the report pertains solely to the following Phase 2A site boundary shown below:

Figure 1.1. Phase 2A Site Boundary

The Site has a history of previous ground investigations either on, or within close proximity to the site boundary shown in blue above. These reports are listed in full later in this report along with a summary of whether the information contained there in is relevant to informing this Remediation Strategy and Verification Plan and / or includes information that falls within the subject site boundary as shown below.

1.1. Objectives of the Report

On the basis of the above, the objectives of this report are to:

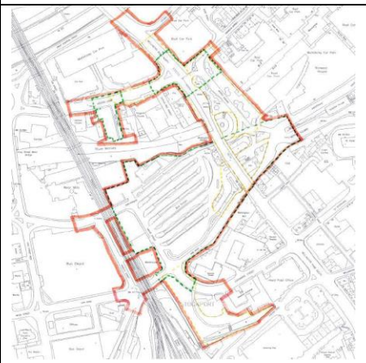
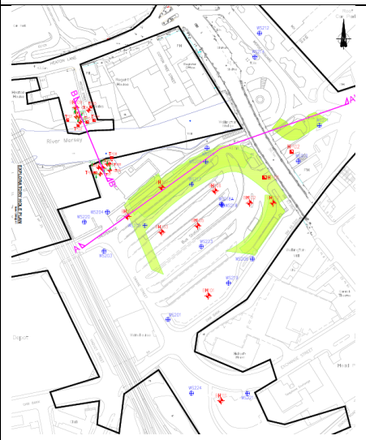
- To assess and summarise the relevance of previous ground investigation and ohe rtechnical reports pertaining to land either on or within the vicinity of the Site;
- To summarise the conclusions of each report with respect to human health and controlled waters risk assessment
- To produce (on the basis of the reviewed information) a Conceptual Site Model;
- Undertake a Remediation Options Appraisal to address any identified risks;
- Produce an on-site Remediation Strategy and Verification Plan on the basis of the selected viable approaches determined during the Remedial Options Appraisal.

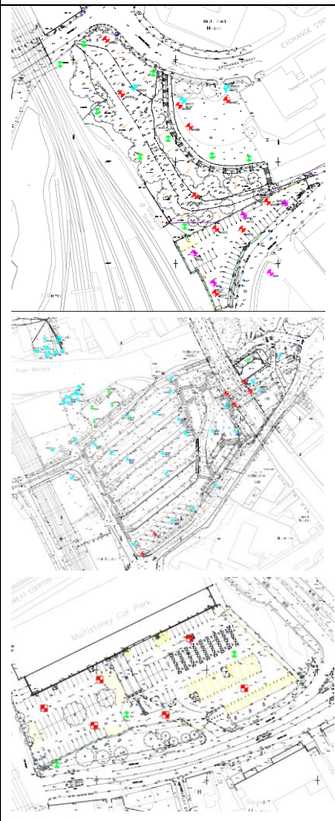
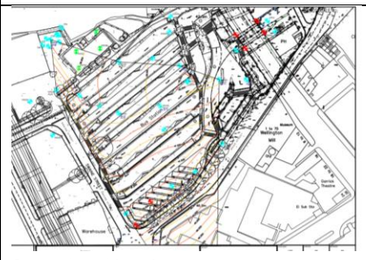
This report, which was designed to meet the requirements of all relevant current guidance including 'Land contamination: risk management' (LC:RM) (which supersedes CLR11) presents the factual information available during this appraisal, interpretation of the data obtained and recommendations relevant to the defined objectives.

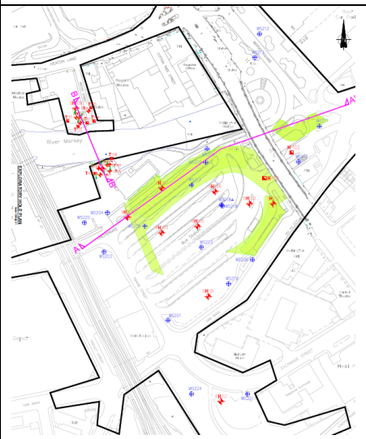
2. PREVIOUS INVESTIGATIONS SUMMARY

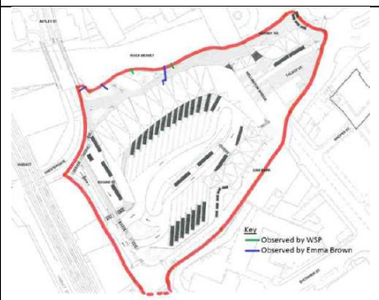
A number of technical investigation reports have been previously conducted at the Site which have been submitted alongside this report and direct reference should be made to these reports for further information. A summary and assessment of their content and relevance to inform this Remediation Strategy and Verification Plan has been conducted in the table below.

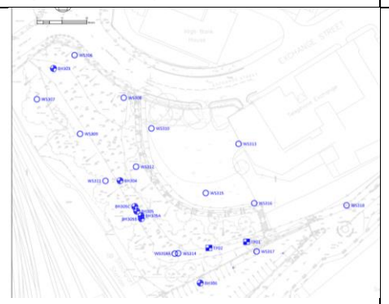
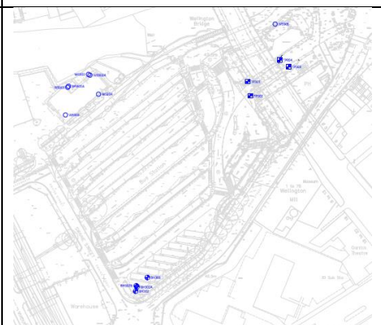
Table 2.1. Summary of Previous Investigations

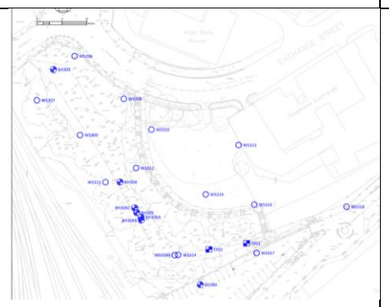
Date of Report	Company	Report Title and Reference	Location of Investigation Relative to Subject Site	Conclusions with Respect to Human Health Risks	Conclusions with Respect to Controlled Waters Risk
13th May 2015	AECOM	Phase 1 Geotechnical and Geoenvironmental Desk Study Report (report reference GEO/01)	 Site area and land to the north and south of the subject site area.	Based on a review of historical maps the site has had a range of industrial land uses both on site and within the surrounding area. The potential risks that have been identified have been assessed by a preliminary risk assessment, which identifies the majority of the risks as being moderate risk. It is considered likely that contaminants persist within the soils and shallow groundwater onsite as a result of historical and recent activities both on and off site. Ground gas may also be present associated with the historic land use including likely Made Ground. The presence of potential contamination and ground gas could pose a risk to human health, controlled waters and proposed buildings and services.	
February 2016	AECOM	Stockport Interchange -Ground Investigation Report (report reference: 60340298/GEO/02)	 Site area and land to the north and south of the subject site area.	**<u>Soils</u>** It was considered that future site users will generally not be exposed to levels of contaminants considered to pose a risk to human health. Construction and maintenance workers could encounter unidentified isolated areas of potentially impacted ground during the proposed development works. It was recommended that landscaped areas on Made Ground should be covered in an appropriate geo membrane and at least 600mm of clean topsoil to break any contaminant linkage. **<u>Ground Gases</u>** Elevated concentrations of ground gases have been recorded. The recorded levels are above published HSE Workplace Exposure Limits and indicated that the site is representative of a Characteristic Situation 2 scenario.	Elevated concentrations above the chosen Screening Values were detected in both leachate testing and groundwater samples taken during the ground investigation. The risk to controlled waters from surface run-off and direct percolation is expected to occur primarily during the development phase. Recommendations included: • Measures should be employed during construction to limit surface water run/off and percolation such as minimising soil exposure and covering of soil stockpiles. • Any water removed during excavation works should be tested and disposed of appropriately.
May 2018	WSP	Environmental Screening Report (report reference: 14113-WSP-SKZ-ZZ-RP-Y-0040)	 Site area and land to the north and south of the subject site area.	Previous investigation works conducted by AECOM in 2016 that identified potentially complete contaminant linkages that required mitigation to protect the health of future site users, primarily associated with the presence of polycyclic aromatic hydrocarbons and asbestos in the Made Ground. Additionally, the ground gas risk assessment produced by AECOM stated gas protection measures were required to be implemented. Widespread gross contamination is not anticipated to be present beneath Exchange Street area of the Main Site but there is potential for localised soil and / or groundwater contamination associated with current use as a car park utilising Made Ground and previous land uses including infilled reservoirs, former buildings and previous use of parts of the Site as a Dye House. Therefore it is considered that there is low to moderate potential for soil and groundwater contamination at the Site.	The reported dissolved phase concentrations were considered to present moderate / low risks to controlled waters (AECOM, 2016). The presence of granular drift deposits has the potential to enable the migration of mobile contamination of the upper superficial deposits easily and potentially into the underlying bedrock. There is the potential for contamination within the ground/ groundwater to be mobilised by piling process into the underlying Principal Aquifer, depending on the technique selected.

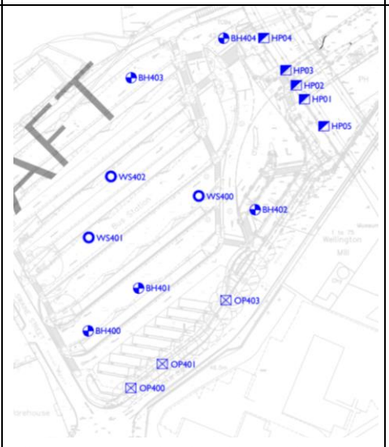
<table>
<tr><th>Date of Report</th><th>Company</th><th>Report Title and Reference</th><th>Location of Investigation Relative to Subject Site</th><th>Conclusions with Respect to Human Health Risks</th><th>Conclusions with Respect to Controlled Waters Risk</th></tr>
<tr><td>26th July 2018</td><td>WSP</td><td>Stockport Interchange Site Investigation Brief report reference: WSP-SKZ-ZZ-RP-Y-0057)</td><td> 
Subject Site and land to the north and south.</td><td colspan="2">This document presents a proposed scope of additional site investigation and provides little additional information with respect to human health or controlled waters risk; however a brief summary of the ground conditions previously identified beneath Stockport Interchange area is reproduced below:
The previous ground investigation encountered superficial deposits comprising cohesive and granular Made Ground, Glacial Clay, and Glacial Sands and Gravels to a maximum depth of 5m BGL. Underlying the superficial deposits bedrock comprised Sherwood Sandstone.
Surfacing across the majority of the site comprised hardstanding (concrete and tarmac) with small landscaped areas.
Asbestos has been previously identified within Made Ground. As such, precautions will need to be taken to minimise the risk to ground workers through appropriate health and safety risk assessment processes and appropriate personal protective equipment.</td></tr>
<tr><td>October 2018</td><td>WSP</td><td>Preliminary Interpretative Geotechnical Report (report reference: 14113-WSP-SKZ-XX-RP-G-0004)</td><td> 
Covers the subject site area</td><td colspan="2">Purely a geotechnical report; however, it does include a useful summary of ground conditions as reproduced below:
Table 2 – Ground Summary
<table>
<tr><th>Strata</th><th>Depth to Base</th><th>Elevation of Base (mAOD)*</th><th>Thickness (m)</th><th>Comments</th></tr>
<tr><td>Concrete / Asphalt / Brick Sets</td><td>0.1 – 0.5</td><td>41.85 – 47.93</td><td>0.1 – 0.5</td><td>Absent from WS201 and WS210</td></tr>
<tr><td>Subbase</td><td>0.7 – 1.2</td><td>41.1 – 44.22</td><td>0.3 – 1.1</td><td></td></tr>
<tr><td>Granular Made Ground</td><td>0.8 – 2.6</td><td>41.05 – 45.79</td><td>0.55 – 2.60</td><td></td></tr>
<tr><td>Cohesive Made Ground</td><td>1.6 – 2.0</td><td>42.10 – 43.61</td><td>0.6 – 1.2</td><td>Only recorded in BH112 and WS201</td></tr>
<tr><td>Relict Topsoil</td><td>2</td><td>41.70</td><td>0.4</td><td>Only recorded in BH112</td></tr>
<tr><td>Glacial Sand & Gravel</td><td>1.6 – >5.09</td><td>38.77 – 43.62</td><td>0.6 – 3.0</td><td>Recorded in every exploratory position that penetrated the Made Ground. Bands of firm clay, between 0.4m and 1.5m thick, recorded in BH101, WS201, and WS208</td></tr>
<tr><td>Weathered Chester Formation Sandstone</td><td>>2.86 – 5.65</td><td>36.82 – <41.34</td><td>>0.41 – 1.95</td><td></td></tr>
<tr><td>Intact Chester Formation Sandstone</td><td>7.5 – 15.3</td><td>27.41 – 34.77</td><td>>11.6</td><td>BH107 encountered a between 7.5m – 9.1m BGL.</td></tr>
</table>
*metres above Ordnance Datum</td></tr>
</table>

Date of Report	Company	Report Title and Reference	Location of Investigation Relative to Subject Site	Conclusions with Respect to Human Health Risks	Conclusions with Respect to Controlled Waters Risk
October 2018	WSP	Contaminated Land Assessment (report reference: 14113-WSP-SKZ-XX-RP-Y-0002)	 Report considered the AECOM 2016 data - Site area and land to the north and south of the subject site area.	A number of potentially contaminating activities that might have impacted on the quality of the soils and groundwater on site have been conducted on and surrounding the site, namely mills, print works and timber yards. The current site use as a bus station is considered to present a potential source of contamination due to potential for spill and leaks; no fuel storage tanks are known to be present on site. Additionally, the presence of imported Made Ground associated with filling and construction activities is considered to be a potential source of contamination. The potential contaminants of concern associated with the historical and current activities on and in the vicinity of the site are considered to include petroleum hydrocarbons, chlorinated hydrocarbons, phenols, polycyclic aromatic hydrocarbons (PAHs), metals, polychlorinated biphenyls (PCBs) and asbestos	
				The review of the AECOM 2016 GIR findings indicated the following: • Concentrations of polycyclic aromatic hydrocarbons in soil were reported in exceedance of the adopted screening criteria (commercial end use). • Trace concentrations of a number of volatile organic compounds were identified. The AECOM GIR adopted the limit of detection as screening value. As part of this assessment, the detected concentrations were compared against the WSP derived generic assessment criteria (GAC) - the reported concentrations were below the GAC for commercial use. • Asbestos was identified in Made Ground at a number of locations, at concentrations below the limit of detection (<0.001%). The presence of asbestos and hydrocarbon contamination in soils are considered to present a potential health risk to future site users if no mitigation measures are put in place. No soil assessment was undertaken in the northern portion of the site where the landscaped area at the banks of River Mersey is proposed to be developed. Given the site history review, this area was occupied by potentially contaminating activities (print works in 1872 and chemical works in 1897) and so the lack of soil/groundwater assessment in this area is considered to present an uncertainty in the risk assessment Remediation measures considered: • The provision of a 600mm thick capping layer of clean soil over a geotextile membrane in landscaped areas in the interchange level to mitigate direct contact exposures and atmospheric dispersion of asbestos. The areas that require the provision of a cover system will be defined in the remediation strategy. • The above excludes potential mitigation/remedial measures in the northern portion of the site that has not previously been assessed.	The report includes a useful summary of the controlled waters sensitivity: The Chester Pebble Beds Formation is classified as a Principal Aquifer. The Glacial Fluvial Deposits are classed as a Secondary A Aquifer whilst the Glacial Till is classed as an Unproductive Strata. The site is not located within a Groundwater Source Protection Zone. The nearest surface water body is the River Mersey which runs along the northern site boundary. The reported dissolved phase concentrations were considered to present moderate/low risks to controlled waters.
				During the 2016 AECOM ground investigation, a total of 24 monitoring wells were monitored 3 times over a 4 week period. The AECOM GIR 2016 classified the site as Characteristic Situation 2 (CIRIA C6651) with gas protection measures required to be implemented based on dioxide carbon concentrations identified in four wells during one monitoring round each. It is noted the response zones in these four wells were within natural strata (medium dense sand or weathered sandstone), with organic matter content of 1.6% on average. The highest dioxide carbon concentration (19.4%) was recorded in one well located in the bus station (WS217), where traffic is considered to be dense. Given the potential for ground gas generation at this location is low, it is considered possible that the recorded concentration might not be representative of the ground gas regime on site. No methane concentrations were reported above the limit of detection in any of the wells. WSP recommended that an appropriate classification of risk for the development with respect to ground gas is Characteristic Situation 1 i.e. no special ground gas precautions are required: The observations to support this professional judgement are: • The proposed development is considered to be of low sensitivity (parts of the development are not directly on the ground); • Ground gas generation potential of the site is low (sources are restricted to natural soils and Made Ground); • Concentrations of carbon dioxide in the ground that exceed the 5% threshold are sporadic and in installations within natural, non-organic soil/rock.	

Date of Report	Company	Report Title and Reference	Location of Investigation Relative to Subject Site	Conclusions with Respect to Human Health Risks	Conclusions with Respect to Controlled Waters Risk
2nd October 2018	WSP	Ground gas risk assessment (report reference: 70031899-11057)	 Site area and land to the north and south of the subject site area.	This report included a review of the AECOM 2016 data and WSP undertook two further ground gas monitoring visits at the site, in April 2018 and September 2018. This improves the overall dataset to 5 occasions to comply with the frequency in CIRIA C665 specified for sites likely to have very low gas generation potential and a low sensitivity development (commercial). Using the highest gas concentration recorded during the additional two ground gas monitoring events and a maximum flow rate recorded in boreholes, the GSV is as follows: • Carbon dioxide – (4.8/100 x 0.1) = 0.0048l/h Based on the two ground gas monitoring rounds conducted by WSP, the GSV indicates the site is characterised as CS1 (very low risk), with no ground gas protection measures required. Based on WSP's review of the extended ground gas monitoring dataset and the ground model, it is recommended that an appropriate classification of risk for the development with respect to ground gas is Characteristic Situation 1 i.e. no special ground gas precautions are required. The observations to support this professional judgement are: • The proposed development is considered to be of low sensitivity (parts of the development are not directly on the ground); • Ground gas generation potential of the site is low (sources are restricted to natural soils and Made Ground); and, • Concentrations of carbon dioxide in the ground that exceed the 5% threshold are sporadic and in installations within natural, non-organic soil/rock.	N/A.
10th October 2018	WSP	Stockport Interchange – Tunnel Investigations memo (report reference: 14113-WSP-XX-XX-CO-Y-0050)	 Northern area of the subject Site.	These reports do not include any human health or controlled waters risk assessment information. The letter does confirm the presence of seven potential tunnel portals (named Portals A to G) identified along the bank of the River Mersey. Further investigation to confirm the route and the presence / absence of bats was recommended.	
October 2018	WSP	Tunnel Assessment (report reference: 14113-WSP-SKX-XX-RP-G-0006)			
February 2019	WSP	Mersey Bank Survey Report (report reference: 14113-WSP-SKZ-XX-RP-G-0005)	 Covers the subject Site area	This report does not include any human health or controlled waters risk assessment information. The principal geotechnical risks posed to the proposed redevelopment by the presence of tunnels beneath the site were considered to be; • potential collapse of the tunnels affecting future foundations or external paved areas; • the potential for piles (the most likely foundations solution) to penetrate tunnels during their formation; and, • the risk of piles, which will likely gain most of their capacity in end bearing, terminating very close to the crown of a tunnel, possibly leading to over stressing of the ground and leading to significant deformation / collapse. Further works recommended included forming a series of boreholes across the likely projection of each tunnel and using a Cavity Auto Laser Scanning System to investigate the orientation and condition of the tunnels.	

Date of Report	Company	Report Title and Reference	Location of Investigation Relative to Subject Site	Conclusions with Respect to Human Health Risks	Conclusions with Respect to Controlled Waters Risk
February 2020	Geotechnics	Stockport Interchange Ground Investigation Factual Report (report reference: PN194052)	 Localised supplementary investigations in the areas shown in blue above. All located within the subject site boundary.	The report solely presents the factual information obtained from the ground investigation works. It does not include any interpretation of the data.	
February 2020	Geotechnics	Exchange Square, Stockport Ground Investigation Factual Report (report reference: PN194054)	 Localised supplementary investigations in the areas shown in blue above. All located within the Exchange Square parcel of land located off-site to the south of the Site.	The report solely presents the factual information obtained from the ground investigation works. It does not include any interpretation of the data.	
March 2020	WSP	Stockport Interchange, Bus Interchange Phase II Geo-Environmental Site Investigation Report (report reference: 14113-WSP-SKZ-XX-RP-Y-0005	 Localised supplementary investigations in the areas shown in blue above. All located within the subject site boundary.	The proposed landscaped area comprised Made Ground (dark greyish brown gravelly sand, gravel of sandstone, limestone, concrete and brick, locally containing ash) to a maximum unproved depth of 4.07m bgl. Elevated concentrations of benzo(a)pyrene were recorded in two locations in exceedance of the adopted GAC protective of human health for a public open space (park) land use scenario. No asbestos or asbestos containing material was identified during the current phase, however the presence of asbestos in Made Ground across the site cannot be discounted based on investigations in other parts of the site. The ground gas risk assessment classifies the site as Characteristic Situation 1 – very low risk. Excavated material as part of the A6 Wellington Bridge works would likely be suitable for re-use within the development as construction fill material (i.e. covered by buildings / hardstanding). Additional validation sampling will be required to confirm suitability. Recommendations included: • In landscaped areas on Made Ground, implementation of a 300mm cover layer of clean soils over a geotextile should be installed to protect the health of future users. • During redevelopment, precautions should be taken to reduce the risk of exposure to the identified contamination through appropriate health and safety mitigation measures, such as adequate personal protective equipment, dampening down for dust suppression and other standard safe practices for construction and maintenance workers. • Measures should be employed to limit surface water runoff such as minimising soil exposure and covering soil stockpiles.	Based on the preliminary CSM sieved by WSP, the controlled waters receptors include shallow perched water within the Made Ground / drift deposits, the underlying principal aquifer and the River Mersey. All the five monitoring wells installed as part of this investigation were dry during the monitoring rounds undertaken in January and February 2020. The reported soil concentrations were generally low and no gross contamination was identified in the Made Ground within the areas assessed. On this basis, potential infiltration of contaminants of concern from the area of investigation to the underlying Principal Aquifer is considered to be minimal However, given the former industrial use of the site, the presence of residual mobile or leachable contamination on site cannot be discounted. It is noted dissolved concentrations of TPH have previously been detected in the Principal Aquifer in the wider Stockport Development area (AECOM, 2016). Based on the above and given the site is not located within a Source Protection Zone or within the vicinity of a potable groundwater extraction well, the risk to controlled waters is considered to be low.

Date of Report	Company	Report Title and Reference	Location of Investigation Relative to Subject Site	Conclusions with Respect to Human Health Risks	Conclusions with Respect to Controlled Waters Risk
				• In the event any previously unidentified contamination is encountered during earthworks, advice from a qualified geo-environmental consultant should be sought; • In the event ACM are encountered during enabling works for the proposed development professional advice should be sought from a qualified asbestos consultant; an Asbestos Management Plan may be required to assist in ensuring the protection of the health of ground workers. • The re-use of materials within the proposed development (e.g. excavated soils, crushed demolition materials etc.) will require demonstration of suitability for use and certainty of use, preferably through a Materials Management Plan (MMP) compliant with the CL:AIRE Definition of Waste Code of Practice. • Excess soils generated by the redevelopment and intended for off-site disposal will require an appropriate waste classification. • Should more sensitive end-uses be considered for the site in the future a re-assessment of the site conditions would be required.	
April 2020	WSP	Exchange Street, Stockport Ground Investigation Report (report reference: 14113-WSP-SKZ-XX-RP-Y-0004)	 Localised supplementary investigations in the areas shown in blue above. All located within the Exchange Square parcel of land located off-site to the south of the Site.	The information contained within this report pertained to geotechnical and ground condition information. Reference is made to contamination issues as follows: *"For a discussion of contamination and ground gas issues, reference should be made to* • *WSP. 2020. 'Exchange Street – Phase II Contaminated Land Assessment', Report ref. 14113- WSP-SKZ-XX-RP-Y-0005"* Tier Environmental have not received a copy of this report for review; however, it covers land that is not located within the subject site boundary.	
9th October 2020	Ramboll	Supplementary Ground investigation Summary (letter reference: 14113-RAM-SKZ-ZZ-TN-Y3-00002)	  All investigations within the subject site boundary.	This additional ground investigation was required for the following reasons: 1. Validate the shallow foundation solution proposed by WSP as part of the Stage 3 Design for the residential tower a. Confirm depth to rock head on the north elevation of tower b. Assess shallow rock characteristics to confirm WSP assumptions 2. Assess depth to rockhead on the northern elevation of the bus terminal 3. Investigate the Daw Bank Retaining Wall (DBRW) foundation 4. Investigate foundations for the A6 viaduct 5. Additional contamination assessment Preliminary screening of the soil data received to date is summarised below: • Metal concentrations are recorded above the limit of detection (LOD), however the concentrations are likely to be insufficiently elevated to pose a significant human health risk; Cyanide recorded below the LOD across the site; • Polyaromatic hydrocarbons (PAHs) are recorded either below the LOD, or at low concentrations across the site; • Aliphatic and aromatic total petroleum hydrocarbons (TPH) are recorded either below the LOD, or at low concentrations towards the southern boundary of the site. Heavy end, and therefore less mobile TPH fractions noted within observation pits OP401 and OP403. The concentrations are likely to be insufficiently elevated to pose a significant human health risk; • BTEX hydrocarbons (benzene, toluene, ethylbenzene and xylenes) are all recorded below the LOD across the site; • VOCs are all recorded below the LOD across the site; • SVOCs are generally all below the LOD, with exception of low concentrations of carbazole, dibenzofuran and 2-methylnaphthalene in two soil samples; • Asbestos was not identified within any of the analysed soil samples; • Alkaline and strongly alkaline pH in boreholes and observation pits samples; • PCBs below the LOD in scheduled samples; and • Photoionisation Detector (PID) concentrations of volatile organic compounds ranged between the limit of detection (<0.1 ppm) and 0.1ppm.	

Date of Report	Company	Report Title and Reference	Location of Investigation Relative to Subject Site	Conclusions with Respect to Human Health Risks	Conclusions with Respect to Controlled Waters Risk
November 2020	Geotechnics	Stockport Interchange Supplementary Ground Investigation (report reference: PN204140)	 All investigations within the subject site boundary.	The report solely presents the factual information obtained from the ground investigation works. It does not include any interpretation of the data.	

3. CONCEPTUAL MODEL AND GENERIC QUANTITATIVE RISK ASSESSMENT OF POLLUTANT LINKAGES

A combined conceptual site model and conceptual exposure model has been developed for the proposed land uses based on the information and conclusions reached from the previous investigation works detailed above..

The potential pollutant linkages identified and a generic quantitative risk assessment are presented in Table 4.1. The terms used in the generic quantitative risk assessment are defined in Appendix C.

3.1. Justification

Results of Site Investigations

- A number of potentially contaminating activities that might have impacted on the quality of the soils and groundwater on site have been conducted on and surrounding the site, namely chemical works in the north, mills, print works and timber yards. The current site use as a bus station is considered to present a potential source of contamination due to potential for spill and leaks; no fuel storage tanks are known to be present on site. Additionally, the presence of imported Made Ground associated with filling and construction activities is considered to be a potential source of contamination.

- The potential contaminants of concern associated with the historical and current activities on and in the vicinity of the site were considered at the desk study stage to include petroleum hydrocarbons, chlorinated hydrocarbons, phenols, polycyclic aromatic hydrocarbons (PAHs), metals, polychlorinated biphenyls (PCBs) and asbestos

- The previous ground investigations encountered superficial deposits comprising cohesive and granular Made Ground, Glacial Clay, and Glacial Sands and Gravels to a maximum depth of 5m BGL. Underlying the superficial deposits bedrock comprised Sherwood Sandstone.

- The Chester Pebble Beds Formation is classified as a Principal Aquifer. The Glacial Fluvial Deposits are classed as a Secondary A Aquifer whilst the Glacial Till is classed as an Unproductive Strata. The site is not located within a Groundwater Source Protection Zone. The nearest surface water body is the River Mersey which runs along the northern site boundary.

- With respect to human health risks, the results of previous ground investigations have demonstrated:

    - Asbestos was identified in Made Ground at a number of locations, at concentrations below the limit of detection (<0.001%).

    - Concentrations of polycyclic aromatic hydrocarbons in soil were reported in exceedance of the adopted screening criteria (commercial end use).

    - Trace concentrations of a number of volatile organic compounds were identified. The AECOM GIR adopted the limit of detection as screening value. As part of this assessment, the detected concentrations were compared against the WSP derived generic assessment criteria (GAC) - the reported concentrations were *below* the GAC for commercial use.

- WSP conducted a detailed Ground Gas Risk Assessment which also took into consideration previous AECOM gas monitoring information. Using the highest gas concentration recorded during the additional two ground gas monitoring events and a maximum flow rate recorded in boreholes, a GSV of 0.0048l/h was derived which indicates the site is characterised as Characteristic Situation 1 (CS1 - very low risk), with no ground gas protection measures required. Further observations to support WSP's professional judgement that the Site is a CS1 were:
    - The proposed development is considered to be of low sensitivity (parts of the development are not directly on the ground);
    - Ground gas generation potential of the site is low (sources are restricted to natural soils and Made Ground); and,
    - Concentrations of carbon dioxide in the ground that exceed the 5% threshold are sporadic and in installations within natural, non-organic soil/rock.
- Based on the preliminary CSM by WSP, the controlled waters receptors include shallow perched water within the Made Ground / drift deposits, the underlying principal aquifer and the River Mersey. All the five monitoring wells installed as part of this investigation were dry during the monitoring rounds undertaken in January and February 2020. The reported soil concentrations were generally low and no gross contamination was identified in the Made Ground within the areas assessed. On this basis, potential infiltration of contaminants of concern from the area of investigation to the underlying Principal Aquifer is considered to be minimal However, given the former industrial use of the site, the presence of residual mobile or leachable contamination on site cannot be discounted.
- It is noted dissolved concentrations of TPH have previously been detected in the Principal Aquifer in the wider Stockport Development area (AECOM, 2016). Based on the above and given the site is not located within a Source Protection Zone or within the vicinity of a potable groundwater extraction well, the risk to controlled waters is considered to be low.

Potential Sources

- Elevated reported soil concentrations of speciated PAHs and low level asbestos

Potential Pathways

- Dermal contact, ingestion, and inhalation of contaminates on Site.
- Migration of ground gas/explosion.
- Lateral and/or vertical migration of mobile contaminants within the shallow groundwater.
- Leaching and migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits.
- Migration of vapours through permeable Made Ground.
- Contaminated dust migration
- Migration via water pipes

Potential Receptors

- Future users of the Site.
- Adjacent Site users.
- Site Investigation, construction and/or groundworks (during the investigation and development of the Site) and future underground service maintenance workers, from hazardous short-term exposure.

Table 3.1. Assessment of Potential Pollutant Linkages.

Pollutant linkage				**Qualitative risk assessment**
	Source	**Pathway(s)**	**Receptor(s)**	
1	Elevated reported soil concentrations of speciated PAHs and low level asbestos	Direct contact, ingestion, and inhalation of dust (indoor and outdoor airspace). Migration of dust during construction.	Future site users	Medium x Likely = Moderate Risk
			Adjacent site users (residential & commercial)	Medium x Unlikely = Low Risk
			Site workers and future maintenance workers	Medium x Likely = Moderate Risk

For definition of the terms used in the qualitative risk assessment, please see Appendix C.

4. REMEDIAL OPTIONS APPRAISAL

The information presented above summarises the physical conditions of the site, the nature of the soils, and the contamination status of the near surface Made Ground soils. For completeness, however, it would be prudent to refer to the previous site investigation reports, should additional information be required. The following section identifies the remediation strategy that could be utilised to effectively manage/mitigate the identified pollutant linkages associated with the soils at the site. In determining the most effective remediation option(s) for the site, consideration needs to be given to a number of techniques, stating (where appropriate) the suitability and limitations of each chosen method. On the basis of the identified pollutant linkages and remediation objectives, the options presented in Table 4.1 have been considered.

Table 4.1 Remedial Options Appraisal

Contaminant Source	**Low level asbestos within the Made Ground soils at the site**	**Elevated PAHs within the Made Ground soils at the site**
Pollutant Linkage	Inhalation by end users, adjacent site users, site investigation, demolition and construction staff and future underground service maintenance workers.	Direct ingestion / inhalation and dermal contact by end users, adjacent site users, site investigation, demolition and construction staff and future underground service maintenance workers.
Excavation with Disposal	Excavation of all low level asbestos fibre impacted Made Ground would result in an unsustainable quantity of soil waste which would require either off-site disposal or treatment which would result in an uneconomic solution particularly given the low level nature of the asbestos identified.	Excavation of all PAH impacted Made Ground would result in an unsustainable quantity of soil waste which would require either off-site disposal or treatment which would result in an uneconomic solution particularly given the low level nature of the asbestos identified.
Excavation with Re-Use	Soils can be reasonably re-used on site if cut and fill volumetrics allow in accordance with CIRIA C733 so long as the CL:AIRE Definition of Waste Code of Practice is followed. Low level asbestos impacted soils could be emplaced beneath hardstanding, buildings or other cover layer.	Impacted soils could be re-used beneath the site in conjunction with a Materials Management Plan in a manner similar to that described for low level asbestos impacted soils.
Capping by hardstanding/building footprint	Is considered economic, sustainable and would effectively break the dust inhalation pathways associated with the low level asbestos fibre impacts.	Is considered economic, sustainable and would effectively break the direct contact and dust inhalation pathways associated with the impacts.
Clean Cover System (only applicable in areas of soft landscaping)	Is considered economic, sustainable and would effectively break the direct contact and dust inhalation pathways associated with the low level residual free fibre impacts.	Is considered economic, sustainable and would effectively break the direct contact and dust inhalation pathways associated with the impacts.
Justification	Localised 300mm clean cover system within soft landscaped areas would be required to break residual dust inhalation pathways associated with the low-level asbestos impacted soils at the Site.	Localised 300mm clean cover system within soft landscaped areas would be required to break residual dust inhalation and direct contact pathways associated with the PAH impacts at the Site.

Following completion of the options assessment, it is considered that the most effective 'remedial' technique to address contamination risks posed to human health by localised PAH impacts and asbestos within near surface soils is:

- Re-use or retention of PAH and low levels asbestos impacted materials beneath proposed buildings or hardstanding or incorporation below a localised 300mm clean cover system in soft landscaped area;
- Implementation of a site wide localised 300mm clean cover system in all soft landscaped areas;

- Validation works with respect to the chemical status of soils used in clean cover systems will need to be undertaken along with confirmatory hand excavated pits to demonstrate that the clean cover system has been implemented as detailed below within this Remediation Strategy.

5. REMEDIATION STRATEGY

5.1. Introduction

Tier Environmental considers that a combined remedial approach will be required to address the following potential contaminants of concern:

- Made Ground containing low level asbestos concentrations that present a potential risk to human health; and,
- Made Ground containing elevated PAH concentrations that present a potential risk to human health

In addition, due consideration has been made within this remediation strategy for previously unidentified and localised visual / olfactory evidence of gross contamination.

5.2. Anticipated Remedial Works

Based upon the findings of the previous ground investigations and risk assessments and the above Remedial Options Appraisal, the following remediation strategy has been devised in order to make the Site safe and suitable for redevelopment, as proposed:

- Removal, crushing and screening of all oversized material and any obstructions in the ground
- Bulk earthworks to achieve the proposed development levels, including with fill materials compacted in accordance with a recognised specification, such as Specification for Highways Works Series 600. Re-use of site won materials to be conducted in via a Materials Management Plan in accordance with the Definition of Waste Code of Practice;
- Installation of a minimum 300mm clean cover system underlain by a geotextile membrane in soft landscaped areas to act as a growing medium and physical barrier between impacted Made Ground soils and the end-users.
- Removal and verification of any previously **unidentified** areas of contamination, where required. This may include, bay way of example:
    - Localised excavation and off-site disposal of grossly contaminated soils (if encountered);
    - Vacuum tanker pumping of grossly impacted groundwater (if encountered) to significantly reduce the primary source mass potentially combined with Localised in situ chemical oxidation or addition of oxidising agents;
    - Verification soil and groundwater chemical analysis (as required);
- Backfill of resultant excavations with suitable material;

The above integrated strategy is designed to;

- Mitigate risks to human health via direct contact, ingestion and dust inhalation pathways;
- Provide contingency arrangements in the event that localised unexpected gross contamination is identified beneath the Site

5.3. Clean Cover System

Installation

In order to remove the direct contact, dust inhalation and ingestion pollutant linkages, it is considered that the soft landscaped areas of the Site should be covered with a 300mm deep clean cover system (150mm Topsoil layer underlain by 150mm subsoil underlain by a Terram geotextile membrane **or** a full 300mm of topsoil underlain by a Terram geotextile membrane). It is considered that a 300mm clean cover system with a geotextile membrane will provide sufficient thickness for the exposure scenarios typical for the proposed land uses and the geotextile will provide a physical barrier in the unlikely event that any excavations are undertaken to this depth. It should be noted that the clean cover system should only be implemented in those areas for which shallow soils still lie at ground surface, i.e. soft landscaped areas as all other areas will be covered in hardstanding and/or buildings which will be sufficient to break the direct contact and dust inhalation pathways in these areas.

The source of the imported subsoil and Topsoil material will be inspected and tested **prior to being brought to site** on site to ensure its chemical suitability and absence of any deleterious materials such as glass, metal, roots, invasive weed species and the like.

Verification

It will be necessary to ensure that the development of the site does not cause an increased risk to receptors. All topsoil / subsoil materials imported to the site will be tested **prior to being brought to site** to determine its chemical suitability for use on the site in the soft landscaping areas. The imported material will be tested for the standard Tier Environmental soil suite listed in Appendix D of this report as part of a verification testing exercise along with speciated TPH analysis and asbestos. The purpose of the testing is to verify the quality of any materials imported to the site and to determine the contaminant concentrations of materials. Imported topsoil materials will need to be tested at a minimum rate of 1 sample per $50m^3$ and imported subsoil will be tested at a minimum rate of 1 sample per $150m^3$.

The samples will be compared with appropriate LQM / CIEH 2015 S4UL values protective of a residential without home grown produce land use to confirm suitability for re-use.

Hand dug pits will be excavated in each soft landscape plot, with the number of holes determined based on the area of the soft landscaped plot as follows:

- up to $20m^2$ = 1 hole;
- 20 to $50m^2$ = 2 holes;
- over $50m^2$ = 3 holes

Photographic records will be presented in a verification report demonstrating that 300mm has been achieved and the presence of the geotextile membrane.

5.4. Contingency for any Unknowns

Whilst relatively uniform ground conditions have been encountered at the Site during previous investigations, a small risk exists of the presence of localised unidentified contamination of Made Ground soils.

Should any suspicious material be encountered during the redevelopment works, works shall be ceased within this part of the site and the area should then be investigated further by a suitably qualified geo-environmental engineer and sampled as necessary. The Contaminated Land Officer (or equivalent) at the local authority should also be notified immediately. Samples will be forwarded to a UKAS/MCERTS accredited laboratory for a suite of analytical testing deemed appropriate based upon an appraisal of the material identified.

Once the results of the analysis are known and have been interpreted, the required remedial action (if any) will be determined and approved with the relevant regulatory authorities.

5.5. Environmental Monitoring and Mitigation

Introduction

In order to mitigate the environmental impacts of the works on nearby surrounding land users, a programme of measures will be implemented during the remediation works.

Dust Mitigation

Appropriate measures shall be implemented at all times during the remediation works, to minimise dust emissions. Soils will be dampened down, as necessary, and activity will be minimised in extremely windy conditions to prevent dust nuisance. An adequate supply of water shall be maintained on site at all times to allow for dust suppression activities to be carried out at short notice.

When dusty material is being loaded onto trucks, extra care will be taken to ensure that the drop height is minimised. Trucks will be suitably covered when leaving the site with contaminated material to prevent dust migration.

The amount of disturbed surfaces left exposed for significant time periods will be minimised. Stockpiles of fine or loose materials should be tamped down or covered, if necessary, to reduce the production of dust. Traffic both entering and working on the site shall obey a maximum speed limit of 10 mph.

Noise

The requirements of BS 5228:1997 “Noise and Vibration Control on Construction Sites” shall be adhered to at all times. All machinery shall be fitted with effective silencers and shall be serviced at regular intervals. No plant shall be operated with engine covers raised.

Run-off into Drains

All potential drainage on site and any discharge points will be identified, including land drains, foul sewers, surface water drains and any combined drains. These will be marked, as appropriate, for easy identification.

Works will be minimised during periods of heavy rainfall to reduce the likelihood of contaminated run-off. Temporary containment and cover measures or tamping down of stockpiles to reduce run-off shall be used where necessary.

5.6. Waste Soils – Basic Characterisation and WAC

In the event that localised previously unidentified contamination or other surplus materials require removal from the Site then the impacted material exported from the site to landfill shall be hauled by a registered waste carrier in accordance with Duty of Care Regulations, 1991 and the Hazardous Waste Regulations, 2005.

There will be requirement for the waste producer to provide appropriate Waste Acceptance Criteria (WAC) testing of the soils for disposal to ensure that the soils are appropriately classified and that the landfill is licensed to receive such soils.

5.7. Verification Report

The SE should ensure that the requirements of the strategy are complied with. On satisfactory completion of all remedial works, a verification report should be produced. This report will comprise all relevant site records and act as certification that the remedial preparation works have been carried out in accordance with this remediation strategy.

The Verification Report shall include the following:

- A description of the works undertaken in accordance with the Remediation Strategy described above;
- Records of the works;
- Progress photographs;
- Waste Transfer Notes;
- Chemical verification test results.

6. REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigations. 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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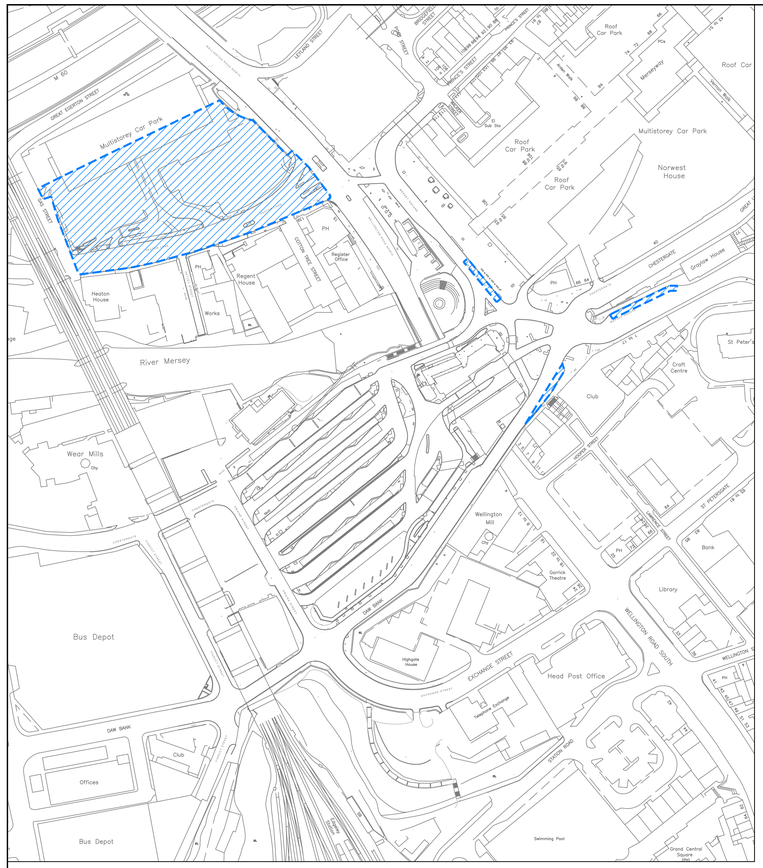
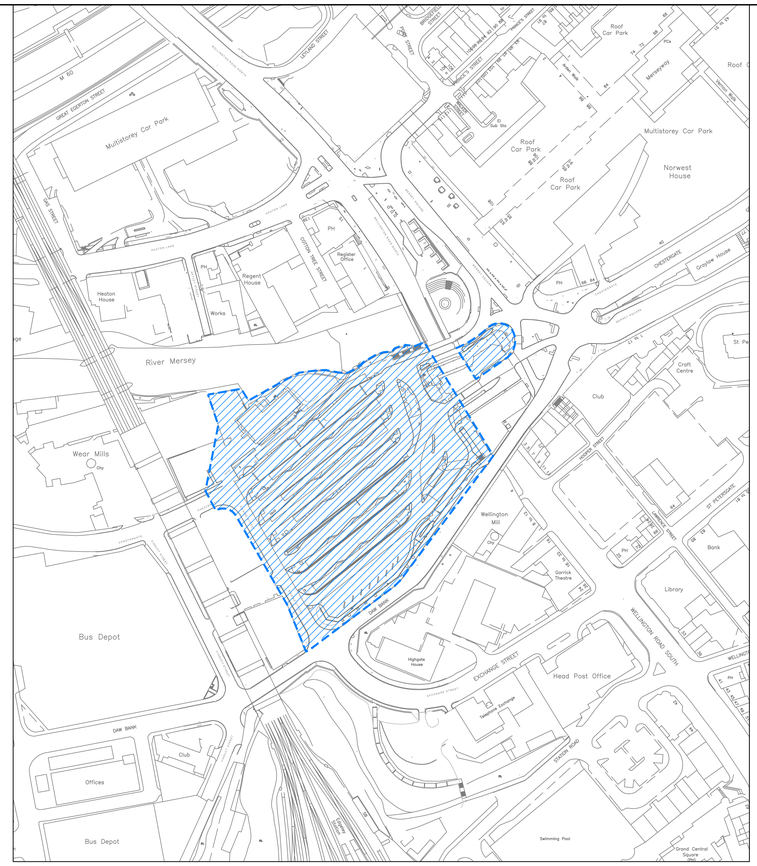
APPENDIX A – FIGURES AND DRAWINGS

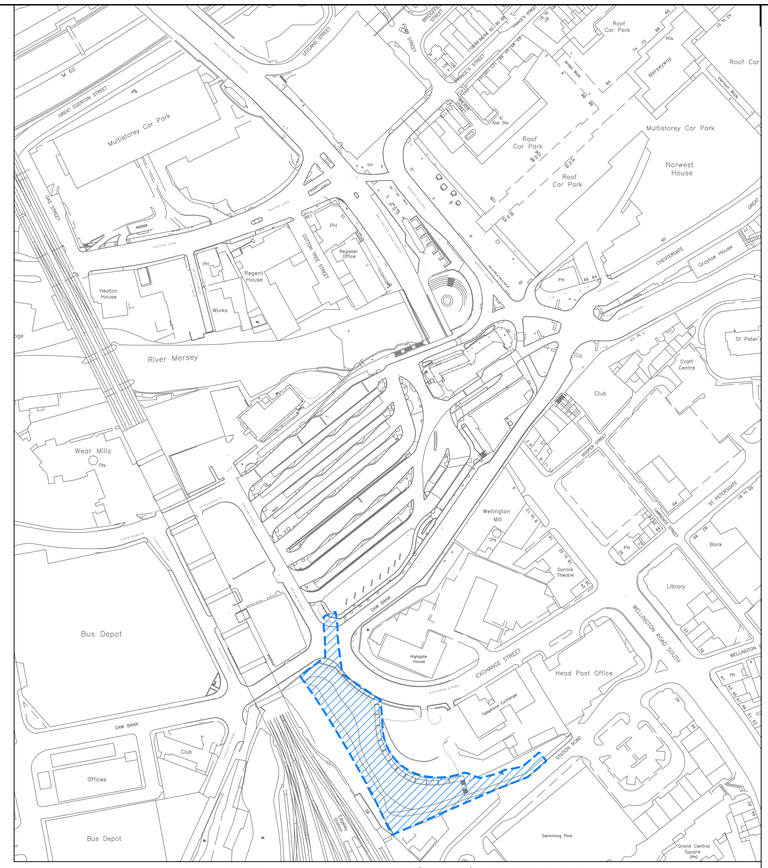
DO NOT SCALE



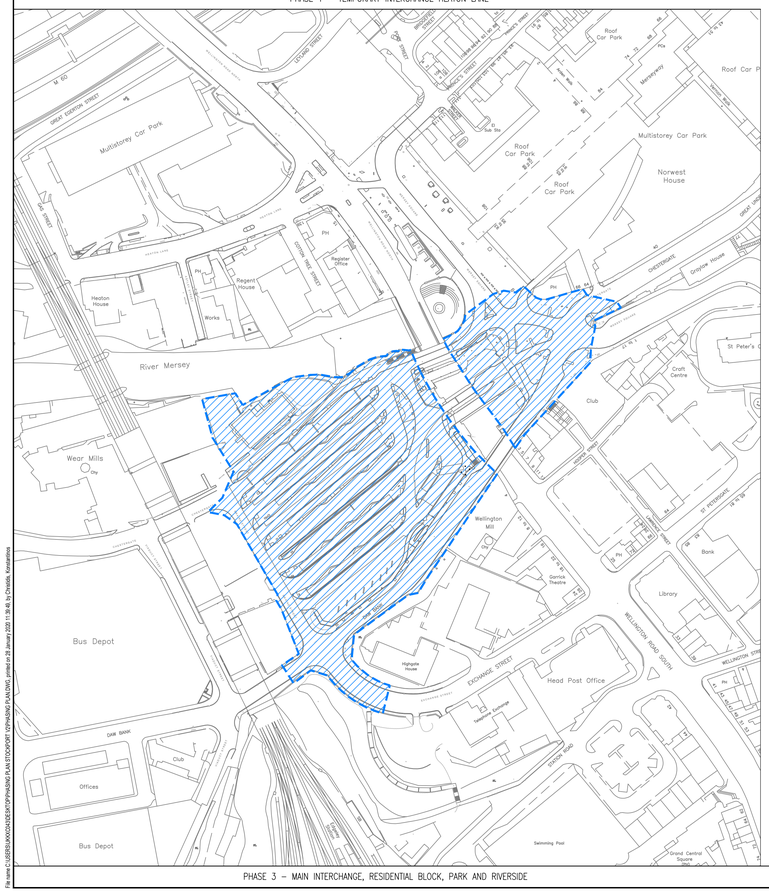
PHASE 1 – TEMPORARY INTERCHANGE HEATON LANE



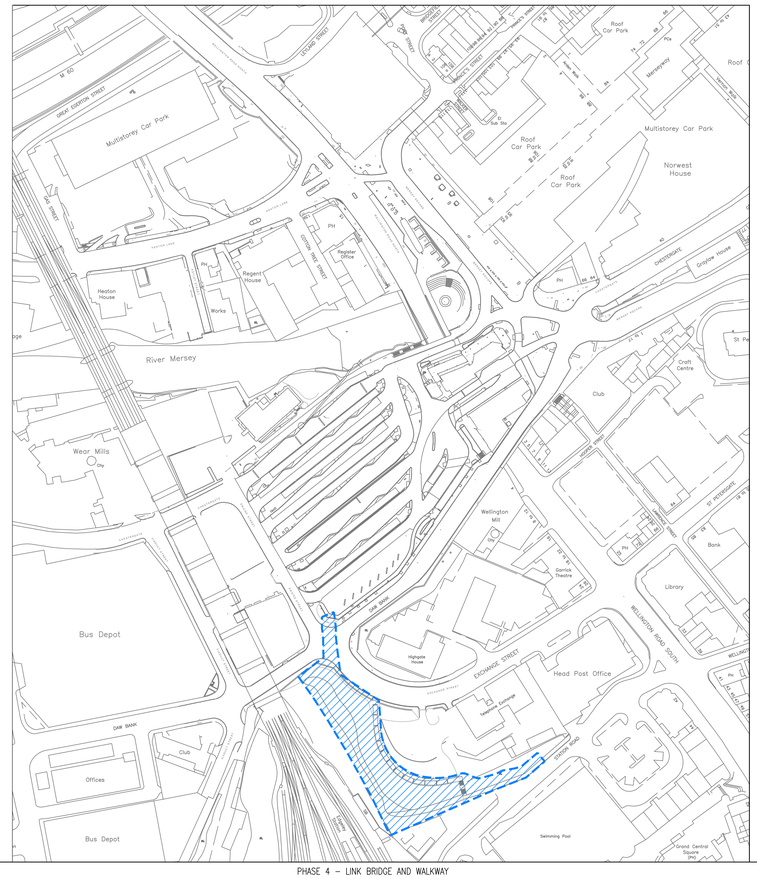
PHASE 2A – SITE CLEARANCE AND EARLY WORKS (FOUNDATIONS) – MAIN SITE



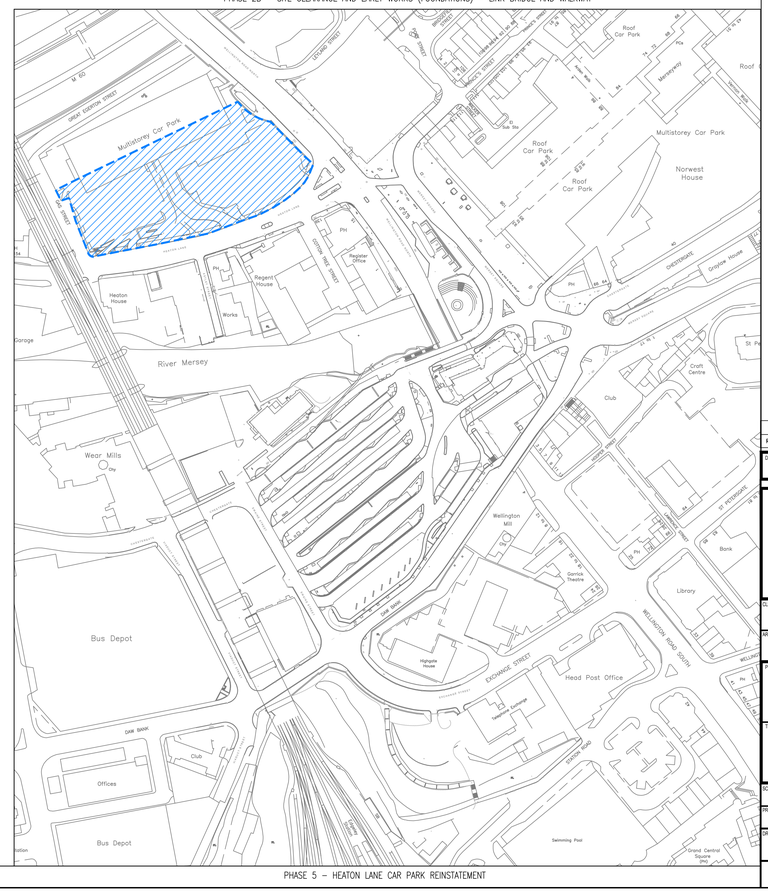
PHASE 2B – SITE CLEARANCE AND EARLY WORKS (FOUNDATIONS) – LINK BRIDGE AND WALKWAY



PHASE 3 – MAIN INTERCHANGE, RESIDENTIAL BLOCK, PARK AND RIVERSIDE



PHASE 4 – LINK BRIDGE AND WALKWAY



PHASE 5 – HEATON LANE CAR PARK REINSTATEMENT

REV	DATE	BY	DESCRIPTION	CHK	APP
A	28/01/2020	KC	FIRST ISSUE	JO	JO

DRAWING STATUS:
S0 - WORK IN PROGRESS

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CLIENT:
TFGM

ARCHITECT:
BDP

PROJECT:
STOCKPORT INTERCHANGE

TITLE:
COMBINED PHASING PLAN

SCALE @ A0:	CHECKED:	APPROVED:
1:1000	JO	JO
PROJECT No:	DESIGNED: / DRAWN:	DATE:
70031899	KC / KC	January 20

DRAWING No: PHASING PLAN — REV: P01

APPENDIX B – 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 of 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
SPT	Standard Penetration Test
SPZ	Source Protection Zone (see Appendix E)
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	95th percentile estimate of the true mean value of a data population (also known as 95%UCL).
VOC	Volatile Organic Compound

APPENDIX C – DEFINITIONS OF TERMS USED IN QUALITATIVE AND QUANTITATIVE RISK ASSESSMENTS

For the qualitative and quantitative assessment of risks posed by potential pollutant linkages have been undertaken using the risk matrix adapted from CIRIA C552 and outlined in the table below.

	Category	Definition
Potential severity	Severe	Acute (short term) risk to human health, Major pollution of sensitive controlled waters, ecosystems or habitat. Catastrophic damage to buildings or property or crops.
	Medium	Chronic (Medium / long term) risk to human health Pollution of sensitive controlled waters, ecosystems or species, Significant damage to crops, buildings or structures
	Mild	Easily preventable permanent health effects on humans. Pollution of non-sensitive controlled waters. Minor damage to buildings or structures.
	Minor	Easily preventable non-permanent health effects on humans, or no effects. Minor, low level and localised contamination of on-site soil. Easily repairable damage to buildings or structures.
Probability of risk	High Likelihood	Pollutant linkage may be present and the risk is almost certain to occur, or there is evidence of harm already occurring.
	Likely	Pollutant linkage may be present and it is probable that the risk will occur over the long term.
	Low Likelihood	Pollutant linkages may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
	Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur are improbable.

		Potential Severity			
		Severe	**Medium**	**Mild**	**Minor**
Probability of risk	**High Likelihood**	Very high	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low Likelihood	Moderate	Moderate/Low	Low	Negligible
	Unlikely	Moderate/Low	Low	Negligible	Negligible

APPENDIX D – 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 *or* 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.

In 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.

For the qualitative and quantitative assessment of risks posed by potential pollutant linkages have been undertaken using the risk matrix adapted from CIRIA C552 and outlined in the table below.

	Category	**Definition**
Potential severity	Severe	Acute (short term) risk to human health, Major pollution of sensitive controlled waters, ecosystems or habitat. Catastrophic damage to buildings or property or crops.
	Medium	Chronic (Medium / long term) risk to human health Pollution of sensitive controlled waters, ecosystems or species, Significant damage to crops, buildings or structures
	Mild	Easily preventable permanent health effects on humans. Pollution of non-sensitive controlled waters. Minor damage to buildings or structures.
	Minor	Easily preventable non-permanent health effects on humans, or no effects. Minor, low level and localised contamination of on-site soil. Easily repairable damage to buildings or structures.
Probability of risk	High Likelihood	Pollutant linkage may be present, and the risk is almost certain to occur, or there is evidence of harm already occurring.
	Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term.
	Low Likelihood	Pollutant linkages may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
	Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur are improbable.

		Potential Severity			
		Severe	**Medium**	**Mild**	**Minor**
Probability of risk	**High Likelihood**	Very high	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low Likelihood	Moderate	Moderate/Low	Low	Negligible
	Unlikely	Moderate/Low	Low	Negligible	Negligible