

TRANSPENNINE ROUTE

UPGRADE



Transpennine Route Upgrade

Clayton Bridge Phase 2 Land Contamination Risk Assessment

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Approval and Authorisation

	Name	Job Title	Signature
Prepared By:	Siddharthan. T	Assistant Engineer	<i>Siddharthan T</i>
Checked By:	C. Escardo	Hydrogeologist	<i>C. Escardo</i>
Approved By:	J. Bohill	Senior Consultant	<i>J. Bohill</i>
Authorised By:	C. Hughes	Associate	<i>C. Hughes</i>

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Table of Contents

EXECUTIVE SUMMARY	7
1. INTRODUCTION.....	9
1.1 Scheme Background.....	9
1.2 Proposed Development	9
THE PROPOSED DEVELOPMENT COMPRISES:.....	9
1.3 Purpose of the Document	9
2. THE DEVELOPMENT	11
2.1 Location of the Development	11
2.2 Information Sources.....	11
2.3 Limitations.....	11
3. SITE CHARACTERISATION	13
3.1 Site Characteristics	13
4. INITIAL CONCEPTUAL SITE MODEL	15
4.1 Introduction	15
4.2 Initial Conceptual Site Model	15
5. GROUND INVESTIGATION	19
5.1 Introduction	19
5.2 Scope of Works	19
6. ENVIRONMENTAL SAMPLING	21
6.1 Soil Sampling.....	21
6.2 PID Testing	21
6.3 Groundwater Level Monitoring and Sampling	21
6.4 Ground Gas Monitoring.....	21
6.5 Laboratory Chemical Analysis	22
7. GROUND CONDITIONS	24
7.1 Summary of Ground Conditions.....	24
7.2 Olfactory and Visual Records of Contamination	25
7.3 Ground Gas Monitoring Results.....	25
8. GENERIC QUANTITATIVE RISK ASSESSMENT	27

8.1 Human Health Risk Assessment	27
8.2 Controlled Water Risk Assessment.....	29
8.3 Ground Gas Risk Assessment.....	32
9. REVISED CONCEPTUAL SITE MODEL.....	35
10. PRELIMINARY WASTE CLASSIFICATION.....	42
10.1 Results of CAT-WasteSOIL	42
10.2 Waste Acceptance Criteria (WAC).....	42
11. CONCLUSIONS AND RECOMMENDATIONS.....	43
11.1 Conclusions	43
11.2 Recommendations	43
12. REFERENCES.....	44
APPENDIX A – DRAWINGS/FIGURES	45
APPENDIX B – GROUND INVESTIGATION FACTUAL REPORT	46
APPENDIX C – GQRA SCREENING SHEET – SOIL, LEACHATE.....	47
APPENDIX D – CSM FRAMEWORK	48
Table 3-1 Summary of Site’s historical and environmental setting	13
Table 4-1 Initial Conceptual Site Model and Risk Assessment.....	16
Table 5-1 Summary of exploratory holes	20
Table 6-1 Summary of PID Results.....	21
Table 6-2 Atmospheric pressure conditions during ground gas monitoring	22
Table 6-3 Soil sample testing suite	22
Table 6-4 Soil leachate testing suite	23
Table 7-1 Summary of Ground Conditions.....	24
Table 7-2 Summary of groundwater levels during Bam Ritchies 2022 Monitoring Regime.....	25
Table 7-4 Summary of visual/olfactory evidence of contamination	25
Table 7-3 Ground Gas Monitoring Results.....	26
Table 8-1 Summary of exceedances.....	28
Table 8-2 Concentration of determinands -LOD.....	28
Table 8-3 Summary of Soil Leachate DWS Exceedances.....	30
Table 8-4 Summary of Soil Leachate EQS Exceedances	30

Table 8-5 Site Characteristic GSV and associated characteristic situation (CS)	33
Table 8-7 Qhg Values	34
Table 9-1 Revised Conceptual Site Model and Risk Assessment (Use of the Site as a strategic construction compound).....	36
Table 10-1 CAT-Waste ^{SOIL} results summary	42

EXECUTIVE SUMMARY

Project Background	The proposed development is part of a wider scheme of works to improve drainage of the railway line for an approximately 300 m stretch of the line adjacent to the northern boundary of Clayton Vale Country Park (CVCP), to the west of the Clayton Bridge level crossing. This is required to alleviate a saturated track foundation problem and prevent the railway from flooding in this location. This report presents the findings of a ground investigation and subsequent risk assessment to identify potential contamination constraints.
Ground Investigations	A phased ground investigation was undertaken by BAM Ritchies in February, March, May and July 2022. The investigation comprised 1 No. cable percussive borehole (BH1), 1 No. window sampler borehole (BH2), 1 No. dynamic windowless sampler borehole (BH2A), 2 No. trial pits (TP1 and TP2) and 4 No. dynamic cone penetration (DCP) tests (DCP1-DCP4). Soil samples were collected and scheduled for chemical testing; groundwater samples have not been collected to date. Three rounds of ground gas monitoring were undertaken in borehole BH2 on in June, July and August 2022 and two rounds of ground gas monitoring in borehole BH2A in July and August 2022.
Ground Conditions	Ground conditions comprise Made Ground overlying boulder clay. In general, Made Ground comprises sand or sand and gravel including ash, brick, coal, clinker, ceramics, wood fragments, blast furnace waste, slate, and sandstone. Made Ground was recorded to a maximum depth of 8.7 m below ground level (bgl). Natural superficial deposits underlying the Made Ground comprise slightly gravelly, slightly sandy clay. Sand was recorded underling the Made Ground in a single location with an unproven thickness (recorded from 0.9 m to 1.2 m bgl). The bedrock was not proven on site. A weak creosote odour was noted in the Made Ground within BH2A between 4.26 to >6.00 m bgl, whilst a strong odour of creosote was noted in BH2 between 0.00 and 2.00 m bgl, recorded as “varying strength” between 2.00 m and 8.50 m bgl.
Human Health Risk Assessment	A total of twenty one soil samples were analysed from the Made Ground. Seven marginal exceedances of the human health generic assessment criteria (GAC) for benzo(a)pyrene. Asbestos was not detected in any of the twenty one samples collected from the Made Ground across the site. Following completion of the new drainage system and attenuation tank the footpath will be reinstated and sufficient thickness or top/subsoil replaced/imported promote vegetation growth. Topsoil, vegetation and hardstanding will restrict public exposure to the Made Ground. The risk to future site users is assessed as low.
Controlled waters Risk Assessment	Marginal exceedances of antimony, arsenic, lead and benzo(a)pyrene were recorded above Drinking Water Standards (DWS) and copper, lead, mercury, nickel, zinc, anthracene, benzo(a)pyrene and fluoranthene were recorded above the Environmental Quality Standards (EQS) within the soil leachate samples. Generally, the concentrations were marginally above the DWS, EQS and/or the limit of detection (LOD) (within the same order of magnitude of the DWS) and are considered unlikely to pose a risk to receptors. However, no groundwater samples were obtained to corroborate this. Further groundwater monitoring and sampling is proposed at this site and an updated groundwater risk assessment will be undertaken following completion of the monitoring.

Gas Risk Assessment	Peak maximum concentrations of 1.0 % volume per volume (v/v) methane and 0.70 % v/v carbon dioxide were recorded. Maximum steady state flow rate of 0.20 litres per hour (l/hr) recorded. Results indicate a very low risk to the development and future site users from ground gas. Maximum recorded photo-ionisation detector (PID) concentrations were 5.50 part per million (ppm). No obvious sources of volatile contaminants were identified during the ground investigation or were identified during chemical analysis of soils.
Preliminary Waste Classification	CAT-Waste^{SOIL} analysis on soil samples collected from the site indicates that nine samples tested are likely to be classified as non-hazardous. Twelve samples were classified by the CAT-Waste^{SOIL} tool as hazardous waste. These were the result of the presence of an unknown hydrocarbon/oil with marker compound and pH. Waste Acceptance Criteria (WAC) analysis was undertaken on a soil sample collected from BH2 at a depth of 0.5 m bgl. This material is classified as hazardous waste which requires disposal in a hazardous waste landfill based on recorded loss on ignition values and total organic carbon values. It is recommended that the waste producer should contact potential landfill operators to confirm their additional testing requirements prior to the off-site disposal of material to ensure the waste materials are transported to an appropriately licensed facility. It is the waste producer's responsibility to agree with the landfill operators the appropriate testing regime.

1. INTRODUCTION

1.1 Scheme Background

The wider TransPennine Route Upgrade (TRU) scheme aims to deliver faster, more frequent and reliable services between York and Manchester via Leeds and Huddersfield and improve connections between key towns and cities across the north of England.

The proposed development is part of a wider scheme of works to improve drainage of the railway line for an approximately 300 m stretch of the line adjacent to the northern boundary of Clayton Vale Country Park (CVCP), to the west of the Clayton Bridge level crossing. This is required to alleviate a saturated track foundation problem and prevent the railway from flooding in this location. Part of these works are within the railway line itself and within Network Rail's (NR) land ownership. As such these works benefit from NR's permitted development rights under Part 8 of the Town and Country Planning (General Permitted Development) (England) Order 2015.

However, part of the site is proposed to be within CVCP, which is in the ownership of Manchester City Council (MCC). Therefore, planning permission is sought for this element.

Atkins Limited (Atkins), has been commissioned by Network Rail to produce a Phase 2 Land Contamination Risk Assessment in support of planning permission for the proposed development.

1.2 Proposed Development

The proposed development comprises:

- An underground drain that will convey surface water from the railway line into an attenuation tank;
- An underground attenuation tank to receive and temporarily store surface water;
- Two pre-cast concrete catch-pits;
- A further underground drain from the attenuation tank to an outfall/headwall; and
- An outfall/headwall to an existing watercourse, which feeds into the River Medlock.

The proposed development is shown on the General Arrangement Drawing (151667-TSA-17-MVL1-DRG-R-DR-060041) included within Appendix A.

1.3 Purpose of the Document

This Phase 2 has been prepared in respect of Condition 5 of the planning permission.

The purpose of this document is to present the findings and interpretation of the recent phases of ground investigation undertaken to inform the design and support the consenting requirements for the Development.

The excavation and re-use of site won materials will be undertaken during the site works. In order to assess the potential risks posed to human and environmental receptors, present during construction and the future use of the Development, from contaminants/gas, ground investigation data from within the Planning Application boundary have been combined and used within this report

The key objectives of the report are to:

- Summarise key information from desk study sources;
- Describe the recent phases of ground investigation and present the findings;
- Production of a generic quantitative risk assessment (GQRA) to assess the potential risk to human health and controlled waters from the Development using recent ground investigation data;

- Preparation of a ground gas risk assessment following on from post-fieldwork monitoring;
- Undertake preliminary waste characterisation;
- Revision of the Conceptual Site Model (CSM);
- Preparation of a geo-environmental assessment report detailing the ground investigation findings and assessment of the results; and
- Provide recommendations and suggestions for further works based on the collated ground and groundwater conditions.

2. THE DEVELOPMENT

2.1 Location of the Development

The site is located west of Berry Brow Road to the north-west of Droylsden. The nearest postcode for the site is M40 1GR. The site is located 80 m north of the River Medlock in the north east corner of Clayton Vale Country Park and the site's northern boundary is located adjacent to the Manchester Victoria and Huddersfield Railway Line. The site is centred on grid reference E388928, N399580 and is shown on the site location plan presented as Drawing 51667-TSA-17-MVL1-DRG-R-DR-060038 within Appendix A.

2.2 Information Sources

The recommendations made in this report are based principally on information contained within the following sources of information:

- Atkins, Clayton Bridge Phase 1 Land Contamination Desk Study 151667-TSA-00-TRU-REP-W-LP-000058 P02, March 2022, which uses the following sources:
 - Groundsure (GSIP-2022-12587-9697) Data Sheet;
 - Groundsure (GSIP-2022-12587-9696) Historical Mapping;
 - Current and historical online aerial imagery **(1)**;
 - British Geological Survey (BGS) GeoIndex and mapping **(2)**;
 - Coal Authority Interactive online map **(3)**;
 - UK Radon Interactive online map **(4)**;
 - DEFRA's Multi Agency Geographic Information for the Countryside (MAGIC) map viewer **(5)**; and
 - Online regional unexploded bomb risk map **(6)**.
- BAM Ritchies Transpennine Route Upgrade Factual Account of Ground Investigation – W1B – SPO5.3W – MVL1 Drainage Tanker Access Assessment – GRIP 5 Transpennine Route (Appendix B).

2.3 Limitations

The report authors are responsible for selecting and summarising the data supplied by third parties but cannot be held responsible for any mistakes or inaccuracies or the completeness of third-party data on which it has relied. As with any point data, ground conditions can only be inferred between test locations and as such localised conditions on site may vary between point locations and groundwater/ground gas conditions may differ from those encountered during the monitoring periods. Therefore, this report cannot guarantee against unexpected ground conditions occurring between the sampling points.

This report presents the preliminary findings of a geo-environmental ground investigation and risk assessment to inform the client about potential contamination hazards and constraints relating to the Development. Constraints relating to geotechnical hazards, coal mining, ecology, heritage, flooding/drainage, utilities, air quality and noise are beyond the remit of this report.

Ground gas and groundwater conditions are based on observations made at the time of the ground investigations and monitoring programmes, and may be subject to variation due to atmospheric, seasonal or other effects.

The CSM developed and GQRA carried out for human health has been based on using screening criteria for a commercial land use scenario. Any changes to the Development from those indicated in Section 2.1 may require revision of the CSM and reassessment of the risk assessment findings if the final development differs substantially from these assumptions.

This report does not advise on measures to deal with asbestos. Detailed advice should be sought from a specialist contractor.

3. SITE CHARACTERISATION

3.1 Site Characteristics

A summary of the historical and environmental setting of the site is presented in Table 3-1. This information has been summarised from the findings of the Phase 1 Land Contamination Desk Study and from observations during the ground investigation works.

Table 3-1 Summary of Site's historical and environmental setting

Item	Description
Current site description and use	The site is irregular in shape and covers an area of 1,019 m ² (0.102 hectares). The elevation of the site is approximately 61.5 m to 72 m AOD, sloping towards the south. The site predominantly comprises public open space which is vegetated and a public hardstanding footpath through the centre of the site orientated east to west. The north of the site is located within Network Rail owned land.
Key historical land uses	A railway station is recorded to the west of the site between 1891 and 1923 and to the north east of the site between 1851 and 1968. A railway line is recorded to the north of the site and Berry Road to the east. In addition, allotment gardens are present on site between 1931 and 1932. An unspecified pit is recorded on site in 1956 and as a refuse heap in 1968.
Geology	Artificial Ground: Made Ground (undivided). Superficial Deposits: Till, Devensian comprising Diamicton, Bedrock: Collyhurst Sandstone Formation
Mining	There are two surface ground workings on site (refuse heap and unspecified pit) and an additional 82 within 250 m of the site.
Hydrogeology	Superficial: Secondary A aquifer Bedrock: Principal aquifer The site is not located within a Source Protection Zone (SPZ). There is one groundwater abstraction licence recorded within 250 m of the site; a historical groundwater abstraction was located 157 m south-east of the site, extracting water for general use and was operated by Manchester Abattoir.
Hydrology	The nearest surface water feature is an "unnamed inland river" and is located 1 m south of the site. The River Medlock is located 80 m south of the site and has a WFD Overall Classification of Moderate.
Flooding	The site and land within 50 m of the site boundary is not at risk of flooding from rivers and seas. A medium risk of flooding from rivers and the sea is located 60 m south of the site, associated with the River Medlock. The highest risk of surface water flooding to occur on site is indicated to be 1 in 100 year, 0.1 m to 0.30 m. The site is within an area of moderate potential for groundwater flooding.
Landfills and Waste	A historical landfill is recorded onsite which was licenced to accept Inert, Industrial, Commercial, Household, Special and Liquid sludge. Two further historical landfills are recorded 82 m north-east and 192 m south-east of the site.
Discharge consents	There are no licensed discharges to groundwater features within 250 m of the site.
Pollution Incidents	A single Category 3 (minor) incident occurred in July 2001 where storm sewage impacted a watercourse 199 m south-east of the site.

Item	Description
Pollution Controls	None recorded within 250 m of the site.
Trade Directory Entries and Fuel Stations	There are two recent industrial land uses within 250 m of the site, relating to an electricity substation, located 164 m south-east and 247 m north-west of the site. There are no fuel stations recorded within 250 m of the site.
Sensitive Land Uses	The site is located within the Clayton Vale Local Nature Reserve (LNR).
Radon	The UK Radon Map also indicates that the maximum radon potential of the site is 1 – 3 %. This indicates that no radon protection measures are required in the construction of new dwellings.
UXO Risk	There is a moderate risk of unexploded bombs (UXB) on the site.

4. INITIAL CONCEPTUAL SITE MODEL

4.1 Introduction

Primary guidance for assessing and managing risks posed by land contamination is presented in Land Contamination: Risk Management (LCRM) published by the Environment Agency on 8 October 2020. LCRM provides a technical framework (and signposts other key guidance) for identifying and remediating contamination through the application of a risk management process. The question of whether a risk is unacceptable in any particular case involves not only scientific and technical assessments, but also appropriate criteria by which to judge the risk and conclude exactly what risk would be unacceptable.

An initial CSM was presented within the Phase 1 Land Contamination Desk Study, this has formed the basis of the CSM presented in Table 4-1. A CSM describes the relationship between potential sources of contamination (resulting from both on- and off-site historical and recent activities) and receptors to the potential contamination. As part of the CSM development, three elements are identified and assessed:

- Source of contamination and associated contaminants;
- Receptors to that contamination – human beings, controlled waters (surface water/groundwater), ecological systems and property/services; and
- Pathways between the sources and receptors.

Where all three elements are present or are likely to be present, they are described as potential contaminant linkages (PCLs), which can then be subjected to the risk assessment and risk management process.

4.2 Initial Conceptual Site Model

The preliminary risk categorisations presented are based on an assessment of the potential consequence of each PCL occurring along with the likelihood that each PCL will occur in accordance with the framework provided in Appendix C. Potential contamination that might be present has been identified through knowledge of historical land uses on or adjoining the site.

Under current health and safety legislation, construction and maintenance staff are required to carry out their own appropriate risk assessments and mitigation to protect their staff, other human receptors and the environment from potential contamination. Such risks must be adequately mitigated by law, specifically the Construction Design Management (CDM) Regulations (Health and Safety Statutory Executive, 2015), that require potential risks to human health and the environment from construction activities are appropriately identified and all necessary steps taken to eliminate/manage that risk. However, for completeness the workers involved in the construction of the Development (or maintenance workers involved in excavations) have been included as human receptors within the CSM.

Table 4-1 Initial Conceptual Site Model and Risk Assessment

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
Potential contaminants in soil/groundwater on-site, originating from the following <u>on-site</u> sources: • Made Ground associated with historical uses of the site; • Refuse heap/historical landfill; • Infilled ground; • Railway station; • Radon.	Inhalation, ingestion and dermal contact with contaminants in soil and soil derived dust.	<u>Human Health</u> – On-site: Members of the public, Network Rail workers Off-site: Members of the public, railway workers and residents	Unlikely	Medium	Low Risk Based on the historical use of the site, it is possible that contamination may be present in the soils. Following completion of the new drainage system and attenuation tank the footpath will be reinstated and sufficient thickness of top/subsoil replaced/imported (subject to meeting re-use/import criteria) to promote vegetation growth. The topsoil/vegetation and hardstanding will restrict public exposure to the underlying Made Ground. It is also assumed that topsoil and/or gravel will be replaced at surface within Network Rail land. Therefore, landfill material underlying the site is unlikely to pose an unacceptable risk to the public or Network Rail employees.
	Inhalation of asbestos fibres.		Unlikely	Severe	Low/Moderate Risk Due to the anticipated presence of landfill materials on site there is the potential for asbestos to be present. The site will be covered in hardstanding or top/subsoil and vegetation which will limit exposure to the underlying Made Ground.
Possible contaminants include: <i>Asbestos</i> <i>Metals</i> <i>Ammonia</i> <i>Cyanide</i> <i>Sulphate</i> <i>Polycyclic aromatic hydrocarbons (PAHs)</i> <i>Petroleum hydrocarbons</i> <i>Volatile organic compounds (VOCs) & Semi-volatile organic compounds (SVOCs)</i> <i>Ground gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide)</i>	Migration of gases into confined spaces/buildings and accumulation (explosion). Inhalation of ground gas (asphyxiation). Inhalation of vapours.	<u>Human Health</u> – On-site: members of the public and Network Rail workers Off-site: Members of the public, railway workers and residents <u>Property</u> – On-site: Infrastructure associated with new drainage and railway infrastructure Off-site: commercial services and residential properties	Low likelihood	Severe	Moderate Risk As no new buildings are proposed on site and exposure times are likely to be low (users of public footpath/park), it is unlikely that ground gas/vapours will pose an unacceptable risk as they would disperse into the atmosphere. No buildings are located within Network Rail land in the north of the site, with the workforce undertaking the majority of their work outdoors. Gas/vapours are likely to disperse into the atmosphere. Potential sources of ground gas have been identified based on desk study information, including the presence of a landfill on site. The degree of risk posed by the landfill will be dependent on the type of material present. The landfill is recorded to have been licensed to accept inert, industrial, commercial, household, special and liquid sludge waste and is noted to have stopped accepting waste in 1968, indicating that over 50 years have passed since infilling stopped. Gas production of inert waste is minimal and any gas generation is likely to have declined over time. However, the presence of an attenuation tank on site may create an enclosed space (particularly when empty) which may result in ground gas build up and explosion if methane is present. Gas risk will need to be considered as part of the design of the proposed works. The nearest residential properties are located 20 m east of the site. However, the proposed works are unlikely to create new gas migration pathways to off-site receptors and the current gas regime is unlikely to be altered.
	Direct contact of foundations/services with aggressive soils and or groundwater. Chemical attack to buried structures.		Likely	Medium	Moderate Risk Due to the likelihood of landfill material being present on site there is the potential for aggressive ground conditions in relation to buried structures (e.g. sulphate concentrations might affect the type of concrete used for the development and plastics utilised within pipes and the attenuation tank). Materials that are chemically resistant may need to be utilised and this should be assessed during design.

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration Lateral and vertical migration through Made Ground, superficial deposits and bedrock. Migration via preferential pathways e.g. proposed service pipes/trenches, piled foundations.	<u>Groundwater Controlled Waters</u> – Secondary A Superficial Aquifer and Principal Bedrock Aquifer.	Likely	Medium	Moderate Risk If significant Made Ground/landfill material is present, there is potential for leaching of contaminants into groundwater in the superficial deposits and bedrock. However, at present the thickness/composition of Made Ground and superficial deposits underlying the site is currently unknown. It is likely that the proposed works are to take place within the Made Ground and/or superficial deposits, with the construction of the attenuation tank requiring the removal of landfill material from site. The presence of heterogeneous Glacial Till underlying the site means that granular layers could be present (which might provide a preferential contaminant migration pathway to, for example, the river). The works undertaken are unlikely to impact upon bedrock underlying the site, with works unlikely to create a pathway to the underlying principal aquifer.
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration Lateral and vertical migration through Made Ground, superficial deposits and bedrock Surface water run off. Migration of contaminated water in drainage ditches to controlled surface waters.	<u>Surface Water Controlled Waters</u> – adjacent stream and the River Medlock	Likely	Medium	Moderate Risk The nearest surface water feature is an unnamed watercourse, currently located adjacent to the southern site boundary. If significant Made Ground or contamination is present, there is a potential risk to surface water as the works may introduce a pathway for contaminants for example along new pipe trench backfill. Ground disturbance during construction is likely to increase leaching, however, this will only be temporary. Works are likely to result in the removal of material from site, primarily landfill material/Made Ground, for the construction of the attenuation tank and pipework. This will result in the reduction of source material on site, therefore reducing the impact upon controlled waters. The development itself is designed to funnel excess water off the surrounding area to a tributary of the River Medlock, therefore managed water flow to the receptors is a key consideration in the development design.
	Contact/absorption of contaminants by flora/fauna in Clayton Vale Local Nature Reserve	<u>Environment and Ecology</u> - Clayton Vale Local Nature Reserve	Unlikely	Medium	Low Risk The site is located within the Clayton Vale Nature Reserve which is underlain by a landfill. It is unlikely that the works undertaken at the site are going to introduce new pathways for contaminant migration as the wider Nature Reserve is underlain by the landfill.
Potential contaminants in soil/groundwater on-site, originating from the following <u>off-site</u> sources: • Made Ground associated with off-site land uses; • Historical railway activities; • Unspecified disused tips and refuse heaps; • Dyeing and finishing works; • Unspecified pits, ground workings, heaps;	Inhalation, ingestion and dermal contact with contaminants in soil derived dust.	<u>Human Health</u> – On-site: members of the public and Network Rail workers Off-site: Members of the public, railway workers and residents	Unlikely	Medium	Low Risk The majority of the surrounding area is currently either covered in residential properties, hardstanding or vegetation, which would limit exposure to underlying soils and thus dust generation.
	Leaching of contaminants from soil and migration to groundwater, followed by	<u>Groundwater Controlled Waters</u> - Secondary A Superficial Aquifer and	Low Likelihood	Medium	Moderate/Low Risk Groundwater is likely to flow to the south towards the River Medlock, so there is a possibility that contaminants from the north of the site might be transported beneath the site by groundwater. Till is

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
• Railway buildings; • Railway station; • Smithy; • Unspecified mill; • Rubber Works; • Unspecified factory; • Electricity sub station; • Discharge consents to surface waters; • Landfills and waste exemptions; and • Pollution incidents. Possible contaminants include: <i>Asbestos</i> <i>Metals</i> <i>PAHs</i> <i>Petroleum hydrocarbons</i> <i>VOCs</i> <i>PCBs</i> <i>Ground gases (radon, methane, carbon dioxide, hydrogen sulphide and carbon monoxide)</i>	lateral migration beneath the site. Migration of gases into confined spaces/buildings and accumulation (explosion). Inhalation of ground gas (asphyxiation).	Principal Bedrock Aquifer. <u>Surface Water</u> <u>Controlled Waters</u> – Unnamed watercourse and the River Medlock <u>Human Health</u> – On-site: members of the public and Network Rail workers Off-site: Members of the public, railway workers and residents <u>Property and Services</u> – On-site: infrastructure associated with new drainage and railway infrastructure Off-site: commercial services and residential properties			heterogeneous and can be highly variable in composition, therefore it is possible that groundwater may flow through granular layers under the site towards the River Medlock. Sources of contamination are present to the north of the site (upgradient) include historical railway activities/features (15 m), unspecified heaps (20 m) and pits (10 m) and a rubber works (215 m). The main sources of off-site contamination which pose a risk to controlled waters are the historical features associated with the railway to the north. The degree of risk posed by this PCL will be dependent on degree of contamination already present within groundwater flowing beneath the site, the geology encountered, the depth to groundwater and whether the proposed works are likely to intercept groundwater. Moderate Risk The main source of gas/vapours is the landfill which extends off site to the south and west. However, due to the age of input ceasing (1968) and the material accepted by the landfill (inert , industrial, commercial, household, special and liquid sludge waste), landfill gas is unlikely to be produced at significant enough levels to pose an unacceptable risk. The remaining potential off-site sources of ground gas are located more than 100 m from the site and are therefore unlikely to produce sufficient gas volumes to migrate over such a distance. Due to the lack of buildings on site and short exposure times, ground gas/vapours are unlikely to pose an unacceptable risk to human health. However, the creation of enclosed spaces, within the attenuation tank, could result in a build-up of ground gas and possible explosion. The proposed design should consider the risk of creating new potential gas migration pathways.

5. GROUND INVESTIGATION

5.1 Introduction

BAM Ritchies have carried out a ground investigation at the site to inform the design of the Scheme, the Factual Report is included as Appendix B.

The aims of the investigation, with respect to land contamination/gas were to:

- collect data on the ground conditions and groundwater depth;
- collect soil and groundwater samples for laboratory analysis of potential contaminants of concern (identified from desk-based information); and
- undertake ground gas and groundwater monitoring from installed wells.

5.2 Scope of Works

The preliminary ground investigation was designed to target potential sources of contamination and to provide an overall summary of ground conditions. Wells were installed to enable collection of groundwater samples from within the Made Ground and superficial deposits to target possible gas migration pathways from on- and off-site sources.

The environmental chemical testing suite was based on contaminants of concern identified during a review of desk-based information, including the historical uses of the site and on the Network Rail owned land adjacent to the north. Volatile head space testing using a photoionisation detector (PID) was undertaken on site by the BAM site engineer, on environmental samples to assess the risk posed by volatile contaminants within soil.

Two exploratory holes, BH02 and BH2A, were installed to monitor ground gas and groundwater. BH2A targeted the Made Ground whilst BH2 targeted the Glacial Deposits. The installation details are shown in the logs presented within the Factual Report included in Appendix B and are summarised in Table 5-1. The locations of the exploratory holes are presented on an exploratory hole location plan presented within the factual report included as Appendix B.

Table 5-1 Summary of exploratory holes

Exploratory Hole Type	Exploratory Hole Number	Termination Depth (m bgl)	BH Purpose/Comment*	Installation response zone (m bgl)	Strata Screened
CP	BH1	12.50	Confirm ground and groundwater conditions.	-	-
WS	BH2	11.00		10.00 – 11.00	Glacial Deposit
WLS	BH2A	6.00		1.00 – 6.00	Made Ground
TP	DCP1	1.20	Confirm shallow ground conditions.	-	-
TP	DCP2	1.20		-	-
TP	DCP3	1.20		-	-
TP	DCP4	1.20		-	-
TP	TP1	1.20		-	-
TP	TP2	1.20		-	-
TP	TP2	1.20		-	-

Note:

* Sampling was undertaken at BH1, BH2, DCP1, DCP2, DCP3, DCP4, TP1 and TP2 for chemical analysis.

CP = Cable Percussion, WS= Window Sampler, WLS= Dynamic (windowless) sampler, DCP= Dynamic Cone Penetrometer, TP = Trial Pit/trench, BH = Borehole.

6. ENVIRONMENTAL SAMPLING

6.1 Soil Sampling

Environmental soil samples were collected on site during the ground investigation by the site engineer and transported to Envirolab for chemical analysis. Envirolab is a United Kingdom Accreditation Service (UKAS) and Monitoring Certification Scheme (MCERTS) accredited laboratory.

21 No. soil samples were collected by the site engineer and transported to the laboratory of Envirolab chain of custody delivery process. It is noted that a duplicate sample has been analysed from BH1 at a depth of 0.2 m bgl, chemical testing results are within the same order of magnitude for this duplicate sample.

6.2 PID Testing

Environmental soil samples were screened on-site by a site engineer with a Photo Ionisation Detector (PID). This test provides an indication of the presence and concentration of Volatile Organic Compounds (VOCs) in soil vapour and informs the appropriate selection of laboratory analysis. In-situ testing results from each exploratory hole are presented on their respective logs and where readings were above the limit of detection are shown in Table 6.1

Table 6-1 Summary of PID Results

Location ID	Depth of headspace test sample (m)	Result of PID analysis (PPM)
BH2	0.20	0.60
BH2	0.50	3.90
BH2	1.00	5.50
BH2	1.60	1.30
BH2	2.40	1.50
BH2	3.40	0.40
BH2	4.40	0.50
BH2	5.40	1.20
BH2	6.40	2.30
BH2	7.40	1.30
BH2	8.30	0.70
BH2	10.20	0.40
DCP4	1.00	2.90
TP2	0.50	0.10
TP2	1.00	2.60

6.3 Groundwater Level Monitoring and Sampling

During 2022 ground investigation, no groundwater was encountered during the drilling in any of the locations. Groundwater monitoring has been undertaken on two occasions for BH2A and three occasions for BH2 between June and August 2022.

Details of groundwater monitoring are included in Section 7.1. No groundwater samples have been obtained to date and this is recommended to characterize the quality of groundwater on site.

6.4 Ground Gas Monitoring

Ground gas monitoring was carried out by a site engineer using a calibrated GA5000 and dip meter at BH2 on three occasions over a 3-month period, between June to August 2022. Gas monitoring was undertaken at a second borehole, BH2A, on two occasions, July and August 2022. Table 6-2 details the atmospheric conditions during the three rounds of monitoring.

Methane, carbon dioxide, carbon monoxide, hydrogen sulphide, oxygen and gas flow rate were recorded along with groundwater levels and are discussed in Section 7.2.

Table 6-2 Atmospheric pressure conditions during ground gas monitoring

Monitoring Round	Date	Pressure (mbar)
one	2022-06-07	1010.00
two	2022-07-07	1023.00
three	2022-08-02	1005.00

6.5 Laboratory Chemical Analysis

Chemical analysis of environmental samples collected during 2022 were scheduled by the authors of this report and carried out by Envirolab under the UKAS and the MCERTS accreditation schemes. Chemical analysis was based on contaminants of concern (CoC) identified in the initial CSM from consideration of historical and current land-uses, in-situ PID testing, and ground conditions encountered on-site.

Soils

Selected soil samples from ground investigation were scheduled for soil analysis comprising the determinands in Table 6-3.

Table 6-3 Soil sample testing suite

Determinand	Number of samples tested
Metals (antimony, barium, beryllium, arsenic, boron, cadmium, chromium, Iron, copper, lead, manganese, mercury, nickel, zinc, selenium and vanadium)	21
Metals (chromium hexavalent)	19
Metals (Molybdenum, barium)	17
pH	21
Chloride	17
Total Organic Carbon (TOC)	21
Total Speciated PCB-WHO12	16
Cyanide (complex & free)	20
Cyanide (total)	21
Thiocyanate	20
Asbestos ID	19
Volatile organic compounds (VOCs)	16
Semi volatile organic compounds (SVOCs)	16
Total petroleum hydrocarbons (TPH UKCWG)	16
Dioxins & Furans	13
Speciated polycyclic aromatic hydrocarbons (PAHs)	16

Soil leachate

Selected soil leachate samples collected during the 2022 ground investigations were scheduled for leachate analysis by the authors of this report, comprising the determinands set out in Table 6-4.

Table 6-4 Soil leachate testing suite

Determinand	Number of samples tested
Metals (antimony, arsenic, boron, cadmium, copper, chromium, lead, magnesium, mercury, nickel, selenium, vanadium, and zinc)	4
pH	4
Ammoniacal Nitrogen as N	4
Sulphate	4
Cyanide (total & free)	4
Total PAH	4
Total Speciated PCB-WHO12	4

7. GROUND CONDITIONS

7.1 Summary of Ground Conditions

Ground conditions have been summarised using data gathered from the 2022 ground investigations in Table 7.1. Olfactory and visual signs of contamination along with PID results are discussed in Section 7.3.

Table 7-1 Summary of Ground Conditions

Strata	Locations	Top of Stratum Depth (m bgl)	Top of Stratum Depth (m AOD)	Bottom of Stratum Depth (m bgl)	Bottom of Stratum Depth (m AOD)	Thickness (m)
Tarmac	DCP	0.0	70.70	0.2	70.50	0.2
Topsoil	BH1, DCP1 and DCP2	0.0	70.69 71.23	– 0.1 – 0.2	70.59 71.03	– 0.1 – 0.2
Made Ground	All	0.0 – 0.2	70.43 71.03	– 1.2* - 8.7	61.99 70.03*	– 1.2* - 8.6
Superficial Deposits – Cohesive	BH1 and BH2	8.5 – 8.7	61.99 62.07	– 11.0* – 12.5*	58.19* 59.57*	– 2.5* - 3.8*
Bedrock	Not encountered					

*maximum depth/thickness not proven

Made Ground

Made Ground was encountered across the site to a maximum depth of 8.70 m bgl within the BH1. Made Ground was generally granular and described as “dark greyish black slightly silty slightly gravelly fine to coarse sand” or “grey very sandy slightly silty gravel”. Within BH2, brownish grey locally yellowish/orangish brown clayey sand and gravel was encountered from 2.00 m to 8.50 m bgl. Within BH2A and DCP2, firm to stiff dark greyish black sandy gravelly clay from 1.2 m to 6.0 m bgl and 0.2 m to 0.9 m bgl, respectively.

Sand in general comprised ash and gravel sized fragments of brick, coal, clinker, slag, mudstone, limestone and sandstone were recorded. Rare ceramic, plastic, metal and wood fragments have also been recorded within the Made Ground.

Topsoil

Topsoil was encountered in 3 exploratory holes across the site to a maximum depth of 0.20 m bgl. Topsoil is described as dark greyish black slightly sandy gravelly clay.

Superficial Deposits

Superficial deposits were encountered in two of the exploratory holes across the site to a maximum depth of 12.50 m bgl. These are generally described as stiff dark brown slightly gravelly slightly sandy clay.

Orangish brown fine to coarse sand was recorded in DCP from 0.9 m to the base of the exploratory hole at 1.2 m bgl.

Groundwater levels

Groundwater levels were monitored by the site engineer during the 2022 ground investigation and no groundwater was detected. Furthermore, groundwater levels were subsequently monitored in the installed boreholes, in BH2 during June and August 2022 and BH2A during July and August 2022. The groundwater levels recorded are summarised in Table 7.2.

Table 7-2 Summary of groundwater levels during Bam Ritchies 2022 Monitoring Regime

Borehole No	Monitoring Round	Water Screen	Groundwater Level (m bgl)	Groundwater Level (m AOD)
BH2	one	10.00 – 11.00	8.90	2.10
BH2	two		8.89	2.11
BH2	three		8.80	2.20
BH2A	one	1.00 – 6.00	Dry	Dry
BH2A	two		Dry	Dry

7.2 Olfactory and Visual Records of Contamination

Soils

The majority of exploratory holes across the site encountered Made Ground which included anthropogenic materials such as ceramics, soft plastics, crushed brick, ash, clinker, slag, coal and partially burnt coal, brick, timber, blast furnace waste, burnt furnace slag, shale and rare inclusions of plastic, glass and metal.

Details of olfactory / visual evidence of hydrocarbon/chemical contamination recorded on logs, within the Made Ground, are outlined in Table 7-4.

Table 7-3 Summary of visual/olfactory evidence of contamination

Exploratory Hole	Depth (m bgl)	Strata	Comment
BH2	0.00 to 2.00	Made Ground	Strong creosote odour
BH2	2.00 to 8.50	Made Ground	Varying creosote odour
BH2A	4.46 to 6.00	Made Ground	Weak creosote odour

No evidence of contamination was recorded in groundwater during the monitoring.

7.3 Ground Gas Monitoring Results

The results of ground gas monitoring are summarised in Table 7-3, with peak and steady state gas concentration values and flow rates taken from across the whole monitoring period presented.

Table 7-4 Ground Gas Monitoring Results

Exploratory Value	Date	Well Screen range (m bgl)	Screened Deposits	Flow (l/hr)		Methane (% v/v)		Carbon dioxide (% v/v)		Oxygen (% v/v)		Max Carbon monoxide (ppm)		Response Zone Flooded
				Max	Max Steady	Max	Max Steady	Max	Max Steady	Min	Min Steady	Max	Max Steady	
BH2	07/06/2022	10.00 to 11.00	Glacial Deposit	0.10	0.10	0.20	0.20	0.20	0.20	21.30	21.30	21.00	21.00	Yes
	07/07/2022			0.20	0.20	0.00	0.00	0.20	0.20	20.70	20.70	2.00	2.00	Yes
	02/08/2022			0.20	0.20	0.90	0.90	0.70	0.70	20.20	20.20	5.00	5.00	Yes
BH2A	07/07/2022	1.00 to 6.00	Made Ground	0.20	0.20	0.00	0.00	0.60	0.60	20.30	20.30	0.00	0.00	No
	02/08/2022			0.20	0.20	1.00	1.00	0.70	0.70	20.20	20.20	0.00	0.00	No

8. GENERIC QUANTITATIVE RISK ASSESSMENT

8.1 Human Health Risk Assessment

Introduction

A generic quantitative risk assessment (GQRA) has been carried out to assess the potential long-term risks to human health receptors in relation to the development at the site and the identified key contaminants of concern. Given the potential pathways identified in the initial CSM, soils have been screened against generic assessment criteria (GAC) based on a Public Open Space (Parks) - 6% SOM Sandy Loam. The GAC are derived following consideration of inhalation, ingestion and dermal contact with the soil/dust and inhalation of vapours originating from soils and groundwater.

Data collected from the 2022 ground investigations have been utilised as part of the human health risk assessment. Asbestos has also been considered within this assessment.

Methodology

In order to identify potential contaminants of concern (CoCs), the soil analytical data has been screened against Atkins' soil screening values (SSVs) or Category 4 Screening Levels (C4SLs) derived to be protective of chronic risks to human health.

SSVs are based on minimal toxicological risk (7) a variety of standard land uses at 1% soil organic matter (SOM) (sand soil type) and 6% SOM (sandy loam soil type) using CLEA v1.071 in accordance with Environment Agency guidance (7).

Based on the ratio of genotoxic PAHs to benzo(a)pyrene, the surrogate marker approach for genotoxic PAHs as set out in the C4SL Project Methodology (8) has been adopted.

Samples were analysed for total organic carbon (TOC) and have been converted to Soil Organic Matter (SOM) by the following formulae $SOM = TOC \times 1.72$. The laboratory data of the soil collected from the site indicates a geometric mean of TOC of 6.82, providing a result of 11.74 for SOM. Samples where visual and/or olfactory evidence of hydrocarbon contamination was noted were excluded from the SOM calculation. The GAC for 6% SOM was selected for use within the GQRA.

Due to the nature of risk from asbestos an SSV cannot be derived using CLEA. Therefore, for generic quantitative risk assessment the limit of detection at the laboratory has been selected as the assessment criterion.

Comparison of Soil Concentration Data with Generic Assessment Criteria

Twenty-one soil samples have been retrieved from across the site during the ground investigations and analysed for a range of contaminants. A full set of analytical results are included in Appendix B and the screening sheets are within Appendix C. These results have been compared against the GAC outlined above and most of the contaminants were recorded below the GAC, with the single GAC exceedance detailed in Table 8-1.

Table 8-1 Summary of exceedances

Determinand	Unit	LOD	GAC (mg/kg)	No. of samples	No. of exceedances	Max value (mg/kg)	Location of exceedance
Benzo(a)pyrene	mg/kg	0.04	21.4	16	7	62.4	BH1, 0.2m; TP2, 0.5m; TP2, 1m; DCP4, 0.5m; BH2, 0.2m; BH2, 0.5m; BH1, 0.2m

Asbestos was not identified within the twenty-one samples collected across the site.

The concentrations of PCBs did not exceed the limit of detections.

Total dioxins, furans, and dioxin like PCBS were analysed for 13 soil samples and recorded concentrations ranged from 0.0185 µg/kg to 5.799 µg/kg. The EA recommend an SGV of 8 µg/kg for a residential end-use scenario (9). This is considered a conservative estimate for the proposed development, however, no exceedances were recorded.

Concentrations of determinands where GACs are not available but exceed the limit of detection (LOD) are outlined in Table 8-2.

Table 8-2 Concentration of determinands -LOD

Determinand	Unit	LOD	No. of samples	Above the LOD	Max value
Dibenzofuran	mg/ kg	0.10	16	11	16.1
Carbazole	mg/ kg	0.10	16	12	12
2-Methylnaphthalene	mg/ kg	0.10	16	10	9.08
Perylene	mg/ kg	0.10	16	12	25.1

Deviating samples

Compounds cyanide (free), cyanide (total), TPH CWG, VOC, SVOC, sulphide and BTEX were recorded to be deviating for various samples from BH2 due the holding times being exceeded. Sulphide was recorded as deviating in samples collected from BH1 as well due to holding times being exceeded.

Human Health Risk Assessment Conclusions

Seven exceedances of the human health assessment criteria for benzo(a)pyrene were recorded across the site. The predominant pathways by which benzo(a) pyrene poses a risk to human health are through direct contact and ingestion of soil and dust. Following completion of the new drainage system and attenuation tank the footpath will be reinstated and sufficient thickness of top/subsoil replaced/imported to promote vegetation growth. The topsoil/vegetation and hardstanding (paths) will restrict public exposure to the underlying Made Ground. The benzo(a)pyrene exceedances recorded are within one order of magnitude of the GAC, therefore they are considered to be marginal, and given the proposed development the risk is assessed as low.

Asbestos was not detected from any of the collected samples.

SVOCs and VOCs tests were analysed, and the results are within the limit of detection with the exception of dibenzofuran, carbozole and perylene. The predominant pathways by which these compounds pose a risk to human health are through direct contact and ingestion of soil and dust. Topsoil/vegetation and hardstanding (paths) will restrict public exposure to the underlying Made Ground. Therefore the risk to future site users has been assessed as low.

The development is likely to comprise of underground drains, attenuation tank and two pre-cast concrete catchpits, this is unlikely to moderate the exposure pathway to the underlying Made Ground for the majority of site users. The short-term risks that might be posed to construction workers excavating for proposed development, etc will be considered by their employers within health and safety risk assessments.

8.2 Controlled Water Risk Assessment

Introduction

The controlled waters GQRA has been undertaken to assess the potential risks posed to the identified controlled waters receptors from the migration of contaminants from potential on site sources. To assess the potential risks to the identified receptors, a comparison of soil leachate and groundwater concentrations against pertinent Water Quality Standards (WQS) has been undertaken.

Methodology

The preliminary ground investigation identified that the majority of the site is underlain with Made Ground. Superficial deposits were generally recorded as cohesive, with a sand horizon noted in one position, with an unknown thickness. The superficial aquifer is classified as a Secondary A, however this is likely associated with the alluvium recorded to the south of the site. Superficial deposits encountered on site are likely to act as an aquiclude between the Made Ground and the Principal bedrock aquifer. The site is not located within a Source Protection Zone (SPZ). There is no active groundwater abstraction licences recorded within 250 m of the site.

The nearest surface water feature is an “unnamed inland river” and is located 1 m south of the site. The River Medlock is located 80 m south of the site and has a WFD Overall Classification of Moderate.

The WQS for the controlled waters assessment are dependent on the nature of the receptors (as identified above). Due to the close proximity of the nearest surface water receptor and as Made Ground is in direct contact with the underlying secondary A Aquifer, the risk to both surface water receptors and groundwater receptors have been considered. Therefore, soil leachate results will be screened against Drinking Water Standards (DWS) and Environmental Quality Standards (EQS). The assessment to groundwater is considered a conservative approach given the site is not located within 250m of a potable water abstraction or SPZ and superficial deposits encountered were cohesive.

Soil-derived leachate tests give an indication of the concentrations at which contaminants might leach from soil into soil pore-water and thereby migrate to groundwater. Groundwater samples provide an indication of the groundwater quality and the contaminants that could migrate within the aquifers underlying the site.

The laboratory results are presented in Appendix B and the screening results in Appendix C.

Results

Results for potential contaminants of concern (i.e. those that exceed the screening value) are presented in Tables 8-5. A full set of screening results are presented within Appendix C.

Soil Leachate

Four soil samples (including a duplicate) from BH1, DCP1 and TP2, ranging in depths from 0.20 m to 0.50 m bgl from Made Ground deposits were scheduled for soil-leachate analysis during the 2022 ground investigations. Leachate samples have been screened against General Assessment Criteria (GAC) based on the DWS and EQS.

A GQRA screening of sample results has identified contaminants above DWS within soil derived leachate.

Table 8-3 Summary of Soil Leachate DWS Exceedances

Determinand	Number of samples	GAC (mg/l)	Number of exceedances	Maximum concentration (mg/l)	Magnitude of exceedances and comment.
Antimony	4	0.005	1	0.006	Exceedance were <10x and therefore not classified as a relative exceedance.
Arsenic	4	0.01	4	0.022	Exceedances were <10x and therefore not classified as relative exceedances.
Lead	4	0.01	4	0.096	Exceedances were <10x and therefore not classified as relative exceedances.
Benzo(a)pyrene	4	0.00001	3	0.00075	Exceedances were in excess of 10x the GAC.

Leachate samples have been screened against General Assessment Criteria (GAC) based on the freshwater standards (EQS)

A GQRA screening of sample results has identified contaminants above EQS within soil- derived leachate.

Table 8-4 Summary of Soil Leachate EQS Exceedances

Determinand	Number of samples	GAC (mg/l)	Number of exceedances	Maximum concentration (mg/l)	Magnitude of exceedances and comment.
Copper	4	0.001	4	0.094	Exceedances were in excess of 10x the GAC.
Lead	4	0.0012	4	0.096	Exceedances were in excess of 10x the GAC.

Determinand	Number of samples	GAC (mg/l)	Number of exceedances	Maximum concentration (mg/l)	Magnitude of exceedances and comment.
Mercury	4	0.00007	1	0.0001	Exceedances were <10x and therefore not classified as relative exceedances.
Nickel	4	0.004	1	0.012	Exceedances were <10x and therefore not classified as relative exceedances.
Zinc	4	0.0139	4	0.104	Exceedances were <10x and therefore not classified as relative exceedances.
Anthracene	4	0.0001	2	0.00168	The exceedance recorded in BH1 was in excess of 10x the GAC. It is noted that the duplicate sample was below the GAC.
Benzo(a)pyrene	4	0.00000017	3	0.00075	Exceedances were in excess of 10x the GAC.
Fluoranthene	4	0.0000063	3	0.01056	Exceedances were in excess of 10x the GAC.

Controlled Waters Discussion

The concentrations of those determinands that exceed DWS and EQS in soil leachate are generally only marginally above the DWS and EQS. Where these are classified as a relative exceedance, these are discussed below.

Benzo(a)pyrene was recorded above the DWS in all four locations. The assessment to groundwater is considered conservative and therefore concentrations are unlikely to pose a risk to controlled waters. However, ongoing groundwater sampling and analysis at the site will confirm this.

Copper, lead, anthracene, benzo(a)pyrene and fluoranthene were recorded above the EQS and classified as relative exceedances, within the Made Ground. The assessment to surface water receptors is considered conservative based on the following:

- Leachate testing by nature is aggressive and not representative of natural leaching processes;
- No samples were collected from the surface water receptor and therefore the EQS for bioavailable compounds (such as copper and lead) are based on the most conservative values; and,
- Processes such as attenuation, dilution and dispersion have not been accounted for.

However, without groundwater data to confirm the above the risk to controlled waters cannot be ruled out. Ongoing groundwater sampling and analysis at the site will allow further assessment and confirmation of risk to surface water receptors.

Groundwater monitoring and sampling is proposed at this site to assess allow a more detailed assessment. An updated groundwater risk assessment will be undertaken following completion of the monitoring.

8.3 Ground Gas Risk Assessment

Methodology

The ground gas risk assessment has been undertaken in general accordance with the methodology presented within the Construction Industry Research Information Association (CIRIA) C665 methodology (10) and BS 8485:2019 (11).

BS8485:2019 (11) states that hazardous gas flow rates (Qhg) should be calculated for methane and carbon dioxide for every borehole for each visit. A worst case Qhg is calculated using the maximum gas concentration recorded (unless lower values can be justified) and the maximum flow rate (unless lower values can be justified) using the below formula:

$$Q_{hg} \text{ (l/hr)} = \text{flow rate (l/hr)} \times [\text{gas concentration (\%)} / 100]$$

The Gas Screening Value (GSV) is the flow rate of a specific hazardous gas considered to be representative of a site, following assessment of all borehole concentrations and gas flow rates, whilst taking account of other influencing factors. Such factors being, for example, whether a response zone was completely flooded (which can compromise gas data), the temporal/spatial nature of the data set and the acute one-off nature of the risk.

BS8485:2019 indicates that a decision must be made to determine whether the maximum Qhg in the dataset is appropriate to represent the site (and thereby be selected as the GSV), or whether maximum gas concentrations and maximum steady state flow rates should be combined from any borehole/visit to derive a “worst case GSV”.

The GSV considered representative for the site is then used to select a Characteristic Situation (CS), which is the ground gas regime assumed for design of gas protection measures for new buildings in accordance with BS8485:2019. The GSVs and CS are presented in **Error! Reference source not found.** (which is based on Table 2 in BS8485:2019).

BS8485:2019 does not include an approach for assessing carbon monoxide or hydrogen sulphide. The relevant Workplace Exposure Limits (WELs) as outlined within the HSE EH40/2015 document (12) have been adopted for use in an assessment of carbon monoxide and hydrogen sulphide:

- Carbon monoxide: 30 parts per million (ppm) for long-term (eight hours) exposure limit and 200 ppm for short-term (15 minutes) exposure limit.
- Hydrogen sulphide: 5 ppm for the long-term exposure limit and 10 ppm for the short-term exposure limit.

Table 8-5 Site Characteristic GSV and associated characteristic situation (CS)

Characteristic Situation	Risk	Qhg (l/hr)	Notes
1	Very Low Risk	<0.07	Typical methane <1 % and/or carbon dioxide <5 %. Otherwise consider increase to Characteristic Situation 2.
2	Low Risk	<0.7	Borehole air flow rate not to exceed 70 l/hr. Otherwise consider increase to Characteristic Situation 3
3	Moderate Risk	<3.5	-
4	High Risk	<15	Quantitative risk assessment required to evaluate scope of protective measure
5	Very High Risk	<70	-
6	Very Low Risk	>70	-

British Standard BS8485:2019 code of practice for design of protective measures for methane and carbon dioxide ground gases for buildings and this the primary guidance used for ground gas risk assessments. However, this guidance relates to permanent buildings, and is therefore considered overly conservative for the proposed Development.

In order to inform the revised CSM in Section 9, the key findings of the initial gas monitoring data have been presented as follows.

Ground/mine gas discussion

Carbon Monoxide

Carbon monoxide concentrations were consistently measured below the limit of detection of 1 ppm. However, a peak reading of 21 ppm was recorded within BH2 on 07 June 2022 during monitoring visit undertaken at this location. The maximum CO concentration did not exceed the long-term exposure limit of 30 ppm (12).

Depleted Oxygen

Oxygen at concentrations below 15 % v/v were not recorded on site.

Methane and Carbon Dioxide

A summary of each monitoring round using the maximum recorded gas concentrations and maximum flow rates for each well is presented in Table 8-6.

Table 8-6 Qhg Values

Location	Monitoring Round	Max. Gas Flow Rate (l/hr)	Methane		Carbon Dioxide	
			Max Concentration (% v/v)	Qhg	Max Concentration (% v/v)	Qhg
BH2	Round 1	0.10	0.20	0.0002	0.20	0.0002
	Round 2	0.20	0.00	0	0.20	0.0004
	Round 3	0.20	0.90	0.0018	0.70	0.0014
BH2A	Round 1	0.20	0.00	0	0.60	0.0012
	Round 2	0.20	1.00	0.002	0.70	0.0014

CIRIA 665 indicates that if carbon dioxide is recorded above 5%v/v, or methane is above 1%v/v then consideration should be made to increase to CS2.

Carbon dioxide did not exceed 5% v/v on any of the monitoring occasions with a maximum carbon dioxide concentration of 0.70 %.

Methane did not exceed 1% v/v on any of the monitoring occasions with a maximum methane detected of 1.00 % v/v.

Given this, the site would be classified as CS1, very low risk.

During construction the risk to construction workers from ground gas should be assessed through good working practices, such as gas testing any confined spaces prior to entry, and risk assessed method statements.

9. REVISED CONCEPTUAL SITE MODEL

The findings of the recent ground investigation and GQRA have been used to update the Initial CSM presented in Section 4.

As with the Initial CSM, future construction and ground maintenance workers are included within the revised CSM for completeness. However, it should be noted that risks to construction workers will be assessed by their employers via health/safety risk assessments to establish safe systems of work and to ensure appropriate mitigation procedures are in place.

The revised CSM has been developed assuming completion of the Development works with no mitigation measures having been applied. The preliminary risk categorisations presented are based on an assessment of the potential consequence of each PCL occurring along with the likelihood that each PCL will occur in accordance with the framework provided in Appendix D. The revised CSM is shown in Table 9-1, together with updated risk levels.

Table 9-1 Revised Conceptual Site Model and Risk Assessment (Use of the Site as a strategic construction compound)

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
Potential contaminants in soil/groundwater on-site, originating from the following <u>on-site</u> sources: • Made Ground associated with historical uses of the site; • Refuse heap/historical landfill; • Infilled ground; • Railway station; • Radon.	Inhalation, ingestion, and dermal contact with contaminants in soil and soil derived dust.	<u>Human Health</u> – On-site: Members of the public, Network Rail workers Off-site: Members of the public, railway workers and residents	Unlikely	Medium	Low Risk The ground investigation recorded concentrations of benzo(a) pyrene above the GAC, however these were marginal. Following completion of the new drainage system and attenuation tank the footpath will be reinstated and sufficient thickness of top/subsoil replaced/ imported (subject to meeting re-use/import criteria) to promote vegetation growth. The topsoil/ vegetation and hardstanding will restrict public exposure to the underlying Made Ground. It is also assumed that topsoil and/or gravel will be replaced at surface within Network Rail land. Therefore, landfill material underlying the site is unlikely to pose an unacceptable risk to the public or Network Rail employees.
	Migration of gases into confined spaces/buildings and accumulation (explosion). Inhalation of ground gas (asphyxiation). Inhalation of vapours.	<u>Human Health</u> – On-site: members of the public and Network Rail workers Off-site: Members of the public, railway workers and residents	Unlikely	Severe	Low Risk Gas monitoring indicated that there is not a risk to the future development from on or off site sources of ground gas. As no new buildings are proposed on site and exposure times are likely to be low (users of public footpath/park). It is unlikely that ground gas/ vapours will pose an unacceptable risk as they would disperse into the atmosphere.

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
		<u>Property –</u> On-site: Infrastructure associated with new drainage and railway infrastructure Off-site: commercial services and residential properties			

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration Lateral and vertical migration through Made Ground, superficial deposits and bedrock. Migration via preferential pathways e.g. proposed service pipes/trenches, piled foundations.	<u>Groundwater</u> <u>Controlled</u> <u>Waters</u> – Secondary A Superficial Aquifer and Principal Bedrock Aquifer.	Likely	Medium	Moderate Risk A significant quantity of Made Ground/ landfill material is present based on the ground investigation, as such there is potential for leaching of contaminants into groundwater in the superficial deposits and bedrock. However, the soil leachate analysis have shown marginal exceedances unlikely to pose a risk to groundwater. It is recommended that further groundwater monitoring and sampling is undertaken to characterise the groundwater quality on site.

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration Lateral and vertical migration through Made Ground, superficial deposits and bedrock Surface water run off. Migration of contaminated water in drainage ditches to controlled surface waters.	<u>Surface Water Controlled Waters</u> – adjacent stream and the River Medlock	Likely	Medium	Moderate Risk The nearest surface water feature is an unnamed watercourse, currently located adjacent to the southern site boundary. Made Ground is present on site and there is a potential risk to surface water as the works may introduce a pathway for contaminants for example along new pipe trench backfill. In general, the soil leachate results showed only marginal exceedances . However further assessment is required to determine the risk to surface water receptors. Works are likely to result in the removal of material from site, primarily landfill material/Made Ground, for the construction of the attenuation tank and pipework. This will result in the reduction of source material on site, therefore reducing the impact upon controlled waters. The development itself is designed to funnel excess water off the surrounding area to a tributary of the River Medlock, therefore managed water flow to the receptors is a key consideration in the development design.
	Contact/absorption of contaminants by flora/fauna in Clayton Vale Local Nature Reserve.	<u>Environment and Ecology</u> - Clayton Vale Local Nature Reserve	Unlikely	Medium	Low Risk The site is located within the Clayton Vale Nature Reserve which is underlain by a landfill. It is unlikely that the works undertaken at the site are going to introduce new pathways for contaminant migration as the wider Nature Reserve is underlain by the landfill.
Potential contaminants in soil/groundwater on-site,	Inhalation, ingestion and dermal contact with contaminants in soil derived dust.	<u>Human Health</u> – On-site: members of	Unlikely	Medium	Low Risk

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
originating from the following <u>off-site</u> sources: • Made Ground associated with off-site land uses; • Historical railway activities; • Unspecified disused tips and refuse heaps; • Dyeing and finishing works; • Unspecified pits, ground workings, heaps; • Railway buildings; • Railway station; • Smithy; • Unspecified mill; • Rubber Works; • Unspecified factory; • Electricity sub station; • Discharge consents to surface waters;		the public and Network Rail workers Off-site: Members of the public, railway workers and residents			The majority of the surrounding area is currently either covered in residential properties, hardstanding or vegetation, which would limit exposure to underlying soils and thus dust generation.
	Leaching of contaminants from soil and migration to groundwater, followed by lateral migration beneath the site.	<u>Groundwater Controlled Waters</u> - Secondary A Superficial Aquifer and Principal Bedrock Aquifer. <u>Surface Water Controlled Waters</u> – Unnamed watercourse and the River Medlock	Low Likelihood	Medium	Moderate/ Low Risk Groundwater is likely to flow to the south towards the River Medlock, so there is a possibility that contaminants from the north of the site might be transported beneath the site by groundwater. Till is heterogeneous and can be highly variable in composition, therefore it is possible that groundwater may flow through granular layers under the site towards the River Medlock. Sources of contamination are present to the north of the site (upgradient) include historical railway activities/ features (15 m), unspecified heaps (20 m) and pits (10 m) and a rubber works (215 m). The main sources of off-site contamination which pose a risk to controlled waters are the historical features associated with the railway to the north. The degree of risk posed by this PCL will be dependent on degree of contamination already present within groundwater flowing beneath the site, the geology encountered, the depth to groundwater and whether the proposed works are likely to intercept groundwater.
	Migration of gases into confined	<u>Human Health</u> –	Unlikely	Severe	Moderate/ Low Risk

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
- Landfills and waste exemptions; and - Pollution incidents.	spaces/buildings and accumulation (explosion). Inhalation of ground gas (asphyxiation).	On-site: members of the public and Network Rail workers Off-site: Members of the public, railway workers and residents <u>Property and Services</u> – On-site: infrastructure associated with new drainage and railway infrastructure Off-site: commercial services and residential properties			Gas monitoring indicated that there is not a risk to the future development from on or off site sources of ground gas. The landfill onsite extends off site and therefore any gas generation from onsite would be negligible compared to that of the wider landfill

10. PRELIMINARY WASTE CLASSIFICATION

10.1 Results of CAT-WasteSOIL

A preliminary waste assessment has been undertaken using the Atkins/McArdle online waste characterisation tool CAT-Waste^{SOIL} (13). This provides an indication of whether waste might be Hazardous in accordance with the current guidance within the Environment Agency's Technical Guidance WM3: Waste Classification – Guidance on the Classification and Assessment of Waste (14). Analytical results from the twenty-one on-site soil samples were uploaded into CAT-Waste^{SOIL}.

Thirteen samples were classified by the CAT-Waste^{SOIL} tool as potentially hazardous waste as detailed in Table 10-1. The remaining samples were classified as non-hazardous waste.

Table 10-1 CAT-Waste^{SOIL} results summary

Exploratory Location	Depth (m)	Strata	Hazardous Property
TP2	0.20 m	Made Ground	pH
TP2	0.20 m	Made Ground	Unknown hydrocarbon/oil with marker compound
TP2	0.50 m	Made Ground	Unknown hydrocarbon/oil with marker compound
TP2	1.00 m	Made Ground	Unknown hydrocarbon/oil with marker compound
DCP4	0.50 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH2	2.40 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH2	0.50 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH2	2.40 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH2	6.40 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH1	0.20 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH1	0.50 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH1	1.00 m	Made Ground	Unknown hydrocarbon/oil with marker compound
BH1	0.20 m	Made Ground	Unknown hydrocarbon/oil with marker compound

10.2 Waste Acceptance Criteria (WAC)

TRU testing undertook sampling of the one exploratory borehole on site (BH2) and submitted the sample for waste acceptance criteria (WAC) testing to determine the type of landfill that might be able to accept excavated materials. The result is detailed below:

BH2: Loss on Ignition, Total Organic Carbon has exceeded the WAC limits for hazardous waste landfill. For the purpose of waste disposal, material would therefore classify as hazardous waste for disposal in an hazardous waste landfill

It is recommended that the waste producer should contact potential landfill operators to confirm their additional testing requirements prior to the off-site disposal of material to ensure the waste materials are transported to an appropriately licensed facility. It is the waste producer's responsibility to agree with the landfill operators the appropriate testing regime.

11. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the development comprising underground drains, attenuation tank, catch pits and outfall/headwall. General Arrangement Drawing 151667-TSA-17-MVL1-DRG-R-DR-060019-P05 found in Appendix A and the initial CSM are key findings of GQRA presented within this report.

11.1 Conclusions

The section indicates that the outcome of GQRA and revised CSM in which shows that conclusion of human health risk assessment, controlled water risk assessment and ground gas risk assessment. In the view of human health risk assessment there are exceedances of the (GAC) for benzo(a)pyrene. However, these are within one order of magnitude and considered to be marginal and is unlikely to pose an unacceptable risk to human health. Asbestos was not detected from the collected samples. SVOCs and VOCs tests were analysed, and the results are within the limit of detection with the exception of dibenzofuran, carbazole and perylene.

The predominant pathways by which benzo(a)pyrene, dibenzofuran, carbazole and perylene compounds pose a risk to human health are through direct contact and ingestion of soil and dust. Topsoil/vegetation and hardstanding (paths) will restrict public exposure to the underlying Made Ground. Therefore the risk to future site users has been assessed as low.

The controlled waters risk assessment using soil leachate samples recorded marginal exceedances of the DWS, exceedances of the EQS were also recorded. Given the conservative nature of the assessments, made ground on site is unlikely to pose a risk to control waters, however, no groundwater samples were collected to confirm this. Groundwater sampling and analysis is recommended to determine the risk to controlled waters.

Gas monitoring results were used to generate gas screening values (GSV) and show that the Characteristic Situation (CS) would be categorised as CS1 for both methane and carbon dioxide posing a very low risk to receptors.

The test results of CatWaste soil indicates the around thirteen samples out of twenty-one samples were found to be hazardous. WAC analysis was undertaken on one hazardous sample indicating material would require to be disposed of in a Hazardous Waste Landfill.

11.2 Recommendations

Further groundwater sampling and analysis is recommended and is ongoing at the site to determine the risk to controlled waters.

The risk assessment detailed within this report will be updated following completion of the groundwater sampling and analysis.

12. REFERENCES

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APPENDIX A – DRAWINGS/FIGURES

APPENDIX B – GROUND INVESTIGATION FACTUAL REPORT

APPENDIX C – GQRA SCREENING SHEET – SOIL, LEACHATE

APPENDIX D – CSM FRAMEWORK

Conceptual Site Model

Primary guidance for assessing and managing ground contamination is presented in the Land Contamination Risk Management (LCRM) guidance. This provides a technical framework for identifying and remediating contamination through the application of a risk management process. The question of whether risk is unacceptable in any particular case involves not only scientific and technical assessments, but also appropriate criteria by which to judge the risk and conclude exactly what risk would be unacceptable.

Development of a Conceptual Site Model (CSM) is central to the risk assessment process. A CSM describes the relationship between potential sources of contamination (resulting from both on-and off- Site historical and recent activities) and receptors to the potential contamination. As part of the CSM development, three elements are identified and assessed;

1. source of contamination and associated contaminants;
2. receptors (human beings, surface water/groundwater, ecological systems and property) to the contamination; and
3. pathways between the sources and receptors.

Where all three elements are present, or are likely to be present, they are described as potential contaminant linkages (PCLs), which can then be subjected to the risk assessment and risk management process.

Risk Evaluation

The contaminated land risk, a function of the probability and the consequence, has been defined using the risk matrix given in Table 1 which is taken from the NHBC and Environment Agency's guide National House-Building Council & Environment Agency, 2008, Guidance on the Safe Development of Housing on Land Affected by Contamination. London: NHBC and Environment Agency (R&D66).

Table A1 - Estimation of the Level of Risk by Comparison of Consequence and Probability

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High Likelihood	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
	Likely	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate/Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate/Low Risk	Low Risk	Very Low Risk	Very Low Risk

The descriptions of the classified risks as given in R&D66 are as follows:

Very High Risk

There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the Site without remediation action OR there is evidence that severe harm to a designated receptor is already occurring. Realisation of that risk is likely to present a substantial liability to the Site owner / or occupier. Investigation is required as a matter of urgency and remediation works likely to follow in the short-term.

High Risk

Harm is likely to arise to a designated receptor from an identified hazard at the Site without remediation action. Realisation of the risk is likely to present a substantial liability to the Site owner / occupier. Investigation is required as a matter of urgency and remediation works likely to follow in the short-term.

Moderate Risk

It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, and if any harm were to occur it is more likely that the harm would be relatively mild. Further investigative work is normally required to clarify the risk and to determine the potential liability to Site owner/occupier. Some remediation works may be required in the longer term.

Low Risk

It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely at worst, that this harm if realised would normally be mild. It is unlikely that the Site owner/or occupier would face substantial liabilities from such a risk. Further investigative work (which is likely to be limited) to clarify the risk may be required. Any subsequent remediation works are likely to be relatively limited.

Very Low Risk

It is a low possibility that harm could arise to a designated receptor, but it is likely at worst, that this harm if realised would normally be mild or minor.