

York Central – Phase 1C

Information Review and Basis of Design

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1 Introduction

1.1 Purpose

This report presents a desk-based review of existing documentation relevant to ground conditions and geoenvironmental issues at York Central prepared by Buro Happold on behalf of McLaren. It has been prepared to determine the baseline conditions at the Site, to determine which data sources are suitable for screening / assessment, and to inform subsequent scoping and specification of ground investigations to facilitate the proposed redevelopment of the masterplan area. There is a large body of existing information relevant to ground conditions, associated with various development plots within the York Central scheme, which have been both provided by the Client or obtained from the York City Council planning portal. The reviewed documents are listed in Appendix A. The location of the York Central masterplan is shown by Figure 1-1.

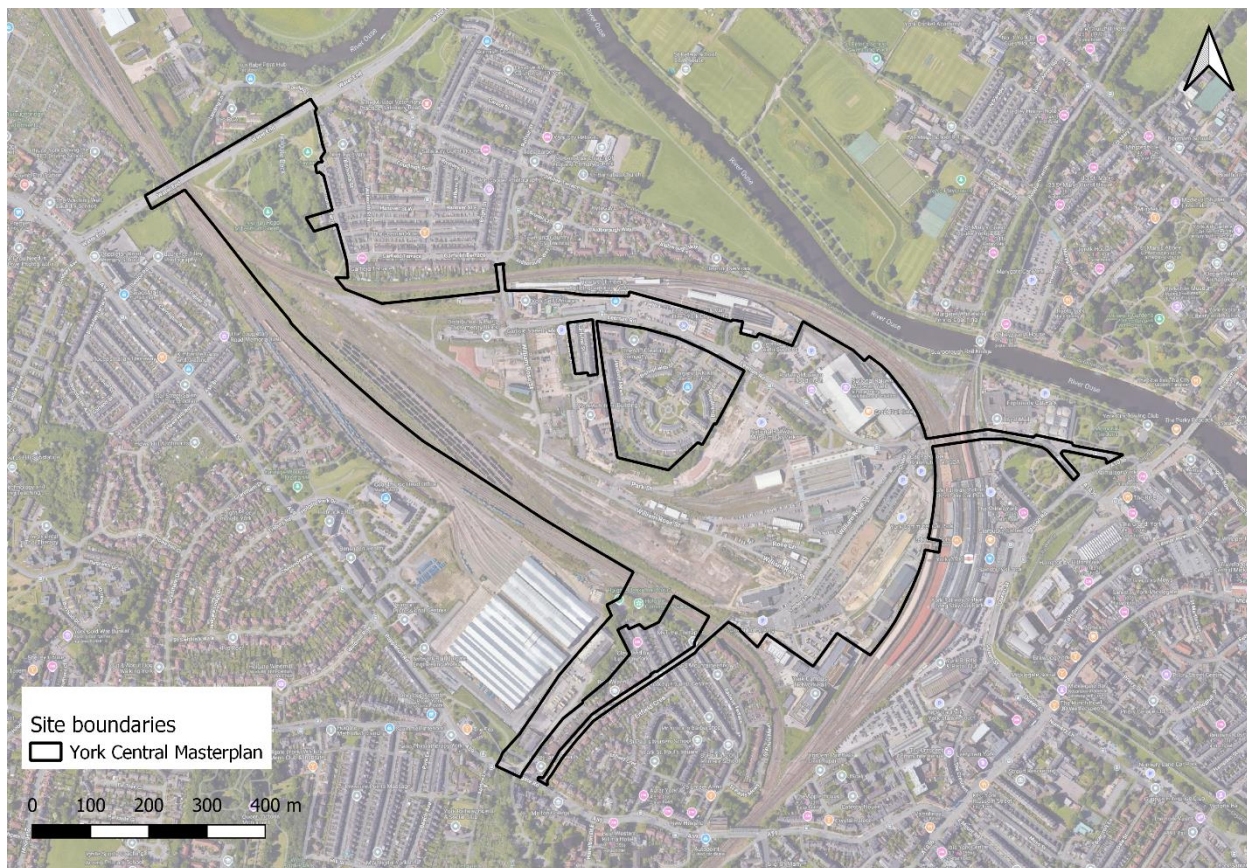


Figure 1-1 - Location of York Central masterplan.

1.2 Document Structure

Section 2 presents a description of the documents reviewed relevant to ground conditions and a very brief description of their contents and chronology of the work completed. A tabulated summary of the available information is provided in Appendix A and a technical review / summary of the contents of each document is included in Appendix B. Section 3 presents a similar review of the documents relevant to UXO and provides comment on the appropriateness of the risk assessments. Our understanding of the ground conditions baseline on the basis of the reviewed desk-based

information is summarised in Section 5. A Basis of Design is included in Section 5. This considers what ground investigation data should be reprocessed / rescreened to inform the scoping and specification of ground investigation during the next stage of work.

2 Document Review – Ground Conditions

2.1 Available Information

A large body of reports / information related to ground conditions have been made available by the Client and also obtained from City of York Council's planning portal, in consultation with the Contaminated Land Officer. The information relates to various projects, including the York Central masterplan, IP2 works, and other development plots within or adjacent to the York Central masterplan site. The study areas related to these various projects are shown by Figure 2-1 below. A tabulated summary of the information reviewed is presented in Appendix A.

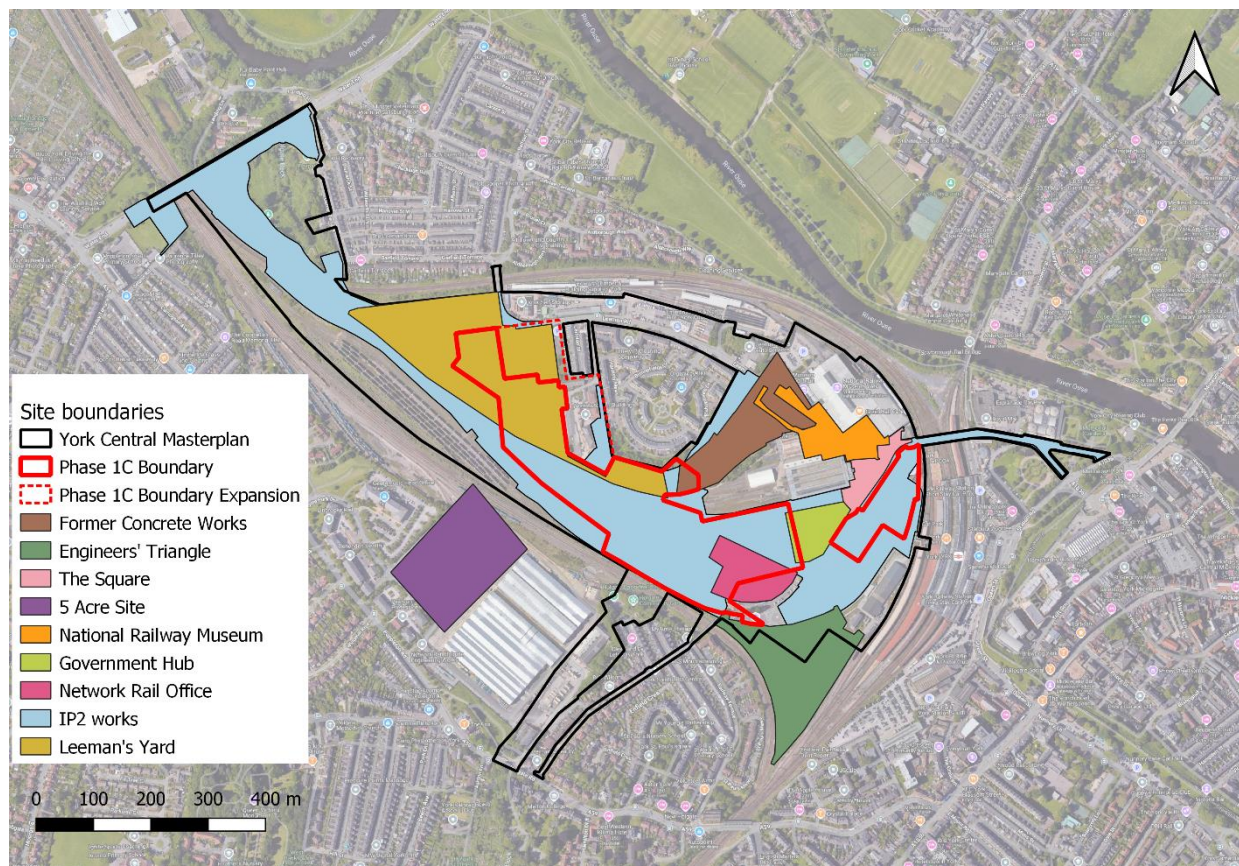


Figure 2-1 - Projects with available information

2.2 Gap Analysis

A gap analysis of the available information has been undertaken by reviewing the references lists of the available reports to determine which documents current are / aren't available. This has informed the ground engineering input to the RFI register. At the time of writing, the vast majority of known studies have been received and reviewed. There is one report that has been requested but not received: Atkins (2023) Proposed Government Hub at York Central Factual Ground Investigation Report Phase 2 by Tetra Tech.

2.3 Description of Previous Work

A brief description of the available information is presented below. The order of projects is presented in chronological order, with the studies associated with each of the projects then also presented in chronological order. A more complete account of the results / findings in terms of ground conditions is provided for context and information in Appendix B.

- **Former Concrete Works:** A Land Quality Review was completed by Entec in 1998 [1]. This comprised a desk-based assessment of existing site investigation information, the site's environmental setting, and made recommendations for additional ground investigation and outline remediation proposals.
- **York Central Masterplan:** In 2006, Carl Bro completed a Preliminary Site Evaluation [2], conducted a ground investigation (reported in a Factual Report [3]) and prepared a geotechnical and geoenvironmental Interpretative Report [4]. These studies were reviewed / updated by Grontmij (formerly Carl Bro) in the context of the amended development proposals in 2008 [5, 6]. Two phases of ground investigation were completed by WYG across the masterplan area in 2020, one primarily to provide ground conditions information and one for archaeological purposes. These are reported in Factual Reports. An Outline Earthworks Strategy and Outline Remediation Strategy were also prepared by Tetra Tech in 2022 [9, 10]. These summarise the overall strategy, principles, and general method of approach to the proposed earthworks and remediation and considers development levels for each of the plots.
- **York Engineers' Triangle:** Ramboll was commissioned by BAM Construction Ltd in 2012 to undertake a geotechnical and contaminated land Desk Study related to the proposed development of York Engineers Triangle, comprising a training facility, rail operation centre, ancillary and service buildings.
- **5 Acre Site:** Socotec completed a Desk Study and geoenvironmental ground investigation in 2017 on behalf of Network Rail. This was associated with proposals to reinstate a fan of railway tracks leading from a depot access line to existing carriage shed.
- **Network Rail Office:** In 2018 to 2019, Jacobs was commissioned by Network Rail to undertake a Preliminary Risk Assessment associated with the proposed construction of modular office accommodation. This was followed by completion and assessment of ground investigation to discharge planning conditions, and preparation of a Remediation Statement.
- **National Railway Museum:** Listers Geo was appointed to undertake a Desk Study and walkover survey; design and complete a ground investigation; and undertake geotechnical and geoenvironmental assessment associated with the proposed development of a new gallery and entrance building at the National Railway Museum. Graham Construction was appointed as the Principal Contractor and prepared a Remediation Implementation Plan associated with their works. Both documents were prepared in 2021.
- **Leeman's Yard:** In 2021, Tetra Tech completed desk top assessment of in-ground constraints at the Leeman's Yard site. This was presented in a report that: reviewed existing desk-based and ground investigation information (for the York Central masterplan area); presented a geoenvironmental assessment and gap analysis, geotechnical appraisal, and archaeological constraints assessment; and made recommendations for further intrusive investigations.
- **Infrastructure Package 2 (IP2):** A large body of work relevant to ground conditions has been completed associated with the IP2 works at York Central. A Desk Study [19] and Geoenvironmental Assessment and Outline Remediation Strategy [20] were prepared by Arup in 2018 and 2020, respectively. This was followed by further programmes of geotechnical and geoenvironmental ground investigation completed by Tetra Tech on behalf of Sisk in 2021, presented in separate Factual Reports. Tetra Tech then went on to prepare a Geoenvironmental Interpretative Report for Homes England based on the results of these investigations in December 2021. John Sisk & Sons prepared a Materials Management Plan in September 2022 to facilitate the reuse of soils materials across the site. A targeted programme of ground investigation was then completed for Homes England in November 2022, with the objective of identifying the location and nature of

contamination associated with a gasholder . Tetra Tech then went on to design a Remediation Strategy for the IP2 works . Four supplementary phases of ground investigation were completed during 2022 to 2023 (presented in a single report . These were commissioned by Sisk and completed by Tetra Tech, and were designed to fill gaps in the existing dataset. One Ground Investigation Report prepared by Sweco in 2023 has been made available for review, which presents a geotechnical assessment and consideration of geotechnical risks based on the above ground investigation data .

- **Proposed Government Hub:** In 2023, Tetra Tech was commissioned by Homes England / Government Property Agency to provide a geoenvironmental and geotechnical ground investigation associated with the development of the proposed government hub. Atkins also prepared a combined geotechnical and geoenvironmental Ground Investigation Report based on this ground investigation data in 2023 .
- **The Square:** Tetra Tech was commissioned by Homes England in 2023 to undertake a Geoenvironmental Desk Study associated with the development of The Square, a proposed area of public open space located at the public pedestrian entrance to the National Railway Museum. The report concluded that there was potential for contamination generally associated with Made Ground, but given the ground investigation already completed there was no requirement for additional intrusive works.

3 Document Review – UXO

3.1 Available Information

This Section presents a review of existing reports relevant to management of UXO at York Central. The objective is to determine which reports are most relevant or appropriate to the proposed development at York Central, to inform (1) the requirement for mitigation measures to be implemented during ground investigation and development, and (2) whether there is a need for additional Detailed UXO Risk Assessments to be commissioned.

The available reports are summarised in **Table 3-1** and have been obtained either from the Client or the planning portal for outline planning permission 18/01884/OUTM.

Table 3-1 - Available reports.

Author and date	Report title	Comment
Dynasafe BACTEC Ltd and FIND Mapping Limited (2017)	York Central Preliminary UXO Risk Assessment. 502608	Submitted as part of planning application for outline planning permission. Forms part of Masterplan UXO Strategy.
1 st Line Defence (2018)	Detailed Unexploded Ordnance (UXO) Risk Assessment. Station Road, York, YO24 1AB. Da6464-00	Forms part of Masterplan UXO Strategy.
Arup (2020)	Condition 60: UXO Strategy. YCL-ARP-RM1-XX-RP-YP-6001	Prepared by Arup on behalf of Homes England and Network Rail Infrastructure Ltd to discharge Condition 60 of outline planning permission for York Central on a site-wide basis.
Zetica UXO (2022)	UXO Desk Study & Risk Assessment. P11758-22-R1. York Central	Zetica Ltd was commissioned by WSP to carry out an Unexploded Ordnance (UXO) Desk Study and Risk Assessment. The study area appears to align with the IP2 works boundary.

3.2 Arup (2020) Condition 60: UXO Strategy

3.2.1 Scope

This UXO Strategy Report was prepared by Arup on behalf of Homes England and Network Rail Infrastructure Ltd to discharge Condition 60 of the outline planning permission for York Central. It was informed by site-wide preliminary and detailed UXO risk assessments which are appended to the report:

- Dynasafe BACTEC Ltd and FIND Mapping Limited (2017) York Central Preliminary UXO Risk Assessment.
- 1st Line Defence (2018) Detailed UXO Risk Assessment. Station Road, York.

The purpose of the report was to provide a strategy for managing site-wide UXO risks during ground investigations and construction. The study area is shown by Figure 3-1 below and corresponds with the redline boundary for the York Central masterplan area.



Figure 3-1 - Study area of Arup (2020) UXO Strategy report.

3.2.2 Risk assessment

Dynasafe BACTEC and FIND Mapping (2017) Preliminary UXO Risk Assessment

This report presents a Preliminary UXO Risk Assessment for the York Central development. The assessment is based on a desktop study of data from historical records and potential UXO sources. The assessment identified the following potential sources of UXO:

- Army explosive ordnance clearance task/recce carried out at the River Ouse, Clifton, approximately 700m north of the site boundary.
- A Royal Ordnance Factory (ROF) used during WWII as an explosives filling factory located approximately 2.4km northeast from the site boundary.
- A press article was found detailing the recovery of grenades from a house at Marygate, York, 1km northeast of the site.
- Historical records of German bombing during WWII indicate a medium level of bombing density across the city of York.

The York Central site was given an overall high risk from UXO. The report recommended that a Detailed UXO Risk Assessment should be undertaken. It also recommended that further research should be conducted to identify whether the site was bombed or damaged during WWII.

1st Line Defence (2018) Detailed UXO Risk Assessment

1st Line Defence was commissioned by Arup to conduct a Detailed UXO Risk Assessment for the proposed works at York Central in accordance with CIRIA . The report assessed the site to comprise areas of Medium and Low Risk from items of aerial delivered UXO, see Figure 3-2.



Figure 3-2 - UXO risk map from 1st Line Defence (2018) Detailed UXO Risk Assessment.

The report concluded that York sustained an overall low density bombing campaign. However, a large proportion of the 178 total recorded bomb strikes appear to have fallen on or surrounding the site location. The site and surroundings were identified by Luftwaffe target mapping and the site comprised one of the few legitimate targets in the city during this period.

Medium risk area

Most of the site is identified as having a medium risk associated with encountering UXO. This is due to the following reasons:

- WWII-era imagery shows evidence of severe bomb damage within the site and immediate surroundings. Imagery also shows evidence of repairs to railway infrastructure, goods sheds and industrial structures. York Station also experienced severe bomb damage.
- A range of ground conditions, including areas of railway, railway infrastructure, roadways and structures occupied the site. The likelihood that evidence of UXO will have been noticed during post-raid inspections

will depend on the conditions and usage of such features e.g., railway sidings are considered less likely to have been regularly used or maintained.

- Consequently, due to limitations in the available records regarding the extent of bombing and damage sustained at the site, no area can be confidently assessed to provide conditions conducive to the discovery of unexploded ordnance.
- Wartime access is thought to have been severely disrupted within parts of the site that sustained bombing. It is thought unlikely that the site area was consistently accessed during air raids.
- Overall, the report concluded that it was not possible to lower the risk associated with UXO. This was largely due to the available record set failing to specify the exact locations of bomb strikes and the subsequent damage caused. It was also due to the 'J-curve' effect, where an items of UXO can become laterally offset from its point of entry.

Low risk area

A section of the south of the site is identified as being at a lower risk of UXO contamination. This is due to the following reasons:

- This section of the site appears to have been consistently occupied with intact structures and roadways throughout WWII.
- No available evidence indicates any bomb strikes within the area or immediately adjacent.
- It is thought that the area likely received regular access throughout the war. It is likely the area would have received wartime checks.

Limitations / caveats

The report notes that some post-war redevelopment '*has occurred within the site area, particularly in the northern and eastern areas of the site. The exact circumstances of development within the site are unclear but are likely to have included some significant intrusive works. The risk of encountering an item of unexploded ordnance is only considered to be mitigated at the exact locations and depths of post-war excavations.*' The report does not identify areas of post-war redevelopment, and therefore it is not possible to identify areas where the risk associated with UXO may be mitigated by any such redevelopment.

The report notes that site-specific geotechnical information was not provided to 1st Line Defence at the time of the report's production. It therefore does not include an assessment of maximum bomb penetration depth.

Recommended mitigation

The Arup (2020) UXO Strategy [32] report provides mitigation measures to be implemented during future construction works. These mitigation measures are based on the recommendations presented in the 1st Line Defence (2018) Detailed UXO Risk Assessment [31]. These include:

- UXO awareness briefings to all personnel conducting intrusive works (all areas).
- Presence on site of a UXO specialist (medium risk areas only).
- Magnetometer surveys of borehole and pile locations (medium risk areas only).

The Arup (2020) UXO Strategy goes on to state that '*it will be a contractual responsibility of future developers to implement these measures (as a minimum) and consider the need for additional measures based on any new information or any recording of UXO on site.*'

3.2.3 Zetica UXO (2022) UXO Desk Study & Risk Assessment

3.2.4 Scope

Zetica Ltd was commissioned by WSP to carry out a UXO Desk Study & Risk Assessment for part of the York Central site. The study area appears to correspond with the IP2 works boundary, however this isn't stated / confirmed in the report (see Figure 3-3).

3.2.5 Risk assessment

The report notes that records have been found indicating that eight high explosive bombs fell on the site during WWII. One of these was recorded as an unexploded bomb and was removed. The bombing caused significant damage to buildings on parts of the site, which may have masked the impact of unexploded bombs. Aerial imagery shows this damage to have occurred on and adjacent to the north of the site. The report states that *'no evidence of significant bomb damage has been identified on the remainder of the site, which comprised railway infrastructure that would have been regularly checked for evidence of UXO after each air raid.'*

Zetica assigned areas of the site with recorded bomb a moderate risk associated with UXO. The remainder of the site was assigned a low risk associated with UXO, see Figure 3-4.

The estimated average bomb penetration depths on site ranged from 4.0m to 9.5m bgl depending on the weight of the bomb. The report also notes that the UXO hazard will have been mitigated within the depth and extents of any post-WWII intrusive works, however the report does not identify these areas.



Figure 3-3 - Study area of Zetica UXO (2022) UXO Desk Study & Risk Assessment

3.2.6 Recommended mitigation

The report provides recommendations for UXO mitigation measures to be implemented during construction works. These include:

- UXO awareness briefings to all personnel conducting intrusive works (all areas).
- Presence on site of a UXO specialist (medium risk areas only).
- Magnetometer surveys of borehole and pile locations (medium risk areas only).

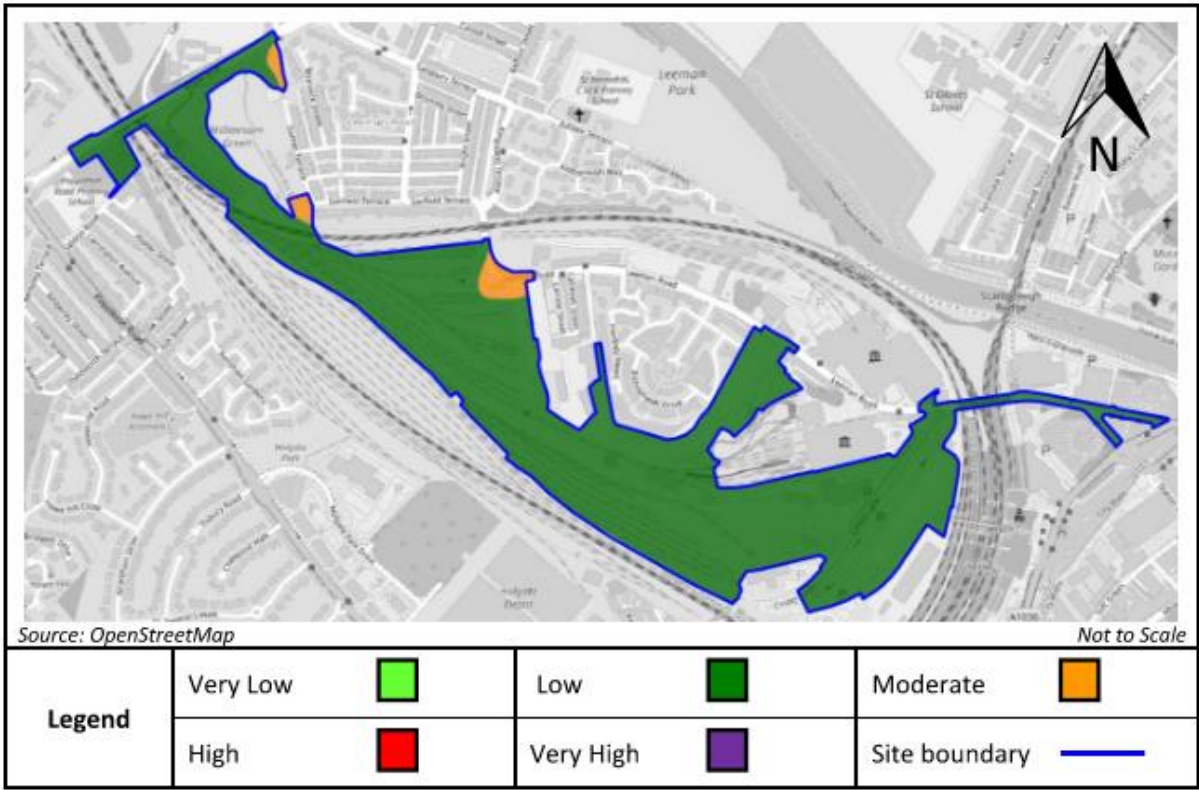


Figure 3-4 - UXO risk map from Zetica UXO (2022) UXO Desk Study & Risk Assessment

3.2.7 Summary

- 1. Four reports relevant to UXO have been made available for review: Dynasafe BACTEC Ltd and FIND Mapping Limited (2017); 1st Line Defence (2018) ; Arup (2020) ; and Zetica UXO (2022) .
- 2. The Dynasafe BACTEC Ltd and FIND Mapping Limited (2017) and 1st Line Defence (2018) report have together informed the Arup (2020) UXO Strategy that applies to the entire York Central masterplan area. This was submitted to discharge Condition 60 of the outline planning permission.
- 3. The Zetica UXO (2022) report is a standalone document that appears to apply to the IP2 works area. However, this is not stated in the report.
- 4. There is significant overlap in the study areas for the York Central masterplan and IP2 works area. However, the assessed level of risk associated with UXO differs between the reports.
 - o Arup (2020) UXO Strategy - identifies most of the York Central area to have a medium risk associated with UXO.
 - o Zetica UXO (2022) UXO Desk Study & Risk Assessment – identified most of the IP2 works area to have a low risk associated with UXO.
- 5. The reason for the differing conclusions is not clear. However:
 - o The reports informing the Arup (2020) UXO Strategy notes that it was not possible to lower the risk of UXO contamination in any significant section of the site due to the available record set failing to specify the exact locations of bomb strikes and the subsequent damage caused. It was also due to the ‘J-curve’ effect, where an items of UXO can become laterally offset from its point of entry. In addition, the report states that it was unlikely that the area was being consistently checked for UXO during air raids.

- Conversely, the Zetica UXO (2022) UXO Desk Study & Risk Assessment zoned the site according to areas where bomb damage was identified from aerial imagery. The report also noted that the area would likely have been regularly checked for evidence of UXO after each air raid, reducing the likelihood of UXO remaining undetected.
6. The Arup (2020) UXO Strategy and Zetica (2022) report recommend the same mitigation measures are employed for each of their respective medium risk and low risk areas.
 - UXO awareness briefings to all personnel conducting intrusive works (all areas).
 - Presence on site of a UXO specialist (medium risk areas only).
 - Magnetometer surveys of borehole and pile locations (medium risk areas only).
 7. It may be worthwhile to commission an additional Detailed UXO Risk Assessment specific to the Phase 1C area. Any additional Detailed UXO Risk Assessment should take in account local ground investigation information and details of post-WWII development – in particular recent IP2 works which likely overlap with the Phase 1C area (see Figure 3-5).
 8. Any such report would need to be shared with the local authority for their consideration and agreement. In particular, this is because the Arup (2020) UXO Strategy states that it will be a contractual responsibility of future developers to implement the measures set out in that report, as a minimum.

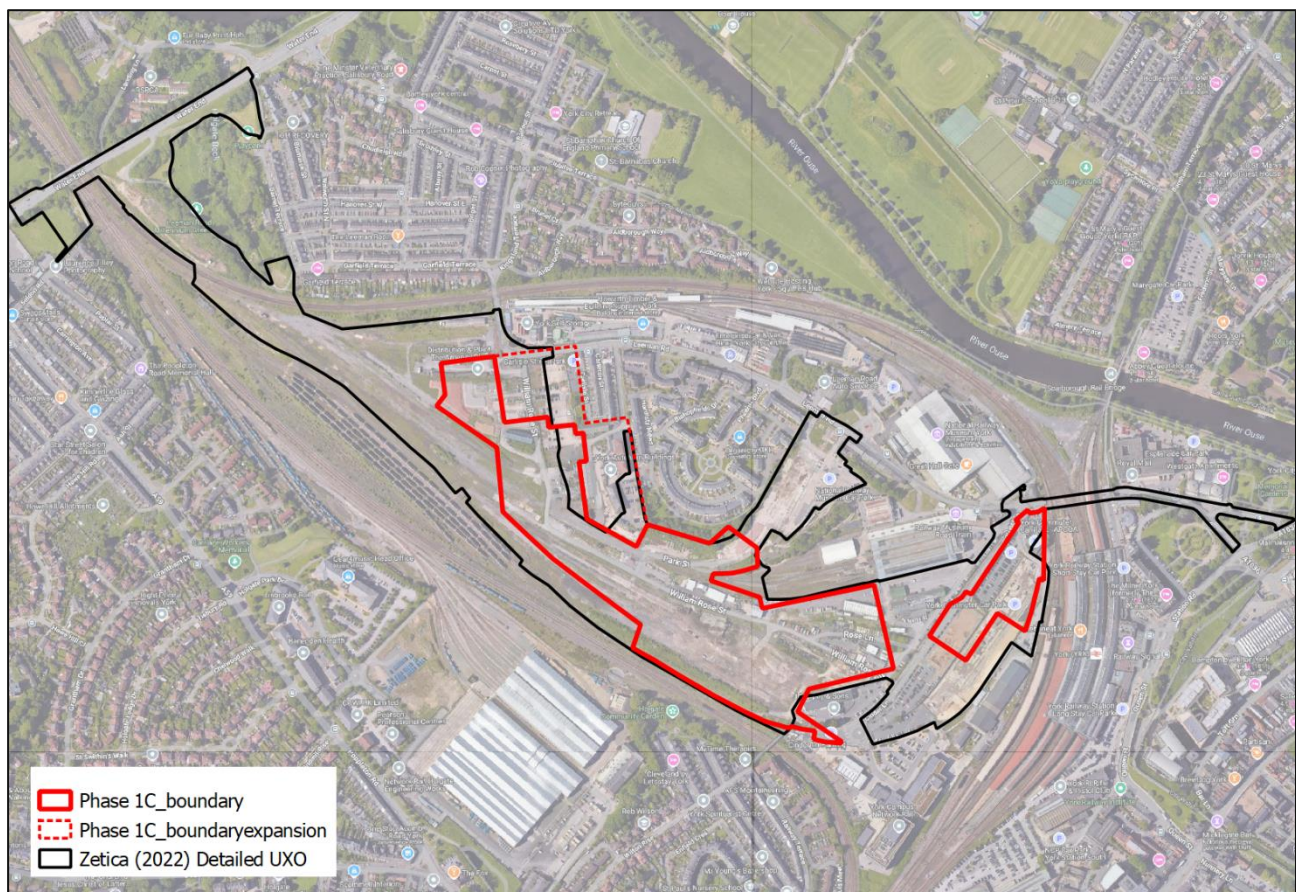


Figure 3-5 - Zetica (2022) Detailed UXO Risk Assessment boundary (IP2 works) compared with Phase 1C boundary.

4 Ground Conditions Summary & Geoenvironmental Assessment

4.1 General

This Section presents an overview of the site setting, environmental setting and geological conditions based on the information reviewed and summarised in Section 2. It also presents understanding of the likely contamination profile, Conceptual Site Model, and the likely scope of remediation.

4.2 Location and Current Site Use

The York Central masterplan area is located to the west of York City Centre. The site encompasses about 46 hectares of land to the west of York Railway Station, south-east of Severus Bridge at Millenium Green and north of the Freight Avoiding Lines. Construction works associated with Infrastructure Package 2 (IP2) are currently taking place across the majority of the area (see Figure 5-1 and observations from site walkover in Section 5.2).

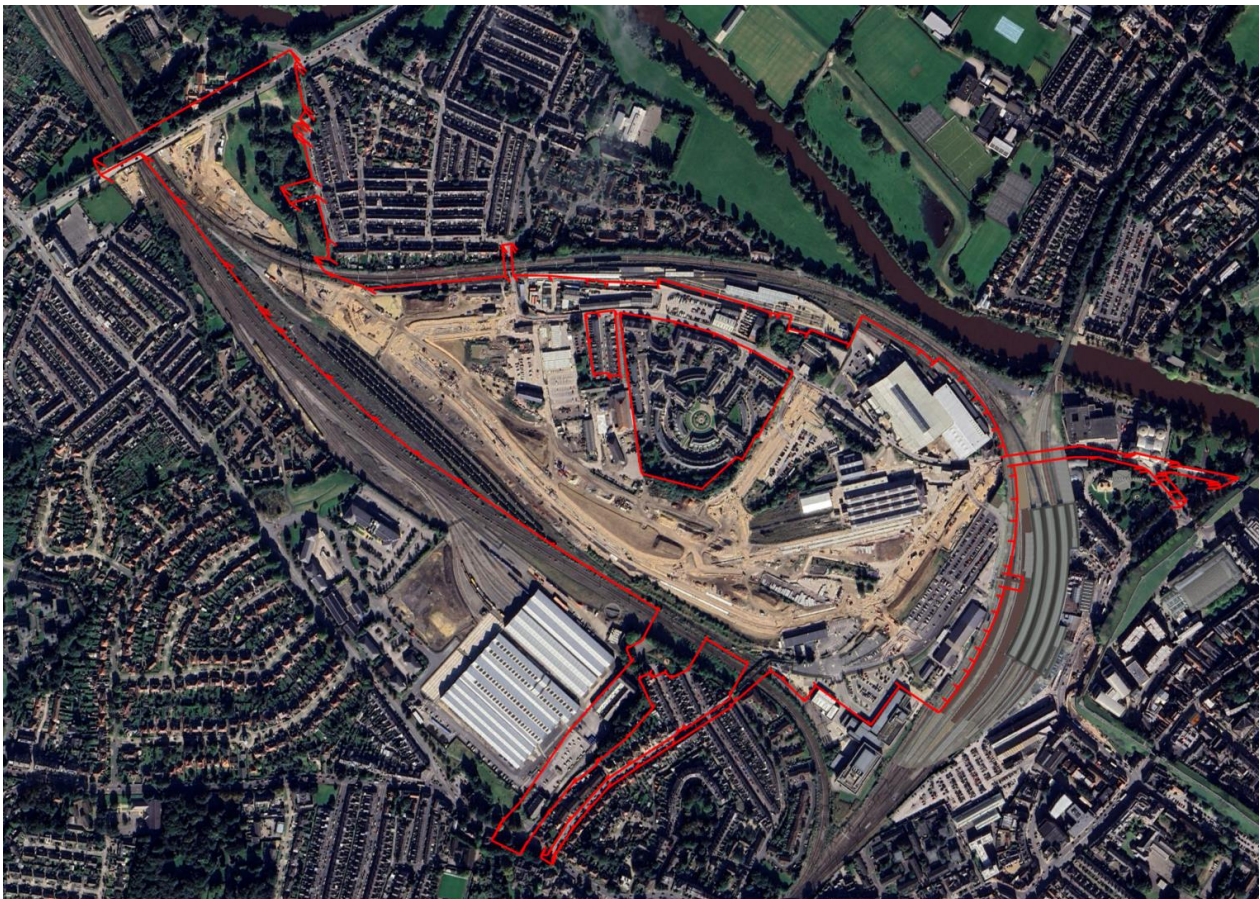


Figure 4-1 - Aerial image. September 2024 (Google Earth).

Other than the IP2 works, the following current uses are present:

- **Northwest:** Millenium Green, a public open space. Holgate Beck, a tributary to the River Ouse, runs through the green space entering a culvert, which extends below the site area towards the southeast.
- **Northeast:** occupied by the National Railway Museum, located on either side of Leeman Road. The complex includes the Great Hall and conferencing facilities to the north of Leeman Road and Grade II listed Museum building to the south.
- **North:** commercial / industrial uses including Howarth Timber & Building Supplies, York Self Storage, Leeman Road Auto Services, Hertz and Enterprise Car Rental.
- **South:** some rail sidings are present.
- **Southeast:** York Central Station and car parking.

The existing St Peter’s Quarter residential development and terrace housing along Carlton Street are located within the masterplan area but excluded from the development proposals.

4.3 Site History

The masterplan area has a long history of industrial development. This is summarised in Table 4-1 using maps and description provided in other reports [2, 10].

Table 4-1 - Summary of site history.

Date	Site use
1849	Majority of the study site was occupied by agricultural land. A single railway line passed through the site.
1892	Railway line has become multiple lines and sidings. Railway buildings present, including a wagon works, carriage works, engine shed and goods shed. Several above ground tanks also shown. A gasworks was present in the far northwestern corner – single gasholder to the north of the railway and three to the south. The Phoenix and Albion Works (an iron works) was present, with three old shafts to the west and southeast. The southeast of the site was identified as the site of a Roman Cemetery. The remaining undeveloped areas comprised open fields.
1910	The Phoenix and Albion Works was disused. The area to the north of Leeman Road was developed by additional tracks, sidings and an engine shed.
1929	The site of the Phoenix and Albion Works was shown as an Engineering Works. Formerly open land to the east now occupied by allotment gardens and a concrete depot.
1930s	A warehouse and water tower are present north of Leeman Road. Additional large building structures shown in former allotment area, used as a laundry. Garage workshops and a timber yard were identified north of Leeman Road. The gasworks was no longer marked, although one gasholder structure was still present. Several cattle pens were also shown.
1940s-1960s	Site is largely unchanged.
1972	Mapping shows a reduction in railway activity. Some sidings, engine shed, turntables and engineering works no longer present. Additional unspecified buildings present in centre of site. Slaughterhouse is present in the northwest of the site.
1980s-1990s	National Railway Museum established by 1985, with additional buildings and structures, including tanks to the west. Area to west of York Railway Station shown as a car park. Old shafts and former gasholder no longer present.
2000s-present	No significant change. Minor alterations to commercial / industrial buildings.

4.4 Geology

The anticipated ground conditions have been determined by reference to the relevant 1:50,000 and 1:10,000 geological maps, along with the available ground investigation information. In summary, the ground conditions comprise a variable thickness of Made Ground (generally 0.3 to 2.0m thick), beneath which is a thickness of superficial deposits (Alluvium and glacial deposits) and bedrock present between about 12 and 38m bgl.

Made Ground has been identified across the site with local variation in composition and thickness associated with historical land use – typically between 0.3 and 2.0m bgl, but locally to between 2.0m bgl and 4.0m bgl. Made Ground is underlain by superficial deposits from several geological units, see Figure 5-3 and Figure 5-2. These include Alluvium, Aine Glaciolacustrine Formation, York Moraine Member and the Vale of York Formation, which all outcrop at surface or are present beneath Made Ground. The Hemingborough Glaciolacustrine Formation is present at depth, above bedrock. Beneath the superficial deposits is bedrock of the Sherwood Sandstone Group, described as extremely weak to weak fine to medium grained sandstone – with the upper part sometimes weathered. The depth and elevation of the upper surface varied considerably throughout the site, varying between 12m bgl and 38.3m bgl.

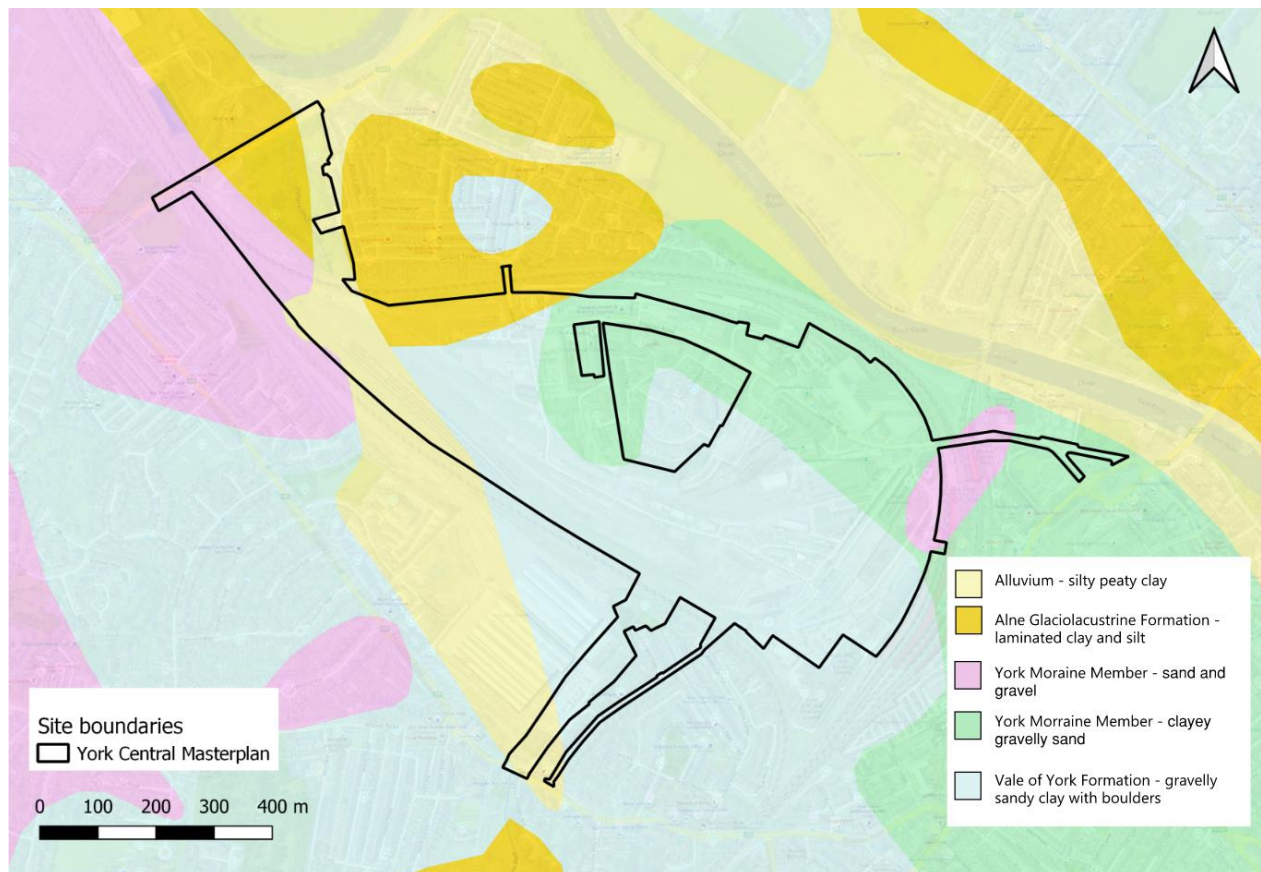


Figure 4-2 - 1:50,000 Superficial Geology (British Geological Survey, 2025)

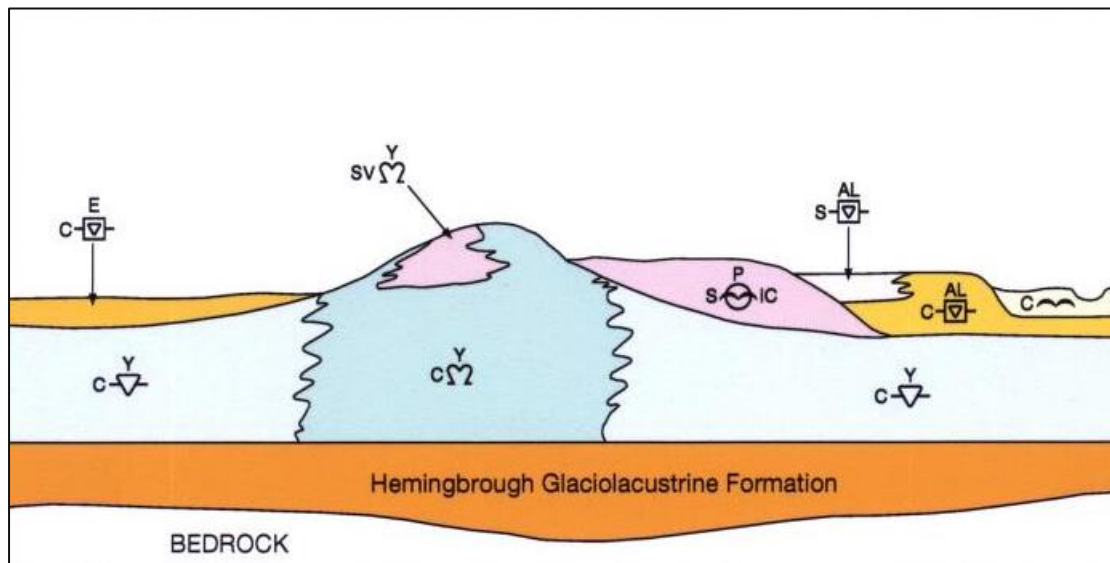


Figure 4-3 - Schematic drawing showing relationship of superficial deposits.

4.5 Hydrogeology

The Alluvium around the former Holgate Beck channel alignment is classified as a Secondary A Aquifer. The other superficial deposits are classified as Secondary (Undifferentiated) Aquifers. The Sherwood Sandstone is classified as a Principal Aquifer. The site does not lie within any Source Protection Zones (SPZ). The nearest recorded groundwater abstraction license is >800m distant.

Groundwater monitoring has been completed as part of previous ground investigations. Water strikes recorded in Made Ground were considered likely to represent perched groundwater. During the 2021 ground investigation, resting groundwater levels were similar in all strata between around +8m AOD in the west and between +10m AOD and +11m AOD in the east, corresponding with groundwater depths between ground level and 2.5m bgl. The investigation recorded artesian or subartesian conditions in all strata. There was considered to be continuity between all strata and upward vertical groundwater flow (i.e. groundwater is migrating vertically upwards from sandstone to superficial deposits).

4.6 Hydrology

The York Central masterplan area is located to the south of a meander in the River Ouse. A tributary to the Ouse, Holgate Beck, is present in a below ground culvert through the site, which is being diverted as part of the IP2 works. The nearest surface water abstraction is located about 190m northwest, a historical licences for abstraction of potable water from the River Ouse.

4.7 Archaeology

The site contains an archaeological landscape which has potential for significant prehistoric organic remains in deeper glacial undulations and potential significant prehistoric to Roman period archaeological features across the landscape in general. However, the large scale topographic engineering from the expansion of the railways and associated industry from the mid-19th century has either buried or truncated this earlier landscape. A previous report for Leeman's Yard concluded the following:

- There are part of the site where archaeology is likely to have been truncated, where it present at within 1.2m bgl or at greater depths.
- A watching brief for archaeological features should be maintained during ground investigation;
- Following ground investigations, evaluating trenching may be required over a maximum of 3% of the site. There may be potential to review these requirements due to practicalities.
- If significant archaeological remains are revealed, then further evaluation and / or mitigation will be required depending on the nature of the archaeology encountered.

4.8 Radon

According to the ukradon.org interactive map, all of the site is located in an area where less than 1% of homes are at or above the Action Level .

4.9 UXO

The site is located in an area that experienced aerial bombardment during WWII. Several reports relevant to UXO are currently available [33, 31, 30, 32], relevant to the masterplan and IP2 works areas. These reports present different conclusions regarding the potential level of risk associated with UXO. Refer to Section 3 for more information.

4.10 Contamination Profile

Made Ground has been recorded across the site, which frequently includes anthropogenic components such as coal, ash, slag, clinker etc. Ground investigations have also recorded generally isolated areas of visual and olfactory evidence of contamination including: hydrocarbon / tar odours, hydrocarbon sheen, black staining, landfill materials and sewage odour within Made Ground. Hydrocarbon odour or sheen was also occasionally recorded in underlying natural soils. Fragments of ACM were also occasionally recorded.

The Tetra Tech (2022) Outline Remediation Strategy for the York Central masterplan [10] includes an assessment of the ground investigation obtained by AIG (1998), Carl Bro (2006) [3, 4], Ramboll (2012) [11], WYG (2019) [7], WYG (2020) [8] and Tetra Tech (2021) [21, 22]. The report presents an assessment of the existing soils data (outside of the IP2 works area) which were screened against assessment criteria for a residential end use with plant uptake. Occasional exceedances were recorded for beryllium, lead, arsenic, mercury, naphthalene, benzo(bk)fluoranthene, dibenzo(ah)anthracene, benzo(a)pyrene and benzo(a)anthracene. Concentrations were generally at the same order of magnitude as the GAC. Asbestos was also recorded across the site, both disseminated in soils or present as visibly pickable fragments.

The majority of the ground investigation completed has been undertaken to support the IP2 works, therefore very limited ground gas monitoring has been completed. Intrusive investigation and gas monitoring will be required to support development of individual plots.

28no. groundwater samples obtained from across the York Central site were screened against the following water quality standards: Water Framework Directive (WFD), Environmental Quality Standards (EQS), WHO 2008, and UK Drinking Water Standards (UK DWS). Metals, PAH, TPH fractions, BTEX and inorganic compounds were identified at concentrations in excess of their respective screening criteria. The majority of the exceedances were recorded in samples from monitoring wells targeting superficial deposits. Very few exceedances were recorded for samples obtained from wells screening bedrock. These were recorded for manganese (3 samples), nickel, zinc and TPH aliphatic C12-C16 (all 1 sample). The majority of exceedances were recorded in the vicinity of the former gasworks.

4.11 Conceptual Site Model

4.11.1 Contamination Sources

A number of potential contamination sources have been identified from the review of information presented above and in Appendix B. These relate to the presence of Made Ground across the site as well as historical and current site uses. The potential contamination sources identified by Buro Happold are summarised in Table 4-2.

Table 4-2 - Summary of Potential Contamination Sources.

Potential Source	Location	Likely Age	Potential Contaminants of Concern
Made Ground	Site-wide	> 100 years	Metals, asbestos, PAHs, TPH Ground gas (carbon dioxide, methane, trace gases) and vapours
Historical gas works area	On-site – northwest corner	> 100 years	Metals, asbestos, PAHs, TPH, cyanide, pH, gasworks wastes Ground gas (carbon dioxide, methane, trace gases) and vapours
Current or historical above ground storage tanks	On-site – discrete locations	> 100 years to recent	PAHs, TPH, oils Vapours
Current or historical railway buildings	On-site – covering large proportion of area	> 100 years to recent	Metals, asbestos, PAHs, TPH
Historical site uses (Phoenix & Albion Works, Engineering Works, Slaughter House)	On-site	50 to 100 years	Metals, asbestos, PAHs, TPH
Railway lines and sidings	On-site – covering large proportion of area	> 100 years to recent	Metals, asbestos, PAHs, TPH
Former petrol filling station	On-site	Approx. 50 years	PAHs, TPH, oils Vapours

4.11.2 Pathways and Receptors

A mixed-use development is proposed at York Central, including residential and commercial uses. The presence of contamination (in soils, liquids or gases) has the potential to impact upon human and environmental receptors both in the short term (during construction) and in the long term (during use and occupation). Those receptors and the pathways that could link them to the sources identified in Table 4-2 are summarised below.

Receptor		Pathway
Human Health	Investigation and construction workers	Direct / dermal contact. Ingestion / inhalation of dusts. Inhalation of gas / vapour.
	Future site users / visitors (residents, workers)	Direct / dermal contact. Ingestion / inhalation of dusts. Inhalation of gas / vapour.
	Off-site occupiers / neighbours	Inhalation of contaminated dusts.
Controlled Waters	River Ouse	Migration via permeable strata, lateral migration and preferential pathways (e.g., earthworks, piling)
	Holgate Beck	Migration via permeable strata, lateral migration and preferential pathways (e.g., earthworks, piling)

Receptor		Pathway
	Secondary Aquifer (superficial deposits)	Migration via permeable strata and preferential pathways (e.g., piling)
	Principal Aquifer (bedrock)	Migration via permeable strata and preferential pathways (e.g., piling)
Built Environment	Buildings / structures	Gas / vapour migration via shallow / permeable strata with accumulation to hazardous concentrations.
	Potable water supply	Direct contact and permeation.
	Below ground concrete	Direct contact and aggressive attack.

4.12 Remediation

4.12.1 Infrastructure Package 2 – Remediation Strategy

At the time of writing, the IP2 works are under construction. A Remediation Strategy [26], to be implemented as part of these works, was published in 2022 by Tetra Tech. A remediation options appraisal was undertaken which concluded the following techniques would be most appropriate at the site: ex-situ bioremediation or stabilisation / solidification of near surface hydrocarbons contaminated soils; hand-picking of asbestos containing materials; 300mm cover layer in landscaped areas; in-situ stabilisation of sludge / soils in the gasholder; and off-site disposal if necessary.

The scope of the remediation works therefore comprised:

- Excavation of soil source contamination requiring remediation;
- Investigation and assessment of any visually contaminated soils identified during the works to determine if the soils exceed relevant remediation criteria;
- Treatment and re-use of off-site disposal of soils exceeding the remediation criteria;
- Chemical testing of soils and screening against remediation criteria following treatment to determine if they are suitable for reuse;
- In-situ treatment or excavation of soils contained within the gasholder;
- Placement of a 300mm cover layer in landscaped areas; and
- Use of barrier pipe or ductile iron water pipes where placed in Made Ground.

Three sets of remediation criteria were developed for the site: Gasworks Remediation Criteria (GRC); Site Remediation Criteria (SRC); and landscaping / import criteria. The GRC was derived by dQRA and professional judgement and includes the TPH concentration of 2,000 mg/kg. This is considered to be a value above which hydrocarbon staining / free product / significant visible hydrocarbon contamination may be present. The GRC also includes a criterion for asbestos which is 'no visible asbestos containing material'. The SRC used the same TPH concentration of 2,000 mg/kg and 'no visible asbestos containing material'. The landscaping / import criteria were based on the generic, Public Open Space (Park) criteria, for use in the upper 300mm of soils places in areas of landscaping.

The following sources were identified as potentially requiring remediation: sources identified by screening laboratory data against the GRC and SRC; sources identified by visual evidence; sources identified by location of historical features (gasholder); and currently unknown sources that might be identified during the works.

4.12.2 York Central – Outline Remediation Strategy

Tetra Tech was also commissioned by Homes England to design an Outline Remediation Strategy for the York Central masterplan in 2022 (excluding IP2 works area) [10]. This has not been implemented but was intended as a guide to

future developers at York Central. This document provides an indication of the scope of remediation works that might be required across the masterplan and accepted by the regulator.

The report presented a remediation options appraisal and concluded that the following techniques would be most appropriate at the site: ex-situ bioremediation or stabilisation / solidification for near surface hydrocarbon, PAH or BTEX contaminated soils; in-situ stabilisation of material contained within the gasholder; hand-picking fragments of ACMs from soils; use of a cover layer in landscaped areas or gardens; in-situ stabilisation for sludge or soils contamination identified in the gasholder; and some off-site disposal as necessary. The outline scope of remediation works was therefore considered to comprise:

- Excavation and remediation of contamination and contaminated structures associated with the historical gasworks located in the west of the site;
- Excavation of identified areas of soil source contamination requiring remediation;
- Investigation and assessment of any visually contaminated soils identified during earthworks / construction to determine if the soils exceed relevant remediation criteria;
- Treatment and re-use or off-site disposal of soils exceeding the relevant remediation criteria;
- Chemical testing of soils and screening of data against relevant remediation criteria following treatment to determine if they are suitable for re-use on site;
- Placement of a 300mm cover layer in landscaped areas or 600mm in domestic gardens;
- Use of barrier pipe or ductile iron pipes for potable water supply.

It was also noted that a Piling Risk Assessment would be required prior to construction as well as hazardous ground gas risk assessment specific to each phase.

The report presents four sets of remediation criteria: Gasworks Remediation Criteria; Site Remediation Criteria; Landscaping / Import Criteria; Residential Development Criteria. The Site Remediation Criteria were intended to: assess soils to confirm presence and extent of soil contamination; assess arisings from excavations; validate excavations; and validate treated materials. The proposed criteria were total TPH of 2000 mg/kg and 'no visible asbestos containing material', therefore aligning with the criteria for the IP2 works. The same criteria were used as Gasworks Remediation Criteria. Landscaping / Import Criteria were based on Public Open Space (park) criteria, to be used for the upper 300mm of soils placed in areas of landscaping (excluding gardens). The Residential Development Criteria were based on generic, published Residential with Plant Uptake criteria, and were intended for the upper 600mm of soils to be placed in domestic gardens.

5 Basis of Design

5.1 General

This section provides a summary of the available ground investigation reports. It outlines the data that should be reprocessed or reassessed to facilitate gap analysis, necessary to ensure efficient scoping and specification of the additional ground investigations necessary for redevelopment during the next package of work.

5.2 Ground Investigation Information

The available ground investigation reports, as outlined in Section 2, are summarised in Table 5-1. Table 5-1 provides a summary of the contractor that completed the works, date of investigation, a description of the location / coverage of the works, identifies the availability of AGS data, and comments on the applicability / relevance of the data. Based on the information presented below, the following reports should be prioritised for reprocessing / reassessment during the next package of work:

- WYG (2020) City of York Council. York Central. Ground Investigation Report. June 2020.
- WYG (2020) City of York Council. York Central Phase 1. Ground Investigation Factual Report. August 2020.
- Tetra Tech (2021) IP2 York Central Geoenvironmental Ground Investigation Report. September 2021. BS029728.
- Tetra Tech (2021) IP2 York Central Geotechnical Ground Investigation Factual Report. November 2021. B029728.
- Tetra Tech (2022) York Central Plot F. Factual Ground Investigation Report.
- Tetra Tech (2023) IP2 York Central. 2022 to 2023. Geo-Environmental and Geotechnical Ground Investigation Factual Report.

These reports have been identified because: the ground investigation data is relatively recent, available in electronic format, and has masterplan-wide applicability.

Table 5-1 - Available ground investigation reports.

Author and Date	Document Title	Project	Location	AGS Data	Comment
Carl Bro Group Ltd (2006)	Yorkshire Forward. York Central Regeneration Project. Volume 2 – Site Investigation Factual Report	York Central Masterplan	On-site – masterplan wide	X	Chemical data aged. Exploratory hole information useful for general understanding of ground conditions
Socotec (2017)	Contaminated Land Investigation: 5 Acre Site – Network Rail NDSMF, Holgate Wagon Works, York	5 Acre Site	Off-site	X	Provides information for an off-site plot. Shallow exploratory holes only. Chemical data likely superseded by development.
Jacobs (2019)	Network Rail PSU2 Accommodation Scheme – York Tear Drop Site. Phase 2 Contaminated Land Assessment Report. February 2019.	Network Rail Office	On-site – provides plot specific information	X	Potential that near surface soils and chemical data have been superseded by development of office.

Author and Date	Document Title	Project	Location	AGS Data	Comment
WYG (2020)	City of York Council. York Central. Ground Investigation Factual Report. June 2020	York Central Masterplan	On-site – masterplan wide	✓	Chemical data and exploratory hole information useful for understanding baseline and ground model.
WYG (2020)	City of York Council. York Central Phase 1. Ground Investigation Factual Report. August 2020.	York Central Masterplan	On-site – masterplan wide	✓	Chemical data and exploratory hole information useful for understanding baseline and ground model.
ListersGEO (2021)	Ground Investigation. National Railway Museum, Leeman Road. Report No: 21.04.023	National Railway Museum	Off-site - adjacent	X	Provides plot specific information. Ground investigation focussed on shallow ground conditions. Potential that information has been superseded by the development.
Tetra Tech (2021)	IP2 York Central Geoenvironmental Ground Investigation Factual Report. September 2021. B029728	Infrastructure Package 2	On-site – masterplan wide	✓	Chemical data and exploratory hole information useful for understanding baseline and ground model.
Tetra Tech (2021)	IP2 York Central Geotechnical Ground Investigation Factual Report. November 2021. B029728	Infrastructure Package 2	On-site – masterplan wide	✓	Chemical data and exploratory hole information useful for understanding baseline and ground model.
Tetra Tech (2022)	York Central Plot F. Factual Ground Investigation Report	Proposed Government Hub	On-site – provides plot specific information	✓	Chemical data and exploratory hole information useful for understanding baseline and ground model.
Tetra Tech (2022)	York Central, IP2 Area. Gasholder Contamination Investigation Report. 784-B0 28855	Infrastructure Package 2	On-site – provides plot specific information	X	Locations of exploratory holes located some distance from Phase 1C. Primary objective was to investigate location of gasholder.
Tetra Tech (2023)	John Sisk and Son Ltd. IP2 York Central. 2022 to 2023. Geo-Environmental and Geotechnical Ground Investigation Factual Report	Infrastructure Package 2	On-site – masterplan wide	✓	Report contains results of four phases of GI. Chemical data and exploratory hole information useful for understanding baseline and ground model.

5.3 Caveats and Limitations

At the time of writing, the IP2 works are under construction, which has a large degree of overlap with the masterplan area. A Remediation Strategy associated with those works has been published, as described in Section 4.12.1. This has enabled discharge of contamination-related planning conditions relevant to the IP2 works reserved matters planning application. Although the Remediation Strategy sets out the broad remediation principles and identifies source areas of contamination requiring remediation, it does not provide detailed information in terms of the location and depth of excavation / earthworks. There is therefore potential for ground investigation data for shallow strata within the IP2

works boundary to have been superseded by the current construction works. Receipt of a Verification Report and accompanying verification data for the IP2 works will be critical for understanding the baseline condition in this area.

6 References

Appendix A Reviewed Information

Author and Date	Document Title and Reference	Document Type	Project / Site	Location	Document link
Entec (1998)	National Railway Museum. Land Quality Review of Former Concrete Works. November 1998.	Desk Study / Preliminary Risk Assessment	Former Concrete Works	Off-site - adjacent	1998-11-16 Entec Land Quality Review - Former Concrete Works.pdf
Carl Bro Group Ltd (2006)	York Central Regeneration Project. Stage 1 Preliminary Site Evaluation. Volume 1. February 2006.	Desk Study / Preliminary Risk Assessment	York Central Masterplan	Overlaps with Phase 1C	2008 Carl Bro York Central Preliminary Site Evaluation.pdf
Carl Bro Group Ltd (2006)	Yorkshire Forward. York Central Regeneration Project. Volume 2 – Site Investigation Factual Report	Factual Report	York Central Masterplan	Overlaps with Phase 1C	2006 Carl Bro Factual Ground Investigation Report.pdf
Carl Bro Group Ltd (2006)	Yorkshire Forward. York Central Regeneration Project. Volume 3- Site Investigation Interpretative Report. May 2006	Interpretative Report	York Central Masterplan	Overlaps with Phase 1C	2006-05 Carl Bro York Central Interpretative SI Report.pdf
Grontmij (2008)	Yorkshire Forward. York Central Regeneration Project. Geotechnical Update. February 2008	Desk-based review	York Central Masterplan	Overlaps with Phase 1C	2008-02 Grontmij Geotechnical Update.pdf
Grontmij (2008)	Yorkshire Forward. York Central Regeneration Project. Contaminated Land Issue Update. March 2008	Desk-based review	York Central Masterplan	Overlaps with Phase 1C	2008-03-19 Grontmij Contaminated Land Update Report.pdf
Ramboll (2012)	York Engineers’ Triangle Contaminated Land and Geotechnical Desk Study Report	Desk Study / Preliminary Risk Assessment	Engineers’ Triangle	Offsite – adjacent	Training and Rail Operations 12-01176-FULM
Socotec (2017)	Contaminated Land Investigation: 5 Acre Site – Network Rail NDSMF, Holgate Wagon Works, York	Desk Study / Preliminary Risk Assessment, Interpretative Report	5 Acre Site	Offsite – 100m south	Network Rail Track Infrastructure 17-02906-FULM
Arup (2018)	York Central Partnership. York Central: Phase 1 Infrastructure Corridor. Geotechnical and geoenvironmental desk study. YCL-ARP-ZZ-XX-RP-CG-0001	Desk Study / Preliminary Risk Assessment	Infrastructure Package 2	Overlaps with Phase 1C	Arup 2018.06 Desk Study YCL-ARP-ZZ-XX-RP-CG-0001 (2).pdf
Jacobs (2018)	Network Rail PSU2 Accommodation Scheme – York Tear Drop Site. Preliminary Risk Assessment. July 2018	Desk Study / Preliminary Risk Assessment	Network Rail Office	Overlaps with Phase 1C	PRELIMINARY RISK ASSESSMENT-2032468.pdf
Jacobs (2019)	Network Rail PSU2 Accommodation Scheme – York Tear Drop Site. Phase 2 Contaminated Land Assessment Report. February 2019.	Interpretative Report	Network Rail Office	Overlaps with Phase 1C	PHASE 2 CONTAMINATED LAND ASSESSMENT-2110162.pdf
Jacobs (2019)	Network Rail PSU2 Accommodation Scheme – York Tear Drop site. Remediation Statement	Remediation Strategy	Network Rail Office	Overlaps with Phase 1C	https://burohappold.sharepoint.com/:b:/r/sites/052817/Shared%20Documents/Ground%20Engineering/01%20Site%20Information/01%20Reports/Network%20Rail%20Office%2018-01685-FULM/PSU2_ACCOMMODATION_SCHEME_-_REMEDIATION_STATEMENT-2172583.pdf?csf=1&web=1&e=OULUgs
WYG (2020)	City of York Council. York Central. Ground Investigation Factual Report. June 2020	Factual Report	York Central Masterplan	Overlaps with Phase 1C	A109518 York Central Factual Report
WYG (2020)	City of York Council. York Central Phase 1. Ground Investigation Factual Report. August 2020.	Factual Report	York Central Masterplan	Overlaps with Phase 1C	York Central Archaeological GI Report FINAL
Arup (2020)	City of York Council. York Central: Phase 1 Infrastructure Corridor. Geoenvironmental assessment and outline remediation strategy. YCL-ARP-IP2-XX-RP-CG-0003	Interpretative Report, Remediation Strategy	Infrastructure Package 2	Overlaps with Phase 1C	2020.08 ARUP YCL-ARP-IP2-XX-RP-CG-0003 Geo Env Assessment and RS.pdf
ListersGEO (2021)	Ground Investigation. National Railway Museum, Leeman Road. Report No: 21.04.023	Desk Study / Preliminary Risk Assessment, Interpretative Report	National Railway Museum	Off-site - adjacent	AOD_23_00120-GROUND INVESTIGATION-2582210.pdf
Graham Construction	National Railway Museum. Great Hall Courtyard. Remediation Implementation Plan	Remediation Strategy	National Railway Museum	Off-site - adjacent	REMEDIATION IMPLEMENTATION PLAN-2643063.pdf
Tetra Tech (2021)	Leeman’s Yard. York Central. Desk Top Appraisal of Geo-Environmental, Geotechnical and Archaeological Risks and Constraints. July 2021	Desk-based review	Leeman’s Yard	Overlaps with Phase 1C	Leeman\u0027s Yard B028855 DR v3 FINAL (FULL REPORT).pdf
Tetra Tech (2021)	Leeman’s Yard. Obstructions Plan	Drawings	Leeman’s Yard	Overlaps with Phase 1C	B028855-TTE-00-00-DR-U-0512 (Leemans Yard Obstructions and Constraints Plan) v2.pdf
Tetra Tech (2021)	IP2 York Central Geoenvironmental Ground Investigation Factual Report. September 2021. B029728	Factual Report	Infrastructure Package 2	Overlaps with Phase 1C	TT IP2 2021 York Central Geoenvironmental Factual Report Reduced File Size
Tetra Tech (2021)	IP2 York Central Geotechnical Ground Investigation Factual Report. November 2021. B029728	Factual Report	Infrastructure Package 2	Overlaps with Phase 1C	IP2 York Central Geotechnical Factual Report Final Nov 2021 (2)
Tetra Tech (2021)	York Central. Phase 1 Infrastructure. Geo-environmental Interpretative Report. B028855	Interpretative Report	Infrastructure Package 2	Overlaps with Phase 1C	IP2 Reserved Matters 20-00710-REMM
Tetra Tech (2022)	York Central Outline Earthworks Strategy. February 2022.	Earthworks Strategy	York Central Masterplan	Overlaps with Phase 1C	B028855 York C Outline FW Strat V2 fin.pdf
Tetra Tech (2022)	York Central Outline Remediation Strategy	Remediation Strategy	York Central Masterplan	Overlaps with Phase 1C	B028855 York Central Outline Remediation Strategy V1 FINAL Part 1 text only .pdf

Author and Date	Document Title and Reference	Document Type	Project / Site	Location	Document link
Tetra Tech (2022)	Combined Tetra Tech Drawings	Drawings	Infrastructure Package 2	Overlaps with Phase 1C	Contam.pdf EWS V2 Feb 2022 Combined TT Drawings (.pdf ground investigation.pdf Obstructions.pdf
Atkins (2022)	Proposed Government Hub at York Central. Ground Investigation Report. YRK2-ATK-ZZ-XX-RP-G-000006_R03. August 2022	Interpretative Report	Proposed Government Hub	Within Phase 1C	Government Hub Reserved Matters 23-02255-REMM
Tetra Tech (2022)	York Central, IP2 Area. Gasholder Contamination Investigation Report. 784-B0 28855	Factual Report	Infrastructure Package 2	Overlaps with Phase 1C	https://burohappold.sharepoint.com/:b:/r/sites/052817/Shared%20Documents/Ground%20Engineering/01%20Site%20Information/01%20Reports/IP2%20Reserved%20Matters%2020-00710-REMM/GASHOLDER CONTAMINATION INVESTIGATION REPORT-2557041.pdf?csf=1&web=1&e=NT4gey
John Sisk & Sons (2022)	York Central CL:AIRE Materials Management Plan	Materials Management Plan	Infrastructure Package 2	Overlaps with Phase 1C	York Central CLAIRE Materials Management Plan (MMP).doc
Tetra Tech (2022)	York Central Phase 1 Infrastructure Works Remediation Strategy. Version 3. November 2022. B028855	Remediation Strategy	Infrastructure Package 2	Overlaps with Phase 1C	IP2 Reserved Matters 20-00710-REMM
Tetra Tech (2023)	The Square, York Central. Geo-environmental Desk Study Assessment	Desk Study / Preliminary Risk Assessment	The Square	Overlaps with Phase 1C	https://burohappold.sharepoint.com/:f:/r/sites/052817/Shared%20Documents/Ground%20Engineering/01%20Site%20Information/01%20Reports/The%20Square%2023-01494-REMM?csf=1&web=1&e=RGbHKH
Tetra Tech (2023)	John Sisk and Son Ltd. IP2 York Central. 2022 to 2023. Geo-Environmental and Geotechnical Ground Investigation Factual Report	Factual Report	Infrastructure Package 2	Overlaps with Phase 1C	IP2 York Central Factual Report July 2023 Issue 3.pdf
Sweco (2023)	York Central Phase 2 Infrastructure Project (IP2). Addendum Ground Investigation Report (GIR). May 2023	Interpretative Report	Infrastructure Package 2	Overlaps with Phase 1C	5762-SWE-IP2C-ZZ-RP-CG-06003 Ground Investigation Report (GIR).pdf

Appendix B Technical Review of Available Reports

This Appendix presents a technical review / summary of the available reports relevant to ground conditions, as summarised in Section 2.

B.1 Former Concrete Works

B.1.1 Entec (1998) Land Quality Review of a Former Concrete Works [1]

This report relates to an area of land referred to as the Former Concrete Works. It is located within the York Central masterplan area and adjacent to the north of the Phase 1C boundary. The report was prepared by Entec on behalf of the National Railway Museum, who were considering acquisition of the land from the City of York to expand their operations. The aims of the review were to: review the existing site investigation information completed by AIG in 1998 (*not available for review by Buro Happold*); review the site's environmental setting; make recommendations for future ground investigation; and provide outline remediation proposals.

The study area was identified as former railway land. The buildings on the Leeman Road frontage were used as stables and a building on the west side was a concrete factory, producing precast units such as sleepers and manhole rings.

From review of existing ground investigation information, contamination within the study area was generally confined to ashy fill material forming the upper layer of Made ground. This material was described as a sandy gravel, consisting mainly of ash, clinker, brick and coal. Elevated concentrations of some metals were recorded within this material. Diesel odours were recorded in two trial holes within natural material.

B.2 York Central Masterplan

B.2.1 Carl Bro (2006) York Central Regeneration Project. Stage 1 Preliminary Site Evaluation [2]

Carl Bro was commissioned by the City of York Council to carry out a feasibility study for the masterplan area for the York Central Regeneration Project. The objectives of the study were to carry out a desk top review of the available technical data, provide recommendations for additional studies, establish likely constraints to development, prepare cost estimates for development, and determine the contamination status of the area.

The report identified a number of former and present activities which may have led to the presence of residual contamination within the study area (including heavy metals, fuel oils, solvents, acids, asbestos and biological pathogens). It also identified a number of tanks within the area and the potential for the high organic matter content within Warp and Lacustrine Clays to generate ground gas.

The Sherwood Sandstone, present at about 15m bgl, was identified as a Major Aquifer (current Principal Aquifer). The River Ouse was identified adjacent to the northeast boundary. Historical OS plans indicate the presence of two shafts within the study area. The report notes that the Coal Authority confirmed the site had not been undermined and were not aware of any shafts within the study area. It was considered possible that one of the shafts is a disused pumping station. The whole of the study area is of archaeological interest, meaning detailed Desk Study and Archaeological Field Evaluation would be required as part of development.

The report made high-level comment on the likely scope of remediation. Presence of localised contamination was considered likely to be present in the vicinity of specific contaminating activities, requiring hotspot removal / treatment. Due to anticipated widespread distribution of heavy metal / inorganic / asbestos contaminants, a cap

barrier system was also considered likely to be required. These requirements would be reviewed following completion of ground investigations.

B.2.2 Carl Bro (2006) York Central Regeneration Project. Multi Disciplinary Engineering Study. Volume 2 – Site Investigation Factual Report [3]

Carl Bro prepared a Factual Site Investigation Report on behalf of Yorkshire Forward. The scope of the investigation works comprised: 20no. boreholes; 8no. rotary follow-on boreholes; 69no. window sample boreholes; sampling of soils; chemical analysis; geotechnical testing; gas monitoring; groundwater sampling and monitoring; and surface water sampling.

Made Ground was recorded across most of the site and was present to depths up to 4m bgl. The upper layers of the were dominated by ballast, ash and clinker. Some of the site contained reworked natural soils underlying black ashy gravel, thought to be associated with the levelling of the land prior to its railway and industrial development. Black staining and organic / hydrocarbon / sulphurous odours were recorded at various locations in Made Ground.

Quaternary Drift deposits were encountered to thicknesses of 15 to 20m, comprising mixed alluvial deposits (soft, organic rich clays, sandy clays, sands and gravel), with glacially derived Boulder Clay (firmer, sandy gravelly clay with large cobbles and boulders at base). Discrete layers of peat were also recorded. Bedrock comprised Sherwood Sandstone, described as grey-brown, fine to medium grained, weak, weathered sandstone. This was recorded to have an undulating surface, occurring between depths of 11.15m bgl and 19.8m bgl.

Obstructions and buried features were encountered at certain locations, including: wooden sleepers and buried drums; fragments of suspected asbestos containing corrugated roofing; engine shed foundations; wooden sleepers and scrap metal; buried demolition rubble; a void, thought to be a buried kiln or similar; and wooden floor.

Limited perched water was encountered at the base of the Made Ground. Groundwater strikes occurred throughout the Drift deposits. One groundwater strike was made in the Sherwood Sandstone aquifer at 12m bgl.

B.2.3 Carl Bro (2006) York Central Regeneration Project. Multi Disciplinary Engineering Study. Volume 3 – Site Investigation Interpretative Report [4]

This interpretative report presents an assessment of the findings from a ground investigation conducted to assist the client in evaluating feasibility of proposed redevelopment. The report notes that only limited contamination was identified, associated with Made Ground and localised 'hot spot' areas. Ground conditions across much of the site are such that it is likely that any unidentified contaminant sources that may be present, are likely to be relatively well contained and limited to areas close to the original contamination source.

The report describes that most of the identified contamination can be managed by careful design and management of soils. The identified outline remediation measures include: clean cover in soft landscaped areas / presence of hardstanding; local remediation of soils to mitigate risks to groundwater; use of suitable materials for potable water supply pipework; implementing health and safety measures to mitigate risk to construction; and passive ground gas protection measures. Localised soil treatment might be required, such as in-situ treatment, ex-situ bioremediation, and replacement of treated fill in 'hot spot' areas. Additional ground investigation and assessment was also noted to be required in areas that were inaccessible.

Due to the highly variable nature of Made Ground and alluvium, spread foundations were not considered viable for the proposed development. Lightly loaded spread foundations (i.e., for structures less than two storeys) may be viable at some locations. Where alluvial deposits extend to >2m in depth, it is likely that ground improvement would be

required to improve settlement and bearing capacity characteristics. Piled foundations were considered appropriate for most of the proposed development and the report provided typical pile design parameters.

B.2.4 Grontmij (2008) York Central Regeneration Project. Geotechnical Update

Grontmij Limited (formerly Carl Bro) was commissioned to provide a re-appraisal of the geotechnical issues relating to the York Central regeneration project, as presented in the Carl Bro (2006) factual and interpretative reports [3, 4]. This was requested due to changes in the proposed masterplan. The conclusions of the previous studies were considered to remain broadly applicable. However, the Geotechnical Update noted that the updated masterplan included higher-rise buildings, basements and semi-basements that had not previously been considered and which would require assessment.

B.2.5 Grontmij (2008) York Central Regeneration Project. Contaminated Land Issues Update

Grontmij Limited was commissioned to provide a reappraisal of land contamination issues related to the York Central regeneration project, as presented in the Carl Bro (2006) factual and interpretative reports [3, 4]. The data obtained during the 2006 ground investigation were re-screened against Generic Assessment Criteria (GACs) published by the Chartered Institute for Environmental Health (CIEH) and Land Quality Management Ltd in November 2006. This generally resulted in a greater number of exceedances of soil screening values used for human health assessment, however the direct implications of this in terms of remediation requirements were considered to be limited. Grontmij concluded that overall recommendations presented in the Carl Bro (2006) Interpretative Report remained largely applicable [4].

B.2.6 WYG (2020) York Central. Ground Investigation Factual Report [7]

WYG were commissioned by City of York Council to undertake a ground investigation to inform the proposed York Central redevelopment. The scope of the ground investigation comprised: UXO clearance; utility clearance; archaeological watching brief; 16no machine excavated trial pits; 13no. hand excavated trial pits; 6no. cable percussion boreholes with rotary follow-on; 17no. windowless sample holes; 8no. Cone Penetration Tests (CPT); 19no. continuous shear wave geophysics locations; 6no. windowless sample holes for archaeological purposes; 1no. machine excavated trial pit for archaeological purposes; 4no. plate bearing tests; and 4no. dynamic cone penetrometer tests.

Several obstructions and constraints were recorded during the works, including: masonry wall; concrete obstructions; suspected utilities (reddish brown, black and yellow ducting, orange plastic pipe). Evidence of contamination included hydrocarbon odours, landfill material, sheen, sewage odour, and tar odour. This was mainly recorded in the Made Ground but extended into natural strata in some locations.

B.2.7 WYG (2020) York Central Phase 1. Ground Investigation Factual Report [8]

WYG were commissioned by City of York Council to undertake a ground investigation for the proposed York Central redevelopment scheme. The purpose of the ground investigation was to investigate the potential for archaeological deposits and features of importance. The scope of ground investigation comprised: 10no windowless sample holes with groundwater monitoring installations; 17no windowless sample holes; 8no. machine excavated trial trenches; 51no. machine excavated trial pits; utility clearance; UXO watching brief; archaeological watching brief; and installation of groundwater level transducer dataloggers, groundwater quality dataloggers and barometric logger. The exploratory hole logs recorded occasional Victorian artefacts.

B.2.8 Tetra Tech (2022) York Central Outline Earthworks Strategy [9]

Tetra Tech was commissioned by Homes England and Network Rail to prepare an outline earthworks strategy for the proposed redevelopment at York Central. The outline earthworks strategy considers development levels for the York Central site, but excludes any design for the Phase 1 Infrastructure Works (see Section **Error! Reference source not found.**). Tetra Tech note that liaison was completed with the contractor and designer for the Phase 1 Infrastructure Works to ensure that the design levels are coordinated. The document summarises the overall strategy, principles, and general method of approach to the proposed earthworks. The objectives of the strategy were to: estimate bulk earthworks volumes to provide suitable development platforms; estimate and optimise final development levels; estimate and optimise space for surplus material storage; optimise cut / fill balance across the site; minimise the requirement for imported materials; minimise the requirement for off-site disposal; identify next steps for optimising materials re-use.

B.2.9 Tetra Tech (2022) York Central Outline Remediation Strategy [10]

Tetra Tech was commissioned by Homes England to design an Outline Remediation Strategy for York Central. It was intended to be used as an overall strategy and guide for the Homes England project, describing remediation and required next steps to address ground and groundwater contamination. The report notes that more detailed remediation strategies will be developed for planning submission for phases of the development as they come forward. The IP2 works were excluded from the strategy.

The most significant area of contamination was expected to be the demolished gasworks at the northwestern end of the site. Other remaining sources with the potential to adversely affect the health of future site users include asbestos, hydrocarbons, and hydrocarbon impacted Made Ground, resulting from the site's historical uses. These were identified on a Drawing that was not included with the version of the report that was provided. Given the limited nature of ground investigation data outside of the IP2 works boundary, there was considered to remain the potential for as yet unidentified areas of contamination across the site, which may require remediation.

The report presents an assessment of the existing soils data which were screened against assessment criteria for a residential end use with plant uptake. Occasional exceedances were recorded for beryllium, lead, arsenic, mercury, naphthalene, benzo(bk)fluoranthene, dibenzo(ah)anthracene, benzo(a)pyrene and benzo(a)anthracene. Concentrations were generally at the same order of magnitude as the GAC. Asbestos was also recorded across the site, both disseminated in soils or present as visibly pickable fragments. At the time of writing, very limited ground gas monitoring had been completed and the report noted that intrusive investigation and gas monitoring would be required to support development of individual plots. The report also assessed the available groundwater data (total of 28no. samples). Groundwater samples taken from wells screened in superficial deposits in the area surrounding the former gasworks identified contaminants with the potential to adversely affect controlled waters. Monitoring wells screened within the underlying bedrock recorded only zinc in exceedance of the relevant screening criteria. As such, it was considered that contaminants within the groundwater bodies within the superficial deposits are not impacting the underlying Principal Aquifer. This may be due to the artesian / sub-artesian nature of the groundwater, resulting in vertical groundwater flow.

The report presented a remediation options appraisal and concluded that the following techniques would be most appropriate at the site: ex-situ bioremediation or stabilisation / solidification for near surface hydrocarbon, PAH or BTEX contaminated soils; in-situ stabilisation of material contained within the gasholder; hand-picking fragments of ACMs from soils; use of a cover layer in landscaped areas or gardens; in-situ stabilisation for sludge or soils contamination identified in the gasholder; and some off-site disposal as necessary. The outline scope of remediation works was therefore considered to comprise:

- Excavation and remediation of contamination and contaminated structures associated with the historical gasworks located in the west of the site;
- Excavation of identified areas of soil source contamination requiring remediation;
- Investigation and assessment of any visually contaminated soils identified during earthworks / construction to determine if the soils exceed relevant remediation criteria;
- Treatment and re-use or off-site disposal of soils exceeding the relevant remediation criteria;
- Chemical testing of soils and screening of data against relevant remediation criteria following treatment to determine if they are suitable for re-use on site;
- Placement of a 300mm cover layer in landscaped areas or 600mm in domestic gardens;
- Use of barrier pipe or ductile iron pipes for potable water supply.

It was also noted that a Piling Risk Assessment would be required prior to construction as well as hazardous ground gas risk assessment specific to each phase.

B.3 York Engineers' Triangle

B.3.1 Ramboll (2012) York Engineers' Triangle. Contaminated Land and Geotechnical Desk Study

Ramboll was commissioned by BAM Construction Ltd to undertake a geotechnical and contaminated land Desk Study related to the proposed development of York Engineers Triangle, comprising a training facility, rail operation centre, ancillary and service buildings. The objectives of the report were to: determine the probable ground and groundwater conditions; provide a preliminary foundation design assessment; assess the potential contamination related risks; provide recommendations for site investigation; determine the suitability of the site for the proposed end use; and provide information to support a planning application.

Geotechnical hazards were considered to include: variability of Made Ground and superficial strata; presence of archaeological artefacts (restricting type of foundations can be used); variability in properties of sandstone; and shallow groundwater. Ramboll considered the development proposals to be of low sensitivity. A moderate risk was identified associated with construction and / or maintenance workers in excavations, water in buried culverts, ground gas/vapours, and UXO. Risks to existing and future site users from soil and gas/vapours, risks to groundwater, surface water in buried culverts, buried services, concrete and plants in soft landscaping were considered to be moderate/low or less. It was considered unlikely that specific contamination remediation would be required, but instead mitigation would be required as part of the development.

B.4 5 Acre Site

B.4.1 Socotec (2017) 5 Acre Site - Network Rail NDSMF. Contaminated Land Investigation

Socotec was commissioned by Network Rail to undertake a Phase 1 and 2 contaminated land investigation, associated with Network Rail's proposals to reinstate a fan of railway tracks leading from a depot access line to existing carriage shed. The proposals would involve scraping and levelling the uppermost layer of soil only. The report includes description of the initial conceptual site model (but no formal preliminary risk assessment), which was used to inform the scope of ground investigation. The scope of ground investigation included hand-excavation of 10no. trial pits to depths of 0.6m bgl and collection of samples for chemical analysis (one from each trial pit). Concentrations of all inorganic and organic determinands were below screening criteria for a commercial land-use and there are no evidence / detection of asbestos containing materials.

B.5 Network Rail Office

B.5.1 Jacobs (2018) York Tear Drop Site. Preliminary Risk Assessment

Jacobs was commissioned by Network Rail to undertake a Preliminary Risk Assessment for the proposed construction of modular office accommodation. The objectives of the report were to: review desk-based information related to the site history and its environmental and geological setting; review existing ground investigation data; develop an initial Conceptual Site Model (CSM); and consider the impacts of the contamination-related risks on the development scheme.

The Preliminary Risk Assessment concluded that risk to construction workers associated with surface contamination in Made Ground was Moderate. The risk associated with gaseous emissions from Made Ground was also assessed as Moderate, to both construction and maintenance workers and future site users. Risks to future site users, neighbours and buildings from potential contamination and ground gas sources were assessed as Very Low to Moderate / Low. Risks to controlled waters were Very Low. It was not considered that contaminative sources would pose a significant constraint to the proposed redevelopment.

B.5.2 Jacobs (2019) York Tear Drop Site. Phase 2 Contaminated Land Assessment Report

Jacobs was commissioned by Network Rail to undertake a Phase 2 intrusive investigation and risk assessment to discharge contamination-related planning conditions for the proposed development. The scope of intrusive works comprised: 5no. cable percussion boreholes; installation of groundwater and ground gas monitoring standpipes; SPTs within boreholes; 24no. machine excavated trial pits; 8no. CPTs; 3no. soakaway tests; obtaining soil samples from exploratory holes and a ballast stockpile; 4no. rounds of post fieldwork monitoring; and chemical and geotechnical testing.

Ground conditions generally comprised localised topsoil, concrete or tarmac hardstanding over Made Ground to depths between 0.3 and 4.0m bgl, typically comprising silty gravelling sand with ash. The Made Ground is underlain by the Vale of York Formation to depths of around 20m bgl, comprising interbedded, locally organic, clayey gravelly sand, sandy gravelly clay and clayey sandy gravel. The underlying bedrock comprises the Sherwood Sandstone Group. Groundwater was encountered within the Vale of York Formation and was typically associated with granular layers. There was no discernible trend or gradient to the groundwater levels. Localised visual and / or olfactory evidence of contamination was recorded within the Made Ground and Vale of York Formation, including hydrocarbon odours and staining and suspected ACMs.

The assessment of soil chemical data with respect to human health screening criteria recorded localised elevated lead. Asbestos was also recorded in several locations within Made Ground and a central rail ballast stockpile. There were several elevated inorganic and organic contaminants in soil leachate and within groundwater in the Vale of York Formation. The potential risk to construction workers, future maintenance workers and adjacent land users associated with elevated lead in Made Ground was assessed as Moderate to Low, while the risk to future site users was assessed as Low. The potential risk to construction workers and future maintenance workers associated with asbestos in Made Ground was assessed as Moderate, while the risks to adjacent land users and future site users was Moderate to Low and Low respectively. The potential risk to the Vale of York Formation and Sherwood Sandstone Group associated with localised elevated leachable contaminants in the Made Ground was assessed as Low, while the risk to the River Ouse and Holgate Beck was Very Low. Post fieldwork monitoring indicated that the site is classified as Characteristic Situation 1, i.e., Very Low Risk.

B.5.3 Jacobs (2019) York Tear Drop Site. Remediation Statement

Jacobs was commissioned by Network Rail to prepare a Remediation Statement associated with the proposed development of modular office accommodation. The Remediation Statement was intended to ensure that the

redevelopment is suitable for its proposed end use and that the site will not present risk of significant harm to future users of the development of adjacent land users. The recommended outline remedial measures included:

- Development works should be completed in accordance with a Construction Phase Plan, method statements, and risk assessments.
- Appropriate PPE should be available, and the construction workforce should adopt precautionary measures to avoid contact with potentially contaminated material.
- A watching brief should be maintained during construction works.
- Waste, dust, and mud should be appropriately controlled.

It was recommended that the implementation of these measures should be documented in a Verification Report.

B.6 Infrastructure Package 2 (IP2)

B.6.1 Arup (2018) York Central: Phase 1 Infrastructure Corridor. Geotechnical and Geoenvironmental Desk Study

Arup was commissioned by the York Central Partnership to prepare a Desk Study associated with the development of the Phase 1 Infrastructure Corridor. The purpose of the report was to examine the available data and develop a rationale for further ground investigation. The report presents the results of the most recent phase of ground investigation and summarises the site history, anticipated ground conditions, contamination risks and previous investigation phases.

B.6.2 Arup (2020) York Central: Phase 1 Infrastructure Corridor. Geoenvironmental Assessment and Outline Remediation Strategy

Arup was commissioned by City of York Council to prepare a Remediation Strategy associated with the construction of the Phase 1 Infrastructure Corridor. Arup specified the ground investigation completed by WYG for the York Central masterplan [7]. The report notes that running sands and artesian groundwater conditions were encountered in some areas of the site.

B.6.3 Tetra Tech (2021) York Central. Geoenvironmental Ground Investigation Factual Report. September 2021

Tetra Tech was commissioned by John Sisk and Son Ltd to provide a geoenvironmental ground investigation for the IP2 works. The purpose of the investigation was to provide supplementary information on ground conditions to inform the remediation strategy. The site works were completed between 2nd June and 23rd August 2021. The scope of works comprised: UXO clearance; archaeological watching brief; 2no cable percussion boreholes with rotary follow on; 2no. cable percussion boreholes; 31no. windowless sample holes; installation of groundwater and ground gas monitoring standpipes; soil samples for chemical and geotechnical testing; 4no. rounds of groundwater and ground gas monitoring; 1no. round of groundwater sampling; 2no. surface water samples from Holgate Beck; installation of 3no. groundwater level transducers; and GPR to identify footprints of former structures.

B.6.4 Tetra Tech (2021) York Central. Geotechnical Ground Investigation Factual Report. November 2021

Tetra Tech was commissioned by SISK to carry out a geotechnical ground investigation for the IP2 works. The purpose of the investigation was to supplement previous ground investigations, to assess ground and groundwater conditions where there were gaps in the dataset. The site works were completed between 17th June and 23rd August 2021. The scope of works comprised: UXO clearance; archaeological watching brief; 9no. cable percussion boreholes with rotary

follow on; 6no. cable percussion boreholes; 19no. windowless sample holes; 2no. mechanically excavated trial pits; 36no. Cone Penetration Tests; 6no. inspection pits; 4no. concrete cores with dynamic cone penetrometer follow-on; installation of groundwater and ground gas monitoring pipes; soil samples for chemical and geotechnical analysis; 4no. rounds of groundwater monitoring; 1no. round of groundwater sampling; variable head tests; and dynamic CPT tests at selected locations.

B.6.5 Tetra Tech (2021) Phase 1 Infrastructure. Geoenvironmental Interpretative Report. December 2021

Tetra Tech was commissioned by Homes England to complete a ground investigation interpretative report to inform the remediation design. The report assessed data obtained during the Tetra Tech (2021) investigations. It also considered the results of previous ground investigations completed by Carl Bro in 2006 [3, 4] and WYG in 2020 [7, 8].

Made Ground was typically between 1m and 3m thick, locally extending to 6.3m bgl. This was underlain by upper cohesive alluvium or glacio-lacustrine deposits, underlain by glacialfluvial deposits of sands and gravels, followed by Glacial Till. Peat was also locally recorded. Superficial Deposits were underlain by the Sherwood Sandstone Formation, present at depths between 15m bgl and 35m bgl. Visual and olfactory evidence of contamination included occasional hydrocarbon odour in Made Ground and black staining, hydrocarbon odour or sheen in superficial deposits in some locations.

Groundwater was present within granular lenses of superficial deposits but did not form a continuous groundwater body. There is also a groundwater body within the Sherwood Sandstone, which is confined and has a piezometric level within superficial deposits. Artesian groundwater conditions were encountered in one borehole. It was considered that artesian groundwater may be encountered during drilling or deep excavation in areas where ground level is lower than 9m AOD.

Assessment of soils chemical data did not identify any significant risks to human health or future site users based on a commercial / industrial end use. Isolated exceedances of assessment criteria were recorded but were considered unlikely to pose significant risk to end uses of the Phase 1 Infrastructure. Some potential source areas were identified that require further action (Detailed Quantitative Risk Assessment or remedial action): areas of historical gasworks and visually identified hydrocarbon contamination in a number of locations.

B.6.6 John Sisk and Sons (2022) York Central CL:AIRE Materials Management Plan

John Sisk and Sons prepared a Materials Management Plan (MMP) to support the reuse of soils on the site of origin to achieve the required ground levels. The MMP identifies proposed stockpiling locations, cut and fill areas, and a schematic showing proposed material movement. The reuse materials would comply with the Series 600 Specification and requirements of the Remediation Strategy. Materials movements would be tracked using plant tracking, with distinct stockpiles formed for materials where treatment is required, where no treatment is required, and where treatment is completed, and materials requiring removal as waste. The Appendices to the MMP have not been provided.

B.6.7 Tetra Tech (2022) Gasholder Contamination Investigation Report. York Central, IP2 Area. November 2022

Tetra Tech was instructed by Homes England to design and undertake a ground investigation to assess the contamination status of the footprint of a historical gasholder located in the north of the IP2 Area, immediately north of the East Coast Main Line. The purpose of the ground investigation was to establish if below ground obstructions remained in-situ associated with the gasholder and to characterise contamination of soils and groundwater that may

be associated with the gasholder and require remediation. The scope of intrusive works comprised: 5no windowless sample boreholes; 4no mechanically excavated trial pits; 1no. hand excavated inspection pit; 1no. cable percussive borehole; laboratory analysis; and 1no. round of groundwater monitoring and analysis.

Initially 3no. windowless sample boreholes were drilled within the footprint of the gasholder to maximum depth of 7m bgl. As no evidence of a solid base was encountered, a borehole was then drilled to 17m bgl. No evidence of the base was recorded. Trial pits confirmed the location of the gasholder wall. Evidence of contamination included: ACMs at surface; strong hydrocarbon odour (diesel rather than gasworks contamination); and strong chemical odour. No evidence of contamination was recorded outside the footprint of the gasholder. The report concluded that ground investigation had identified material within the footprint of the gasholder that exceeded remediation criteria, related to contaminants of concerns in soils and groundwater. It was recommended that soils present at <2m bgl are removed and verification testing / sampling undertaken. For deeper soils, excavation and remediation, use of metal casing for piles, or insitu stabilisation of soils was recommended.

B.6.8 Tetra Tech (2022) Phase 1 Infrastructure Works. Remediation Strategy. Version 3. November 2022

Tetra Tech was commissioned by Homes England to design a Remediation Strategy for the Phase 1 Infrastructure Works at York Central. A remediation options appraisal was undertaken which concluded the following techniques would be most appropriate at the site: ex-situ bioremediation or stabilisation / solidification of near surface hydrocarbons contaminated soils; hand-picking of asbestos containing materials; 300mm cover layer in landscaped areas; in-situ stabilisation of sludge / soils in the gasholder; and off-site disposal if necessary.

The scope of the remediation works therefore comprised:

- Excavation of soil source contamination requiring remediation;
- Investigation and assessment of any visually contaminated soils identified during the works to determine if the soils exceed relevant remediation criteria;
- Treatment and re-use of off-site disposal of soils exceeding the remediation criteria;
- Chemical testing of soils and screening against remediation criteria following treatment to determine if they are suitable for reuse;
- In-situ treatment or excavation of soils contained within the gasholder;
- Placement of a 300mm cover layer in landscaped areas; and
- Use of barrier pipe or ductile iron water pipes where placed in Made Ground.

Three sets of remediation criteria were developed for the site: Gasworks Remediation Criteria (GRC); Site Remediation Criteria (SRC); and landscaping / import criteria. The GRC was derived by dQRA and professional judgement and includes the TPH concentration of 2,000 mg/kg. This is considered to be a value above which hydrocarbon staining / free product / significant visible hydrocarbon contamination may be present. The GRC also includes a criterion for asbestos which is 'no visible asbestos containing material'. The SRC used the same TPH concentration of 2,000 mg/kg and 'no visible asbestos containing material'. The landscaping / import criteria were based on the generic, Public Open Space (Park) criteria, for use in the upper 300mm of soils places in areas of landscaping.

The following sources were identified as potentially requiring remediation: sources identified by screening laboratory data against the GRC and SRC; sources identified by visual evidence; sources identified by location of historical features (gasholder); and currently unknown sources that might be identified during the works. The Remediation Strategy went on to describe the procedure for excavation of contaminated materials, verification of excavations, and

verification of material following treatment. The report went on to describe that the Definition of Waste Code of Practice would be utilised to facilitate soils reuse and describe the procedure for preparation of the verification report.

B.6.9 Tetra Tech (2023) IP2 York Central. 2022 to June 2023. Geo-Environmental and Geotechnical Ground Investigation Factual Report

Tetra Tech were commissioned by John Sisk and Son Ltd to undertake an additional geo-environmental and geotechnical ground investigation to support the IP2 works. The purpose of the investigation was to supplement previous ground investigations, to assess the ground and groundwater conditions across the site where there are gaps in the current data set. This was undertaken in four phases: the first phase in March 2022; the second phase in May 2022; the third phase in September 2022; and the fourth phase in November 2022 to June 2023.

The scope of the first phase of works comprised: UXO clearance; archaeological watching brief; 3no. cable percussion boreholes; 12no. windowless sample boreholes; 23no. Cone Penetration Tests; 16no. machine excavated trial pits; installation of groundwater and ground gas monitoring standpipes; soil sampling; and groundwater monitoring. The scope of the second phase of works comprised: 6no. windowless sample holes; 6no. mechanically excavated trial pits; 1no. cable percussive borehole; 1no. hand excavated inspection pit; installation of groundwater and ground gas monitoring standpipes; soil sampling; GPR survey; UXO clearance; archaeological watching brief; and ground gas and groundwater monitoring. The third phase comprised: 6no. windowless sample holes; 3no. mechanically excavated trial pits; soakaway tests; groundwater samples; installation of groundwater and ground gas monitoring standpipes; soil samples; UXO clearance; archaeological watching brief; and groundwater monitoring. The fourth phase comprised: 4no. slope climber boreholes; 2no. modular windowless sample holes; 1no. cable percussion with rotary follow-on borehole; installation of groundwater and ground gas monitoring standpipes; soil sampling; UXO clearance; and archaeological watching brief.

B.6.10 Sweco (2023) York Central Phase 2 Infrastructure Project (IP2). Addendum Ground Investigation Report (GIR)

This report is an addendum to the York Central IP2 factual Ground Investigation Report, Document 5757-SWE-IP2E-ZZ-RP-CG-06001 (*not available for review*), which was based on findings from the WYG (2020) ground investigation and Tetra Tech (2021) ground investigations. The report was updated to reflect further phases of ground investigation completed by Tetra Tech in 2022 to 2023. The report presents: geological interpretation of the ground conditions; updated parameter plots; updated recommendations, conclusions and risk assessments; and a record of groundwater monitoring obtained over a one-year period. Geoenvironmental aspects are excluded.

Geotechnical risks were identified to include: soft and high compressible materials; buried obstructions; aggressive ground conditions; encountering services; UXO; high / artesian groundwater; Holbeck culvert; unexpected ground conditions; variable rock head levels / weathering profile; slope instability; archaeology; gasholder structure; existing highway embankment; settlement; variable bedrock level and strength; ground movements due to ground improvement; ground investigation data gaps, amongst others.

B.7 National Railway Museum

B.7.1 Listers Geotechnical Consultants Ltd (2021) Ground Investigation Report. Proposed Museum Redevelopment

Listers Geo was appointed by The Board Of Trustees of the Science Museum to: undertake a Desk Study and walkover survey; undertake a ground investigation; provide an assessment of the geotechnical engineering properties of the ground; determine the extent of any soil, gas or groundwater contamination; and undertake preliminary assessment of the feasibility of soakaway drainage. This was required associated with the proposed development of a new gallery and entrance building to act as a linkage between existing buildings.

The scope of the ground investigation included: 5no. cable percussive boreholes to max. depth 25m bgl; 2no. continuous sampler boreholes; 2no. dynamic probes; installation of standpipes in exploratory holes; and 3no. hand-dug foundation inspections pits. The recorded ground conditions included hardstanding or Made Ground over York Moraine Member. No exploratory holes encountered bedrock. Made Ground generally comprised brown to grey sandy gravelly clay with fragments of brick, wood and occasional clinker and cobbles of concrete. During monitoring, groundwater was recorded at depths between 2.96 and 3.05m bgl.

Six samples of Made Ground were obtained and subject to chemical analysis for a range of determinands. Concentrations of all determinands were below commercial screening criteria, and asbestos was not detected in any samples. The report also concluded that no ground gas protection measures would be required and that the site does not pose a significant risk to controlled waters. Shallow foundations were considered of at least 1m depth or 0.2m into natural soils were considered appropriate for light loads, while piled foundations would be required for heavier loads. Preliminary assessment concluded that soakaways may be suitable as part of a Sustainable Drainage System.

B.7.2 Graham Construction (2021) National Railway Museum. Remediation Implementation Plan

Graham Construction was appointed as the Principal Contractor for the expansion of the National Railway Museum. The report describes additional ground investigation completed within the Great Hall Courtyard, during which contamination was recorded (elevated zinc and PAHs). The report then describes the broad remedial measures (removal of excavated soils as waste, segregation of impacted areas, import of suitable soil materials), to be implemented on site as well as proposals for validation.

B.8 Leeman's Yard

B.8.1 Tetra Tech (2021) Desk Top Appraisal of Geo-Environmental, Geotechnical and Archaeological Risk and Constraints

Tetra Tech was commissioned by Homes England to provide a desk top assessment of in-ground constraints at the Leeman's Yard site. The report reviews existing desk-based and ground investigation information, presents a geoenvironmental assessment and gap analysis, presents a geotechnical appraisal, presents an archaeological constraints assessment, and makes recommendations for further intrusive investigations. It presents a series of drawings showing: locations of existing exploratory holes; site historical layout plan; the conceptual site model; locations of exceedances of chemical screening criteria; locations of visual / olfactory evidence of contamination; obstructions plan (amongst others).

The report describes that the potential contamination sources include tanks, Made Ground (associated with railway use), hydrocarbon spillages, bunds and mounds. The key contamination receptors were future residents, construction workers, groundwater and Holgate Beck. Ground investigation identified concentrations of lead, arsenic, copper and zinc in soil and groundwater in exceedance of screening criteria. Hydrocarbons were also identified in several locations. The ground gas regime had not been adequately characterised by existing ground investigation. On this basis, likely remediation measures were considered to comprise: remediation of hydrocarbon impacted areas; cover layer in gardens and soft landscaping; hand-picking of asbestos; appropriate health and safety measures during

development; appropriate soils management; off-site disposal of Made Ground; upgrade of water supply pipes; and allowance for ground gas protection measures.

The report identified that there are substantial gaps in ground investigation data, with the thickness of Made Ground and superficial deposits being very variable. Made Ground was not considered to be a suitable founding stratum. Residential buildings were considered to require a deep foundation solution or ground improvement. Obstructions including slabs and foundations are likely to be present. Potentially three shafts were identified by historical mapping (not associated with mining), which would require assessment, avoidance, or capping / backfilling. Made Ground was described to be typically loose and given generally shallow groundwater, open trenches are likely to be unstable. Additional ground engineering constraints were considered to include: Holgate Beck flowing within a Culvert; a 1200mm combined sewer; utilities; active railway line; and potential for presence of UXO.

In terms of archaeology, the site contains an archaeological landscape which has potential for significant prehistoric organic remains in deeper glacial undulations and potential significant prehistoric to Roman period archaeological features. The large-scale topographic engineering from the expansion of the railways and associated industry from the mid-19th century has either buried or truncated this earlier landscape. The report notes that more thorough evaluation is required to determine if anything is present.

B.9 Proposed Government Hub

B.9.1 Tetra Tech (2023) York Central Plot F. Factual Ground Investigation Report

Tetra Tech was commissioned by Homes England / Government Property Agency to provide a geoenvironmental and geotechnical ground investigation for Plot F at York Central. The purpose of the investigation was to assess the ground and groundwater conditions across the site. The scope of the completed ground investigation work comprised: 5no. cable percussive boreholes with rotary follow on; 1no. cable percussive borehole; high pressure dilatometer testing in 2no. boreholes; self-boring pressuremeter testing in 1no. borehole; installation of 5no. 19mm and 3no. 50mm diameter groundwater monitoring wells; installation of 3no. 50mm diameter ground gas monitoring wells; soil samples; groundwater sampling; groundwater and ground gas monitoring; installation of groundwater level transducers; UXO clearance; and archaeological watching brief.

B.9.2 Atkins (2023) Proposed Government Hub at York Central. Ground Investigation Report

Atkins was appointed by the Government Property Agency to prepare a Ground Investigation Report associated with the proposed development of a Government Hub within the York Central Site. The first round of ground investigation was completed prior to demolition of existing structures and was completed in October and November 2022. At the time of writing, a second phase of ground investigation was proposed to be conducted post-demolition.

The completed ground investigation confirmed that the encountered ground conditions comprise: Made Ground (mixed cohesive and granular) to 1m bgl; Glacial Till (cohesive and granular) to depth of 21.3 to 25.0m bgl; followed by bedrock of the Sherwood Sandstone Formation (extremely weak sandstone). Groundwater levels were variable but generally shallow and subartesian.

A range of geotechnical hazards were considered, including: presence of Made Ground and existing foundations and the impact on settlement, excavate-ability, and foundation installation; bedrock depth variability and presence of extremely weak sandstone; and the presence of shallow and sub artesian groundwater condition and the effect on foundation, basement and retaining wall design. A Generic Quantitative Risk Assessment (GQRA) was completed. Overall, no significant risks to human health, property or controlled water receptors were identified. The report concluded / recommended the following: exposure of the workforce to soils / groundwater should be mitigated

through appropriate work procedures / PPE; risk to controlled waters requires further consideration during foundation design; and the site has an overall gas risk classification of Characteristic Situation 1 (gas protection measures unlikely to be required).

B.10 The Square

B.10.1 Tetra Tech (2023) The Square, York Central. Geo-Environmental Desk Study Assessment

Tetra Tech was commissioned by Homes England to undertake a Geoenvironmental Desk Study associated with the development of The Square, a proposed area of public open space located at the public pedestrian entrance to the National Railway Museum. The report included review of existing ground investigation reports / information completed in the area, including WYG (2020) ground investigation [7] and Listers Geo (2021) ground investigation , amongst others. The report identified the following contamination-related risks: low risk to future site users associated with potential contaminants in Made Ground; moderate/low risk to future site users associated with ground gas and potential contaminants at historical gasometer location; moderate risk to construction workers associated with potential contamination in Made Ground and moderate/low risk associated with ground gas; low risk to groundwater; moderate risk to drinking water supply pipes associated with potential permeation; and moderate / low risk to adjacent site users associated with ground gas.

The report concluded that there was potential for contamination to generally be associated with Made Ground, however because of the quantum of hardstanding proposed as part of the public open space; the risk to future site users was reduced. The existing ground investigation data was assessed and it was concluded that additional ground investigation was unlikely to be required.

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