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KIRKLEES CULTURAL HEART

GEOTECHNICAL AND GEOENVIRONMENTAL TECHNICAL NOTE

CDT430201-ARP-XX-XX-RP-CG-000001

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1. Introduction

1.1 Scope

This report relates to the Kirklees Cultural Heart development located in Huddersfield town centre. A Phase 1 geotechnical and geoenvironmental desk study was produced by Aecom in 2020 [1], however, it does not cover the site area in entirety. Ove Arup and Partners Ltd (Arup) has been commissioned by Kirklees Council (the Client) to produce a geotechnical and geoenvironmental desk study addendum and coal mining risk assessment that, in conjunction with the Aecom report [1], will be sufficient for submission with the planning application for the Kirklees Cultural Heart scheme.

This purpose of this report is to:

- Summarise the environmental and geological setting of the site;
- Summarise the history of the site;
- Present a coal mining risk assessment;
- Summarise the contaminated land conceptual site model in accordance with Environment Agency guidance Land Condition: Risk Management [2];
- Provide conclusions and recommendations for next steps.

1.2 Previous reports

This report summarises information from the Aecom, 2020, Kirklees Council Queensgate Quarter, Soundspace Phase 1 geo-environmental report [1] and incorporates more recent ground investigation from GeoCon Site Investigations Ltd, 2021, Geoenvironmental site investigation report, Phase II site investigation on land at Market Street car park [3].

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

- British Geological Survey (BGS) online GeoIndex [4];
- BGS 1:50,000 geological map series, Sheet 77, Huddersfield, Solid and Drift [5]
- Zetica UXO online mapping [6];
- Public Health England radon mapping [7];
- BRE report 211, Radon: Guidance on protective measures for new buildings [8]
- CIRIA C758D Abandoned mine workings manual [9];

1.3 Proposed development

The proposed development is for the demolition of the existing Piazza shopping centre, part removal of elements of Queensgate Market, and demolition/retention of service tunnels; with redevelopment of the site to form new public realm space (including public park and gardens, play areas, public square/outdoor event space); refurbishment and change of use of existing Queensgate Market Hall into new food hall (Use Class E (b) Sale of food and drink for consumption, mostly, on the premises); refurbishment and extension of existing library and art gallery building to form a new museum (Use Class F.1); change of use of part existing market hall building and extension to form a new public library (Use Class F.1); construction of new indoor event venue incorporating multi-storey car park below (Sui-Generis); erection of new public gallery building (Class F.1); and associated infrastructure on land and buildings at Queensgate Market, Huddersfield Library and Art Gallery, and Piazza (and The Shambles) Shopping Centre, Huddersfield.

The new developments are expected to be able to be founded on shallow foundations.

2. The site

2.1 Site location

The site is located in Huddersfield town centre. The site is bounded to the south and southeast by Queensgate, to the northeast by Queen Street, to the north by King Street, and to the west by Victoria Lane, Peel Street and Alfred Street. The site generally slopes gently to the east with elevation decreasing from approximately 90mOD to 80mOD.

From south to north the site is currently occupied by a vacant plot formerly a multi-storey car park, Queensgate Market, Huddersfield Library, public open space and the Piazza Shopping Centre. The Piazza Centre is served by below ground service tunnels.

The site boundary is shown in red and the site area considered in the Aecom desk study [1] is shown in blue on Figure 1.

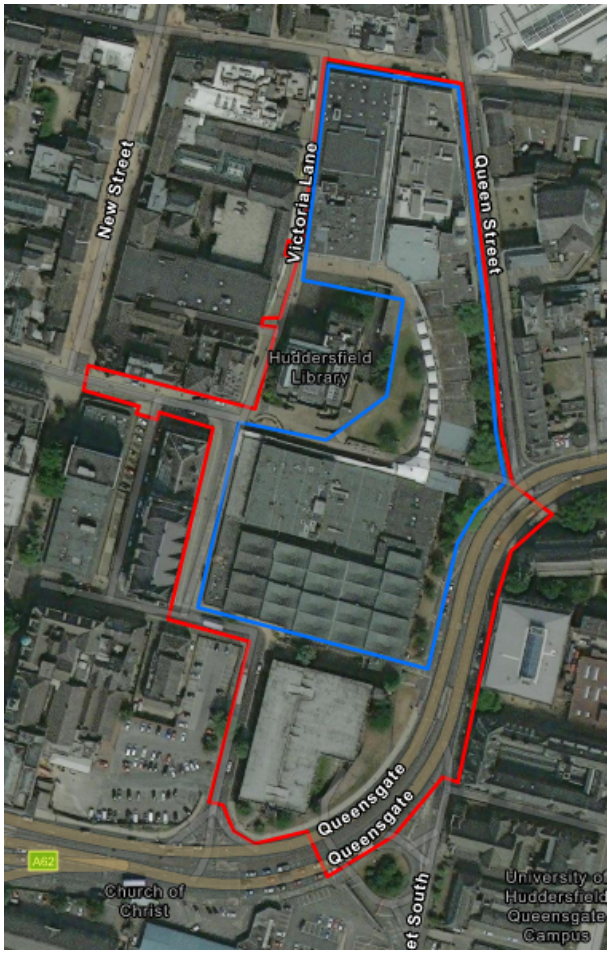

Figure 1: Red line boundary and former boundary considered

2.2 Site history

Most of the site and surrounding area were already developed prior to the first available mapping in 1854. The former multi-storey car park plot in the south of the site was undeveloped in 1854 but developed shortly after. Throughout its history the site has had a variety of different uses, with potentially contaminative uses such as a saw mill, timber yard, fire station on site and a variety of different works and garages adjacent to the site. However all potentially contaminative uses were relatively small scale and have not been present for several decades.

A Congregational Chapel was shown in the location of the current library from 1890 mapping until 1938 and has been identified as a potential area of archaeological interest due to the potential for a graveyard.

A former landfill has been identified approximately 170m to the north of the site that accepted commercial and industrial waste. No closing date was given, but the landfill licence was issued in 1986 [1].

The Aecom desk study [1] includes a Groundsure Insight report, including historical maps.

2.3 Geology

2.3.1 Superficial deposits

Geological mapping shows the site to be underlain by Head deposits. Made ground is not mapped on the site but is anticipated to be present as a result of historical site uses.

2.3.2 Bedrock

Geological mapping shows the site to be underlain by the Middle Band Rock, a named sandstone unit of the Pennine Lower Coal Measures. Underlying the Middle Band Rock is undifferentiated Pennine Lower Coal Measures of mudstone, siltstone, and sandstone. The Soft Bed Coal is anticipated to underlie the site at around 20m below ground level. Bedrock is dipping shallowly (around 4°) to the east [5].

2.4 Mining

The site is in a "Development High Risk Area" and a CON29M Coal Mining Report was purchased for the central and northern part of the site by Aecom [1]. The mining report shows the site to be underlain by probable shallow workings, associated with the Soft Bed Coal. The mining report identifies no known mine entries or historical workings beneath the site. The Coal Authority interactive map identifies no mine shafts or known workings in the area of the site outside the area covered by the Coal Mining Report (library and former multi-storey car park plot). The nearest identified mine shafts are approximately 300m to the west, beneath the railway.

A coal mining risk assessment is included in Section 4 of this report.

2.5 Hydrology

The nearest surface water features are the Broad Canal and River Colne, approximately 300m and 540m east of the site respectively.

The site is in an area classified as being at a very low risk of flooding from rivers and seas, which has a less than 1 in 1000 chance of flooding in any given year [1].

2.6 Hydrogeology

The Head deposits are classified as a Secondary aquifer – undifferentiated. However the head deposits are thin and unlikely to be saturated. The head deposits are unlikely to represent a water resource or aquifer body that could be considered a controlled waters receptor

The Pennine Lower Coal Measures bedrock is classified as a Secondary (A) aquifer. The sandstone units of the Pennine Lower Coal Measures, such as the Middle Band Rock present at the site, can provide local water supply or baseflow to watercourses.

The Millstone Grit Formation, underlying the Pennine Lower Coal Measures, is a more significant aquifer unit that has provided water supply, in particular to industry, in the Huddersfield area.

2.7 Radon

The site is in an area with a maximum radon potential of 1% to 3% [7]. Radon protection measures are not required [8].

2.8 Unexploded ordnance

The site is in an area classified as at a low risk of unexploded bombs, according to Zetica online mapping [6].

3. Ground model

A combination of BGS mapping, available borehole logs and ground investigation data from the former multi-storey car park plot have been used to create a ground model for the site.

3.1 Historical ground investigation data

3.1.1 BGS GeoIndex

No historical boreholes are available from the BGS GeoIndex [4] within the site, however, there are boreholes present close to the site. The 2020 Aecom report [1] gives a detailed description of the nearby available boreholes.

All holes described similar stratigraphy of around 1m to 2m of made ground, overlying Head deposits to 2mbgl to the west of the site and up to around 7mbgl to the east overlying bedrock.

Head deposits were typically thicker to the east consisting of clay, sand, gravel and boulders, and where encountered to the west were typically clay.

Borehole SE11NW23 encountered the Soft Bed Coal at approximately 21mbgl. Borehole SE11NW801 to the west of the site did not identify the Soft Bed Coal but did note the Soft Bed Flags (directly underlying the coal stratigraphically) at approximately 21mbgl, suggesting a shallow easterly dip.

Borehole SE11NW23 proved the top of the Millstone Grit Formation at approximately 66mbgl.

3.1.2 Multi-storey car park ground investigation

After the demolition of the multi-storey car park, a ground investigation was carried out in 2020 consisting of twelve hand pits, three rotary open holed boreholes and eleven window samples [3].

The window samples typically recorded refusal at around 1mbgl on obstructions within the made ground or shallow sandstone bedrock.

The three rotary open-holed boreholes each went to 40mbgl and did not identify the Soft Bed Coal. They identified sandstone, mudstone and siltstone to approximately 10mbgl and then only mudstone to the base of the hole. The ground investigation report did not note any loss of flush or soft pushing during the rotary open hole drilling.

3.2 Ground model

Based on the above historical ground investigation information for the site and geological mapping, the following stratigraphy is anticipated beneath the site.

Table 1: Anticipated stratigraphy

Stratum	Description	Depth to top of stratum (mbgl)	Thickness (m)
Made ground	General demolition rubble from historical site uses and backfill to retaining structures.	0	1-3
Head deposits	Typically clay (and thinner) to the west and varied (and thicker) to the northeast.	1-3	1-7
Middle Band Rock	Sandstone of the Pennine Lower Coal Measures. Not present in the east where there are thicker Head	2 - 5	0-5

Stratum	Description	Depth to top of stratum (mbgl)	Thickness (m)
	deposits and the ground level is lower.		
Undifferentiated Pennine Lower Coal Measures	Mudstone, siltstone and sandstone	7 - 11	60 - 67
Soft Bed Coal	Possible worked coal seam	21	0.6 – 0.8
Millstone Grit Group	Rough Rock sandstone	66	Not proven

No groundwater was encountered in any of the available exploratory holes.

4. Coal mining risk assessment

4.1 Coal mining hazards

4.1.1 Occurrence of workings

The proposed site lies within a Development High Risk Area due to the presence of the Soft Bed Coal at shallow depth. There is currently limited information for the depth of the coal, positively identified in one of five available exploratory holes at a depth of 21mbgl. It was identified as 0.6m thick. The Soft Bed Coal lies at the base of the Lower Coal Measures and there are no significant underlying coal seams.

Three rotary open holed boreholes drilled to 40mbgl in the south of the site (see Section 3.1.2), did not record the coal and did not record normal evidence of mineworkings such as voids, broken ground, loss of flush or soft push. It is possible that coal in this area is deeper than expected (e.g. due to geological faulting or the dip of strata) or it may be locally absent due to washout.

Bedrock was typically identified from 2mbgl to 8mbgl and so, depending on final levels, there is likely to be at least 10m of intact rock between the Soft Bed coal and proposed development (assuming a depth of around 21mbgl and shallow foundations on the rock). A typical rule of thumb is that if there is at least 10 times the seam thickness of rock above the worked coal, there should be a very low risk for roof collapse to cause subsidence that affects foundations. However, this may not be applicable to other collapse mechanisms, such as pillar failure [9].

Due to the level changes across the site, the Soft Bed coal may be shallower on the east of the site.

No deep workings are recorded beneath the site.

4.1.2 Mine entries

No recorded mine entries are shown beneath the site from the Coal Authority interactive map viewer, with the nearest entries approximately 300m to the east. Unrecorded mine entries may be present beneath the site.

4.1.3 Ground gas

No ground gas monitoring data is available for the site. Mineworkings are a potential source of hazardous gas. If such gas is present at depth, there is potential for it to migrate through the overburden rock and soil to surface, where it may enter enclosed spaces in the proposed development.

4.1.4 Coal combustion

The Soft Bed Coal is not identified by the Coal Authority as a coal seam having a history of spontaneous combustion. However, given the right conditions any coal seam has the potential for combustion.

4.2 Coal mining risk assessment summary

Table 2: Coal mining risk assessment

Source	Location	Hazard	Risk
Shallow underground mineworkings in the Soft Bed coal	Site wide	Void migration leading to foundation settlement	Low to moderate depending on depth to coal and occurrence of mining
Deep underground mineworkings	Not recorded beneath the site	General subsidence	Very low
Unrecorded mine entries	Site wide	Local collapse subsidence	Low to moderate depending on occurrence of mining
Hazardous ground gas emissions	Site wide	Hazardous gas migration into proposed buildings	Moderate

Source	Location	Hazard	Risk
Coal combustion	Where piles or deep boreholes are proposed through the Soft Bed Coal	Surface or underground fire cause by introduction of air	Negligible for shallow foundations. Moderate for borehole drilling or piling techniques that use air flush.

4.3 Risk mitigation

4.3.1 Shallow workings

A ground investigation is proposed that will determine the depth to the Soft Bed coal across the site and look for evidence of mineworkings. This information will be used to carry out a risk assessment based on the depth to workings below the proposed development, the nature and thickness of overburden rock, and the proposed foundation type.

If required, the workings could be treated by drilling and grouting across the site, however, this may not be feasible beneath existing buildings that are to remain.

4.3.2 Unrecorded mine entries

No recorded mine entries underlie the site. Due to the structures on site and the small dimensions of a shaft it would not be practicable to identify the shafts with probe drilling or geophysical surveys prior to construction.

As shallow foundations are proposed, the buildings are to be founded on bedrock, and a watching brief should be maintained during excavations for possible mine shafts.

4.3.3 Hazardous ground gas

Ground gas monitoring will form part of the ground investigation for the site. A hazardous ground gas risk assessment should be undertaken as part of the geoenvironmental risk assessment after the investigation to determine if gas protection measures will be required.

4.3.4 Coal combustion

Suitable precautions will need to be taken during any activities that intercept the coal seams beneath the site, for example, the potential ground source heat pump.

5. Geoenvironmental assessment

This section summarises the possible risks, if any, from potential contamination at the site from past or current potentially contaminative uses and presents a strategy to mitigate the risks. A detailed preliminary risk assessment is provided in the Aecom report [1] and is applicable to the entire site.

5.1 Conceptual site model

The risk assessment process for environmental contaminants is based on a source-pathway receptor approach recommended in the regulatory guidance LCRM [2], where:

- Source: hazardous substance that has the potential to cause adverse impacts;
- Pathway: route where a hazardous substance may come into contact with a receptor; and
- Receptor: Someone or something that may be affected by contamination.

For a risk to be present, all three elements (source-pathway-receptor) of a plausible contaminant linkage must be present.

5.1.1 Sources

The Aecom report [1] and Section 2.2 above includes a summary of the site history that identifies the possible sources of contamination given the past site uses. Table 3 indicates the potential sources of contamination at the site.

Table 3: Potential sources of contamination

Source	Potentially contaminative material	On site or off site
Contaminated made ground	Heavy metals, inorganics including sulphate, pH, TPH, SVOCs, VOCs, asbestos and ACMs.	On site
Contaminated perched and shallow ground water	Heavy metals, inorganics including sulphate, pH, TPH, SVOCs, VOCs, and ACMs.	On site
Infilled land	Heavy metals, PAH, TPH, SVOCs, VOCs, acids, alkalis, asbestos and solvents	Off site
Mine workings	Mine gas	On and off site

5.1.2 Receptors

The following are identified as relevant potential receptors:

- Construction and maintenance workers;
- Site neighbours;
- End users of the proposed development;
- Secondary A aquifer;
- Buried concrete and potable water supply pipes.

5.1.3 Pathways

The following pathways may be present during the construction and operation of the proposed development:

- Human health – dermal contact, or ingestion of soil or dust;

- Human health – inhalation of dust or vapour;
- Controlled waters – leaching into shallow and/or deep groundwater;
- Controlled waters – migration of impacted shallow groundwater to Secondary aquifer;
- Buried concrete and potable water supply pipes – direct contact with contaminated soils;
- Ground gas – accumulation of ground gases into buildings, including confined spaces.

5.2 Preliminary risk assessment

Table 4 shows the conceptual site model for the proposed redevelopment (construction and operation) and potential risks to the receptors with identification of possible mitigation to address the plausible contaminant linkages.

Table 4: Conceptual site model

Source	Pathway	Receptor	Potential severity	Likelihood	Risk	Justification or mitigation measures	Plausible contaminant linkage (with mitigation in place) during construction and operation
Contaminated made ground Potentially contaminated perched and shallow groundwater	Dermal contact or ingestion of soil or dust	Construction and maintenance workers	Medium	Likely	Moderate	Ground investigation and further risk assessment. Ensure appropriate measures in place during construction and maintenance.	No, pathway removed
		End users	Medium	Likely	Moderate	Ground investigation and further risk assessment. If contamination is identified, a clean cover layer may be appropriate or the material treated/removed from site	No, pathway removed
	Inhalation of dust or vapour	Construction and maintenance workers	Medium	Likely	Moderate	Appropriate measures in place during construction and maintenance.	No, pathway removed
		Site neighbour	Medium	Likely	Moderate	Dust suppression measures during construction, appropriate cover following development	No, pathway removed
		End user	Medium	Low	Moderate/low	Ground investigation and further risk assessment. If contamination is identified a clean cover layer may be appropriate or the material treated/removed from site	No, pathway removed
	Leaching into shallow and/or deep groundwater	Secondary Aquifer	Medium	Likely	Moderate	Ground investigation and further risk assessment. If contamination is identified a low permeability capping	No, pathway removed

Source	Pathway	Receptor	Potential severity	Likelihood	Risk	Justification or mitigation measures	Plausible contaminant linkage (with mitigation in place) during construction and operation
						layer may be appropriate or material treated/removed from site	
	Direct contact	Buried concrete and potable water supply	Medium	Very likely	Moderate	Investigate aggressive chemicals present and choose appropriate concrete class and pipe specification	No, receptor removed
Shallow mineworkings	Accumulation of ground gases into buildings, including confined spaces	Construction and maintenance workers	Severe	Likely	High risk	Ensure appropriate measures in place to prevent build up of ground gases in confined spaces	No, pathway removed
		End user	Severe	Likely	High risk	Ground gas monitoring to quantify risk. If required, ground gas protection can be installed.	No. Source will not be present or pathway removed

6. Conclusions and recommendations

This addendum report summarises the contaminated land preliminary risk assessment presented in the Aecom 2020 report, confirms the assessment is applicable to the entire redline planning boundary and presents a coal mining risk assessment. In conjunction with the Aecom report, this addendum report is suitable for submission with the planning application for the Kirklees Cultural Heart scheme.

The following key points have been noted in this desk study:

- The site has had previous potentially contaminative uses both on site and in the surrounding area that have potentially resulted in soil and groundwater contamination beneath the site;
- The site is underlain by Head deposits overlying the Middle Band Rock (a Lower Coal Measures sandstone unit), which in turn overlies undifferentiated Pennine Lower Coal Measures, and Millstone Grit at over 60m depth;
- The Soft Bed Coal, which may have been worked, is anticipated to underlie the site at around 20mbgl;
- There is a risk that potential shallow workings and unrecorded mine entries may be present within the site and could affect the proposed development;
- There is a risk of potential ground gas migration from abandoned mineworkings;
- The presence of soil contamination at the site that may affect construction and maintenance workers, site neighbours, end users and Secondary aquifer.
- Significant data gaps remain that should be addressed by further ground investigation and assessment.

Ground investigation is in progress (August-September 2022) that aims to identify:

- Depth to Soft Bed coal (and potential workings);
- Thickness of rockhead above coal and below proposed development;
- Potential contamination of made ground across the site;
- Presence of ground gas with monitoring across the site.

Following the ground investigation, the following is recommended:

- Update the ground model to include site specific ground investigation data;
- Update the coal mining risk assessment and determine any remedial measures that may be required;
- Assess the contamination present and mitigation that may be required for the proposed development (construction and operation);
- Assess the risk of ground gas on the proposed development and necessary mitigation.

References

[1] Aecom, “Kirklees Council Queensgate Quarter Sound Space, Phase 1 geo-environmental report,” 2020.

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