RoC Consulting, on behalf of Far East Consortium

Plots NT02, NT03 and NT04, Northern Gateway, Dantzic Street

Phase 3a Detailed Remediation Strategy Report

11834 R02 (04)

RSK GEOSCIENCES

February 2024

RSK GENERAL NOTES

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Client: RoC Consulting, on behalf of Far East Consortium

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

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1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by RoC Consulting (RoC), acting on behalf of Far East Consortium (the Client), to prepare a Phase 3a Detailed Remediation Strategy for land associated with Plots NT02, NT03 and NT04 of the Northern Gateway Strategic Regeneration Framework, Dantzic Street, Manchester (the site).

The current Phase 3a Remediation Strategy is an update to the original revision (ref: 11834 R02 (00), dated Nov 2023) which focussed primarily on the remediation requirements for Plots NT03 and 4. This revision has been updated to incorporate remediation requirements for Plot NT02 following completion of supplementary ground investigation works by RoC Consulting in Oct and Nov 2023. This report supersedes and replaces the aforementioned previous version of the remediation strategy for the site.

The project was carried out to an agreed brief as set out in RSK's proposal (email to RoC Ref. 11834 TL01 (00), dated 21 April 2023).

This report is subject to the RSK service constraints given in **Appendix A.**

The site is located in Manchester, at approximate National Grid reference E384690 N399470 and has been divided into three development plots termed NT02, NT03 and NT04. These boundaries are indicated on Drawing 4328-ROC-ZZ-XX-DR-ES-ES200 presented in **Appendix C.**

Development proposals across the site comprise a mixture of high and medium rise residential buildings to heights of between 20 and 35 stories with smaller buildings varying in heights of between 4 and 8 storeys. The development is also anticipated to include small areas of soft landscaping, and a new access road. No basement structures are proposed across the site with ground levels remaining (broadly) around existing to suit tie-ins with adjacent land and highways. Proposed development drawings are included within **Appendix B.**

An initial Enabling stage of works is proposed across the site entailing the demolition of existing structures, grubbing out of below ground foundations/obstructions, reprofiling of the site to provide development/piling platforms, formation of a new piled retaining structure supporting adjacent Network Rail land to the south; and remedial works to address contaminated soils and groundwater.

The site is divided into three distinct areas based on current land uses and master plan requirements, namely:

- Plot NT02 is present at the west of the site and is occupied by two warehouse/light industrial type buildings with associated service yards and hardstanding.
- Plot NT03 occupies the centre of the development site. It is understood that a portion of the south of Plot NT03 is owned by Network Rail. The north of the Plot is largely covered with hardstanding while the southern part and Network Rail land are occupied by two large earth mounds which likely overlap somewhat.
- Plot NT04 occupies the east of the development site is comprised of semi vegetated disused land.

The site has been subjected to a number of geo-environmental site investigations, including:

- Hydrock, December 2015. Ground Conditions Desk Study (ref: R/151819/G001)
- Allied Exploration & Geotechnics Ltd, March 2019. Northern Gateway Final Factual Report (Contract Number: NW1580)
- LK, March 2020. Phase 2 Geo-Environmental Investigation, Risk Assessment and Remediation Strategy, at **Plot NT02 only** (ref: CL-602-LKC 20 1060-01)
- RoC Consulting, January 2023. Phase 1 Desktop Study (ref: 4328-ROC-ZZ-XX-RP-ES-PH1DTS)
- RoC Consulting, January 2023. Technical Note at **Plot NT03** Network Rail Mound (ref. 4328-ROCZZ-XX-TN-ES-TN2)
- Phase 2 site investigation report covering **all plots**, completed by RoC Consulting in October 2022 (ref. 4328-ROC-ZZXX-RP-ES-P2-101 Rev05), updated following completion of supplementary SI works in June 2023, November and December 2023
- RSK Controlled Waters Risk Assessment (CWDQRA), at **Plot NT02 only,** completed by RSK in July 2023 and updated in December 2023 (ref. 11847 R01 (01))
- RSK Outline Phase 3a Remediation Strategy report dated August 2023 (ref:11834 R01 (00)) covering **all plots.**

It is recommended the findings and results from the above reports are reviewed in tandem with this Remediation Strategy (along with other relevant earthworks, demolition and enabling works drawings, specifications and information).

1.1 Objective and Scope

Following the results of various rounds of ground investigations, the results from these studies indicated that soil, groundwater and ground gas remediation works are required to facilitate the development for both the protection of future site users and the wider environment.

This Remediation Strategy has been developed to support the planning application for the proposed development. The document presents the preferred remediation options, to address the identified geotechnical and contamination risks for the proposed residential end use of the site as shown on **Appendix B.**

The purpose of the current Phase 3a Remediation Strategy is to detail the treatment options considered suitable to redress ground contamination concerns at Plots NT02, NT03 and NT04..

Overall, it considers in general terms the methods to be employed, and general requirements for mitigation of health and safety and environmental controls to be employed during the works, (which the Designer is obliged to consider as part of his formal duties under the CDM regulations). These methods and requirements will be improved and refined within subsequent detailed design upon appointment of a specialist remediation contractor.

The Remediation Strategy will form the basis of the subsequent Remediation Method Statement and detailed design drawings and Remediation Contract Documents, which will form part of the Tender Package to the Contractor.

The Remediation Strategy has been developed in accordance with the guidance provided in Land Contamination Risk Management (LCRM) (Environment Agency 2020). This document supersedes CLR11 Model Procedures for the Management of Contaminated Land and provides best practice for guidance on producing an Options Appraisal and the implementation of a Remediation Strategy.

The Remediation Strategy is a 'live' document and will be revised to reflect subsequent consultations with consultees, planning authority, and other stakeholders any further risks or issues that may be identified within detailed design and following the appointment of specialist contractors and the application for the necessary permits and consents.

1.2 Limitations

The Remediation Strategy is presented to a level of detail considered sufficient for the purposes of planning and regulatory authorities. Whilst it is considered sufficient for this purpose the report on its own does not present a remedial design or specification to the level of detail that will be required for contractual negotiations, quantity surveying, or remediation tendering purposes. It is envisaged this report will instead form the basis from which contractors plan and specify the required program of remediation works across the site, with further detailed information on remediation techniques, results from any pilot trials, site monitoring and validation testing requirements further elaborated upon as part of a Remediation Method statement for the works. The RS can be relied upon for those areas of the site where ground investigation data has been provided. Extrapolation of data to cover areas where no data are available has not been adopted.

It should be noted any change to the development layout, proposed end uses, or other significant amendment will impact on the findings and recommendations of this strategy and may require its full or partial reinterpretation.

This report is subject to the RSK service constraints given in **Appendix A.**

2 SITE DETAILS

2.1 Site location

Site location details are presented in **Table 1**.

Table 1: Site location details

Site name	Plots NT02, NT03 and NT04, Dantzic Street, Manchester
Full site address and postcode	M4 4NL
National Grid reference (centre of site)	E384690, N399470

2.2 Site description

The subject site covers an area of circa 2.30 hectares located to the south of Dantzic Street in Manchester and is centred at National Grid Reference E384690, N399470.

The site termed “Plot NT02” covers a roughly rectangular parcel of land within the wider Plot NT03 and 04 development master plan area. The site is bounded by Dantzic Street to the north beyond which lies a Travellers site and the River Irk (flowing roughly northeast to southwest) circa 21.00 m to the north of the site; an electrified railway line on a viaduct to the south with car repair garages; the wider Plot NT0X site to the east (comprising a former waste management operator); and the Victoria Riverside high rise apartment scheme to the west.

The southern light industrial building was operated by Astra Signs Ltd; a sign making company. The topography of the Plot NT02 is relatively flat with levels varying between 31.20 mAOD at the interface with Dantzic Street and 34.80 mAOD in the southern portion of the site. Plot NT02 is accessed from the east through a gate leading from Dantzic Street onto Plot NT03.

Plot NT03 currently comprises a large National Rail owned soil mound built up against the Network Rail Viaduct at the southern boundary of the site. Immediately north of this, and along the wall to the east of the Network Rail mound, are smaller stockpiles of loose, topsoil-like material left in place by the former operators of the site, Ryan Topsoil Ltd. Large portions of the central part of the site are covered in concrete slabs.

The Plot NT03 is also accessed via a gate onto Dantzic Street. A small portion of this Plot, also covered with hardstanding, is fenced off from the remainder and accessed separately, also from Dantzic Street. Levels on the Plot NT03 vary significantly due to the presence of a large stockpile of soil which rises to 45.65 mAOD at its peak and sloping to 33.27 mAOD at its base in the centre of the plot. The hardstanding working area, extending from the base of the mound to the northern boundary, varies in elevation from 33.00 m to 31.38 mAOD.

Plot NT04 is comprised of semi vegetated disused land. The southern boundary is formed by the Network Rail Viaduct. Dantzic Street and Dalton Street form the northern boundary with a disused warehouse and the River Irk beyond.

The eastern boundary is formed by Dalton Street and residential housing. Relic walls of a former structure are present in the northern portion of the Plot, likely part of the historic Dalton Print Works.

Parts of the south of the site are covered with hardstanding, with stockpiles of construction material present at the time of the site works. Levels in this Plot fall from south (41.50 mAOD) to north (32.00 mAOD). Levels in the eastern portion of NT04 generally appears to be higher than the rest with the north-eastern corner of the site generally sitting at circa 39.00 to 40.00 mAOD. The Plot NT04 is accessed via a gate onto Dalton Street in the east of the Plot.

2.3 Development plans

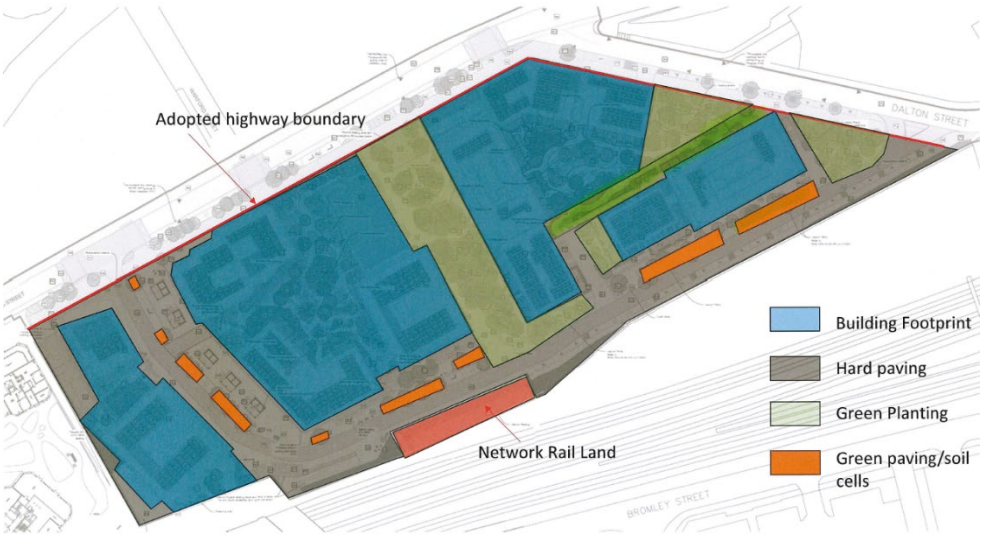
2.3.1 Main development

The proposed layout of the site, at the time of preparing this report, is shown in **Appendix B**.

It is understood that the site is to be developed with a mixture of high and medium rise residential buildings, with the former to heights of between 20 and 35 stories and the latter to heights of between 4 and 8 storeys. It is understood that there will be no basement structures, however some structures may straddle slopes and be stepped, with the ground floor on one side of the building, being lower than the other. A new access road is proposed to be constructed which will pass between NT02 to the west and NT03 and continuing to the east along the southern site boundary.

The development is also anticipated to include small areas of soft landscaping comprising green planting and green paving/soil cell areas in communal spaces, as shown in **Image 1** below:

Image 1: Proposed landscaped areas



2.3.2 Enabling works

The development is to be subject to a site Enabling Works Phase to prepare the site for the follow-on Construction Phase. The scope of these Enabling Works is to include; demolition of existing buildings and hardstanding, vegetation clearance, including invasives, services disconnections, formation of a new piled retaining structure supporting adjacent Network Rail land to the south, general earthworks and site remediation.

An initial cut/fill exercise has been undertaken for the Enabling works on the site (see Drawing RDB/ROC/22/XX/DR/C/0612 within **Appendix D**).

No information on service routes, other than the proposed diversion route for the High Pressure Gas Main are available (shown on Drawing RDB/ROC/22/XX/DR/C/0612 within **Appendix D**).

An area of the development site in the southern portion of Plot NT03 comprises an existing earth embankment belonging to Network Rail. Following ground investigation work on the embankment it is believed that this offers localised support to the track at viaduct level.

As part of the development proposal on the NT03 site, earthworks are proposed to excavate the existing National Rail mound to facilitate construction and the wider regeneration of the site (see Drawings RDB/ROC/ZZ/XX/DR/C/0610 and RDB/ROC/ZZ/XX/DR/C/0611 within **Appendix D**). As the mound offers support to track level, a new retaining structure is required prior to allow removal of in order to maintain stability to the viaduct.

A new retaining wall structure comprised of a CFA or bored contiguous piled retaining wall with an integral in-situ reinforced concrete cantilever retaining wall above is proposed at the interface between the viaduct and the National Rail mound to facilitate its removal and release the NT03 site for development.

2.4 Surrounding land uses

The site is in Manchester city centre, near Victoria Station, within a predominantly commercial/residential setting, though much of the surrounding land is currently vacant. Immediate surrounding land uses are described in **Table 2**.

Table 2: Surrounding land uses

North	Dantzic Street to the north with vacant derelict land, previously used as a caravan site and warehousing/works beyond, which back on to the River Irk.
East	Dalton Street and residential housing.
South	Network Rail viaduct.
West	Plot NT09, Victoria Riverside development.

2.5 Site history/operations

Based on the site's historical use, potentially contaminative activities/land uses at Plot NT02 include: the Victoria Screw and Bolt works (1891 – c. 1950), which later included the Victoria Paint Works (1891 and 1908), Collyhurst Foundry (c.1950 to 1960), Asphalt Works (1968 – 1989) and Tripe Works (c. 1950 – 1989). A waste management company known as Farlam Waste Management is known to have operated in the eastern portion of Plot NT02 only having ceased operation within the past decade. In addition, there is anecdotal evidence to suggest that the southern portion of the plot was used as a storage yard for construction plant.

Potentially contaminative historical activities/land uses include a former unspecified works (1891 to mid-1900s), scrap metal works (late 1968 to 1991), works (1984 – 1989) and finally the site's most recent use as a yard for topsoil stockpile storage. A small area of the southern boundary of the Plot NT03 was previously occupied by a signal box on an embankment adjacent the railway viaduct. It is not clear from historical records if there is a retaining wall which supports the viaduct in this location or if the viaduct is supported by the embankment which is visible on historic plans and aerial photography and still present today.

Potentially contaminative activities/land uses at Plot NT04 include; the Darlton Works print works (present from 1891 and demolished in 20143). The site is also surrounded by potential historic sources of contamination in the general vicinity, that may have impacted the site via migration of contaminated groundwater including a gasworks to the south, a rubber works to the west and gas holders to the north.

3 PREVIOUS REPORTS

A summary of pertinent information from previous investigations is included below in **Table 3.** Relevant information relating to the identified ground and groundwater conditions has not been included within the table below but has been incorporated into **Section 4.**

Table 3: Summary of previous investigation

Report 1	
Report details	LK, March 2020. Phase 2 Geo-Environmental Investigation, Risk Assessment and Remediation Strategy, at Plot NT02 only (ref: CL-602-LKC 20 1060-01) Summary based on review of report presented within the RoC 2023 GI report.
Site coverage	Whole site
Summary scope of works	The LK investigation comprises 7 window sample locations to a maximum depth of 4.45 m below ground level (bgl) and 2 rotary borehole locations to a maximum depth of 20.00 m bgl covering the whole of Plot NTO2.
Does the client have reliance upon the report?	Yes
Key findings relevant for controlled waters	Results from chemical testing undertaken by LK Consult revealed the following issues in the Plot NT02 regarding contamination: • Elevated levels of heavy metals (lead) in soil at WS104, SP1 and SP2 (Likely associated with ash, clinker and coal noted within made ground deposits) • Elevated levels of polycyclic aromatic hydrocarbons (PAHs) - benzo(a)pyrene and naphthalene in soil at WS102, WS103, WS105, TP103, TP105 SP1 and WS205 (likely associated with ash, clinker and coal noted within made ground deposits) • Elevated levels of total petroleum hydrocarbons (TPH) – aliphatic >C12-C16, aromatic >C8-C10 and aromatic >C10-C12 in soil at WS205 (beneath the light industrial building and likely associated with the numerous historic industrial activities in this area of the site) • Elevated levels of VOCs/semi-volatile organic compounds (SVOCs) – benzene and TCE in made ground and superficial deposits at WS205, WS201, WS202 and WS204. Photo-ionisation detector (PID) readings in the southwest of the plot also indicate the presence of volatile contamination with readings between 4.3ppm and 207ppm (likely associated with the historic industrial activity in this area of the site) • Elevated concentrations of contaminants in groundwater including vinyl chloride (VC) at RBH101 and TCE in RBH103. The report hypothesizes these may be linked to historic industrial activity on site or a result of historic industry across the wider area, such as the former gasworks.

Report 2	
Report details	Phase 2 site investigation report, completed by RoC Consulting between October 2022 and December 2023 (ref. 4328-ROC-ZZXX-RP-ES-P2-101).
Site coverage	The 2022 (Phase 2a) RoC site investigation covered the entire site to establish baseline ground conditions and target known or suspected sources of contamination highlighted by the Phase 1 Desk Study. The April to May 2023 (Phase 2e) supplementary SI works were completed to address data gaps identified by the initial site investigation, namely, to further assess the nature and extent of the TCE plume identified within Plot NT02 and to increase coverage across Plots NT03 and 04. Further investigation works were completed within the National Rail (NR) mound within the southern area of Plot NT03, and a final phase of investigation works (Phase 2f) completed in October - November 2023 within NT02 and the western portion of NT03 in order to further characterise the TCE plume.
Summary scope of works	The scope of the October 2022 (Phase 2a) SI comprised 11 window sample locations, 16 trial pits and 10 rotary borehole locations to a maximum depth of 25.00 mbgl spread across the site. The scope of the April-May 2023 (Phase 2e) SI comprised 13 window sample locations, 9 trial pits and 7 rotary boreholes to a maximum depth of 18.00 mbgl. The scope of the September 2023 NR mound investigation comprised 3 window sample with rotary follow-on boreholes to a maximum depth of 21.00 mbgl. The scope of the November 2023 (Phase 2f) SI comprised 5 rotary boreholes across Plot NT02 and the western part of NT03 to maximum depth of 20.00 mbgl.
Does the client have reliance upon the report?	Yes
Soil contamination	**Plot NT02** Lead and PAH concentrations within the unsaturated made ground soils at several locations at Plot NT02 were found to exceed generic assessment criteria (GAC) relating to a proposed commercial land use. A delineation exercise also revealed Trichloroethene (TCE) contamination within the made ground soils beneath the warehouse in the southern area of this site, thought to have arisen as a result of long-term industrial operations on site, possibly the use lubrication or degreasing agents in bolt making operations and their leakage over time into soils through floor slabs or drainage networks. 25 soil samples from Plot NT02 were scheduled for asbestos identification testing, of these, 10 returned a positive result. Quantification testing revealed that only one sample had concentrations of asbestos high event to classify the material as hazardous waste. Generally, distribution of these contaminants across the Plot was observed, either laterally or

	with depth, indicating that the source of these contaminants may have arisen as a result of long-term industrial operations on site. **Plot NT03** Lead concentrations exceeding relevant GACs (either commercial or public open space, depending on the proposed land use at the plot) were also detected within a single location in the west of NT03. Of the 14 samples tested at the main plot, 5 samples returned a positive asbestos result, one of which was determined at a concentration which exceeds the hazardous waste threshold. 3 further samples from the topsoil mounds were tested for asbestos, none of which returned a positive result. The occurrence of soil contamination is thought to be associated with the previous construction/demolition activities, along with the site's former use as an unspecified works and later scrap metal works. During the September 2023 NR soil mound investigation, hydrocarbon odours were noted within the made ground soils of boreholes RBH401 - 403. Given that no residential development is proposed within the mound area, soil samples retained from the mound were screen against criteria for a proposed commercial end use – no exceedances of commercial GACs were reported. Additionally, no positive asbestos results were returned for samples collected from the NR mound. **Plot NT04** Lead contamination appears to be generally widespread across NT04 within made ground deposits. This is likely attributable to a combination of the makeup of the made ground. Furthermore, 3 of the 27 samples tested at this Plot returned a positive result for asbestos, concentrations within these samples were below the hazardous waste threshold.
Ground Gas	**Plot NT03** The results of 6 return ground gas monitoring visits undertaken at Plot NT03 revealed maximum methane and carbon dioxide concentrations of 0.1% and 8.3% respectively, with gas flow rates ranging between 0 and 0.1l/hr. These worst-case gas levels and borehole flow rates equate to a Gas Screening Value (GSV) 0.0083l/hr which falls below the value for the site to be classified at CS1, however CIRIA665 guidance recommends that (CS2) is adopted in instances where carbon dioxide concentrations routinely exceeds 5%. Since carbon dioxide concentrations exceeded 5% at the site during several monitoring visits, the site has been classified as CS2. **Plots NT02 and NT04** Following 6 return rounds of ground gas monitoring undertaken at Plots NT02 and NT04 over the course of 10 weeks, the maximum methane concentration was recorded as 0% and the maximum carbon dioxide level as 4.4% with gas flow rates ranging between 0 and 0.1l/hr. These worst-case gas levels and borehole flow rates equate to a Gas Screening Value (GSV) 0.0044l/hr which corresponds to an anticipated Characteristic Situation of CS1. However, given that several boreholes at

	Plot NT02 recorded concentrations of C02 >5% on several occasions, in line with CIRIA665 Table 8.5, Plot NT02 was classified as CS2. NT04 remains as CS1. Given presence of VOC contamination within soils and groundwater within the Plot NT02 site, and required remediation works, there is a potential for soil vapour ingress into new structures in this area also. However, the severity of this risk will be affected by the proposed remediation works relating to TCE contamination. As such, further consideration of these risks will be required once an approved remediation approach for TCE contamination has been reached.
Groundwater	**Plot NT02** During previous ground investigation phases undertaken by RoC, 12 soil leachate samples in total were collected from across Plots NT02 – 04 to assess the probability of contaminants having entered the groundwater (dissolved phase). The test results were screened against appropriate target concentrations (Drinking Water Standards DWS). Soil leachate concentrations were found to exceed target values at the following locations at Plot NT02: • Arsenic at TP202, WS301, WS397, WS309 • Lead at TP202, WS309 • Nickel WS309 • Sulphate at TP202, TP203, WS301, WS307 • PAH at WS202, WS309, RBH203 • Carbon Tetrachloride at WS202 • TPH at WS202, WS209 and RBH203 • Trichloroethane at WS202, WS304 In addition, samples were collected directly from the groundwater during return monitoring visits. Results of laboratory testing revealed the following exceedances when screened against DWS: • Arsenic at LK BH01, RBH201, RBH301, RBH502 • Sulphate at RBH201, RBH301, RHB502 P2, RBH503 • Carbon Tetrachloride at WS202 • Chloroform at RBH203 • Cis 1,2-Dichloroethene at LK BH1, RBH301, RBH503 • Trans 1,2-Dichloroethene at LKBH01 • Vinyl Chloride at LKBH01, RBH301, RBH503 • TPH at RH502 • Trichloroethane at WS202, WS304 • Benzene at LKBH01, RBH301, RBH502 P2 (385), RBH503, RBH505

	Plot NT03 The results of soil leachate analysis of samples collected from NT03 revealed arsenic, lead, sulphate, PAH and TPH exceedances when screen against DWS within RBH403 (NR mound). The results of a groundwater analysis results screen identified the following exceedances: • Arsenic at RBH403 • Cadmium at RBH403 • Lead at RBH403 • Sulphate at RBH306 and RBH202 • Manganese at RBH205 • Nickel at RBH306 and RBH403 • PAH at RBH403 • Carbon Tetrachloride at RBH303 • Cis 1,2-Dichloroethene at RBH303 • Trichloroethane at RBH303 • Benzene at RBH303 **Plot NT04** Soil leachate concentrations were found to exceed target values at the following locations at Plot NT04: • Lead (leachable) at TP214 and TP216 • Nickel (leachable) at TP307 • Sulphate (leachable) at TP307 In addition, samples were collected directly from the groundwater during return monitoring visits. Results of laboratory testing revealed the following exceedances when screened against DWS: • Sulphate at RBH208 and RBH209 • Arsenic at RBH208 • Manganese at RBH206
Surface water	Due to the presence of River Irk in close proximity to the site, 2 surface water samples were collected from the river (SS301 and SS304, collected up and down stream of the site) provide a direct assessment of the water quality. Contaminant concentrations were screened against relevant EQS and both upstream and downstream samples exhibited concentrations which exceeded EQS for zinc, and the downstream samples exhibited concentrations which exceeded EQS for nickel and copper. Further assessment was undertaken using the UKTAG Metal Bioavailability Tool (M-BAT) approach. The tool was used to calculate the site-specific predicted no effect concentrations (PNEC) for these compounds. Laboratory results were then compared with the PNEC. The regional background concentration of zinc of 2.90µg/l was subtracted from the exceedances.

	The analytical results for surface waters were the PNEC indicating that concentrations of copper, nickel and zinc recorded in groundwater had not resulted in the presence of unacceptable concentrations of determinants within the adjacent surface water.
Geo-environmental conclusions	**Human health risks** Given the elevated concentrations of concentrations of contaminants, including heavy metals, PAH, and asbestos detected in the unsaturated made ground soils across Plots NT02, NT03 and NT04, it was concluded that a risk to human health exists at the site with regards to future site users. It was recommended that detailed remediation design should be undertaken as part of a Remediation Strategy for the site, likely to include provision of a clean soil capping system in areas of proposed soft landscaping, with a minimum thickness of 600 mm, of which 150 mm should be topsoil. It was also recommended that, with regards to the TCE contamination noted within the made ground on the Plot NT02 portion of the site, the risk posed to human health and controlled waters should be further assessed via the production of a DQRA, which in turn would inform site specific remedial targets and remediation design. This work has now been completed and is included within the RSK DQRA report for Plot NT02 (see Report 3 summary below). **Controlled waters** Elevated concentrations of heavy metals, TPH and PAH have been detected in soils across the site, due to the absence of limited thickness of Till, particularly in the west at Plot NT02 and Plot NT03 there is the potential for leaching of contamination from unsaturated soils into the underlying CHES principal aquifer and MM Secondary B aquifer, particularly in areas not covered with buildings or hard standing. i.e. proposed areas of public open space. Additionally, a diffuse TCE source in unsaturated soils has been identified beneath the warehouse in the southern portion of Plot NT02, extending into the southwest of Plot NT03, in an area where historic industrial activities including the bolt works and foundry were located. The leaching potential of the soils was initially investigated in the July 2022 and April 2023 site investigations by the analysis of 12no. soil leachate samples This was later supplemented in subsequent phases of site investigation by groundwater sampling from locations across the site and an additional 3no. soil leachate samples from the Network Rail mound in November 2023. As the primary controlled waters receptor is the Principal aquifer (Chester Formation), the analytical results for groundwater samples have been assessed against DWS protective of groundwater quality. 45no. groundwater samples (plus three duplicate samples) have been tested from across the site (17no. groundwater samples (plus three duplicate samples from September/October 2022, 3no. groundwater samples from January 2023, 13no. groundwater samples from May 2023 and 12no. groundwater samples from November 2023).

	TCE exceedances of the DWS were reported in groundwater in the shallow sandstone in LK BH03, RBH203 and RBH501 located in the south of Plot NT02 and extending over the eastern site boundary to RBH303 and RBH504 located in Plot NT03. Carbon tetrachloride was also reported to exceed the DWS in LK BH01, LK BH03, RBH203, RBH302, RBH501, RBH502 and RBH504 and chloroform exceedances were reported at RBH203. TCE daughter compounds cis-1,2-dichloroethene, trans 1,2-dichloroethene (DCE), vinyl chloride (VC) were reported to exceed the DWS in the shallow sandstone on the outskirts of the TCE groundwater plume and down hydraulic gradient to the north of the site. An exceedance of the DWS was also reported for DCE in the shallow Manchester Marl to the west of the TCE plume core at RBH502 P2. Benzene exceedances were reported in groundwater in the sandstone and marl in the north of Plot NT02 and TPH fractions aliphatic and aromatic C12-C16 and benzene were reported to exceed the DWS in the southwest of the site. The profile of the TPH fractions indicates that these contaminants likely represent two distinct sources of TPH and benzene at the site and considering the absence of benzene detections in soils and leachate, the report concludes that both sources are most likely to have migrated onto site from off-site sources to the west and south. It was noted that the metals, PAH compounds and TPH fractions detected in leachate testing and the other SVOC detected in soils testing were not reported at concentrations exceeding the generic assessment criteria (GAC) in groundwater likely due to degradation in the unsaturated zone and/or more preferential sorption to soils. The report concluded that a potentially complete pollutant linkage for the migration of chlorinated VOC to the wider principal and secondary aquifers and recommended further assessment of potential risks to controlled waters via DQRA specifically for TCE, carbon tetrachloride, cis and trans-1,2-dichloroethene and vinyl chloride. Benzene was detected in the Marl formation at depths circa 15.00-20.00 mbgl with evidence to suggest the contamination is coming from an off-site source (namely a former Gas Works up gradient to the south of the site, and former gas holders to the north). As such we have not considered the Benzene contamination to require further assessment, modelling or remediation as part of the proposed development process.
Report 3	
Report details	Controlled Waters Risk Assessment, Plots NT02 Dantzic Street (Ref. 11847 R01 (01)), prepared for RoC Consulting, December 2023.
Site coverage	Plot NT02
Summary scope of works	Review of previous reports; interpretation of recently acquired hydraulic conductivity field tests data; refinement of the hydrogeological assessment of the

	site; preparation of a controlled waters DQRA, using the EA's Remediation Targets Methodology.
Does the client have reliance upon the report?	Yes
Key findings relevant for the remediation strategy	The main contaminants of concern identified at the site are TCE detected as a diffuse source within the unsaturated soils in the south of the site (Plot NT02) within the footprint of the historic bolt works and TCE, its daughter products, DCE and VC and carbon tetrachloride present as a dissolved phase plume within the underlying the Chester Formation (sandstones), designated as principal aquifer by the EA. The following plausible potential pollutant pathways in relation to sensitive controlled waters: • migration of leachable contaminants from impacted soils present in the unsaturated zone • vertical and lateral migration of dissolved phase contaminants within the Chester Sandstones (CHES) and the Manchester Marls (MM) aquifers. • Lateral migration of dissolved phase contaminants within the CHES and MM to the River Irk approximately 20.00 m to the north pf the site Remediation Targets Values have been derived for the protection of the Chester Sandstone aquifer, using the EA's RTM, at a compliance point of 50.00 m from the boundary of the source zone, has been adopted, in accordance with the current guidance. Screening of the soil and groundwater results against the proposed RTV results in exceedances for TCE in soil at LK WS201, WS302, WS304, WS305 and WS308 in the south of Plot NT02 and three exceedances at for groundwater at LKBH03, RBH203 and RBH303 located in the south of Plot NT02 and approximately 5.00 m beyond the eastern site boundary within Plot NT03. An exceedance of the is also reported in groundwater for DCE and VC at LKBH01 in the north of the site. In accordance with this remediation shall be required at the site. Subject to agreement of the targets derived with the EA, the derived RTVs should be used to inform remedial works at the site.

4 SUMMARY OF CONCEPTUAL MODEL AND RISK ASSESSMENT

4.1 Introduction

The Conceptual Site Model (CSM) is a key tool to enable linkages between contaminant sources, pathways, and receptors to be assessed in accordance with the DEFRA and Environment Agency Environment Agency (EA) publication, the Model Procedures for the Management of Land Contamination (CLR11).

A CSM was initially developed within the RoC Phase 1 Desk Study report (ref. 4328-ROC-ZZ-XX-RP-ES-PH1DTS, dated January 2023) and subsequently refined during the following phases of ground investigations and associated Phase 2 Site Investigation report (SIR) (RoC ref. 4328-ROC-ZZXX-RP-ES-P2-101, dated December 2023), as reported in **Section 3.** In addition, a conceptual site cross section indicating the various relationships and interactions between the underlying geology and contamination has been collated and is provided at **Figure 2.**

Based on the findings of the previous works, but largely based on the RoC (2023) SIR, a summary of the refined CSM is presented in the following sections and tables, in terms of geology, hydrology, hydrogeology and potential pollution linkages, including discussing the contamination type, concentrations and lateral & vertical distribution in soils and groundwater.

4.1.1 Geology

A summary of the ground profile Plots NT02 - NT04 are included in the following **Table 4** below.

Table 4: Geology at the site

Geological unit	Description	Historically encountered thickness (m)
Made Ground	In **Plot NT02** there is a surface covering of concrete and tarmac within and outside of buildings which is typically underlain by made ground of demolition fill type material. Typically, this is a gravelly sand or sandy gravel containing whole and half bricks and chunks of concrete; gravel of brick fragments, slate, clinker, and slag. Other anthropogenic inclusions include wire, metal, glass, plastic, metal pipes and beams, clay pipes, fabric, rubber, and timber.	2.50 (m)
	In **Plot NT03** there is a surface covering of concrete and tarmac within and outside of buildings which is typically underlain by made ground of demolition fill type material.	
	The southern part of **NT04** is surfaced with a concrete slab while the remainder comprises overgrown vegetation and weeds. Made ground was generally encountered as a gravelly sand or gravelly clay containing clinker, concrete, brick, slag, slate, coal, and ceramics. Within **TP214 material suggestive of an informal domestic waste landfill was encountered** with domestic products such as food	8.40 (m)

Geological unit	Description	Historically encountered thickness (m)
	containers, plastic, clothing, rubber, rebar, and sheet metal encountered. This material appears to be limited to the immediate vicinity of TP214 and no similar material was encountered in neighbouring exploratory holes.	
Superficial deposits – River Terrace Deposits (RD) ***(Plot NT03 only)***	Encountered in **Plot NT03** at (RBH304) beneath made ground, as rounded sandy gravel of sandstone, quartzite and siltstone from a depth of 3.60 m to termination at a depth of 9.45 m. Also encountered within NR mound boreholes (RBH401 - RBH403) beneath the made ground as medium dense gravelly sand becoming silty and less gravelly in areas. It is also feasible these soils may extend further to the east into Plot NT04.	5.85 (m) not fully proven by drilling
Superficial deposits – Till (Devensian)	Underneath **Plot NT02,** the Till is often thin and sometimes comprises granular soils. Most typically Devensian Till was encountered as brown sandy gravelly clay ranging in consistency from very soft to stiff but generally becoming stiff with depth.	2.50 (m)
	Underneath **Plot NT03**, the Till was encountered as a firm to stiff slightly gravelly slightly sandy clay.	5.80 (m)
	Underneath **Plot NT04**, the Till was typically encountered as a stiff brown or blueish grey clay, slightly gravelly in places. The Till is thickening progressively from West to East.	7.80 (m)
Bedrock – Chester Formation (Lower Triassic Sandstones)	**Plot NT02** Bedrock of the Chester Formation (CHES) was encountered beneath Devensian Till deposits in all locations in NT02. The upper horizons of the Chester Formation were encountered to be significantly weathered and are effectively sand for up to the first 8.00 m. Deeper horizons of the bedrock also show weaknesses and may be affected by faulting.	15.07 (m)
	Plot NT03 Bedrock of the Chester Formation was encountered beneath Devensian Till deposits in all locations in NT03; the upper horizons of the Chester Formation are significantly weathered and are effectively sand for up to the first 6.00 m. Deeper horizons of the bedrock also show weaknesses and may be affected by faulting.	1.0 (RBH306) – 6.32 (RBH206, Plot NT04 west)
	Plot NT04 Bedrock of the Chester Formation was encountered in only one location at the western edge of NT04, RBH206. The upper horizons of the Chester Formation are significantly weathered. The Chester Formation is thinning progressively from West to East.	Absent
Bedrock – Manchester Marls Formation (Upper Permian mudstones)	**Plot NT02** Reddish brown mudstone recovered as clay when weathered, with interbedded siltstone laminated layers and layers of weak reddish brown fine grained sandstone, up to ~3.00 m thick.	Manchester Marls Formation (MM) was proven by drilling up to a depth of 25.00 mbgl.
	Plot NT03 Reddish brown mudstone and fine to medium grained reddish brown sandstone in layers up to 1.50 m thick.	

Geological unit	Description	Historically encountered thickness (m)
	Plot NT04 Reddish brown mudstone and weak reddish brown fine grained sandstone and siltstone thin layers < 1.00 m.	
Source: On-site exploratory hole records presented in RoC Phase 2 report.		

Exploratory hole locations from the previous phases of ground investigation completed by RoC are provided within **Appendix C.**

4.1.2 Hydrology

A summary of the hydrology within the site area is presented in **Table 5**.

Table 5: Summary of hydrology in site area

Condition	Description
Surface watercourses/features	The nearest surface water feature (River Irk) is indicated 21.00 m to the north. Water quality of this receptor indicates a GQA Grade of "E" (Poor) and a flow rate of less than 2.5 cumecs. The riverbed level is approximately at 26.30 mAOD and the surface water level at 26.90 mAOD in proximity of the site (as confirmed by RoC Consulting who have completed site level and earthworks appraisals). The river levels are comparable to the static groundwater elevations in the north of the site (around the time of the site levels survey in June 2023) at LK BH01 at 26.63 mAOD installed within the CHES and MM indicating that there is likely some connectivity between groundwater in the north of the site and the River Irk.
Surface water abstractions	There are no active surface water abstractions at the site or within 500 m of the site boundary. The nearest active discharge consent is indicated 73.00 m to the northwest and held by United Utilities for the release of storm sewage overflow into the River Irk.
Site drainage	Surface drainage from the site appears to discharge into a local network to an outfall point into the existing adopted sewer network. Any areas of open ground or broken hard standing across the site (or damaged drainage runs) allow surface water to infiltrate into underlying soils and likely provide inputs into the underlying groundwater table, although quantification of these inputs is not possible at time.
Preliminary flood risk assessment	The indicative floodplain map for the area, shows that the site lies within the designated floodplain of the River Irk, with a long-term flood risk classified as 'medium', according to latest info on gov.uk website, meaning that this area has a chance of flooding of between 1% and 3.3% each year.

4.1.3 Hydrogeology

Table 6 provides a summary of hydrogeology information for Plots NT02, 3 and 4 in terms of groundwater levels and flow field, hydraulic gradient, hydraulic conductivity and infiltration.

Table 6: Summary of hydrological setting

Condition	Description
Aquifer characteristics	The central-western part of the wider site (approximately Plots NT02 and 03) is underlain by the CHES principal aquifer. The eastern part of the wider site (approximately PlotNT04) is underlain by a secondary aquifer relating to the MM. Given the variability in the bedrock geology encountered beneath the site groundwater movement (vertical and lateral) via fracture flow and pore flow may be active processes beneath the site. However, it is likely that the majority of the groundwater flow is occurring in the upper weathered portion of the bedrock. The thickness of the weathered CHES is between approximately 2.60 m and 8.00 m, the thicker part is located mostly within Plot NT02 and extending into Plot NT03, among holes RBH201, RBH202 and RBH203. The thickness of MM is unproven but was found to underlie either the CHES formation or glacial till beneath the entire site, dipping roughly from east to west across the site with a low point in the south west corner of Plot NT02 (depth circa 18.30 mbgl to top of MM at BH502). When considering both Formations, the thickness weathered bedrock shows a peak (i.e., thicker weathered bedrock area) mostly within Plot NT02, and a (much larger) depression (i.e., thinner weathered bedrock area) mostly within Plot NT04, extending off-site to the south up to Bromley Street.

Condition	Description
Groundwater depth and flow	Throughout the monitoring period, covering a full hydrological year, the following can be highlighted: • A single well screened in the Made Ground deposits (WS311) was found to contain groundwater. Groundwater in this location had a hydraulic head varying between 34.64 and 34.51 mAOD over a monitoring period from April to August 2023. • The hydraulic head of the well screened in RBH304 in the River Terrace Deposits located in the centre south of Plot NT03 ranges from 27.25 (April 2023) to 27.43 mAOD (June 2023), it should be noted however that this well was largely dry and these levels may be attributable to rainfall infiltrating into the well. • The hydraulic head of the subsequently installed RBH403 ranges from 29.23 to 29.11 mAOD (November 2023). RBH401 which was also installed within the River Terrace Deposits at the same depth and with the same response zone as RBH403 was dry during all visits. The groundwater within RBH403 is therefore likely to be an isolated pocket of groundwater sitting above the low permeability clay encountered at 26.53 mAOD in this location which was not encountered at RBH401. • The hydraulic head of the wells screened both in the CHES and the MM (only two holes have screens in both formations, LKBH01 and LKBH03) ranges from 26.63 mAOD (LKBH01 nearby the river in the northwest of site, in June 2023) to 27.13 mAOD (LKBH03 in the southwest of the site, in January 2023). • The hydraulic head of the wells screened in the CHES ranges from 26.44 mAOD (RBH305 nearby the river in the centre-north of Plot NT03, in June 2023) to 27.60 mAOD (RBH302 in the southwest of Plot NT02, in November 2023). • The hydraulic head of the wells screened in the MM ranges from 25.78 mAOD (RBH205 nearby the river in the north of Plot NT04, in September 2022) to 29.74 mAOD (RBH306 in the centre-east of Plot NT03, in April 2023).
Hydraulic gradient	Results from various monitoring events across all seasons indicates a degree of variability with groundwater tables, aquifer characteristics and groundwater flows, with a mixture of highly permeable and lower permeability bedrock formations beneath the site separated by a geological fault roughly along its centre. This geology is reflected by variance in hydraulic heads between monitoring wells and increases in hydraulic gradient. Overall, the groundwater flow within the CHES formation appears to be trending from southwest to north/north east toward the River Irk and in line with local surface topographical features. Flows within the deeper MM formation appear to trend from east to west with some evidence of northern flow patterns also. The results from both rounds of investigations have been used to increase our understanding of groundwater flows and potential interactions with contaminants present on site
CHES hydraulic conductivity	The calculated geometric mean from the site data (0.82 m/day) is considered suitable for adoption within the DQRA model set up

Condition	Description
Infiltration	Approximately 95% of the site is anticipated to be hardstanding and/or covered by buildings, thus increasing runoff; as such, the overall infiltration (aquifer recharge) has been estimated to be approximately 20% of the total rainfall (~173 mm/year).

4.2 Quantitative risk assessment

4.2.1 Human health – heavy metal, PAH and VOC contamination (Linkage 1)

Exceedances of human health criteria have been observed in Made Ground soils across all plots. Primarily these comprise lead, with others such as PAHs distributed less frequently. In addition, TCE contamination was found to be concentrated within made ground soils beneath the warehouse in Plot NT02 (and a limited area of Plot NT03). Whilst only one sample of this material exhibited concentrations exceeding GACs, levels were found to be elevated within almost all samples tested in this area, The criteria used for this assessment was based on the location of the sampled soil with respect the proposed land use within the proposed development plan (following agreement with Manchester City Council of a mixed commercial/POS GAC screening criteria for the development to reflect ground floor end uses).

As the development layout is to comprise only commercial units at ground level, it was considered appropriate to screen soils collected from areas beneath proposed hard standing against commercial GACs, whereas soils beneath proposed soft landscaping were screened against GACs for public open space. It is considered future site users could be at risk of exposure to sources of contamination these proposed areas of soft landscaping. Remediation measures will be required to break the linkage between contaminants present within the shallow made ground on site and future occupants/maintenance/construction workers, in such proposed soft landscaped areas.

4.2.2 Human health - Asbestos (Linkage 2)

Asbestos in the form of loose fibres amosite, chrysotile, chrysotile and crocidolite, as well as a chrysotile fragment were identified in 18 of the 76 samples tested across the site throughout the previous site investigations undertaken by RoC. The asbestos sample concentrations were ranged between <0.001% to 0.013% by weight. A single chrysotile fragment was identified with a maximum concentration of 2.6% w/w within TP203 (1.20 mbgl) at Plot NT03. A potential linkage therefore exists between asbestos that has been identified on site for the future site users, and for construction workers and users of adjacent sites during development works.

4.2.3 Ground gas (Linkage 3)

4.2.3.1 Plot NT02

Ground gas monitoring has revealed elevated levels of Carbon Dioxide and depleted Oxygen levels in monitoring wells installed into made ground and shallow natural deposits on Plot NT02. Carbon Dioxide levels are consistently above 5% on this plot and on occasion in exceedance of 10%.

Ground gas protection will be a requirement in new buildings in accordance with a CIRA C665 CS2 scenario at this Plot. This portion of the site is also locally affected by TCE soil and groundwater contamination. The TCE contamination has the potential to release gas vapour that could pose a risk to human health that may require remedial measures in buildings in this area.

4.2.3.2 Plot NT03

The results of return ground gas monitoring at Plot NT03 recorded a peak CO_2 concentration of 8.3%, whilst flows where generally negligible. Although these values yield a worst case GSV which falls within the threshold of CS1, in line with CIRIA guidance the Plot has been characterised as CS2 (low risk) given that CO_2 levels within WS310 were frequently greater that 5%.

The origin of the Ground Gas appears to be ashes and foreign matter, wood, cloth within the made ground materials.

Ground gas protection will be a requirement in new buildings in accordance with a CIRA C665 CS2 scenario at this Plot.

4.2.3.3 Plot NT04

The ground gas monitoring results from Plot NT04 record a maximum CO_2 concentration of 4.4% at WS211 and maximum flow rate of 0.1l/hr, yielding a GSV of 0.0044/hr which falls within the threshold of CS1 (very low risk). Ground gas protection measures are not a requirement at Plot NT04.

4.2.4 Controlled waters (Linkage 4)

4.2.4.1 Groundwater

<u>Heavy Metals, TPH & Other Inorganics</u>

The most sensitive controlled water receptor is considered to be groundwater within the Chester Sandstone Formation (CHES - Principal aquifer) and the Manchester Marl Formation (MM - Secondary aquifer). Whilst exceedances of sulphate, manganese, and nickel where recorded when comparing soil leachate concentrations to DWS, the marginal and localised nature of these exceedances suggest that they do not pose a significant risk to wider groundwater quality (namely the CHES and MM aquifers).

<u>Benzene</u>

Benzene exceedances were reported in groundwater in the CHES and the MM in the north of Plot NT02 and TPH fractions aliphatic and aromatic C12-C16, and benzene are reported to exceed the DWS in the southwest of the plot. It was concluded that these contaminants are most likely to have migrated onto site from off-site sources to the west and south.

Since the majority of the benzene contamination is in the deeper marl (secondary B aquifer) and not in the overlying principal sandstone aquifer and since it is most likely due to an off-site source, benzene was not considered to be a primary risk driver for site remediation. However, consideration of this potential off site contamination source is covered within the recommendations for our Discovery Strategy (see **Section 7.8**).

VOCs

Exceedances of TCE was recorded to exceed DWS within groundwater samples collected from the CHES within the southern portion of NT02 (beneath the warehouse) and also within the western portion of NT03, close to the boundary between NT02. Several other VOC namely, carbon tetrachloride exceeded DWS, predominantly in the shallow sandstone in the south of Plot NT02, and at the western portion of NT03. TCE daughter compounds cis-1,2-dichloroethene, trans 1,2-dichloroethene, vinyl chloride were reported to exceed the DWS in the CHES in the north of Plot NT02, and in the west of NT03 supports the predicted groundwater model for the CHES which indicates a flow direction towards the north-northeast.

Some migration of chlorinated VOC into the deeper sandstone and top of the MM was also detected, however given that concentrations were significantly lower than those reported in the CHES, was considered that migration of chlorinated VOC is primarily occurring in the higher permeability CHES formation.

Based on the results of the groundwater screening assessment, the following priority contaminants of concern CoCs were taken forward to DQRA:

- TCE
- Carbon tetrachloride
- Cis and trans-1,2-dichloroethene

Based on the initial screening assessment, it was considered that groundwater table and leachate potential beneath Plot NT02 was the most significantly impacted in terms of these contaminants, and therefore would be the main focus of the DQRA. CoCs detected within the groundwater in the western portion of Plot NT03 would be addressed as part of the DQRA for NT02.

DQRA modelling indicates that the TCE detected in unsaturated soils and the existing TCE dissolved phase plume, and its daughter products pose a potential risk to the wider principal aquifer primarily. The DQRA assessment noted that the predicted levels of TCE at identified off site compliance points would pose a risk to controlled waters and a series of remedial target values for soils and groundwater were produced for inclusion within this remediation strategy (see **Section 5**).

4.2.4.2 Surface water

The nearest down gradient surface water receptor is the River Irk located approximately 21.00 m to the north of the site and is reported to be of low water quality (Grade E). A gas works is located adjacent to the northern site boundary between the site and the River Irk. There are also numerous other potentially polluting current and historic industrial sites within the vicinity of this stretch of the River Irk including a dye works and additional gas works.

The River Irk is considered a sensitive receptor to mobile contamination beneath the site, however, its proximity to the site in comparison to the underlying Principal Bedrock aquifer, makes it a secondary risk receptor. The primary risk receptor and driver for remediation works will be the underlying Sandstone aquifer and the treatment and improvement of water quality within this receptor that will arise from remedial works will also reduce risks posed by offsite contaminant flows down gradient to the River Irk.

4.2.5 Creation of potential exposure pathways as a result of piling works (Linkage 5)

Given the anticipated building loadings coupled and the presence of contaminated soils the adoption of conventional shallow foundations is not considered appropriate in this instance. The use of a piled foundation solution is recommended, with piles taken to competent rock within the Chester Formation and Manchester Marls Formations. In addition, it is proposed that a new piled retaining structure will be constructed in the southern area of NT03 to support adjacent Network Rail land to the south. It is considered that currently, a risk to controlled waters is posed by a diffuse source of TCE and daughter products) present within the unsaturated made ground in the southern area of NT02 and southwestern area of NT03, which will be remediated via source removal prior to the commencement of the development (the methods by which are detailed in later sections of this report).

The adoption of piled foundations has the potential to create preferential pathways for contaminants within the made ground on site to enter the underlying Principal and Secondary aquifers of the Chester and Manchester Marls Formation. The risk will need to be further evaluate through the completion of a piling risk assessment by the contractors at such a time when the precise nature, depth and design of piling is known.

4.3 Contaminant linkages requiring remedial action

Following the quantitative risk assessment, the following contaminant linkages were identified as still being potentially complete and requiring remediation or mitigation measures to be incorporated into the redevelopment planned for the site:

- Linkage (1) – Plausible contaminant linkage to site occupants/workers and off-site residents/workers by dermal contact/inhalation of vapours/dusts of heavy metals, PAH and VOCs
- Linkage (2) – Plausible contaminant linkage to site occupants/workers and off-site residents/workers by inhalation of airborne asbestos fibres from impacted soil
- Linkage (3) - Plausible contaminant linkage to future site workers and occupants from migration of onsite and offsite ground gasses and vapours into indoor areas via preferential pathways (such as backfill around services or compromised drainage) with subsequent risk of inhalation, asphyxiation or explosion.
- Linkage (4) – Plausible contaminant linkage to Principal and Secondary B aquifers (CHES and MM) from leachable contaminants in impacted soils in the unsaturated zone and vertical and lateral migration of leachable contaminants.
- Linkage (5) – Creation of potential exposure pathways to controlled waters as a result of piling works

4.4 Geotechnical risks

Given the size and height of the structures proposed piled foundations will be required. In respect of this solution two Geotechnical risks have been identified.

Geotechnical Risk 1 (GR1) - The site has had several phases of building and relict foundations, slabs and roadways are widespread and will potentially act as obstructions

to piling. The majority of these are concentrated within the Made Ground, with some penetration into the underlying till, and weathered marl and Chester Formation.

Geotechnical Risk 2 (GR2) - Sulphate attack on concrete. Aggressive ground conditions are present predominantly within the Made Ground. If left in-situ or replaced this will require DS2/AC2 grade concrete.

5 REMEDIAL TARGET VALUES FOR CONTROLLED WATERS

The RSK (2023) Controlled Waters DQRA (CWDQRA) reports the modelled preliminary remedial target values (RTV); these are level 2 soil remedial targets and level 3 groundwater targets. The comparison of the RTVs with the soil and groundwater results included in **Appendix F** show the following soil and groundwater exceedances, to inform the remediation of the site.

Table 7: Soil and groundwater RTV for controlled waters

COPC	Soil RTV (mg/kg)	Locations of soil RTV exceedances and max concentration (mg/kg)	Groundwater RTV (mg/l)	Locations of groundwater RTV exceedances and max concentration (mg/l)
Trichloroethene (TCE)	0.224	LK WS201 0.7m bgl (5.40) WS302 1.50 m bgl (0.602) WS304 0.50 m bgl (0.23) WS305 1.00 m bgl (0.427) WS308 0.60 & 1.00 m bgl (max 1.13)	0.0271	LKBH03 (max 0.250), RBH203 (max 0.572), RBH303 (max 0.277)
Carbon tetrachloride	0.116	NR	0.149	RBH203 (max 0.265), RBH302 (max 0.207)
Cis and trans-1,2-dichloroethene	NA	NA	0.0902	LKBH01 (max 0.602) RBH301 (0.102) RBH503 (0.100) RBH504 (0.151)
Vinyl chloride	NA	NA	0.00425	LKBH01 (max 0.016) RBH503 (0.044)

Notes:
NR – no RTV exceedances recorded
NA – DCE and VC not included in the leaching pathway model

6 REMEDIAL AND DEVELOPMENT OBJECTIVES

6.1 General

The following remediation strategy has been completed following on from completion of the site investigation works as presented below.

6.1.1 Remediation Objectives

In preparing the Remediation Strategy, several key objectives will be taken into consideration. These can be split between management objectives and technical objectives as follows:

6.1.1.1 Site Specific Technical Objectives

The assessments have identified that the key risk to the future development, which require addressing within the Remediation Strategy are:

- **Human Health Risk** to development and maintenance workers, future users from direct contact (dermal contact, ingestion and inhalation) with contaminated soil and (inhalation via dust) site neighbours. **(Linkage 1)**
- **Human Health Risk** to development and maintenance workers, future users from (inhalation) of loose asbestos fibres. **(Linkage 2)**
- Risk to maintenance and development workers (excavations and confined spaces), future end users, future building structures (CS2 Levels of protection required at Plot NT03 only) from Elevated Levels of Carbon Dioxide **(Linkage 3)**
- **Risk to the underlying Principal and Secondary B aquifers (CHES and MM)** from leachable contaminants in impacted soils in the unsaturated zone and vertical and lateral migration of leachable contaminants **(Linkage 4)**
- Risk of potential exposure pathways to underlying Principal aquifer within the Chester Formation and Secondary aquifer within the Manchester Marls Formation and as a result of piling works **(Linkage 5)**

6.1.2 Technical objectives

General technical objectives to be achieved;

- Following the remediation work the Site will not be considered ‘Contaminated Land’ as defined by Part 2a of the Environmental Protection Act 1990 and as such there will be no residual liability for future land owners;
- the remediation options employed must be effective in reducing or controlling the identified contamination risks to the future development to an acceptable level;
- the remediation options must be feasible and practical taking into consideration factors such as the ground conditions, environmental setting, ecological issues and the phasing of the development and not involve excessive cost;

- sustainability of the strategy in terms of how it fits other environmental objectives e.g., habitat enhancement, use of natural resources and avoiding or minimising adverse environmental impacts e.g., transportation, water, environment, air and off -site landfill disposal
- to integrate remediation design with geotechnical design, and
- to consider the additional benefits of the strategy in terms of enhancement of amenity and ecological value.

6.1.3 Management objectives

- To produce a Remediation Strategy that will permit the construction of the residential development and associated landscaping.
- To produce a remediation strategy that can be agreed with all key regulatory stakeholders.
- To meet all regulatory requirements applicable to the development of contaminated land and to consider the views of stakeholders on how significant risks should be managed.
- To meet all regulatory requirements during the implementation of the remediation.
- To comply with all current UK guidance where appropriate, to avoid unacceptable health and safety and environmental impacts during the remediation.
- To carry out the remediation in accordance with good technical practice.
- To give due consideration to the management and mitigation of potential unforeseen sources of contamination that may be revealed during either remediation or main construction phases.
- To provide commentary and guidance on the retention of groundwater monitoring wells required to support remediation works including the protection of infrastructure, frequency of monitoring/sampling and their subsequent decommissioning.
- To provide commentary on short term contingency measures that are to be employed during site construction or remediation works to prevent the unintentional mobilisation of contamination present beneath the site.
- To achieve successful phased remediation within the timescales and budgets required by the development.
- To mitigate as far as reasonably practical the nuisance and inconvenience to the wider community.

7 REMEDIATION STRATEGY

7.1 Introduction

This section outlines the general principles underpinning the proposed remediation. This report should be used by contractors to collate a Remediation Method Statement for the works within which further details and elaboration on the implementation of remediation requirements outlined below are provided, along with details of associated control measures and validation/monitoring requirements.

7.2 Primary and secondary contamination source removal

7.2.1 Excavation, on-site processing and off-site treatment/disposal of TCE impacted unsaturated soils

TCE and its breakdown products DCE, VC and carbon tetrachloride, have been detected as a diffuse source within the unsaturated made ground soils on site on site. Much of the soil contamination is concentrated within the southern portion of Plot NT02 and southwest of NT03. Whilst only a single exceedance of TCE against commercial GACs was recorded as part of the screening assessment for human health (though it should be noted that elevated concentrations of TCE were detected in the majority of exploratory hole locations in this area), the risk to controlled waters posed by the presence of the TCE impacted soils has been proven by the prevalence of VOC contamination within the groundwater of the CHES (principal aquifer) in this area. Thus, the risk to controlled waters is considered the main driver for the remediation of this material.

The general area of VOC impacted unsaturated made ground soils has been proven during previous ground investigation by virtue of visual and olfactory evidence of contamination and laboratory testing. The area generally encompasses the southern portion of NT02 and southwestern portion of NT03 within the footprint of the former bolt works as shown in Figure 4328-ROC-ZZ-XX-DR-ES-ES208 and extends to a depth of c. 2.00mbgl (which encroaches into the underlying Till and weathered CHES).

Remediation works will require excavation and treatment/removal of TCE impacted soils in this area.

This method would involve the selective excavation of contaminated soils, on site processing (screening, handpicking, testing) to recover an acceptable fraction and off-site disposal of the heavily impacted soils for either further treatment at an offsite recovery centre or disposal to landfill.

The DQRA model and associated assessment assumes a more conservative primary soil source area of being the entire footprint of the former Nut & Bolt works that was historically located in this area of the site. In order to confirm the precise extent of the affected area, the contractor shall complete a program of soil sampling and inspection across this area on a 5.00 x 5.00 m grid. The sampling and inspection shall comprise the formation of machine excavated trial pits to depths circa 2.00 -3.00 m with a visual inspection of soils completed, PID screening and sampling of chemical analysis at an accredited testing facility to check for levels of TCE and its daughter products.

This sampling will allow confirmation of the area of soil removal as well as its likely depth. The results from this plume confirmation exercise should be recorded for inclusion within the site validation report.

This approach to final soil plume delineation and removal would serve to:

- Remediate risks relating to soil contamination in the area (contaminant linkages 1, 2, 3 ,4, and 5) as well as geotechnical risks GR1 (buried obstructions & foreign matter) and possibly GR2 (requirement for sulphate resistant concrete dependent on the acceptability criteria selected for re-use of soils on the site).
- Allow the recovery of coarse granular material, suitable for use within piling mats, which may offset the requirement to import material.
- Reduce the risk of exposure from soil borne contaminants in the area to construction workers.
- May negate the need for a cover layer in proposed soft landscaped areas provided backfill material meets the import/reuse criteria set in this strategy
- Reduce or remove the secondary risks of soil vapour ingress into new structures associated with TCE and other VOC contaminants.

Current earthworks models for the development predict significant cut of the made ground material across the site (net cut of c. 37,500 m^3) will be required to achieve formation levels. This includes a cut of c. 1.00 - 2.00 m across the southern area of NT02 and southwestern NT03. While this will remove a significant portion of the impacted made ground material, additional excavation will likely be required beneath the existing enabling works cut/fill level to ensure all contaminated material is sufficiently remediated. This may lead to an increase in the proposed excavation and filling volumes.

Processing of the excavated material will likely significantly reduce off-site disposal volumes. Further details on the requirements for material reuse is included within **Section 7.8**.

Soils containing elevated levels of VOCs are unlikely to be acceptable for re-use on site without further treatment. Soils contaminated with high levels of entrained loose asbestos fibres may require offsite disposal to landfill. Further details on off-site disposal requirements are included in **Section 7.9**.

7.2.2 Removal of domestic landfill material identified at Plot NT04

During the October 2022 RoC site investigation works, material suggestive of an informal domestic waste landfill was encountered with domestic products such as food containers, plastic, clothing, rubber, rebar, and sheet metal. This material was encountered within TP214 at Plot NT04. No similar material was encountered in neighbouring exploratory holes, suggesting that this material appeared to be limited to the immediate vicinity of TP214. There will be a requirement for all such landfill waste material encountered in this location to be chased out during the enabling works, excavated and removed off site to an appropriately licensed treatment or disposal facility. Further details on off-site disposal requirements are included in **Section 7.9**.

7.2.3 Management of previously unidentified contamination

Other sources of contamination (e.g. below ground storage tanks, significantly contaminated soils, immediate risks to controlled waters) and secondary sources (e.g., lower-level soil contamination, minor or localised hydrocarbon impacted material) requiring removal have not been identified at the site. An initial strategy for the management of unanticipated contamination has been collated and is provided within **Section 7.**

7.3 Remediation of contaminant linkage 1 (Human Health – heavy metal, PAH and VOC contamination)

7.3.1 Use of an imported clean soil cover layer

On completion of the development, the majority of the site will comprise of surface hard cover (buildings and car parking) and, where present, this will be sufficient to provide a physical breakage in the contaminant linkage toward end-users of the site, however there are several communal green planting and green paving/soil cell areas proposed (shown as orange and green areas respectively on **Image 1**).

Given the incidence of contamination observed within the shallow made ground soils across Plots NT02, NT03 and NT04, site-derived “topsoil” or made ground will not to be suitable to remain within 600 mm of soft cover finish level and imported natural sub and topsoil’s will be required to be used as fill in these areas.

A minimum 600 mm capping layer will be required in proposed soft landscaping zones with 600 mm taken as the depth below final finished floor levels. Site won soils excavated from these soft standing areas will need to be either retained on site (where possible) beneath areas of hard standing; or disposed of from site to a suitably licensed facility.

Any imported soils used in these areas should be subject to chemical validation testing of material imported and compared against the range of determinants and requirements for a simple soil cover system presented in **Section 7.3** (and in accordance with validation requirements outlined in **Section 8**). In addition, any material used as capping in these soft landscaped areas will need to possess sufficient infiltration characteristics to allow site drainage networks to function.

Photographs recording that the soil capping depth has been achieved will be required once completed along with information on the source for any imported clean soils. Photographs should include a survey staff for measurement as evidence the 600 mm capping requirements have been achieved. This information will be required for completion of the Phase 3b Site Validation Report for the project.

7.4 Remediation of contaminant linkage 2 (Human Health – Asbestos)

Asbestos in the form of loose fibres (chrysotile, amosite, anthophyllite and crocidolite) and fragment (chrysotile) have been identified in 18 of the 83 samples of made ground scheduled for analysis throughout previous investigations by RoC. 11 of the 18 samples subjected to quantification analysis recorded asbestos concentrations above the laboratory lower limit of detection of 0.001%.

The distribution of asbestos in soil detected during previous site investigation suggests that the asbestos is likely to be consistently present throughout all plots. As such it will be necessary to employ asbestos mitigation measures during the redevelopment work to safeguard the health and safety of site staff and users of adjacent sites (further details of which are provided in this section).

7.4.1 Use of a clean soil cover layer

Where hardstanding is proposed as part of the development, this will serve as a physical breakage to prevent the exposure of future end users to asbestos within the made ground. Where soft standing is proposed, there will remain a contaminant linkage between the made ground soils and site end users. Remediation measures will be required in these areas via the implementation of a clean cover system, the specification of which should be as per **Section 7.3.1** in order to sever the pathway of contamination to future users.

7.4.2 Safety of construction workers during ground works

Asbestos fibres are released more readily from granular soil. Exploratory hole records for previous investigations at the site indicate that the large majority of made ground underlying the site. Fibres are also released more readily during dry and windy conditions with fibre release reduced when soil moisture contents are maintained greater than 10%. Asbestos fibre concentrations in the soil range between <0.001% and 0.013%. To prevent, where practicable, exposure and spreading of asbestos fibres in line with the Control of Asbestos Regulations (2012) mitigation measures are recommended (see **Section 7.4**).

7.4.3 Users of adjacent sites during the earthworks

The site generally lies within a commercial/industrial setting, with a viaduct to the north, various works to the north and discussed Plot NT02 to the west. However adjacent to the east of Plot NT04 are residential dwellings, as well as an active caravan site to the northwest of Plot NT03. Immediately adjacent to the west of Plot NT02, is the Victoria Riverside Project, which is currently undergoing construction. Given the potential close proximity of the general public to the proposed works, this linkage will require mitigation measures to prevent, where practicable, exposure to adjacent occupants in line with the Control of Asbestos Regulations (2012) (see **Section 7.4**).

7.4.4 Mitigation measures for dealing with asbestos

It is likely that the identified asbestos in soil relates to asbestos containing materials (ACMs) historically contained within the building fabric of demolished former structures (such as the former screw and bolt works, foundry and asphalt and tripe works at Plot NT02, the unspecified works, demolished in the mid-20th century at Plot NT03, and Dalton Print Works demolished c. 2013 at Plot NT04) that have become mixed during the various phases of redevelopment at the site. From onsite testing, granular made ground, which is present across the majority of both Plots has been found to contain asbestos fibres and chrysotile cement. Therefore, asbestos mitigation measures should be implemented site wide.

It will be necessary to control the release of nuisance dust from the site during the works and such control will also limit the release of asbestos. RSK considers the works are not licensable and that notification of the works to HSE is not required.

To manage spreading and exposure risks RSK recommends:

- Excavations within the granular made ground and stockpiles comprising granular made ground (incorporating rubble waste) be dampened down.
- Stockpiles of granular made ground (incorporating rubble waste) to be covered.
- All site staff to receive training on the identification of ACM and an understanding of actions to be implemented if ACM is identified.
- A watching brief should be implemented during the excavation of all granular made ground to identify the presence of ACM.
- Implement stop work procedures if potential unforeseen ACM is identified.

To demonstrate these mitigation works are adequate and because of the potentially close proximity of general public, RSK recommends boundary monitoring be undertaken during periods when excavating, handling and transporting the rubble waste. Further details of the boundary monitoring are provided in the following subsections.

7.4.5 Mitigation measures to manage spreading and exposure

The asbestos contamination within the granular made ground presents a potential risk to site personnel and the general public during the development of the site. Disturbance of the made ground on site by vehicles and excavation activity has the potential to cause airborne fibre release. Fibre release is generally considered to be greatest from granular material with a low moisture content. This type of material is potentially present across the majority of the site. This shall be minimised by the implementation of the following control measures:

- The exposed made ground soil should be dampened down to reduce the potential for asbestos fibre release. The moisture content at the surface of the area being excavated and in any uncovered stockpiles of excavated made ground material should be maintained at >10%.
- To prevent spreading of potential asbestos contamination to ‘clean’ soils, where excavated granular made ground should, if possible, be stored on impacted areas that are later to be excavated and removed or on hard standing. If this is not possible, stockpiles should be placed on plastic sheeting.
- If stockpiles are to be left in place for more than 12 hours, leading to possible drying out (or sooner if the weather conditions dictate), they shall be covered to prevent the possible release of fibres.
- When impacted soils are required to remain on site outside of working hours then appropriate fencing and signage should be present to secure the area.
- Vehicle movements need to be managed to avoid spreading of asbestos fibres. To minimise the potential for affecting natural soils within the site, vehicular movement routes should be signed and where possible loading areas will be restricted either to hard standing, or to haul roads constructed of ‘clean’ imported fill or natural clean soils from site.

- Should the exterior or wheels of any tipper lorry be affected by potentially contaminated material, a vehicle jet-wash will be used to clean the vehicle, with the wash water directed into the contaminated area.

7.4.6 Health and safety of site personnel

It is the responsibility of the principal contractor and any appointed sub-contractors to enforce an appropriate health and safety regime for all site personnel. Full details regarding the proposed working practices in connection with the remediation works shall be agreed in advance of the commencement of the works with the Principal Designer.

A project health and safety plan will be produced before site works commence. This will detail the anticipated hazards associated with the site work, for example asbestos, machinery and open excavation. It will also detail the control measures that will be put in place to reduce these risks to an acceptable level. This plan will also document emergency procedures and include the address and location of the nearest hospital with an A & E department. A copy of this will be made available to principal contractor before commencement and also kept on site and made available on request.

RSK engineers carry their own personal protective equipment, as detailed in RSK's in house procedures. This includes respiratory protection and protective clothing where it is considered necessary. Measures will be necessary to protect the health and safety of site workers during the site works. The contractors will be under a statutory obligation to take reasonable care to protect the health and safety of their employees. The following measures are suggested to provide a minimum level of protection.

- All site staff should undergo asbestos awareness training as part of the site induction.
- All ground workers on-site should be issued with protective clothing, respiratory protective equipment to FFP3 standard, footwear and gloves. These should not be removed from site, and advice should be given on when and how they are to be used.
- Care should be taken to minimise the amount of dust and mud generated on-site.
- Good practices relating to personal hygiene should be adhered to on-site, i.e., food and drink should only be consumed within designated areas on the site and smoking should be prohibited in all working areas.

Reference should also be made to the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Development of Contaminated Land".

7.4.7 Mitigation measures to manage unforeseen ACM

Owing to the potential for previously unidentified concentrations of ACM throughout excavation of granular made ground, RSK recommends a watching brief be maintained by a suitably experienced engineer. The engineer should carefully inspect the soil for the presence of previously unidentified ACM, such as clumps of fibrous asbestos, material that may contain asbestos such as board, rope, textile, vinyl or ceramics. Should the engineer suspect ACM from their visual observations, works should cease, and the situation re-evaluated. The duration and frequency of the watching brief can be reviewed during the works to allow certainty that an engineer is present during the higher risk operations.

Re-evaluation may require wetting of soil, additional monitoring, risk assessment and personal protective equipment to be adopted. Should it be necessary to obtain samples for bulk analysis or quantification of asbestos, samples will be taken in a controlled manner and utilising appropriate dust suppression techniques. Samples will be double bagged at the sampling location and uniquely labelled. The approximate location will be recorded on the site plan for future reference.

7.4.8 Air monitoring and analysis

Upon commencement of excavation works air sampling and counting of asbestos fibres should be undertaken.

The air monitoring should be undertaken during the first week of the excavation works only and reviewed after this time. If the fibre levels are above the limit of quantification (0.01 fibres/ml (f/ml)), additional air monitoring should be undertaken until the clearance levels are satisfied (0.01 f/ml).

The specific location of air monitoring will depend upon wind direction and the extent of the excavation works. Therefore, it will be determined upon arrival at the site on the day of monitoring. The monitoring location will be recorded by the engineer undertaking the 'watching brief'.

Where power is available on site, the results of air sampling will be determined on site following completion of the tests. Should power not be available, then fibre levels would need to be determined back at RSK's laboratories with results reported later the same day or first thing on the following day.

7.5 Remediation of contaminant linkage 3 (Ground Gas)

The results of ground gas monitoring undertaken by RoC during previous site investigations at Plot NT02 revealed a peak CO2 concentration of 13.4%, and negligible flow rate. Although these values yield a worst case GSV which falls within the threshold of CS1, in line with CIRIA guidance the Plot has been characterised as CS2 (low risk) given that CO_2 levels within several wells were frequently greater that 5%, **Ground gas protection measures protective of carbon dioxide will be required Plot NT03.**

Similarly, while Plot NT03 revealed a peak CO2 concentration of 8.3%, and negligible flow rate, CO_2 levels within WS310 were frequently greater that 5% which warranted a characterisation of CS2. **Ground gas protection measures protective of carbon dioxide will be required at Plot NT03.**

Based on the results of the return ground gas monitoring data obtained during the RoC site investigation, **Plot NT04 has been characterised as CS1 (very low risk) and therefore no ground gas protection measures are required at this Plot.**

The risks to development from ground gases have been assessed in accordance with BS8485:2015+A1:2019 (BS8485), which provides guidance on ground gas (methane and carbon dioxide) characterisation and hazard assessment, as well as providing a framework for the prescription of protection measures within new buildings.

Gas protection measures within new buildings are prescribed using a point scoring system, taking into consideration the CS and the proposed building type.