Network Rail (Huddersfield to Westtown(Dewsbury)Improvements) Order

Condition 5b(x): Environmental Design Plan (Land Contamination and Hydrogeology) – Stage 5

Appendix B - Piling Risk Assessment (OLE) Addendum – OLE foundations in Mirfield area

Document reference: 151667-TSA-00-TRU-REP-W-EN-001806

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1. INTRODUCTION

1.1 Scheme Background

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

1.2 Objectives

1.2.1 The objective of this report is to assess the potential risk to controlled waters and human health associated with the proposed piling activities required to support the new overhead line equipment (OLE) structures that are to be installed on an embankment adjacent to land currently occupied by Dr Reddy's Laboratories Eu Ltd, between Wheatley's Viaduct and Hurst Way.

1.2.2 This assessment was undertaken in general accordance with CLAIRE's "Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention" dated 2025 (1), which supersedes the Environment Agency's guidance published in the early 2000s.

1.3 Information sources

1.3.1 The following sources of information have been used in this report:

- Groundsure, Enviro Insight report and historical mapping, 2020 (2).
- Network Rail, Environmental Statement Volume 2ii: Huddersfield, 2021 (3).
- Magic Map, DEFRA 2025 (4);
- Transpire Alliance, W3 - GEO - Mining Risk Mitigation Remit: Report, 151667-TSA-W3-000-REP-W-GE-030510 A01, May 2022 (5).
- Environment Agency, Surface Water and Groundwater Abstraction Licence Details Data EA ref: RA/2024/147073/01, 2024 (6)
- Information obtained from Kirklees Council:
    - Private water supply data (received April 2024).
    - Landfill data (received April 2022).
    - Information on the Contaminated Land site in paper archive (viewed in April 2022).

1.3.2 Factual Ground Investigation Reports used in this assessment:

- Structural Soil, 151667-TSA-W3-MVN2-DM3-X-MF-702905, May 2024;
- Bam Ritchies, 151667-TSA-W3-000-DM3-X-MF-702128, June 2023;
- Structural Soil, 151667-TSA-W3-MVN2-DM3-X-MF-701534, March 2023;
- Bam Ritchies, 151667-TSA-W3B-MVN2-DM3-X-MF-701244, June 2022;
- Bam Ritchies, 151667-TSA-W3-000-DM3-X-MF-701246, June 2022;
- Bam Ritchies, 151667-TSA-W3-000-DM3-X-MF-701233, February 2024; and,
- Central Alliance Geo, 151667-TSA-09-MVL3-DM3-X-MF-300015, July 2018.

1.3.3 Structural Soil preliminary borehole logs relevant to this report:

- 151667-TSA-W3-MVL3-DM3-X-MF-961847, March 2024; and,
- 151667-TSA-W4-MDL1-DM3-X-MF-702975, January 2023.

1.4 Limitations

1.4.1 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.

1.4.2 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. Therefore, this report cannot guarantee against unexpected ground conditions occurring between the sampling points.

1.4.3 Constraints relating to geotechnical hazards, ecology, heritage, flooding/drainage, utilities, air quality and noise are beyond the remit of this report.

1.4.4 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.

1.4.5 This assessment has been carried out under current guidance and legislation, if these are revised in the future, then the assessment contained within this report may also need to be updated.

1.4.6 This report does not advise on measures to manage risks associated with asbestos, where present. Detailed advice will be obtained from an asbestos specialist by the construction contractor.

1.4.7 This report was prepared for Network Rail and for use solely by Network Rail. Thereafter, this report must not be relied upon, or transferred to any other parties without the express written consent of Network Rail. If an unauthorised third party comes into possession for this report, they rely on its contents at their own risk.

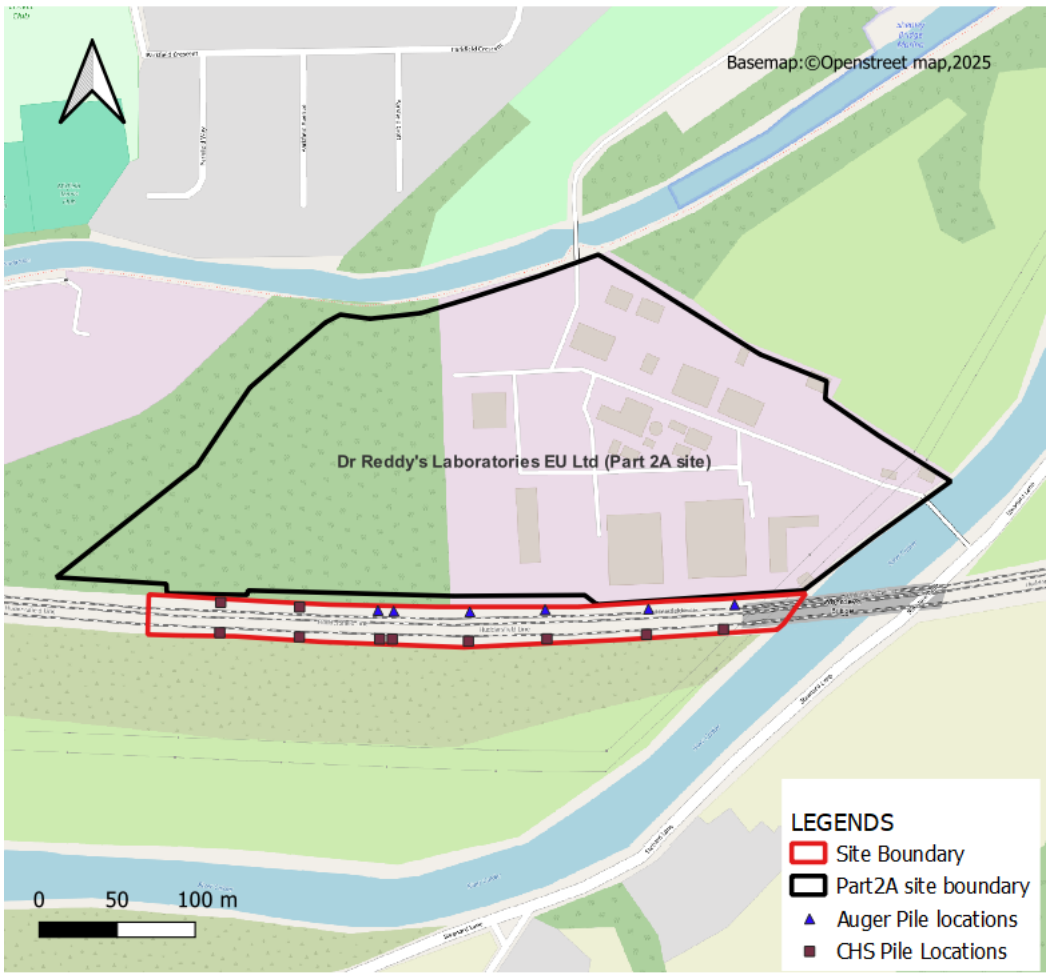
2. THE DEVELOPMENT

2.1 Site location

2.1.1 The site is located between Wheatley's Viaduct and Hurst Way, approximately 570 m east of Mirfield Railway Station, and is part of the existing Huddersfield Line railway line. The site is centred on Ordnance Survey coordinates 421183E, 419392N and is located directly west of Wheatley's Viaduct.

2.1.2 The site encompasses an area of approximately 0.99 hectares (ha) and the proposed OLE piling works will occur within the existing rail corridor. The site comprises the current active three track railway and adjacent ballast with vegetated land to the south and north-west (all located upon an embankment). The River Calder is located adjacent to the eastern site boundary. Dr Reddy's Laboratories Eu Ltd occupies land that has been determined as contaminated land under the Part 2A regime, which is located adjacent to the northern site boundary. The location of these features is shown in Figure 2-1.

Figure 2-1 – Site location plan



2.2 Proposed development

2.2.1 There are 16 OLE foundations proposed across the site to accommodate the gantries to be installed to facilitate the electrification of the Scheme.

2.2.2 The OLE foundation types will comprise a combination of the following:

- Six concrete auger piles (1000 mm diameter) to depths of approximately 3.4 m to 4.1 m below ground level (bgl) are proposed along the northern side of the embankment crest. This pile methodology was selected to minimise ground vibrations, due to sensitive plant/equipment in the adjacent laboratories.
- Ten driven steel circular hollow section (CHS) piles (610 mm diameter) are proposed across the remainder of the site. The CHS piles will be vibrated and/or hammered to depths of approximately 3.7 m to 4.5 m bgl.

2.2.3 The approximate locations of the auger and CHS piles are shown on Figure 2-1.

3. SITE CHARACTERISTICS

3.1.1 A summary of the historical and environmental setting of the site is presented in Table 3-1. This information has been summarised from the information sources listed in Section 1.3.

Table 3-1 Summary of the historical and environmental setting of the site

Item	Description
Current site description and use	Railway embankment and live railway.
Key historical land uses	The following features were identified on-site: - Cuttings (1892): associated with railway tracks on the north-western site boundary. The following key historical features were located within 250m of the northern site boundary (and are up-hydraulic gradient of the site): - Unspecified pits: adjacent south (1982-1993), 85 m north (1966) and 115m west (1938). - Refuse heap: 111 m west of the site (1931-1951). - Unspecified heap: 185 m south-west (1905) and 107 m west (1931-1951) of the site. - Chemical works: adjacent north (1931-1966)[1] - Dye works (1931-1951): 117m north-west of the site. - Electricity substation: adjacent north-west (1954) and 122 m north-west (1989-1993).
Geology	**Made Ground:** Made Ground (Undivided). Likely associated with railway embankment. **Superficial Deposits:** Alluvium (clay, silt, sand and gravel). **Bedrock Geology:** Pennine Lower Coal Measures Formation (PLCM), comprising mudstone, siltstone and sandstone.
Mining	As per the Mining Remediation Authority (MRA) interactive map viewer (https://datamine-cauk.hub.arcgis.com), the site is within a Coal Mining Reporting Area. The site is not located within an area of either recorded or probable past shallow coal workings. No mine entries are recorded on-site. The Groundsure data indicates that a historical surface mineral working for sand and gravel may have occurred at Sands Lane Quarry, located to the east of the site, beyond the river. Surface ground workings for unspecified pits are located adjacent south, 85 m north and 115 m west of the site. A refuse heap is located 111 m west of the site and an unspecified heap is located 185 m south-west of the site. The TRU Scheme designers have confirmed the site as low risk from underground mining instability (7).
Hydrogeology	**Superficial Aquifer:** Secondary A aquifer (Alluvium). **Bedrock Aquifer:** Secondary A aquifer (PCLM). The site is not located within 250 m of a groundwater Source Protection Zone (SPZ).

[1] This land has been determined as contaminated land under Part 2A

Item	Description
	Information obtained from the Environment Agency indicates an active groundwater abstraction is located 140 m north-east at Dr Reddy's Laboratories Eu Ltd. The licence start date is listed as 2014 and it relates to non-evaporative cooling. Water is abstracted from the PLCM Formation. Data provided by Kirklees Council confirmed the site is not located within 250 m of private water supplies.
Hydrology	The River Calder is located adjacent to the eastern site boundary and flows from the south-west to the north. The Calder and Hebble Navigation Canal is located approximately 200 m north of the site. There is one active surface water abstraction licence associated with James Walker Textiles Ltd located approximately 240 m south-west of the site. Water is abstracted from the River Calder for 'general use relating to secondary category (medium loss)'. The licence has been effective since 20 January 1996. There are no other surface water abstractions located within 250 m of the site.
Landfills and Waste	**Landfill:** There are no recorded historical or active landfills located on-site or within 250 m of the site. **Licensed waste sites:** There is one licensed waste site within 250 m of the site, located 95 m north-east of the site at Mitchell Cotts Chemicals Ltd which has an in-house storage facility, licence issued in 1992. (This site is also located within the contaminated land determined under Part 2A regime.)
Contaminated Land (Part 2A site)	Dr Reddy's Laboratories (which now occupies land formerly occupied by Mirfield Chemical Works) was determined as contaminated land under Part 2A of the Environmental Protection Act 1990 in 2002. This Part 2A land is located adjacent to the northern site boundary (immediately west of the Wheatley Viaduct) Information obtained from Kirklees Council indicates groundwater is transporting numerous contaminants (primarily organic compounds) from the contaminated land site beneath the railway embankment towards the River Calder. Remedial works were undertaken by the Environment Agency in the early 2000s, which comprised the construction of a barrier along the riverbank to intercept the organic compounds. Contaminants are collected and pumped via pipes through the underpass (beneath the railway) to temporary storage tanks located within the Part 2A site.
Discharge consents to groundwater	No discharge consents are recorded on-site but there is one licensed discharge consent to controlled waters located within 250 m of the site. The consent, dated 1957, is located 140 m east of the site and is associated with cooling water / trade discharge into the River Calder from Mitchell Cotts Limited. The consent was transferred from R(PP)A between 1951-1961. Mitchell Cotts Limited does not currently occupy the land at the location of the discharge consent therefore this is assumed to be a historical consent.
Pollution Incidents	There have been no pollution incidents reported within 250m of the site as per the Groundsure report (2). Only pollution incidents to the north and north-west of the of the site have been considered. Given that the River Calder is located to the south/south-east of the site, it is likely that the groundwater flow is from the north/north-west towards south/ south-east. Consequently, any pollution incidents or contaminants present south of the site are unlikely to migrate to the site.

Item	Description
Pollution Controls	A current COMAH site, Dr Reddy's Laboratories (former Mirfield Chemical Works), is located adjacent to the northern site boundary. No pollution control sites (LAPPCs and IPPCs), Hazardous Substance Storage Sites, List 1 and 2 Dangerous Substance Consents have been recorded within 250 m of the site.
Trade Directory Entries and Fuel Stations	A total of three recent industrial land uses were identified up-hydraulic gradient of the site and within 250 m of the site boundary, these include: - Electricity substation - Food and beverage industry machinery - Factories No current petrol stations are located with 250 m of the site.
Sensitive Land Uses	The Magic Map (4) application and information received from the Kirklees Council indicates the site is not located within 250 m of any statutory designated sites for nature conservation (for example, Sites of Special Scientific Interest, National/Local Nature Reserves or ancient woodland) or Local Wildlife Sites.
UXO Risk	A detailed unexploded ordnance (UXO) assessment was undertaken by 1st Line Defence for the wider TRU Scheme using a 'buffer zone' forming a corridor either side of the existing railway. The UXO report concluded the railway was in a low risk area and recommended site-specific UXO awareness briefings be given to all personnel conducting intrusive works. Further sub-surface assessments, including UXO and utility checks, on areas not covered by the initial assessment of the rail corridor, are implemented through Network Rail Health and Safety contractual requirements with its contractors.

4. GROUND INVESTIGATION

4.1 Introduction

4.1.1 Several phases of ground investigation have been undertaken at the site from 2018 to 2024. In order to understand how the piles may interact with the Made Ground and deeper geology of the site, the deep boreholes have been the primary focus of this report. Ten deep boreholes have been completed across the site: namely BH4038, BH4882A, BH4794, BH4792, BH4784, BH4783, BH4378, BH4368, BH4372, BH4374, with four boreholes (BH5864, BH5451,BH5453A and BH5453) completed on the adjacent land to the south of the site. Additionally, two BGS boreholes (BGS borehole SE21NW113 and BGS borehole SE21NW114 were also used to provide an indication of the geology beneath the off-site Part 2A site. Factual reports are available for all the locations except for BH4882A where a preliminary borehole log is available. Borehole locations are presented in Figure 4-1.

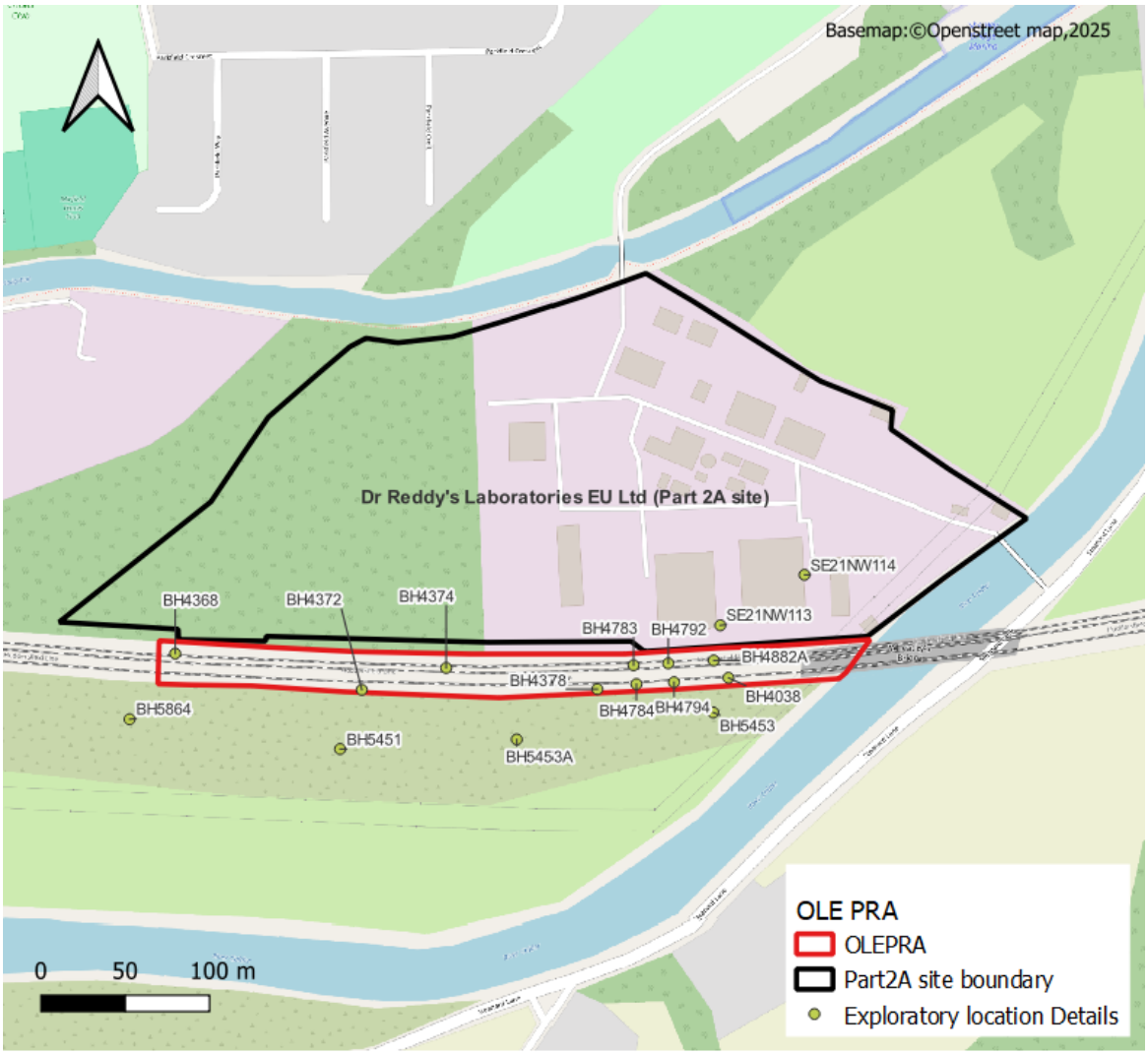


Figure 4-1 – Borehole Location Plan

4.1.2 The boreholes on-site were completed via a mixture of inspection pit and tracked window sampling techniques, to a maximum depth of 11.80 m bgl. Boreholes BH4372, BH4378, BH4783 and BH4792 were installed with 50 mm diameter groundwater monitoring

standpipes. The four boreholes located off-site to the south (BH5451, BH5453, BH5453A and BH5864) were completed using rotary drilling, to a maximum depth of 40.2m bgl at BH5453A.

4.2 Ground conditions

4.2.1 Ground conditions encountered, along with general descriptions of the geology logged, are summarised in Table 4-1 and Table 4-2 below.

Table 4-1 Summary of Ground Conditions on-site (beneath the existing railway tracks)

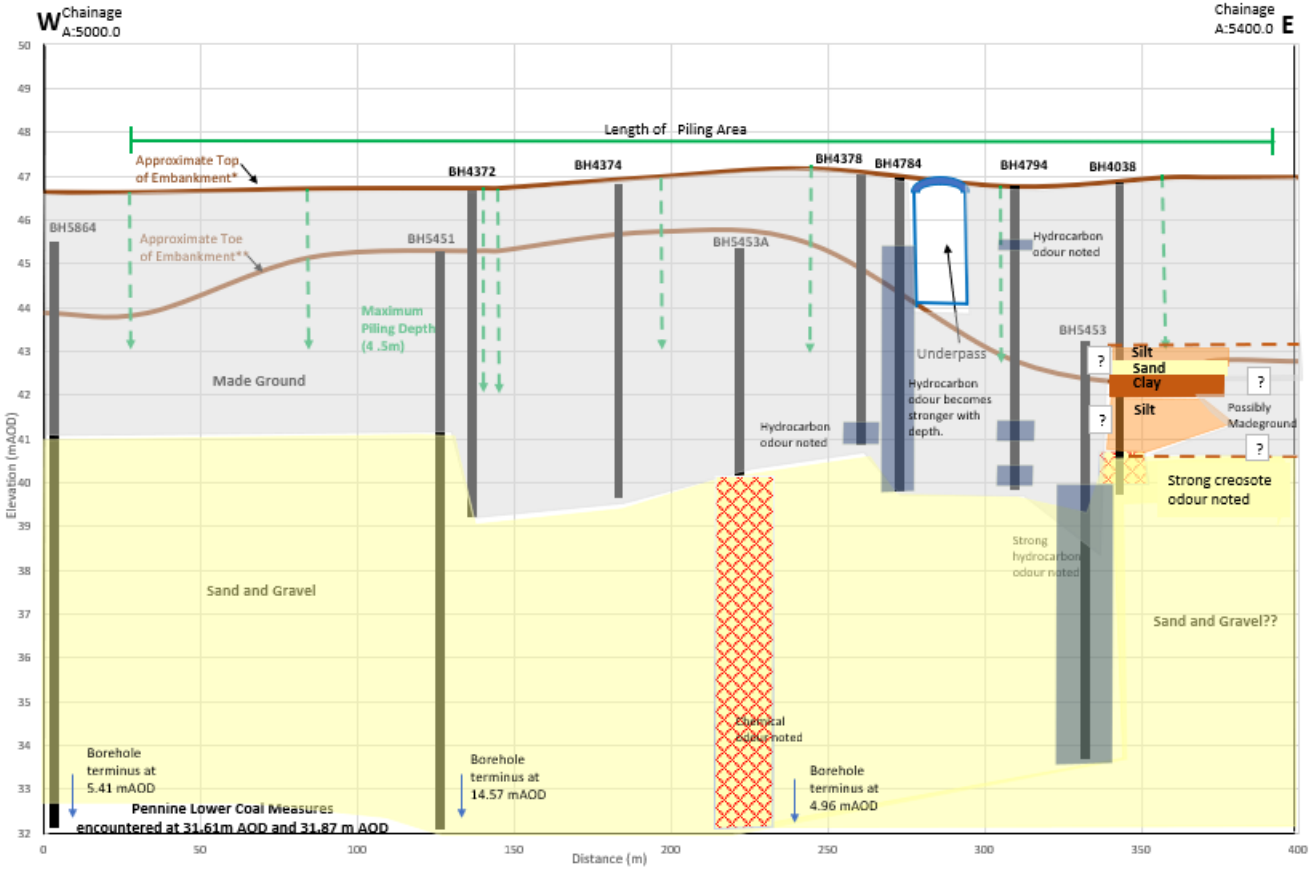
Strata	Depth of strata (m bgl)	Thickness of strata (m)	General description
Ballast	0.00 – 1.20	0.05 – 1.20	Grey angular to subangular fine to coarse gravel of granite and igneous/ sandy ashy gravel of igneous lithologies.
Made Ground	0.00 – 7.45	3.70 – 7.20	Clay, silt and ashy sand. Grey to black sandy clayey, sandy silty or sandy clayey silty ashy; angular to subangular fine to coarse gravel of igneous lithologies and sandstone with occasional brick. Soft consistency greyish brown to orangish brown slightly sandy gravelly silty, sandy gravelly clay. Sand is fine to coarse.
Slit	3.70 – 6.34	0.35 – 1.45	Firm low strength dark grey slightly sandy SILT with frequent sand pockets. Encountered only in BH4038.
Sand	4.05 – 7.00	0.44 – 0.66	Dark grey slightly gravelly fine to medium SAND (with strong creosote odour at depth). Gravel is subangular fine to medium of various lithologies. Encountered only in BH4038.
Gravel	7.00 – 7.45	0.00 – 0.45	Dense brown sandy slightly clayey subrounded fine to coarse GRAVEL of sandstone. Sand is fine to coarse. Encountered only in BH4372.
Clay	4.49 – 4.89	0.00 – 0.40	Stiff grey mottled yellow slightly sandy CLAY. Encountered only in BH4038.

Table 4-2 Summary of Ground Conditions off-site (beneath adjacent Part 2A site)

Strata	Depth of strata (m bgl)	Thickness of strata (m)	General description
Made Ground	0.00 – 2.30	2.10 – 2.30	Reinforced concrete, masonry slabs. Ash, gravel etc (described as 'chemical contaminated').
Clay	2.10 – 3.50	0.15 – 1.40	Soft greenish brown CLAY with occasional gravel
Sand and Gravel	2.45 – 11.35	1.5 – 8.90	Medium dense becoming dense dark grey/brown contaminated SAND and GRAVEL
Bedrock	11.35 – 11.80	0.50	Weathered grey shaly mudstone

4.2.2 The cross-section presented in Figure 4-2 focuses on the southern side of the embankment crest where the majority of the CHS piles are proposed. The cross-section was drawn using data from boreholes along the southern half of the railway embankment and four boreholes located off-site to the south of the railway (BH5453, BH5453A, BH5451 and BH5864) to obtain information on the deeper geology.

Figure 4-2- Geological cross section (with CHS pile length/locations)



* the level of the southern side of the embankment crest is approximated from the borehole logs

** approximate levels of the toe of the southern side of the embankment slope was provided by the Designers

4.2.3 Ballast was recorded on site at surface level to depths of 0.80 to 1.20 m bgl overlying Made Ground.

4.2.4 Made Ground with a thickness ranging from 2.88 m to 7.00 m was encountered across the site. Made Ground was recorded to a maximum depth of 7.45 m bgl beneath the railway line on-site.

4.2.5 It is noted that thick Made Ground is present below the railway and also beneath the adjacent land to the south, which was historically railway sidings.

4.2.6 Superficial deposits were recorded beneath the site at two locations. Gravel was encountered at BH4372 (from 7.00 – 7.45 m bgl). In BH4038 silt, sand and clay layers were recorded from 3.70 to 7.00 m bgl, which might be Made Ground (as other boreholes through the embankment and on the former railway sidings to the south did not record natural deposits at such a shallow depth).

4.2.7 Superficial deposits recorded beneath the Part 2A site at two bore holes (SE21NW113 and SE21NW114). Clay layer recorded is approximately 0.15m to 1.4m depth and thick sand/gravel layer is recorded approximately 1.5m bgl to 8.9m bgl, followed by bedrock.

4.3 Visual and Olfactory Evidence of Contamination

4.3.1 A summary of visual and olfactory evidence of contamination recorded on borehole logs is presented in Table 4-3 below.

Table 4-3 Evidence of hydrocarbon and chemical contamination

Location	Depth (m bgl)	Description	Strata
BH4372	2.60 – 3.00	Organic odour*	Made Ground
	3.60	Possible hydrocarbon odour	
	5.40 – 5.45	Possible hydrocarbon odour *	
	6.85 – 7.00	Hydrocarbon odour	
BH4378	5.80 – 6.43	Hydrocarbon odour	Made Ground
BH4784	1.60 – 4.40	Hydrocarbon odour	
	4.40 – 4.78	Hydrocarbon odour	
	4.78 – 6.00	Strong hydrocarbon odour / black shiny lustre	
	6.00 – 7.00	Strong hydrocarbon odour / black shiny lustre	Possible Made Ground
BH4794	1.55 – 1.65	Slight hydrocarbon odour	Made Ground
	5.70 – 6.00	Very strong hydrocarbon odour	
	6.70 – 7.00	Very strong hydrocarbon odour	Possible Made Ground
BH4038	6.34 – 7.00	Strong creosote odour	Gravelly Sand
BH4783	5.50 – 6.00	Strong hydrocarbon odour	Made Ground
BH4792	5.60 – 6.45	Strong hydrocarbon odour	Made Ground
	6.45 – 6.80	Strong hydrocarbon odour	
BH5453 Off-site - south	3.30 – 9.50	Strong hydrocarbon odour (with oily sheen with very strong hydrocarbon and chemical odour at 9.30 m)	Possible Made Ground and underlying very gravelly Sand
BH5453A Off-site - south	6.00 – 14.80	Strong chemical odour	Sand and Gravel
BGS borehole (SE21NW113) Part 2A site	0.00 – 2.30	Chemical contaminated	Made Ground
	2.45 – 11.35	Contaminated	Sand and Gravel

Location	Depth (m bgl)	Description	Strata
BGS borehole (SE21NW114) Part 2A site Off-site	0.35 – 2.10	Chemical contaminated	Made Ground
	3.50 – 5.00	Contaminated	Sand and Gravel
* odours in clay with rootlets and may not relate to contamination.			

4.3.2 The majority of hydrocarbon odours and all creosote/chemical odours were deeper than 5 m bgl in the boreholes located on-site and south of the site. Whereas chemical contamination was observed from the near surface in the BGS boreholes located on the Part 2A site to the north, which is up hill from the site. As the olfactory evidence of contamination is generally absent from the upper 5 m of Made Ground on the site, the deeper contamination is likely to be related to dissolved contaminants being transported within groundwater flowing beneath the embankment from the Part 2A site.

4.3.3 Hydrocarbon odours were detected at shallower depths in boreholes BH4784 and BH4794 ranging between 1.60 m bgl to 4.40 m bgl and 1.30 m bgl to 1.65 m bgl, respectively. Strong hydrocarbon odours were detected in BH4784 at 4.78m bgl to 6.0m bgl, which coincides with a black shiny lustre. The nearby boreholes (BHs 4378, 4783 and 4792 did not encounter this shallow contamination, which suggests that the shallow contamination recorded in BH4784 is highly localised.

4.3.4 BH4784 is located on the west side of the underpass. Plans from Kirklees Council show a pipe (that transports oily fluid from the remedial barrier) passes through the western side of the underpass to tanks located within the Part 2A site. The shallower contamination noted in BH4784 might be associated with this pipeline, or possibly localised contamination that was deposited with the Made Ground when the embankment was constructed.

4.4 Soil Sampling

4.4.1 Chemical test data has been considered from the on-site deep boreholes (shown on Figure 4-1) and from other shallow boreholes (terminating within 5 m of surface in Made Ground) that were undertaken along the railway tracks to provide data on ballast and shallow Made Ground.

4.4.2 A total of 63 samples of Made Ground were obtained from the exploratory holes located on-site. The samples were sent for laboratory analysis for a range of determinands including asbestos, inorganics, metals, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH) and BTEX compounds (benzene, toluene, ethylbenzene and xylene).

4.4.3 Ten of the soil samples collected from the boreholes were also scheduled for soil-leachate analysis for a range of determinands including inorganics (sulphate, cyanide), metals and PAHs.

4.4.4 The laboratory reports identified concentrations of inorganic determinands, metals, TPHs and PAHs above laboratory limits of detection (LOD) as expected of ballast and Made Ground. For soil-leachate analysis concentrations of inorganic determinands, metals and PAHs were detected above laboratory LODs.

4.4.5 The maximum reported concentration of total TPH was 837 mg/kg from a sample at 0.3 m bgl in BH4794 and the geometric mean was 76.36 mg/kg. The maximum reported concentration of total PAHs was 41.10 mg/kg, reported in a sample taken from 1.00 m bgl in BH5752 and the geometric mean was 3.53 mg/kg. For soil-leachate analysis the

maximum reported concentration of total PAHs was 3.83 ug/l, reported in a sample taken from 0.50 m bgl in BH4783 and the geometric mean was 0.11 mg/kg.

4.4.6 A total of 61 soil samples were tested for asbestos and two samples were identified as containing chrysotile in the form of loose fibres. Asbestos was only quantified in the BH5751 sample (<0.001 %w/w).

4.5 Chemical Attack – Sulphate Classification

4.5.1 Sulphate classification of ground conditions will be undertaken by the pile design team.

4.6 Groundwater level

4.6.1 Groundwater strikes were recorded during the ground investigation at 0.90m bgl in BH4792, 0.80m bgl in BH4882A and 4.50m bgl in BH4378, no other groundwater strikes were recorded. Hence, it is likely that the proposed piling works on-site might interact with highly localised water perched within the embankment fill.

4.6.2 Groundwater levels were recorded between 4.02 m bgl to 5.78 m bgl, at locations BH4783, BH4792 and BH5864.

4.6.3 It is anticipated that groundwater flow direction across the site will be down topographic gradient towards the River Calder (i.e. flowing from north /north-west to south-east direction).

5. PROPOSED PILING TECHNIQUE

5.1.1 Piling activity to support the OLE masts is currently proposed to include six concrete auger piles (1000 mm diameter) to a maximum depth of 4.10 m bgl and ten CHS piles (610 mm diameter) to a maximum depth of 4.50 m bgl.

5.1.2 Concrete auger piles are a non-displacement piling method with materials brought to the surface by the auger and the piles cast in-situ by pumping concrete into the borehole after the auger has been retracted. Sacrificial steel casing will be inserted into the embankment prior to augering to support the upper part of the pile through the ballast and upper Made Ground that is predominantly granular (casing will be a minimum 1.8 m in length but might need to be extended deeper if granular fill with groundwater inflow is encountered at depth).

5.1.3 CHS piles are driven or vibrated into the ground using a pile driver. No spoil is produced during the installation process as this method displaces the soil without the removal of soil to the surface. Soil displacement generally occurs in a radial-horizontal direction. There is little downwards vertical movement of soil under the toe of the hollow pile, although some soil movement may occur due to frictional drag along the sides of the pile shaft, but for CHS this is typically of a limited extent both horizontally and vertically.

6. PILING RISK ASSESSMENT

6.1 Methodology

6.1.1 The piling risk assessment has been completed in general accordance with the methodology and framework set out in the CLAIRE March 2025 (1).

6.1.2 This guidance sets out the following seven pollution scenarios (PS) that may occur during piling operations on potentially contaminated sites:

- PS1 - Creation of preferential pathways through a low permeability layer (an aquitard) to allow potential contamination of an underlying aquifer.
- PS2 - The driving of solid contaminants down into an aquifer during pile driving;
- PS3 - Contamination of groundwater and subsequently surface waters by turbidity, support fluids, concrete, cement paste or grout;
- PS4 - Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials (where the secondary effects are to increase the potential for contaminant migration).
- PS5 – Creation of preferential pathways through a low permeability layer, to allow upward migration of landfill gas, soil gas, mine gas or contaminant vapours (e.g. VOCs) to the surface.
- PS6 - Causing off site migration of ground gas or increased vertical emissions as a result of vibration or other effects from the pile installation process; and
- PS7 - Direct contact of site workers/others with contaminated soil arisings that have been brought to the surface, and runoff to surface waters.

6.1.3 The pile designers state the potential risk of piles impeding groundwater flow and resulting in groundwater mounding is negligible as the individual piles are widely spaced along the embankment.

6.1.4 The CLAIRE guidance document (1) provides four risk bands that can be used within an assessment:

A. Negligible risk - Pollution scenario not likely to be an issue if using this method provided workmanship and QA/QC measures are appropriate.

B. Low risk - Subject to appropriate workmanship, mitigation and QA/QC measures, to be outlined in the FWRA and incorporated in the design and contract specification, this method is likely to be acceptable.

C. Moderate risk - This method may be considered acceptable, depending on specific type used and subject to appropriate workmanship, mitigation and QA/QC measures, to be outlined in the FWRA report. However, a more suitable piling or ground improvement method may be available.

D. High risk - This method should normally be avoided on sites where this pollution scenario is likely to be an issue.

6.1.5 The following section provides a summary of the likelihood and magnitude of potential risks associated with the proposed piling activities described in Section 5 against the seven pollution scenarios. As part of this assessment, it has been assumed that standard mitigation measures during piling, good working practices and QA/QC, and adherence to design guidance will be incorporated in the piling design and construction process.

6.2 Piling Scenario Assessment

6.2.1 Table 6-1 presents site specific considerations, overall risk and outlines possible mitigation measures for each of the identified pollution scenarios.

Table 6-1 Summary of pollution / risk scenarios for piling activities under current site conditions

Pollution Scenario	Comment	Risk Level	Mitigation Measures
No. 1 Creation of preferential pathways, through a low permeability layer (an aquitard), to allow potential contamination of an underlying aquifer	• Made Ground is present across the piling area to depths of between 3.70 m to 7.35 m bgl. The Made Ground comprises cohesive and granular layers, with the lower layers predominantly consisting of a clay matrix. • Superficial deposits were only encountered in two boreholes on-site (i.e. beneath the railway embankment); BH4372 (gravel) and BH4038 (thin layers of silt, sand, clay [0.40 m thick] and silt). The superficial deposits are unlikely to act as a consistent aquitard due to the lack of a laterally persistent cohesive layer between the Made Ground and the 8+ m thick sand/gravel deposit (which was proven in the boreholes drilled off-site to the south). • Groundwater level was recorded between 4.02 m bgl to 5.78 m bgl, at locations BH4783, BH4792 and BH5864. As the proposed maximum termination depths for the auger and CHS piles are approximately 4.10 m bgl and 4.50 m bgl, respectively, some of the piles may intercept the groundwater. • The strong hydrocarbon/chemical odours were predominantly recorded in deposits deeper than 5 m bgl and likely been transported beneath the site by groundwater flowing from the Part 2 A site. The shallower hydrocarbon odours in BH4784 were not recorded in nearby boreholes (except BH4794 in which a slight hydrocarbon odour was noted between 1.55 and 1.65 m bgl). • It is unlikely the CHS piles or the sacrificial casing (inserted prior to augering) would create new preferential pathways for perched water within the embankment fill to migrate downwards, as the piles/casing are likely to terminate within the clayey Made Ground layers. The horizontal movement of the soil will also create a stress field in the zone of influence that will tend to make the soil close up around the pile/casing after the driving is complete, especially in cohesive materials (1). In	<u>Concrete auger piles:</u> B - Low	• Backfill the auger holes with concrete as soon as practicable to close the potential temporary pathway. • Good workmanship during construction of the hole to ensure hole does not collapse. • Watching brief approach. Monitor composition of arisings. Seek advice if visual or olfactory evidence of contamination is identified.
		<u>CHS piles:</u> A - Negligible	• No method-specific mitigation required (as an aquitard is not present in the superficial deposits).

Pollution Scenario	Comment	Risk Level	Mitigation Measures
	addition, the piles/casing will terminate 1 to 3 m above the deposits with strong hydrocarbon/chemical odours. • A temporary pathway could potentially be created during construction of the auger piles. However, as perched water was only intermittently recorded within the embankment fill, it is likely seepages would be minimal. The concrete will be poured into the borehole shortly after the auger is retracted, sealing the borehole and severing the potential pathway. In the absence of a head of contaminated liquid, seepage of a significant volume of contamination is unlikely to occur along this pathway (1).		
No. 2 The driving of solid contaminants down into an aquifer during pile driving	• Groundwater level was recorded between 4.02 m bgl to 5.78 m bgl, at locations BH4783, BH4792 and BH5864. The majority of the CHS piles and sacrificial casing are likely to terminate before they reach shallow groundwater in the superficial deposits. • Laboratory analysis has shown there are concentrations of inorganic and organic determinands above LOD within soil and soil-leachate samples throughout the Made Ground. • The CHS piling methods and insertion of sacrificial casing will push small volumes of material downwards. However, due to the relatively small surface area of the open-ended steel pile/casing, particles of Made Ground would likely be continually displaced laterally from the end as the pile/casing advances. CHS might become plugged with soil from the upper layers of the ground through which the piles are driven and push this into deeper part of the Made Ground, but as the volumes of soil are small (and unlikely to be very heavily contaminated) it is not likely to pose an unacceptable risk (1). • In addition, the strong hydrocarbon/chemical odours recorded towards the base of the Made Ground and in the superficial deposits are associated with contaminated groundwater originating from the adjacent Part 2A site. The CHS piles and sacrificial casing are unlikely to form new pathways for the	<u>Concrete auger piles:</u> A - Negligible	• Ensure no under-rotation of augers.
		<u>CHS piles:</u> A - Negligible	• No method-specific mitigation required.

Pollution Scenario	Comment	Risk Level	Mitigation Measures
	gross contamination to reach the shallow aquifer, as it is already present within the shallow groundwater. • It is unlikely the piling works would form new pathways to the deep aquifer in the PLCM, as none of the piles are going deep enough to intercept rockhead. • The auger will not push material downwards, as material is removed to the surface when the auger is retracted.		
No. 3 Contamination of groundwater and, subsequently, surface waters by turbidity, support fluids, concrete, cement paste or grout	• Leaching of wet concrete may occur in fast-flowing groundwater (e.g. permeable gravel formations) until initial/final setting of the concrete occurs, which can take a few hours to a few days (1). However, the auger piles are likely to terminate before encountering groundwater or only extend less than 0.5 m below the water table. • As the auger piles are likely to terminate above or only extend less than 0.5 m below the water table, it is unlikely that sufficient concrete would leach into groundwater to pose an unacceptable risk.	<u>Concrete auger piles:</u> B - Low	• Good QA/QC and computer monitoring of grouting rates and total volume used, compared to predicted volumes to provide an early indication of potential migration.
		<u>CHS piles:</u> N/A	• N/A.
No. 4 Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials (where the secondary effects are to increase the	• Proposed locations will penetrate Made Ground and superficial deposits. Contact between piles and potential contaminants in Made Ground and localised perched water within the embankment fill is likely. • Laboratory analysis has shown there are concentrations of inorganic and organic determinands above LODs within soil and soil-leachate samples throughout the embankment fill. However, such contaminants/concentrations are not unusual for Made Ground used in embankment fill and minimal visual/olfactory evidence of hydrocarbon contamination was recorded in boreholes close to the augered pile locations. • Research has shown that hydrocarbons could reduce the strength gain in fresh concrete placed in contact with the contamination, if present in sufficient concentrations (more likely with NAPL) (1). The effect of petroleum hydrocarbons on hardened concrete, which has achieved its design strength, is	<u>Concrete auger piles:</u> B - Low <u>CHS piles:</u> B - Low	• Classification of ground/water conditions to be undertaken by the piling design team, including consideration of the hydrocarbons and possible creosote in groundwater. • Appropriate material grade for piles is to be selected by the designers based on the ground conditions and aggressivity following appropriate guidance/legislation (8).

Pollution Scenario	Comment	Risk Level	Mitigation Measures
potential for contaminant migration)	of limited concern, except for creosote-derived contamination that can affect hardened concrete (1). However, the auger piles are likely to terminate before encountering groundwater or only extend less than 0.5 m below the water table. • Ground aggressivity has not been classified as such an assessment is beyond the remit of this report.		
No. 5 Creation of preferential pathways, including through a low permeability layer, to allow upward migration of landfill gas, soil gas, mine gas or contaminant vapours (e.g. VOCs) to the surface	• Made Ground was identified across the site and does not appear to contain putrescible materials. However, volatile vapours and/or ground gas might be present as strong hydrocarbon/chemical odours were recorded towards the base of the Made Ground and in the superficial deposits across the eastern half of the site (associated with contaminated groundwater flowing from the Part 2A site). • Most of the piles are likely to terminate within the lower clayey Made Ground layers just above groundwater level. The piles will not encounter the PLCM. • A temporary pathway for gas/vapour from the contaminated groundwater to reach the surface could potentially be created during augering. Concrete will be poured into the borehole shortly after the auger is retracted, which would seal the borehole and sever the potential pathway • The CHS piles are not expected to create a pathway as this technique does not involve an open borehole to facilitate pile placement. The clayey layers within the Made Ground are likely to partially re-seal against the steel sides of the pile reducing the risk of upward migration of gas/vapours from the deposits with strong hydrocarbon/chemical odours.	<u>Concrete auger piles:</u> B - Low <u>CHS piles:</u> A - Negligible	• See mitigation for PS1 and: • Contractors to take due consideration of hazardous gas and volatile vapour risk and assess accordingly, using available data. Contractors to provide mitigation for employees as required, e.g. use of gas/vapour monitors
No. 6 Causing off site migration	• The vibrations caused by driven pile installation can cause ground to densify, resulting in reduced volume for gas and possible displacement of gas (if there is a sufficiently large	<u>Concrete auger piles:</u> A - Negligible	• No method-specific mitigation required.

Pollution Scenario	Comment	Risk Level	Mitigation Measures
of ground gas or increased vertical emissions as a result of vibration or other effects from the pile installation process	reservoir across the whole site – e.g. landfill) (1). The majority of the CHS pile length will be installed within the embankment fill, which the GI indicates is likely to have a low gas generation potential (minimal evidence of putrescible materials and highly localised slight hydrocarbon odours). It is unlikely the CHS piles would cause the off-site migration of ground gas or volatile vapours. • Concrete augering is unlikely to cause disturbance of the ground sufficient to cause off-site migration of gas. As the adjacent industrial facility has equipment that is extremely sensitive to vibrations the sacrificial casing will be steadily inserted into the embankment to minimise vibrations.	CHS piles: A - Negligible	
No. 7 Direct contact of site workers and others with contaminated soil arisings which have been brought to the surface	• Made Ground was identified across the site. • Augering produces arisings, which will be brought to the surface. Site workers could come into contact with the arisings and there is potential for run-off (containing contaminants) to enter railway drainage and thereby the river. • The CHS piles will not create arisings. • Concentrations of various metals, PAHs and TPHs were recorded above the LODs from samples of Made Ground. • Asbestos was encountered at two locations within the site.	Concrete auger piles: B - Low	• It is pertinent that precautions are taken to prevent pile arisings being entrained in surface water run-off and thereby avoid discharge to drainage and the River Calder. A Flood Activity Permit may also be required as per Environment Agency guidance (9). • Take a 'watching brief' approach. Monitor the composition of arisings. Seek advice if contaminated material or potential asbestos is encountered. Implement appropriate health and safety measures (e.g. use of personal protection equipment). • It is assumed that all arisings will be removed from the site. The arisings will be appropriately classified and treated/ disposed off-site at a suitable waste management facility under an appropriate duty of care. If arisings are to be re-used on-site then they must be assessed appropriately and re-use done under a

Pollution Scenario	Comment	Risk Level	Mitigation Measures
			relevant materials management plan or permit.
		CHS piles: N/A	• N/A.

7. SUMMARY AND RECOMMENDATIONS

7.1 Risk Assessment Summary

7.1.1 The findings of the FWRA are summarised in Table 7-1.

Table 7-1 Summary of FWRA findings

Pollution Scenario	Risk Level*	
	Concrete Auger	CHS
1 - Creation of preferential pathways, through a low permeability layer (an aquitard), to allow potential contamination of an underlying aquifer	B - Low	A - Negligible
2 - The driving of solid contaminants down into an aquifer during pile driving	A - Negligible	A - Negligible
3 - Contamination of groundwater and, subsequently, surface waters by turbidity, support fluids, concrete, cement paste or grout	B - Low	N/A
4 - Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials (where the secondary effects are to increase the potential for contaminant migration)	B - Low	B - Low
5 - Creation of preferential pathways, including through a low permeability layer, to allow upward migration of landfill gas, soil gas, mine gas or contaminant vapours (e.g. VOCs) to the surface	B - Low	A - Negligible
6 - Causing off site migration of ground gas or increased vertical emissions as a result of vibration or other effects from the pile installation process	A - Negligible	A - Negligible
7 - Direct contact of site workers and others with contaminated soil arisings which have been brought to the surface	B - Low	N/A
* Note: the assigned risk levels have assumed that certain QA/QC/mitigation will be implemented: A - Negligible risk - Pollution scenario not likely to be an issue if using this method provided workmanship and QA/QC measures are appropriate. B - Low risk - Subject to appropriate workmanship, mitigation and QA/QC measures, to be outlined in the FWRA and incorporated in the design and contract specification, this method is likely to be acceptable.		

7.2 Outline mitigation to be implemented

7.2.1 The pile Designers will:

- assess the potential for aggressive ground conditions and identify the appropriate pile materials for this site following appropriate guidance/legislation and undertake pile design in accordance with the latest guidance.
- Ensure the environmental QA/QC procedures are detailed within the piling specification.

7.2.2 The Contractors will:

- Review the ground investigation data to assess risk to their workers from volatile vapours and ground gas associated with the strong hydrocarbon/chemical odours

recorded 5 m below the railway tracks, and implement the appropriate mitigation measures (e.g. use of volatile vapour / gas monitors and/or alarms).

- Ensure the environmental QA/QC procedures are carried out in accordance with the those specified within the piling specification.
- Take precautions to prevent pile arisings being entrained in surface water run-off to avoid discharge to railway drainage and the river. A Flood Activity Permit may also be required as per Environment Agency guidance (9).
- To minimise risk of creating pollution pathways: Ensure no under-rotation of augers, minimise risk of hole collapsing, and that concrete is emplaced during auger withdrawal.
- Good QA/QC and computer monitoring of grouting rates and total volume used, compared to predicted volumes to provide an early indication of potential migration into granular superficial deposits/groundwater.
- Take a ‘watching brief’ approach during augering and stop to seek advice if grossly contaminated material encountered.
- Ensure the piling works are undertaken with appropriate workmanship, mitigation and ensuring appropriate QA/QC measures are adopted to enable workmanship to be monitored and verified. The piling works will also be subject to appropriate oversight and method statements. All QA/QC information/data should be collated and included in the geotechnical feedback report

7.2.3 Should the proposed depths or techniques of piling be changed then this assessment will be reviewed.

8. REFERENCES

1. **CLAIRE.** *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention.* s.l. : CLAIRE, March 2025.

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6. **Environment Agency.** *Surface Water and Groundwater Abstraction Licence Details Data EA ref: RA/2024/147073/01.* 2024.

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