

REPORT

Castlefield Viaduct, Manchester

Land Quality Interpretative Ground Investigation and
Generic Quantitative Risk Assessment Report

Client: National Trust

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Executive Summary

Royal HaskoningDHV has been commissioned by the National Trust (the Trust) to undertake a ground investigation and assessment of Castlefield Viaduct, Manchester. The assessment will inform proposals to repurpose the historic viaduct structure into an elevated park with an integrated active travel hub.

The Trust's vision is for the urban park to be utilised in a variety of ways, ranging from exhibitions, fruit and vegetable growing, sculptures, workspace, onward travel information, community meeting and green space. A Phase 1 Pilot Scheme 'micro park' will be delivered on the eastern section of the viaduct, for a 12-week period in the summer of 2021. The temporary scheme will be undertaken to test the design possibilities and opportunities at the viaduct and generate momentum and support for the proposed scheme.

The railway is recorded as being dismantled in the late 1960s. The land underlying the viaduct was historically occupied by a roman fort, timber wharf, canal network and warehouses. The area surrounding the site has a long industrial history including use as railways, quaysides, wharfs, garages, gravel and sand pits, dye works, chemical works, paper mills, gas works and an abattoir.

The principal objective of the works was to evaluate the suitability of the site for the proposed elevated park. The works included an intrusive ground investigation, comprising a total of 10 hand dug pits, was undertaken by Royal HaskoningDHV on the 8th July 2021. The investigation included the collection of soil, paint scrapings and a surface water sample for laboratory analysis.

In order to evaluate potential risk to human health and controlled waters, soil, paint scrapings and soil-derived leachate analytical data were compared with pertinent Generic Assessment Criteria (GACs). To assess risks to controlled waters (surface waters) data was compared with Environmental Quality Standards (EQSs).

Based on the findings of the ground investigation and subsequent assessment detailed herein, the site soils potentially pose an unacceptable risk to site users, construction/maintenance workers and (if installed) potable water supply pipes. Paint scrapings indicate concentrations of metals that may pose an unacceptable risk to maintenance and construction workers.

Exceedances of the EQS for copper, zinc, lead, fluoranthene and benzo(a)pyrene were recorded. It was determined that lead, fluoranthene and benzo(a)pyrene have the potential to leach at concentrations which may pose an unacceptable risk to surface waters irrespective of development proposals.

Mitigation is required to reduce the risk and possible measures include covering of the ground with temporary boarding, or similar, removal of ballast and soil or processing of the ballast to remove the soil matrix, refurbishment of the drainage network, installation of new potable pipework and raised planting beds.

A remediation strategy and options appraisal should be completed to support the future redevelopment of the site.

1 Introduction

Royal HaskoningDHV was appointed by the National Trust (the Trust) to undertake a ground investigation and assessment for the proposed redevelopment of Castlefield Viaduct, Manchester, centred at Ordnance Survey (OS) Grid Reference 383005 Easting 397626 Northing (herein referred to as the 'site'). This assessment will inform proposals to develop the historic viaduct structure into an elevated urban park with integrated active travel hub. A site location plan is provided in Figure 1.1, at the end of this report.

This report should be read in conjunction with the Royal HaskoningDHV Castlefield Viaduct, Manchester Land Quality Desk Study and Preliminary Risk Assessment Report (Royal HaskoningDHV, 2021).

1.1 Description of the Proposed Scheme

Castlefield Viaduct is an unused, 330m long, historic structure in the heart of Manchester. The Trust wishes to bring the viaduct back into use by repurposing the structure into an elevated urban park and integrated active travel hub. The Trust's vision is for the urban park to be utilised in a variety of ways, ranging from exhibitions, fruit and vegetable growing, sculptures, workspace, onward travel information, community meeting and green space.

A Phase 1 Pilot Scheme 'micro park' will be delivered on the eastern section of the viaduct, for a 12-week period in the summer of 2021. The temporary scheme will be undertaken to test the design possibilities and opportunities at the viaduct, generate momentum and support for the permanent scheme. The temporary scheme will comprise the use of the viaduct as a 'micro park' for community events and organised walking tours. An architectural narrative booklet has been produced for the scheme, referred to as the Castlefield Story Book by Twelve Architects, in July 2020. Visualisations included within the booklet indicate the installation of a footpath across parts of the viaduct, the erection of weather shelters and the placement of planting containers.

The Phase 2 'permanent urban park and travel hub scheme' will comprise a permanent development on the viaduct inclusive of food / beverage stands, garden areas, exhibition stalls, seating areas, an events space and toilet facilities.

1.2 Aims and Objectives

The overall aims and objectives of the ground investigation and assessment were as follows:

- Provide information on the current ground conditions of the site with respect to land contamination.
- Refine the Conceptual Site Models (CSMs) and assess potential contaminant linkages associated with the proposed scheme.
- Identify potential unacceptable risks to human health or the environment via a Generic Quantitative Risk Assessment (GQRA).
- Identify potential risks, liabilities and constraints associated with the site and the proposed development.
- Determine if the site is suitable for the proposed scheme with regards to land contamination.
- Provide high level recommendations for further assessment, mitigation or remediation to render the site suitable for use and allow the proposed development to proceed.
- Facilitate and support the planning process.

1.3 Scope of Works

The scope of the investigation and assessment presented herein comprises:

- Intrusive ground investigation.
- A summary of the ground conditions encountered during the ground investigation works undertaken by Royal HaskoningDHV.
- Review the data presented in this report to identify any contaminant linkages that would need to be addressed to permit the safe redevelopment of the site for humans and to controlled waters.
- Complete a human health and controlled waters GQRA utilising soil, soil leachate, ballast leachate and paint laboratory analytical data collected during the ground investigation.
- Use the GQRA findings to refine the CSMs and update potential contaminant linkages, identify the environmental liabilities and how these may affect the proposed redevelopment of the site.
- If required, provide recommendations for further assessment of the environmental conditions of the site and evaluation of environmental risks and liabilities.
- If required, provide high level remedial recommendations to mitigate against the risks associated with the contaminant linkages to render the site suitable for use.

1.4 Legislative Context and Guidance

The key legislation applicable to this work is Part 2A of the Environmental Protection Act 1990.

Part 2A provides a statutory definition of 'Contaminated Land' and sets out the nature of liabilities that can be incurred as a result of contaminated land and groundwater. Contaminated land is defined as "*Any land which appears to the local authority in whose area it is situated to be in such condition, by reason of substances in, on or under the land that:*

- a) significant harm is being caused, or there is significant possibility of such harm being caused; or*
- b) significant pollution of controlled waters is being caused or there is a significant possibility of such pollution being caused."*

Central to the regulatory system is a phased risk-based approach, which is used to establish the existence of 'contaminated land'.

The assessment undertaken in accordance with the following good practice and statutory guidance:

- Environment Agency (EA) 'Land Contamination Risk Management Framework' (2021)
- Ministry of Housing, Communities and Local Government 'National Planning Policy Framework' (2019)
- British Standard 'Investigation of Potentially Contaminated Sites – Code of Practice', BS EN 10175:2011+A1:2013
- Defra 'Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance' PB13735 (2012)
- British Standard 'Code of Practice for Ground Investigations' BS 5930:2015
- EA 'Groundwater Protection Position Statements' (2018)
- CIRIA 'Contaminated Land Risk Assessment – A Guide to Good Practice', C552 (2001)

1.5 Sources of Information

The following information sources have been reviewed to inform the assessment:

- Royal HaskoningDHV, Castlefield Viaduct, Manchester Land Quality Desk Study and Preliminary Risk Assessment 2021. Ref PC2387-RHD-ZZ-XX-RP-Z-0002, dated 10th May 2021

2 Site Setting

2.1 Site Location and Description

Castlefield Viaduct is a Victorian railway viaduct built in 1893, located in Castlefield within Manchester City Centre. It is located approximately 200 metres (m) west of Deansgate-Castlefield Tram Station, which services the Metrolink light rail system and approximately 400 m west of Deansgate Train Station which services the trains. The viaduct is owned by the Department for Transport and is currently disused.

The viaduct is linear in shape, approximately 330 m in length and approximately 14m wide, comprising eight spans. The viaduct is raised off the ground by approximately 16m. It is constructed predominantly of wrought iron / steel and has decorative castellations along its length. Behind the castellations are bearing plates that support the end posts of 16 trusses, the longest of which reaches 53m. The viaduct is a Grade II listed structure.

The top of the viaduct is accessed by foot from Deansgate-Castlefield car park via a locked gate on the eastern site boundary. Vehicular access to the Deansgate-Castlefield car park is made via a ramp off Albion Street. The ground surface of the car park is approximately 0.5 m higher in elevation than the viaduct surface and there is a step down to the viaduct at the gate. There is no vehicular access onto the viaduct. Access is prevented by a vehicle restraint system (VRS) barrier present along the eastern site boundary shared with Deansgate-Castlefield car park.

Historically, three railway tracks ran across the viaduct carrying trains in and out of Manchester Central Station (now known as Manchester Central convention complex). Today, the railway tracks are no longer evident, as the surface of the viaduct is covered by a layer of railway ballast and vegetation.

The land below the viaduct is occupied by land parcels, roads, canals (Rochdale Canal and Bridgewater Canal) and a railway line.

A site layout plan is provided in Figure 2.1, at the end of this report.

2.2 Description of the Site Surroundings

The viaduct is located within a mixed-use setting, land uses adjacent to the site are summarised in Table 2-1 below.

Table 2-1: Current Surrounding Site Uses

Direction	Description
North	Immediately to the north of the western half of the viaduct is Potato Wharf and the Bridgewater Canal and basins. Beyond Potato Wharf are blocks of residential flats (10 m from the northern site boundary) and a construction site.
	Giant's Basin is located immediately north of the centre of the site with a YHA youth hostel present on its bank, approximately 60 m from the northern site boundary. Beyond the youth hostel is a railway line, orientated in a south-east to north-west direction. The railway line is located approximately 280 m north of the western half of the site and travels directly under the viaduct in the eastern part of the site.
	To the north of the eastern half of the site is the Bridgewater Canal Tow Path, Castle Street, the railway line and an events area, referred to as the Castlefield Bowl (50 m from the northern site boundary). To the north of the easterly end of the viaduct are Duke Street, grassed areas, the

Direction	Description
	Castlefield Urban Heritage Park and Beaufort Street (40 m from the north site boundary at its closest point). The River Medlock is located approximately 40 m to the north west of the site, the river flows in a western direction and then to the south where it flows below the Dawson Street road bridge.
East	Immediately to the east of the site is Deansgate-Castlefield car park. The car park is flat and roughly level with the viaduct (approximately 0.5 m higher in elevation). The car park area is raised above the surrounding ground level by red brick arches, which are accessed along Bridgewater Street to the north east of the site. The arches are used as commercial units and car parking facilities. Warehouses, commercial units, residential flats and offices are located in the wider area east of the site. A staircase which leads from ground level to the Deansgate-Castlefield car park is located to the north east of the site. The staircase is located approximately 20m south of Beaufort Street and 10 m from the eastern site boundary.
South	Immediately to the south is a tramline, which runs parallel to the viaduct. Beyond the tramline is a railway line, which also runs parallel to the viaduct and tramline. The Bridgewater Canal and canal basin are located to the south of the tram and railway lines. Beyond the canal is Slate Wharf, Merchant Bridge and Castle Street, the buildings on Castle Street comprise art galleries, offices, residential flats, restaurants and bars. The railway archway immediately below the railway line to the west of Castle Street has been developed into a restaurant with associated outdoor dining area. The Rochdale Canal is located approximately 50 m south the site. It runs in an east to west orientation and terminates at Rochdale Canal Lock 92, approximately 30 m east of a footbridge where Castle Street crosses the canal. A building, which was part of a former sawmill with a chimney, is located on the northern bank of the Rochdale Canal, approximately 50 m east of the site. This building appears to have been repurposed for use as a gallery and residential apartments. Merchants Bridge footbridge crosses the Bridgewater Canal and connects Catalan Square on the northern bank to Slate Wharf on the southern bank. Slate Wharf is characterised by residential apartment blocks, Castlefield Green area of grass, canal quay, car parks and road networks. The Slate Wharf Bridge is closed to public access via a locked gate and is located approximately 20 m south of the viaduct beyond the tram and active railway lines.
West	Immediately west of the site is a parcel of vacant land covered in railway ballast, which would have historically formed part of the railway which crossed the viaduct. This area tapers in width becoming narrower due to the change in trajectory of the tramline located immediately south. Egerton Street and Dawson Street (A56) are located approximately 50 m west of the site and runs in a north to south direction. The River Medlock flows below Dawson Street Bridge at this point. Land to the west is occupied by roads, residential and commercial buildings.

3 Environmental Setting

A summary of relevant background information and site history for the site prior to the ground investigation is presented below in Table 3-1. The information is presented in full within the Land Quality Desk Study and Preliminary Risk Assessment (Royal HaskoningDHV, 2021).

Table 3-1: Summary of Environmental Setting and Site History

Categories	Details
Geology	No superficial deposits recorded.
	Bedrock – Chester Pebble Bed Formation (Principal Aquifer).
Mining & Ground Working	Site is not located within an area affected by historical coal mining. There are 19 records of surface ground workings on the land below the viaduct; these include 12 records of canals, four records of unspecified wharves, one quay, one unspecified and one timber wharf. An additional 24 records of surface ground working are located within 250m of the site.
Groundwater Vulnerability	High in the eastern half of the site and low in the western half of the site.
Source Protection Zone (SPZ)	Not located within an SPZ. SPZ 3 (Total Catchment) located approximately 474 m east.
Groundwater Abstraction	No active groundwater abstractions are recorded on the land directly below or within 1km of the viaduct.
Nearest Surface Water	Bridgewater Canal basin complex is located below the viaduct extending to the north and south.
River / Sea Flooding	Land directly below the viaduct has a high risk of river flooding (Flood Zone 2).
Groundwater Flooding	Land directly below the viaduct has a moderate to high risk of groundwater flooding.
Surface Water Abstractions	No active surface water abstractions are recorded on the land directly below, or within 250m, of the viaduct.
Discharge Consents	No active discharge consents are attributed to the site. The nearest active consent is located 79m south west relating to the discharge of sewer storm overflow into the River Medlock.
Sensitive Land Use	The viaduct is not located in, or within 250 m of a Site of Special Scientific Interest (SSSI), Ramsar Site, Special Area of Conservation (SAC), Special Protection Area (SPA), National or Local Nature Reserve (NNR/LNR) or Ancient Woodland. There are no Nitrate Vulnerable Zones (NVZs) located at or within 250 m of the site. The viaduct is a Grade II listed structure.
Pollution Incidents to Controlled Waters	None attributed to the viaduct. The nearest recorded incident is 172 m north west: June 2001; the pollutant is recorded as diesel which had a minor impact to water (category 3 incident).
Registered landfill, historical landfill or other waste disposal sites	The EA records show that there are no active landfills or recorded historical landfills located at or within 250 m of the viaduct. Local Authority mapping identifies that there were two scrap yards adjacent to the northern boundary and to the south west of the site. Further details are not provided.

Categories	Details
	There are three records of mobile plant licences being issued 164m north west to R E M Mobile Plant and Rec Remediation Ltd.
Waste exemptions	There are six recorded waste exemptions with multiple activities recorded at the same address within 250 m of the site. The nearest is 69 m south of the site and is recorded as sorting of controlled drugs for disposal.
Historical garages	There are three records of historical garages located below the site; additional details on the garages are not included within the information reviewed.
Historical tanks	There is one record of an unspecified tank located below the site recorded on the map of 1922.
Fuel Sites	There is one record of a petrol station located within 250 m of the site. Now obsolete it was located 96 m south.
Historical industrial land uses	The following historical industrial land uses are recorded on or underlying the site: wharves, railways buildings and sidings, unspecified depots and unspecified ground workings. Within 250 m of the site, the following historical industrial land uses are recorded: ■ railway buildings, sidings and stations ■ unspecified depot / commercial / industrial / goods sheds ■ gravel / sand pits / unspecified ground workings ■ wharves, quays and docks ■ paper mill / unspecified mills / silk and cotton mills / sawmill ■ corporation yard ■ cleansing depot ■ refuse heap / unspecified heap ■ chemical works / automobile works
Unexploded Ordnance	Moderate Risk within the general vicinity of the site.
Site & Immediate Surrounding History	The Castlefield Viaduct was constructed in 1893 to carry heavy rail traffic in and out of Manchester Central Station (now Manchester Central convention complex). The viaduct had three rail tracks to carry rail traffic. Manchester Central Station closed in 1969 and the viaduct fell into disuse with the tracks later dismantled. The viaduct has been derelict since then. Prior to the creation of the viaduct, a timber wharf was present on the land underlying the viaduct from the earliest available mapping (1848). In addition to the timber wharf, part of the land underlying the viaduct was occupied by rectangular warehouses from the earliest available OS mapping (1848) until the 1990s, these buildings also extended to the north of the viaduct. The area below and surrounding the viaduct has a history of both industrial and commercial activities since the earliest available mapping to the present day. A number of residential properties have also surrounded the site, also since the earliest available mapping to the present day.
Summary of Preliminary Risk Assessment	Three end use scenarios were considered: leaving the site in its current condition; the pilot scheme in Phase 1; and, permanently repurposed in Phase 2.

Categories	Details
	The PRA is summarised as follows: ■ To remain in its current condition, it was considered that the site poses a moderate to low risk to site visitors / trespassers and controlled waters. ■ In undertaking Phase 1, the site poses a moderate to low risk to future site users, development workers and controlled waters. ■ In undertaking Phase 2, the site poses a moderate to low risk to future site users and a moderate to low risk to construction workers, controlled waters & future buildings / utilities.

4 Ground Investigation Methodology

4.1 Introduction

An intrusive ground investigation comprising the excavation of 10 hand dug pits and 10 paint scrapes was undertaken on the 8th July 2021. The hand dug pits and paint scrapes were undertaken by Royal HaskoningDHV environmental engineers.

4.2 Summary of Field and Laboratory Work

4.2.1 Service Clearance

Intrusive investigation locations were positioned to avoid features identified on the service drawings.

4.2.2 Hand Dug Pits

Hand dug pits were excavated at 10 locations across the viaduct to a maximum depth of 0.3m below ground level (bgl). The exploratory hole locations are illustrated on Figure 3.1, at the end of this report. Each hand dug pit was backfilled with arisings to pre-excavation levels. Exploratory hole logs are presented as Appendix A.

4.2.3 Paint Scrape Samples

Paint scrape samples were collected from ten locations across the viaduct. The locations of the paint samples are illustrated on Figure 3.1, at the end of this report.

4.2.4 Soil Logging

At each hand dug pit location a description of the soils, total depth of the location and differences in soil type or strata was recorded. Soil logging was undertaken in general accordance with BS 5930:2015 + A1:2020 and Eurocode 7. Recorded sample depths and water strikes were recorded on the exploratory hole logs. The exploratory hole logs are presented as Appendix A and exploratory hole photographs as Appendix B.

4.3 Soil and Soil Leachate Sampling

Soil samples were collected from each exploratory hole location in accordance with BS 10175:2011 + A2:2017 'Investigation of Potentially Contaminated Sites'. Sampling was informed by visual and olfactory indicators of contamination.

Soil samples for laboratory analysis were obtained from the arisings of each exploratory location by hand. Disposable nitrile gloves were worn during sampling, with a clean pair of gloves used for each sample to avoid cross contamination.

The soils were separated from the track ballast and placed into appropriate sample tubs and jars as provided by the laboratory. Sample jars intended for volatile organic compounds (VOC) testing were filled with as much material as possible to reduce void space / trapped air.

The sample jars were labelled and dated upon completion of each sample collection, and the containers were placed in a cool box to maintain their temperature for transportation to the laboratory.

4.4 Paint Sampling

Paint samples were collected from each paint scrape location. Paint samples for laboratory analysis were obtained by scraping the paint flakes off the viaduct using a stainless-steel paint scraper. The stainless-steel paint scraper was cleaned after each sample was collected to avoid cross contamination.

Paint samples were placed into appropriate sample jars as provided by the laboratory. Sample jars were filled with a minimum of 5 g of paint as specified by the laboratory.

The sample jars were labelled and dated upon completion of each sample collection, and the containers were placed in a cool box to maintain their temperature for transportation to the laboratory.

4.5 Surface Water Sampling

Surface water sampling was undertaken at one point within the Bridgewater Canal (SW1). The sample was collected using a bucket. The surface water sample was placed into appropriate sample bottles as provided by the laboratory. The surface water monitoring location is presented on Figure 3.1, at the end of this report.

The sample bottles were labelled and dated upon completion of each sample collection, and the containers were placed in a cool box to maintain their temperature for transportation to the laboratory.

4.6 Laboratory Chemical Analysis

A total of 11 soil samples collected from the Made Ground were scheduled for the following analysis:

- Asbestos.
- pH, Total Organic Carbon (TOC) and ammoniacal nitrogen as N.
- Metals: arsenic, barium, beryllium, boron, cadmium, chromium III, chromium VI, copper, lead, mercury, nickel, selenium, vanadium and zinc.
- Polycyclic aromatic Hydrocarbons (PAH) speciated (EPA 16).
- Petroleum hydrocarbons (Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG) with aromatic/aliphatic split).
- Phenols.
- VOCs and Semi Volatile Organic Compounds (SVOCs).

In addition, a total of three soil samples collected for the Made Ground were scheduled for the analysis of herbicides.

A total of 11 soil (Made Ground) and 11 ballast samples were collected and tested for the following soil-leachate chemical analysis:

- pH, sulphate, ammoniacal nitrogen as N and total alkalinity.
- Metals: arsenic, barium, beryllium, boron, cadmium, chromium III, chromium VI, copper, lead, mercury, nickel, selenium, vanadium and zinc.
- PAHs speciated (EPA 16).
- TPH CWG with aromatic/aliphatic split.

- Phenols.
- VOCs and SVOCs.

In addition, a total of three soil leachate samples collected for the Made Ground were scheduled for the analysis of herbicides.

One surface water sample was collected for the following chemical analysis:

- pH, sulphate, ammoniacal nitrogen as N and total alkalinity.
- Metals: arsenic, barium, beryllium, boron, cadmium, chromium III, chromium VI, copper, lead, mercury, nickel, selenium, vanadium and zinc.
- PAHs speciated (EPA 16).
- TPH CWG with aromatic/aliphatic split.
- Phenols.
- VOCs and SVOCs.
- M-BAT (calcium and dissolved organic carbon).

A total of 10 paint samples were collected for the following chemical analysis:

- Metals: cadmium, chromium, lead, nickel and zinc.

The laboratory analysis was undertaken by i2 Analytical UK Ltd. The original laboratory certificates are presented in Appendix C.

4.7 Laboratory Quality Control

One in every 10 samples was collected as a duplicate. The duplicate sample was collected in an identical manner and scheduled for laboratory analysis as part of the quality assurance process to identify potential laboratory variability. The duplicate samples were labelled and numbered anomalously, so that the laboratory was not aware that the sample was a duplicate.

Duplicate samples were collected from one location as summarised below.

Table 4-1: Duplicate Samples

Duplicate ID	Exploratory Hole Location	Depth (m bgl)
HP Dup 1 (soil)	HP110	Ground Level – 0.10
HP Dup 1 (soil-leachate)		
HP Dup Ballast	HP110B	

5 Ground Investigation Findings

5.1 Site Specific Ground Conditions

A summary of the encountered geology on the viaduct is provided in Table 5-1 below.

Table 5-1: Site Specific Geology

Stratum	Geological Unit	Depth to top of stratum	Depth to base of stratum	Thickness (m)	Description
Made Ground	Made Ground	Ground Level	0.30	0.30	Dark brown sandy clayey Gravel with occasional rootlets. Sand is fine to coarse. Gravel is fine to coarse, angular to subangular ballast.

5.2 Visual and Olfactory Evidence of Contamination

Visual and olfactory observations of potential contamination was identified during the ground investigation and is summarised in Table 5-2 below.

Table 5-2: Summary of Visual and Olfactory Evidence of Contamination

Exploratory Hole Location	Visual/olfactory evidence of contamination	Strata
HP101	Oily/greasy feel on soil. Some hydrocarbon staining on track ballast.	Made Ground
HP102		
HP103		
HP104		
HP105		
HP106		
HP107		
HP108		
HP109		
HP110		

5.3 Features and Obstructions

Features and obstructions were identified within the hand dug pit locations across the site. The hand dug pits were terminated at the depth of the obstructions and features. A summary is presented below in Table 5-3.

Table 5-3: Summary of Features and Obstructions

Hand Dug Pit	Depth m bgl (m AOD)	Feature / Obstruction
HP101	0.25 (30.85)	Timber sleeper.
HP102	0.30 (30.70)	Metal Viaduct base.
HP103	0.15 (30.85)	
HP104	0.30 (30.70)	
HP105	0.20 (30.90)	

Hand Dug Pit	Depth m bgl (m AOD)	Feature / Obstruction
HP106	0.30 (30.70)	
HP107	0.30 (30.70)	
HP108	0.30 (30.70)	
HP109	0.15 (30.85)	
HP110	0.10 (30.80)	

5.4 Laboratory Quality Assurance / Quality Control

A comparison of the duplicate sample data sets has been undertaken and a summary of the differences between the samples are provided in the Table 5-4 below.

Table 5-4: Comparison of Duplicate Sample Data Sets

Sample	Duplicate	Differences detected	Greatest difference	Sample concentration (mg/kg)	Duplicate concentration (mg/kg)
HP110 (soil)	HP_Dup_1	Metals PAH TPH	Lead (28.6%) Benzo(k)fluoranthene (36%) Aromatic >EC10-EC12 (50%)	1400 150 43	1000 96 23
HP110 (soil leachate)	HP_Dup_1	Metals PAH	Copper (24.2%) Fluoranthene (71.4%)	9.10 0.21	12.00 0.06
HP110_B (ballast)	HP_Dup_Ballast	Metals PAH	Copper (78.7%) Pyrene (66.7%)	7.50 0.06	1.60 0.02

The differences in concentrations recorded in metals, PAHs and TPHs within soil and soil-leachate samples represents the variability of the samples and is not likely to be representative of invalid laboratory analysis. The differences in the dataset does not make a material difference to the assessment and report conclusions, therefore have been included.

6 Human Health Generic Quantitative Risk Assessment

6.1 Introduction

In order to provide an assessment of the risks to humans presented by contaminants within soils, a human health GQRA has been undertaken. The GQRA involves comparing contaminant concentrations observed at the site with appropriate generic assessment criteria (GACs). The GQRA forms Tier 2 of the tiered approach to assessing risks from land contamination as set out in the EA 2021 Land Contamination Risk Management Framework (LCRM).

The GACs used to screen the soil data include:

- Department for the Environment and Rural Affairs (CL:AIRE, 2014), Category 4 Screening Levels (C4SLs) and in their absence;
- Land Quality Management and the Chartered Institute for Environmental Health, Suitable for Use Levels (S4UL) (LQM,2014); and,
- In the absence of a C4SL or S4UL, data within the Environmental Industries Commission (EIC) / The Association of Geotechnical and Geoenvironmental Specialists (AGS) / Contaminated Land: Applications in Real Environment (CL:AIRE, 2010) have been utilised.

C4SLs are values that have been derived for use in England and Wales to define sites posing low or no risk to human health. The Environmental Protection Act 1990 Contaminated Land Statutory Guidance (DEFRA, 2012) includes a categorisation for land contamination assessment, ranging from Category 4 (low risk) to Category 1 (significant / high risk).

C4SLs are set contaminant levels which are not representative of significant possibility of significant harm (SPoSH) and, as such, where concentrations are below these levels as site would not be classed as a contaminated land as defined by Part 2A of the Environmental Protection Act.

The C4SLs have been adopted by the Department for Communities and Local Government (DCLG) for use under UK planning to define whether land is suitable for use. To date C4SL, have been published for nine contaminants (benzo(a)pyrene, benzene, lead, arsenic, cadmium, chromium VI, tetrachloroethene, trichloroethene and vinyl chloride).

In the absence of C4SLs, the S4ULs have been utilised which are based on minimal risk levels to human health. In the absence of C4SLs and S4ULs, EIC / AGS derived GACs have been used which are also based on minimal risk levels.

Generic parameters are currently published for the following land uses:

- Residential land use with gardens used for growing vegetables.
- Residential land use with gardens not used for growing vegetables.
- Public open space parkland.
- Public open space within residential developments.
- Allotments.
- Commercial land use.

To assess risk to site users, the scenario of public open space – park (POS_{park}) has been adopted as this land use is the most similar to the site's conceptual site model. In a POS_{park} land use scenario, the key receptor is considered to be a young child (age 0 – 6 years) who accompanies parents visiting the park for family visits, picnics and dog walking. It has been assumed that children visit the park 170 days a year and are on site for two hours per day. The exposure pathways considered relevant to young children are:

- Ingestion of soils and dust (outdoors).
- Dermal contact with soils and dusts (outdoors).
- Inhalation of dusts (outdoors).
- Inhalation of vapours (outdoors).

Soil samples have also been screened against allotment GACs to assess the potential risks should food stuffs be grown on the viaduct in the future. This scenario is considered to be a very conservative screen. The exposure pathways relevant to this end use scenario are:

- Direct ingestion of soil (outdoors) and dust derived from soils (indoors).
- Ingestion of soil attached to fruit/vegetables.
- Ingestion of fruit/vegetables.
- Dermal contact with soils (outdoors).
- Inhalation of dust derived from soils (outdoors).
- Inhalation of vapours (outdoors).

The GACs are derived for a variety of Soil Organic Matter (SOM) contents at 1%, 2.5% and 6%. As part of the ground investigation, SOM analysis was completed on representative samples. The SOM concentration of Made Ground soils on site ranged from 8.3% to 14%. It is thought that the SOM concentrations within Made Ground soils recorded are reflective of the PAH and TPH concentrations in all samples rather than true organic matter content. Therefore, a conservative SOM of 1% has been applied to the analysis.

6.2 Soil Screening Results

The soil data collected during the investigation have been screened against the POS_{park} and allotment GACs relevant to the site. The laboratory certificates of chemical analysis are provided within Appendix D.

6.2.1 Soil Sample Assessment

The soil sample data screened against the GAC for a public open space (park) end use identified exceedances for metals and PAHs. A summary of the screening for soil samples is provided below in Table 6-1.

Table 6-1: Summary of Screened Chemical Data – POS_{park} End Use

Determinands	Total number of samples	GAC (mg/kg)	Data range (min – max) mg/kg	No. of results above GAC	Location and exceedance of GAC
Lead	11	1300	59 – 4400	4	HP103 (0.00 – 0.15 m) – 4400 mg/kg HP105 (0.00 – 0.20 m) – 1400 mg/kg HP107 (0.00 – 0.30 m) – 2100 mg/kg HP110 (0.00 – 0.10 m) – 1400 mg/kg

Determinands	Total number of samples	GAC (mg/kg)	Data range (min – max) mg/kg	No. of results above GAC	Location and exceedance of GAC
Chrysene	11	93	6.3 – 270	3	HP103 (0.00 – 0.15 m) – 94 mg/kg HP110 (0.00 – 0.10 m) – 270 mg/kg HP Dup 1 (0.00 – 0.10 m) – 220 mg/kg
Benzo(a)pyrene	11	10	6.4 – 320	10	HP101 (0.00 – 0.25 m) – 37 mg/kg HP102 (0.00 – 0.30 m) – 12 mg/kg HP103 (0.00 – 0.15 m) – 62 mg/kg HP104 (0.00 – 0.30 m) – 13 mg/kg HP105 (0.00 – 0.20 m) – 39 mg/kg HP106 (0.00 – 0.30 m) – 22 mg/kg HP107 (0.00 – 0.30 m) – 72 mg/kg HP108 (0.00 – 0.30 m) – 16 mg/kg HP110 (0.00 – 0.10 m) – 320 mg/kg HP Dup 1 (0.00 – 0.10 m) – 280 mg/kg

The soil sample data screened against the GAC for an allotment end use identified exceedances for metals, TPHs and PAHs. A summary of the screening for soil samples is provided below in Table 6-2.

Table 6-2: Summary of Screened Chemical Data – Allotment End Use

Determinands	Total number of samples	GAC (mg/kg)	Data range (min – max) mg/kg	No. of results above GAC	Location and exceedance of GAC
Arsenic	11	49	16 – 83	9	HP101 (0.00 – 0.25 m) – 62 mg/kg HP102 (0.00 – 0.30 m) – 69 mg/kg HP103 (0.00 – 0.15 m) – 51 mg/kg HP104 (0.00 – 0.30 m) – 66 mg/kg HP106 (0.00 – 0.30 m) – 76 mg/kg HP107 (0.00 – 0.30 m) – 66 mg/kg HP108 (0.00 – 0.30 m) – 83 mg/kg HP110 (0.00 – 0.10 m) – 60 mg/kg HP Dup 1 (0.00 – 0.10 m) – 62 mg/kg
Lead	11	80	59 – 4400	10	HP101 (0.00 – 0.25 m) – 1200 mg/kg HP102 (0.00 – 0.30 m) – 550 mg/kg HP103 (0.00 – 0.15 m) – 4400 mg/kg HP104 (0.00 – 0.30 m) – 520 mg/kg HP105 (0.00 – 0.20 m) – 1400 mg/kg HP106 (0.00 – 0.30 m) – 1100 mg/kg HP107 (0.00 – 0.30 m) – 2100 mg/kg HP108 (0.00 – 0.30 m) – 1200 mg/kg HP110 (0.00 – 0.10 m) – 1400 mg/kg HP Dup 1 (0.00 – 0.10 m) – 1000 mg/kg
Nickel	11	53	39 – 150	10	HP101 (0.00 – 0.25 m) – 67 mg/kg HP102 (0.00 – 0.30 m) – 80 mg/kg HP103 (0.00 – 0.15 m) – 150 mg/kg HP104 (0.00 – 0.30 m) – 61 mg/kg HP105 (0.00 – 0.20 m) – 55 mg/kg HP106 (0.00 – 0.30 m) – 70 mg/kg HP107 (0.00 – 0.30 m) – 70 mg/kg HP108 (0.00 – 0.30 m) – 73 mg/kg HP110 (0.00 – 0.10 m) – 60 mg/kg

Determinands	Total number of samples	GAC (mg/kg)	Data range (min – max) mg/kg	No. of results above GAC	Location and exceedance of GAC
					HP Dup 1 (0.00 – 0.10 m) – 61 mg/kg
Zinc	11	620	110 – 990	3	HP101 (0.00 – 0.25 m) – 680 mg/kg HP110 (0.00 – 0.10 m) – 990 mg/kg HP Dup 1 (0.00 – 0.10 m) – 790 mg/kg
Naphthalene	11	4.1	0.58 – 18	2	HP110 (0.00 – 0.10 m) – 18 mg/kg HP Dup 1 (0.00 – 0.10 m) – 12 mg/kg
Acenaphthene	11	34	1.4 – 85	2	HP110 (0.00 – 0.10 m) – 85 mg/kg HP Dup 1 (0.00 – 0.10 m) – 73 mg/kg
Fluorene	11	27	0.97 – 50	2	HP110 (0.00 – 0.10 m) – 50 mg/kg HP Dup 1 (0.00 – 0.10 m) – 44 mg/kg
Phenanthrene	11	15	11 – 540	8	HP101 (0.00 – 0.25 m) – 49 mg/kg HP103 (0.00 – 0.15 m) – 54 mg/kg HP104 (0.00 – 0.30 m) – 20 mg/kg HP105 (0.00 – 0.20 m) – 24 mg/kg HP106 (0.00 – 0.30 m) – 22 mg/kg HP107 (0.00 – 0.30 m) – 68 mg/kg HP110 (0.00 – 0.10 m) – 540 mg/kg HP Dup 1 (0.00 – 0.10 m) – 450 mg/kg
Fluoranthene	11	52	17 – 760	6	HP101 (0.00 – 0.25 m) – 81 mg/kg HP103 (0.00 – 0.15 m) – 170 mg/kg HP105 (0.00 – 0.20 m) – 65 mg/kg HP107 (0.00 – 0.30 m) – 140 mg/kg HP110 (0.00 – 0.10 m) – 760 mg/kg HP Dup 1 (0.00 – 0.10 m) – 660 mg/kg
Pyrene	11	110	16 – 710	4	HP103 (0.00 – 0.15 m) – 170 mg/kg HP107 (0.00 – 0.30 m) – 130 mg/kg HP110 (0.00 – 0.10 m) – 710 mg/kg HP Dup 1 (0.00 – 0.10 m) – 600 mg/kg
Chrysene	11	4.1	6.3 – 270	11	HP101 (0.00 – 0.25 m) – 39 mg/kg HP102 (0.00 – 0.30 m) – 12 mg/kg HP103 (0.00 – 0.15 m) – 94 mg/kg HP104 (0.00 – 0.30 m) – 14 mg/kg HP105 (0.00 – 0.20 m) – 33 mg/kg HP106 (0.00 – 0.30 m) – 22 mg/kg HP107 (0.00 – 0.30 m) – 64 mg/kg HP108 (0.00 – 0.30 m) – 14 mg/kg HP109 (0.00 – 0.15 m) – 6.3 mg/kg HP110 (0.00 – 0.10 m) – 270 mg/kg HP Dup 1 (0.00 – 0.10 m) – 220 mg/kg
Benzo(a)pyrene	11	5.7	6.4 – 320	11	HP101 (0.00 – 0.25 m) – 37 mg/kg HP102 (0.00 – 0.30 m) – 12 mg/kg HP103 (0.00 – 0.15 m) – 62 mg/kg HP104 (0.00 – 0.30 m) – 13 mg/kg HP105 (0.00 – 0.20 m) – 39 mg/kg HP106 (0.00 – 0.30 m) – 22 mg/kg HP107 (0.00 – 0.30 m) – 72 mg/kg HP108 (0.00 – 0.30 m) – 16 mg/kg

Determinands	Total number of samples	GAC (mg/kg)	Data range (min – max) mg/kg	No. of results above GAC	Location and exceedance of GAC
					HP109 (0.00 – 0.15 m) – 6.4 mg/kg HP110 (0.00 – 0.10 m) – 320 mg/kg HP Dup 1 (0.00 – 0.10 m) – 280 mg/kg
Aromatic C10-C12	11	13	<1 – 46	2	HP110 (0.00 – 0.10 m) – 46 mg/kg HP Dup 1 (0.00 – 0.10 m) – 23 mg/kg
Aromatic C12-C16	11	23	8.3 – 230	8	HP101 (0.00 – 0.25 m) – 30 mg/kg HP102 (0.00 – 0.30 m) – 27 mg/kg HP103 (0.00 – 0.15 m) – 42 mg/kg HP104 (0.00 – 0.30 m) – 24 mg/kg HP105 (0.00 – 0.20 m) – 26 mg/kg HP107 (0.00 – 0.30 m) – 31 mg/kg HP110 (0.00 – 0.10 m) – 230 mg/kg HP Dup 1 (0.00 – 0.10 m) – 170 mg/kg
Aromatic C16-C21	11	46	52 – 1300	11	HP101 (0.00 – 0.25 m) – 210 mg/kg HP102 (0.00 – 0.30 m) – 73 mg/kg HP103 (0.00 – 0.15 m) – 410 mg/kg HP104 (0.00 – 0.30 m) – 81 mg/kg HP105 (0.00 – 0.20 m) – 170 mg/kg HP106 (0.00 – 0.30 m) – 110 mg/kg HP107 (0.00 – 0.30 m) – 340 mg/kg HP108 (0.00 – 0.30 m) – 78 mg/kg HP109 (0.00 – 0.15 m) – 52 mg/kg HP110 (0.00 – 0.10 m) – 1200 mg/kg HP Dup 1 (0.00 – 0.10 m) – 1300 mg/kg
Aromatic C21-C35	11	370	86 – 1300	6	HP101 (0.00 – 0.25 m) – 380 mg/kg HP103 (0.00 – 0.15 m) – 790 mg/kg HP105 (0.00 – 0.20 m) – 430 mg/kg HP107 (0.00 – 0.30 m) – 680 mg/kg HP110 (0.00 – 0.10 m) – 1000 mg/kg HP Dup 1 (0.00 – 0.10 m) – 1300 mg/kg

Asbestos analysis was undertaken on each of the soil samples collected as part of the investigation. No asbestos was detected within the samples analysed.

6.2.2 Discussion of Potential Risks to Human Health from Site Soils

This section of the report focuses primarily on exceedances for the POS_{park} end use as this land scenario closely matches the proposed end use. It is also likely that foodstuffs would be grown in elevated planters due to the matrix of the track ballast and associated soils to support plant growth.

6.2.2.1 Metals

Lead

Lead has been recorded above the POS_{park} GAC of 1mg/kg within four of the 11 soil samples collected from the site. Exceedances were recorded within HP103, HP105, HP107 and HP110 at concentrations ranging from 1400mg/kg to 4400mg/kg. The highest concentration was recorded within the soil sample collected from HP103.

The exceedances recorded are three orders of magnitude greater than that of the associated GAC. Therefore, the concentrations present have the potential to cause an unacceptable risk to human health receptors if mitigation measures are not incorporated into the design of the scheme.

6.2.2.2 Polycyclic Aromatic Hydrocarbons

Chrysene

Chrysene was recorded above the POS_{park} GAC of 93mg/kg within three of the 11 soil samples collected from the site. Exceedances were recorded within HP103, HP110 and HP Dup 1, the concentrations recorded were 94mg/kg, 270mg/kg and 220mg/kg respectively.

The exceedances of the GAC associated with chrysene are considered to be localised hotspots within the site rather than widespread. The exceedance within HP103 is considered to be marginal, whereas the remaining two exceedances associated with HP110 and its duplicate are an order of magnitude greater. Therefore, concentrations present within HP110 and its duplicate may potentially represent an unacceptable risk to human health receptors if mitigation measures are not incorporated into the design of the scheme within these areas.

Benzo(a)pyrene

Benzo(a)pyrene was recorded above the POS_{park} GAC of 11mg/kg within ten of the 11 soil samples collected from the site. An exceedance of benzo(a)pyrene was not recorded within HP109. Concentrations in excess of the GAC ranged from 12mg/kg to 320mg/kg, with the highest concentration recorded within HP110.

The exceedances were recorded across the site and benzo(a)pyrene contamination is considered to be widespread rather than an isolated occurrence. Therefore, the concentrations present have the potential to represent an unacceptable risk to human health receptors if mitigation measures are not incorporated into the design of the scheme.

6.2.2.3 Allotment End Use

The screening of the soil chemical data against GACs protective of an allotment end use is considered to be overly conservative given the proposed end use of the viaduct. However, it is understood that foodstuffs / 'greenstuff' will be planted directly into planters.

6.3 Drinking Water Pipes Assessment

The screening of the analytical results against United Kingdom Water Industry Research (UKWIR) Water Supply Threshold Values criteria indicates that at least one or more determinands that have the potential to permeate drinking water pipes and contaminate the supply (hydrocarbons and PAHs) are recorded above the UKWIR in No. 11 soil samples. The screened data are presented in Appendix D.

If new drinking water pipes are to be laid in Made Ground soils, a bespoke assessment needs to be undertaken along the route of future pipelines in accordance with the local water authority requirements. A risk assessment in line with United Utilities guidance needs to be completed and submitted for their consideration. Mitigation measures could include service runs of 'clean' inert materials that could be utilised and/or barrier piping to be protective of the potable water supply.

6.4 Paint Sample Screening Results

Paint samples collected as part of the ground investigation were assessed against the SoBRA aGAC protective of construction and maintenance workers who, for example, may be involved in repainting the viaduct structure.

6.4.1 Paint Sample Assessment

The paint samples screened against SoBRA aGAC identified no exceedances for cadmium. No additional aGAC values are currently available for the remaining metals assessed as part of the laboratory analysis.

Table 6-3: Summary of Paint Samples

Determinands	Total Number of samples	aGAC (mg/kg)	Data range (min-max) mg/kg
Cadmium	10	12,000	<0.20 – 10
Chromium	10	N/A	110 – 310
Lead	10	N/A	55,000 – 66,000
Nickel	10	N/A	12 – 30
Zinc	10	N/A	1,200 – 6,500

Due to the concentrations of lead and zinc recorded in the paint samples, there is the potential for unacceptable risks to construction and maintenance workers should appropriate mitigation measures, such as use of PPE, not be incorporated into the scheme design. In addition, the release of the paint flakes needs to be controlled when being worked on and not released into the wider environment. The works to refurbish the viaduct should be undertaken by a suitably qualified contractor who will provide the appropriate working methodologies and risk assessments to undertake work of this nature.

6.5 Human Health GQRA Summary

The assessment of the soil and paint chemical data identified the following key points:

- Concentrations of benzo(a)pyrene in excess of their respective POS_{Park} GAC are widespread across the site and may potentially present an unacceptable risk to human health receptors if appropriate measures are not incorporated into the design.
- Exceedances of GAC for lead and chrysene are considered to be localised. The concentrations recorded may pose a potentially unacceptable risk to human health if appropriate mitigation measures are not incorporated into the design.
- Should the end use for the site change to an allotment, mitigation measures would be required above those required for a POS_{Park} end use due to the degree of exceedances recorded.
- If potable water pipes are to be laid as part of the proposed scheme, risk assessment in line with United Utilities guidance needs to be completed.
- Paint samples containing high levels of lead and zinc were identified, mitigation measure protective of the health of construction and maintenance works should be incorporated into the project design and maintenance scheme to reduce the potential risks to these receptors.

7 Controlled Waters Generic Quantitative Risk Assessment

The controlled waters GQRA assessment evaluates potentially unacceptable risks posed to identified controlled water receptors from the migration of potential on-site sources of contamination as identified in the CSM. The GQRA has assessed the following data from the site investigation:

- Soil leachate data.
- Ballast leachate data.
- Surface water data.

7.1 Methodology

To support the evaluation of potential risks to controlled water receptors from contaminants within soils and ballast, a controlled waters GQRA has been undertaken. This has been carried out by comparing the results of the soil leachate and ballast leachate analysis with the relevant screening criteria for the key controlled waters receptors.

To assess the risks to surface water receptors, soil-leachate derived data has also been compared with Water Framework Directive (WFD) EQS for inland surface water.

The Water Framework Directive United Kingdom Technical Advisory Group (WFD-UKTAG) (WFD-UKTAG, 2013) river and lake assessment method for specific pollutants (metals) Metal Bioavailability Assessment Tool (M-BAT) was used to derive Tier 2 site specific EQS values for copper, lead, zinc, and nickel. These parameters were obtained from analysis of a surface water sample recovered from the surface water receptor (Bridgewater Canal).

The WFD-UKTAG ambient background concentration (ABC) for 'all other freshwaters not listed' of 1.4µg/l was added to the zinc EQS.

The risk to groundwater beneath the viaduct has not been considered from site soils / ballast, primarily due to the lack of plausible pollutant linkages between the source and receptor.

7.2 Assessment of Risks to Surface Water Receptors

7.2.1 Soil and Ballast Leachate Assessment

Table 7-1 summarises the soil leachate assessment with respect to data recorded above the EQS. Screened data are presented in Appendix D.

Table 7-1: Soil Leachate Data EQS Assessment

Determinands	Total number of samples	EQS (µg/l)	Data range (min – max) µg/l	No. of results above EQS	Location of exceedance of the EQS
Copper	11	17.1	5.2 – 24	2	HP101 (0.00 – 0.25 m) – 24 µg/l HP102 (0.00 – 0.30 m) – 20 µg/l
Lead	11	4.99	2.1 – 9.6	7	HP101 (0.00 – 0.25 m) – 5.6 µg/l HP103 (0.00 – 0.15 m) – 5.2 µg/l HP105 (0.00 – 0.20 m) – 9.6 µg/l HP107 (0.00 – 0.30 m) – 7.7 µg/l HP108 (0.00 – 0.30 m) – 7.0 µg/l HP110 (0.00 – 0.10 m) – 5.9 µg/l

Determinands	Total number of samples	EQS (µg/l)	Data range (min – max) µg/l	No. of results above EQS	Location of exceedance of the EQS
					HP Dup 1 (0.00 – 0.10 m) – 5.5 µg/l
Zinc	11	24.66	3.4 – 28	1	HP101 (0.00 – 0.25 m) – 28 µg/l
Anthracene	11	0.1	<0.01 – 0.14	1	HP109 (0.00 – 0.15 m) – 0.14 µg/l
Fluoranthene	11	0.0063	0.03 – 1.6	11	HP101 (0.00 – 0.25 m) – 0.16 µg/l HP102 (0.00 – 0.30 m) – 0.08 µg/l HP103 (0.00 – 0.15 m) – 0.39 µg/l HP104 (0.00 – 0.30 m) – 0.03 µg/l HP105 (0.00 – 0.20 m) – 0.14 µg/l HP106 (0.00 – 0.30 m) – 0.11 µg/l HP107 (0.00 – 0.30 m) – 0.62 µg/l HP108 (0.00 – 0.30 m) – 0.08 µg/l HP109 (0.00 – 0.15 m) – 1.6 µg/l HP110 (0.00 – 0.10 m) – 0.21 µg/l HP Dup 1 (0.00 – 0.10 m) – 0.06 µg/l
Benzo(a)pyrene	11	0.00017	<0.01 – 0.81	8	HP101 (0.00 – 0.25 m) – 0.05 µg/l HP103 (0.00 – 0.15 m) – 0.1 µg/l HP105 (0.00 – 0.20 m) – 0.14 µg/l HP106 (0.00 – 0.30 m) – 0.05 µg/l HP107 (0.00 – 0.30 m) – 0.32 µg/l HP109 (0.00 – 0.15 m) – 0.81 µg/l HP110 (0.00 – 0.10 m) – 0.11 µg/l HP Dup 1 (0.00 – 0.10 m) – 0.09 µg/l

Note: the assessment criteria are lower than the laboratory limit of detection (LoD) for determinands such as fluoranthene and benzo(a)pyrene. Only samples that exceeded the laboratory LoD have been included in this assessment.

Table 7-2 summarises the ballast leachate assessment with respect to data recorded above the EQS. Screened data is presented in Appendix D.

Table 7-2: Ballast Leachate Data EQS Assessment

Determinands	Total number of samples	EQS (µg/l)	Data range (min – max) µg/l	No. of results above EQS	Location of exceedance of the EQS
Lead	11	4.99	1.4 – 30	7	HP101B (0.00 – 0.25 m) – 9.8 µg/l HP103B (0.00 – 0.15 m) – 23 µg/l HP105B (0.00 – 0.20 m) – 30 µg/l HP107B (0.00 – 0.30 m) – 13 µg/l HP108B (0.00 – 0.30 m) – 15 µg/l HP109B (0.00 – 0.15 m) – 19 µg/l HP110B (0.00 – 0.10 m) – 7.9 µg/l
Fluoranthene	11	0.0063	0.01 – 0.1	11	HP101B (0.00 – 0.25 m) – 0.04 µg/l HP102B (0.00 – 0.30 m) – 0.01 µg/l HP103B (0.00 – 0.15 m) – 0.06 µg/l HP104B (0.00 – 0.30 m) – 0.02 µg/l HP105B (0.00 – 0.20 m) – 0.06 µg/l HP106B (0.00 – 0.30 m) – 0.02 µg/l HP107B (0.00 – 0.30 m) – 0.05 µg/l HP108B (0.00 – 0.30 m) – 0.02 µg/l HP109B (0.00 – 0.15 m) – 0.1 µg/l HP110B (0.00 – 0.10 m) – 0.06 µg/l

Determinands	Total number of samples	EQS (µg/l)	Data range (min – max) µg/l	No. of results above EQS	Location of exceedance of the EQS
					HP Dup B (0.00 – 0.10 m) – 0.02 µg/l
Benzo(a)pyrene	11	0.00017	<0.01 – 0.09	2	HP109B (0.00 – 0.15 m) – 0.09 µg/l HP110B (0.00 – 0.10 m) – 0.07 µg/l

Note: the assessment criteria are lower than the laboratory limit of detection (LoD) for determinands such as fluoranthene and benzo(a)pyrene. Only samples that exceeded the laboratory LoD have been included in this assessment.

7.2.2 Surface Water Assessment

Table 7-3 summarises the surface water assessment with respect to the data recorded above the EQS. Screened data are presented as Appendix D. The surface water sample was collected from the Bridgewater Canal.

Table 7-3: Surface Water Data EQS Assessment

Determinands	EQS (µg/l)	Exceedance concentration (µg/l)
Lead	4.99	8.4
Zinc	24.66	25
Fluoranthene	0.0063	0.02

Note: the assessment criteria are lower than the laboratory limit of detection (LoD) for determinands such as fluoranthene and benzo(a)pyrene. Only samples that exceeded the laboratory LoD have been included in this assessment.

7.2.3 Discussion of Potentially Unacceptable Risks Relating to Surface Water Receptors

Concentrations of contaminants in soil-derived leachate, ballast-derived leachate and surface water were assessed against EQS protective of the Bridgewater Canal and River Medlock, a discussion of the results is provided below.

7.2.3.1 Metals and Metalloids

A comparison of exceedances of the EQS for metals in soil-derived leachate and ballast-derived leachate is presented below in Table 7-4.

Table 7-4: Comparison of Metals in Soil-Derived Leachate and Ballast-Derived Leachate EQS Assessment

Determinands	No. of samples (soil-Leachate)	No. of exceedances (soil-leachate)	No. of samples (ballast-leachate)	No. of exceedances (ballast leachate)
Copper	11	2	11	0
Lead	11	7	11	7
Zinc	11	1	11	0

Copper

Copper was recorded above its EQS of 17.1 µg/l within two of the 11 soil leachate samples analysed. The exceedances were recorded within HP101 and HP102 at concentrations of 24 µg/l and 20 µg/l respectively. No additional exceedances of the copper EQS were recorded within the remaining soil leachate or ballast leachate samples.

The concentrations of copper recorded within the soil leachate samples are marginally above the site specific EQS. It is therefore considered unlikely that the recorded concentrations of copper at the site represent an unacceptable risk to surface water receptors.

Lead

Lead was recorded above its EQS of 4.99 µg/l within seven of the 11 soil leachate samples and seven of the 11 ballast leachate samples. Six of the exceedances of the lead EQS were recorded in both the soil leachate and ballast leachate samples from the same exploratory holes. An exceedance of lead was also recorded within the surface water sample.

The concentrations of lead recorded within the ballast leachate samples were generally higher than those recorded in the soil leachate samples. Within the soil leachate samples the exceedances were within the same order of magnitude as the EQS. However, within the ballast leachate samples, apart from two samples, all exceedances were one order of magnitude greater than the EQS.

Exceedances of the lead EQS are widespread across the site and could potentially represent an unacceptable risk to surface water receptors.

Zinc

Zinc was recorded above its EQS of 24.66 µg/l within one of the 11 soil leachate samples analysed. The exceedance was recorded within HP101 at a concentration of 28 µg/l. No additional exceedances of the zinc EQS were recorded within the remaining soil leachate or ballast leachate samples. However, an exceedance of zinc was also recorded within the surface water sample at a similar concentration to that of the soil leachate sample (25 µg/l).

The concentration of zinc recorded within the soil leachate sample was marginally above the site specific EQS and is not considered widespread across the site. It is therefore considered unlikely that the recorded concentration of zinc at the site represents an unacceptable risk to surface water receptors.

7.2.3.2 Polycyclic Aromatic Hydrocarbons

A comparison of the exceedances of the EQS for PAHs in soil leachate and ballast leachate is presented in Table 7-5.

Table 7-5: Comparison of PAHs in Soil Leachate and Ballast Leachate – EQS Assessment

Determinands	No. of soil leachate samples	No. of exceedances (soil leachate)	No. of ballast leachate samples	No. of exceedances (ballast leachate)
Anthracene	11	1	11	0
Fluoranthene	11	11	11	11
Benzo(a)pyrene	11	8	11	2

Anthracene

Anthracene was recorded above its EQS of 0.1 µg/l in one of the 11 soil leachate samples analysed at the site. The exceedance was recorded within the sample obtained from HP109 at a concentration of 0.14 µg/l. Apart from one soil leachate sample, the remaining soil leachate samples and all ballast leachate samples recorded concentrations of anthracene below the laboratory limit of detection.

Analysis of the soil leachate and ballast leachate samples indicates that the exceedance of anthracene is isolated and not widespread across the site. Therefore, it is considered unlikely that anthracene represents an unacceptable risk to surface water receptors.

Fluoranthene

Fluoranthene was recorded above its EQS of 0.0063 µg/l in all soil leachate samples at concentrations ranging from 0.03 µg/l to 1.6 µg/l. Fluoranthene was also recorded above its EQS in all ballast leachate samples. Exceedances were recorded at concentrations between 0.01 µg/l and 0.1 µg/l within the ballast leachate samples. The greatest exceedance for both the soil leachate and ballast leachate was recorded in samples collected from HP109 and HP019B. An exceedance of fluoranthene was also recorded within the surface water sample collected as part of the ground investigation.

Analysis of the chemical data indicates that fluoranthene has the potential to leach from the soils and the ballast site wide at a concentration which may pose an unacceptable risk to surface waters. The impact would come via the present drainage arrangement.

Benzo(a)pyrene

Benzo(a)pyrene was recorded above its EQS of 0.00017 µg/l within eight of the 11 soil leachate samples analysed at the site. Exceedances of benzo(a)pyrene ranged from 0.05 µg/l to 0.81 µg/l with the most elevated concentration recorded in HP109.

Benzo(a)pyrene was also recorded above its EQS in two of the 11 ballast leachate samples analysed at the site. The exceedances of the EQS were recorded in HP109B and HP110B at concentrations of 0.09 µg/l and 0.07 µg/l respectively.

Concentrations of benzo(a)pyrene within the surface water sample was recorded as being below the laboratory limit of detection.

Analysis of the chemical data indicates that benzo(a)pyrene contamination within soil leachate samples is widespread across the site. Within the ballast leachate samples, the exceedances are localised. In terms of risk to surface water receptors, it is considered that it has the potential to leach from the soils at a concentration which may pose an unacceptable risk to surface waters. The impact would come via the present drainage arrangement.

7.3 Controlled Waters GQRA Summary

Based on the findings of the ground investigation and subsequent assessment, the following conclusions can be made for controlled waters:

- It is considered unlikely that the recorded concentrations of copper and zinc at the site represent an unacceptable risk to surface water receptors.
- Lead, benzo(a)pyrene and fluoranthene have the potential to leach at concentrations which may pose an unacceptable risk to surface waters.

Whilst exceedances of the EQS have been identified within soil-leachate sample results, the following needs to be considered:

- The method of laboratory analysis overestimates what could be leached from the soil in a real-life scenario from rainfall due to the aggressive nature of the sample preparation.
- The most elevated exceedances of the EQS were recorded for metals (copper, zinc and lead) and PAHs (benzo(a)pyrene and fluoranthene) and these generally have a low groundwater mobility.
- It is known that surface water runoff is collected via a drainage system located on the viaduct and discharged into the Bridgewater Canal. It is considered likely that the canal is lined with puddle clay

forming an impermeable barrier between the surface water and groundwater bodies therefore a risk to groundwater has not been considered further.

8 Refined Conceptual Site Model

The CSM presented in the PRA identifying potential contamination source, pathway and receptors (Royal HaskoningDHV, 2021) has been updated following the GQRA. The refined CSM incorporates the site geology, hydrogeology, hydrology and the site-specific data gathered during this phase of investigation to determine the potential contaminant linkages (PCLs).

The refined CSM is described below prior to inclusion in the refined risk assessment table. The pathways are considered to be the same.

8.1 Refined Sources

Based on the available information for the site the following potential sources of contamination have been identified in Table 8-1 below.

Table 8-1: Refined Sources on the Viaduct Structure

Potential Source	Refined Contaminants
Railway land and ballast/soil matrix (on viaduct structure)	Soils (human health) - lead, chrysene and benzo(a)pyrene.
	Soils (water pipelines) - hydrocarbons and PAH.
	Soil-Leachate (surface water receptors) – primarily lead, fluoranthene and benzo(a)pyrene.
Metals and paint flaked off from viaduct structure (on viaduct structure)	Lead and Zinc.

The potential for further contamination may be present within areas between exploratory hole locations.

Potential offsite sources below and within the immediate vicinity of the scheme have been summarised below. In the absence of ground investigation, the sources and potential contaminants have been reduced.

Table 8-2: Refined Off-Site Sources on the Viaduct Structure

Potential Source	Refined Contaminants
Land uses above and below ground (historical and current) which have the potential to impact the ground.	Contaminants of potential concern include metals and metal compounds, cyanides, sulphates, phenols, PAHs, creosote, paints and solvents (aromatic hydrocarbons and chlorinated aliphatic hydrocarbons), organotin, cyanides, biocides, fuels and oil hydrocarbons and asbestos.

8.2 Potential Pathways and Receptors

Three potential scenarios have been identified in relation to the use of the site, these include:

- The site in its current condition (current CSM).
- The site during the Phase 1 'Pilot Scheme' being utilised as a 'micro park' this includes the introduction of a temporary footpath surface, the erection of temporary pop-up shelters (assumed to be well ventilated) and placement of planters (Phase 1 Pilot Scheme CSM).
- The site when it is permanently repurposed in Phase 2 as an urban park and travel hub. This will include the construction of food / beverage stands, gardens, stalls, seating areas, an events space and toilet facilities. It has been assumed that raised planting beds will be created and a pathway between railway ballast and consumption of site grown vegetables is not considered (Phase 2, Permanent Urban Park and Travel Hub CSM).

Table 8-3 below outlines which receptors and pathways would be associated with each of the three scenarios in relation to the refined model.

Table 8-3: Refined Pathways and Receptors

Receptors	Pathways	Current CSM	Phase 1 - Pilot Scheme CSM	Phase 2- Permanent Urban Park and Travel Hub CSM	Comments regarding sources
Human Health					
Site users (visitors, trespassers, maintenance, future workers and visitors)	Direct exposure through dermal contact, ingestion or inhalation of contaminants within the ballast cover across the viaduct.	✓	✓	✓	
	Direct exposure through dermal contact, ingestion or inhalation of contaminants within the paintwork.	✓	✓	✓	
	Inhalation of volatile contaminants.	X	X	X	Not identified in investigation
Development workers during construction	Direct exposure through dermal contact, ingestion or inhalation of contaminants within the ballast cover across the viaduct.	X	✓	✓	
	Direct exposure through dermal contact, ingestion or inhalation of contaminants within the paintwork.	✓	✓	✓	
	Inhalation of volatile contaminants.	X	X	X	Not identified in investigation
Controlled Waters					
Chester Pebble Bed Formation – Principal Aquifer	Migration via preferential pathways caused by piling (if required).	X	X	✓	Specifically, at ground level
Bridgewater Canal (below the viaduct and in immediate surrounding area)	Leaching, dissolution and migration of contaminants from the ballast covering the site via surface drainage and discharge into surface water receptors.	✓	✓	✓	
River Medlock (40m west of the site)		✓	✓	✓	
Buildings and Utilities					
Future utilities (on the structure and below)	Direct contact and permeation of water supply pipes.	X	X	✓	High level assessment identifies a risk

Table 8-4: Revised Conceptual Site Model for Current Use

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
Historical site use as railway land, ballast/soil layer covering viaduct and paint on the viaduct.	Direct exposure through dermal contact, ingestion or inhalation of soil/ballast and associated dusts.	Site visitors and trespassers	Health risk	Severe	Low likelihood	Moderate to low risk	Exceedances of the POS _{park} GACs for lead and PAHs were identified within the soil samples analysed. Exposure is possible but it would be unlikely that visitors and trespassers would be interfering with the soil matrix surrounding the ballast.
		Maintenance Workers		Severe	Likely	High	Maintenance workers who visit the site in order to undertake vegetation clearance may come into direct contact with the contaminants identified on site specifically lead and PAH. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures coupled with PPE.
	Direct exposure through dermal contact, ingestion or inhalation of paint flakes and associated dusts.	Site visitors and trespassers		Severe	Low likelihood	Moderate to low risk	High concentrations of metals, in particular lead and zinc, were recorded within paint samples collected from the site. Exposure is possible but it would be unlikely that visitors and trespassers would be interfering with the paint work.
		Maintenance Workers		Severe	Likely	High	Maintenance workers who visit the site in order to undertake painting of the viaduct may come into direct contact with the contaminants identified on site specifically lead and zinc. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures coupled with PPE.
	Leaching of contaminants and migration via surface water network.	Bridgewater Canal and River Medlock	Pollution of controlled waters	Mild	Likely	Moderate to Low	Exceedances of EQS for lead and PAHs were recorded in both soil leachate and ballast leachate samples analysed at the site. A widespread impact was noted for lead and fluoranthene. This is an aggressive test. There was no evidence of water within the exploratory holes and the timeframes between raining and drainage of the viaduct maybe insufficient for leachate to be generated.

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
							There may be an unacceptable risk to surface water receptors. The risk could be lowered through appropriate drainage arrangements.

Table 8-5: Revised Conceptual Site Model for Phase 1 – Pilot Scheme

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
Historical site use as railway land, ballast/soil layer covering viaduct and paint on the viaduct.	Direct exposure through dermal contact, ingestion or inhalation of soil/ballast and associated dusts.	Future site users	Health risk	Severe	Low likelihood	Moderate to low risk	Exceedances of the POS _{park} GACs for lead and PAHs were identified within the soil samples analysed. Exposure is possible but it would be unlikely that future site users would be interfering with the soil matrix surrounding the ballast. Further mitigation will occur if the ballast was covered to create a level walkway.
		Development workers during construction		Severe	Likely	High	Construction workers will come into direct contact with the ballast / soil matrix and the contaminants identified on site specifically lead and PAH. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures incorporated into a CEMP coupled with PPE.
		Maintenance Workers		Severe	Likely	High	Maintenance workers who visit the site may come into direct contact with the contaminants identified on site specifically lead, zinc and PAH. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures coupled with PPE.
	Direct exposure through dermal contact, ingestion or inhalation of paint flakes and associated dusts.	Future site users		Severe	Low likelihood	Moderate to low risk	High concentrations of metals, in particular lead and zinc, were recorded within paint samples collected from the site. Exposure is possible but it would be unlikely that future users would be interfering with the paint work.
		Development workers during construction		Severe	Likely	High	Construction workers will come into direct contact with the paint work and the elevated metal concentrations specifically lead and zinc. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures incorporated into a CEMP coupled with PPE.

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
		Maintenance Workers		Severe	Likely	High	Maintenance workers who visit the site in order to undertake painting of the viaduct may come into direct contact with the contaminants identified on site specifically lead and zinc. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures coupled with PPE.
	Inhalation of volatile contaminants.	Future site users	Health risk	Medium	Unlikely	Low risk	Analysis of soil samples indicated that there were no exceedances of POS _{park} GACs for either VOC or SVOC.
	Leaching of contaminants and migration via surface water network.	Bridgewater Canal and River Medlock	Pollution of controlled waters	Mild	Likely	Moderate to Low	Exceedances of EQS for lead and PAHs were recorded in both soil leachate and ballast leachate samples analysed at the site. A widespread impact was noted for lead and fluoranthene. This is an aggressive test. There was no evidence of water within the exploratory holes and the timeframes between raining and drainage of the viaduct maybe insufficient for leachate to be generated. There may be an unacceptable risk to surface water receptors. The risk could be lowered through appropriate drainage arrangements.

Table 8-6: Revised Conceptual Site Model for Phase 2 – Permanent Urban Park and Travel Hub

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
Historical site use as railway land, ballast layer covering viaduct and paint on the viaduct.	Direct exposure through dermal contact, ingestion or inhalation of soil/ballast and associated dusts.	Future site users	Health risk	Severe	Low likelihood	Moderate to low risk	Exceedances of the POS _{park} GACs for lead and PAH were identified within the soil samples analysed. Exposure is possible but it would be unlikely that future site users would be interfering with the soil matrix surrounding the ballast. If left exposed at the surface, site visitors may come into direct contact with the contaminants identified. However, it is likely that the underlying soil and ballast will be covered by a temporary or permanent walkway and therefore breaking the source-pathway-receptor linkage. Should any area of the viaduct be developed in such a way that food stuffs be planted directly into the ground additional mitigation measures would need to be incorporated into the design scheme.
		Development workers during construction		Severe	Likely	High	Construction workers will come into direct contact with the ballast / soil matrix and the contaminants identified on site specifically lead and PAH. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures incorporated into a construction environmental management plan (CEMP) coupled with PPE.
		Maintenance Workers		Severe	Likely	High	Maintenance workers who visit the site may come into direct contact with the contaminants identified on site specifically lead and PAH. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures coupled with PPE.
	Direct exposure through dermal contact, ingestion or	Future site users		Severe	Low likelihood	Moderate to low risk	High concentrations of metals, in particular lead and zinc, were recorded within paint samples collected from the site. Exposure is possible but it would be unlikely that future users would be interfering with the paint work.

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
	inhalation of paint flakes and associated dusts.	Development workers during construction		Severe	Likely	High	Construction workers will come into direct contact with the paint work and the elevated metal concentrations specifically lead and zinc. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures incorporated into a CEMP coupled with PPE.
		Maintenance Workers		Severe	Likely	High	Maintenance workers who visit the site in order to undertake painting of the viaduct may come into direct contact with the contaminants identified on site specifically lead and zinc. The likelihood of a linkage being present can be lowered through appropriate hygiene and working procedures coupled with PPE.
	Inhalation of volatile contaminants.	Future site users		Medium	Unlikely	Low risk	Analysis of soil samples indicated that there were no exceedances of POS _{park} GACs for either VOC or SVOC. In addition, odours were not noted during the investigation works.
		Development workers during construction		Medium	Unlikely	Low risk	
		Maintenance Workers		Medium	Unlikely	Low risk	
	Leaching of contaminants and migration via surface water network.	Bridgewater Canal and River Medlock	Pollution of controlled waters	Mild	Likely	Moderate to Low risk	Exceedances of EQS for lead and PAHs were recorded in both soil leachate and ballast leachate samples analysed at the site. A widespread impact was noted for lead and fluoranthene. This is an aggressive test. There was no evidence of water within the exploratory holes and the timeframes between raining and drainage of the viaduct maybe insufficient for leachate to be generated. There may be an unacceptable risk to surface water receptors. The risk could be lowered through appropriate drainage arrangements.
	Direct contact and permeation of water supply pipes.	Future buildings and utilities	Building and foundation corrosion and impact to	Medium	Likely	Moderate risk	Exceedances of UKWIR screening criteria for PAH and TPH were recorded within the soil samples analysed. If drinking water pipes are to be laid, then the appropriate risk assessments should be complete and submitted to United Utilities in order to mitigate and lower the risk.

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
			potable water supplies				
Sources below the viaduct and within the immediate vicinity as identified in Table 4-2	Direct exposure through dermal contact, ingestion or inhalation of soils, dusts or vapours.	Development workers during construction if works are required to the viaduct structure at ground level, such as the installation of new access ways or via piling	Health risk	Medium	Low likelihood	Moderate to low risk	Exposure to potential contaminants can be mitigated during construction with the use of appropriate working methods incorporated into a CEMP and use of PPE.
	Creation of preferential migration pathways via piling or construction works at ground level.	Surface water receptors (Bridgewater Canal and River Medlock)	Pollution of controlled waters	Mild	Low likelihood	Low Risk	If construction works are required at ground level, such as excavation works or piling, this has the potential to mobilise contaminants within soils or groundwater underlying the site associated with historical activities.

Source	Pathway	Receptor	Associated hazard	Potential consequence of contaminant linkage	Likelihood of contaminant linkage	Risk classification	Justification
		Groundwater: Principal Aquifer (Chester Pebble Bed Formation)		Medium	Low Likelihood	Moderate to Low risk	Piled foundations, if required, could potentially create a preferential pathway between sources underlying the viaduct and receptors.
	Direct contact and permeation of water supply pipes.	Future buildings and utilities	Building and foundation corrosion and impact to potable water supplies	Medium	Likely	Moderate	If new water pipes are required at ground level to service the viaduct, potential organic contaminants in soils could permeate potable water supplies and have detrimental impacts on human health.

9 Conclusions and recommendations

9.1 Conclusions

9.1.1 Summary of Human Health Risk Assessment

Based on the findings of the ground investigation and subsequent assessment, the following conclusions can be made for human health:

- The refined risk assessment has identified the following:
 - If the site remains the same the risk from the soil / ballast / paint in the absence of mitigation is considered to pose a moderate to low risk to site visitors/trespassers and a high risk to maintenance workers.
 - If the Phase 1 – Pilot Scheme is implemented the risk from the soil / ballast / paint in the absence of mitigation is considered to pose a moderate to low risk to site visitors/trespassers and a high risk to construction / maintenance workers. The risk from volatile contaminants to all receptors is considered low.
 - If the Phase 2 – Permanent Urban Park/Travel Hub is implemented the risk from the soil / ballast / paint in the absence of mitigation is considered to pose a moderate to low risk to site visitors/trespassers and a high risk to construction / maintenance workers. The risk from volatile contaminants to all receptors is considered low. The risk from off site sources, i.e. below the structure, is considered to be moderate to low to construction workers and moderate to potable water supply pipes.

9.1.2 Summary of Controlled Waters Risk Assessment

Based on the findings of the ground investigation and subsequent assessment, the following conclusions can be made for controlled waters:

- The refined risk assessment has identified the following:
 - In the sites current condition the soil / ballast has the potential to leach at concentrations which may pose a moderate to low risk to surface waters.
 - If the Phase 1 – Pilot Scheme or Phase 2 – Permanent Urban Park/Travel Hub is implemented the soil / ballast has the potential to leach at concentrations which may pose a moderate to low risk to surface waters.
 - If the Phase 2 – Permanent Urban Park/Travel Hub is implemented with the inclusion of piled foundations the risk from off-site sources (i.e. below the viaduct and within the immediate vicinity), is considered to be moderate to low risk in relation groundwater receptors and a low risk to surface water receptors.

9.2 Recommendations

The following recommendations are made:

- If new drinking water pipes are to be laid in Made Ground soils as part of the permanent scheme, a bespoke assessment needs to be undertaken along the route of future pipelines in accordance with the local water authority requirements.
- A CEMP should be prepared which should include measures to reduce the impact of ground conditions including:

- Provision of PPE to minimise direct contact of workers with site soils.
- Provision of adequate hygiene and welfare facilities for construction workers.
- Preparation and adoption of a site and task specific health and safety plan.
- Provision of adequate storage of stockpiled soils.
- Adequate storage of fuels/ chemicals and associated emergency response spillage control procedures.
- Method statements for use if unexpected contamination in soil or groundwater is encountered during construction and to ensure safe management and disposal of materials.
- Currently an assumption that a bridge proposed for the permanent Phase 2 permanent urban park and travel hub scheme can be supported from the viaduct and piling to provide support is not required. This is subject to change should Historic England find this design unacceptable on a Grade II listed structure. As such, intrusive investigation to obtain soil samples for both geo-environmental and geotechnical purposes will be required at ground level, and assessment of potential risks to controlled waters through piling as a contamination pathway
- Should piling be proposed to be undertaken within the aquifer located below the site. Consultations in respect to potential disturbance to water abstractions should be undertaken with the EA, and it may be necessary to undertake a piling risk assessment. If required, the risk assessment should be undertaken in accordance with industry guidance NC/99-17: Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention (2001).

9.2.1 Recommendations for Re-use of Ballast with Soil Matrix

The following bespoke recommendations are made with regards to development of the site with the reuse of ballast material with soils:

- The risk to site users needs to be lowered by some form of treatment, e.g. covering of the ground with boarding, thereby interrupting the pathway and breaking the pollutant linkage.
- The risk to surface waters from onsite sources can be lowered through the refurbishment of the drainage network, i.e. interruption of the pathway resulting in the pollutant linkage being broken.
- If the installation of 'green stuff' such as vegetable plots or fruit growing areas – a recommendation is made that any planting is within raised beds disconnected from ballast, due to the degree of exceedances of the allotment GAC recorded.

9.2.2 Recommendations for Re-use of Ballast without Site Soil Matrix

The following bespoke recommendations are made with regards to the development of the site with the reuse of ballast material without site soils:

- The risk to site users needs to be lowered by some form of treatment for example potentially removing the soil matrix resulting in source removal and the pollutant linkage being broken.
- The risk to surface waters from onsite sources can be lowered through the refurbishment of the drainage network, i.e. interruption of the pathway resulting in the pollutant linkage being broken alternatively removal of the soil matrix will result in betterment.

9.2.3 Drainage of the Structure Presently and in the Future

The following recommendations are made with regards to the present and future drainage on the site:

- The drainage on site needs to be suitably refurbished so that rainwater is not retained around the ballast or ballast plus matrix giving it time to generate leachate impacted water.
- To address the risk from metals within the site soils and ballast will be required, which could include the following:
 - Sampling of surface water from the downpipe.
 - Installation of drainage that does not outfall directly into the canal system.
 - The installation of a multi-layer substrate technologies could be potentially be utilised for the direct treatment of surface water leached through the surface of the viaduct.
 - Removal of the soil matrix (as discussed above) to result in betterment.

9.2.4 Next Steps

A remediation strategy and options appraisal should be produced. The appraisal will include a discussion on remedial measures to mitigate / lower the risk to the identified receptors in line with current guidance and is likely to be required to support the discharge of planning conditions.

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Figures

Appendix

Appendix A – Hand Dug Pit Logs

Appendix

Appendix B – Exploratory Hole Photographs

Appendix

Appendix C – Chemical Analysis Laboratory Certificates

Appendix

Appendix D – Screened Chemical Data

Appendix

Appendix E – Limitations



Royal HaskoningDHV is an independent, international engineering and project management consultancy with over 138 years of experience. Our professionals deliver services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural development and water.

Backed by expertise and experience of 6,000 colleagues across the world, we work for public and private clients in over 140 countries. We understand the local context and deliver appropriate local solutions.

We focus on delivering added value for our clients while at the same time addressing the challenges that societies are facing. These include the growing world population and the consequences for towns and cities; the demand for clean drinking water, water security and water safety; pressures on traffic and transport; resource availability and demand for energy and waste issues facing industry.

We aim to minimise our impact on the environment by leading by example in our projects, our own business operations and by the role we see in “giving back” to society. By showing leadership in sustainable development and innovation, together with our clients, we are working to become part of the solution to a more sustainable society now and into the future.

Our head office is in the Netherlands, other principal offices are in the United Kingdom, South Africa and Indonesia. We also have established offices in Thailand, India and the Americas; and we have a long standing presence in Africa and the Middle East.



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