Norwich Western Link

Environmental Statement

Chapter 13: Geology & Soils

Appendix 13.3: Ground Contamination Interpretive Report – Addendum

Part 1 of 3

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Document Reference: 3.13.03d

Version Number: 00

Date: March 2024

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Executive Summary

Ramboll UK Limited have prepared a Ground Contamination Interpretative Report for the Proposed Scheme. The Proposed Scheme comprises a new section of dual carriageway linking the A47 to the A1067 to the north-east of Norwich. The addendum report relates to the additional phase of investigation which considers the Alignment Refinement of the River Wensum Crossing. The site investigation area is within the updated alignment of the viaduct and the associated infrastructure. This assessment has been undertaken assuming the area within the Site Boundary will be redeveloped for an end-use comprising the Proposed Scheme. The area for the Alignment Refinement is shown in Figure 1 and the Site Boundary highlighted in red below, compared to the original investigation area (supplementary GI), shown in grey. A borehole location plan is included in Figure 2 of this report.

This Ground Contamination Interpretative Report includes the objectives and reasons for undertaking a generic quantitative risk assessment (GQRA), provides a summary of relevant background information, details how a ground investigation was designed and findings of that investigation, specifies how relevant generic assessment criteria (GAC) were selected, provides a quantitative risk assessment and conceptual site model and identifies data gaps and further actions which are required.

Potential contaminant linkages (PCLs) were identified at Preliminary Risk Assessment (PRA) stage through development of a preliminary conceptual site model (CSM) by WSP (as detailed in their Interpretative Environmental Desk Study Report, document reference 3.13.01). Ramboll designed the ground investigation,

and included locations targeting historical potentially contaminated land uses, as highlighted by the WSP report.

The River Wensum and its tributaries run through the Proposed Scheme and the surrounding area. The groundwater in the chalk beneath the Proposed Scheme is a principal aquifer and the entire Proposed Scheme is also within a Source Protection Zone 3 and as such the groundwater and surface water are classed as sensitive receptors.

The ground conditions within the Site Boundary were identified through the ground investigation to comprise topsoil (approximately 0.3 m thick) over superficial deposits (up to 23 m thick). The superficial deposits comprise Peat, Alluvium, River Terrace Deposits, Glacial Deposits and the Sheringham Cliff Formation. Cohesive components of the Sheringham Cliff Deposits were recorded as pockets and lenses of varying thicknesses between the main granular components and therefore it is unlikely that a continuous cohesive layer is present above the bedrock. Localised areas of Made Ground were noted during the investigation, with average thicknesses of 0.5 m. This included a suspected historical waste tip areas and areas around residential areas of the site. The underlying bedrock is Chalk, which comprises the undifferentiated components of the Lewes Nodular Chalk Formation, the Seaford Chalk Formation, the Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation.

An assessment of groundwater levels shows that the general direction of flow is towards the north-east. This is likely to be in hydraulic continuity with the River Wensum. It is considered likely that groundwater is continuous between the superficial deposits and bedrock strata due to the absence of any aquitards above the chalk aquifer at many locations. However, the absence of groundwater in many of the monitoring wells and the presence of a variety of granular and cohesive materials within the superficial deposits indicates that groundwater is not continuous within the various superficial deposits.

Human Health Assessment

Chemical testing results from a total of 404 soil samples were screened against Norfolk County Council specified GAC for public open space. All concentrations were below the Norfolk County Council's GAC with the exception of arsenic, lead and benzo(a)pyrene which were recorded above the GAC in the two samples from TP245 and WS202, collected from the Made Ground and peat strata, respectively. The pH samples ranged between 3.0-11.3 and in general the alkali samples were from the chalk and the more acidic samples were from the peat. No potential ACMs were identified during the ground investigation and no asbestos fibres were identified in the 24 soil samples screened for asbestos. Pendimethalin (a selective herbicide) was identified in six locations, up to concentrations of 710 µg/kg, but was not assessed as being a significant risk to the groundwater and surface water due to its high affinity to bind with soil and sediment.

The risk to the future site users of the Proposed Scheme from contaminants in the soil is considered to be low. Provided that construction workers and future maintenance workers utilise appropriate vigilance and work in accordance with construction health and safety best practice, the risk to them from contaminants in soil within the Site Boundary is also anticipated to be Low.

Controlled Waters Assessment

Leachate testing has been completed for thirty (30) soil leachate samples and the concentrations have been screened against Environmental Quality Standards (EQS) and Drinking Water Standards (DWS). Exceedances of the EQS were noted for leachable chromium, lead, copper, nickel, zinc, anthracene and fluoranthene. Exceedances of the DWS included leachable arsenic, benzo(a)pyrene and the sum of 4 PAH. The metal exceedances were noted at several locations (across the topsoil, made ground, superficial and chalk) and the PAH exceedances were noted in one specific location (in the Made Ground at WS202, in the north of the site). Given that the process of extracting leachate from soil is vigorous and unlikely to represent conditions on site, it is likely that this is a conservative view of the risk to controlled waters from the soils. Given that the metal concentrations are likely to

reflect background concentrations of the soil and the localised exceedances of the PAH, the risk to controlled waters is considered to be low.

To date, thirty (30) groundwater samples have been collected during three rounds (October 2022, December 2022 and February 2023) and were screened against DWS and EQS. One further groundwater sampling visit is planned for March 2023 to the boreholes included in the Woodland Campaign. Interpretation of these results will be undertaken following the issue of the laboratory data.

Arsenic exceeded the DWS criteria and copper and nickel exceeded the EQS criteria during all three rounds of groundwater monitoring. The copper exceedances were noted across several locations, the arsenic exceedances was recorded at one location over the three rounds and the nickel exceedances were observed in two locations over the three rounds. The majority of the exceedances are marginal (i.e. less than one order of magnitude). The elevated metals are likely to represent background levels within the Site Boundary, in both the superficial and the chalk deposits. The exceedances are minor, and there is no known contamination source from the current or historic land uses within the Site Boundary. As such, the risk to controlled waters is considered to be low.

Ground Gas Assessment

Six (6) ground gas monitoring rounds have been undertaken between September 2022 and February 2023, and three of those rounds were conducted during a period of falling pressure. The results of the gas monitoring have been assessed using guidance provided in the Health and Safety Executive Workplace Exposure Limits (WEL) HSE EH40/2005 to consider the risks to workers in confined spaces. Hydrogen sulphide was not measured above the long term or short term WEL during any of the rounds and methane was not recorded at concentrations within the lower and upper explosive limits. Carbon monoxide was recorded above the long term exposure limit on three (3) occasions. Carbon dioxide was measured at concentrations above the long term WEL on forty (40) occasions and above the short term WEL on seventeen (17) occasions. The carbon dioxide levels are likely to represent natural underground conditions given the similarity of concentrations

across a large spatial area; however, the flow rates are consistently low within the Site Boundary.

The risk to Human Health for the end-use of the Proposed Scheme is low; however, mitigation measures will need to be put in place for construction workers during the construction phase.

Initial Waste Assessment

From the information gathered during this investigation and the assessment, it is expected that the majority of excavated natural soils will be suitable for re-use from a chemical perspective. Based on the results of a preliminary waste assessment, the majority of the material is classed as not-hazardous. Two samples have been classed as hazardous by HazWaste Online for their concentrations of TPH (WS202, 0.2 m) and metals (TP246, 0.1 m). The sample from WS202 was from the Made Ground and the sample from TP246 was taken from the peat horizon. Material excavated from this area should be segregated and stockpiled separately. Further testing of this material is required to determine whether it is suitable for re-use.

Re-Use Summary

Chemical analysis of the soil indicates that all material, with the exception of two localised exploratory holes, are within the re-use criteria set by Norfolk County Council and the risk to Human Health from the material is classed as Low. Additional leachate and groundwater assessment show some metal exceedances of Norfolk County Council's water criteria; however, these likely relate to background conditions within the Site Boundary. Localised PAH exceedances were noted in the same locations as the exploratory holes exceeding the soil re-use criteria; however, given these are localised, the overall assessment remains to be a Low risk to Controlled Waters. Given the results of the assessment, it is likely that the majority of the material excavated during the construction phase may be re-used on the Proposed Scheme provided that:

- Construction and maintenance workers utilise appropriate PPE and health and safety best practices;

- Material is confirmed to be geotechnically suitable for reuse in accordance with an Earthworks Specification (to be prepared separately).

However, it is noted that the material from the two locations exceeding Norfolk County Council's re-use criteria (WS202 and TP246), Made Ground, and any unexpected contamination identified during the works will need to be chemically tested when excavated to ensure the material is in line with the findings of this investigation.

1 Introduction

1.1 Brief

1.1.1 Harrison Group Environmental Ltd (HE) on behalf of the Applicant hasundertaken an intrusive ground investigation required in relation to the design and construction of the Proposed Scheme. The Proposed Scheme comprises the construction of a new section of dual carriage highway linking between the existing A47 road to the south-west to the existing A1067 Fakenham Road tonorth-east. The Proposed Scheme includes a number of cuttings, embankments, drainage features, underpasses and bridge structures including a proposed viaduct crossing over the Wensum Valley floodplain in Ringland.

1.1.2 This addendum report relates to the additional phase of investigation which considers the Alignment Refinement of the River Wensum Crossing (hereafter referred to as 'the Proposed Scheme'). The site investigation area is within the updated alignment of the viaduct and the associated infrastructure, within the Scheme Boundary. The Proposed Scheme Location Plan is provided in Figure 1.

1.1.3 This report follows as an addendum report to the Ground Contamination Interpretative Report first issued in September 2022 (Reference 3.13.03). The Site Boundary extends in a north-east to south-west trend with the far north-east situated off the A1067 Fakenham Road roundabout at National Grid Reference (NGR) 614853, 315625 through to the far south-west located north of Weston Road at NGR 612032, 314583.

1.1.4 This report presents the objectives, scope, findings and conclusions of an intrusive ground investigation undertaken for the Proposed Scheme with respect to contaminated land, within the Site Boundary.

1.2 Objectives and Scope of Report

1.2.1 The objectives of this report are to provide a generic quantitative risk assessment (GQRA) identifying potential risks and constraints associated with ground and groundwater conditions and identifying potential locations of concern within the Site Boundary with respect to ground and groundwater contamination.

1.2.2 The scope of this report is to:

- Undertake a review of relevant reports pertaining to the Proposed Scheme, where available;
- Document and interpret the environmental ground conditions encountered from an intrusive ground investigation;
- Assess the presence, likely extent and nature of potential contaminants;
- Conduct a contaminated land generic quantitative risk assessment (GQRA) with respect to the proposed land use based on the results of the ground investigation;
- Produce a conceptual site model for the site based on the GQRA and to provide recommendations for future works, where appropriate; and
- Provide a commentary on contaminated land risks under the proposed end use within the Site Boundary.

1.3 Proposed Development

1.3.1 The Proposed Scheme Site Boundary extends in a north-east to south-west trend with the far north-east situated off the A1067 Fakenham Road roundabout (national grid reference (NGR) 614853, 315625) through to the far south-west located north of the A47 (NGR 609696, 312490).

1.3.2 This phase of the investigation was undertaken in the area of the proposed River Wensum Viaduct. This route has been updated since the time of the first investigation described in the initial Ground Contamination Interpretative Report

(Reference 3.13.03). The investigation was undertaken across land parcels situated between the north of the A1067 Fakenham Road to the north of Western Road. The Proposed Scheme is to comprise a new dual carriageway in a general north-east to south-west orientation that will pass through areas of agricultural land, woodland, and some country roads. The Proposed Scheme will incorporate a cutting and embankments, number of road overpasses and underpasses, wildlife crossings and bridge structures including the proposed viaduct that will cross the River Wensum and associated floodplain. The alignment refinement scheme takes into consideration the realignment for the proposed viaduct and associated infrastructure crossing the Wensum Valley floodplain and immediate surrounding area. The locations of the key features of the scheme are shown in the general arrangement drawings, document reference 2.03.00.

1.3.3 The ground investigation for the alignment refinement scheme was split into two ground investigations. The initial ground investigation (May – August 2022) was undertaken across individual parcels of agricultural farmland, with sections of woodland and the Wensum Valley floodplain. A number of areas were inaccessible at the time of the initial investigation; therefore, a supplementary 'Woodland Campaign' investigation was undertaken at a later date (September – October 2022), within the woodland and surrounding areas situated south of the Wensum Valley floodplain, agricultural land north of Ringland Lane and within land situated within Easton Estate. The surface across the two investigations was noted to comprise arable land for pig farming, woodland areas, lightly cultivated agricultural land and areas of the floodplain comprising grassland used for grazing cattle.

1.3.4 The surrounding area comprised similar land uses with the villages of Ringland and Taverham located approximately 1km south-east and east of the Site Boundary and villages of Attlebridge, Weston Longfield and Weston Green located within approximately 1km north-west, west and south of the Site Boundary. RAF Attlebridge airfield was also located in close proximity to the site, situated approximately 800m west.

1.4 Scope of Ground Investigation Works

1.4.1 The ground investigation was undertaken on behalf of The Applicant by Harrison Group Environmental Ltd (HGE) comprised the following works completed between 9th May 2022 and 2nd August 2022:

- 22 cable percussion boreholes (BH201-BH205, BH207, BH227-BH228, BH236, BH238, BH242-BH247, BH251-BH254, and BH257-BH258) drilled between 17th May 2022 to 14th July 2022 to a maximum depth of 30m below ground level (bgl) (hand excavated starter pits were completed to a maximum of 1.2m depth for each location prior to drilling);
- Upon completion, seven cable percussive boreholes were installed with groundwater/gas monitoring standpipes. Boreholes that did not require a monitoring installation were backfilled with bentonite/cement and reinstated accordingly;
- 32 rotary cored boreholes (BH206, BH208-BH209, BH211-BH220, BH222-BH226, BH229-BH231, BH233-BH235, BH237, BH239-BH241, BH249-BH250 and BH255-BH256) and 2 rotary open boreholes (BH210, BH221) were completed between 16th May 2022 and 1st August 2022 up to a maximum depth of 60.65m bgl. Ten boreholes were installed for monitoring purposes. Cable percussive drilling was used to advance the majority of the boreholes through the superficial deposits and into the surface of the bedrock where the boreholes were then advanced using a rotary rig;
- 12 dynamic continuous sampler (window sampler) boreholes (WS201-WS206, WS211-WS216) were drilled between 23rd May 2022 and 28th June 2022 to a maximum depth of 10m bgl. Hand excavated starter pits were completed to a maximum of 1.2m depth. Five of the boreholes were installed for monitoring purposes;
- 12 dynamic cone penetrometer (DCP) tests undertaken utilising TRL-DCP between 21st June 2022 and 18th July 2022;

- 3 cone penetration tests (CPT201-CPT203) undertaken on the 6th and 7th June 2022 to depths between 17.66m and 24.60m bgl. Prior to each CPT, a hand starter pit was completed to 1.2m;
- 61 machine excavated trial pits (TP201-TP252 incl. TP209A, TP214A, TP15A TP224A, TP224B, TP32A, TP233A, TP234A, TP247A, TP252A) to a maximum depth of 5.0m bgl undertaken between 23rd May 2022 and 4th August 2022. 24 trial pits were partially backfilled (TP205-TP210 incl. TP209A, TP222-TP230 incl. TP224A, TP224B and TP235-TP240) with gravel to maintain stability and temporary monitoring pipe to enable subsequent infiltration testing to BRE DG 365 methodology;
- 5 machine excavated trial trenches (TR201-TR205) were completed between 9th June 2022 and 2nd August 2022. On completion the trenches were backfilled in compacted layers with topsoil replaced;
- 23 in-situ plate load tests (PLT) (PLT-TP211-TP213, PLT-TP231, PLT-TP232A-TP234A, PLT-TP243-TP244, PLT-TP246, PLT-TP249, PLT-TP251 and PLT-TP252A, PLT-TR201 (D-F), PLT-TR202 (D-F), PLT-TR203D (1-2) and PLT-TR203 (E-F) were undertaken between the 26th May 2022 and 28th July 2022 at depths between 0.25-1.0m within a proportion of the trial pit and trial trench locations;
- 40 light weight deflectometer (LWD) tests were carried out between 24th May 2022 and 4th August 2022 at depths between 0.25-1.0m within a proportion of the trial pit and trial trench locations;
- Sand replacement density (SRD) tests were completed between 26th May 2022 and 27th July 2022 adjacent to the PLT and LWD testing at a proportion of the trial pit and trial trench locations;
- 53 pressuremeter tests were undertaken at 12 locations between 10th June 2022 and 28th July 2022 at the following locations: BH209, BH211, BH214-BH215, BH218-BH219, BH223-BH224, BH237, BH239, BH241

and BH55) using either a reaming pressuremeter (RPM or PIP) or high-pressure dilatometer (HPD);

- In situ and geotechnical/ geo-environmental laboratory testing;
- 6 rounds of groundwater level monitoring and 3 rounds of groundwater sampling from well installations, where groundwater was encountered;
- 6 rounds of gas monitoring from well installations;
- All environmental samples were subject to screening of volatile organic compounds (VOC) using a photo ionisation detector (PID) and sent directly to the chemical testing laboratory within 24 hours of sampling with chain of custodies; and
- Production of an interpretative report, to include comparison of the analytical results with the Norfolk County Council specified Generic Assessment Criteria (GAC) and the GAC derived in accordance with UK guidance on risk assessment, a qualitative source-pathway-receptor risk assessment (based on a commercial land use of the area within the Site Boundary) and production of a conceptual site model.

1.4.2 An additional ground investigation was undertaken on behalf of The Applicant by Harrison Group Environmental Ltd (HGE) to provide coverage of the ground conditions within parcels of woodland which were previously inaccessible and within areas where supplementary investigation was required. This was undertaken between the 12th September 2022 and 18th October 2022 and comprised the following works:

- Eight cable percussion boreholes (BH232, BH248, BH259-BH264) drilled to a maximum depth of 60m bgl (hand excavated starter pits were completed to a maximum of 1.2m depth for each location prior to drilling) between 12th September 2022 and 18th October 2022;
- Upon completion, five of the cable percussive boreholes (BH260-BH264) were installed with groundwater/gas monitoring standpipes.

Boreholes that did not require a monitoring installation were backfilled with bentonite/cement and reinstated accordingly;

- Three dynamic continuous sampler (window sampler) boreholes (WS08-WS10) were drilled to a maximum depth of 3.45 m bgl on 26th September 2022. Hand excavated starter pits were completed to a maximum of 1.2m depth;
- Three dynamic cone penetrometer tests utilising TRL-DP completed to a depth of 1.5m bgl on 20th September 2022;
- Three machine excavated trial pits (TP254, TP255, TP255A) to a maximum depth of 2.4m bgl were undertaken on 21st September 2002 and 5th October 2022. On completion all three trial pits were backfilled in compacted layers with topsoil deposits replaced;
- Three light weight deflectometer (LWD) tests were carried out at depths between 0.5-0.6m on 10th October 2022;
- In situ and geotechnical/ geo-environmental laboratory testing;
- All environmental samples were subject to screening of volatile organic compounds (VOC) using a photo ionisation detector (PID) and sent directly to the chemical testing laboratory within 24 hours of sampling with chain of custodies; and
- Production of a factual ground investigation report.

1.4.3 The scope of works was in general accordance with that initially proposed by Ramboll, with any deviation agreed with the Investigation Supervisor. Ground investigation data for both the Alignment Refinement and Woodland Campaign ground investigations are provided in the respective Factual Ground Investigation Reports. A plan of the exploratory hole locations is presented as Figure 2.

1.4.4 In the preparation of this report Ramboll has made reference to UK regulatory guidance and methodologies, including, but not limited to: Land Contamination:

Risk Management (LCRM) 2020; BS5930:2015+A1:2020 Code of Practice for site Investigation; and BS10175:2011 + A2:2017 Code of Practice for the Investigation of Potentially Contaminated sites.

1.5 Contaminated Land Scope of Works

- Ground Investigation – input to scope and ground investigation specification (prepared by The Applicant's geotechnical team), liaison with the ground investigation contractor during the site works and scheduling of laboratory testing, review of the factual report produced by the ground investigation contractor;
- Contaminated land interpretative reporting based on comparison of the soil and groundwater results against the Norfolk County Council's generic assessment criteria (GAC) and including a general qualitative risk assessment;
- Initial assessment of the acceptability of the soil to be re-used within the Site Boundary.

1.6 Previous Relevant Reports

1.6.1 The following existing reports provide information relating to the ground conditions and contamination for the wider Proposed Scheme:

- WSP Interpretative Environmental Desk Study Report. (Reference 3.13.01)
- WSP (2019) Norwich Western Link Geotechnical Desk Study. Ref: NCCT41361-04-B-02-01
- WSP Ground investigation Report. This report has not been reviewed by Ramboll
- Ramboll UK (2022) Ground Contamination Interpretative Report. (Reference 3.13.03)

1.6.2 Previous ground investigations have been undertaken to provide information on the area of the Proposed Scheme; however, the above reports are not specific to the route of the Alignment Refinement of the River Wensum Viaduct. A summary of these reports (not including the WSP Ground Investigation Report) can be found in the Ramboll Ground Contamination Interpretative Report (Reference 3.13.03).

1.7 Constraints and Limitations

1.7.1 This report has been prepared by Ramboll exclusively for the intended use by The Applicant, defining, among others, the purpose, the scope and the terms and conditions for the services. No other warranty, expressed or implied, is made as to the professional advice included in this report or in respect of any matters outside the agreed scope of the services or the purpose for which the report and the associated agreed scope were intended, or any other services provided by Ramboll.

1.7.2 Confirmation of Harrison Group's appointment on the project was initiated on the 13th August 2021 with final agreement of the contract documentation settled on 29th September 2021.

1.7.3 In preparation of the report and performance of any other services, Ramboll has relied upon publicly available information, information provided by The Applicant and information provided by third parties. Accordingly, the conclusions in this report are valid only to the extent that the information provided to Ramboll was accurate, complete and available to Ramboll within the reporting schedule.

1.7.4 Ramboll's services are not intended as legal advice, nor an exhaustive review of site conditions within the Site Boundary and/ or compliance. This report and accompanying documents are initial and intended solely for the use and benefit of The Applicant for this purpose only and may not be used by or disclosed to, in whole or in part, any other person without the express written consent of Ramboll. Ramboll neither owes nor accepts any duty to any third party, unless

formally agreed by Ramboll through that party entering into, at Ramboll's sole discretion, a written reliance agreement.

1.7.5 The ground investigation works were undertaken during a discrete period of time. The findings and conclusions presented in this report are accordingly factually limited by these circumstances and, unless stated otherwise in the report, are preliminary. The field investigations were restricted to a level of detail necessary to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant period of time has elapsed since the sampling took place. The interpretation of the geological and environmental quality conditions is based on extrapolation from point-source data in a heterogeneous environment. Accordingly, more detailed investigation may be appropriate dependent upon The Aplicant's objectives.

1.7.6 Six (6) groundwater monitoring rounds and six (6) ground gas monitoring rounds were scheduled to follow the site investigation. Three (3) groundwater sampling rounds have been undertaken. The chemical testing laboratory certificates are presented in the Harrison Group Environmental Ltd Factual Ground Investigation Report.

2 Site Setting

2.0.1 The Proposed Scheme location and details of the site setting are provided in Table 2.1 and a Proposed Scheme location plan is provided as Figure 1.

Table 2.1: Site Setting Details

Parameter	Details
Site Location	Area extends in a north-east to south-west trend with the far north-east situated off the A1067 Fakenham Road roundabout (NGR 614853, 315625) through to the far south-west located north of Weston Road (NGR 612032, 314583).

Parameter	Details
General setting	At the time of investigation, the area within the Site Boundary mainly comprised individual parcels of agricultural farmland, with section of woodland and the Wensum Valley floodplain. The surface was variable at the time of investigation but predominantly comprised arable land used for pig farming and lightly cultivated agricultural land with areas of the floodplain comprising grassland used for grazing cattle.
Current site use	At the time of investigation, the site comprised individual parcels of agricultural farmland, sections of woodland, and the Wensum Valley floodplain.
Current regulated activities on-site	None present.
Topography	The River Wensum crosses through the Site Boundary with a wide floodplain area at the base of the valley in the east.
Land bounding site – use NORTH	The Proposed Scheme is largely surrounded by agricultural farmland and the villages of Weston Longville (1.25km), Attlebridge (1.5km) and Morton on the Hill (2km).
Land bounding site – use SOUTH	The Proposed Scheme is largely surrounded by agricultural farmland with the village of Ringland (850m).
Land bounding site – use EAST	The Proposed Scheme is largely surrounded by agricultural farmland with the village of Taverham 2km distant.
Land bounding site – use WEST	The Proposed Scheme is largely surrounded by agricultural farmland with RAF Attlebridge (800m) and Weston Green (1.0km).

3 Desk Study Summary

3.0.1 The information presented in Section 3 describes the site setting based on desk-based information and provides a preliminary CSM, which is a simplified representation of the environmental conditions within the Site Boundary and surrounding area. The CSM is used to initially identify potentially sensitive receptors and potential pollutant linkages. Information obtained during the environmental site investigation, described in the following sections of this report, is then used to refine and update this preliminary conceptual model in Section 8.

3.0.2 The information in Section 3 has been collected from publicly available sources and further summaries of the wider Proposed Scheme can be found in Ramboll's Contaminated Land Interpretative Report (Reference 3.13.01).

3.1 Anticipated Geology and Hydrology

3.1.1 The geological information provided within this section is based primarily on information from the following sources which were accessed in December 2022:

- British Geological Survey (BGS) (https://www.bgs.ac.uk/): Aylsham (Sheet 147 Bedrock and Superficial Deposits) and Norwich (Sheet 161 Solid and Drift Edition) [Accessed 13 December 2022];
- Review of publicly available historical BGS borehole logs within the Site Boundary or in the vicinity;
- Regulatory authority websites including the Environment Agency (EA); and
- Websites including the UK Government's 'MAGIC' maps (https://magic.defra.gov.uk/MagicMap.aspx).

3.1.2 A summary of the anticipated natural geology identified from publicly available information is provided in Table 3.1.

Table 3.1: Anticipated Natural Geology

Superficial or Bedrock	Stratum	Distribution Across the Site	Description	Estimated Average Thickness (m)	EA Aquifer Designation	Hydrogeological Significance
Superficial	Alluvium	This unit is predominately present in a band along the River Wensum floodplain.	Silt, sand, peat and basal gravel	Variable, up to 10 m	Secondary B	Lower permeability formations with potential to support small abstractions.

Superficial or Bedrock	Stratum	Distribution Across the Site	Description	Estimated Average Thickness (m)	EA Aquifer Designation	Hydrogeological Significance
Superficial	Head Deposits	This unit is present along Ringland Lane and to the south-west of the River Wensum floodplain.	Clay, gravel and sand	Variable, up to 20m	Secondary B	Lower permeability formations with potential to support small abstractions.
Superficial	River Terrace Deposits	This unit is present to the north of the Alluvium deposits on the River Wensum valley floodplain.	Sand and gravel	Unknown	Secondary A	Permeable formations with potential to support localised abstractions.
Superficial	Sheringham Cliff Formation	Dominates the superficial deposits for the majority of the site.	Sand and gravel	Variable, up to 40m	Secondary A	Permeable formations with potential to support localised abstractions.
Bedrock	Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation	The unit underlies the entire Site Boundary	Chalk	Unknown	Principal	Highly permeable, with significant water storage. Able to support large abstractions.

3.1.3 The Environment Agency's Catchment Data Explorer indicates that groundwater beneath the Proposed Scheme is part of the Wensum Up Stream Norwich groundwater body. The Environment Agency has not classified the ecological or chemical status for the groundwater body. The ecological status for the surface water is classed as 'moderate' and the chemical status as 'fail' under the Water Framework Directive (WFD) Scheme as of 2019.

3.1.4 The Proposed Scheme is located within a Source Protection Zone (SPZ) 3.

3.1.5 Publicly available borehole logs were identified within the vicinity of the Proposed Scheme. Borehole log (ref: TG11NW29) to the south of the A1067 identified the underlying geology as;

- Glacial sand and gravel to depth of 8.53m bgl, underlain by
- Soft 'putty' chalk to a depth of 10.97m bgl, underlain by
- Firm chalk and flints to a depth of 27.43m bgl, underlain by
- Soft chalks and flints to a depth of 33.53m bgl where drilling was terminated.

3.2 Ecology

3.2.1 The River Wensum within the east of the Site Boundary is designated as a site with statutory designation for its ecological value. Designations include Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC)

3.3 Surface Water

3.3.1 The River Wensum (the nearest WFD-classified surface water course) crosses the northern-eastern section of the Proposed Scheme, running from north west to south east with several small unnamed inland rivers within the vicinity of the Site Boundary. The EA currently classifies the River Wensum as being of 'moderate' ecological quality and 'failing' chemical quality under the WFD classification scheme as of 2019.

3.3.2 There are no licensed surface water abstractions within 2km of the Site Boundary.

3.4 Unexploded Ordnance

3.4.1 The WSP Interpretative Environmental Desk Study (Reference 3.13.01) reported information surrounding a preliminary assessment of unexploded ordnance (UXO) that had been carried out for the Proposed Scheme. The WSP report states that a preliminary unexploded ordnance (UXO) risk assessment for the Proposed Scheme has been undertaken by Landmark, in association

with 6 alpha associates (document reference NCCT41793-04-B-02-02). The findings of the reports show that due to the proximity of the Proppsed Scheme to a former airfield (RAF Attlebridge) to the west of the Site Boundary, a further detailed UXO threat and risk assessment is required. The former airfield has been assessed as being likely to contain WWI and WWII ordnance and required further investigation and assessment to be undertaken. No other areas of potential UXO hazards are identified within the extents of the Site Boundary.

3.4.2 A further UXO risk assessment was carried out by Fellows in August 2019. The assessment identifies a low risk from both German Air Dropped Weapons and British Anti-Aircraft munitions across the Proposed Scheme. There is a medium risk from 'Other Munitions' in two distinct areas within the Site boundary – the north western and southern section of the Proposed Scheme, as shown in Figure 3.1. This area includes the Alignment Refinement of the River Wensum Viaduct.

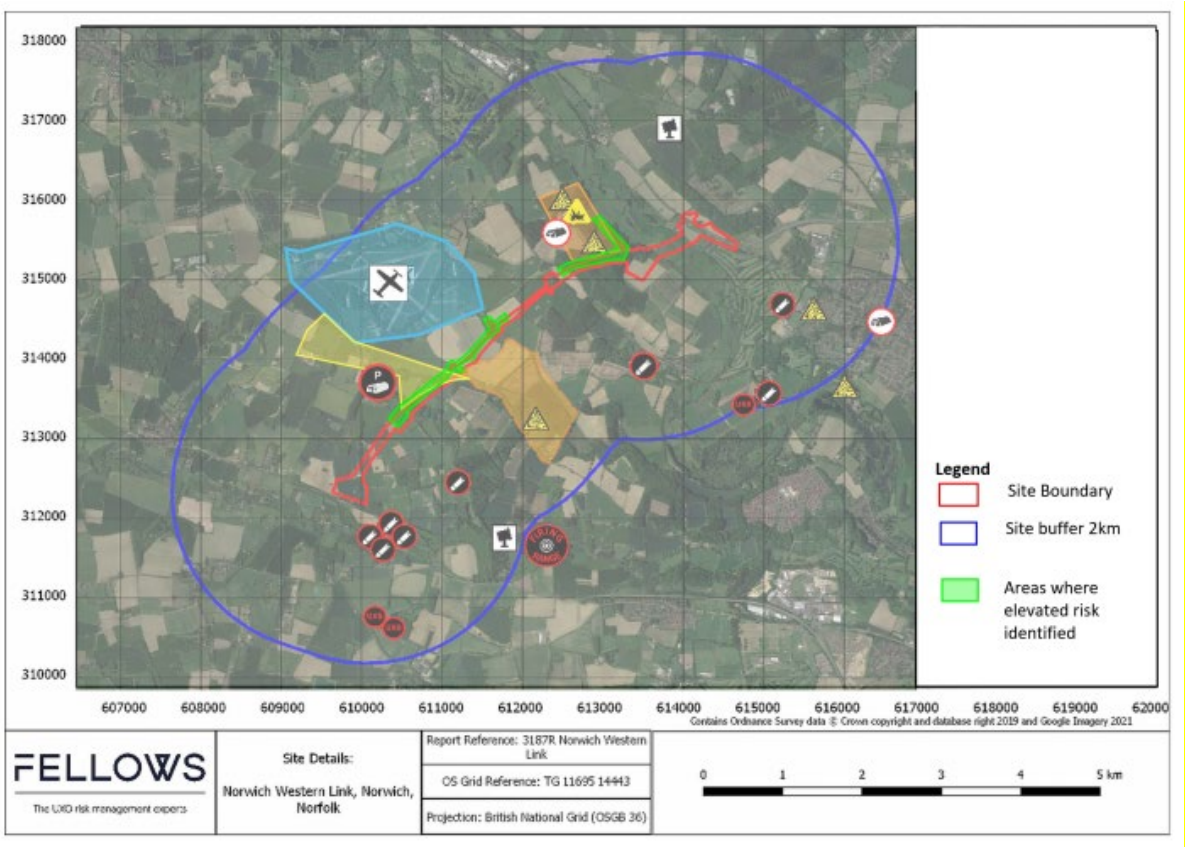

Figure 3.1 Areas of elevated risk from 'Other Munitions'

3.4.3 The recommended mitigation by Fellows was to have an UXO engineer on site for monitoring of the earthworks and excavations within the areas of elevated risk.

3.5 Historical and Current Site Use

3.5.1 Information summarised from WSP's Interpretative Environmental Desk Study (Reference 3.13.01). was reviewed and potentially contaminative former land uses on-site and within a 250m radius in the surrounding area were identified. A full summary of the historical site uses is provided in Ramboll's Gorund Contamination Interpretative Report (Reference 3.13.03).

3.5.2 In summary, the history for the area of the Alignment Refinement shows that the area was primarily agricultural land. Plantations and nurseries were present at various locations transecting and surrounding the site. Longrow Lane, an unnamed road and a track transect the Site Boundary in the southern end. By 1971 Longrow Lane was renamed as Ringland Lane and the track is labelled as the A1067 in 1970 and as Fakenham Road in 1994.

3.5.3 A Marl Pit is present within the north of the Site Boundary in the 1882 historical map, shown to be infilled by mapping dated 1970. Marl Pits are also recorded 20m and 135m north of the Site Boundary in the 1882 mapping, and a pond is located 150 m to the north-west. By the 1973-1976 historical maps, the pond remained; however, the Marl pit were no longer noted and presumed to be infilled.

Environmental Database Records

3.5.4 Information obtained from a third-party environmental database (Envirocheck) disclosed in the WSP Interpretative Environmental Desk Study Report (Reference 3.13.01) recorded a historical landfill and a licensed waste management facility within 500m of the alignment refinement investigation area, as discussed below:

- There are records of one (1) historical landfill site (Deighton Hills) located 300m north-west of the Site Boundary. The landfilled was licensed to

Rytonberry Limited. According to information contained within the database, the landfill was authorised for deposited waste included inert waste; and the first input date was given as 31st December 1980 and the last input date 31st December 1985; and

- There are records of one (1) licensed waste management facility located 240m north of the Site Boundary. This is Attlebridge Landfill, operated by Biffa Waste Services Ltd. According to information contained within the database, the facility was licensed for construction, demolition and dredging waste. The license was first issued 6th March 1974 with records showing the licensed was transferred on the 30th October 2000. No information is provided in the database to suggest the licensed has been rescinded.

3.6 Preliminary Conceptual Site Model

3.6.1 Based upon the current and historical uses within the Site Boundary and its surroundings, potential contaminants, pathways and receptors are summarised in the preliminary CSM. The CSM was developed specifically for this report from the information reported in this Section, following the review of the previous WSP reports, and publicly available information. The CSM has assessed potential ground contamination issues within the Site Boundary, in line with the current UK framework. For a risk of pollution or environmental harm to occur as a result of ground contamination, all of the following elements must be present:

- A contaminant, i.e., a substance that is capable of causing pollution or harm;
- A receptor, i.e., something which could be adversely affected by the contaminant; and
- A pathway, i.e., a route by which the contaminant can reach the receptor.

3.6.2 If one of these elements is absent there can be no significant risk. If all are present then the magnitude of the risk is a function of the magnitude and

mobility of the source, the sensitivity of the receptor and the nature of the migration pathway.

3.6.3 The potential severity of the risk and the probability of the risk occurring have been combined in accordance with the following matrix in order to give a level of risk for each potential hazard.

Table 3.2: Risk Matrix

N/A (Not applicable)	Consequence	Consequence	Consequence	Consequence
Probability	**Severe**	**Medium**	**Mild**	**Minor**
High Likelihood	Very high	High	Moderate	Low
Likely	High	Moderate	Moderate/Low	Low
Low Likelihood	Moderate	Moderate/ Low	Low	Very low
Unlikely	Moderate/ Low	Low	Very low	Very low

3.6.4 The assessment has been undertaken based on the Proposed Scheme – Alignment Refinement Scheme.

3.6.5 A summary of potential sources of contamination, pathways and receptors that may be present on-site and in the immediate surrounding area are included in Table 3.2. The sources of contamination are based on the current and historical uses within the Site Boundary and surrounding area. The pathways and receptors are based on the environmental setting of the site and surroundings. The preliminary CSM is presented in Table 3. .

Table 3.3: Preliminary Conceptual Site Model

Source	Pathway	Receptor	Risk of Contaminant Linkage
Potential current and / or historical contamination (on-site). Contaminants include metals, inorganics, TPH, PAH, asbestos, fertilisers and pesticides. The fertilisers and pesticides are associated with the current and historical use within the Site Boundary as agricultural land. Asbestos, metals/inorganics and TPH is associated with the potential Made Ground beneath or surrounding the on-site public highways.	Leaching to groundwater	Groundwater in the Chalk Bedrock-Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation	Low. There is a low risk of contamination being present; however, if present, contamination may be able to leach into shallow groundwater in the underlying Principal Aquifer to the north of the Site Boundary (Line 4/5) where tracks/roads transect the Site Boundary. The underlying bedrock in the Principal Aquifer is highly permeable, with significant water storage. Able to support large abstractions in the chalk.
Potential current and / or historical contamination (on-site). Contaminants include metals, inorganics, TPH, PAH, asbestos, fertilisers and pesticides. The fertilisers and pesticides are associated with the current and historical use within the Site Boundary as agricultural land. Asbestos, metals/inorganics and TPH is associated with the potential Made Ground beneath or surrounding the on-site public highways.	Direct contact, ingestion and inhalation of dust, gas and/ or vapours	Construction workers and future maintenance workers	Very Low. Construction and maintenance workers have the potential to come into contact with soils, dust and ground gas (methane and carbon dioxide) during groundworks. Contamination within the Made Ground may be present and there is also a potential for the generation of Ground Gas in the Made Ground. Given the area within the Site Boundary is currently largely undeveloped agricultural land, with little areas of potential Made Ground, the risk of construction workers coming into contact with Made Ground, and the potential for Ground Gas generation is very low. Potential risk to workers from gas and/ or vapours if confined spaces were to be introduced in the form of maintenance areas, manholes etc.

Source	Pathway	Receptor	Risk of Contaminant Linkage
Potential current and / or historical contamination (on-site). Contaminants include metals, inorganics, TPH, PAH, asbestos, fertilisers and pesticides. The fertilisers and pesticides are associated with the current and historical use within the Site Boundary as agricultural land. Asbestos, metals/inorganics and TPH is associated with the potential Made Ground beneath or surrounding the on-site public highways.	Direct contact, ingestion and inhalation of dust, gas and/ or vapours	Future Proposed Scheme users	Very Low. The potential for future users of the road coming into contact with fill materials or areas of contamination is likely to be low due to the presence of hardstanding on the majority of publicly accessible areas, and the lack of contamination present at the site. There are no buildings planned for the Proposed Scheme.
Potential current and / or historical contamination (on-site). Contaminants include metals, inorganics, TPH, PAH, asbestos, fertilisers and pesticides. The fertilisers and pesticides are associated with the current and historical use within the Site Boundary as agricultural land. Asbestos, metals/inorganics and TPH is associated with the potential Made Ground beneath or surrounding the on-site public highways.	Aggressive ground conditions	Infrastructure/ foundations	Very Low. Below ground concrete and the permeation of contaminants through plastic pipes may have the potential to impact concrete in infrastructure/ foundations, however the presence of contaminants in high enough concentrations to impact infrastructure is unlikely.
Potential current and historical off-site contamination sources in the vicinity of the Proposed Scheme including former airfield (RAF Attlebridge) to the west of the Site Boundary. Contaminants may include metals, TPH, PAH and asbestos. Infilled Clay and Marl Pits and Attlebridge Landfill are present in the vicinity of the Site Boundary. Contamination may include TPH, PAH, metals and inorganics.	Lateral migration of contaminants in groundwater.	Groundwater in the Chalk-Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation	Moderate/Low. The underlying superficial deposits are anticipated to include permeable formations with potential to support localised abstractions (Secondary A) and lower permeability formations with potential to support small abstractions (Secondary B) with some potential for migration of contamination.

Source	Pathway	Receptor	Risk of Contaminant Linkage
Potential current and historical off-site contamination sources in the vicinity of the site including former airfield (RAF Attlebridge) to the west of the site. Contaminants may include metals, TPH, PAH and asbestos. Infilled Clay and Marl Pits and Attlebridge Landfill are present in the vicinity of the site. Contamination may include TPH, PAH, metals and inorganics.	Migration of vapours or ground gases	Construction workers, future Proposed Scheme users	Low. A number of potential vapour and/ or ground gas sources have been identified within the surrounding area, including in potential Made Ground associated with the infilling of the Clay and Marl pits. However, given the anticipated lower permeability of the underlying superficial deposits near surface, the potential for migration of ground gas and vapours towards the Proposed Scheme is likely to be low.

3.6.6 The ground investigation strategy was designed to assess the key potential contamination sources and potential pollutant linkages identified in the preliminary conceptual site model and provide a good coverage of the ground conditions across the area proposed for the alignment refinement of the Wensum Valley viaduct infrastructure. The following sections describe the site investigation strategy, the results of laboratory chemical analysis and a qualitative source-pathway-receptor risk assessment; the revised conceptual model is then presented in Section 8.

4 Ground Investigation Details

4.1 Design

4.1.1 The ground investigation was designed by Ramboll and Ferrovial Construction (UK) Limited (Ferrovial) to investigate the ground, ground gas and groundwater conditions within the Site Boundary. The scope of the ground investigation was prepared by Ramboll and Ferrovial.

4.1.2 The exploratory locations targeted distinct areas of the Proposed Scheme such as locating deeper boreholes to inform the piling requirements for the proposed bridge over the River Wensum, targeting road crossing areas, and targeting potential contamination source areas such as infilled ground.

4.1.3 The results from the ground investigation will be incorporated into the Geotechnical Design Documents and aid in refining the Conceptual Site Model for the Proposed Scheme and highlighting any risk to receptors. The scope of the ground investigation is summarised in Section 1.4.

4.2 Ground Investigation Activities

4.2.1 The Alignment Refinement ground investigation was undertaken from 9th May – 2nd August 2022 followed by the Woodland Campaign ground investigation from 12th September – 18th October 2022 to provide coverage in areas which were previously inaccessible. The ground investigation was undertaken by Harrison Group Environmental Ltd (HGE) and Ramboll UK Limited (Ramboll) acted as the Investigation Supervisor for the ground investigation works.

4.2.2 The intrusive ground investigation was undertaken in general accordance with:

- BS 5930:2015+A1:2020 Code of Practice for Ground Investigation;
- BS 10175:2011+A2:2017 Investigation of Potentially Contaminated Sites – Code of Practice; and
- The Ground Investigation Scope Report.

4.2.3 Any deviation from the Ground Investigation Specification was agreed with the Investigation Supervisor.

4.2.4 The Factual Ground Investigation Report including chemical testing laboratory certificates and well designs is presented in the Harrison Group Environmental's Factual Ground Investigation Report and Factual Ground Investigation Report 'Woodland Campaign'. A plan of exploratory hole locations is presented as Figure 2.

4.2.5 A summary of the scope of the Factual Ground Investigation Report is presented in Table 4.1.

Table 4.1: Summary of Intrusive Works

Item	No.	Comments
Boreholes (cable percussive boreholes)	30	Drilling method: Thirty (30) percussive boreholes (BH201-BH205, BH207, BH227-BH228, BH232, BH236, BH238, BH242-BH248, BH251-BH254, and BH257-BH264) were drilled to a maximum depth of 60 mbgl. Hand excavated starter pits were completed to a maximum of 1.2m depth for each location prior to drilling. Depth range: 10.0-60.0 m The following monitoring wells were installed with 19mm HDPE install: BH201, BH236, BH245. The following monitoring wells were installed with 50mm HDPE install: BH203, BH226, BH228, BH243, BH246. BH260-BH264 were installed with 50 mm HDPE install during the Woodland Campaign. Gas and groundwater monitoring commenced in October 2022 and is ongoing at the time of publication of this report. Wells were of appropriate construction for the ground conditions encountered. The well designs are detailed within borehole logs appended to the factual reports.
Boreholes (rotary cored Boreholes); and rotary open hole Boreholes)	32 2	Drilling method: Thirty-two (32) rotary cored boreholes (BH206, BH208-BH209, BH211-BH220, BH222-BH226, BH229-BH231, BH233-BH235, BH237, BH239-BH241, BH249-BH250 and BH255-BH256) and 2 rotary open boreholes (BH210, BH221) were completed to a maximum depth of 60.65 mbgl. Depth range rotary cored boreholes: 24.95-60.65 m. Depth range rotary open boreholes: 60.0 m. The following monitoring wells were installed with 50mm HDPE install: BH206, BH210, BH221, BH229, BH231, BH233 BH235, BH237, BH241. The following monitoring well was installed with 19mm HDPE install: BH235. Cable percussive drilling was used to advance the majority of the boreholes through the superficial deposits and into the surface of the chalk bedrock where the boreholes were then advanced using a rotary rig. Gas and groundwater monitoring commenced in October 2022 and is ongoing at the time of publication of this report. The well designs are detailed within borehole logs appended to the factual reports.

Item	No.	Comments
Dynamic Continuous Sampling (window sampling boreholes)	15	Drilling Method: Fifteen (15) dynamic continuous sampler (window sampler) boreholes (WS08-WS10, WS201-WS206, WS211-WS216) were drilled to a maximum depth of 10 mbgl. The following monitoring wells were installed with 50mm HDPE install: WS211-WS213, WS215-WS216. Hand excavated starter pits were completed to a maximum of 1.2 m depth. Depth range: 1.20-10.45 m
Dynamic Cone Penetrometer Tests	15	Method: 54 dynamic cone tests using a TRL-DCP undertaken at fifteen (15) locations (DCP201-DCP213 incl. DCP203A, DCP214). Tests were completed to a depth of 1.5 m below ground level with early termination where 4mm or less penetration was achieved after 40 consecutive blows. The test conducted at DCP203 was repeated due to refusal at 0.4 m, and upon reattempt as DCP203A the test was successfully advanced to the scheduled depth of 1.5 m. Depth range: 0.40-1.73 m
Cone Penetration Tests	3	Method: CPT was undertaken (CPT01-CPT03) undertaken at three (3) locations. Depth range: 17.66m and 24.60m.
Machine Excavated Trial Pits	64	Method: 64 machine excavated trial pits using a JCB 3CX (TP201-TP252 (incl. TP209A, TP214A, TP15A TP224A, TP224B) TP254-TP255, TP55A, TP32A, TP233A, TP234A, TP247A, TP252A) to a maximum depth of 5.0 mbgl. 27 trial pits were partially backfilled (TP205-TP210 (incl. TP209A) TP222-TP230 (incl. TP224A, TP224B), TP235-TP240, TP254-TP255 (incl. TP55A)) with gravel to maintain stability and temporary monitoring pipe to enable subsequent infiltration testing to BRE DG 365 methodology. Depth range: 0.30-5.0 m
Machine Excavated Trial Trenches	5	Method: 5 machine excavated trial trenches (TR201-TR205) were completed. On completion the trenches were backfilled in compacted layers with topsoil deposits replaced. TR201-TR203 were completed for the purpose of investigating the geological profiles, geotechnical sampling, geotechnical sampling and in-situ testing (plate load testing, light weight deflectometer testing and sand replacement density testing). TR204 and TR205 were completed to determine the extent of a historically infilled area.
Pressuremeter Testing	53	Method: 53 pressuremeter tests were undertaken at 12 locations between 10th June 2022 and 28th July 2022. The locations were: BH209, BH211, BH214-BH215, BH218-BH219, BH223-BH224, BH237, BH239, BH241 and BH55) using either a reaming pressuremeter (RPM or PIP) or high-pressure dilatometer (HPD).

Item	No.	Comments
Soil Sampling and Analysis	404	During the site investigation, soil samples were recovered from each exploratory hole location. All environmental samples were subject to screening for volatile organic compounds (VOC) using a photo ionisation detector (PID). A total of 404 soil samples were scheduled for analysis. Selected soil samples were analysed for predetermined suite of contaminants (see Section 4.6), selected to be reflective of the area within the Site Boundary's historical and contemporary uses. Thirty (30) of the 404 soil samples tested were subjected to further analysis as soil leachate. Six (6) of the 404 soil samples tested were subjected to further waste acceptance criteria (WAC) classification.
Groundwater Sampling and Analysis	30	Six (6) rounds of groundwater level monitoring were undertaken on the 13th to 15th September 2022, 17th to 20th October 2022, 14th to 16th November 2022, 12th to 13th December 2022, 11th January 2023 and 13th February 2023. A total of eight (8) groundwater samples were obtained during the first round of sampling (17th to 18th October 2022) and eleven (11) groundwater samples were obtained from each of the second and third rounds of sampling, undertaken on 12th to 13th December 2022 and 13th to 14th February 2023. All thirty (30) samples were scheduled for analysis for a pre-determined suite of contaminants (see Section 4.6). Resting groundwater levels were monitored using a dip meter and checked for NAPLs (non-aqueous phase liquid using an Interface Probe). The groundwater samples were analysed for a suite of contaminants selected to be reflective of the area within the Site Bounadary's historic users as shown in Section 4.6.
Ground Gas Monitoring	21	Six (6) rounds of ground gas monitoring have been undertaken at twenty-one (21) monitoring wells across the area within the Site Boundary on the 13th to 15th September 2022, 17th to 20th October 2022, 14th to 15th November 2022, 12th to 13th December 2022, 11th January 2023 and 13th February 2023. All rounds of ground gas monitoring were undertaken using a GA5000/G504267 gas analyser.

4.3 Sample Location Rationale

4.3.1 The rationale for positioning the sampling locations is described in Table 4.2.

Table 4.2: Exploratory Hole Geoenvironmental Rationale

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH201	CP	10	Yes	Cable percussive hole to verify overburden conditions, chalk head levels and deriving ground model. Standard Penetration Tests full depth. Geotechnical and geo-environmental groundwater sampling and instrumentation.	A1067 – structures and Junction
BH202	CP	10	No	Cable percussive hole to verify overburden conditions, chalk head levels and deriving ground model. Full geotechnical sampling for soil and chalk laboratory testing. Standard Penetration Tests full depth.	Mainline chainage -214 to 20
BH203	CP	10	Yes	Cable percussive hole to verify overburden conditions, chalk head levels and deriving ground model. Full geotechnical sampling for soil and chalk laboratory testing. Standard Penetration Tests full depth.	Mainline chainage -214 to 20
BH204	CP	20	No	Cable percussive hole to verify overburden conditions, chalk head levels and deriving ground model. Full geotechnical sampling for soil and chalk laboratory testing. Standard Penetration Tests full depth.	Mainline chainage -214 to 20

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH205	CP	20	No	Cable percussive holes to verify overburden conditions, chalk head levels and deriving ground model. Full geotechnical sampling for soil and chalk laboratory testing. Standard Penetration Tests full depth.	Mainline chainage -214 to 20
BH206	CP+RO	60	Yes	Cable percussive hole with rotary follow-on in the chalk.	Mainline chainage -214 to 20
BH207	CP	20	No	Cable percussive holes to verify overburden conditions, chalk head levels and deriving ground model. Full geotechnical sampling for soil and chalk laboratory testing. Standard Penetration Tests full depth.	Mainline chainage -214 to 20
BH208	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH209	CP+RO	60	No	Cable percussive boreholes with rotary follow-on in the chalk with 4 no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500
BH210	OH	60	Yes	Open holed. Install groundwater instrumentation to check for artesian conditions.	Mainline chainage 20 to 500
BH211	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk with 4 no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH212	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH213	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH214	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk with 4no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500
BH215	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk with 4no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500
BH216	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH217	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH218	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk with 4no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500
BH219	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk with 4no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500
BH220	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH221	OH	60	Yes	Open holed. Install groundwater instrumentation to check for artesian conditions.	Mainline chainage 20 to 500

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH222	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH223	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk with 4no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500
BH224	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk with 4no. Menard pressuremeter tests in the chalk.	Mainline chainage 20 to 500
BH225	CP+RO	60	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 20 to 500
BH226	CP+RO	60	Yes	Cable percussive borehole with rotary follow-on in the chalk. Groundwater instrumentation.	Mainline chainage 500 to 800
BH227	CP	15	No	Cable percussive borehole with Geotechnical and Geo-environmental sampling.	Mainline chainage 500 to 800
BH228	CP	15	Yes	Cable percussive borehole with Geotechnical and Geo-environmental sampling.	Mainline chainage 500 to 800
BH229	CP+RO	25	Yes	Cable percussive boreholes with rotary follow-on in the chalk for sheet piled wall design. High quality samples required for investigating chalk properties.	Mainline chainage 800 to 1250

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH230	CP+RO	25	No	Cable percussive boreholes with rotary follow-on in the chalk for sheet piled wall design. High quality samples required for investigating chalk properties.	Mainline chainage 800 to 1250
BH231	CP+RO	25	Yes	Cable percussive boreholes with rotary follow-on in the chalk for sheet piled wall design. High quality samples required for investigating chalk properties.	Mainline chainage 800 to 1250
BH232	CP	25	No	Cable percussive borehole for sheet piled wall design.	Mainline chainage 800 to 1250
BH233	CP+RO	25	Yes	Cable percussive boreholes with rotary follow-on in the chalk for sheet piled wall design. High quality samples required for investigating chalk properties.	Mainline chainage 800 to 1250
BH234	CP+RO	25	No	Cable percussive boreholes with rotary follow-on in the chalk for sheet piled wall design. High quality samples required for investigating chalk properties.	Mainline chainage 800 to 1250
BH235	CP+RO	25	Yes	Cable percussive boreholes with rotary follow-on in the chalk for sheet piled wall design. High quality samples required for investigating chalk properties.	Mainline chainage 800 to 1250
BH236	CP	15	Yes	Cable percussive borehole for general coverage.	Mainline chainage 800 to 1250

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH237	CP+RO	30	Yes	Cable percussive borehole with rotary follow for contiguous piled wall. 6 no. pressuremeter tests (depths: 3 m, 8 m, 13 m, 18 m, 23 m, 28 mbgl) for contiguous piled wall.	Mainline chainage 800 to 1250
BH238	CP	15	No	Cable percussive borehole for general coverage.	Mainline chainage 800 to 1250
BH239	CP+RO	30	No	Cable percussive borehole with rotary follow for contiguous piled wall. 6 no. pressuremeter tests (depths: 3 m, 8 m, 13 m, 18 m, 23 m, 28 m bgl) for contiguous piled wall.	Mainline chainage 800 to 1250
BH240	CP+RO	30	No	Cable percussive borehole with rotary follow-on in the chalk.	Mainline chainage 800 to 1250
BH241	CP+RO	30	Yes	Cable percussive borehole with rotary follow for contiguous piled wall. 6 no. pressuremeter tests (depths: 3 m, 8 m, 13 m, 18 m, 23 m, 28 m bgl) for contiguous piled wall.	Mainline chainage 800 to 1250
BH242	CP	15	No	Cable percussive borehole for area of cut.	Mainline chainage 800 to 1250
BH243	CP	15	Yes	Cable percussive boreholes for cutting. Sampling and in situ testing, geotechnical and geo-environmental groundwater instrumentation and sampling.	Mainline chainage 1250 to 1540

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH244	CP	15	No	Cable percussive boreholes for cutting. Sampling and in situ testing, geotechnical and geo-environmental groundwater instrumentation and sampling.	Mainline chainage 1250 to 1540
BH245	CP	10	Yes	Cable percussive borehole for embankment with geotechnical and geo-environmental groundwater instrumentation and sampling.	Mainline chainage 1540 to 1800
BH246	CP+RO	20	Yes	Cable percussive boreholes with rotary follow-on in the chalk with geotechnical and geo-environmental groundwater instrumentation and sampling.	Mainline chainage 1540 to 1800
BH247	CP+RO	20	No	Cable percussive boreholes with rotary follow-on in the chalk with geotechnical and geo-environmental groundwater instrumentation and sampling.	Mainline chainage 1540 to 1800
BH248	CP	25	No	Cable percussive borehole for sheet piled wall design.	Mainline chainage 800 to 1250
BH249	CP+RO	30	No	Cable percussive borehole with rotary follow for contiguous piled wall.	Mainline chainage 800 to 1250
BH250	CP+RO	30	No	Cable percussive borehole with rotary follow for contiguous piled wall.	Mainline chainage 800 to 1250

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
BH251	CP	30	No	Cable percussive borehole for general coverage.	Mainline chainage 20 to 500
BH252	CP	30	No	Cable percussive borehole for general coverage.	Mainline chainage 20 to 500
BH253	CP	30	No	Cable percussive borehole for general coverage.	Mainline chainage 20 to 500
BH254	CP	30	No	Cable percussive borehole for general coverage.	Mainline chainage 20 to 500
BH255	CP+RO	60	No	Cable percussive boreholes with rotary follow-on in the chalk with 4 no. pressuremeter tests in the chalk	Mainline chainage 20 to 500
BH256	CP+RO	60	No	Cable percussive boreholes with rotary follow-on in the chalk	Mainline chainage 20 to 500
CPT201	CPT	30	No	Cone penetration test with porewater measurement. Dissipation tests. For embankment consolidation parameters.	Mainline chainage -214 to 20
CPT202	CPT	30	No	Cone penetration test with porewater measurement. Dissipation tests.	Mainline chainage 500 to 800
CPT203	CPT	30	No	Cone penetration test with porewater measurement. Dissipation tests.	Mainline chainage 800 to 1250
DCP201	DCP	1.5	No	To determine short-term in situ CBRs.	Mainline chainage -214 to 20
DCP202	DCP	1.5	No	To determine short-term in situ CBRs.	Mainline chainage -214 to 20

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
DCP203	DCP	1.5	No	To determine short-term in situ CBRs.	Mainline chainage -214 to 20
DCP204	DCP	1.5	No	To determine short-term in situ CBRs.	Mainline chainage -214 to 20
DCP205	DCP	1.5	No	To determine short-term in situ CBRs.	Mainline chainage -214 to 20
DCP206	DCP	1.5	No	To determine short-term in situ CBRs.	Mainline chainage -214 to 20
DCP207	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 500 to 800
DCP208	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 500 to 800
DCP209	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 500 to 800
DCP210	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 800 to 1250
DCP211	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 1250 to 1540
DCP212	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 1250 to 1540
DCP213	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 1250 to 1540
DCP214	DCP	1.5	No	In situ CBRs along access track.	Mainline chainage 1800 to 2400
TP201	TP	4.5	No	Collect large bulk samples.	A1067 – structures and Junction

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
TP202	TP	4.5	No	Lightweight deflectometer test. Collect large bulk samples.	A1067 – structures and Junction
TP203	TP	3	Yes	Investigate at grade formation. Large bulks.	Mainline chainage -214 to 20
TP204	TP	3	Yes	Verify ground conditions under access track, Lightweight deflectometer test. Large bulks.	Mainline chainage -214 to 20
TP205	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 14.20 mOD)(Basin A1067/1). Large bulks.	Infiltration ponds/ ditches
TP206	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 14.20 mOD)(Basin A1067/1). Large bulks.	Infiltration ponds/ ditches
TP207	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 14.20 mOD)(Basin A1067/1). Large bulks.	Infiltration ponds/ ditches
TP208	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 14.20 mOD)(Basin A1067/1). Large bulks.	Infiltration ponds/ ditches
TP209	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 16.10 mOD)(Basin 2). Large bulks.	Infiltration ponds/ ditches

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
TP210	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 16.10 mOD)(Basin 2). Large bulks.	Infiltration ponds/ ditches
TP211	TP	3	No	Plate bearing test, sand replacement test and lightweight deflectometer tests at shallow depth. Collect large bulk samples.	Mainline chainage 800 to 1250
TP212	TP	3	No	Plate bearing test, sand replacement test and lightweight deflectometer tests at shallow depth. Collect large bulk samples.	Mainline chainage 800 to 1250
TP213	TP	3	No	Plate bearing test, sand replacement test and lightweight deflectometer tests at shallow depth. Collect large bulk samples.	Mainline chainage 800 to 1250
TP214	TP	4.5	No	Collect large bulk samples	Mainline chainage 800 to 1250
TP215	TP	4.5	No	Collect large bulk samples	Mainline chainage 800 to 1250
TP216	TP	4.5	No	Collect large bulk samples	Mainline chainage 800 to 1250
TP217	TP	4.5	No	Collect large bulk samples	Mainline chainage 800 to 1250
TP218	TP	4.5	No	Collect large bulk samples	Mainline chainage 800 to 1250
TP219	TP	4.5	No	Collect large bulk samples	Mainline chainage 800 to 1251

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
TP220	TP	4.5	No	Collect large bulk samples	Mainline chainage 1250 to 1540
TP221	TP	4.5	No	Collect large bulk samples	Mainline chainage 1250 to 1540
TP222	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 22.00 mOD)(Basin 3). Large bulks.	Infiltration ponds/ ditches
TP223	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 16.10 mOD)(Basin 2). Large bulks.	Infiltration ponds/ ditches
TP224	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 16.10 mOD)(Basin 2). Large bulks.	Infiltration ponds/ ditches
TP225	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 21.0 mOD)(Basin 4). Large bulks.	Infiltration ponds/ ditches
TP226	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 21.0 mOD)(Basin 4). Large bulks.	Infiltration ponds/ ditches
TP227	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 21.0 mOD)(Basin 4). Large bulks.	Infiltration ponds/ ditches

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
TP228	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 21.0 mOD)(Basin 4). Large bulks.	Infiltration ponds/ ditches
TP229	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 22.00 mOD)(Basin 3). Large bulks.	Infiltration ponds/ ditches
TP230	TP	2	No	Soakaway tests at or below pond invert level. Depth TBC by Engineer (Basin inv lev = 22.00 mOD)(Basin 3). Large bulks.	Infiltration ponds/ ditches
TP231	TP	2	No	With plate bearing test, sand replacement tests, lightweight deflectometer tests. Collect large bulk samples.	Mainline chainage 1800 to 2400
TP232	TP	3	No	With plate bearing test, sand replacement tests, lightweight deflectometer tests. Collect large bulk samples.	Mainline chainage 1800 to 2400
TP233	TP	3	No	With plate bearing test, sand replacement tests, lightweight deflectometer tests. Collect large bulk samples.	Mainline chainage 1800 to 2400
TP234	TP	3	No	With plate bearing test, sand replacement tests, lightweight deflectometer tests. Collect large bulk samples.	Mainline chainage 1800 to 2400

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
TP235	TP	2	No	Soakaway tests at or below pond invert level, depth TBC by Engineer (Pond Basin level TBC). Large bulks.	Infiltration ponds/ ditches
TP236	TP	2	No	Soakaway tests at or below pond invert level, depth TBC by Engineer (Pond Basin level TBC). Large bulks.	Infiltration ponds/ ditches
TP237	TP	2	No	Soakaway tests at or below pond invert level, depth TBC by Engineer (Pond Basin level TBC). Large bulks.	Infiltration ponds/ ditches
TP238	TP	2	No	Soakaway tests at or below pond invert level, depth TBC by Engineer (Pond Basin level TBC). Large bulks.	Infiltration ponds/ ditches
TP239	TP	2	No	Soakaway tests at or below infiltration ditch level. Depth of test TBC by Engineer. Large bulks.	Infiltration ponds/ ditches
TP240	TP	2	No	Soakaway tests at or below infiltration ditch level. Depth of test TBC by Engineer. Large bulks.	Infiltration ponds/ ditches
TP241	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP242	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP243	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
TP244	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP245	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP246	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP247	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP248	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP249	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP250	TP	1.5	No	With Plate bearing test, sand replacement test and light weight deflectometer test.	Mainline chainage 20 to 500
TP251	TP	3	No	With plate bearing test, sand replacement test and lightweight deflectometer test. Collect large bulk samples.	Mainline chainage 1800 to 2400
TP252	TP	3	No	With plate bearing test, sand replacement test and lightweight deflectometer test. Collect large bulk samples.	Mainline chainage 1800 to 2400

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
TR201	TR	2	No	7 m long trench to investigate the variation in ground conditions at subgrade level. 3nr plate bearing tests to determine CBRs. Sand replacement tests. 3 nr lightweight deflectometer tests. Large bulks.	Mainline chainage 500 to 800
TR202	TR	2.5	No	7 m long trench to investigate the variation in ground conditions at subgrade level. 3nr plate bearing tests to determine CBRs. Sand replacement tests. 3 nr lightweight deflectometer tests. Large bulks.	Mainline chainage 1800 to 2400
TR203	TR	2.5	No	7 mlong trench to investigate the variation in ground conditions at subgrade level. 3 nr plate bearing tests to determine CBRs. Sand replacement tests. 3 nr lightweight deflectometer tests. Large bulks.	Mainline chainage 1800 to 2400
WS201	WS	5	No	Geotechnical and Geo-environmental sampling.	Mainline chainage -214 to 20
WS202	WS	5	No	Geotechnical and Geo-environmental sampling.	Mainline chainage -214 to 20
WS203	WS	10	No	Geotechnical and Geo-environmental sampling.	Mainline chainage 500 to 800
WS204	WS	10	No	Geotechnical and Geo-environmental sampling.	Mainline chainage 500 to 800
WS205	WS	10	No	Geotechnical and Geo-environmental sampling.	Mainline chainage 500 to 800

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
WS206	WS	3	No	Geotechnical and Geo-environmental sampling.	Mainline chainage 800 to 1250
WS207	WS	10	No	Geotechnical and Geo-environmental sampling.	Mainline chainage 800 to 1250
WS208	WS	3	No	Window sampling to verify ground conditions at cutting/ embankment transition. Lightweight deflectometer test at each WS location at shallow depth.	Mainline chainage 1250 to 1540
WS209	WS	3	No	Window sampling to verify ground conditions at cutting/ embankment transition. Lightweight deflectometer test at each WS location at shallow depth.	Mainline chainage 1250 to 1540
WS210	WS	3	No	Window sampling to verify ground conditions at cutting/ embankment transition. Lightweight deflectometer test at each WS location at shallow depth.	Mainline chainage 1250 to 1540
WS211	WS	5	Yes	Geotechnical and geo-environmental groundwater instrumentation and sampling.	Infiltration pond
WS212	WS	5	Yes	Geotechnical and geo-environmental groundwater instrumentation and sampling.	Infiltration pond
WS213	WS	5	Yes	Geotechnical and geo-environmental groundwater instrumentation and sampling.	Infiltration pond

Exploratory Hole ID	Type (see note)	Scheduled Depth (mbgl)	Installation required for gas and groundwater monitoring	Remarks	Location
WS214	WS	5	Yes	Geotechnical and geo-environmental groundwater instrumentation and sampling.	Infiltration pond
WS215	WS	5	Yes	Geotechnical and geo-environmental groundwater instrumentation and sampling.	Infiltration pond
WS216	WS	5	Yes	Geotechnical and geo-environmental groundwater instrumentation and sampling.	Infiltration ditch

Note: CP – cable percussion borehole, CPT – cone penetration testing, RO – rotary open-hole borehole, DCP – dynamic cone penetrometer, WLS – windowless sample hole, CP+RO – cable percussion to rotary cored borehole, TP – trial pit.

4.3.2 All exploratory holes reached their target depth, with the exception of the locations summarised in Table 4.3 below.

Table 4.3: On-site constrains affecting target depth

Exploratory Hole	Termination Reason	Depth Achieved (mbgl)	Installed as Monitoring Well?
BH217	Approved by Ramboll	59.95	No
BH222	Difficulty with casing and tooling	57.45	No
BH226	Hole collapsed	57.00	Yes
BH233	Approved by Ramboll	24.95	Yes
BH234	Approved by Ramboll	24.95	No
WS201	Dense stratum	1.20	No
WS202	Dense stratum	3.00	No
WS205	Dense stratum	3.00	No
WS211	Dense stratum	3.00	Yes

Exploratory Hole	Termination Reason	Depth Achieved (mbgl)	Installed as Monitoring Well?
WS212	Dense stratum	4.00	Yes
WS214	Dense stratum	1.20	No
WS215	Dense stratum	2.00	Yes
WS216	Dense stratum	3.00	Yes
DCP203	Refusal	0.40	No
TP201	Maximum reach of excavator	4.10	No
TP203	Pit collapsed	2.60	No
TP214	Pit collapsed	1.70	No
TP215	Pit collapsed	2.20	No
TP216	Pit collapsed	3.90	No
TP217	Pit collapsed	3.40	No
TP219	Pit collapsed	3.60	No
TP220	Pit collapsed	4.00	No
TP221	Pit becoming unstable	3.00	No
TP242	Groundwater encountered	1.00	No
TP243	Groundwater encountered	0.90	No
TP244	Groundwater encountered	1.15	No
TP245	Groundwater encountered	0.80	No
TP246	Groundwater encountered	0.85	No
TP247	Very soft ground	0.30	No
TP248	Groundwater encountered	0.88	No
TP250	Maximum depth achievable with hand tools	1.20	No
TR202SE	Trench collapsed	1.30	No

4.4 Sampling and Monitoring

Soil and Leachate Samples

4.4.1 Soil samples were recovered from each of the exploratory locations where required and subject to headspace testing with a photo-ionisation detector (PID) on-site. A total of 404 soil samples were scheduled for analysis. Thirty (30) of these soil samples were also scheduled for leachate analysis.

4.4.2 Samples were placed in containers supplied by the laboratory appropriate to the type of analysis being undertaken and stored in cool boxes with ice packs. All samples were dispatched accompanied by chain of custody documentation.

4.4.3 Laboratory test results are presented as part of Harrison Group Environmental's factual report.

Groundwater Monitoring and Sampling

4.4.4 Six (6) rounds of groundwater level monitoring have been undertaken on the Alignment Refinement monitoring wells and the Woodland Campaign monitoring wells. The Alignment Refinement wells were monitored on 13th to 15th September 2022, 17th to 20th October 2022, 14 to 15th November 2022, 12th to 13th December 2022, 11th January 2023 and 13th February 2023. The Woodland Campaign wells were monitored on 17th to 19th October 2022, 14th to 16th November 2022, 13th of December 2022, 11th January 2023 and 14th February 2023. A total of eight (8) groundwater samples were obtained from the Alignment Refinement well network between 17th to 18th October 2022 and eleven (11) samples were collected during each of the second and third rounds of groundwater sampling each between 12th to 13th December 2022 and 13th to 14th February 2023. All groundwater samples were scheduled for laboratory analysis.

4.4.5 Prior to sampling, the depth to the resting groundwater level (where present) and base of the monitoring wells were measured using an interface probe. The interface probe also detected whether non-aqueous phase liquid (NAPL) was present in the well.

4.4.6 An initial well development round for the Alignment Refinement well network was completed between 19th July and 24th August 2022. Well development for the Woodland Campaign wells was undertaken on 12th October 2022. Three times the well volume was generally purged from each installation where possible. If water became clear during purging, the sampling began. If the water remained silty, more than three times the well volume was purged until the monitoring of the electrical conductivity measurement became stable. Where groundwater was slow to recharge, the well was pumped dry and samples were taken once the monitoring well had recharged.

4.4.7 All monitoring wells were installed with 50mm HDPE standpipes with the exception of BH201, BH235, BH236 and BH245, which were installed with 19mm HDPE standpipes.

4.4.8 Groundwater samples were collected in accordance with BS 10175:2011+A2:2017 and were stored within appropriate sample containers and stored in cool boxes with ice packs prior to being forwarded to an independent approved MCERTS accredited analytical laboratory (i2 Analytical Ltd) with an accompanying chain of custody form.

4.4.9 A summary of the groundwater level data collected to date is presented in Table 4.4 and Table 4.5. and a summary of field parameters are presented as part of the Harrison Group Environmental's factual report.

4.4.10 It is noted that the surface level in the area of the Woodland Campaign is approximately 20 m higher than that of the Alignment Refinement area.

Table 4.4: Summary of Groundwater Monitoring Wells – Alignment Refinement

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH201	1	1.5 – 8.0	Dry	N/A	7.85	18.16	Superficial
BH201	2	N/A	Dry	N/A	7.85	18.16	N/A
BH201	3	N/A	Dry	N/A	7.85	18.16	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH201	4	N/A	Dry	-	7.85	18.16	N/A
BH201	5	N/A	Dry	-	7.85	18.16	N/A
BH201	6	N/A	Dry	-	7.86	18.15	N/A
BH203	1	1.0 – 4.0	Dry	-	3.69	12.19	Superficial
BH203	2	N/A	Dry	-	3.73	12.15	N/A
BH203	3	N/A	Dry	-	3.65	12.23	N/A
BH203	4	N/A	Dry	-	3.65	12.23	N/A
BH203	5	N/A	Dry	-	3.66	12.22	N/A
BH203	6	N/A	Dry	-	3.73	12.15	N/A
BH206	1	2.5 – 6.5	2.64	10.13	6.37	6.40	Superficial
BH206	2	N/A	2.83	9.94	6.41	6.36	N/A
BH206	3	N/A	2.62	10.15	6.00	6.77	N/A
BH206	4	N/A	2.65	10.12	6.37	6.40	N/A
BH206	5	N/A	2.21	10.56	5.98	6.79	N/A
BH206	6	N/A	2.56	10.21	6.27	6.50	N/A
BH210 (Pipe 1)	1	50 – 55	0.41	8.79	52.05	-42.85	Chalk
BH210 (Pipe 1)	2	N/A	0.86	8.34	52.05	-42.85	N/A
BH210 (Pipe 1)	3	N/A	1.37	7.83	52.05	-42.85	N/A
BH210 (Pipe 1)	4	N/A	0.41	8.79	52.05	-42.85	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH210 (Pipe 1)	5	N/A	1.02	8.18	52.05	-42.85	N/A
BH210 (Pipe 2)	6	N/A	0.32	8.88	53.1	-43.90	N/A
BH210 (Pipe 2)	1	1.0 – 2.0	0.60	8.60	1.93	7.27	Peat
BH210 (Pipe 2)	2	N/A	0.86	8.34	1.81	7.39	N/A
BH210 (Pipe 2)	3	N/A	0.82	8.38	1.77	7.43	N/A
BH210 (Pipe 2)	4	N/A	0.77	8.43	1.96	7.24	N/A
BH210 (Pipe 2)	5	N/A	0.87	8.33	1.77	7.43	N/A
BH210 (Pipe 2)	6	N/A	0.71	8.49	1.90	7.30	N/A
BH221	1	40 – 45	2.02	6.87	44.52	-35.63	Chalk
BH221	2	N/A	0.45	8.44	44.50	-35.61	N/A
BH221	3	N/A	0.48	8.41	44.09	-35.20	N/A
BH221	4	N/A	0.17	8.72	44.23	-35.34	N/A
BH221	5	N/A	-0.33	9.22	43.81	-34.92	N/A
BH221	6	N/A	0.20	8.69	43.25	-34.36	N/A
BH226	1	4.0 – 8.0	3.46	8.04	7.43	4.07	Chalk
BH226	2	N/A	2.99	8.51	7.56	3.94	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH226	3	N/A	3.01	8.49	7.57	3.93	N/A
BH226	4	N/A	2.69	8.81	7.59	3.91	N/A
BH226	5	N/A	2.25	9.25	7.67	3.83	N/A
BH226	6	N/A	2.76	8.74	7.42	3.98	N/A
BH228	1	9.0 – 12	Dry	-	11.12	4.48	Chalk
BH228	2	N/A	Dry	-	11.17	4.43	N/A
BH228	3	N/A	Dry	-	11.09	4.51	N/A
BH228	4	N/A	Dry	-	11.09	4.51	N/A
BH228	5	N/A	Dry	-	11.10	4.50	N/A
BH228	6	N/A	Damp	-	11.10	4.50	N/A
BH229	1	1.0 – 6.0	Dry	-	5.63	18.43	Superficial and Chalk
BH229	2	N/A	Dry	-	5.29	18.77	N/A
BH229	3	N/A	Dry	-	5.33	18.73	N/A
BH229	4	N/A	Dry	-	5.33	18.73	N/A
BH229	5	N/A	Dry	-	5.37	18.69	N/A
BH229	6	N/A	Dry	-	5.71	18.35	N/A
BH231	1	5.0 – 25	20.06	5.02	24.74	0.34	Chalk
BH231	2	N/A	215.38	9.70	24.80	0.28	N/A
BH231	3	N/A	20.16	4.92	24.45	0.63	N/A
BH231	4	N/A	16.19	8.89	25.95	-0.87	N/A
BH231	5	N/A	19.43	5.65	24.43	0.65	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH231	6	N/A	16.10	8.98	24.80	0.28	N/A
BH233 **(Pipe 1)**	1	9.0 – 24.5	20.70	8.97	24.56	5.11	Chalk
BH233	2	N/A	20.15	9.52	24.40	5.27	N/A
(Pipe 1)	3	N/A	20.02	9.65	24.40	5.27	N/A
BH233	4	N/A	20.89	8.78	24.85	4.82	N/A
(Pipe 1)	5	N/A	19.91	9.76	24.41	5.26	N/A
BH233	6	N/A	19.18	10.49	24.25	5.42	N/A
BH233 **(Pipe 2)**	1	1.0 – 4.0	Dry	-	3.73	25.94	Superficial
BH233 **(Pipe 2)**	2	N/A	Dry	-	3.72	25.95	N/A
BH233 **(Pipe 2)**	3	N/A	Dry	-	3.72	25.95	N/A
BH233 **(Pipe 2)**	4	N/A	Dry	-	3.72	25.95	N/A
BH233 **(Pipe 2)**	5	N/A	Dry	-	3.73	25.94	N/A
BH233 **(Pipe 2)**	6	N/A	Dry	-	3.72	25.95	N/A
BH235 **(Pipe 1)**	1	15 – 16	Dry	-	15.01	16.37	Chalk
BH235 **(Pipe 1)**	2	N/A	Dry	-	15.00	16.38	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH235 (Pipe 1)	3	N/A	Dry	N/A	15.00	16.38	N/A
BH235 (Pipe 1)	4	N/A	Dry	N/A	15.00	16.38	N/A
BH235 (Pipe 1)	5	N/A	Dry	N/A	15.00	16.38	N/A
BH235 (Pipe 1)	6	N/A	Dry	N/A	15.01	16.37	N/A
BH235 (Pipe 2)	1	3.0 – 7.5	Dry	N/A	7.39	23.99	Superficial and Chalk
BH235 (Pipe 2)	2	N/A	Dry	N/A	7.36	24.02	N/A
BH235 (Pipe 2)	3	N/A	Dry	N/A	7.39	23.99	N/A
BH235 (Pipe 2)	4	N/A	Dry	N/A	7.48	23.90	N/A
BH235 (Pipe 2)	5	N/A	Dry	N/A	7.34	24.04	N/A
BH235 (Pipe 2)	6	N/A	Dry	N/A	7.34	24.04	N/A
BH236	1	2.0 – 6.5	Dry	N/A	6.32	28.37	Superficial
BH236	2	N/A	Dry	N/A	6.31	28.38	N/A
BH236	3	N/A	Dry	N/A	6.31	28.38	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH236	4	N/A	Dry	N/A	6.32	28.37	N/A
BH236	5	N/A	Dry	N/A	6.32	28.37	N/A
BH236	6	N/A	Dry	N/A	6.31	28.38	N/A
BH237	1	9.0 – 10	Dry	N/A	9.92	25.73	Superficial
BH237	2	N/A	Dry	N/A	9.89	25.76	N/A
BH237	3	N/A	Dry	N/A	9.90	25.75	N/A
BH237	4	N/A	Damp	N/A	9.90	25.75	N/A
BH237	5	N/A	Dry	N/A	9.99	25.66	N/A
BH237	6	N/A	Dry	N/A	9.97	25.68	N/A
BH241	1	8.5 – 10.4	Dry	N/A	10.28	29.20	Superficial
BH241	2	N/A	Dry	N/A	10.29	29.19	N/A
BH241	3	N/A	Dry	N/A	10.29	29.19	N/A
BH241	4	N/A	Dry	N/A	10.29	29.19	N/A
BH241	5	N/A	Dry	N/A	10.25	29.23	N/A
BH241	6	N/A	Dry	N/A	10.23	29.25	N/A
BH243	1	1.0 – 13	Dry	N/A	12.18	28.02	Superficial
BH243	2	N/A	Dry	N/A	12.26	27.94	N/A
BH243	3	N/A	Dry	N/A	12.25	27.95	N/A
BH243	4	N/A	Dry	N/A	12.25	27.95	N/A
BH243	5	N/A	Dry	N/A	12.25	27.95	N/A
BH243	6	N/A	Dry	N/A	12.25	27.95	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
BH245	1	2.0 – 2.5	Dry	N/A	2.37	20.86	Made Ground
BH245	2	N/A	Dry	N/A	2.37	20.86	N/A
BH245	3	N/A	Dry	N/A	2.37	20.86	N/A
BH245	4	N/A	Dry	N/A	2.37	20.86	N/A
BH245	5	N/A	Dry	N/A	2.37	20.86	N/A
BH245	6	N/A	Dry	N/A	2.37	20.86	N/A
BH246	1	1.5 – 3.0	Dry	N/A	2.74	21.19	Superficial
BH246	2	N/A	Dry	N/A	2.74	21.19	N/A
BH246	3	N/A	Dry	N/A	2.73	21.20	N/A
BH246	4	N/A	Dry	N/A	2.73	21.20	N/A
BH246	5	N/A	Dry	N/A	2.73	21.20	N/A
BH246	6	N/A	Dry	N/A	2.73	21.20	N/A
WS211	1	2.5 – 3.0	Dry	N/A	2.67	21.31	Superficial
WS211	2	N/A	Dry	N/A	2.67	21.31	N/A
WS211	3	N/A	Dry	N/A	2.70	21.28	N/A
WS211	4	N/A	Dry	N/A	2.69	21.29	N/A
WS211	5	N/A	Dry	N/A	2.67	21.31	N/A
WS211	6	N/A	Dry	N/A	2.70	21.28	N/A
WS212	1	2.0 – 4.0	Dry	N/A	3.18	18.82	Superficial
WS212	2	N/A	Dry	N/A	3.21	18.79	N/A
WS212	3	N/A	Dry	N/A	3.21	18.79	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth to Water mbgl	Depth to Water mAOD	Depth to Base mbgl	Depth to Base mAOD	Response Zone strata
WS212	4	N/A	Dry	N/A	3.22	18.78	N/A
WS212	5	N/A	Dry	N/A	3.22	18.78	N/A
WS212	6	N/A	Dry	N/A	3.22	18.78	N/A
WS213	1	1.0 – 5.0	Dry	N/A	4.49	10.93	Superficial and Chalk
WS213	2	N/A	Dry	N/A	4.48	10.94	N/A
WS213	3	N/A	Dry	N/A	4.47	10.95	N/A
WS213	4	N/A	Dry	N/A	4.49	10.93	N/A
WS213	5	N/A	Dry	N/A	4.48	10.94	N/A
WS213	6	N/A	Dry	N/A	4.49	10.93	N/A
WS215	1	1.0 – 2.0	Dry	N/A	1.91	14.30	Superficial
WS215	2	N/A	Dry	N/A	1.88	14.33	N/A
WS215	3	N/A	Dry	N/A	1.88	14.33	N/A
WS215	4	N/A	Dry	N/A	1.88	14.33	N/A
WS215	5	N/A	Dry	N/A	1.88	14.33	N/A
WS215	6	N/A	Dry	N/A	1.88	14.33	N/A
WS216	1	1.0 – 2.0	Dry	N/A	1.81	19.77	Superficial
WS216	2	N/A	Dry	N/A	1.73	19.85	N/A
WS216	3	N/A	Dry	N/A	1.73	19.85	N/A
WS216	4	N/A	Dry	N/A	1.73	19.85	N/A
WS216	5	N/A	Dry	N/A	1.73	19.85	N/A
WS216	6	N/A	Dry	N/A	1.74	19.84	N/A

Table 4.5: Summary of Groundwater Monitoring Wells – Woodland Campaign

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth To Water mbgl	Depth To Water mAOD	Depth To Base mbgl	Depth To Base mAOD	Response Zone strata
BH260	1	14.5 – 19.5	16.00	8.63	19.75	4.88	Chalk
BH260	2	N/A	15.84	8.79	19.58	5.05	N/A
BH260	3	N/A	15.79	8.84	20.21	4.42	N/A
BH260	4	N/A	15.63	9.00	20.19	4.44	N/A
BH260	5	N/A	15.68	8.95	19.62	5.01	N/A
BH260	6	N/A	14.95	9.68	19.79	4.84	N/A
BH261	1	1.0 – 5.0	4.39	45.58	4.82	45.15	Superficial
BH261	2	N/A	Dry	N/A	4.77	45.20	N/A
BH261	3	N/A	1.13	48.84	4.86	45.11	N/A
BH261	4	N/A	0.47	49.50	4.77	45.20	N/A
BH261	5	N/A	1.70	48.27	4.72	45.25	N/A
BH261	6	N/A	1.10	48.87	4.88	45.09	N/A
BH262	1	1.5 – 2.5	Dry	N/A	2.92	46.89	Superficial
BH262	2	N/A	0.88	48.93	2.85	46.96	N/A
BH262	3	N/A	0.90	48.91	2.82	46.99	N/A
BH262	4	N/A	0.39	49.42	2.85	46.96	N/A
BH262	5	N/A	1.08	48.73	2.68	47.13	N/A
BH262	6	N/A	Dry	-	2.85	46.96	N/A
BH263	1	1.0 – 5.0	5.00	45.27	5.11	45.16	Superficial
BH263	2	N/A	4.97	45.30	4.99	45.28	N/A

Monitoring Well	Monitoring Round (R)	Response Zone mbgl	Depth To Water mbgl	Depth To Water mAOD	Depth To Base mbgl	Depth To Base mAOD	Response Zone strata
BH263	3	N/A	1.08	N/A	5.11	45.16	N/A
BH263	4	N/A	2.03	N/A	5.00	45.27	N/A
BH263	5	N/A	1.40	N/A	5.11	45.16	N/A
BH263	6	N/A	2.60	N/A	5.14	45.13	N/A
BH264	1	6.0 – 8.0	Damp	N/A	8.47	41.73	Superficial
BH264	2	N/A	Dry	N/A	8.18	42.02	N/A
BH264	3	N/A	Dry	N/A	8.31	41.89	N/A
BH264	4	N/A	8.13	42.07	8.18	42.02	N/A
BH264	5	N/A	Dry	N/A	8.26	41.94	N/A
BH264	6	N/A	Dry	N/A	8.34	41.86	N/A

4.4.11 Laboratory test results from groundwater sampling are presented in Harrison Group Environmental's Factual Ground Investigation Report.

4.5 Ground Gas Monitoring

4.5.1 Six (6) rounds of ground gas monitoring have been undertaken at twenty-one (21) monitoring wells within the Site Boundary on the 13th to 15th September, 17th to 20th October, 14th to 15th November, 12th to 13th December 2022, 11th January 2023 and 13th February 2023.

4.5.2 Ground gas monitoring was completed using a calibrated multi-parameter Gas Analyser GA5000/G50427 with reference to CIRIA C665 and BS 8576:2013 Guidance on Investigations for Ground Gas. A photo ionisation detector (PID) was used to monitor the volatile organic compounds (VOC) and was conducted using a calibrated Tiger Handheld VOC Detector. Monitoring data for the following parameters was gathered from the boreholes:

- VOC (ppm);
- methane (% vol);
- carbon dioxide (% vol);
- oxygen (% vol);
- carbon monoxide (ppm);
- hydrogen sulphide (ppm); and
- flow rate (l/hr).

4.5.3 Gas flow rates were measured at all monitoring boreholes and the contractor recorded the range in flow rates until a steady state was reached. Ground gas monitoring wells are summarised in Section 7 Table 7.1.

4.6 Laboratory Analysis

Analytical Rationale

4.6.1 Table 4.6 summarises the analytical schedule for soil and groundwater samples together with the rationale for analysis.

Table 4.6: Summary of Analytical Strategies

Analytical Suite	Rationale	No. of Soil Samples Scheduled	No. of Soil Leachate Samples Scheduled	No. of Groundwater Samples Scheduled to date (three rounds)
Heavy Metals (incl. As, Ba, Bo, Cd, Cu, Cr (III and VI), Pb, Hg, Ni, Se, Sb, V, and Zn)	Typically associated with a range of industrial uses in high concentrations. May be present in elevated concentrations in historical fill material depending on point of origin. May also occur naturally.	401	30	30

Analytical Suite	Rationale	No. of Soil Samples Scheduled	No. of Soil Leachate Samples Scheduled	No. of Groundwater Samples Scheduled to date (three rounds)
Inorganics (sulphate, ammoniacal nitrogen, total organic carbon (TOC))	Naturally occurring, with elevated concentrations potentially associated with industrial uses. May be present in elevated concentrations in historical fill material depending on point of origin.	401	25	30
Organics (Total Petroleum Hydrocarbons (TPH), Polycyclic Aromatic Hydrocarbons (PAH), Benzene, Toluene, Ethylbenzene and Xylenes (BTEX), phenols)	Typically associated with fuels and oils. May be present in elevated concentrations in historical fill material depending on point of origin.	337	30	30
Volatile Organic Compounds (VOCs)	Typically associated with fuels/ oils and with ash deposits. May be present in elevated concentrations in historical fill material depending on point of origin.	11	0	11
Semi-volatile Organic Compounds (SVOCs)	Typically associated with fuels/ oils and with ash deposits. May be present in elevated concentrations in historical fill material depending on point of origin.	11	0	30
Herbicides, Organophosphorus Pesticides (OPP)	Herbicides are commonly applied to agricultural land. Unlikely to be present in significant concentration.	33	0	11

4.7 Data Quality Assurance

4.7.1 The laboratory selected to perform the analysis (i2 Analytical Ltd) is accredited by UKAS to ISO 17025 and MCerts standards. Internal quality assurance checks are carried out by the laboratory data prior to the laboratory certificates being issued.

5 Ground Conditions

5.1 Ground Conditions

5.1.1 The ground conditions encountered during the ground investigation are summarised in Table 5.1. The information provided is a summary of the ground conditions encountered within the Site Boundary. A full lithological description is recorded on the exploratory hole logs that are provided as part of the Harrison Group Environmental's factual reports.

Table 5.1: Summary of Ground Conditions

Stratum	Description	Depth to Top (mbgl) [mAOD]	Approximate Average Thickness (where encountered) (m)
Topsoil	Dark brown sandy clay or clayey sand with gravels of flint, sandstone, quartz and chalk. Rare to frequent roots and rootlets.	0.00 [8.79-57.6]	0.36
Made Ground	Dark brown slightly gravelly clayey sand with gravels of flint, chalk and brick and occasional anthropogenic constituents including plastic, string, rope, ash, wood, charcoal, rubber and electrical cable fragments.	0.00-0.10 [12.2-40.4]	0.56
Peat	Plastic / Spongy dark brown to black clayey / slightly sandy fibrous peat with occasional relic roots and wood. Strong organic odour. Peat was located in the River Wensum Floodplain	0.0-0.80 [8.41-9.06]	1.07

Stratum	Description	Depth to Top (mbgl) [mAOD]	Approximate Average Thickness (where encountered) (m)
Alluvium	Orangey brown fine to coarse angular to subrounded flint gravel and medium to coarse sand. Some very soft to soft dark brown sandy organic clay with gravels of flint.	0.20-1.15 [7.68-21.0]	0.79
River Terrace Deposits	Loose to medium dense yellowish brown very gravelly slightly silty medium to coarse sand with a low cobble content.	0.2-2.90 [6.13-19.4]	5.55
Head Deposits	Stiff to very stiff light brown slightly gravelly clay and medium dense to dense orangey bron fine to medium sand.	0.30-3.00 11.2-48.9]	1.92
Sheringham Cliffs Formation	Gravelly fine to medium sand or silty gravelly fine to medium sand and firm to stiff sandy gravelly clay.	0.00-4.05 [-0.55-58.5]	4.64
Lowestoft Formation	Firm to stiff sandy gravelly clay and medium dense clayeye gravelly sand.	0.25-31.0 [17.8-51.3]	7.48
Glacial Deposits	Yellowish brown silty fine to coarse sand and firm to stiff cream calcareous silt.	0.15-16.4 [4.53-36.9]	2.13
Chalk	Structureless chalk	Not proven	Not proven

5.1.2 The ground conditions encountered within the Site Boundary are generally comparable to the geology described in the British Geological Survey (BGS) map of the area with respect to natural ground. The ground conditions encountered during the Alignment Refinement and Woodland Campaign GIs are in line with the findings of the Supplementary GI. Peat was noted in more locations the River Wensum Floodplain compared to the Supplementary GI.

5.1.3 The underlying bedrock is Chalk, which comprises the undifferentiated components of the Lewes Nodular Chalk Formation, the Seaford Chalk Formation, the Newhaven Chalk Formation, Culver Chalk Formation and

Portsdown Chalk Formation. Chalk was encountered at sixty-eight (68) locations at depths varying from 0.4 mbgl to 23.3 mbgl. There is no obvious trend of depth to the chalk being greater in any particular area within the Site Boundary.

5.1.4 Glacial deposits were encountered across the entire area within the Site Boundary and were typically found overlying the chalk. They were recorded to a maximum depth of 21.3 mbgl with a variable thickness within the Site Boundary. These deposits comprise glacial sands, gravel, silts and clays which are difficult to separate into distinct continuous strata, but are nonetheless considered to be the product of glacial activity. The deposits can generally be described as being granular with cohesive lenses. The Sheringham Cliffs Formation (granular glacial deposits) was found overlying the glacial deposits and was also recorded at varying thickness within the Site Boundary. Cohesive components of the Sheringham Cliffs Formation were typically found as pockets and lenses of varying thicknesses between the main granular components. Across the floodplain the chalk is overlain by superficial deposits comprising peat, alluvium and river terrace deposits.

5.1.5 The superficial deposits are generally granular in nature and directly overlay the chalk. Cohesive layers are present within the various superficial strata; however, they are localised and appear to be laterally discontinuous.

5.2 Groundwater

5.2.1 The depth to resting groundwater level was recorded during the groundwater monitoring rounds. A summary of the groundwater levels throughout the monitoring period is provided in Table 5.2.

5.2.2 Table 5.2 and 5.3 show the monitoring results during six (6) rounds of groundwater level monitoring. Only seven (7) of the twenty-five (25) installed monitoring wells on the Alignment Refinement area had groundwater present within the wells. Four (4) of the five (5) installed wells on the Woodland Campaign site had groundwater present. The remainder of the monitoring wells were found to be dry during all four monitoring rounds carried out to date.

5.2.3 Of the seven (7) water bearing wells on the Alignment Refinement site, five (5) were installed within the chalk deposits, one (1) within the superficial deposits and one (1) installed within peat. Of the five (5) water bearing wells on the Woodland Campaign site, four (4) were installed within superficial deposits and one (1) within the chalk.

5.2.4 The groundwater within the chalk across wells installed during both the Alignment Refinement and Woodland Campaign investigations was noted to be between 4.92 and 10.56 m AOD. The groundwater within the superficial deposits over both sites ranged from 9.94 to 49.19 m AOD. The groundwater within the superficial deposits in the area of the Woodland Campaign were at lower elevations (9.94 – 10.56 m AOD) compared to the area of the Alignment Refinement (42.07 – 49.19 m AOD).

5.2.5 Given the lack of wells producing groundwater it is not possible to determine an accurate groundwater direction within the chalk or superficial deposits; however, the groundwater monitoring data does indicate a north-eastwards flow in the superficial deposits towards the River Wensum.

5.2.6 Given the absence of any aquitards between the granular superficial deposits and the chalk aquifer at many locations it is considered likely that groundwater is continuous between the superficial deposits and bedrock strata. Perched water may still be present within the superficial deposits above any layers of low permeability soils, but these are unlikely to present a separate groundwater body.

Table 5.2: Summary of Groundwater Observations - Alignment Refinement

Monitoring Well	Response Zone Strata (depth mbgl)	Surface Elevation (m AOD)	First Round 13/09/2022-15/09/2022	Second Round 17/10/2022 20/10/2022	Third Round 14/11/2022 15/11/2022	Fourth Round 12/12/2022 13/12/2022	Fifth Round 11/01/2023	Sixth Round 13/02/2023
BH201	Superficial (1.5-8.0)	26.01	Dry	Dry	Dry	Dry	Dry	Dry
BH203	Superficial (1.0-4.0)	15.88	Dry	Dry	Dry	Dry	Dry	Dry
BH206	Superficial (2.5-6.5)	12.77	2.64 [10.13]	2.83 [9.94]	2.62 [10.15]	2.65 [10.12]	2.21 [10.56]	2.56 [10.21]
BH210 (Pipe 1)	Chalk (50-55)	9.20	0.41 [8.79]	0.86 [8.34]	1.37 [7.83]	0.41 [8.79]	1.02 [8.18]	0.32 [8.88]
BH210 (Pipe 2)	Peat (1.0-2.0)	9.20	0.60 [8.60]	0.86 [8.34]	0.82 [8.38]	0.77 [8.43]	0.87 [8.33]	0.71 [8.49]
BH221	Chalk (40-45)	8.89	2.02 [6.87]	0.45 [8.44]	0.48 [8.41]	0.17 [8.72]	-0.33 [9.22]	0.20 [8.69]
BH226	Chalk (4.0-8.0)	11.50	3.46 [8.04]	2.99 [8.51]	3.01 [8.49]	2.69 [8.81]	2.25 [9.25]	2.76 [8.74]
BH228	Chalk (9.0-12)	15.60	Dry	Dry	Dry	Dry	Dry	Damp

Monitoring Well	Response Zone Strata (depth mbgl)	Surface Elevation (m AOD)	First Round 13/09/2022-15/09/2022	Second Round 17/10/2022 20/10/2022	Third Round 14/11/2022 15/11/2022	Fourth Round 12/12/2022 13/12/2022	Fifth Round 11/01/2023	Sixth Round 13/02/2023
BH229	Superficial and Chalk (1.0-6.0)	24.06	Dry	Dry	Dry	Dry	Dry	Dry
BH231	Chalk (5.0-25)	25.08	20.06 [5.02]	15.38 [9.70]	20.16 [4.92]	16.19 [8.89]	19.43 [5.65]	16.10 [8.98]
BH233 (Pipe 1)	Chalk (9.0-24.5)	29.67	20.70 [8.97]	20.15 [9.52]	20.02 [9.65]	20.89 [8.78]	19.91 [9.76]	19.18 [10.49]
BH233 (Pipe 2)	Superficial (1.0-4.0)	29.67	Dry	Dry	Dry	Dry	Dry	Dry
BH235 (Pipe 1)	Chalk (15-16)	31.38	Dry	Dry	Dry	Dry	Dry	Dry
BH235 (Pipe 2)	Superficial and Chalk (3.0-7.5)	31.38	Dry	Dry	Dry	Dry	Dry	Dry
BH236	Superficial (2.0-6.5)	34.69	Dry	Dry	Dry	Dry	Dry	Dry
BH237	Superficial (9.0-10)	35.65	Dry	Dry	Dry	Damp	Dry	Dry

Monitoring Well	Response Zone Strata (depth mbgl)	Surface Elevation (m AOD)	First Round 13/09/2022-15/09/2022	Second Round 17/10/2022 20/10/2022	Third Round 14/11/2022 15/11/2022	Fourth Round 12/12/2022 13/12/2022	Fifth Round 11/01/2023	Sixth Round 13/02/2023
BH241	Superficial (8.5-10.4)	39.48	Dry	Dry	Dry	Dry	Dry	Dry
BH243	Superficial (1.0-13)	40.20	Dry	Dry	Dry	Dry	Dry	Dry
BH245	Made Ground (2.0-2.5)	23.23	Dry	Dry	Dry	Dry	Dry	Dry
BH246	Superficial (1.5-3.0)	23.93	Dry	Dry	Dry	Dry	Dry	Dry
WS211	Superficial (2.5-3.0)	23.98	Dry	Dry	Dry	Dry	Dry	Dry
WS212	Superficial (2.0-4.0)	22.00	Dry	Dry	Dry	Dry	Dry	Dry
WS213	Superficial and Chalk (1.0-5.0)	15.42	Dry	Dry	Dry	Dry	Dry	Dry
WS215	Superficial (1.0-2.0)	16.21	Dry	Dry	Dry	Dry	Dry	Dry
WS216	Superficial (1.0-2.0)	21.58	Dry	Dry	Dry	Dry	Dry	Dry

Notes: Depth to groundwater level given in mbgl, reduced levels in brackets as metres above Ordnance Datum (m AOD)

Table 5.3: Summary of Groundwater Observations – Woodland Campaign

Monitoring Well	Response Zone Strata (m bgl)	Surface Elevation (m AOD)	First Round 17/10/2022 20/10/2022	Second Round 14/11/2022 15/11/2022	Third Round 12/12/2022 13/12/2022	Fourth Round 11/01/2023	Fifth Round 14/02/2023	Sixth Round 14/03/2023
BH260	Chalk (14.5-19.5)	24.63	16.00 [8.63]	15.84 [8.79]	15.79 [8.84]	15.63 [9.00]	15.68 [8.95]	14.95 [9.68]
BH261	Superficial (1.0-5.0)	49.97	4.39 [45.58]	Dry	1.13 [48.84]	0.47 [49.50]	1.70 [48.27]	1.10 [48.87]
BH262	Superficial (1.5-2.5)	49.81	Dry	0.88 [48.93]	0.90 [48.91]	0.39 [49.42]	1.08 [48.73]	Dry
BH263	Superficial (1.0-5.0)	50.27	5.00 [45.27]	4.97 [45.30]	1.08 [49.19]	2.03 [48.24]	1.40 [48.87]	2.60 [47.67]
BH264	Superficial (6.0-8.0)	50.20	Damp	Dry	Dry	8.13 [42.07]	Dry	Dry

5.3 Field Evidence of Contamination

5.3.1 The section below summarises visual and olfactory evidence of contamination encountered throughout the ground investigation.

Soil

5.3.2 Visual evidence of contamination, thought to be a former waste tip area, was noted in archaeological trench 45 (NGR 613142, 315215). To investigate this possible waste tip area the scope of the ground investigation included two trial trenches at this location to a depth of 0.55m bgl (TR204 and TR205). Contamination identified in TR204 included Made Ground with frequent pockets of ash and inclusions of wood, charcoal, string, plastic and rope proven to a depth of 1.1 mbgl. The exact dimensions for the waste tip were not obtained. Further information and photographs are provided in the Ground Investigation Report.

5.3.3 In general, soil samples across the site did not show any major evidence of visual and olfactory contamination. A summary of peak Photo-Ionisation Detector (PID) readings from monitoring wells that recorded above 1ppm on the Alignment Refinement site and Woodland Campaign site are presented in Table 5.4 and Table 5.5 below.

Table 5.4: Evidence of Contamination – Alignment Refinement

Monitoring Well	Monitoring Well Installed	Depth to base (m bgl)	Peak PID Concentration (ppm)	Peak PID Depth (m bgl)	Strata at Peak PID Depth
BH203	Yes	3.65 - 3.73	2.1	0.5	Superficial
BH204	No	20.00	1.7	2.0	Superficial
BH228	Yes	11.09 – 11.17	1.4	0.2	Topsoil
BH209	No	60.65	1.2	1.0	Peat
BH210	Yes	52.05	1.8	1.0	Peat
BH211	No	60.00	1.2	1.2	Superficial

Monitoring Well	Monitoring Well Installed	Depth to base (m bgl)	Peak PID Concentration (ppm)	Peak PID Depth (m bgl)	Strata at Peak PID Depth
BH212	No	60.45	1.3	2.0	Superficial
BH217	No	59.95	10.1	0.2	Peat
BH218	No	6.45	12.9	0.5	Peat
BH220	No	60.45	9.5	0.2	Peat
BH223	No	60.45	1.3	0.1	Topsoil
BH226	Yes	7.43 – 7.59	1.5	3.0	Superficial
BH233	Yes	15.00	1.7	3.0	Superficial
BH234	No	24.95	1.7	0.1	Topsoil
BH256	No	60.45	1.1	1.0	Peat
WS201	No	1.20	1.1	0.5	Superficial
WS211	Yes	2.67 – 2.70	1.1	0.4	Topsoil
WS213	Yes	4.47 – 4.49	1.8	0.5	Topsoil
WS214	No	1.20	1.4	0.1 and 1.0	Superficial
CPT201	No	1.2	4.2	0.2	Topsoil
CPT203	No	1.2	4.2	0.2	Topsoil
TP202	No	4.5	3.2	1.0	Superficial
TP204	No	3.00	2.1	1.0	Superficial
TP209A	No	2.80	1.2	0.2	Topsoil
TP210	No	1.40	1.3	0.2 and 1.0	Topsoil and Superficial
TP214A	No	5.00	1.1	0.6 and 2.0	Superficial
TP217	No	3.40	2.7	3.0	Superficial
TP218	No	4.50	4.8	0.5	Superficial

Monitoring Well	Monitoring Well Installed	Depth to base (m bgl)	Peak PID Concentration (ppm)	Peak PID Depth (m bgl)	Strata at Peak PID Depth
TP219	No	3.60	2.6	2.0	Superficial
TP221	No	3.00	1.1	3.0	Superficial
TP223	No	1.20	1.2	0.2	Topsoil
TP233	No	3.10	1.2	3.0	Superficial
TP234	No	3.00	1.3	1.0	Superficial
TP242	No	1.0	1.2	1.0	Peat
TP245	No	0.80	1.1	0.5	Peat
TP247A	No	1.50	2.7	0.5 and 1.0	Peat and Superficial
TR201A	No	2.00	1.4	0.1	Made Ground
TR202NW	No	2.50	3.7	1.0	Superficial

Table 5.5: Evidence of Contamination – Woodland Campaign

Monitoring Well	Monitoring Well Installed	Depth to base (m bgl)	Peak PID Concentration (ppm)	Peak PID Depth (m bgl)	Strata at Peak PID Depth
BH232	No	60.00	1.3	1.0	Superficial
BH248	No	60.00	1.6	0.7	Superficial

5.3.4 The most elevated reading recorded during both phases of the site investigation was 12.9 ppm at BH218 on the Alignment Refinement site. This was located in the peat horizon. Similar concentrations were noted in adjacent samples from the peat (at BH217 and BH220). The elevated readings are likely linked to the decay of natural material within the peat horizon; however, given the absence of any major visual and olfactory evidence of contamination and generally low PID readings any contamination across the site is anticipated to be a localised area of limited impact and not of any significance.

Groundwater

5.3.5 A sulphurous odour was noted in BH260 (woodland), BH221, BH226 and BH228 during the sixth groundwater monitoring round.

5.3.6 No other visual or olfactory evidence of groundwater contamination, such as odours or the detection of light non-aqueous phase liquids (LNAPL) or dense non-aqueous phase liquids (DNAPL) were recorded during the groundwater monitoring visits.

6 Ground Contamination - Generic Quantitative Risk Assessment

6.1 Introduction

6.1.1 The results of the contamination testing from the additional investigation have been screened against the following generic assessment criteria (GAC) to allow for the interpretation of soil and groundwater chemical analyses:

Human Health

- Following the withdrawal of the Soil Guideline Values (SGVs) and in the absence of an industry-wide, accepted set of GAC, it is down to individual practitioners to derive their own soil assessment criteria for human health. On this basis Norfolk County Council prepared a set of GAC for use on this project.
- Norfolk County Council prepared the criteria using the approach provided within DEFRA's SR2, SR3, SP1010, CLEA Workbook v1.071 and SR47 guidance documents to produce a set of minimal risk GACs. The chemical-specific data within two key publications were considered during their production: CL:AIRE 20108 and LQM 20159.
- The criteria has been developed to ensure the re-use of excavated materials does not represent a potential human health risk to future

users of the public open space area. Limited values have been generated using CLEA v1.06 assuming a public open space exposure scenario that considers female children between 0-6 years old as the most sensitive receptor with an exposure frequency defined by 78 days/year (25 days/year for ages 0-1 years old) with a 3-hour daily exposure.

- Soil Organic Matter (SOM) of 1% was used for conservatism.
- It is to be noted that all re-use criteria values are subject to consultation and agreement with the relevant statutory bodies and shall be treated as draft until written confirmation of their acceptance has been received.

Water Quality

- The Proposed Scheme is located with a Source Protection Zone 3 for total catchment. The River Wensum and other unnamed water features are also present on site and within close proximity of the site. For these reasons, Norfolk County Councildirected that groundwater and soil leachate samples are to be assessed using the Drinking Water Standards (DWS) and Environmental Quality Standards (EQS) for fresh water.

Ground Gas

- As the Proposed Scheme comprises a road scheme, it is not considered appropriate to derive gas screening values to determine a ‘characteristic situation’ for gas in accordance with BS8485:2015+A1:2019, as this guidance is based on considering risks to buildings.
- Instead, the results of the ground gas monitoring have been assessed using guidance provided in the Health and Safety Workplace Exposure Limits HSE EH40/2005 to consider the risk to workers in confined spaces. The methane concentrations have also

been assessed against the lower explosive limit (LEL) and upper explosive limit (UEL).

6.1.2 The assessment criteria outlined above for human health and water quality have been used to provide an initial screen of chemical results from the soil, soil leachate, groundwater and ground gas monitoring. The findings from the assessment are shown below. Further details relating to the legislative context and methodologies are presented in Appendix A.

6.2 Human Health Assessment

Soil Screening Results

6.2.1 The soil laboratory test results and soil screening assessment are presented in Appendix C. The soil assessment is based on the information collected during the Alignment Refinement and Woodland Campaign investigations only.

6.2.2 A total of 404 soil samples were tested for a suite of determinands selected based on the Site Boundary extent's historical and contemporary uses (as detailed in Table 3.1). Of these twenty-three (23) samples comprised Made Ground, seventy-four (74) samples comprised topsoil, two hundred and twenty-five (225) samples comprised superficial deposits, thirty-two (32) comprised peat samples and fifty (50) comprised chalk samples. The chemical concentrations were screened against the Norfolk County Council's GAC.

6.2.3 Metals were recorded above the limit of detection in all locations across the extents of the Site Boundary; however, only one location had exceedances of Norfolk County Council's GAC (based on public open spaces), which were recorded at TP246 (0.1m bgl), in the north of the River Wensum floodplain, with an exceedance of arsenic at 240 mg/kg (GAC 168 mg/kg) and lead at 2200 mg/kg (GAC 808 mg/kg). The sample was taken from the peat strata.

6.2.4 PAHs were recorded above the limit of detection at twenty-five (25) samples across the site. Of the sixteen (16) U.S. Environment Protection Agency (USEPA) PAHs[1], only benzo(a)pyrene and naphthalene are included in Nofolk County Council's list of GACs. One exceedance of Norfolk County Council's GAC for benzo(a)pyrene (11 mg/kg) was recorded in the Made Ground layer at WS202 to the north-east of the River Wensum floodplain, on an access track with a concentration of 87 mg/kg at 0.2m. The Made Ground was associated with crushed material forming a road, and not a pavement or subbase material. There were no exceedances of the naphthalene GAC.

6.2.5 For completeness, the remaining USEPA PAHs were compared against Ramboll's Public Open Space GACs and no exceedances were recorded.

6.2.6 The pH range for the soil samples varied from 3.0 – 11.4, with the average pH measuring 7.8 and the majority of samples (93.75%) falling between 5.4 and 9.0. In general the pH values above pH 9 were associated with the chalk and pH values below 5.4 are associated with samples from the peat. This is expected given the acidic nature of peat and alkaline nature of chalk. The outliers are topsoil and superficial samples from WS209 (to the north of Ringland Lane), with values of 4.4 and 4.3 respectively; a peat sample from BH221 (in the north of the River Wensum floodplain)with a value of 11.4; and two Made Ground samples from WS202 (north-east of the River Wensum floodplain) with a value of 10.1 and 10.6, respectively.

6.2.7 Total petroleum hydrocarbons (TPH) tested using the TPH Criteria Working Group (TPH CWG) methodology were analysed in twenty-six (26) samples. TPH fractions were measured below the detection limit at all locations except WS202 (0.2m - Made Ground within an access track to the north-east of the River Wensum floodplain. The Made Ground was crushed material rather than a pavement or subbase material) with total aliphatic fractions (EC5-EC44) recorded at a concentration of 57 mg/kg

[1] Office of Federal Registration (OFR) (1982) Appendix A: Priority Pollutants

and total aromatic fractions (EC5-EC44) at a concentration of 1 600 mg/kg. There were no exceedances of the Norfolk County Council's GAC. Benzene, toluene, ethylbenzene and xylene (BTEX) were analysed for in the same twenty-two (22) samples and all concentrations recorded below the detection limit.

6.2.8 VOCs and SVOCs were analysed in nine (9) samples, none of which recorded concentrations exceeding the method detection limit or Norfolk County Council's GAC.

6.2.9 Pesticides and acid herbicides were analysed in 32 samples from the shallow strata (<0.5 mbgl). An additional herbicide suite was analysed in one sample at a depth of 0.1 mbgl (topsoil). All pesticides, herbicides and acid herbicides were below the method detection limit with the exception of Endosulfan II (beta isomer) and Pendimethalin. Endosulfan II was detected at one location (in the topsoil horizon at TP248, 0.1m bgl, in the southern end of the River Wensum floodplain) at a concentration of 11 µg/kg. Pendimethalin was detected at six (6) locations above the level of detection of 10 µg/kg, as listed below:

- BH230 (11 µg/kg at 0.1 m);
- TP214 (710 µg/kg at 0.1 m);
- BH201 (100 µg/kg at 0.1 m);
- TP233 (16 µg/kg at 0.2 m);
- BH262 (17 µg/kg at 0.1 m); and
- TR202A (33 µg/kg at 0.1 m).

6.2.10 There are no Norfolk County Council GACs for Pendimethalin or Endosulfan. Ramboll's GAC for Endosulfan is 2,300 mg/kg for public open space. The concentration observed in the topsoil at TP248 is below the Ramboll GAC.

Asbestos

6.2.11 No visible fragments of potential asbestos-containing materials were observed during the ground investigation. Twenty-four (24) soil samples from the Made Ground, topsoil, and shallow superficial deposits were screened for the presence of asbestos. None of the samples recorded the presence of any identifiable levels of asbestos.

6.2.12 It is noted that while no asbestos was detected in the samples subjected to analysis, there is the potential for asbestos to be identified elsewhere within the Site Boundary in locations not targeted by the ground investigation. However, given the testing and site history, the likelihood of soils being contaminated by asbestos is considered to be low.

6.3 Soil Leachate Assessment

Methodology

6.3.1 Leachate testing is undertaken on soil samples in the laboratory by vigorous mixing of soil and water to ascertain the degree to which contaminants in soil may leach into the dissolved phase. The process represents a 'worst case' scenario as the vigorous laboratory process would not be expected to be replicated on site either during construction or operation of the Proposed Scheme. As such, the leachate testing results generally provide an over estimation of the true leachability of contaminants in soils. The exception is for volatile substances, which may volatilise and be lost during the leachate preparation process, as such leachate results for VOCs should be treated with caution.

Leachate Screening Results

6.3.2 Leachate preparation and testing has been completed on thirty (30) soil samples. The samples include six (6) samples from topsoil, five (5) from peat horizons, seven (7) from Made Ground, one (1) from the chalk and eleven (11) from superficial deposits of clay, sand, silt and gravel. Samples were tested for heavy metals, inorganics (including ammoniacal nitrogen), TPH (including BTEX/MTBE) and PAH.

6.3.3 The GACs used for soil leachate are a combination of the DWS and EQS as described in Section 6.1.1. Details on the exceedances of the DWS or EQS in the soil leachate samples are summarised in Table 6.1. The screening results of soil leachate testing and the soil leachate data assessment are presented in Appendix C.

6.3.4 The pH range in the leachates varied from 5.6 – 8.8, with the average measuring 7.5. Three (3) samples from BH222, BH234 and BH253 (from the peat and topsoil horizons to the south of the River Wensum floodplain)sat outside the Noroflk County Council's GAC range for pH (6.5 – 10) recording 6.3, 6.4 and 5.6, respectively.

Table 6.1: Summary of Soil Leachate Exceedances

Substance	Unit	EQS	DWS	Discussion	Location of exceedances (m bgl)
Arsenic	µg/l	50	10	Four (4) samples exceeds the DWS. Two samples exceed the EQS. The exceedance was in the topsoil and the Made Ground.	12 µg/l at BH215 (0.2) 48 µg/l at TR205HP (0.6) 110 µg/l at TR205HP (1.2) 120 µg/l at TR204CZ (0.05)
Chromium	µg/l	4.7	50	Two (2) samples exceed the EQS with the maximum at BH256. No DWS exceedances. The exceedances were in the superficial deposits and topsoil	8.1 µg/l at BH259 (1.0) 6.9 µg/l at BH215 (0.2)
Lead	µg/l	1.2	10	Twenty-eight (28) samples exceed the EQS.No DWS exceedances. The exceedances were across the topsoil, peat, Made Ground and superficial deposits and chalk.	The maximum concentration of 6.3 µg/l at BH214 (0.5)
Copper	µg/l	1	2000	All thirty (30) samples exceed the EQS with the maximum 37 µg/l at BH253. No DWS exceedances. The exceedances were across the topsoil, peat, Made Ground and superficial deposits and chalk.	All samples, with a maximum concentration of 37 µg/l at BH253 (1.0)

Substance	Unit	EQS	DWS	Discussion	Location of exceedances (m bgl)
Nickel	µg/l	4	20	Fourteen (14) samples exceed the EQS. No DWS exceedances. The exceedances were recorded within wells screened within peat, Made Ground and superficial deposits.	6.9 µg/l at BH222 (0.5-0.55) 6.8 µg/l at BH259 (1.0) 6.7 µg/l at BH219 (0.5) 5.1 µg/l at BH214 (0.5) 4.9 µg/l at BH208 (0.5) 4.7 µg/l at BH254 (0.5) 4.6 µg/l at BH253 (1.0) 4.3 µg/l at BH215 (0.2) 4.3 µg/l at BH263 (3.0) 4.2 µg/l at BH218 (0.5) 4.2 µg/l at BH218 (0.2) 4.1 µg/l at TP234 (3.0) 4.1 µg/l at TR201A (0.1) 4.1 µg/l at TR205HP (0.6)
Zinc	µg/l	12.9	N/A	Two (2) samples exceed the EQS. The exceedances were in the superficial and peat horizons.	90 µg/l at BH253 (1.0) 15 µg/l at BH219 (0.5)
Anthracene	µg/l	0.0001	N/A	One (1) sample exceeded the EQS. The exceedance was from the Made Ground.	0.29 µg/l at WS202 (0.2)
Fluoranthene	µg/l	0.0063	N/A	One (1) sample exceeded the EQS. The exceedance was from the Made Ground.	1.1 µg/l at WS202 (0.2)
Benzo(a)pyrene	µg/l	-	0.01	One (1) sample exceeded the DWS. The exceedance was from the Made Ground.	0.91 µg/l at WS202 (0.2)
Sum of 4 PAH*	µg/l	-	0.1	One sample exceeds the DWS. The exceedance was from the Made Ground.	2.08 ug/l at WS202 (0.2)

*includes benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene.

6.3.5 Five (5) leachate samples recorded concentrations exceeding the DWS criteria. The sample from the Made Ground (crushem material rather than pavement or subbase) at WS202 (0.2), located on an access track to the

north-east of the River Wensum floodplain, exceeded the DWS for benzo(a)pyrene (0.91 µg/l compared to a DWS of 0.01 µg/l) and the sum of 4 PAHs (2.08 µg/l compared to a DWS of 0.1 µg/l). The sample in the topsoil at BH215 (0.2), in the northern part of the River Wensum floodplain) exceeded the DWS for arsenic (12 µg/l compared to the DWS of 0.01 µg/l). The exceedance of the arsenic DWS is considered a marginal exceedance (defined as less than ten times the DWS value). Three samples from the Made Ground in area of the historic waste pit exceeded the DWS and two of the samples also exceeded the EQS for arsenic. These exceedances are localised and are unlikely to pose a significant risk to the groundwater or surface waters.

6.3.6 All samples exceed the EQS for copper (1 µg/l). Twenty eight (28) samples exceed the EQS for lead (1.2 µg/l), fourteen (14) samples exceeded the EQS for nickel (4 µg/l), two (2) samples exceeded the EQS for chromium (4.7 µg/l), and two samples exceeded the EQS for zinc (12.9 µg/l). The exceedances listed here are in the same order of magnitude as the EQS and are considered to be marginal exceedances.

6.3.7 The Made Ground sample at WS202 at 0.2 m bgl exceeded the EQS for both anthracene and fluoranthene. Whilst the exceedances are over an order of magnitude difference to the EQS, the exceedances are localised in one location. The Made Ground was described as crushed material making up the access track rather than pavement or subbase material.

6.3.8 It is noted that the process for extracting soil leachate is vigorous and is unlikely to represent conditions on-site, and therefor this is a conservative view of the risk to controlled waters from on-site soils.

6.4 Controlled Waters Assessment

Methodology

6.4.1 Norfolk County Council specified GAC for controlled waters have been selected to assess potential risks to the identified environmental receptors which includes:

- Superficial Alluvium, Head Deposits (Secondary B Aquifer);
- River Terrace Deposits, Sheringham Cliffs Formation (Secondary A Aquifer);
- Lowestoft Formation (Secondary Undifferentiated Aquifer);
- Bedrock geology of Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation (Principal Aquifer); and
- River Wensum and various unidentified surface water features.

6.4.2 Three (3) rounds of groundwater sampling have been undertaken to date on 17th to 20th October, 12th to 13th December 2022 and 13th to 14th February 2023. A total of eight (8) groundwater samples were obtained during the October round from BH206, BH210 (both installations), BH221, BH226, BH231 and BH233 from the Alignment Refinement wells and BH260 from the Woodland Campaign. Eleven (11) samples were collected during each monitoring round in December 2022 and February 2023 from BH206, BH210 (both installations), BH221, BH226, BH231 and BH233 from the Alignment Refinement well network and BH260, BH261, BH262, BH263 from the Woodland Campaign wells. All samples were obtained from monitoring wells with response zones in different geologies (see Table 4.4 and 4.5 for the response zones).

6.4.3 Samples were tested for metals, inorganics (including ammoniacal nitrogen, chloride and nitrate), total petroleum hydrocarbons, PAH, VOCs, SVOCs, phenols, herbicides and organophosphorus pesticides. Only a maximum of twelve (12) of the thirty (30) installed monitoring wells had groundwater present within the wells to date. The remainder of the monitoring wells were found to be dry during all six monitoring rounds carried out.

Groundwater Screening Results

6.4.4 Table 6.2 identifies the contaminants in groundwater which were found to exceed the DWS and EQS. Further results will be analysed given the on-going monitoring and groundwater collection.

Table 6.2: Summary of Groundwater Exceedances of GAC

Substance	Units	EQS	DWS	Discussion	Location of exceedances
Arsenic	µg/l	50	10	Three (3) samples exceeded the DWS. No EQS exceedances. The exceedances were from a well screened in the chalk.	14.9 µg/l at BH226 (12th December) 11.9 µg/l at BH226 (18th October) 10.3 µg/l at BH226 (13th February)
Copper	µg/l	1	2000	Twenty (20) samples exceeded EQS. No DWS exceedances. The exceedances were from wells screened in the chalk and superficial deposits.	20 µg/l and 3.6 µg/l at BH261 (12th December and 14th February) 3.8 µg/l and 1.9 µg/l at BH263 (12th December and 14th February) 3.7 µg/l at BH06 (13th February) 3.2 µg/l, 2.7 ug/l and 2.3 µg/l at BH231 (18th October, 12th December and 13th February) 3.1 µg/l, 3.5 µg/l and 4 µg/l at BH233 (18th October, 12th December and 13th February) 3.0 µg/l, 2.2 µg/l and 1.4 µg/l at BH260 (18th October, 12th December and 14th February) 2.4 µg/l at BH206 (18th October and 12th December) 1.8 µg/l and 14 µg/l at BH262 (12th December and 14th February) 1.2 µg/l and 1.5 µg/l at BH210 (18th October and 12th December)

Substance	Units	EQS	DWS	Discussion	Location of exceedances
Nickel	µg/l	4	20	Six (6) samples exceeded the EQS. No DWS exceedances. The exceedances were from wells screened in the chalk and superficial deposits.	7.5 µg/l, 10 µg/l and 6.4 µg/l at BH226 (18th October, 12th December and 13th February) 10 µg/l at BH261 (12th December) 8.8 µg/l at BH262 (14th February) 5.7 µg/l at BH263 (12th December)

6.4.5 All exceedances of heavy metals are marginal (less than one order of magnitude) with the exception of BH261 (screened in the superficial deposits) that recorded a concentration of 20 µg/l of copper (EQS 1 µg/l).

6.4.6 No samples recorded concentrations of PAHs, TPH or VOCs above the laboratory detection limits. The only SVOCs recorded above the detection limits were phenols including 2-methylphenol, 4-methylphenol and 2,4-dimethylphenol. No EQS or DWS are available for these compounds.

6.4.7 All samples were analysed for pesticides and herbicides, including organochlorine pesticides, organophosphorus pesticides and organonitrogen pesticides during one monitoring round. None of the samples tested had concentrations above the method detection limit.

6.4.8 It should be noted that the laboratory detection limits for the following determinands were above the EQS values:

- Anthracene;
- Fluoranthene;
- Mercury;
- TPH-CWG Aromatic >C10-C12;
- TPH-CWG Aromatic >C12-C16;
- TPH-CWG Aromatic >C16-C21; and
- TPH-CWG Aromatic >C21-C35.

Controlled Waters Summary

6.4.9 The pH groundwater analysed within both rounds of groundwater monitoring were within the acceptable range for EQS and DWS. Minor exceedances of the copper and nickel EQS were recorded, as well as an exceedance of the arsenic DWS. All exceedances were less than an order of magnitude of the relevant standard, with the exception of BH261 and BH262, both screened in the superficial deposits within the Woodland Campaign area, and as such are not considered to a pose a high risk to controlled waters.

7 Ground Gas Risk Assessment

7.1 Background

7.1.1 The results of the gas monitoring have been assessed using guidance provided in the Health and Safety Executive Workplace Exposure Limits HSE EH40/2005[2] to consider the risks to workers in confined spaces. The lower explosive limit (LEL) and upper explosive limit (UEL) have also been considered for methane.

7.1.2 As the Proposed Scheme comprises a road it is not considered appropriate to derive a gas screening value to determine the 'characteristic situation' for gas in accordance with BS8485:2015+A1:2019 as this guidance is based on considering risks to new buildings.

7.2 Ground Gas Data

7.2.1 Results from the six (6) rounds of ground gas monitoring undertaken on the 13th to 15th September, 17th to 20th October, 14th to 15th November, 12th to 13th December 2022, 11th January 2023 and 13th February 2023 have been summarised below.

[2] Health and Safety Executive (2020) EH40/2005 Workplace Exposure Limits.

7.2.2 All rounds of ground gas monitoring were completed under high pressure conditions, with the falling pressure conditions in the 48hrs prior to the September, November and February monitoring rounds and rising pressure conditions in the 48hrs prior to the October and January monitoring rounds. The December monitoring round recorded relatively steady pressures in the 48hrs prior to monitoring. The monitoring sheets are presented in Harrison Group Environmental's factual report.

7.2.3 Twenty-one (21) locations were monitored during the gas monitoring rounds. Of these locations, four (4) were flooded (where the presence of groundwater was noted within the screened section of the well) during various rounds, and the data is unlikely to be representative of the ground gas regime. The monitoring wells at locations BH210 (Pipe 1 and Pipe 2), BH221 and BH226 had groundwater that completely covered the screened response zone, preventing ground gas from entering the well. BH210 (Pipe 2) was screened within peat and BH210 (Pipe 1), BH221 and BH226 within the chalk.

7.2.4 As the Proposed Scheme comprises a road, gases generated from groundwater are not considered to present a risk to current or future users. Drainage and service routes may have the potential to form preferential pathways for ground gas migration and should be considered as enclosed spaces presenting a risk to maintenance workers. Excavations undertaken by construction and maintenance workers could also become confined spaces.

Flow Rates

7.2.5 The flow rates were all recorded at 0.0 (l/hr) in all monitoring wells with the exception of the following (recorded at a steady state):

- BH203 at 0.2 l/hr (11th January) and 0.3 l/hr (13th February);
- BH206 at 0.4 l/hr (11th January) and 0.3 l/hr (13th February);

- BH210 (Pipe 1) at 0.1 l/hr and BH210 (Pipe 2) at 0.4 l/hr (13th February);
- BH221 at 0.3 l/hr (13th February);
- BH226 at 0.3 l/hr (11th January);
- BH228 at 0.1 l/hr (14th November and 12th December, 11th January) and 0.4 l/hr (13th February);
- BH229 at 0.1 l/hr (14th September), 0.2 l/hr (11th January) and 0.3 l/hr (13th February);
- BH231 at 0.1 l/hr (13th February);
- BH233 (Pipe 1) at 0.3 l/hr (11th January) and 0.4 /hr (13th February);
- BH233 (Pipe 2) at 0.1 l/hr (12th December) and 0.3 l/hr (13th February);
- BH235 at 0.1 l/hr (12th December) and 0.2 l/hr (11th January);
- BH237 at 0.1 l/hr (12th December);
- BH241 at 0.1 l/hr (11th January and 13th February);
- BH243 at 0.1 l/hr (12th December);
- BH246 at -0.1 l/hr (15th September), 0.2 l/hr (11th January) and 0.3 l/hr (13th February);
- WS211 at 0.1 l/hr (14th November, 12th December and 11th February) and 0.2 l/hr (11th January);
- WS212 at 0.1 l/hr (14th November and January 11th), 0.2 l/hr (12th December) and 0.5 l/hr (13th February);
- WS215 at 0.1 l/hr (12th December and 11th January) and 0.3 l/hr (13th February); and
- WS216 at 0.1 l/hr (14th November) and 0.3 l/hr (13th February).

Hydrogen Sulphide

7.2.6 The results obtained for hydrogen sulphide were below detection limits (<1ppm) in all monitoring rounds. A sulphurous odour was noted in locations BH260 (woodland), BH221, BH226 and BH228 during the sixth groundwater monitoring round; however, the ground gas data does not suggest hydrogen sulphide gas to be present here.

Carbon Monoxide

7.2.7 The results obtained for carbon monoxide were below detection limits (<1ppm) in all monitoring rounds with the exception of those stated in Table 7.1 below (recorded at steady flow rates):

Table 7.1:Summary of Carbon Monoxide concentrations above detection level.

Well ID	Screened strata	Carbon Monoxide (ppm)	Steady Flow rate (l/hr)	Date of Monitoring Round
BH210	Chalk	1	0.0	13th September 2022
BH226	Chalk	1 1	0.0 0.0	15th September 2022 14th November 2022
BH226	Chalk	55 57	0.0 0.3	12th December 2022 11th January 2023
BH226	Chalk	113	0.0	13th February 2023
BH228	Chalk	5 1	0.0 0.0	14th September 2022 17th October 2022
BH228	Chalk	1	0.1	14th november 2022
BH229	Superficial and Chalk	4	0.0	12th December 2022
BH231	Chalk	2 1 1 2	0.0 0.0 0.0 0.0	14th September 2022 14th November 2022 11th January 2023 13th February
BH233	Superficial	2 1	0.1 0.1	12th December 2022 11th January 2023

Well ID	Screened strata	Carbon Monoxide (ppm)	Steady Flow rate (l/hr)	Date of Monitoring Round
BH235	Chalk	2	0.0	14th September 2022
BH237	Superficial	24 1	0.0 0.0	14th September 2022 17th October 2022
BH237	Superficial	24 1	0.0 0.0	14th November 2022 11th January 2023
BH241	Superficial	8 6	0.0 0.0	14th September 2022 17th October 2022
BH241	Superficial	1 2	0.0 0.1	14th November 2022 11th January 2023
BH243	Superficial	1	0.0	14th November 2022
BH246	Superficial	2	0.2	11th January 2023
WS211	Superficial	2 1	0.2 0.1	11th January 2023 13th February 2023
WS212	Superficial	4	0.2	12th December 2022
WS213	Superficial and Chalk	1	0.0	14th November 2022
WS213	Superficial and Chalk	3	0.0	12th December 2022
WS215	Superficial	2	0.3	13th February 2023
WS216	Superficial	2	0.3	13th February 2023

7.2.8 Concentrations of carbon monoxide were detected at sixteen (16) wells in the area of the Alignment Refinement GI. The highest concentrations were noted in BH226 (chalk) and BH237 (superficial), both located to the south of the River Wensum floodplain. It is noted that the flow rates are low at these locations. The concentrations in both wells vary throughout the monitoring rounds and do not seem to correlate with the atmospheric pressure measured during the rounds. BH228 is also installed in the chalk adjacent to BH226 but does not show the same concentrations of carbon monoxide, suggesting the source of carbon monoxide is localised.

Methane

7.2.9 The methane steady state concentration ranged between below detection limits (<1%) to the highest concentration recorded in BH226 at 39% at steady and 63.5% at peak concentrations on the 13th February 2023.

Carbon Dioxide

7.2.10 Carbon dioxide steady state concentrations ranged between 0.1% to the highest concentration recorded in BH246 at 3.2% at steady and peak concentrations on the 11th January 2023.

Oxygen

7.2.11 Oxygen steady rate concentrations ranged between 11.4% at BH246 on the 12th December 2022 to the highest concentration 22% recorded in BH228 on the 13th February 2023.

Workplace Exposure Assessment

7.2.12 The gas monitoring results for carbon dioxide, methane (including the lower explosive limit (LEL) and upper explosive limit (UEL)), carbon monoxide and hydrogen sulphide have been assessed against the short term and long-term workplace exposure limits as indicated by the Health and Safety Executive in Workplace Exposure Limits EH40/2005. The results of this assessment are summarised in Table 7.2.

Table 7.2: Summary of Gas Monitoring Assessment

Substance	Long Term Workplace Exposure Limit (8-hour TWA* reference Period) (ppm)	Short Term Workplace Exposure Limit (15-minute reference Period) (ppm)	LEL/ UEL (%)	No. of wells with Long Term Exceedances	No. of Wells With Short Term Exceedances	Peak Concentration
Carbon Monoxide	30 (0.003%)	200 (0.02%)	N/A	1	0	113ppm at BH226 (13th February 2023)
Hydrogen Sulphide	5	10	N/A	0	0	All below <1ppm
Carbon Dioxide	5000 (0.5%)	15000 (1.5%)	N/A	19	10	3.2% at BH246 (11th January 2023)

Substance	Long Term Workplace Exposure Limit (8-hour TWA* reference Period) (ppm)	Short Term Workplace Exposure Limit (15-minute reference Period) (ppm)	LEL/ UEL (%)	No. of wells with Long Term Exceedances	No. of Wells With Short Term Exceedances	Peak Concentration
Methane	N/A	N/A	>5 / >17	-	-	20.3% at BH226 (12th December 2022)

*Note: TWA = time-weighted average

7.2.13 Methane steady state concentrations did not fall between the LEL and UEL at any location, and therefore did not fall within the explosion limit.

7.2.14 Carbon monoxide was recorded above the long-term exposure limit at one location (BH226) over three monitoring rounds. The wells in the surrounding area that are also screened in the chalk do not show the same concentrations, indicating that this is a localised source of carbon monoxide.

7.2.15 Carbon dioxide concentrations were recorded above the long-term workplace exposure of 0.5% at least once across the monitoring rounds in all monitoring wells except BH210 and BH221 which recorded concentrations below the long-term workplace exposure limit in all monitoring rounds.

7.2.16 Carbon dioxide concentrations were recorded above the short-term exposure limit of 1.5% in the following monitoring wells (at steady flow rate):

- 2.8%, 2.9% and 2.7% at BH229 (13th September, 14th November 2022 and 13th February 2023);
- 1.7%, 2.0% and 2.3% at BH231 (13th September, 17th October and 14th November 2022);
- 2.1% and 2.4% at BH233 (Pipe 1) (13th September and 12th December 2022);

- 2.0% at BH233 (Pipe 2) (13th September 2022);
- 1.4% at BH235 (12th December 2022);
- 1.5%, 1.4% and 3.2% at BH246 (14th November and 12th December 2022, 11th January 2023);
- 1.5% at WS211 (14th November 2022);
- 1.8% at WS215 (13th September and 17th October 2022);
- 2.1% and 1.6% at WS215 (14th November 2022 and 11th January 2023); and
- 1.8% at WS213 (17th October 2022).

7.2.17 Potential mitigation may be required for construction works in areas where the ground gas concentrations are above the WEL for both carbon monoxide and carbon dioxide.

8 Ground Contamination Risk Evaluation

8.1 Revised Conceptual Site Model

8.1.1 The information presented in the previous sections of this report has been collated and evaluated to refine the preliminary conceptual site model for the Proposed Scheme. The conceptual site model has been updated in accordance with the guidance contained within CIRIA document C552 and EA/NHBC publications.

Contaminants

8.1.2 A summary of the potential sources identified includes those as given in Table 8.1.

Table 8.1: Summary of Potential Sources Identified

Contaminants	Comment
Contaminants in soils	Metals were recorded above the limit of detection in all locations across the site; however, the only exceedance of Norfolk County Council's GAC (based on public open spaces) was recorded within the peat TP246 (0.1m bgl) with an exceedance of arsenic at 240 mg/kg (GAC 168 mg/kg) and lead at 2,200 mg/kg (GAC 808 mg/kg). One (1) exceedance of Norfolk County Council's GAC for benzo(a)pyrene (11 mg/kg) was recorded at WS202 with a concentration of 87 mg/kg at 0.2 m (Made Ground). No other exceedances of Norfolk County Council's GACs or Ramboll's Public Open Space GAC were recorded in EPA PAHs. Concentrations of Pendimethalin above the detection limit were noted at six (6) locations. The locations are spread out across the extents of the Site Boundary and were all at depths of <0.2 m bgl. The concentrations ranged from 11 – 710 µg/kg. The source of the pendimethalin is likely to be from the use of herbicides and pesticides for agricultural purposes. There is no Norfolk County Council or Ramboll derived GACs for pendimethalin. Endosulfan II was recorded above the detection limit at one (1) location with a concentration of 11 µg/kg detected at a depth of 0.1m bgl at TP248 (topsoil). There is no Norfolk County Council GAC for Endosulfan; however, the concentration recorded is below the Ramboll GAC. Given that the exceedances are localised, it is unlikely that there is a risk to human health to future end users of the road from soils at the site. Mitigation measures and safe systems of work may need to be implemented for construction and maintenance workers, such as good hygiene measures and personal protective equipment.

Contaminants	Comment
Contaminants in groundwater	Leachate testing undertaken on soil samples recorded exceedances of the EQS for copper in all thirty (30) samples tested, for the EQS of lead in twenty-eight (28) samples and for the EQS of nickel in thirteen (13) of the samples. These exceedances were measured across all ground types – Made Ground, superficial, topsoil, peat and chalk and is likely to represent background levels within the Site Boundary. Other exceedances of EQS were noted for chromium and zinc, both of which recorded two (2) exceedances at BH215 and BH259, and BH219 and BH253 respectively. These were within the superficial deposits, topsoil and peat. A marginal exceedance of the DWS for arsenic was also recorded at BH215 (topsoil), and arsenic exceedances of the DWS were also noted in the Made Ground from the area of the historical waste pit. Two of the three samples of Made Ground also exceeded the arsenic EQS. These exceedances are likely to represent rarer and more localised areas of contamination rather than pose a risk to the site wide controlled waters. It is noted that leachate testing is undertaken on soil samples in the laboratory by vigorous mixing of soil and water to ascertain the degree to which contaminants in soil may leach into the dissolved phase. The process represents a 'worst case' scenario and as such the leachate testing results generally provide an over estimation of the true leachability of contaminants from soils. Groundwater DWS for arsenic (10 µg/l) was exceeded at BH226 during all three sampling rounds (11.9 µg/l in the first sampling round, 14.9 µg/l in the second sampling round and 10.3 µg/l in the third sampling round). EQS exceedances were recorded for copper within twenty (20) samples across the three sampling rounds. These exceedances were recorded from the superficial and chalk screened wells at BH206, BH210, BH231, BH233, BH260, BH261, BH262 and BH263, with the maximum concentration 20 µg/l recorded in the December 2022 sampling at BH261. Six (6) samples also recorded exceedances of the nickel EQS at the superficial and chalk screened wells at BH226, BH261, BH262 and BH263 across the three monitoring rounds. No samples recorded PAHs, TPH or VOCs above the method recording limits. The only SVOCs recorded above the detection limits were phenols including 2-methylphenol, 4-methylphenol and 2,4-dimethylphenol in wells screened in both the superficial and chalk strata.

Contaminants	Comment
Ground gas	The ground gas monitoring results to date have been assessed against the WELs as set out in EH40. Since the Proposed Scheme is a road, the WELs are more appropriate to assess the risk from gas, due to the lack of enclosed structures. Hydrogen sulphide was measured at concentrations below the short and long term WELs. Carbon monoxide exceeded the long term WELs at one location (BH226) over three monitoring rounds. Carbon dioxide was found in concentrations above the short and long term WELs across a number of locations in all monitoring rounds to date. These concentrations within the Site Boundary are likely to represent the degassing of the natural soils. Methane concentrations did not fall between the LEL and UEL at any location, and therefore did not fall within the explosion limit. Risk assessments should be undertaken for works in confined space, as set out in the CDM regulations, and mentioned in Section 7 above.

Receptors

8.1.3 The site-specific receptors that could potentially be affected by the contamination hazards are summarised in Table 8.2.

Table 8.2: Potential Receptors

Feature	Comment
Future Proposed Scheme Users	Users of the Proposed Scheme including members of the public
Groundworkers / maintenance workers	Any workers coming in contact with the ground including construction workers and future maintenance workers.
Groundwater	Principal Aquifer of the Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation. Alluvium and Head Deposits (Secondary B Aquifer), River Terrace Deposits and Sheringham Cliff Formation (Secondary A Aquifer) and Lowesoft Formation (Secondary Undifferentiated).
Surface water	River Wensum and various other unnamed surface water features within the Site Boundary and in the surrounding area.

Feature	Comment
Infrastructure and foundations	Concrete foundations may be impacted by aggressive ground conditions. This risk is assessed in the Geotechnical Ground Investigation Report by Ramboll and as such is not considered further in this report.

Pathways

8.1.4 In order for the identified contaminants to reach potential receptors there have to be viable pathways for the contaminants to travel from the sources to those receptors. Potential pathways were identified within the preliminary conceptual site model and are discussed further in Table 8.3 in relation to the identified sources and receptors.

Table 8.3: Potential Pathways and Pollutant Linkages

Receptor	Pathway	Comment
Future Proposed Scheme Users (i.e. members of the public) and Construction workers (during construction) Maintenance workers (during operation)	Dermal contact Ingestion of soil/ soil dust Inhalation and accumulation of asphyxiative/ explosive ground gas and vapours	Future Proposed Site users and construction/ maintenance workers may be exposed to contaminated soil via dermal contact/ingestion/inhalation during use or maintenance (including intrusive groundworks) of the Proposed Scheme. Construction and maintenance workers may be exposed to potentially asphyxiative ground gas and vapours when working in deep excavations. PPE and best-practice health and safety measures will be required to mitigate this risk. It is unlikely that future users (members of the public) will come into contact with the soil given that the majority of the development will be covered in hardstanding. Landscaped areas will be capped using soil that is suitable for public open space.

Receptor	Pathway	Comment
Groundwater	Leaching and/ or vertical migration of contaminants to groundwater	Given that the Proposed Scheme is underlain by a Principal Aquifer and highly permeable soils there may be potential for vertical and lateral migration of groundwater through the Site Boundary, as well as onto the Site Boundary from off-site sources. Piled foundations are likely to be required for the Proposed Scheme in specific areas (e.g. road bridges). The deep foundations may open up a pathway from the shallow groundwater in the superficial deposits to the principal aquifer in the chalk. Since the majority of the superficial deposits are granular, and no aquitards are present, it is unlikely that this will impact on the deep groundwater.
Surface Water	Lateral migration of contaminants to surface water receptors through groundwater or surface water runoff.	The River Wensum and associated floodplain crosses the centre of the Site Boundary. In addition, there are multiple other unnamed water features located within the Site Boundary. There is a potential for contaminated run-off from the Proposed Scheme to enter these water courses. Initial data suggests that groundwater flow direction are to the north east, towards the River Wensum. The River is likely to be in hydraulic continuity with the groundwater and lateral migration may also impact the surface waters running through the extents of the Site Boundary. The Proposed Scheme will have a surface water drainage system included within the design, therefore reducing the risk from contaminated run off to surface water courses. There will be similar requirements for the control of surface water run-off during the construction works.
In ground infrastructure (concrete and pipes)		This assessment was outside the scope of this report and is discussed within the Ramboll geotechnical Ground Investigation Report.

8.2 Qualitative Risk Assessment

8.2.1 Potential pollutant linkages are identified using the source-pathway-receptor framework detailed in Appendix A. An assessment of the potential significance of each linkage is then made by consideration of the likely

magnitude and mobility of the source, the sensitivity of the receptor and the nature of the migration/exposure pathways between them.

8.2.2 This qualitative assessment has been undertaken in accordance with NHBC (National House Building Council) and Environment Agency guidance. Further details of which are provided in Appendix A including definition of risk categories.

8.2.3 Table 8.4 below summarises the pollutant linkages and risk ratings associated with the Proposed Scheme as assessed following interpretation of the results of the ground investigation.

Table 8.4: Ground Contamination Risk Assessment

Source	Pathway	Receptor	Consequence of Risk	Probability of Risk being Realised	Risk Classification	Requirement for Further Action
Contaminants in soils	Direct contact, ingestion and inhalation of dust, gas and/ or vapours.	Construction workers/ maintenance workers	Mild	Unlikely	Very Low	None required provided use of PPE and health and safety best practices during construction and maintenance works. Future Proposed Scheme users unlikely to come into direct contact with soil.
Contaminants in soils	Direct contact, ingestion and inhalation of dust, gas and/ or vapours.	Future Proposed Scheme users	Mild	Unlikely	Very Low	None required provided use of PPE and health and safety best practices during construction and maintenance works. Future Proposed Scheme users unlikely to come into direct contact with soil.
Contaminants in soils	Leaching and vertical migration. Lateral migration.	Groundwater[1] Surface water[2]	Mild	Low	Low	None required. Piling for bridges may create a pathway, however since the majority of the superficial deposits are granular, the groundwater in the chalk is likely to be in continuity with groundwater in the superficial deposits. No sources of contamination identified other than one small area of infilled ground. Groundwater does not appear to be contaminated beyond naturally occurring concentrations.

Source	Pathway	Receptor	Consequence of Risk	Probability of Risk being Realised	Risk Classification	Requirement for Further Action
Contaminants in groundwater	Lateral migration.	Groundwater Surface water	Mild	Low	Low	None required. Contamination within the groundwater is minimal and localised. The end use of the site is unlikely to introduce further significant contamination to groundwater and surface water. A Construction Environmental management Plan (CEMP) should detail best practice and safe systems of work to protect controlled waters during the construction works.
Ground gas	Migration into confined spaces.	Construction workers/ maintenance workers	Medium	Low	Low to Moderate	Carbon dioxide has been observed in concentrations above the long term and short term WEL at most monitoring well locations. Carbon monoxide concentrations have been observed at concentrations above the long term WEL at one location. Health and safety measures will be required in excavations / confined spaces.

Note: Risks identified as being moderate/low or higher are considered to be significant and warrant further consideration.

[1] Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation=Principal Aquifer. Superficial Alluvium, Head Deposits= Secondary B Aquifer. Superficial River Terrace Deposits and Sheringham Cliff Formation=Secondary A Aquifer. Lowesoft Formation- Secondary (Undifferentiated) Aquifer.

[2] The nearest surface watercourse is the River Wensum which is within the centre of the Site boundary from north-west to south-east.

9 Preliminary Waste Assessment

9.1 Methodology

9.1.1 A preliminary waste classification has been undertaken using HazWasteOnline™ to assess whether the soils present within the Site Boundary are likely to be hazardous or not hazardous (in accordance with Technical Guidance WM3) should they need to be disposed off-site as waste. This was accomplished using the soil sample results obtained from the ground investigation. Further details on the waste classification methodology are presented in Appendix A.

9.1.2 The following materials are expected to be excavated as part of the Proposed Scheme:

- Topsoil stripped from the surface within the Site Boundary;
- Natural soils (superficial deposits) and limited Made Ground for the creation of new roadways, junctions and infiltration ponds for highway drainage;
- Arisings from piling works (including superficial deposits and chalk bedrock); and
- Natural soils and chalk arising from bridges and associated foundations.

9.1.3 From the information gathered during this investigation and the assessment included in Section 6, it is expected that the majority of excavated natural soils will be suitable for re-use from a contamination perspective.

9.1.4 The majority of the Made Ground samples indicate that re-use of this material is also suitable. However caution should be paid to the re-use of Made Ground due to the material being more heterogenous than natural

deposits. Made Ground should be segregated and stockpiled separately from the natural deposits during excavation works.

9.1.5 Suitability for re-use from a geotechnical perspective is discussed in the Ramboll Geotechnical Report.

9.1.6 Material that is surplus to requirement will be considered to be a waste.

9.1.7 A total of 404 soil samples were tested for a suite of determinands selected based on the site's historical and contemporary uses (as detailed in Table 3.1). Of these twenty-three (23) samples comprised Made Ground, seventy-four (74) samples comprised topsoil, two hundred and twenty-five (225) samples comprised superficial deposits, thirty-two (32) comprised peat samples and fifty (50) comprised chalk samples. The samples were assessed using the HazWasteOnline assessment tool. These comprised samples of topsoil, Made Ground, natural superficial deposits, and shallow chalk deposits.

9.1.8 The HazWasteOnline output sheets are provided in Appendix B.

9.2 Results

9.2.1 Based on the results of the HazWasteOnline assessment, a total of two samples from two separate locations were identified as hazardous material. One sample (WS202) is from the Made Ground (crushed demolition material that forms an access track) and the other from the peat horizon (TP246). These hazardous samples are summarised below:

- WS202 at 0.2 m bgl (hazardous property HP7 – Carcinogenic; HP11 - Mutagenic);
- TP246 at 0.1 m bgl (hazardous property HP7 – Carcinogenic; HP14 - Ecotoxic);

9.2.2 WS202 is located to the south of Fakenham Road and TP246 is located in the north of the River Wensum Floodplain. Only one sample was collected from the trial pit TP246; however, two samples were collected

from WS202. The second sample was from the superficial deposits at 2 m bgl. The deeper sample was non-hazardous in the HazWasteOnline assessment, suggesting that the issue is localised to the Made Ground horizon and that the superficial deposits in this area are would not be considered to be hazardous if they were to be disposed off-site as waste.

9.2.3 WS202 is in a similar location to location PC-011 that was excavated during the supplementary GI. PC-011 was also found to be hazardous; however, this was due to the PAH concentrations of the pavement cores. The logs do not note asphalt or tarmacadam at location WS202.

9.2.4 TP246 and WS202 also exceed the Norfolk County Council's GAC (TP246 exceeds for arsenic and lead in soils and WS202 exceeds for pH and PAHs in soil and PAHs in the leachate sample) and it is therefore considered that material in the area of these locations are not suitable for re-use at the site. If excavation of material is required in this area, it would not be suitable for re-use and if the material should require disposal from site as a waste, it should be classified as hazardous waste based on the above assessment. Alternatively, further statistical analysis of the reuse or a detailed quantitative risk assessment (DQRA) may be undertaken to determine a suitable area for re-use (i.e. at depth to break the pathway for human health and at a distance from watercourses to decrease the risk of migration to controlled waters).

9.2.5 The sample from WS202 was hazardous based on the TPH concentrations whilst the sample from TP246 was found hazardous based on the concentrations of lead and zinc. Table 9.1 shows the concentrations for the metal and TPH from both samples. It is noted that not all samples were tested for TPH and further samples may prove to be hazardous should further analysis be undertaken.

Table 9.1: Summary of concentrations for hazardous samples

Determinand (laboratory concentrations)	Units	WS202	TP246
Classification Result		Hazardous	Hazardous
Depth	m	0.20	0.10-0.10
Moisture content	%	3.7	58
pH	pH	10.6	6.1
Antimony	mg/kg	<1	50
Arsenic	mg/kg	8.2	240
Boron	mg/kg	3.2	18
Barium	mg/kg	120	270
Cadmium	mg/kg	<0.2	<0.2
Chromium in chromium(III) compounds	mg/kg	17	88
Chromium in chromium(VI) compounds	mg/kg	<1.8	5.6
Copper	mg/kg	17	320
Lead	mg/kg	26	2,200
Mercury	mg/kg	<0.3	<0.3
Nickel	mg/kg	6.7	17
Selenium	mg/kg	<1	<1
Zinc	mg/kg	49	1,100
Vanadium	mg/kg	54	40
TPH (C6 to C40) petroleum group	mg/kg	1,657	
Methyl tert-butyl ether;	mg/kg	<1	
Benzene	mg/kg	<1	
Toluene	mg/kg	<1	

Determinand (laboratory concentrations)	Units	WS202	TP246
Ethylbenzene	mg/kg	<1	
Xylene	mg/kg	<1	
Naphthalene	mg/kg	<0.05	<0.05
Acenaphthylene	mg/kg	4.8	<0.05
Acenaphthene	mg/kg	12	1.3
Fluorene	mg/kg	12	3
Phenanthrene	mg/kg	120	36
Anthracene	mg/kg	33	5.6
Fluoranthene	mg/kg	250	49
Pyrene	mg/kg	220	33
Benzo[a]anthracene	mg/kg	150	4.1
Chrysene	mg/kg	120	3.1
Benzo[b]fluoranthene	mg/kg	99	0.95
Benzo[k]fluoranthene	mg/kg	60	0.3
Benzo[a]pyrene; benzo[def]chrysene	mg/kg	87	0.39
Indeno[123-cd]pyrene	mg/kg	54	<0.05
Dibenz[a,h]anthracene	mg/kg	15	<0.05
Benzo[ghi]perylene	mg/kg	50	<0.05
Hazard Property		HP7; HP11	HP7; HP14

Notes:

HP14: Ecotoxic: ‘waste which presents or may present immediate or delayed risks for one or more sectors of the environment’.

HP11: Mutagenic: ‘waste which may cause a mutation, that is a permanent change in the amount or structure of genetic material in a cell.

HP 7: Carcinogenic: 'waste which induces cancer or increases its incidence'.

9.2.6 Waste Acceptance Criteria (WAC) testing was undertaken on parts within the Site Boundary that are in areas of cut and in areas of contamination. Six samples were collected as below:

- BH201 (1 m bgl);
- BH243 (3 m bgl);
- BH253 (1 m bgl);
- BH244 (1 m bgl);
- TR204CZ (0.55 m bgl); and
- TR205HP (0.6 m bgl).

9.2.7 The WAC samples obtained from TR204CZ and TR205HP were taken from the Made Ground, the sample from BH253 was taken from the peat strata, the samples taken from BH243 and BH244 were from the superficial (sand) deposits, and the sample taken from BH201 was from the superficial (clay) deposits.

9.2.8 All of the WAC samples with one exception (TR204CZ) were deemed to be suitable for disposal to an inert landfill if the material sampled was to be removed off-site as a waste. The sample from TR204CZ exceeded the inert landfill WAC for arsenic and would therefore be deemed suitable for disposal to a non-hazardous landfill if the material sampled was to be removed off-site as waste. No WAC samples were taken from WS202 and TP246 and so further testing will be required during the construction works if material in the area of these exploratory holes is excavated and needs to be disposed off-site as a waste.

9.2.9 It is noted that waste classification has been undertaken on localised samples and is only indicative of the waste classification of the strata the samples have been collected from if that material was surplus to requirements on site and needed to be disposed of as waste. Further

assessment will likely be required during the construction works for a more accurate representation of the materials to be removed from within the Site Boundary. Any waste material will require off-site disposal to a suitably licensed soil treatment or waste disposal facility by a suitably qualified contractor. Waste duty of care information (including the types and amounts of waste disposed of, waste classification and WAC analysis, waste transfer and consignment notes and applicable site and carriers' licenses) should be maintained.

9.3 Asbestos

9.3.1 Where waste contains identifiable pieces of asbestos (i.e., any particle of a size that can be identified as potentially being asbestos by a competent person by the naked eye), then further testing and assessment will be required.

9.3.2 Where the asbestos is deemed to be of a fibrous nature (free fibres and fibre bundles the Health and Safety Executive (HSE) require that the handling of the material is undertaken by a suitably licensed company. The Carriage of Dangerous Goods (etc.) Regulations 2009 (CDG2009) applies in this instance.

9.3.3 The Hazardous Waste (England and Wales) Regulations 2005 requires that any waste having an asbestos (ACM) content greater than 0.1% w/w be classified as Hazardous Waste. Any waste with an asbestos content of less than 0.1% w/w can be classified as non-hazardous waste, unless there are other contaminants present which would make the waste hazardous. Additionally, if the waste contains fibres that are free and dispersed then the waste will be hazardous if the waste as a whole contains 0.1% w/w or more asbestos.

9.3.4 It is noted that while no asbestos was detected in the samples subjected to analysis or visually during the ground investigation, there is the potential for asbestos to be identified elsewhere within the Site Boundary in locations not targeted by the ground investigation.

9.4 Discussion / Summary

9.4.1 The results of the preliminary waste assessment suggest that localised areas of the Made Ground and peat strata have the potential to be classified as hazardous should it be removed from site as waste. All other material (including, superficial deposits and the shallow chalk) have been shown to be not hazardous.

9.4.2 The majority of the material excavated at the site is considered to be suitable for general re-use on-site provided that:

- Construction and maintenance workers utilise appropriate PPE and health and safety best practices; and
- Material is confirmed to be geotechnically suitable for reuse in accordance with an Earthworks Specification (to be prepared separately).

9.4.3 The majority of the topsoil, Made Ground, superficial deposits and the shallow chalk from the proposed cutting and piling works are anticipated to be suitable for re-use or disposal off-site as not hazardous waste, however if visual or olfactory evidence of contamination is identified in these materials during excavation, then the impacted material should similarly be stockpiled separately and subjected to additional chemical testing prior to disposal or reuse.

9.4.4 While no asbestos was identified during the ground investigation or chemical testing of soil samples, given the inherent heterogeneity of Made Ground it would be prudent to make a provisional allowance for encountering visible fragments of ACMs and asbestos-impacted soils that will need to be disposed of under appropriate Duty of Care procedures. Contractor vigilance and specialist advice is advised along with further asbestos screening and/ or quantification testing to determine the appropriate waste stream for materials requiring disposal.

9.4.5 Note that the indicative waste classifications provided as a part of this assessment should be confirmed by any receiving facility prior to disposal, under Duty of Care, following discussions with the producer of the waste.

WAC analysis is likely to be required to be undertaken by the contractor prior to disposal, under current legislative requirements post excavation.

9.4.6 Should the re-use of site won materials be required, consideration should be given to adoption of the CL:AIRE DoW COP which would enable the works to be completed without Made Ground, peat and contaminated soils being automatically regarded as a waste material. This would require the preparation of a Materials Management Plan (MMP) and, in due course, an MMP Verification Report to demonstrate that the requirements of the MMP have been met. Please note that if the CL:AIRE DoW CoP is to be applied, the MMP will need to be declared by a Qualified Person before earthworks are commenced, due to the need to demonstrate certainty of use before the materials are excavated. Please note that an MMP may not be worthwhile if only limited volumes of Made Ground and contaminated soils are present, where re-use under exemptions from the Environmental Permitting Regulations may be more appropriate.

9.4.7 It should be noted that disposal of surplus site won soils to landfill is not considered to be sustainable. The most sustainable solution is to minimise excavations and maximise opportunities to re-use site won materials on-site. However, where surplus materials remain, alternative approaches to disposal to landfill should be explored. These could include recycling of the materials at an off-site soil treatment centre, or identifying alternative sites where these materials can be re-used (subject to compliance with the Environmental Permitting Regulations (as amended) at the receiving site as the material would still need to be handled as a waste).

10 Conclusions and Recommendations

10.1 Summary

10.1.1 This Ground Contamination Interpretative Report for the Alignment Refinement has been to aid in the design and construction of the Proposed Scheme. This report has been prepared to refine the conceptual site model for the Proposed Scheme and provide a qualitative risk assessment with respect to contaminated land.

10.2 Human Health Assessment

10.2.1 Chemical testing results from a total of 404 soil samples were screened against Norfolk County Council specified GAC for public open space. All concentrations were below the Norfolk County Council GAC with the exception of one sample which exceeded the GAC for arsenic and lead. The exceedances were recorded in TP246 (0.1 m bgl) in the northern part of the River Wensum floodplain, within a layer of peat. No potential ACMs were identified during the ground investigation and no asbestos fibres were identified in the 24 soil samples screened for asbestos.

10.2.2 The use of Norfolk County Council specified GACs based on public open space is considered to be conservative, due to the majority of the Proposed Scheme being covered in hardstanding or imported topsoil, with minimal potential for direct contact with underlying soil.

10.2.3 Pendimethalin was detected in six locations, within the top 0.2 m of soil. Pendimethalin is a selective herbicide used to control broadleaf and grassy weeds. It is slightly toxic by the oral and eye route and is practically non-toxic by the dermal and inhalation routes. Pendimethalin dissipates in the environment by binding to soil, and is essentially immobile in soil. Pendimethalin is slightly to moderately persistent in aerobic soil environments. It's persistence decreases with increased temperature, increased moisture and decreased soil organic carbon. Pendimethalin's high affinity to bind to soil and sediment particles is likely to limit the

concentrations within the surface water and groundwater. No pendimethalin was detected in the groundwater samples collected.

10.2.4 The risk to the future users of the Proposed Scheme from contaminants in the soil is considered to be low. Provided that construction workers and future maintenance workers at the site utilise appropriate vigilance and work in accordance with construction health and safety best practice, the risk to them from contaminants in soil is also anticipated to be Low.

10.3 Controlled Waters Assessment

10.3.1 Leachate testing has been completed for 30 soil leachate samples. Five (5) leachate samples recorded concentrations exceeding the DWS criteria. The sample from the Made Ground at WS202 (0.2), located on an access track to the north-east of the River Wensum floodplain, exceeded the DWS for benzo(a)pyrene (0.91 µg/l compared to a DWS of 0.01 µg/l) and the sum of 4 PAHs (2.08 µg/l compared to a DWS of 0.1 µg/l). The sample in the topsoil at BH215 (0.2), in the northern part of the River Wensum floodplain) exceeded the DWS for arsenic (12 µg/l compared to the DWS of 0.01 µg/l). The exceedance of the arsenic DWS is considered a marginal exceedance (defined as less than ten times the DWS value). Three samples from the Made Ground in area of the historic waste pit exceeded the DWS and two of the samples also exceeded the EQS for arsenic. These exceedances are localised and are unlikely to pose a significant risk to the groundwater or surface waters. Only two (2) locations recorded leachate concentrations in excess of the DWS – these were located at BH215 (arsenic exceedance) and WS202 (benzo(a)pyrene and sum of 4 PAH exceedances); however the exceedances were only marginal. Exceedances of the EQS were noted for leachable chromium, copper, lead, nickel and zinc at several locations. The EQS was also exceeded for anthracene and fluoranthene in one sample (WS202 at 0.2 m bgl).

10.3.2 Metals including chromium, copper, lead, mercury, nickel and zinc exceed the EQS. The majority of the exceedances are marginal (i.e. less than one order of magnitude). The elevated metals are likely to represent background levels across the site. Exceedances of PAHs were noted in one leachate sample from the Made Ground in WS202. The exceedances are localised, and there is no suggestion of a contamination source from the current or historic land uses. As such, the risk to controlled waters is considered to be Low.

10.3.3 To date, thirty (30) groundwater samples have been collected and were screened against DWS and EQS (as is set out in the Norfolk County Council's GAC). The pH groundwater analysed within both rounds of groundwater monitoring were within the acceptable range for EQS and DWS. Minor exceedances of the copper and nickel EQS were recorded, as well as an exceedance of the arsenic DWS across wells screened in both the superficial and chalk strata. All exceedances were less than an order of magnitude of the relevant standard, with the exception of BH261 and BH262, both screened in the superficial deposits within the Woodland Campaign area, and as such are not considered to a pose a high risk to controlled waters.

10.4 Ground Gas Assessment

10.4.1 Carbon monoxide concentrations were measured above the limit of detection in sixteen (16) locations and was measured in exceedance of the long term WEL for carbon monoxide in BH226 during three monitoring rounds (December 2022, January 2023 and February 2023).

10.4.2 Monitoring results exceeded both the long term WEL for carbon dioxide at nineteen (19) wells and the short term WELs at ten (10) wells. The carbon dioxide concentrations are likely to represent the natural ground conditions beneath the extents of the Site Boundary given the similarity of the concentrations across the large spatial area. However, the flow rates are consistently low across the extents of the Site Boundary.

10.4.3 It should be noted that under current health and safety legislation, construction and maintenance workers are required to carry out appropriate risk assessments and instigate appropriate mitigation measures to protect themselves, other human receptors and the environment from contamination that may be present. Such risks must be adequately mitigated by the measures required under legislation, specifically the Construction Design Management (CDM) Regulations, which required the potential risks to human health and the environment from construction activated are appropriately identified and all necessary steps taken to eliminate / manage that risk. On this basis it has been assumed that personal protective equipment (PPE) and health and safety best practises will be adopted during the construction works and acute risks to construction workers / site visitors during construction have therefor not been considered as part of this assessment. However the data from ground investigation reports should be provided to the construction team and used to inform the PPE and Health and Safety requirements.

10.5 Material Re-Use & Preliminary Waste Classification

10.5.1 Based on the results of a preliminary waste assessment, two samples were classified as hazardous for the purposes of disposal. One sample was taken from the Made Ground (TP246) and the other sample was from the peat (Ws202). This material should be stockpiled separately and subjected to chemical testing to confirm waste classification or suitability for re-use on-site as appropriate.

10.5.2 Other materials excavated within the Site Boundary are considered to be suitable for re-use on-site provided that:

- Construction and maintenance workers utilise appropriate PPE and health and safety best practices; and
- Material is confirmed to be geotechnically suitable for reuse in accordance with an Earthworks Specification (to be prepared separately).

10.5.3 However, further sampling should be undertaken during excavations if any unexpected contamination is identified, within made ground, and within peat to ensure that the material is in line with the findings of this investigation and therefore suitable for reuse from a contamination perspective.

10.6 Recommendations for Further Work

10.6.1 Based on the results of the ground investigation, no significant sources of contamination have been identified that would preclude development, with the site considered to be of low contamination risk, which is in line with the findings of the Contaminated Land Report for the supplementary investigation. It is noted that this risk assessment takes into account the finalised layout of the Proposed Scheme, however if significant changes are subsequently made to the layout, then the assessment will need to be revised.

10.6.2 Based on the findings of this risk assessment, the following actions are recommended to be undertaken prior to the commencement of construction works:

- Preparation of a Land Quality Method Statement to fulfil the requirements of a remediation strategy, outlining the mitigative measures to be undertaken in relation to risks identified to human health and controlled waters and in the event of identifying areas of unexpected contamination during the enabling works and construction phase;
- If re-use of site won material is required, preparation of an MMP once detailed earthworks design drawings are made available, setting out how site won material and imported soils will be managed during the construction works;
- Management of construction works to ensure that the requirements of the Land Quality Method Statement and MMP (if any) are

complied with, including the collection of evidence to demonstrate that this was the case; and

- On completion of construction works, preparation of a Verification Report using the collated evidence to demonstrate that the Land Quality Method Statement and MMP requirements (if any) have been implemented.

- TP246 and WS202 also exceed the Norfolk County Council's GAC and it is therefore considered that material in the area of these locations are not suitable for re-use at the site. If excavation of material is required in this area, it would not be suitable for re-use and if the material should require disposal from site as a waste, it should be classified as hazardous waste based on the above assessment. Alternatively, further statistical analysis of the reuse or a detailed quantitative risk assessment (DQRA) may be undertaken to determine a suitable area for re-use (i.e. at depth to break the pathway for human health and at a distance from watercourses to decrease the risk of migration to controlled waters).

10.6.3 For any remaining surplus material, opportunities should be explored to divert the material from disposal at landfill.

10.6.4 In all cases the recommendations outlined above should be implemented in line with the Proposed Scheme programme.