REMEDIATION AND ENABLING WORKS VALIDATION REPORT

Former Stagecoach Bus Depot
Land off Bowes Street
Manchester

Prepared for:

Rowlinson Construction

Report Ref: 11-813-R2- Rev C
Date Issued: August 2019

e3p | Environmental | Energy | Engineering

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REMARKS	***Final – Rev B***	***Final – Rev C – updated proposed development layout***
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IMS Template Reference
QR001-1

EXECUTIVE SUMMARY	
Site Address	Former Stagecoach Depot, Bowes Street, Manchester, M14 7JQ
Grid Reference	E383996, N395006
Site Area	~2.2Ha
Stated Objective	The primary purpose of this report is to document the implementation and subsequent validation of regulatory compliant land remediation and enabling works completed as part of the construction of a residential development on a parcel of derelict land off Bowes Street in Manchester. This document also defines the 'Build Phase' mitigation measures that are required in the construction of the proposed dwellings to ensure all potential pollutant linkages are addressed.
Site Remediation and Enabling Works	All works at the site have been conducted in accordance with the agreed Remediation Strategy. The main outputs from the works are: • Implement all works in strict accordance with UK Environmental Permitting and Local Planning Authority Requirements. • Controlled removal of all trees and vegetation; • Removal and treatment of all invasive plant species (as required) in accordance with specialist contractor method statement, validation and independent certification; • Delineation and removal of hydrocarbon impacted soil in vicinity of TP214, validation testing of material that remains and removal of all unsuitable soils; • Validation leachate analysis to be undertaken of Made Ground soils in eastern sector with hotspot delineation and excavation where and if necessary; • Removal of all structures, relict foundations and buried features in their entirety; • Removal of all materials considered geotechnically deleterious; • Excavation and processing of Made Ground in a controlled manner with the sorting, processing and segregation of identified deleterious materials to geotechnical specification; • Validation sampling and leachate testing to confirm material retained on-site pose no unacceptable risk to the residential end users, controlled waters or wider environ; • Importation of suitable material (if required) to achieve the required development levels; and, • Replacement of material in accordance with the E3P enabling specification & engineering requirements. • Management of all works so as to ensure that no environmental nuisance is created through dust emissions, noise or vibration levels & compliance with the CEMP; • Ensure that all works are completed in a manner so as not to create any structural risk to the adjacent highways / infrastructure; *Continued…*

EXECUTIVE SUMMARY	
	• Inspection of all works by a qualified Geo-Environmental Engineer to confirm the suitability of material for re-use and to confirm the findings of the Contamination Conceptual Site Model (CSM); • Provide suitable development platform to facilitate the construction of the proposed roadways, drainage infrastructure, pavements and areas of hard-standing; to be delivered in accordance with the Engineer's Specification; and, • Confirm the absence of any previously unidentified contamination sources.
Materials Management Plan & Legislative Waste Compliance	All waste transfer notes and duty of care certification are held by the Remediation Contractor in the site completion file. The works did not require the treatment of any materials and therefore no Environmental Permit was registered for the site.
Ground Gas	The ground gas assessment, as detailed within the Capita Geo-Environmental Report, indicated that the site is Characteristic Situation 2 – Amber 1, thus requiring mitigation measures that conform to BS8485 (2015) (A1-2019) in the construction of new homes. It should be further noted that appropriate hydrocarbon resistant membranes are present within all proposed plots.
Build Phase Development Works	Post Remediation Constraints for the site will include: • Placement of clean subsoil and topsoil in all gardens and soft landscaped areas must be a minimum of 600mm or natural ground (whichever is the shallower); and • Independent validation of the cover system by a suitably qualified E3P engineer. • Independent validation of the hydrocarbon membranes within all residential properties by a suitably qualified E3P engineer.

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1. ,INTRODUCTION

1.1 Background

This report details the remediation and enabling works operations that were undertaken by Rowlinson Construction under the supervision of E3P to facilitate the preparation of the low-rise residential development on a parcel of land off Bowes Street, Manchester, herein referred to as ***the site***.

E3P were appointed by Rowlinson Construction as independent Geo-Environmental Consultant for the site remediation, preparation / enabling and validation works and the subsequent production of a suitably detailed report to ensure the satisfaction of the relevant planning conditions and geotechnical engineering requirements for Building Control, warranty providers and the future adoption of infrastructure by the Highways Authority and statutory service providers.

The development area is approximately 2.2 hectares in size and is situated approximately 3km south of Manchester, close to Princess Road (see site location plan in Figure 1.1).

Figure 1.1 Location Plan

1.3 Site Location / Setting

Site address	Former Stagecoach Depot, Bowes Street, Manchester, M14 7JQ
National grid reference	E383996, N395006
Area	~2.2ha

Prior to the commencement of demolition works, the site comprised of a former bus and tram depot and associated infrastructure, as well as a school. An electrical substation is present

along the northern boundary. A historically infilled pond is also present at the northern boundary.

The site is currently disused and surface cover is a general fill material across the whole of the site with access gained from two entrances off Bowes Street. Residential areas border the north, south and east boundaries and Princess Road borders the western boundary.

1.4 Proposed Development

Rowlinson Construction propose to redevelop the site for low rise residential end use comprising a series of apartment dwellings with gardens, access roads, driveways and adopted drainage infrastructure under planning permission reference 127796/JO/2020. For the avoidance of doubt this report covered both the blue and red boundaries illustrated within figure 1.1 below.

The detailed development layout for the site is presented within Drawing No. 11-813-002 (Rev B) included within Appendix III.

Figure 1.2 Snapshot of Proposed Development

1.5 Summary of Parties Involved

NAME OF PARTY	FUNCTION / INTEREST
Land Owner	Rowlinson Construction
Developer	Rowlinson Construction
Geo-Environmental Consultant	E3P
Main Contractor	Rowlinson Construction
Remediation Contractor	Rowlinson Construction
Human Health Regulator / Local Planning Authority	Manchester City Council
Controlled Waters Regulator	Environment Agency

1.6 Limitations

The limitations of this report are presented in Appendix I.

1.7 Confidentiality

E3P has prepared this report solely for the use of the Client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from E3P; a charge may be levied against such approval.

2. CONTAMINATION, REMEDIATION & ENABLING WORKS REQUIREMENTS

The following phases of Geo-Environmental investigations have previously been carried out at the site:

- Beech Group – Validation Works, Northern Area. Report Reference: BC/1702/691/R14, dated July 2012.
- Capita – Phase 1 Geo-Environmental Desk Study, Bowes Street, Manchester. Report Reference: CS/088198-P1DS, dated August 2016.
- Capita – Phase 2 Ground Investigation & Assessment, Bowes Street, Manchester. Report Reference: CS/088198-GIA, dated March 2017.
- Capita – Remediation Strategy, Bowes Street, Manchester. Report Reference: CS/088198-RS, dated March 2017.

It has been noted that there are other various stages of investigation reports (primarily by Curtins Consulting) completed during the site's construction as a Stagecoach depot. The reports have not been provided however their findings have been summarised within the Capita reports and will therefore also be a consideration as part of the development of the E3P Remediation Strategy.

Furthermore, a phase of partial remediation was undertaken on the site by GB-Building Solutions, validated by Beech Remediation in 2012 (prior to the Capita investigations) with details included within the aforementioned Beech Group Validation Report, but was only intended to remove slabs, foundations and below ground storage tanks. Subsequent investigation in these localities identified that below ground storage tanks may have leaked historically and a degree of soil remediation will be required.

Pertinent points from the above reports were considered with the preparation of the E3P remediation strategy and the key findings are summarised in Table 2.1.

Table 2.1 Summary of Contaminated Land Risk Assessments

Contaminated Land Assessment	
Human Health Risk Assessment	The Tier I Human Health risk assessment identified the presence of elevated concentrations inorganic heavy metals, PAH compounds and hydrocarbons within shallow Made Ground deposits. The shallow made ground is therefore not suitable for use within proposed 'soft' areas where a direct exposure pathway exists. In the case of Heavy Metals, non-volatile PAH and TPH compounds the viable exposure pathway is associated direct contact, inhalation of particulates, consumption of home grown vegetables and ingestion of soil. The proposed development of the site will include hard cover and the importation of certified sub-soil and topsoil soil in areas of private gardens and landscaping, thus removing this pathway. With regards to the elevated naphthalene and volatile TPHs, these compounds present potential volatilisation to indoor air risk. ***Continued…***

Human Health Risk Assessment	Following the review of the existing information and E3P assessment the remediation issues, potentially volatile hydrocarbon contamination has been confirmed to be widespread in the shallow Made Ground strata associated with petroleum and diesel range impact which has spread by a plume across the eastern sector. Considering the widespread nature of the elevated TPHs and naphthalene across the eastern and southern sectors, delineation and hotspot validation works will not be possible for much of the impact. One remediation option would be to undertake a reduced level dig of the impacted Made Ground with subsequent excavation and ex-situ treatment, however this is unlikely to be viable given the scale of the 'smear zone' contaminant impact. It is therefore intended for the Made Ground soils to be retained on the site with the identified risk to the proposed dwellings to be mitigated by the installation of hydrocarbon resistant membranes to mitigate the potential for any vapour volatilisation to indoor air. Within the locality of TP214 in the northern sector of the site, hydrocarbon impact has been identified to significant depth migrating to substratum and thus in direct contact with the bedrock geology. Considering the migration and depth, it is likely this hydrocarbon impact is due to the position of underground storage tanks in the area (now removed) which have leaked in the past, allowing petroleum and diesel to enter the soils. As this hydrocarbon impact is present at depth and at significantly greater concentrations than in other areas of the site, this localised area will require delineation, excavation and chemical validation to remove the impacted hydrocarbon soils in their entirety. Investigation has confirmed that overlying soils may be retained for use within the development (pending chemical validation) however it is likely that the hydrocarbon impacted soils will require disposal off-site due to the concentrations recorded. Chemical analysis of the natural clay drift deposits has identified that the majority of the natural soils on the site are chemically suitable however there are locations where the natural soils are elevated in hydrocarbons (albeit this will be removed during a hotspot validation). If site natural soils are intended to be utilised for the subsoil element of the cover system, supplementary validation analysis is required in order to confirm chemical suitability and ensure concentrations hydrocarbons within these soils are not elevated when considering protection to human health in a residential setting. There is no suitable topsoil source on site, therefore all topsoil deposits for the garden areas will require importation of chemically validated material.
Controlled Waters Risk Assessment	The primary area of hydrocarbon impact within soils and groundwater identified as being in the vicinity of TP214 where hydrocarbon impact is confirmed to depth (~4.00m bgl) and in direct contact with the bedrock. This area is considered to pose a potentially significant risk to the underlying aquifer in its current situation, therefore a phase of remediation by delineation, excavation and validation will be required to remove all impacted soils prior to their treatment and disposal. These works will ensure the complete removal of any soils that represent a significant and unacceptable degree of risk to the underlying aquifer. Following a review of the Capita reports, as an evolving Remediation Strategy, E3P considered it prudent to undertake a detailed controlled waters risk assessment utilising the EA RTM methodology to generate site specific screening criteria to use within the remediation of this localised area to ensure there is no unacceptable risk to the controlled water receptors from the ***Continued…***

	remaining soils across the wider area. This will be considered as Source Area 1. Following review of the information, E3P considered that further assessment was required if soils where hydrocarbon compounds capable of entering the dissolved phase (at any concentration) are to be retained in-situ. The shallow Made Ground soils that occupy the southern and eastern sectors of the site are impacted by hydrocarbon compounds and naphthalene. Whilst investigation has identified no evidence of vertical migration of these contaminants towards the underlying aquifer, no quantitative assessment of future migration potential is made within the Capita Report. Whilst E3P would consider the soils to be suitable for retention in their current location where they will pose no unacceptable risk to human health (subject to the installation of a cover system and hydrocarbon membranes within all proposed dwellings), it was considered essential to undertake a Tier 2 controlled waters risk assessment to confirm the existing soils will present no undue risk to the underlying Principal Aquifer and generate further SSRTs which may be utilised should any localised hotspot remediation be required. This will be considered as Source Area 2. A Tier 2 controlled waters assessment has been undertaken to generate SSRTs for the remediation of Source Area 1 and confirm the absence of significant risk of associated with residual soluble phase hydrocarbon impact within shallow Made Ground soils to be retained in situ in the eastern sector of the site. Validation leachate analysis will need to be undertaken of these Made Ground soils to confirm they will present no significant risk of migration to the underlying aquifer, compared to the SSRTs generated for Source Area 2.
Ground Gas	The ground gas assessment as completed by Capita has identified the site to be classed as Characteristic Situation 2 / Amber 1 therefore proposed plots will require low level gas protection measures to be installed within proposed plots. Due to the presence of hydrocarbon vapours within the Made Ground, all plots will also require the installation of a hydrocarbon resistant membrane.

Based on the above risk assessments, E3P developed a comprehensive Remediation and Enabling Works Strategy that is summarised in Table 2.2.

Table 2.2 Summary of Remediation and Enabling Works

Summary of Site Remediation & Enabling Works	The site Remediation / Enabling Works Strategy provides a comprehensive specification for the regeneration of the land to negate identified pollutant linkages and construct a development platform that will be geotechnically suitable for the proposed end use. The salient features of the Remediation & Enabling Works Strategy are summarised below: • Implement all works in strict accordance with UK Environmental Permitting and Local Planning Authority Requirements. • Controlled removal of all trees and vegetation; • Removal and treatment of all invasive plant species (as required) in accordance with specialist contractor method statement, validation and independent certification; • Delineation and removal of hydrocarbon impacted soil in vicinity of TP214, validation testing of material that remains and removal of all unsuitable soils; ***Continued…***

Summary of Site Remediation & Enabling Works	• Validation leachate analysis to be undertaken of Made Ground soils in eastern sector with hotspot delineation and excavation where and if necessary; • Removal of all relict foundations and buried features in their entirety; • Removal of all materials considered geotechnically deleterious; • Excavation and processing of Made Ground in a controlled manner with the sorting, processing and segregation of identified deleterious materials to geotechnical specification; • Validation sampling and leachate testing to confirm material retained on-site pose no unacceptable risk to the residential end users, controlled waters or wider environ; • Importation of suitable material (if required) to achieve the required development levels; and, • Replacement of material in accordance with the E3P enabling specification & engineering requirements.
Summary of Build Phase Mitigation Requirements	The developer's works will also include the completion of the following additional elements: • Provision of a 600mm cover system using certified material with appropriate validation within proposed garden areas, comprising 450mm subsoil (potentially site won natural drift deposits) overlain by 150mm topsoil; and, • Provision of a 300mm cover system using certified material with appropriate validation within proposed areas of Public Open Space and soft landscaping. • Installation of hydrocarbon resistant membranes within proposed plots. • Construction of specific dwellings with appropriate gas mitigation to be compliant with CS2 / Amber 1 for elevated CO2 in isolated area; and, • Construction of appropriate potable water supply infrastructure.

2.1 Environmental Permit & Approvals

2.3.2 Local Authority Pollution Control – LAPC Part B Licensing

The use of crushing plant was not required for this part of the works.

2.3.2 Standard Rules Permit.

In this instance no inert wastes were re-used / or imported to site and as such there was no requirement for the notification of works under a U1 or T5 standard rules permit.

2.3.2 CL:AIRE MMP – Definition of Waste

A Materials Management Plan (MMP) was developed in accordance with the industry Code of Practice (Version 2) to document the proposed materials management operations and corresponding management objectives to demonstrate the safe, sustainable and legislatively compliant management and re-use of soils on-site.

The MMP was subject to review by an Qualified Person (QP) in accordance with the requirements of the CoP prior to the signed declaration being made to the CL:AIRE.

Copies of the MMP & QP Declaration are available from the Remediation Contractor on request.

2.2 Summary of Remediation & Enabling Works Objectives

The proposed remediation activities were detailed within the E3P Remediation Strategy and Enabling Works Plan (10-557-r1; dated March 2015) and supplementary supporting documents provided by E3P.

This report has been prepared to document the completion of all necessary land remediation and enabling works and to record the presence of any variation in ground conditions or previously unidentified sources of potential contamination, environmental impact or potential nuisance to the wider environ.

ENABLING WORKS NO.	GENERAL OVERVIEW OF OBJECTIVES
EW1	Implementation of works with regulatory compliance
EW2	Environment and nuisance control
EW-3	Risk to infrastructure
EW-4	Identification, isolation and treatment of invasive plants
EW-5	Site clearance operations
EW-6	Delineation, excavation, validation and disposal of impacted materials at TP214
EW-7	Validation leachate analysis of shallow Made Ground soils in eastern sector
EW-8	Excavation, breaking and processing of all above and below ground structures
EW-9	Cut and filling of Made Ground to development levels
EW-13	Preparation of garden for cover systems – Pending
EW-14	Provision of Subsoil – Pending
EW-15	Provision of Topsoil – Pending
EW-16	Independent validation – watching brief
EW-17	Post-remediation Detailed Vapour Risk Assessment

EW-18	Remedial Verification Report

Second Phase Remediation & Enabling Works – Build Phase

A second post remediation phase of works will be required to ensure the proposed development is constructed in a manner that incorporates the required mitigation measures to ensure the development is compliant with UK Building Regulations and the Local Authority Planning requirements.

Once the ground has been stabilised and rendered suitable for development, the builder will be required to undertake a second phase of remediation works to mitigate the identified theoretical risk to human health.

- *Provide and place a 600mm thick soft growing medium to all garden areas of the development (150mm imported topsoil, 450mm site won subsoil).*
- *Provision of a 300mm cover system using certified material with appropriate validation within proposed areas of Public Open Space and soft landscaping.*
- *Hydrocarbon gas membrane installations in accordance with British Standard BS8485 (2015) within all proposed residential dwellings and their validations of instalment;*

3. DETAILED REMEDIATION & EARTHWORKS ACTIVITIES

The focus of the remediation and enabling works are to address the contaminant issues previously identified within the site investigations that presented an unacceptable risk to human health following the redevelopment of the site.

Furthermore, given the previously developed nature of the site (former bus and tram depot) at the time of the Site Investigation by Capita and corresponding access limitations, the scope of the Validation was extended to include a watching brief during all earthworks to ensure the appropriate assessment previously unidentified contamination.

For completeness, each of these activities has been discussed below within the context of the actual remediation works that were undertaken on site.

The Remediation & Site Enabling works commenced on the 21st June 2018 and were completed by the Rolwinson Construction.

3.1 Remediation works
Date of Works Undertaken 21st June 2018 – 3rd August
Photographs Plates 1 – 25
Overview of Works The subject site was historically occupied by Princess Road Bus and Tram Depot, and a school. However, the site was demolished prior to work commenting by Rowlinson Construction. The main works involved the excavation, delineation and validation of Source Area 1 to circa 4.00m bgl and the further investigation of Made Ground soils in the south east of the site in the vicinity of Source Area 2. Excavated materials from Source Area 1 were stockpiled on a membrane in the east of the site and were chemically tested over a period of three weeks to monitor chemical levels and qualify the material to be removed from site. E3P maintained a part time watching brief during the excavation of Source Area 1 to audit and validate the site enabling works in addition to inspecting all materials excavated with a PID device. Source Area 2 was subject to further trial pitting in order to investigate previously identified contamination that, originally, was identified as having no unacceptable risk to human health and controlled waters by Capita. However, E3P advised Rawlinson this risk assessment may not have been suitable, therefore, further investigation was completed. 12 No borehole were advanced in order to complete a gas assessment of the area in question, a summary of which is discussed in section 3.5 and Appendix VII. 20 No. trial pits were advanced for leachate analysis to prove there was no risk of contaminants leaching into the underlying Principal Aquifer. Photographs of the site remediation and enabling works through to completion are included within Appendix IV of this report.
3.2 Risk to Infrastructure
All site works were completed in a manner that ensured no risk of disturbance to the adjacent infrastructure.

3.3 Removal of Invasive Plant Species

Overview of Works

No invasive plant species were identified within the site boundary and no special precautions were required.

3.4 Delineation, Excavation, Validation and Disposal of Impacted Materials At TP214

Chemical Testing
Excavated Material Samples:
S1A4 (18-91525), S1A5 (18-91525), S1A8 (18-92831)

Validation Soil and Leachate Samples Source Area 1:
VB001 (18-89732), VB002 (18-89948), VB003 (18-90493), VS001 (18-89732), VS002 (18-89948) VS003 (18-90493), VS004 (18-91525), VS005 (18-91525), VS006 (18-91525), VS007 (18-91525) VS008 (18-91525), VS009 (18-91525), VS010 (18-91525)

Photographs
Plates 1-10

Background
The soils in the locality of TP214 were identified, if retained in situ, to present a significant risk to the underlying Principal Aquifer due to the concentrations of hydrocarbon impact in close proximity to the bedrock geology.

This area had apparently undergone previous remediation with the removal of underground storage tanks, however, investigation determined that whilst tanks may have been removed, the surrounding soils, which are likely to have become impacted from the leakage of these tanks, did not undergo remediation and have been left in place. Therefore, it was considered necessary to remove impacted soils in order to reduce the risk to controlled waters.

Overview of Works

A suitably qualified E3P engineer was in part-time attendance during the excavation of Source Area 1. Soils were excavated to circa 4.0m bgl, with the top 1.0m being retained for re-use on site. This soil surrounding the impact was then validated between the 19th June 2018 and the 4th July 2018, sampling locations can be found in Appendix III (Drawing No 11-813-008).

The results of validation samples from remaining soil (Appendix V) were directly compared to the Site Specific Remediation Targets (SSRTs) (Appendix VI) for leachates. This exercise confirmed there were no exceedances and therefore no associated risk to the underlying aquifer within that area.

All excavated soils were screened with a Photo Ionisation Detector (PID) once stockpiled on a suitable protective membrane, so as to not further contaminate the site, showing no elevated readings. PID screening was continued and frequent sampling of the contaminated material was undertaken to monitor TPH and naphthalene levels before the material was removed from site. Waste Transfer Notes can be obtained from the site contractor.

3.5 Validation Leachate Analysis of Shallow Made Ground Soils in the Eastern Sector

Photographs
Plates 14-18

Background
Shallow Made Ground soils Source Area 2 contained widespread concentrations of TPHs and naphthalene. The DQRA, with respect to controlled waters, identified that the elevated heavy end TPHs presented a theoretical risk to the underlying aquifer, however intrusive investigation and analysis confirmed there was no vertical migration of these elevated contaminants and there has been no elevated concentrations present within groundwater samples.

With this in mind, it was determined that the shallow Made Ground soils may be retained in situ (subject to the installation of cover systems and hydrocarbon membranes), however, a phase of validation leachate analysis was also required of the upper 1m of Made Ground (circa 1 sample per 500m^3).

Overview of Works

E3P was in full-time attendance during the trial pitting of Source Area 2. 20 No. trial pits were advanced through the ground to give a sampling frequency of 1 per 500m^3. Soils were excavated to circa 1.0m bgl and a leachate and chemical soil sample were taken from each trial pit. A location plan for this exercise can be found in Appendix III (Drawing No. 11-813-006)

The results from these samples (Appendix V) were compared to the SSRTs generated for Source Area 2 and confirmed the absence of any long-term risk to the underlying aquifer. Therefore, no further excavation was required.

3.7 Cut and Filling of Made Ground to Development Levels

No significant cut and fill works were undertaken on the site.

3.10 Preparation of Garden for Cover Systems

As part of the land remediation works, garden areas will be prepared in a manner that will facilitate the placement of the clean cover system during the development phase of the woks. The preparation of the areas requiring clean cover is critical in ensuring delivery of the site in a manner that will ensure no risk to the proposed end users.

Where Made Ground is deemed unsuitable for retention in a garden, the area will be subject to a reduced level dig to remove unsuitable material to a minimum depth of 600mm below finished garden level or verified natural stratum (whichever is the shallower).

Excavated soil will be stockpiled pending the results of the appropriate validation testing (to be completed in accordance with this specification) prior to re-use in an area of no sensitivity or where necessary, this material will be removed from site in accordance with UK Waste Management Legislation.

The placement of certified sub-soil and topsoil will be completed as part of the developer works / build phase mitigation plan. All garden areas where a cover system is required will be subject to plot specific independent validation.

3.11 Provision of Topsoil / Subsoil

The shallow natural drift deposits (predominantly cohesive soils) are deemed suitable for use within the upper 600mm of clean cover to residential gardens and areas of soft landscaping. It is therefore deemed viable to re-use and materials that are cut as part of the wider earthworks or through a soil inversion (regulated by an MMP) to generate the requited volumes of material.

No material that would be deemed suitable for use as topsoil is present on-site and as such there will be requirement to import suitable material for use within the proposed development.

Topsoil will require testing in line with the schedule present within Section 4.4 and Table 4.2 of the Remediation Enabling Works Strategy.

The garden and landscaped areas will require depth validation to satisfy the requirement of CML in order to demonstrate that the appropriate thickness has been provided.

3.12 Post-remediation Detailed Vapour Risk Assessment

Photographs
Plates 12 and 13

11-813-3L (21st November 2018) outlines the findings of the further assessment completed within Source Area 2 in relation to a vapour risk assessment and further leachate analysis.

E3P completed a soil vapour survey to quantify the actual naphthalene and TPH vapour concentrations present in the subsurface soils and determine whether these will present a long-term human health risk to the future site users through indoor volatilisation and inhalation.

E3P installed twelve Tenax tubes on the 11th September 2018, the Tenax tubes were then left within the monitoring wells until the 2nd October 2018. The tubes were hung within the monitoring well at depths between 0.50m and 1.00m bgl within soils where naphthalene and volatile TPH had previously been identified.

On removal of the tubes they were sealed in strict accordance with the laboratory sampling procedures. Once the compounds have absorbed onto the carbon sorption tubes, the sample is stable and is not subject to degradation.

Samples were stored at E3P in a controlled environment prior to shipment by courier to Concept Life Sciences Laboratory for UKAS accredited speciated TPH and naphthalene analysis. Following the analysis of the tubes, the laboratory contacted E3P to inform them that the tubes appeared to have become saturated whilst suspended within the boreholes. This may be due to the perched groundwater within the Made Ground soils. The Laboratory advised that the results could not be relied upon, therefore E3P have not used the results within the vapour assessment.

E3P have used the chemical results gathered during the additional ground investigation (outlined in Section 3.5 abve) in order to assess the potential volatilisation to indoor air risk.

E3P has undertaken a Tier 1 qualitative risk assessment to determine if any potential contaminants within the underlying soils give an unacceptable level of risk to the identified receptors. At a Tier 1 stage, the long term (chronic) human health toxicity of the soil has been assessed by comparing the on-site concentrations of organic and inorganic compounds with reference values published in LQM / CIEH S4UL (S4UL3267).

The results of this comparison are summarised in 11-813-3L (Appendix VII) and confirm the requirement for hydrocarbon membranes within all proposed developments in order to mitigate the potential for any vapour volatilisation to indoor air. It is recommended that protection measures are agreed with the local authority prior to their adoption on-site. Furthermore, all protection measures adopted should be validated by a suitably qualified engineer.

3.13 Delineation, Excavation, Validation and Disposal of Impacted Materials at Former Substation

Chemical Testing

Preliminary Trial Pits for PCBs:
TP1-TP5 (19-35128) and TP1 (19-36040)

WAC Testing of Arisings:
WAC 101 Sub (19-43180 and 19-43182) and WAC 102 Sub (19-43180 and 19-43182)

Validation Results:
Validation Base 101 (19-44164), Validation Side 101 (19-44164), Validation Base 102 (19-44164), Validation Side 102 (19-44164), Validation Base 103 (19-44581), Validation Side 103 (19-44581), Validation Base 104 (19-44581), Validation Side 104 (19-44581), Validation Base 105 (19-45473), Validation Side West 105 (19-45473), Validation Side South 106 (19-45473), Validation Side East 106 (19-45473), Validation Base 106 (19-45473).

Photographs
Plates 23-32

Background

The soils in the locality of the substation were identified, if retained in situ, to present a significant risk to the underlying Principal Aquifer due to the concentrations of hydrocarbon impact in close proximity to the bedrock geology.

The area surrounding the former substation, prior to its demolition, underwent preliminary investigation to assess whether any contamination had leaked from the station to the surrounding soils. This was completed by a qualified E3P engineer in full time attendance and samples were sent for PCB testing to determine whether there was any risk to the soils surrounding this structure. On the reporting of the results, it was found that there were no impacted soils identified in the surrounding area of the substation. Post demolition of the substation, an unknown tank was uncovered beneath the former structure and it was visually evident there was contamination within soils.

Overview of Works

As the presence of the tank was previously unknown, it had not undergone remediation and had been left in place. Therefore, it was considered necessary to remove impacted soils in order to reduce the risk to controlled waters and human health. E3P witnessed the removal of impacted soils in part time attendance of their excavation.

Due to immediately adjacent infrastructure and live services within Bowes Street, a trench box was utilised to brace the sides of the excavation. Following removal of the contamination immediate backfilling with clean material was carried out to prevent trench collapse. Perched water within Made Ground caused excavation to be difficult at times as contamination was then impacting water and was at risk of migration. Thus several sumps were created to divert water into a controlled location to prevent further spread of contamination. The water was collected in IBC's and send off site to a registered waste facility.

A suitably qualified E3P engineer was in part-time attendance during the excavation of the hotspot. Soils were excavated to circa 4.0m bgl, with the top 1.0m being retained for re-use on site. This soil surrounding the impact was then validated between the 4th June 2019 and the 12th June 2019, sampling locations can be found in Appendix III (Drawing No 11-813-008).

The results of validation samples from remaining soil (Appendix V) were directly compared to the Site Specific Remediation Targets (SSRTs) (Appendix VI) for Source Area 2 as this hotspot was in closer proximity to this area.

The base of the excavation and side walls of the excavations were visually inspected from a safe distance to confirm no further olfactory evidence of contamination was no longer present. The excavation was imminently backfilled, due to health and safety reasons the excavation could not remain open due to the proximity of Bowes Street to the excavation. Validation samples confirmed there were four areas with minor heavy end aromatic TPH exceedances (VB004 and side validations 005 and 006) when compared to SSRT hotspot 2 levels. Due to the close proximity to Bowes Street and evidence the removal of the contaminated material may have weakened the wall the excavation could not be safely reopened. It should be noted that nearby This has meant the full extent of the contamination could not be excavated in this area, however, full hydrocarbon resistant membranes are being installed on a site wide basis, therefore there is minimal risk to human health as a result.

4. POST REMEDIATION BUILD PHASE REQUIREMENTS

4.1 Overview of Build Phase Requirements

This document details the construction works that are required to ensure full compliance with the remediation Strategy, Regulatory Authorities, Building Control & Warranty Providers;

The following should be implemented during the build phase of the development:

- Laboratory testing of the imported topsoil;
- Chemical validation of any additional subsoil imported for use within gardens;
- Placement and validation of sub-soil (clean material) in a 450mm layer within any plots where the material was not placed during the Remediation & Enabling works;
- Placement and chemical validation of imported topsoil within all gardens; and,
- Installation and validation of hydrocarbon and ground gas protection measures.

4.2 Requirements for Further Works Prior to Substructure Construction

The following items remain to be addressed prior to construction of the development:

ITEM	DISCUSSION
Submission of Validation Report to Regulators	N/A

4.3 Gas Mitigation Measures

Ground gas monitoring to date suggests that the site will fall into the bracket for Characteristic Situation 2 / Amber 1 which will require specialist mitigation measures to be constructed in accordance with BS8485 as summarised below. Additionally, due to the presence of hydrocarbon vapours within the Made Ground, all plots will also require the installation of a hydrocarbon resistant membrane.

GAS PROTECTION SCORES FOR THE STRUCTURAL BARRIER	SCORE
a) **Floor and substructure design**	
Precast suspended segmental subfloor (i.e. beam and block).	0
Cast in situ ground bearing floor slab (with only nominal mesh reinforcement.	0.5
Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations.	1 or 1.5
Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing.	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing.	2.5

PROTECTION ELEMENT SYSTEM		SCORE	COMMENTS
Gas protection scores for ventilation protection measures			
(a) Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building)		0.5	Whenever possible a pressure relief pathway (as a minimum) should be installed in all gas protection measures systems. If the layer has a low permeability and / or is not terminated in a venting trench (or similar), then the score is zero.
(b) Passive sub floor dispersal layer: Media used to provide the dispersal layer are: • *Clear void* • *Polystyrene void former blanket* • *Geocomposite void former blanket* • *No-fines gravel layer with gas drains* • *No-fines gravel layer*	Very good performance	2.5	The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer. The selected score should be assigned taking into account the recommendations in Annex B of BS8485:2015. Passive ventilation should be designed to meet at least "good performance".
	Good performance	1.5	
(c) Active dispersal layer, usually comprising fans with active abstraction (suction) from a sub floor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers.		1.5 to 2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place. There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least "good performance".
(d) Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket.		1.5 to 2.5	This system relies on continued operation of the pumps, therefore alarm and response systems should be in place. The score assigned should be based on the efficient "coverage" of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least "good performance".
(e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park)		4	Assumes that the car park is vented to deal with car exhaust fumes, designed to *Buildings Regulations 2000, Approved Document F [9].*

PROTECTION ELEMENT SYSTEM	SCORE	COMMENTS
Gas protection score for the gas resistant membrane		
Gas resistant membrane meeting all of the following criteria: - *Sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m²/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method_;* - *Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;* - *Sufficiently strong to withstand in-service stresses (eg settlement if placed below a floor slab);* - *Sufficiently strong to withstand the installation process and following trades until covered (eg penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools etc);* - *Capable, after installation, of providing a complete barrier to the entry of the relevant gas; and,* - *Verified in accordance with CIRIA C735.*	2	The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints. For example, a minimum 0.40mm thickness (equivalent to 370g/m² for polyethylene) reinforced membrane (virgin polymer) meets the performance criteria opposite. If a membrane is installed that does not meet all the criteria opposite then the score is zero.

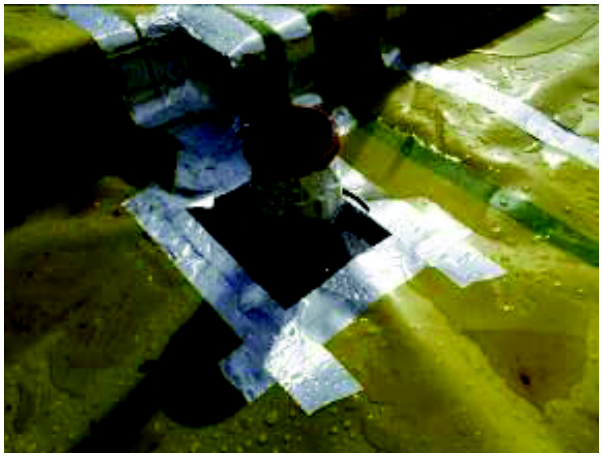
The validation inspection is to include verification of the items below:

INSPECTION	METHOD
Product Verification	Confirmation that suitable products have been installed to consist of photographs of product types, labels on packaging and delivery tickets.
Wall Cavity Inspection	Confirmation that gas membrane spans the external wall cavity above the periscopic vents.
General Condition	The membrane is to be inspected to ensure there are no tears, punctures or rips.
Jointing	The engineer is to check the overlaps between membranes are correctly sealed with sufficient overlaps.
Service Entry Points	Verification of the presence of preformed tophats sealed to the pipe and membrane as per the construction detail.
Passive Venting Systems	The engineer should verify the presence of vents at 2m centres on at least 3 of the external walls. Verification of the stone venting layer and presence of pipes to be supplied by photographic records from site.

Examples of gas membrane verification (photographs include different membrane types for demonstrative purposes only – gas membranes are site specific):

Photographs 1 and 2: Check general condition of membrane for punctures / tears etc

Photograph 3: Confirm membrane product type and check joints between rolls of membrane to ensure 150mm overlap and presence of double sided butyl tape (by touch – may not be visible) and girth jointing tape.



Photograph 4: Check top hat is sealed to membrane and pipework. If the formed top hat is not tight to the pipework then also confirm presence of jubilee clip beneath butyl tape.

The gas membrane specification is included in Appendix III.

4.4 Water Pipeline Risk Assessment

A UKWIR Risk Assessment was completed by E3P in March 2018 to fully inform the design of potable water infrastructure. PE barrier type A has been selected due to the exceedances in TPH concentrations within in-situ Made Ground.

4.5 Chemical Analysis of Clean Cover System

The Remediation Strategy for the site, with respect to human health of the future site users includes the provision of a chemically suitable clean material to be installed in all garden and landscaped areas; the construction of the clean cover / placement of clean material shall consist of:

- 450mm subsoil; and,
- 150mm topsoil.

In accordance with the current requirements of the regulatory authorities, validation samples will be collected from all materials that are to be imported or re-used on site to confirm the proposed development will pose no unacceptable risk to human health or the wider environ. Subsoil and topsoil shall be free of any deleterious materials, such as buildings materials, timber, plastics etc and conform to the requirements of BS 3882:2007.

The testing of all sub-soil will / has been completed as part of the remediation works undertaken. Therefore, the only requirement for further analysis of sub-soil would be in the event of importation of additional material during construction.

The agreed sampling frequency for these materials is presented in Table 4.1 below.

Table 4.1 Specification of Materials Validation Laboratory Analysis

Material Use	Testing Frequency	Suite of Analysis
Site generated Sub-Soil (450mm garden cover)	1 Sample Per 250m³	A / B / C / D
Imported Topsoil (150mm garden cover)	1 sample per 50m³	A / B / C / D

Notes – Table 4.1
Suites of Analysis
A) Speciated PAH
B) Banded TPH (C5-C35)
C) Asbestos (ID)
D) CLEA Inorganic

All analysis prescribed above to be completed by UKAS accredited laboratory.

Source testing certificates and validation testing of the imported materials shall be provided and is required to comply with the criteria set out in Appendix VI.

4.5 Placement of Chemically Suitable Cover System

Proposed garden and landscaped areas within the residential development require a chemically suitable cover system in order to break the exposure pathway between the end user and the contaminants.

Procedure for Placement:

- *If proposed utilities are to be placed within the cover system, the clean cover should be placed prior to installation of these utilities;*
- *If natural drift deposits are encountered, excavation can cease here;*
- *Garden and landscaped areas need to be backfilled with 450mm chemically validated subsoil, with 150mm topsoil overlaying this.* ***Topsoil is required to be confirmed as chemically suitable prior to placement.***

Garden Validation Procedure

The placement of 600mm of clean material will be undertaken during the build phase works of the project.

The placement of subsoil and corresponding validation will be documented within the Garden Validation Letters (to be issued on completion of the contractor's works).

Where sub-soil is not placed during Remediation & Enabling works, E3P will be required to return to site and undertake independent validation of the correct placement of sub-soil.

E3P will collect photographic evidence of the placement of 150mm of certified topsoil and 450mm of subsoil on completion of construction works. This element will also be checked by the Building Control Officer as part of the site completion prior to issuing of a CML certificate.

PROCEDURE	METHOD
Chemical Validation	Imported sub-soils and topsoil will need to be chemically analysed to confirm suitability for use with the proposed cover system prior to installation and completion of the garden systems. E3P will issue an email to the Countryside Properties Development Engineer with an assessment of the chemical suitability of both sub soils and topsoils. If acceptable the materials can be installed to the required depth at which time the plot will be deemed complete following a validation procedure by a suitability qualified E3P engineer.
Trial Holes	Trial holes are deemed necessary for the all plots given that the 600mm cover system will need to be placed on each plot during the build phase.
Validation	Photographic evidence will be taken (by E3P or Countryside Properties) of the topsoil placement demonstrating the depth of topsoil and practical completion of works are required for each and every plot. For plots where sub-soil depths requires validation by E3P during the build phase, photographs will be taken and collated by E3P.
Validation Certificate	Once the photographs of the placement of topsoil (over the clean material) have been provided, E3P will issue a plot specific validation certificate to demonstrate that the required subsoil and topsoil has been placed in the required garden plots along with the chemical analysis.
Completion Report	Upon completion of all garden and landscaped areas within the development, a Completion Report will be issued providing the confirmation that all remediation requirements have been achieved.

Photographs 1 and 2: Examples of validation photographs demonstrating clean cover.

4.6 Notes

If any of the procedures as outlined within the Build Phase Development Requirements Plan are not completed, this may result in a delay in obtaining a Warranty and Council for Mortgage Lenders and a Certificate of Completion.

Post Remediation Constraints for the site will include:

- Topsoil to be supplied by the developer, with appropriate quality checks if any further topsoil is required;
- Placement of clean subsoil and topsoil in soft landscaped areas must be a minimum of 600mm or natural ground (whichever is the shallower). The placement of this material will require independent validation by a suitably qualified professional;
- Foundation strategies should take into account the properties of the strata left in-situ; and,
- Consultations will have to be completed with the Local Authority to enable the satisfactory discharge of planning conditions associated with the planning consent for the site.

5. CONCLUSION AND RECOMMENDATIONS

E3P has completed the validation of the agreed land remediation and enabling works completed as part of the regeneration of the former Princess Road Depot on Bowes Street, Manchester.

E3P can confirm that the works have been implemented in accordance with the agreed Remediation Strategy with all materials managed in such a way as to ensure that the completed works posed no risk to construction operatives or the wider environ.

E3P can also confirm that all materials that remain in-situ pose no unacceptable degree of potential risk to the identified receptors within the context of the developed Conceptual Site Model (CSM) and as such the site is deemed suitable for use subject to the installation, validation and testing of the build phase mitigation works.

As part of the on-going construction works the developer will be required to construct and validate the items listed below in strict accordance with the requirements of the regulatory authorities as documented in detail within this report.

- Placement of clean subsoil and topsoil in all gardens and soft landscaped areas must be a minimum of 600mm or natural ground (whichever is the shallower); and
- Independent validation of the cover system by a suitably qualified E3P engineer.
- Independent validation of the gas hydrocarbon membranes within all residential properties by a suitably qualified E3P engineer.

END OF REPORT