Trinity Academy, Barnsley

Geo-Environmental Assessment

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This document has been prepared and checked in accordance with Waterman Group's IMS (BS EN ISO 9001: 2015, BS EN ISO 14001: 2015 and BS EN ISO 45001:2018)

Issue	Date	Prepared by	Checked by	Approved by
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Comments	
8.1.3	Draft – to be updated upon receipt of groundwater test results and completion of ground gas monitoring

Comments

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Executive Summary

Objectives	
Waterman Infrastructure & Environment Limited was instructed by Turner & Townsend to undertake a Geoenvironmental Assessment for the proposed redevelopment of the Keresforth Centre NHS Facility, Barnsley.	
Site Setting	
Current Use	The Site comprises two distinct land parcels, the Keresforth Medical Centre at the north-east and an area of Public Open Space at the south-west. The Keresforth Medical Centre is largely disused and comprises low-rise buildings with access roads, parking areas and soft landscaping in the north-east. The POS is a flat grassed area of land.
History	A review of the historical plans indicates the Site remained undeveloped until the Medical Centre was constructed circa 1978. Previous to this, the Site comprised arable farmland. Within the surrounding area, industrial land uses including foundries, works, mills and quarrying activities are recorded.
Ground Conditions	The Site is underlain by Made Ground, which is typically less than 1m thick. More substantial thicknesses of Made Ground may be present beneath the western half of the Site. A layer of Glacial Till, up to 1.8m in thickness, is present overlying the Pennine Middle Coal Measures. The Pennine Middle Coal Measures are present to depth beneath the Site. The Barnsley Coal Seam is present at shallow depths across the Site, between 7.5m and 22.0m below ground level. Evidence of workings within the Barnsley Coal Seam has been identified beneath the proposed building footprint.
Human Health	Given the proposed end use for the Site, the contaminant concentrations were assessed against the Residential without plant uptake land use. Without published re-use criteria for a school end-use, this is considered to provide a conservative assessment of the risk to human health. Minor exceedances of the relevant GACs for PAHs and metals were identified in the Made Ground beneath the playing fields in the west of the Site. No exceedances were recorded in the east of the Site.
Controlled Waters	The Middle Pennine Coal Measures beneath the Site is designated as a Secondary A Aquifer. A small watercourse is located 26m south-east of the Site. The results of testing carried out on groundwater samples will therefore be assessed against the lowest value for each contaminant as given in the UK Drinking Water Standards (DWS) and the Environment Agency (EA) Environmental Quality Standards (EQS). Results of groundwater analysis are currently outstanding.
Ground Gas Regime	The recorded methane and Carbon dioxide GSVs and review of the ground gas monitoring results identify them as being consistent with a Characterisation Situation 1 (CS1) ground gas regime classification in which the ground gas risk is low and mitigation measures in the built development would not be required. This risk assessment should be reviewed upon completion of the subsequent monitoring rounds. Given the presence of a potential source of ground gas beneath the Site (shallow mine workings), it may be prudent to allow for the installation of gas protection measures in accordance with Characteristic Situation 2 at this stage. The Preliminary Environmental Risk Assessment identifies the Site to be partially within an area of elevated radon levels (between 1% and 3%). Correspondingly, basic protective measures may be required in the proposed development. The approach should be confirmed with the Building Control Officer.
UXO	A UXO Risk Assessment has been prepared by 1st Line Defence (Report Ref: DA11373-00, Dated: 24/06/2020), which has assessed that there is an overall Low Risk from German and anti-

aircraft unexploded ordnance at the site. There is an assessed Negligible Risk from Allied ordnance.

The Risk Assessment recommends that a UXO Risk Management Plan is developed for the Site and that specific UXO awareness briefings are given to all personnel conducting intrusive works.

Conclusions

Given the proposed end use the overall risk rating for the Site is medium.

Geotechnical Assessment

Mining

The ground investigation confirmed the presence of the Barnsley Coal Seam as follows:

- RC101 records zones of no recovery at 1.5m to 1.98m, 3m to 3.53m, and at 4.5m to 4.96m. These are interpreted to be the result of weathered or weak rock being further weakened by the drilling resulting in no core being obtained. Zones of no recovery at 7.5m to 8.4m and 9m to 10.26m are interpreted as suspected mine workings, as they are associated with a loss of drilling flush at 8m. Intact coal was encountered at 10.5m to 10.9m.
- RC102 records zones of no recovery at 1.5m to 2.19m, 4.5m to 5.36m, and 6.0m to 7.02m. These are interpreted to indicate the presence of weathered or weak rock. Zones of no recovery at 7.5m to 8.4m and a void noted at 9.0m to 10.5m are interpreted as suspected mine workings, as they are associated with a loss of drilling flush from 8m.
- RC103 records intact coal at 19.5m to 22.0m.
- RC104 records zones of no recovery at 3.0m to 3.72m, 4.5m to 4.84m, 6m to 6.6m, and 7.5m to 7.69m. These are interpreted to indicate the presence of weathered or weak rock. A void is identified at 15.4m to 16.8m and is interpreted as suspected mine workings.

All of the suspected mine workings and intact coal are thought to be associated with the Barnsley Coal Seam.

The greatest thickness of no recovery or void associated with the Barnsley Coal seam was 3.0m beneath the Site in RC102, from 7.5m to 10.5m bgl. Based on a likely propagation of voids to 10 times worked seam thickness through rock, as per CIRIA C758D, voids could migrate upwards by 30m.

There is an insufficient thickness of rock cover to arrest the upward migration of voids from the Barnsley Coal Seam and therefore workings are considered to constitute a risk of surface instability.

Therefore, it is recommended further investigation is undertaken below the footprint of the proposed buildings, which should take the form of Primary Consolidation Grouting to confirm the presence of workings or otherwise, with Secondary Grouting should workings be identified.

A mine shaft has been identified in trial pit TP110, in the playing fields in the west of the Site. The shaft was found to be uncapped and to have a diameter of approximately 2.5m. The shaft backfill was present from approximately 0.5m below ground level and comprised of Colliery Spoil.

The mine shaft should be fully investigated and appropriately treated, most likely by construction of a reinforced concrete cap. It is recommended that the design of the proposed sports pitches in this area of the Site includes mitigation for the risk of ground collapse associated with unidentified coal mining features.

The remedial works to be implemented to both the shallow mine workings and mine shaft should be agreed with The Coal Authority, with appropriate permissions and licenses obtained.

Shallow Foundations

Made Ground and soft/ loose natural deposits are not considered to be suitable bearing strata. Where these materials are identified, foundations should be placed on adequate bearing strata at deeper levels. Foundations should be placed on uniform founding strata to avoid differential settlement.

Identification of the appropriate founding stratum on site must be undertaken by an experienced engineer. If necessary, Waterman should be contacted to provide further advice.

The descriptions and results of lab and in-situ testing suggest that strip foundations could be placed on the high strength deposits at relatively shallow founding depths (i.e. approximately 1m below existing ground level). Foundations should be placed on a uniform bearing strata, and as such it may be necessary to deepen foundations if Made Ground or soft/ loose materials are encountered at foundation level.

Given the presence of the Barnsley Coal Seam at relatively shallow depth beneath the Site, the foundation designer should consider the influence of foundation loads on potential shallow mine workings. Appropriate rock cover should be present between the base of shallow foundations and underlying coal seams. Consideration should be given to the use of a raft slab. Coal Authority approval should be gained for the design as part of the Permitting process.

The design bearing resistance(s) quoted above have been estimated in accordance with EC7, Design Approach 1. Bearing resistance and settlement are functions of shape and depth of foundation, and the magnitudes of inclined, static and variable loads and these should be checked as part of detailed geotechnical design.

Piled Foundations

For foundation loads significantly in excess of the design bearing resistance estimated above or where the presence of shallow mine workings precludes the use of shallow foundations, piled foundations could be utilised. It is recommended that the advice of a specialist piling contractor should be obtained to confirm the suitability of piling and the most appropriate pile type. However, based on the site investigation information, end bearing piles would key into the Pennine Middle Coal Measures bedrock present from approximately 2m to 3m below ground level or would be extended to between 10m and 25m below ground level to extend through the worked Barnsley Coal Seam.

Given the presence of the Barnsley Coal Seam at relatively shallow depth beneath the Site, the pile design should consider the influence of piling on potential shallow mine workings. Appropriate rock cover should be present between the termination depth of piled foundations and underlying coal seams. The piling contractor should seek Coal Authority approval for their design as part of the Permitting process.

The final design of the piles will be the responsibility of the piling contractor. An allowance for probing of pile positions and/or drilling of obstructions should be allocated. The carrying capacity of the actual pile groups will in part depend on the number, type and size of pile chosen by the contractor and the quality of workmanship. Where cast in situ concrete piles are proposed, the roughness of the rock socket will influence the carrying capacity of the pile.

The piles should be designed based on the requirements of Eurocode 7 and guidance such as CIRIA Report 181, Piled Foundations in Weak Rock.

During detailed pile design the choice of factors of safety should ensure that appropriate safe working loads and settlement tolerances are met.

Subject to any piling trials, an acceptable percentage of piles should be load tested to at least twice working load. All piles should be integrity tested.

Consideration should be given to the re-use of pile arisings if bored piles are used. It may be possible to re-use pile arisings subject to risk assessment; however, certainty of use and volume should be confirmed in accordance with the requirements of CLAIRE guidance.

Given the proximity of existing structures, the effects of noise and vibration (e.g. from piling plant) should be addressed as part of the Contractor's method statement.

Shrinkability / Volume Change Potential

Glacial Till has been shown to have a medium shrinkability.

Foundations placed on shrinkable soils should be deepened where necessary to accommodate the effects of trees and hedgerows. Where foundations are beyond the influence of existing and proposed planting (i.e. 1.5 times the mature tree height), the minimum founding depth in soils of a medium volume change potential would be 0.9m below existing or proposed ground level (whichever is lower).

Foundations within the zone of influence of existing or proposed trees should be deepened as necessary in accordance with recommendations provided in NHBC Chapter 4 – Building Near Trees. If trees are present within influencing distance of proposed foundations, a tree survey should be undertaken to identify appropriate founding depths.

Design Class for Concrete

Based on the characteristic values derived from SD1 testing, the Design Sulphate (DS) and Aggressive Chemical Environment for Concrete (ACEC) classifications are considered to be:

- Concrete in contact with Made Ground: DS-1 AC-1
- Concrete in contact with Pennine Middle Coal Measures: DS-1 AC-1

This is based on the site characterisation as "Brownfield-pyritic" and the assumption of mobile groundwater.

Earthworks / Pavement Design

The results of compaction testing undertaken on samples of the shallow soils indicate that the Made Ground and Glacial Till could generally be recompacted to achieve >95% of MDD and <5% air voids.

Based upon the results obtained, Made Ground and Glacial Till could potentially be used as an engineered fill, subject to other suitability considerations. Made Ground may require treatment prior to re-use due to it generally being wet of Optimum Moisture Content. It should be noted that suitability for compaction is highly dependent on the initial moisture content of the material to be compacted. PSD results indicate that the Made Ground would be classified as Class 2C and the Glacial Till would be classified as Class 2A/2B in accordance with the Specification for Highway Works.

It would be sensible to subject proposed earthworks materials to a confirmatory testing regime where they were required to achieve a compaction specification as a general fill. Site won materials are unlikely to prove suitable as a structural fill, being generally cohesive in nature.

Construction plant should be provided with an adequate working platform in line with the requirements of BRE report, "BR 470: Working Platforms for Tracked Plant". Further advice should be sought from the temporary works designer.

Areas of roadway and hardstanding will be included in the development and will likely have a subgrade comprising Made Ground or Glacial Till. Significant earthworks may be required prior to construction and pavement design should allow for the potential presence of a thickness of engineered fill above natural strata.

Subgrade strength may vary considerably across the site, especially where affected by variations in moisture content. During construction, the in-situ CBR value must be checked against the Design CBR value, to confirm design requirements are being met, in accordance with CD225 or Local Authority guidance.

Floor Slabs

Given that there is limited Made Ground in the vicinity of the proposed school building, no identified risk of heave (earthworks cut is unlikely in this area of the Site) and ground conditions are likely to be relatively uniform across the proposed building footprint, ground bearing floor slabs are potentially viable for the proposed development.

Significant earthworks may be required prior to construction and floor slab design should allow for the potential presence of a thickness of engineered fill above natural strata.

The design of floor slabs should only be finalised when the updated gas monitoring has been completed and assessed, as the recommendations of the gas monitoring report will influence the final choice of floor slab design. The above advice is provided for guidance only at this stage.

Groundwater / Stability of Excavations

Comments relating to the stability of excavations (i.e. trial pits) and groundwater seepages are included in the logs in Appendix B. No groundwater was encountered during the ground investigation.

Groundwater monitoring indicates water levels between 5.48mbgl in RC104 and 10.72mbgl in RC101, and borehole RC102 was reported as dry. RC103 was flooded at the time of the first round of groundwater monitoring. This data indicates a groundwater elevation range of 129.88m AOD (RC01) to 134.99m AOD (RC104).

It should be noted that levels are likely to fluctuate dependant on the time of year and prevailing weather conditions. For design purposes, it is recommended that the groundwater level be assumed at 5.5m bgl. This level will be reviewed on completion of the groundwater monitoring visits.

Based on observations made during fieldwork, shallow excavations (<1.2m) are likely to be stable in the short term. However, should deeper Made Ground be encountered, particularly where this is associated with historical mining features, then some instability should be expected, and appropriate mitigation measures utilised.

Consideration should be given to the re-use of arisings from foundation trenches / drainage runs etc. Where contamination has been encountered, it may be possible to reuse foundation arisings; however, certainty of use and volume should be confirmed in accordance with the requirements of CL:AIRE guidance. Waterman Supplementary Ground Investigation Report should be consulted with regards to suitability for re-use of materials.

In line with BS6031, all excavations should be examined daily by a competent person to ensure that they remain safe. Where the sides cannot be sloped back to a safe angle, as approved by a competent and experienced person, their continued stability should not be taken for granted. Vertical or steep faces should be provided with support unless instructed otherwise by a competent person.

Recommendations

The following actions are recommended to address the potentially unacceptable risks that remain:

- A programme of mine workings investigation and treatment should be undertaken below the footprint of the proposed buildings, which should take the form of Primary Consolidation Grouting to confirm the presence of workings or otherwise, with Secondary Grouting should workings be identified.
- Further ground investigation should be undertaken to confirm the extent of mining related features identified and to assess the ground conditions for the design of foundations for temporary classrooms in the west of the Site;
- The design of the proposed sports pitches in the west of the Site should mitigate the risk of ground collapse impacting users of the sports fields.
- A Remediation Strategy should be prepared outlining the mitigation measures to ensure the Site meets the appropriate standards for its intended use following redevelopment;

- An appropriate cover system should be installed in soft landscaping areas to break the contamination receptor linkage. Material/topsoil imported to Site should be certified suitable for use prior to importation and use on-site;
- A Materials Management Plan should be produced by the Contractor to ensure that materials that may be excavated during their works (including pile arisings) may be suitable for re-use on the Site. The re-use of materials should be identified and designated under the CL:AIRE Definition of Waste: Code of Practice (DoWCoP), i.e. the earthworks phase of the development should be planned and managed such that re-use of suitable site-won arisings is maximised and waste is minimised;
- Following completion of the proposed Development a Verification Report should be produced detailing the remedial measures undertaken during construction to break the potentially active pollutant linkages;
- Construction works should be undertaken in accordance with the Control of Asbestos Regulations 2012;
- A Construction Environmental Management Plan (CEMP) should be prepared including measures for managing waste during development work, and techniques for suppressing dust;
- All fuels and chemicals to be stored on-site during construction works should be stored and bunded in line with EA best practice and guidance;
- Construction workers should be provided with Personal Protective Equipment (PPE) for use as necessary when interacting with soils and groundwater beneath the Site. Workers should also adopt appropriate hygiene practices;
- Below-ground structures should utilise the appropriate concrete classes to prevent aggressive ground conditions. The use of barrier water pipes at the completed Development (as per UKWIR project steering group guidance) should be agreed with the relevant water authorities; and,
- Appropriate UXO mitigation should be employed during below ground works, such as piling.

1. Introduction

1.1 Objectives and Brief

Waterman Infrastructure & Environment Limited ('Waterman') was instructed by Turner & Townsend to undertake a Geoenvironmental Assessment for the proposed redevelopment of the Keresforth Centre NHS Facility, Barnsley. The main objectives of the report are to:

- Provide an exploratory investigation as defined by BS10175 (2011+A2:2017);
- Develop a refined conceptual site model based on the investigation, including a decision record for the development of the model;
- Assist in discharging planning conditions relating to the investigation and remediation of contaminated land;
- Derive representative geotechnical parameters in accordance with Eurocode 7 and characterize the ground for the purposes of geotechnical design;
- Provide an assessment of suitable foundation types for the proposed development;
- Assess the suitability of materials arising in earthworks activities for re-use on site or disposal;
- Provide a preliminary waste classification of the likely waste soils;
- Provide an initial assessment of mining risk and advice relating to the stabilisation of shallow workings/shafts affecting the site;
- Investigate pavement design and provide CBR values at selected locations at formation level;
- Provide an assessment of hazardous gas risk in accordance with CIRIA Report C665 / BS8485 and preliminary recommendations relating to protective measures required in foundations (if any); and
- Allow feasible remediation options to be evaluated and determine the most appropriate remediation strategy to be developed.

This assessment has been undertaken in general accordance with the Model Procedures for Management of Land Contamination (Contaminated Land Report 11 – Environment Agency, September 2004) and forms a decision record in relation to the assessment of the site. The report also provides a refined conceptual based on the findings of the ground investigation, an evaluation of potential risks and recommendations relating to any necessary remediation.

The assessment was undertaken in accordance with the scope agreed between Waterman and Turner & Townsend, as documented in Waterman's fee letter, and with Waterman's standard Terms of Appointment. The benefit of this report is made to Turner & Townsend.

1.2 The Proposed Development

It is proposed to demolish all structures within the site boundary, to facilitate the construction of Trinity Academy, Barnsley, which is to provide a 900-place secondary school. This development will include a new school building in the north-east, hard landscaping car park in the centre of the site and both soft and hard landscaping sports fields in the surrounding area. New residential buildings with private gardens will be built in the north of the site.

The proposed development is presented on Watson Batty Architects Drawing Ref: TRNTY-WBA-EX-ZZ-DR-A-X-001 P2, included in Appendix A.

1.3 Limitations

The information contained in this report is based on the findings of the Preliminary Environmental Risk Assessment (Report Ref. WIE17125-100-R-1.2.1-RJM) and the Coal Mining Risk Assessment (Report Ref. WIE17125-100-R-7-1-3-CMRA), observations made on site, exploratory hole records, laboratory test results, groundwater monitoring and ground gas monitoring.

The ground conditions reported relate only to the point of excavation and do not necessarily guarantee a continuation of the ground conditions throughout the non-inspected area of the site. Whilst such exploratory holes would usually provide a reasonable indication as to the general ground conditions, these cannot be determined with complete certainty.

Waterman has endeavoured to assess all information provided to them during this investigation, but makes no guarantees or warranties as to the accuracy or completeness of this information.

The scope of this site investigation includes an assessment of the presence of asbestos containing materials in the ground at the site but not within buildings or structures or below ground structures (basements, buried service ducts and the like).

The conclusions resulting from this study are not necessarily indicative of future conditions or operating practices at or adjacent to the site.

2. Outline Conceptual Model

The outline conceptual model is contained in the Preliminary Environmental Risk Assessment (Ref. WIE17125-100-1.2.1-RJM) and is summarised below.

2.1 Anticipated Ground Conditions

The anticipated ground conditions are summarised in Table 1:.

Table 1: Ground conditions

Stratum	Area Covered	Depth to Top of Stratum (m bgl)	Typical Description
Made Ground or Topsoil	Entire Site	0 to 1.0m – deeper in the west	Topsoil over colliery waste or soft brown clay with fragments of brick, concrete and pottery
Glacial Till	Entire Site	0.45 to 1.06	Soft to firm grey laminated sandy clay with silt partings and bands of medium-coarse gravel.
Pennine Middle Coal Measures Formation	Entire Site	1.5 to 2.7	Interbedded hard, grey siltstone with bands of soft mudstone, and black coal shale.

A large area in the west of the Site is indicated to be underlain by Made Ground on the BGS mapping.

A geological fault crosses the northern area of the Site trending from north east to south west and downthrowing to the south. The Barnsley Coal is indicated to subcrop beneath the north of the Site, to the north of the fault. The Barnsley Coal is shown to subcrop approximately 100m to the west of the Site, to the south of the fault. Based on the thickness of the Barnsley Coal Seam and its depth from surface, a risk of surface instability is presented should any workings be present.

The Barnsley Rider Coal is shown to subcrop beneath the eastern site boundary and, given the regional dip direction to the east, is not considered to be present beneath the vast majority of the Site, including the areas proposed for development.

Seams of the Pennine Lower Coal Measures are thought to be present at greater depth, including the Flockton Thick, Fenton, Parkgate, Thorncliffe and Silkstone coal seams. These deeper seams are also thought to have been worked in the vicinity of the Site, but any workings are unlikely to impact the proposed development due to their depth.

2.2 Mining

Located within the Yorkshire Coal Field; parts of the Site are located in a Coal Authority High Risk Development Area. A Coal Mining Risk Assessment (Reference WIE17125-100-R-7.1.3-CMRA, dated October 2020) was therefore completed for the Site as part of the Phase 1 works. This report indicates that the Barnsley Coal Seam sub-crops below the north of the Site and is likely to be present at shallow depth beneath a large proportion of the Site. The seam is recorded to have been worked beneath some areas of the Site, with suspected, but unrecorded, workings likely to be present beneath a larger area of the Site. These workings are likely to be at a sufficiently shallow depth that they present a risk of surface instability. Intrusive ground investigation, including rotary coring, was therefore recommended to positively confirm the depth and condition of the Barnsley Coal Seam below site down to a maximum 30m bgl.

The Coal Mining Risk Assessment identifies that remedial works have previously been undertaken in the area of the playing fields. These comprised the infilling of collapsed ground. It is considered that this may be associated with the collapse of a shallow mine entry in this area. Three roadways were noted to extend away from the base of the collapsed ground; however, these were not treated at the time of the remedial works.

It is recommended that further investigation is undertaken in the area of the remedial works to establish the extent of the roadways, and determine if further mining features are present in this area of the Site.

The potential presence of further unrecorded mine entries in the western half of the site cannot be discounted and it is recommended that a watching brief for mining related features is maintained during construction works.

It is understood that temporary classrooms are proposed in the existing playing fields in the west of the Site, during construction of the proposed new school in the east of the Site. It is therefore recommended that ground investigation is undertaken in the proposed location of the classrooms to ensure that the risk of the temporary facilities being impacted by the shallow mining are appropriately mitigated.

2.3 Unexploded Ordnance (UXO)

A UXO Risk Assessment has been prepared by 1st Line Defence (Report Ref: DA11373-00, Dated: 24/06/2020), which has assessed that there is an overall Low Risk from German and anti-aircraft unexploded ordnance at the site. There is an assessed Negligible Risk from Allied ordnance. The Risk Assessment recommends that a UXO Risk Management Plan is prepared for the Site and that Site Specific UXO Awareness Briefings are given to all personnel conducting intrusive works.

2.4 Potentially Significant Pollution Linkages

Potentially significant linkages between contamination hazard sources and relevant receptors are summarised below.

- The accumulation of ground gas and vapours associated with shallow mine workings were considered to pose a medium risk to site end users.
- Windbourne, potentially contaminated, dust and runoff from contaminated materials were considered to pose a medium risk to off site receptors, including nearby residents.
- Direct contact and ingestion, inhalation of dust, and the accumulation of ground gas as a result of potentially contaminated Made Ground being present was identified to pose a medium risk to construction workers.
- Potentially contaminated Made Ground was considered, through direct contact, to pose a medium risk to site structures and services.
- Construction materials stored on site were considered to pose a medium risk to surface water course 26m to the south of the Site, due to the potential for spills to migrate through surface run-off.

3. Methodology

The intrusive investigation was undertaken in general accordance with Eurocode 7, the Code of Practice for Ground Investigation BS 5930 (2015) and the Code of Practice for the Investigation of Potentially Contaminated Sites and its Investigation BS 10175 (2011).

The objectives of the investigation are to characterise the ground conditions, the hazard sources, pathways and receptors and to reduce uncertainties associated with the proposed redevelopment.

3.1 Design of Investigation

Sampling locations were carefully selected in order to characterise the features identified in the conceptual model and to target, as far as possible, potentially contaminated areas identified in the Preliminary Environmental Risk Assessment.

A summary of the investigation locations and features investigated is presented in Table 2: Ground Investigation Strategy

Table 2: Ground investigation strategy

Layer / Target feature	Exploratory Holes	Monitoring Wells	Comments
Made Ground	All holes	-	No Made Ground of sufficient depth encountered to allow for the installation of monitoring standpipes.
Potential shallow mine workings	RC101, RC102, RC103, RC104	RC101, RC102	-
Mine shaft	TP110	-	-
Areas of indicated fill on BGS maps	TP110, TP111, TP112	-	-
Geotechnical design of proposed structure	RC101, RC102, RC103, RC104	RC101, RC102, RC103, RC104	-

3.2 Quality Control

A Waterman Geo-Environmental Engineer monitored the performance, quality of work and health and safety compliance throughout the investigation period. Samples were despatched in batches on a daily basis under a chain of custody procedure to Element who are a UKAS accredited laboratory, for subsequent chemical analysis. Where appropriate, samples were stored within cool boxes containing ice packs.

Soil samples taken for geotechnical testing were transported to Professional Soils Laboratory for analysis.

All contractors, including laboratories, used during this project have been approved by Waterman as a part of in-house Integrated Management System (BS ISO 9001, BS ISO 14001) procedure. This requires all third parties to demonstrate competence and a high standard of work during a regular audit scheme.

3.3 Health and Safety

All work carried out on site was in accordance with Groundtech Consulting Ltd's Construction Phase Health and Safety Plan (Ref: GRO-20063-1788, Dated: September 2020).

4. Fieldwork

The works were procured to Groundtech Consulting and the main activities and supervision, are shown in chronological order of the works undertaken in Table 3.

Table 3: Summary of fieldwork activities

Phase of Work.	Activity	Contractor	Date	Supervision
Service survey	Scanning for services	Groundtech Consulting	September 2020	Waterman
Ground Investigation	4No. rotary boreholes to 30.0m bgl max. depth			
	12No. trial pits to 4.1m bgl max. depth			
Monitoring Well Installation	4No. monitoring wells to a maximum depth of 10.5m bgl			
Groundwater and Ground Gas Monitoring	Monitoring, sampling and analysis of four wells on six occasions		October – December 2020	

Note: m bgl = metres below ground level

4.1 Constraints

Borehole RC104 was originally proposed to be drilled in the car park in the centre of the Site. However, due to the operational status of the car park and the immediately adjacent building meant that this hole was relocated to an area of landscaping to the south. This also led to the relocation of trial pit TP108 to landscaping further to the south.

The locations of the actual exploratory holes excavated are shown in Groundtech Consulting Drawing Reference: GRO-20063-P02 in Appendix A.

4.2 Ground Investigation

12No. trial pits were excavated to an average depth of 2.94m bgl using a wheeled mechanical excavator with a backactor. Upon completion, excavations were backfilled as far as possible with arisings. The surface of the excavation was reinstated to the original conditions.

4No. rotary boreholes were drilled to depths of between 20.0m and 30.0m below ground level (m bgl). Inspection pits were excavated at each location to confirm the absence of buried services to a depth of 1.2m bgl. Standard Penetration Tests (SPT) were carried out at regular intervals in Made Ground and superficial deposits to assess the relative density of granular deposits and the consistency of cohesive strata. Coring was completed from rockhead for 10m in boreholes RC101, RC102 and RC104, the boreholes were then advanced using rotary open hole drilling to the full depth of the boreholes. Monitoring wells were installed in all boreholes.

4.3 Soil Sampling

During excavation, samples for chemical analysis were placed on plastic sheeting to prevent cross-contamination of soil. Representative soil samples were obtained from the exposed strata and sealed in one litre plastic tubs with airtight lids, phials and glass jars containing preservatives, as appropriate. The soil samples taken were subject to screening by a photo ionisation detector (PID).

Disturbed and undisturbed samples were taken at regular intervals and retained for geotechnical and geo-environmental testing and logging.

4.4 Monitoring Wells

On completion of drilling, a 50mm diameter slotted HDPE standpipe with gas tap and bung was installed in four of the exploratory holes to enable future ground gas and groundwater monitoring and sampling. The response zone of the wells was within the shallow natural strata. The intake section comprised a slotted pipe with a geotextile sock. The boreholes are kept sealed by a lockable secure cap at ground level.

4.5 Groundwater Monitoring

Groundwater monitoring is to be carried out during six monitoring visits over a period of three months. One monitoring visit has been completed to date. Prior to the monitoring being undertaken, each well was developed by high-rate pumping for 1h.

The presence of hydrocarbon free product on the groundwater was investigated using a free phase dip-meter using a disposable bailer, which did not show evidence of a hydrocarbon sheen on the surface.

Groundwater samples were obtained from the monitoring wells following purging of three well volumes using submersible pump. On-site testing of groundwater for temperature, pH, conductivity and dissolved oxygen was undertaken. The collected water samples were then sealed into bottles with pre-measured fixatives where necessary, as supplied by the specialist laboratory, and transported in cool boxes or refrigerated for 24hrs prior to despatch to the testing laboratory.

A set of groundwater monitoring results, including the model type and detection limits of the onsite equipment used for the fieldwork, is presented in Appendix C.

4.6 Ground Gas Monitoring

Ground gas monitoring is to be carried out during six monitoring visits over a period of three months. One monitoring visit has been completed to date. The ground gas monitoring was undertaken when the barometric atmospheric pressure was 974mb to 975mb. On each of the monitoring visits, the peak and steady concentration readings of methane, carbon dioxide and oxygen were recorded at each installed monitoring standpipe, together with borehole gas flow readings and atmospheric pressure. This was undertaken using an infrared gas analyser, gas flow data monitor and flame ionisation detector. Groundwater levels were also measured on each visit.

A set of ground gas monitoring results, including the model type and detection limits of the onsite equipment used for the fieldwork, is presented in Appendix C.

5. Results

Detailed logs of the strata encountered, together with records of the samples taken during both trial pitting and borehole installation and PID readings, are provided in Appendix B. A summary of the geological strata and manmade underground structures encountered is presented below.

5.1 Geological Strata

The strata encountered in the investigation were generally consistent with the anticipated geology identified in the Preliminary Environmental Risk Assessment. A summary of the geological strata encountered is shown in Table 4.

Table 4: Geological strata encountered

Soil Type	Depth of Top of Stratum (mbgl)	Thickness (m)	Typical Description
Made Ground	0 – 3.10	0.20 to 3.10	Grass over dark grey brown sandy clayey topsoil with gravel of ash, sandstone, quartzite, ceramic, coal, brick, glass, concrete and limestone to depths between 0.2m and 0.42m bgl. Soft to stiff grey brown sandy gravelly clay with a low cobble content of concrete and brick and gravel of brick, wood, concrete, steel, sandstone, coal and plastic.
Glacial Till	0.20 - 3.20m	0.40 – 1.80	Firm to very stiff medium to high strength orange brown mottled grey sandy gravelly silty clay. Gravel is angular to sub-rounded fine to medium of coal and sandstone. 0.60m in TP109 noted: extremely weak grey to brown mudstone residually weathered recovered as clayey angular to subangular fine to coarse gravel of mudstone.
Pennine Middle Coal Measures Formation	0.20 – 3.20	>24.80m	Interbedded brown to grey sandstone and siltstone with bands of soft mudstone Extremely to very weak brown to grey fine-grained sandstone highly weathered, recovered as slightly sandy slightly clayey angular to subangular fine to coarse gravel and tabular cobbles of sandstone. Sand is fine to medium. Extremely weak grey siltstone, highly weathered with horizontal rough planar closely spaced discontinuities and small-scale bedding structures present.

5.2 Underground Structures and Obstructions

TP103 was terminated at 2.85mbgl as the excavator was unable to advance through the coal. A suspected mine shaft was encountered in TP110 measuring approximately .2.5m wide, and present to the base of trial pit, which was terminated at 3.1mbgl due to instability within the backfilled material. These are detailed in the trial pit logs included within Appendix B.

5.3 Potential Sources of Contamination

Historically, coal seams and mining activities were undertaken on-site. Evidence of historical mine workings was encountered at the site as a suspected mine shaft was encountered in TP110, broken ground was encountered in RC101 and RC102 and, and void was encountered in RC104.

The presence of an above ground storage tank and fuel lines on-site is a potential source of contamination. However, no hydrocarbon contamination was noted during the ground investigation.

5.4 Chemical Analysis

The laboratory test results are presented in Appendix E.

5.5 Asbestos

Ten samples of Made Ground were screened for asbestos and no asbestos was recorded on-site. No visually identifiable asbestos containing materials was recorded during the Site investigation.

5.6 Visual and Olfactory Evidence of Contamination

Visual evidence of ash was observed within the topsoil at TP110 and TP112, in the west of the Site. Furthermore, a band of black ash and clinker was observed in TP112 between 0.42m and 0.53mbgl. No visual and olfactory evidence of hydrocarbon contamination was noted.

Soil headspace analysis recorded a peak concentration of 1ppm in TP112. The relatively low soil headspace analysis concentrations indicates the volatile component of contamination is not significant.

5.7 Groundwater Levels

No groundwater strikes were observed during the ground investigation. Groundwater levels were monitored on one occasion during the site works and subsequent monitoring visits, the results of which are included in Appendix C.

Groundwater monitoring indicates water levels between 5.48mbgl in RC104 and 10.72mbgl in RC101, RC102 was reported as dry. RC103 was reported to be flooded at the time of the first monitoring visit, as the result of localised puddling due to heavy rain. This data indicates a groundwater elevation range of 129.88m AOD (RC01) to 134.99m AOD (RC104).

It should be noted that levels are likely to fluctuate dependant on the time of year and prevailing weather conditions.

5.8 Ground Gas

As part of the site investigation, the installed boreholes were monitored on one occasion to date in order to detect the presence of ground gas. Six monitoring rounds will be undertaken at fortnightly intervals over a period of three months. The design of the borehole installation resulted in gas concentrations being recorded from Made Ground and suspected mine workings in RC101 and RC102. RC103 and RC104 were installed in the uppermost horizons of natural ground (sandstone/mudstone).

During each monitoring visit, the following parameters were recorded:

- Methane (peak and steady state conditions);

- Carbon dioxide (peak and steady state conditions);
- Oxygen (lowest and steady state);
- Borehole gas flow rates; and
- Groundwater levels.

Borehole RC103 was noted to be flooded above head, so peak concentrations were not recorded during the first monitoring round.

A set of ground gas results is included within Appendix C. Below Table 5 summarises the peak carbon dioxide and methane gas results recorded to date for each of the boreholes.

Table 5: Ground gas monitoring summary

Monitoring Point	Peak Gas Concentration (%)			Steady Gas Concentration (%)		
	CH_4	CO_2	O_2	CH_4	CO_2	O_2
RC101	0	2.9	14.7	0	2.7	16.7
RC102	0	0.1	13.5	0	0.3	16.1
RC103	N/A	N/A	N/A	0	0	16.2
RC104	0	0.1	1.6	0	0	16.2

The gas flows in the same monitoring wells ranged between -50.2 (RC104) and 0.01 litres per hour (RC101 and RC102).

6. Geotechnical Testing

6.1 In-Situ Testing

6.1.1 Standard Penetration Tests

Standard Penetration Tests (SPTs) were undertaken at regular intervals in the shallow deposits within the boreholes to provide 'N' values for empirical assessment of strength and density parameters. Detailed results of the SPT tests and blow counts are included on the borehole logs included in Appendix B and a summary is presented in Table 6:

Table 6: Standard penetration test results

Stratum / Geological Origin	Range of SPT 'N' Values	Number of Tests	Comments	Derived Values Range of φ' or cu
Weathered Pennine Middle Coal Measures	>50	2	Extremely weak sandstone recovered as sandy clayey Gravel of sandstone	φ' = >43°

6.1.2 Hand Vane Tests

Hand vane tests were undertaken at regular intervals within the trial pits to provide strength parameters for the shallow soils. Detailed results of the hand vane tests are included on the trial pit logs included in Appendix B and a summary is presented in Table 7 below:

Table 7: Hand vane test results

Stratum / Geological Origin	Range of shear strength values	Number of Tests	Comments
Made Ground	62 – 140kPa	3	Medium to high strength Clay
Glacial Till	66 – 140kPa, typically 110 – 140kPa	15	Medium to high strength Clay, typically high strength Clay

6.2 Laboratory Testing

Representative soil samples were scheduled for:

- Natural moisture content and plasticity index;
- Particle Size Distribution testing;
- Compaction Testing;
- Undrained Triaxial Testing;
- Point Load Strength Testing; and,
- pH value and water soluble sulphate (SD1 Suite).

The results are summarised below and presented in Appendix D.

6.2.1 Natural Moisture Content and Plasticity Index

Samples of natural cohesive material were taken for moisture content and plasticity index determinations. The test results are included in Appendix D and are summarised in Table 8.

Table 8: Atterberg Limit test results

Stratum / Geological Origin	Sample Loc & Depth	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% passing 425 microns	Comments
Made Ground	TP101 at 1.0m	40	20	20	95	Cohesive
	TP110 at 1.0m	45	22	23	98	Cohesive
Glacial Till	TP101 at 1.5m	60	26	34	98	Cohesive
	TP103 at 0.8m	39	21	18	100	Cohesive
	TP107 at 0.8m	38	22	16	98	Cohesive
	TP110 at 1.0m	45	22	23	98	Cohesive
	TP111 at 0.5m	54	23	31	98	Cohesive
	TP112 at 1.0m	42	21	21	97	Cohesive

The modified plasticity index can be used as an indicator of volume change potential of the soil and is calculated as the plasticity index of the soil multiplied by the fraction of particles less than 425µm.

Table 9: Volume change potential

Stratum / Geological Origin	Range of Plasticity Indices % (Modified)	Volume Change Potential
Made Ground	19 – 22	Low to medium
Glacial Till	20 – 25	Medium

6.2.2 Particle Size Distribution Testing

Particle Size Distribution (PSD) testing was undertaken on 5No. samples to allow the materials to be classified. Results indicate the Made Ground samples tested to comprise Clay and Silt sized material with secondary components of Gravel and Sand. The Glacial Till is noted to comprise Clay and Silt sized material with secondary components of Gravel and Sand. The results of the PSD tests are presented within Appendix D and summarised within Table 10.

Table 10: Summary of Particle Size Distribution Test Results

Stratum / Geological Origin	Sample Loc & Depth	Cobbles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
Made Ground	TP101 at 1.0m	0	27	22	18	33
	TP102 at 0.5m	0	28	20	19	33
	AVERAGE	**0**	**28**	**21**	**18**	**33**
Glacial Till	TP103 at 0.5m	0	15	18	29	38
	TP107 at 1.0m	0	28	24	20	28
	TP111 at 0.5m	0	5	12	37	46
	AVERAGE	**0**	**16**	**18**	**28**	**38**

6.2.3 2.5kg Dry Density / Moisture Content Relationship Testing

Dry Density / Moisture Content Relationship testing was undertaken on a total of 3No. samples of the shallow soils to assess the feasibility of re-compaction of material at the site. The results of the compaction tests are presented within Appendix D and summarised within Table 11 below.

Table 11: Dry Density / Moisture Content Relationship Results

Stratum / Geological Origin	Sample Loc & Depth	Maximum Dry Density (Mg/m^3)	Initial Moisture Content %	Optimum Moisture Content %	> 95% of MDD?	<5% air voids?
Made Ground	TP102 – 0.5m	1.86	17	14	Y	Y
Glacial Till	TP103 – 0.5m	1.87	14	14	Y	Y
	TP107 – 1.0m	1.82	15	15	Y	Y

The compaction data has been assessed by comparing the results against criteria commonly used in earthworks to achieve an adequate density for engineered fills. The criteria summarised in the above table indicate whether the samples could achieve in excess of 95% of maximum dry density (a requirement often included in highways specifications) and whether they could be compacted to less than 5% air voids ratio (a requirement applied where raft foundations are to be adopted).

6.2.4 Undrained Triaxial Testing

1No. quick undrained triaxial test (single-stage) on a 100mm diameter specimen was undertaken to determine the shear strength of the natural shallow strata . The results of these tests are presented in Appendix D, and are summarised in Table 12:

Table 12: Triaxial test results

Stratum / Geological Origin	Undrained shear strength values (kN/m^2)	Undrained Shear Strength / Comments
Glacial Till	250kN/m^2 at 1.2m bgl in RC104	Very high strength Clay

6.2.5 Point Load Strength

Point Load Tests were undertaken to inform an assessment of the strength of the bedrock present beneath the Site. The results of the Point Load tests are presented within Appendix D and summarised in Table 13. .

Table 13: Point Load Strength Tests

Stratum	$I_{s(50)}$ (MPa)	Approximate unconfined compressive strength (MPa)	Comments
Pennine Middle Coal Measures	0.07 – 4.87	1.19 – 82.79	Very weak to strong, typically very weak, Sandstone, Siltstone and Mudstone

A factor of 17 has been applied to the $I_{s(50)}$ to determine an approximate unconfined compressive strength from the Point Load test results (from Hoek and Bray 1982). The results of Point Load tests should be utilised with caution as the in-situ strength characteristics of the rock are likely to be determined more by the aperture and spacing of discontinuities rather than the strength of the rock itself.

6.2.6 pH Value and Water Soluble Sulphate (SD1 Suite)

The Aggressive Chemical Environment for Concrete classifications for the soil types identified at the site have been determined in accordance with BRE Special Digest 1:2005 (SD1). SD1 requires that sites are first identified as being in one of four categories based on natural ground / 'Brownfield' conditions and pyrite content. The site has been categorised as: Brownfield - pyritic.

The results of laboratory testing are included in Appendix D and summarised in Table 14.

Table 14: Summary of SD1 suite analysis

Stratum / Geological Origin	Characteristic Water Soluble Sulphate Value (mg/l SO_4)	Characteristic pH Value
Made Ground	<10	7.5
Pennine Middle Coal Measures	12	5.6

As the characteristic value of sulphate is less than 3,000mg/l and the characteristic pH is greater than 5.5, the concentrations of magnesium, nitrate and chloride are not considered significant in determining the design sulphate class.

6.3 Excavations and Trench Shoring

All trenches should be excavated in accordance with CIRIA Report 97 'Trenching Practice'. Comments relating to the stability of excavations (i.e. trial pits) and groundwater seepages are included in the logs in Appendix B and a summary of the stability is provided in Table 15.

Table 15: Stability of excavations and groundwater flows

Stratum / Geological Origin	Stability / Seepages	Comments
Made Ground	No seepages or instability noted. Instability and perched groundwater associated with historical mining features should be anticipated.	Shallow excavations (<1.2m) likely to be stable in the short term. Excavations in soft/loose/water bearing strata likely to require shoring to maintain stability. Simple sump pumping may be required to control moderate groundwater seepages in granular materials.
Glacial Till	No seepages or instability noted.	Shallow excavations (<1.2m) likely to be stable in the short term.

7. Generic Environmental Assessment Criteria

The information requirements for generic quantitative risk assessment will depend on:

- The substance being assessed;
- The receptors being considered;
- The pathways being considered; and
- The complexity of the site.

The outline conceptual model developed for the Site has identified potential contaminant linkages. These potential contaminant linkages have been investigated and the results assessed against generic assessment criteria. The generic assessment criteria selected for each potential contaminant linkage are summarised in Table 16 below:

Table 16: Generic assessment criteria

Source	Pathway	Receptor	Generic Assessment Criteria
Potential contamination in Made Ground and shallow soils from land uses surrounding the Site.	Dermal contact, inhalation and ingestion of contamination in shallow soils and windborne dust.	Future Site residents/users Off-site users	Generic Assessment Criteria for residential land use without plant uptake. Category 4 Screening Levels (C4SLs), LQM/CIEH S4ULs (Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3060. All rights reserved), CL:AIRE (2009) PAH assessment using Benzo(a)pyrene surrogate marker assessment
Contamination in Made Ground, shallow soils, and shallow groundwater.	Migration through Glacial Till to nearby watercourses.	Secondary A Aquifers (Glacial Till and Pennine Coal Measures)	UK Drinking Water Standards and Environmental Quality Standards for freshwater
Ground gas from Worked Coal Seams Vapours from Worked Coal Seams	Ingress into structures. Risk of explosion and asphyxiation. Off-site migration of contamination.	Future Site residents/users Future on-site structures Off-site users Off-site structures	Preliminary Gas Screening Value determination and assessment in accordance with CIRIA C665 and BS8485:2015+A1:2019 and CL:AIRE Technical Bulletin 17 Semi-quantitative risk Assessment for vapours utilising PID measurements alongside soil and groundwater contamination results in accordance with CIRIA C682 and BS8576: 2013.
Potential contamination in Made Ground and shallow soils from land uses surrounding the Site.	Direct Contact	New water supply pipes	Water Regulations Advisory Scheme Information and Guidance Note UKWIR Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites
Potential contamination in Made Ground and shallow soils from land	Contact with building foundations and buried services	Future on-Site structures and services.	BRE Special Digest 1: 2005 Concrete in Aggressive Ground.

Source	Pathway	Receptor	Generic Assessment Criteria
uses surrounding the Site.			
Potential contamination in Made Ground and shallow soils from land uses surrounding the Site. Windborne dust from stockpiled soils and bare earth surfaces during construction	Dermal contact, ingestion and inhalation	Construction Workers	Qualitative Risk Assessment

The generic assessment criteria used in this report are included in Appendix G.

7.1 Site Specific Information used to Support the Generic Risk Assessment

The site specific information used to support the generic risk assessment undertaken as part of this investigation are described in the sections below:

Human Health Risk

Future Site Users

The Site is proposed to provide a 900-place secondary school. This development will include a new school building in the north-east, hard landscaping car park in the centre of the site and both soft and hard landscaping sports fields in the surrounding area. New residential buildings with private gardens will be built in the north of the site. Given the proposed end use for the Site the contaminants will be assessed against the Residential without plant uptake land use. This will be a highly conservative assessment given the current proposed Development, and will be used to give additional context to the contamination magnitudes recorded.

Construction Workers

A qualitative assessment of the risk to construction workers will be undertaken.

Off-site Residents and Users

Risks to off-site residents and users was assessed qualitatively through review of the recorded ground investigation information and the Site's and surrounding areas environmental setting.

Controlled Waters

Sensitive controlled water receptors identified include; the small watercourse 26m south-east and Secondary A Aquifers in Glacial Till and Pennine Coal Measure strata. Groundwater and surface water abstractions are absent within a 1km radius of the Site.

Groundwater in the superficial and bedrock deposits are potentially in hydraulic continuity with the water course. Potable groundwater receptors are absent on-site or in the surrounding area, groundwater samples will therefore be assessed against the lowest value for each contaminant as given in the UK Drinking Water Standards (DWS) and the Environment Agency (EA) Environmental Quality Standards (EQS). The assessment against the lowest values of the DWS and EQS will be used as an indication of the groundwater's contamination status given the small watercourse.

Re-use of Topsoil

Potential re-use of topsoil is possible and could pose a risk to future Site residents/users, off-site users, future on-Site and off-site structures, and construction workers. Testing for phytotoxic contaminants will be undertaken in accordance with methods specified in BS3882:2007.

Ground Gas

Potential receptors of ground gas generation are future Site residents/users, off-site users, future on-Site and off-site structures, and construction workers.

The potential risk arising from ground gas to the development was assessed using the approach recommended in CIRIA C665, BS 8485:2015+A1:2019, and BS 8576: 2013.

Vapours

A semi-quantitative approach was used to assess risks from vapours in accordance with CIRIA C682. Concentrations of hydrocarbon vapours (ppm) have been recorded in monitoring wells using a PID. Soil headspace testing has been used to supplement the vapour monitoring along with analysis for VOCs and SVOCs in soil and groundwater samples.

Off-site structures

Risks to off-site structures from contamination in groundwater, ground gases and vapours was assessed through analysis of soil, groundwater, ground gas and vapour concentrations on-Site, assessment of the hydrogeological regime at the Site and potential for off-site migration of contamination, ground gas and vapour.

8. Quantitative Environmental Risk Assessment – Risk Estimation

8.1 Regulatory Context

This assessment has been undertaken in general accordance with the Land Contamination Risk Management (Environment Agency, October 2020). The environmental risk assessment includes the following:

- outline preliminary Conceptual Model, as detailed in the PERA;
- results of Intrusive Ground Investigation;
- confirmation of Generic Assessment Criteria used to assess risks;
- assessment of results against Generic Assessment Criteria;
- formulation of an updated Conceptual Model for the Site;
- identification of potentially unacceptable risks; and
- recommendations for further action.

This report forms a decision record for the contaminant linkages identified, the generic assessment criteria used to assess risks, the unacceptable risks identified and the proposed next steps in relation to the site. The report also provides an explanation of the refinement of the outline conceptual model following the ground investigation, the selection of criteria and assumptions, the evaluation of potential risks and the basis for the decision on what happens next.

The Site comprises the former Keresforth Centre NHS facility, and a playing field adjacent to the A6133 Broadway. The NHS site was a base that originally provided a range of services on behalf of South West Yorkshire Partnership NHS Foundation Trust. The Site is on split-levels, the buildings located at the back of the site on the lower lying land and the open space on higher land fronting Broadway.

It is proposed to demolish all structures within the Site boundary, to facilitate the construction of Trinity Academy, Barnsley which is to provide a 900 place secondary school on the Site. This development will include a new school building in the north-east, hard landscaping car park in the centre of the Site and both soft and hard landscaping sports fields in the surrounding area. New residential buildings with private gardens will be built in the north of the Site.

The National Planning Policy Framework (NPPF) 2019 sets out Government planning policy for England and how this is expected to be applied to development. Paragraph 118 of Section 11 – Making effective use of land and paragraphs 170, 178, 179 and 183 of Section 15 – Conserving and enhancing the natural environment of the NPPF relate to contaminated land matters and state the following:

118. Planning policies and decisions should:

c) give substantial weight to the value of using suitable brownfield land within settlements for homes and other identified needs, and support appropriate opportunities to remediate despoiled, degraded, derelict, contaminated or unstable land;

170. Planning policies and decisions should contribute to and enhance the natural and local environment by:

e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability.

Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and

f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.

178. Planning policies and decisions should ensure that:

a) a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);

b) after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and

c) adequate site investigation information, prepared by a competent person, is available to inform these assessments.

179. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.

183. The focus of planning policies and decisions should be on whether proposed development is an acceptable use of land, rather than the control of processes or emissions (where these are subject to separate pollution control regimes). Planning decisions should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a particular development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities.

In order to assess the contamination status of the Site, with respect to the proposed end use, it is necessary to assess whether the Site could potentially be classified as “Contaminated Land”, as defined in Part IIA of the Environmental Protection Act 1990 and Contaminated Land Statutory Guidance 2012. This is assessed by the identification and assessment of potential contaminant linkages. The linkage between the potential sources and potential receptors identified needs to be established and evaluated.

To fall within this definition, it is necessary that, as a result of the condition of the land, substances may be present in, on or under the land such that:

a) significant harm is being caused or there is a significant possibility of such harm being caused; or

b) significant pollution of controlled waters is being caused, or there is significant possibility of such pollution being caused.

It should be noted that DEFRA has advised (Ref. Section 4, DEFRA Contaminated Land Statutory Guidance 2012) Local Authorities that land should not be designated as “Contaminated Land” where:

a) the relevant substance(s) are already present in controlled waters;

b) entry into controlled waters of the substance(s) from land has ceased; and

c) it is not likely that that further entry will take place.

These exclusions do not necessarily preclude regulatory action under the Environmental Permitting (England and Wales) Regulations 2016, which make it a criminal offence to cause or knowingly permit a water discharge of any poisonous, noxious or polluting matter to controlled waters. In England and Wales,

under The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009, a works notice may be served by the regulator requiring appropriate investigation and clean-up.

The potential contaminant linkages identified in Section 7 have been evaluated using the Generic Assessment Criteria described in Section 7 and Appendix G. The results of this evaluation are reported below:

8.2 Risk to Human Health

The soil laboratory results were assessed against the GAC for a residential land use without plant uptake. Contaminants in exceedance are included in Table 17.

Table 17: Summary of generic quantitative risk assessment for human health

Stratum	Contaminant	Location, depth (m bgl)	Concentration (mg/kg)	Generic Assessment Criteria (mg/kg)
Made Ground	Beryllium	TP110, 1.00 TP112, 0.20	2.30 1.90	1.7
Made Ground	Benzo(b)fluoranthene	TP112, 0.20	6.81	3.90
Made Ground	Benzo(a)pyrene	TP112, 0.20	5.32	3.20
Made Ground	Di-benzo(a.h.)anthracene	TP112, 0.20	0.72	0.31

Contaminants in exceedance were limited to two locations (TP110 and TP112) in the west of the Site, with PAHs in exceedance in TP112, and metal (beryllium) marginally in exceedance in TP110 and TP112. The recorded soil laboratory results show a potential hotspot of contamination in TP112, where the exploratory hole log identifies the Made Ground to contain ash.

No olfactory evidence of contamination was observed. Visual evidence of contamination of ash was observed within the topsoil of TP110 and TP112. This could potentially be the source of the exceedances recorded.

No asbestos was recorded in the Made Ground samples subject to testing.

8No. samples were tested for Calorific Value with one elevated concentration of 2.75MJ/kg being recorded in a sample collected from TP101 at 0.5m bgl. This elevated concentration is likely associated with ash in the Made Ground at this location. No further elevated concentrations were recorded in the samples tested, however, given the significant mining heritage in the vicinity of the Site, it is considered likely that materials with high Calorific Value may be present on site.

Volatile Organic Compounds (VOC) and Semi-Volatile Organic Compounds (SVOC) laboratory testing recorded all contaminants to be below the laboratory detection limit. Hydrocarbon testing reported TP111 to be above the limit of detection (<52mg/kg), however, the recorded concentration of 115mg/kg is below the relevant GAC.

The laboratory soil results identify the Made Ground in the west of the Site as containing elevated contaminants, which could pose a risk to future site users should they be allowed to come into direct contact with the Made Ground. In areas of proposed hardstanding future site users will be prevented from coming into direct contact with the contaminants in the Made Ground by a physical barrier, breaking the pollutant linkage and mitigating the risk. In areas of soft and hard landscaping, a cover layer of sufficient thickness will be required to mitigate the risk of future site users coming into direct contact with contaminants.

8.2.1 Off-site users

The soil laboratory results have identified the Made Ground as containing contaminants above natural background concentrations. During construction works the contaminants could mobilise via wind entrainment and migrate off-site. To break the pollutant linkage and mitigate the risk, dust suppression methods will be required to limit the mobilisation of dust off-site. Suitable mitigation for these issues should be detailed in a Construction Environmental Management Plan (CEMP).

8.2.2 Risk to Construction Workers

The ground investigation has recorded soil contaminant concentrations above the natural levels in Made Ground. A potential risk to construction workers is therefore present. To mitigate the risk construction workers should wear appropriate Personal Protective Equipment (PPE) during any below ground works in order to mitigate potential effects from direct contact, dermal absorption, inhalation, and ingestion of any residual contaminants in soils and groundwater.

All construction workers should be subject to mandatory health and safety requirements under the Construction, Design and Management (CDM) Regulations 2015 and Control of Substances Hazardous to Health (COSHH) Regulations 2002, the Confined Space Regulations 1997, and Control of Asbestos Regulations 2012 (CAR 2012).

Whilst asbestos has not detected in ten samples and has not been largely identified in soils, construction workers should be asbestos awareness trained.

8.3 Risk to Controlled Waters

Results from testing undertaken on groundwater samples are currently outstanding. Once results are received, this report should be updated to include an assessment of the risks to controlled waters.

8.4 Risk to Ecological Systems/Vegetation

Assessment of soils laboratory analysis against phytotoxic contaminant threshold criteria reported no exceedances.

8.5 Risk to Structures

8.5.1 Risk to Water Supply Pipes

Contaminants have been recorded in the soil on-site. The UKWIR project steering group decided that barrier pipes would provide sufficient protection for the supply of drinking water in all Brownfield site conditions. The local water company should be contacted at the appropriate time to confirm the most appropriate material for drinking water supply pipes.

8.6 Ground Gas

Gas monitoring is currently being undertaken at the site. One round of ground gas monitoring was undertaken on 27th October 2020. Six rounds of monitoring will be undertaken at fortnightly intervals.

Based on the available monitoring data, ground gas monitoring results from the from one monitoring round has recorded the following peak ground gas concentrations and flow rates;

- Methane – 0%
- Carbon dioxide – 2.9% (RC101)
- Flow rate – 0.1/hr (RC101 and RC102)

Methane was recorded below the equipment's detection Limit (<0.1). The relatively low methane concentrations indicate no microbial degradation of low quantities of organic material in the soil is occurring. Further assessment of Site's ground gas regime will be assessed when additional monitoring rounds have been undertaken.

The absence of a high ground gas monitoring flow rate during monitoring round does not confirm the absence of a significant ground gas generating source as being present on-site as additional information and further assessment is required. Calculation of the Gas Screening Value (GSV) from the ground gas monitoring rounds completed records a methane GSV of 0.0001l/hr, and carbon dioxide GSV of 0.0087/hr. The recorded methane and Carbon dioxide GSVs and review of the ground gas monitoring results identify them as being consistent with a Characterisation Situation 1 (CS1) ground gas regime classification in which the ground gas risk is low and mitigation measures in the built development would not be required.

This risk assessment should be reviewed upon completion of the subsequent monitoring rounds. Given the presence of a potential source of ground gas beneath the Site (shallow mine workings), it may be prudent to allow for the installation of gas protection measures in accordance with Characteristic Situation 2 at this stage.

The Preliminary Environmental Risk Assessment identifies the Site to be partially within an area of elevated radon levels (between 1% and 3%). Correspondingly, basic protective measures may be required in the proposed development. The approach should be confirmed with the Building Control Officer.

8.7 Vapour

A review of the lines of evidence used to assess whether a significant vapour regime is present on-site records the following;

- Soil headspace analysis of samples recorded low concentrations across the Site between 0 ppm – 1.0ppm; and,
- Soil laboratory analysis records the volatile contaminants as being below the laboratory limit of detection.

The vapour lines of evidence as detailed above show that a significant vapour regime is absent. The implementation of vapour protection measures in the proposed Development would not be required.

This assessment should be updated upon receipt of results of chemical laboratory testing undertaken on groundwater samples.

9. Geotechnical Assessment

9.1 Proposed Development

It is proposed to demolish all structures within the site boundary, to facilitate the construction of Trinity Academy, Barnsley. The development will include a new three storey school building in the north east, hard landscaping car park in the centre of the site and both soft and hard landscaping sport fields in the surrounding area. No basements are proposed. Lift access will be provided to upper storeys.

A proposed site layout (Watson Batty Architects Drawing Ref: TRNTY-WBA-EX-ZZ-DR-A-X-001 P2) is included in Appendix A.

If development proposals change, it may be necessary to revise the conclusions and recommendations made in this report and Waterman should be contacted to provide further advice.

9.1.1 Mining

The ground investigation confirmed the presence of the Barnsley Coal Seam as follows:

- RC101 records zones of no recovery at 1.5m to 1.98m, 3m to 3.53m, and at 4.5m to 4.96m. These are interpreted to be the result of weathered or weak rock being further weakened by the drilling resulting in no core being obtained. Zones of no recovery at 7.5m to 8.4m and 9m to 10.26m are interpreted as suspected mine workings, as they are associated with a loss of drilling flush at 8m. Intact coal was encountered at 10.5m to 10.9m.
- RC102 records zones of no recovery at 1.5m to 2.19m, 4.5m to 5.36m, and 6.0m to 7.02m. These are interpreted to indicate the presence of weathered or weak rock. Zones of no recovery at 7.5m to 8.4m and a void noted at 9.0m to 10.5m are interpreted as suspected mine workings, as they are associated with a loss of drilling flush from 8m.
- RC103 records intact coal at 19.5m to 22.0m.
- RC104 records zones of no recovery at 3.0m to 3.72m, 4.5m to 4.84m, 6m to 6.6m, and 7.5m to 7.69m. These are interpreted to indicate the presence of weathered or weak rock. A void is identified at 15.4m to 16.8m and is interpreted as suspected mine workings.

All of the suspected mine workings and intact coal are thought to be associated with the Barnsley Coal Seam.

The greatest thickness of no recovery or void associated with the Barnsley Coal seam was 3.0m beneath the Site in RC102, from 7.5m to 10.5m bgl. Based on a likely propagation of voids to 10 times worked seam thickness through rock, as per CIRIA C758D, voids could migrate upwards by 30m.

There is an insufficient thickness of rock cover to arrest the upward migration of voids from the Barnsley Coal Seam and therefore workings are considered to constitute a risk of surface instability.

Therefore, it is recommended further investigation is undertaken below the footprint of the proposed buildings, which should take the form of Primary Consolidation Grouting to confirm the presence of workings or otherwise, with Secondary Grouting should workings be identified.

A mine shaft has been identified in trial pit TP110, in the playing fields in the west of the Site. The shaft was found to be uncapped and to have a diameter of approximately 2.5m. The shaft backfill was present from approximately 0.5m below ground level and comprised of Colliery Spoil.

The mine shaft should be fully investigated and appropriately treated, most likely by construction of a reinforced concrete cap. It is recommended that the design of the proposed sports pitches in this area of the Site includes mitigation for the risk of ground collapse associated with unidentified coal mining features.

The remedial works to be implemented to both the shallow mine workings and mine shaft should be agreed with The Coal Authority, with appropriate permissions and licenses obtained.

9.1.2 Characteristic Values

Based upon the ground investigation data and a review of the derived values summarised in Section 6, characteristic values can be assigned to each strata. EC7 defines the characteristic value of a soil or rock as a cautious estimate of the value affecting the occurrence of the limit state. The characteristic values to be used in design are highlighted in Table 18.:

Table 18: Characteristic values for geotechnical design

Stratum / Geological Origin	Strength / Density Descriptor	Range of Derived Values	Characteristic Undrained Strength (cu - kPa)	Characteristic Unconfined Compressive Strength (UCS - MPa)	Characteristic Angle of Shearing Resistance (φ' - °)
Glacial Till	Medium to very high strength Clay, typically high strength Clay	cu = 66 – 250kPa, typically 110 – 140kPa	100kPa	-	-
Weathered Pennine Middle Coal Measures	Extremely weak sandstone recovered as sandy clayey Gravel of sandstone	φ' = >43°	-	-	φ' = 30°
Pennine Middle Coal Measures	Very weak to strong, typically very weak, Sandstone, Siltstone and Mudstone	UCS = 1.4 – 97.4MPa, typically 2 – 5MPa	-	2MPa	-

The imposed permanent and variable actions (loads) are not currently know. Horizontal actions are not considered in detail here and these should be checked as part of detailed geotechnical design.

For the purposes of estimating design bearing resistance, shallow foundations placed on high strength cohesive deposits (i.e. Glacial Till), with a characteristic cu value of approximately 100kPa would be expected to have a an allowable bearing capacity of at least 150kPa. Long term consolidation settlement has a limiting influence on the design resistance of cohesive deposits; a higher design bearing resistance may be obtained if a more detailed assessment of consolidation settlement is undertaken.

The above preliminary assessment of design bearing resistance is based on a strip footing founded in suitable bearing strata at 1m below ground level, where horizontal actions are less than 20% of the total vertical actions.

It has also been assumed that a maximum total settlement of 25mm would be acceptable within the serviceability of the design. Differential settlement should be assessed when the foundation layout has been developed, however provided all foundations are taken onto a consistent bearing strata, strip foundations should yield differential settlements of less than 1 in 400.

9.1.3 Shallow Foundations

Made Ground and soft/ loose natural deposits are not considered to be suitable bearing strata. Where these materials are identified, foundations should be placed on adequate bearing strata at deeper levels. Foundations should be placed on uniform founding strata to avoid differential settlement.

Identification of the appropriate founding stratum on site must be undertaken by an experienced engineer. If necessary, Waterman should be contacted to provide further advice.

The descriptions and results of lab and in-situ testing suggest that strip foundations could be placed on the high strength deposits at relatively shallow founding depths (i.e. approximately 1m below existing ground level). Foundations should be placed on a uniform bearing strata, and as such it may be necessary to deepen foundations if Made Ground or soft/ loose materials are encountered at foundation level.

Given the presence of the Barnsley Coal Seam at relatively shallow depth beneath the Site, the foundation designer should consider the influence of foundation loads on potential shallow mine workings. Appropriate rock cover should be present between the base of shallow foundations and underlying coal seams. Consideration should be given to the use of a raft slab. Coal Authority approval should be gained for the design as part of the Permitting process.

The design bearing resistance(s) quoted above have been estimated in accordance with EC7, Design Approach 1. Bearing resistance and settlement are functions of shape and depth of foundation, and the magnitudes of inclined, static and variable loads and these should be checked as part of detailed geotechnical design.

9.1.4 Piled Foundations

For foundation loads significantly in excess of the design bearing resistance estimated above or where the presence of shallow mine workings precludes the use of shallow foundations, piled foundations could be utilised. It is recommended that the advice of a specialist piling contractor should be obtained to confirm the suitability of piling and the most appropriate pile type. However, based on the site investigation information, end bearing piles would key into the Pennine Middle Coal Measures bedrock present from approximately 2m to 3m below ground level or would be extended to between 10m and 25m below ground level to extend through the worked Barnsley Coal Seam.

Given the presence of the Barnsley Coal Seam at relatively shallow depth beneath the Site, the pile design should consider the influence of piling on potential shallow mine workings. Appropriate rock cover should be present between the termination depth of piled foundations and underlying coal seams. The piling contractor should seek Coal Authority approval for their design as part of the Permitting process.

The final design of the piles will be the responsibility of the piling contractor. An allowance for probing of pile positions and/or drilling of obstructions should be allocated. The carrying capacity of the actual pile groups will in part depend on the number, type and size of pile chosen by the contractor and the quality of workmanship. Where cast in situ concrete piles are proposed, the roughness of the rock socket will influence the carrying capacity of the pile.

The piles should be designed based on the requirements of Eurocode 7 and guidance such as CIRIA Report 181, Piled Foundations in Weak Rock.

During detailed pile design the choice of factors of safety should ensure that appropriate safe working loads and settlement tolerances are met.

Subject to any piling trials, an acceptable percentage of piles should be load tested to at least twice working load. All piles should be integrity tested.

Consideration should be given to the re-use of pile arisings if bored piles are used. It may be possible to re-use pile arisings subject to risk assessment; however, certainty of use and volume should be confirmed in accordance with the requirements of CLAIRE guidance.

Given the proximity of existing structures, the effects of noise and vibration (e.g. from piling plant) should be addressed as part of the Contractor's method statement.

9.1.5 Shrinkability / Volume Change Potential

Glacial Till has been shown to have a medium shrinkability.

Foundations placed on shrinkable soils should be deepened where necessary to accommodate the effects of trees and hedgerows. Where foundations are beyond the influence of existing and proposed planting (i.e. 1.5 times the mature tree height), the minimum founding depth in soils of a medium volume change potential would be 0.9m below existing or proposed ground level (whichever is lower).

Foundations within the zone of influence of existing or proposed trees should be deepened as necessary in accordance with recommendations provided in NHBC Chapter 4 – Building Near Trees. If trees are present within influencing distance of proposed foundations, a tree survey should be undertaken to identify appropriate founding depths.

9.1.6 Design Class for Concrete

Based on the characteristic values derived from SD1 testing, the Design Sulphate (DS) and Aggressive Chemical Environment for Concrete (ACEC) classifications are considered to be:

- Concrete in contact with Made Ground: DS-1 AC-1
- Concrete in contact with Pennine Middle Coal Measures: DS-1 AC-1

This is based on the site characterisation as "Brownfield-pyritic" and the assumption of mobile groundwater.

9.1.7 Earthworks / Pavement Design

The results of compaction testing undertaken on samples of the shallow soils indicate that the Made Ground and Glacial Till could generally be recompacted to achieve >95% of MDD and <5% air voids.

Based upon the results obtained, Made Ground and Glacial Till could potentially be used as an engineered fill, subject to other suitability considerations. Made Ground may require treatment prior to re-use due to it generally being wet of Optimum Moisture Content. It should be noted that suitability for compaction is highly dependent on the initial moisture content of the material to be compacted. PSD results indicate that the Made Ground would be classified as Class 2C and the Glacial Till would be classified as Class 2A/2B in accordance with the Specification for Highway Works.

It would be sensible to subject proposed earthworks materials to a confirmatory testing regime where they were required to achieve a compaction specification as a general fill. Site won materials are unlikely to prove suitable as a structural fill, being generally cohesive in nature.

Construction plant should be provided with an adequate working platform in line with the requirements of BRE report, "BR 470: Working Platforms for Tracked Plant". Further advice should be sought from the temporary works designer.

Areas of roadway and hardstanding will be included in the development and will likely have a subgrade comprising Made Ground or Glacial Till. Significant earthworks may be required prior to construction and pavement design should allow for the potential presence of a thickness of engineered fill above natural strata.

Subgrade strength may vary considerably across the site, especially where affected by variations in moisture content. During construction, the in-situ CBR value must be checked against the Design CBR value, to confirm design requirements are being met, in accordance with CD225 or Local Authority guidance.

9.1.8 Floor Slabs

Given that there is limited Made Ground in the vicinity of the proposed school building, no identified risk of heave (earthworks cut is unlikely in this area of the Site) and ground conditions are likely to be relatively uniform across the proposed building footprint, ground bearing floor slabs are potentially viable for the proposed development.

Significant earthworks may be required prior to construction and floor slab design should allow for the potential presence of a thickness of engineered fill above natural strata.

The design of floor slabs should only be finalised when the updated gas monitoring has been completed and assessed, as the recommendations of the gas monitoring report will influence the final choice of floor slab design. The above advice is provided for guidance only at this stage.

9.1.9 Groundwater / Stability of Excavations

Comments relating to the stability of excavations (i.e. trial pits) and groundwater seepages are included in the logs in Appendix B. No groundwater was encountered during the ground investigation.

Groundwater monitoring indicates water levels between 5.48mbgl in RC104 and 10.72mbgl in RC101, and borehole RC102 was reported as dry. RC103 was flooded at the time of the first round groundwater monitoring. This data indicates a groundwater elevation range of 129.88m AOD (RC01) to 134.99m AOD (RC104).

It should be noted that levels are likely to fluctuate dependant on the time of year and prevailing weather conditions. For design purposes, it is recommended that the groundwater level be assumed at 5.5m bgl. This level will be reviewed on completion of the groundwater monitoring visits.

Based on observations made during fieldwork, shallow excavations (<1.2m) are likely to be stable in the short term. However, should deeper Made Ground be encountered, particularly where this is associated with historical mining features, then some instability should be expected, and appropriate mitigation measures utilised.

Consideration should be given to the re-use of arisings from foundation trenches / drainage runs etc. Where contamination has been encountered, it may be possible to reuse foundation arisings; however, certainty of use and volume should be confirmed in accordance with the requirements of CL:AIRE guidance. Waterman Supplementary Ground Investigation Report should be consulted with regards to suitability for re-use of materials.

In line with BS6031, all excavations should be examined daily by a competent person to ensure that they remain safe. Where the sides cannot be sloped back to a safe angle, as approved by a competent and experienced person, their continued stability should not be taken for granted. Vertical or steep faces should be provided with support unless instructed otherwise by a competent person.

10. Conclusions and Risk Evaluation

10.1 Environmental Assessment

Following the implementation of the ground investigation, the contaminant linkages identified during the Preliminary Environmental Risk Assessment have been re-evaluated and reclassified in relation to the additional information obtained. The results of the reassessment are summarised in Table 19 below:

Table 19: Estimation of environmental risks associated with the subject site

Receptor	Potential sources	Pathway	Risk	Justification/Mitigation
Human Health				
Future Site Users	Potential contamination in Made Ground and shallow soils from land uses surrounding the Site.	Dermal contact and inhalation of dust from contaminated soils during works Contact with potential contamination in shallow soils in areas of soft landscaping.	**Low**	Elevated contaminant concentrations are present in the Made Ground on-site as beryllium and PAH exceeded the GAC. In areas of proposed hardstanding the direct pathway to future Site users will be removed breaking the contaminant linkage. In areas of hard and soft landscaping potential remains for future Site users to come into contact with Made Ground. In these areas a cover layer of suitable thickness and of suitable for use material will be installed. The thickness of the clean cover layer will be dependent on the type and magnitude of the contaminants recorded and will be established in the Remediation Strategy. Upon implementation of the cover layer in areas of soft landscaping the risk to future Site users will be mitigated and no further remedial measures will be required.
Worked Coal Seams (Ground gas and vapours)	Worked Coal Seams (Ground gas and vapours)	Accumulation in confined spaces, leading to inhalation.	**Medium**	A significant ground gas or vapour regime is absent on-site. However, ground gas and vapour monitoring will confirm the Sites' ground gas regime. Further monitoring will confirm if ground gas or vapour protection measures would be required in the completed Development.
Off-Site Users and nearby residents	Potential contamination in Made Ground and shallow soils.	Windborne, potentially contaminated construction dust. Runoff from stockpiled soils.	**Medium**	Elevated contaminant concentrations have been recorded in the Made Ground in two locations. During construction, these contaminants may become mobilised by wind entrainment and migrate off-site. Residential and public land uses are present in the surrounding area. During construction good working practices for

Receptor	Potential sources	Pathway	Risk	Justification/Mitigation
				dust suppression should be employed to limit dust creation and migration as far as practically possible. Where suitable dust suppression is employed the risk to off-site users would be mitigated.
Construction Workers	Potential contamination in Made Ground, shallow soils, and shallow groundwater.	Dermal contact and ingestion. Dust inhalation. Ground gas and vapour accumulation in trenches and confined spaces, leading to inhalation followed by asphyxiation and risk of explosion.	**Medium**	The ground investigation has recorded elevated contaminant concentrations. To mitigate the risk construction workers should wear appropriate Personal Protective Equipment (PPE) during any below ground works in order to mitigate potential effects from direct contact, dermal absorption, inhalation, and ingestion of any residual contaminants in soils and groundwater. All construction workers should be subject to mandatory health and safety requirements under the Construction, Design and Management (CDM) Regulations 2018 and Control of Substances Hazardous to Health (COSHH) Regulations 2002, the Confined Space Regulations 1997, and Control of Asbestos Regulations 2012 (CAR 2012).
Construction workers and nearby residents.	Unexploded Ordnance	Direct contact	**Low**	No UXO was encountered during the ground investigation. However, an UXO Risk Management Plan will be prepared for the Site. Site Specific UXO Awareness Briefings will be provided to all personnel conducting works.
Property				
Site structures and services	Contamination in Made Ground, shallow soils, and shallow groundwater.	Direct contact with building foundations and buried services leading to chemical attack.	**Medium**	Foundations and building at the new development will be designed to resist any contamination identified by the ground investigation, which will mitigate the risk to future structures.
Off-Site Structures	Contamination in Made Ground, shallow soils, and shallow groundwater.	Direct contact with building foundations and buried services leading to chemical attack.	**Low**	Elevated contaminant concentrations are present in the Made Ground on-site as beryllium and PAH exceeded the GAC in two locations. The ground investigation has identified the lateral migration of contaminants has being limited. The risk to off-site structures is low.
Controlled Waters				
Surface watercourse	Contamination in Made Ground,	Migration through Glacial Till to	**Low**	Groundwater sampling will confirm the status of the groundwater on-site and

Receptor	Potential sources	Pathway	Risk	Justification/Mitigation
26m south of the Site	shallow soils, and shallow groundwater.	nearby watercourses. Runoff from stockpiled soils.		the magnitude of its impact relative to the surrounding environment.
Surface watercourse 26m south of the Site	Construction materials stored on-Site as part of development works.	Spills to ground, and the nearby watercourse.	**Medium**	Groundwater sampling will confirm the status of the groundwater on-site and the magnitude of its impact relative to the surrounding environment. A CEMP should be prepared for the demolition and construction works on-Site, detailing measures to minimise the potential risk to controlled waters.

The potential contaminant linkages described above require further ground investigation and assessment, which would be undertaken as a Detailed Quantitative Risk Assessment.

The potential contaminant linkages described above can be managed by design of appropriate mitigation measures during the redevelopment of the site.

10.2 Ground Gas

Based on the available and limited monitoring data, at this stage the site is considered to be: Characteristic Situation 1 (No Special Gas Measures). Given the presence of a potential source of ground gas beneath the Site (shallow mine workings), it may be prudent to allow for the installation of gas protection measures in accordance with Characteristic Situation 2 at this stage.

The Preliminary Environmental Risk Assessment identifies the Site to be partially within an area of elevated radon levels (between 1% and 3%). Correspondingly, basic protective measures may be required in the proposed development. The approach should be confirmed with the Building Control Officer.

Any recommendations relating to gas protective measures in foundations should be considered provisional until issue of our hazardous gas risk assessment at the end of the monitoring period.

10.3 Geotechnical Assessment

10.4 Proposed Development

It is proposed to demolish all structures within the site boundary, to facilitate the construction of Trinity Academy, Barnsley. The development will include a new three storey school building in the north east, hard landscaping car park in the centre of the site and both soft and hard landscaping sport fields in the surrounding area. No basements are proposed. Lift access will be provided to upper storeys.

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10.4.1 Mining

The ground investigation confirmed the presence of the Barnsley Coal Seam as follows:

- RC101 records zones of no recovery at 1.5m to 1.98m, 3m to 3.53m, and at 4.5m to 4.96m. These are interpreted to be the result of weathered or weak rock being further weakened by the drilling resulting in no core being obtained. Zones of no recovery at 7.5m to 8.4m and 9m to 10.26m are interpreted as suspected mine workings, as they are associated with a loss of drilling flush at 8m. Intact coal was encountered at 10.5m to 10.9m.
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- RC104 records zones of no recovery at 3.0m to 3.72m, 4.5m to 4.84m, 6m to 6.6m, and 7.5m to 7.69m. These are interpreted to indicate the presence of weathered or weak rock. A void is identified at 15.4m to 16.8m and is interpreted as suspected mine workings.

All of the suspected mine workings and intact coal are thought to be associated with the Barnsley Coal Seam.

The greatest thickness of no recovery or void associated with the Barnsley Coal seam was 3.0m beneath the Site in RC102, from 7.5m to 10.5m bgl. Based on a likely propagation of voids to 10 times worked seam thickness through rock, as per CIRIA C758D, voids could migrate upwards by 30m.

There is an insufficient thickness of rock cover to arrest the upward migration of voids from the Barnsley Coal Seam and therefore workings are considered to constitute a risk of surface instability.

Therefore, it is recommended further investigation is undertaken below the footprint of the proposed buildings, which should take the form of Primary Consolidation Grouting to confirm the presence of workings or otherwise, with Secondary Grouting should workings be identified.

A mine shaft has been identified in trial pit TP110, in the playing fields in the west of the Site. The shaft was found to be uncapped and to have a diameter of approximately 2.5m. The shaft backfill was present from approximately 0.5m below ground level and comprised of Colliery Spoil.

The mine shaft should be fully investigated and appropriately treated, most likely by construction of a reinforced concrete cap. It is recommended that the design of the proposed sports pitches in this area of the Site includes mitigation for the risk of ground collapse associated with unidentified coal mining features.

The remedial works to be implemented to both the shallow mine workings and mine shaft should be agreed with The Coal Authority, with appropriate permissions and licenses obtained.

10.4.2 Shallow Foundations

Made Ground and soft/ loose natural deposits are not considered to be suitable bearing strata. Where these materials are identified, foundations should be placed on adequate bearing strata at deeper levels. Foundations should be placed on uniform founding strata to avoid differential settlement.

Identification of the appropriate founding stratum on site must be undertaken by an experienced engineer. If necessary, Waterman should be contacted to provide further advice.

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The design bearing resistance(s) quoted above have been estimated in accordance with EC7, Design Approach 1. Bearing resistance and settlement are functions of shape and depth of foundation, and the magnitudes of inclined, static and variable loads and these should be checked as part of detailed geotechnical design.

10.4.3 Piled Foundations

For foundation loads significantly in excess of the design bearing resistance estimated above or where the presence of shallow mine workings precludes the use of shallow foundations, piled foundations could be utilised. It is recommended that the advice of a specialist piling contractor should be obtained to confirm the suitability of piling and the most appropriate pile type. However, based on the site investigation information, end bearing piles would key into the Pennine Middle Coal Measures bedrock present from approximately 2m to 3m below ground level or would be extended to between 10m and 25m below ground level to extend through the worked Barnsley Coal Seam.

Given the presence of the Barnsley Coal Seam at relatively shallow depth beneath the Site, the pile design should consider the influence of piling on potential shallow mine workings. Appropriate rock cover should be present between the termination depth of piled foundations and underlying coal seams. The piling contractor should seek Coal Authority approval for their design as part of the Permitting process.

The final design of the piles will be the responsibility of the piling contractor. An allowance for probing of pile positions and/or drilling of obstructions should be allocated. The carrying capacity of the actual pile groups will in part depend on the number, type and size of pile chosen by the contractor and the quality of workmanship. Where cast in situ concrete piles are proposed, the roughness of the rock socket will influence the carrying capacity of the pile.

The piles should be designed based on the requirements of Eurocode 7 and guidance such as CIRIA Report 181, Piled Foundations in Weak Rock.

During detailed pile design the choice of factors of safety should ensure that appropriate safe working loads and settlement tolerances are met.

Subject to any piling trials, an acceptable percentage of piles should be load tested to at least twice working load. All piles should be integrity tested.

Consideration should be given to the re-use of pile arisings if bored piles are used. It may be possible to re-use pile arisings subject to risk assessment; however, certainty of use and volume should be confirmed in accordance with the requirements of CLAIRE guidance.

Given the proximity of existing structures, the effects of noise and vibration (e.g. from piling plant) should be addressed as part of the Contractor's method statement.

10.4.4 Shrinkability / Volume Change Potential

Glacial Till has been shown to have a medium shrinkability.

Foundations placed on shrinkable soils should be deepened where necessary to accommodate the effects of trees and hedgerows. Where foundations are beyond the influence of existing and proposed planting (i.e. 1.5 times the mature tree height), the minimum founding depth in soils of a medium volume change potential would be 0.9m below existing or proposed ground level (whichever is lower).

Foundations within the zone of influence of existing or proposed trees should be deepened as necessary in accordance with recommendations provided in NHBC Chapter 4 – Building Near Trees. If trees are present within influencing distance of proposed foundations, a tree survey should be undertaken to identify appropriate founding depths.

10.4.5 Design Class for Concrete

Based on the characteristic values derived from SD1 testing, the Design Sulphate (DS) and Aggressive Chemical Environment for Concrete (ACEC) classifications are considered to be:

- Concrete in contact with Made Ground: DS-1 AC-1
- Concrete in contact with Pennine Middle Coal Measures: DS-1 AC-1

This is based on the site characterisation as "Brownfield-pyritic" and the assumption of mobile groundwater.

10.4.6 Earthworks / Pavement Design

The results of compaction testing undertaken on samples of the shallow soils indicate that the Made Ground and Glacial Till could generally be recompacted to achieve >95% of MDD and <5% air voids.

Based upon the results obtained, Made Ground and Glacial Till could potentially be used as an engineered fill, subject to other suitability considerations. Made Ground may require treatment prior to re-use due to it generally being wet of Optimum Moisture Content. It should be noted that suitability for compaction is highly dependent on the initial moisture content of the material to be compacted. PSD results indicate that the Made Ground would be classified as Class 2C and the Glacial Till would be classified as Class 2A/2B in accordance with the Specification for Highway Works.

It would be sensible to subject proposed earthworks materials to a confirmatory testing regime where they were required to achieve a compaction specification as a general fill. Site won materials are unlikely to prove suitable as a structural fill, being generally cohesive in nature.

Construction plant should be provided with an adequate working platform in line with the requirements of BRE report, "BR 470: Working Platforms for Tracked Plant". Further advice should be sought from the temporary works designer.

Areas of roadway and hardstanding will be included in the development and will likely have a subgrade comprising Made Ground or Glacial Till. Significant earthworks may be required prior to construction and pavement design should allow for the potential presence of a thickness of engineered fill above natural strata.

Subgrade strength may vary considerably across the site, especially where affected by variations in moisture content. During construction, the in-situ CBR value must be checked against the Design CBR value, to confirm design requirements are being met, in accordance with CD225 or Local Authority guidance.

10.4.7 Floor Slabs

Given that there is limited Made Ground in the vicinity of the proposed school building, no identified risk of heave (earthworks cut is unlikely in this area of the Site) and ground conditions are likely to be relatively uniform across the proposed building footprint, ground bearing floor slabs are potentially viable for the proposed development.

Significant earthworks may be required prior to construction and floor slab design should allow for the potential presence of a thickness of engineered fill above natural strata.

The design of floor slabs should only be finalised when the updated gas monitoring has been completed and assessed, as the recommendations of the gas monitoring report will influence the final choice of floor slab design. The above advice is provided for guidance only at this stage.

10.4.8 Groundwater / Stability of Excavations

Comments relating to the stability of excavations (i.e. trial pits) and groundwater seepages are included in the logs in Appendix B. No groundwater was encountered during the ground investigation.

Groundwater monitoring indicates water levels between 5.48mbgl in RC104 and 10.72mbgl in RC101, and borehole RC102 was reported as dry. RC103 was flooded at the time of the first round groundwater monitoring. This data indicates a groundwater elevation range of 129.88m AOD (RC01) to 134.99m AOD (RC104).

It should be noted that levels are likely to fluctuate dependant on the time of year and prevailing weather conditions. For design purposes, it is recommended that the groundwater level be assumed at 5.5m bgl. This level will be reviewed on completion of the groundwater monitoring visits.

Based on observations made during fieldwork, shallow excavations (<1.2m) are likely to be stable in the short term. However, should deeper Made Ground be encountered, particularly where this is associated with historical mining features, then some instability should be expected, and appropriate mitigation measures utilised.

Consideration should be given to the re-use of arisings from foundation trenches / drainage runs etc. Where contamination has been encountered, it may be possible to reuse foundation arisings; however, certainty of use and volume should be confirmed in accordance with the requirements of CL:AIRE guidance. Waterman Supplementary Ground Investigation Report should be consulted with regards to suitability for re-use of materials.

In line with BS6031, all excavations should be examined daily by a competent person to ensure that they remain safe. Where the sides cannot be sloped back to a safe angle, as approved by a competent and

experienced person, their continued stability should not be taken for granted. Vertical or steep faces should be provided with support unless instructed otherwise by a competent person.

11. Recommendations

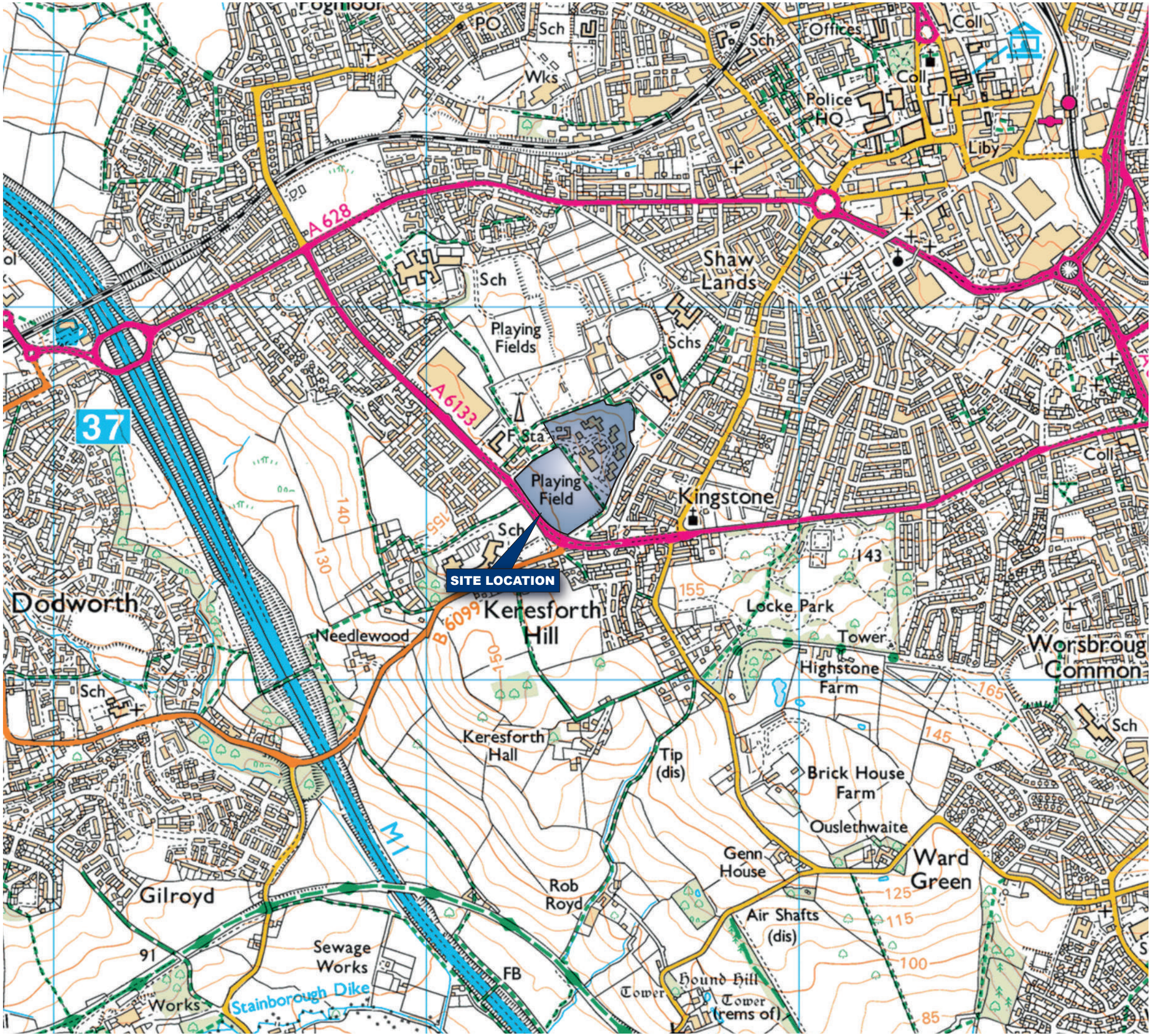
The following actions are recommended to address the potentially unacceptable risks that remain:

- A programme of mine workings investigation and treatment should be undertaken below the footprint of the proposed buildings, which should take the form of Primary Consolidation Grouting to confirm the presence of workings or otherwise, with Secondary Grouting should workings be identified.
- Further ground investigation should be undertaken to confirm the extent of mining related features identified and to assess the ground conditions for the design of foundations for temporary classrooms in the west of the Site;
- The design of the proposed sports pitches in the west of the Site should mitigate the risk of ground collapse impacting users of the sports fields.
- A Remediation Strategy should be prepared outlining the mitigation measures to ensure the Site meets the appropriate standards for its intended use following redevelopment;
- An appropriate cover system should be installed in soft landscaping areas to break the contamination receptor linkage. Material/topsoil imported to Site should be certified suitable for use prior to importation and use on-site;
- A Materials Management Plan should be produced by the Contractor to ensure that materials that may be excavated during their works (including pile arisings) may be suitable for re-use on the Site. The re-use of materials should be identified and designated under the CL:AIRE Definition of Waste: Code of Practice (DoWCoP), i.e. the earthworks phase of the development should be planned and managed such that re-use of suitable site-won arisings is maximised and waste is minimised;
- Following completion of the proposed Development a Verification Report should be produced detailing the remedial measures undertaken during construction to break the potentially active pollutant linkages;
- Construction works should be undertaken in accordance with the Control of Asbestos Regulations 2012;
- A Construction Environmental Management Plan (CEMP) should be prepared including measures for managing waste during development work, and techniques for suppressing dust;
- All fuels and chemicals to be stored on-site during construction works should be stored and bunded in line with EA best practice and guidance;
- Construction workers should be provided with Personal Protective Equipment (PPE) for use as necessary when interacting with soils and groundwater beneath the Site. Workers should also adopt appropriate hygiene practices;
- Below-ground structures should utilise the appropriate concrete classes to prevent aggressive ground conditions. The use of barrier water pipes at the completed Development (as per UKWIR project steering group guidance) should be agreed with the relevant water authorities; and,
- Appropriate UXO mitigation should be employed during below ground works, such as piling.

APPENDICES

Appendix A Site Plans

- **Site Location Plan (Fig. A1)**
- **Site Plan (Fig. A2)**
- **Ground Investigation Plan (Fig. A3)**



Project Details	WIE17125-103: Keresforth Academy
Figure Title	Figure A1: Site Location Plan
Figure Ref	WIE17125-103_GR_PRA_A1A
Date	June 2020
File Location	\\s-lncs\wiel\projects\wie17125\103\graphics\pra\issued figures

Site Boundary

N

Project Details	WIE17125-103: Keresforth Academy
Figure Title	Figure A2: Site Plan
Figure Ref	WIE17125-103_GR_PRA_A2A
Date	June 2020
File Location	\\s-lncs\wiel\projects\wie17125\103\graphics\pra\issued figures

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SITE EXTENT

CONSTRUCTION WORKERS PROVIDED WITH APPROPRIATE PPE FOR BELOW GROUND WORKS AND MADE AWARE OF GOOD HYGIENE PRACTICES

MEASURES TO PREVENT RUNOFF OR WINDBORNE DUST FROM STOCKPILED SOILS OR SPILLS / LEAKS OF CONSTRUCTION MATERIALS CONTROLLED THROUGH CREATION OF A CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN FOR THE WORKS

PROPOSED NEW COLLEGE BUILDINGS

PROPOSED NEW RESIDENCES WITH PRIVATE GARDENS

PROPOSED NEW SPORTS PITCH

MADE GROUND

STOCKPILED EXCAVATED SOILS AND CONSTRUCTION MATERIALS

RISK OF CHEMICAL ATTACK TO FUTURE BELOW GROUND STRUCTURES ASSESSED AS PART OF GEO-ENVIRONMENTAL GROUND INVESTIGATION

POTENTIAL FOR GROUND GAS INGRESS INTO NEW BUILDINGS ARISING FROM PENNINE MIDDLE COAL MEASURES BENEATH THE SITE, ASSESSED AS PART OF THE GROUND INVESTIGATION

GLACIAL TILL

SIGNIFICANT POTENTIALLY CONTAMINATIVE LAND USES HAVE NOT BEEN IDENTIFIED AT THE SITE. THE ABSENCE OF ANY GROUND OR GROUNDWATER CONTAMINATION WILL BE CONFIRMED BY GEO-ENVIRONMENTAL GROUND INVESTIGATION

PENNINE MIDDLE COAL MEASURES

NO SIGNIFICANT GROUNDWATER ANTICIPATED AT SHALLOW DEPTHS BENEATH THE SITE, MINIMISING THE POTENTIAL FOR TRANSPORT OF GROUND CONTAMINATION ON OR OFF THE SITE.

Project Details	WIE17125-103: Keresforth Academy
Figure Title	Figure A3: Conceptual Site Model
Figure Ref	WIE17125-103_GR_PRA_A3A
Date	June 2020
File Location	\\s-lncs\wiel\projects\wie17125\103\graphics\pra\issued figures

Appendix B Groundtech Consulting Draft Factual Report

GROUNDTECH
CONSULTING

Job title:	Trinity Academy, Barnsley
Report type:	Factual Geo-Environmental Report
Prepared for:	Waterman I&E
Date:	October 2020

Document Control Form	
PROJECT	*TRINITY ACADEMY, BARNSLEY*
REPORT NAME	*FACTUAL GEO-ENVIRONMENTAL REPORT*
REPORT REFERENCE	*GRO-20063-1894*
STATUS	*FINAL*
ISSUE DATE	*27 OCTOBER 2020*
REVISION	
CLIENT	*WATERMAN I&E*
CLIENT CONTACT	*ANDREW MOULD*

For and Behalf of Groundtech Consulting	
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AUTHOR	Callum Holden BSc (Hons) FGS
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SIGNATURE	
REVIEWED	James Doyle BSc (Hons) CGeol FGS

TABLE OF CONTENTS

Plans		
Plan Reference	*Revision*	*Title*
GRO-20063-P01	-	*Project Location Plan*
GRO-20063-P02	-	*Exploratory Hole Location Plan*

1.0 INTRODUCTION

1.1 Project Objectives

Groundtech Consulting Limited have been instructed by Waterman I&E to undertake a Ground Investigation for a site at Keresforth Close in Barnsley.

A main investigation was undertaken in accordance with BS 5930:2015, BS 10175:2017, BS 8576:2013, BS 22475 and CIRIA C758D.

Coal Authority permissions were obtained prior to the works.

1.2 Proposed Development

The proposed development is commercial end use comprising a new college with associated car parks, infrastructure and sports pitches.

Proposed Development

1.3 Limitations

Other conditions may exist on the site that have not been taken into account in this assessment as they are outside the scope of works. Groundtech Consulting are not responsible for these circumstances that are not outlined in the report.

The assessment has been prepared for the exclusive use of the client. No third parties may rely on or reproduce the contents of the report without the written permission of Groundtech Consulting Limited. If any unauthorised third party comes into possession of the report, they rely on it at their own risk and Groundtech Consulting Limited will not be obliged to provide a duty of care.

2.0 SITE SETTING

2.1 Location

The site is located circa 1.3 kilometres south west of Barnsley Town Centre, as shown on the Project Location Plan *GRO-20063-P01* and is approximately centred on National Grid Reference 433397, 405532.

Project Location

Access to the site is gained off Keresforth Close to the north.

2.2 Site Description

The site which is irregular in shape is approximately 4.8 hectares in area and generally slopes down to the north east.

South Western Area

The south western half of the site is formed by a rectangular shaped featureless playing field which is flat lying. Semi-mature trees, shrubs and bushes are present along the field's boundaries to the east, south and west. Keresforth Close bounds the playing field to the north where it enters the site from the A6133. The site is bounded to the south west by the A6133.

North Eastern Area

Directly north east of the playing field the site level drops by circa 6m to the lower lying north eastern portion of the site, which is populated by a number of modern brick built buildings collectively known as the Keresforth Centre (NHS facility partially remaining in use). The development has numerous facilities and parking areas with Keresforth Close being the main access road that loops through the premises connecting back to the main tarmac surfaced car park in approximately the centre of the site. The majority of the site area between the buildings is covered by soft landscaping.

The extreme northern part of the site is formed by an elongate area of soft landscaping which becomes wooded nearer the site boundaries, with semi-mature and mature trees present and some areas of inaccessible dense vegetation. The site slopes down steeply to the north east in this area of the site.

The site boundaries to the north and east are not clearly defined due to dense vegetation.

The site is surrounded by following features/land uses:

- *North - Barnsley Rugby Football Club and Shaw Lane Sports Club.*
- *East - Housing with associated gardens and allotments.*
- *South - A6133, Greenacre School, houses and fields.*
- *West - Houses, commercial buildings and former Barnsley Fire Station.*

Site photographs are presented in *Appendix 2*.

3.0 SCOPE OF INVESTIGATION AND RATIONALE

3.1 Project Objectives

The aim of the fieldwork was to:

Determine the stratification beneath the site.
Maintain a watching brief for visual and olfactory evidence of contamination.
Obtain samples using methodology in current guidance for contamination analysis.
Obtain samples using methodology in current guidance for geotechnical analysis.
Determine the presence of any mine workings at borehole locations.
Target and locate a mine shaft indicated on site.
Install monitoring standpipes for gas and groundwater monitoring.

3.2 Scope of Works

The following scope of works was completed between the dates of 21st September and 1st October 2020:

- *Twelve machine dug trial pits (TP101 to TP112) were excavated to depths between 0.9m and 4.1m bgl using a wheeled JCB 3CX excavator.*
- *Three boreholes (RC101, RC102 and RC104) were dynamic sampled to depths between 1.5m and 3.0m bgl which was in turn followed by rotary coring to 10.5m bgl and rotary open hole drilling to depths of between 20.0m and 30.0m bgl using a Beretta T41 Rotary Drilling Rig.*
- *A single rotary open hole (RC103) was advanced from 1.2m bgl to 30.0m bgl using a Beretta T41 Rotary Drilling Rig.*

The exploratory hole locations are presented on Groundtech Plan *GRO-20063-P02* and the logs are presented in *Appendix 3*.

The exploratory hole locations were cleared for below ground services by a specialist utility company prior to breaking ground.

Exploratory hole locations and levels were surveyed in upon completion of the works.

The exploratory holes were positioned by Waterman I&E and the locations were set out and agreed with Waterman I&E prior to any works being undertaken. TP110 was set out using surveying equipment to target a specific location where a mine shaft was recorded to be present.

Location	Target Rationale
TP101 to TP109, TP11 and TP112	*Non targeted / 25m grid*
TP110	*Mine Shaft*
RC101 to RC104	*Proposed building footprint*

The exploratory holes were logged by a suitably experienced geo-environmental engineer in general accordance with the following current guidance:

- *BS 5930 'Code of Practice for Site Investigations' 2015.*

- *BS EN 14688-1:2002 'Geotechnical Investigation and Testing – Identification and classification of soil'.*
- *BS EN ISO 14689:2002 'Geotechnical investigation and testing – Identification and classification of rock'.*

3.3 Soil Sampling

During the intrusive investigation, representative samples were taken at regular intervals, changes of strata and where evidence of contamination existed. Laboratory analysis was scheduled on the samples obtained.

The samples obtained are summarised in the table below:

Soil Sample	Number
Environmental Sample	*43*
Disturbed Sample	*42*
Bulk Sample	*29*
Undisturbed U100 Sample	*1*

The samples have been obtained in accordance with current environmental and geotechnical guidance. The sampling plan has been designed to obtain samples from all required strata using the correct methodology.

Disturbed samples of soil for geo-environmental testing were placed in the correct sampling containers as required by the laboratory in accordance with their MCERTS and UKAS Accreditation. Transportation was arranged in a timely manner and the samples were at the correct temperature.

The sample locations and depths are recorded on the exploratory logs.

3.4 Geo-Environmental Testing

All Geo-Environmental and Geotechnical testing was scheduled and received by Waterman I&E.

3.5 Gas and Groundwater Monitoring

Gas and groundwater monitoring installations were constructed in the boreholes. The standpipes consisted of high-density polyethylene (HDPE) pipe - a bentonite seal was placed around the plain pipe and a clean gravel pack was placed around the slotted pipe. A summary of the installation construction is presented in the table below:

Location	Depth	Response Zone (m bgl)	Targeted Strata	Reason
RC101	*10.5*	*8.0 – 10.5*	*Suspected Workings*	*Ground Gas*
RC102	*9.5*	*7.5 – 9.5*	*Suspected Workings*	*Ground Gas*
RC103	*4.0*	*1.0 – 4.0*	*Mudstone/ Sandstone*	*Ground Gas/Groundwater*
RC104	*7.0*	*4.0 – 7.0*	*Sandstone*	*Ground Gas/Groundwater*

Permanent gas and flow rate monitoring was carried out using a GFM 436 infrared gas monitor with integral electronic flow analyser. The measurements taken are listed below:

- *Oxygen (O_2), carbon dioxide (CO_2) and methane (CH_4) as the percentage volume in air (%v/v).*
- *Hydrogen sulphide (H_2S) and carbon monoxide (CO) as the percentage volume in air (%v/v).*

- *Lower Explosive Limit (%LEL) of methane.*
- *Atmospheric and borehole pressure, including pressure trend.*
- *Flow measurements (l/hr).*
- *Weather and ground surface conditions.*

Both peak and steady state conditions were monitored to understand the behaviour of the permanent ground gas, the steady state conditions were recorded by allowing the gas monitor to run for a minimum of 3 minutes.

Interim permanent gas and groundwater monitoring results are presented in *Appendix 4*.

3.6 Vapour Survey - Photo Ionisation Detector

Standard sampling protocol and preservation of samples was undertaken as described in the EA guidance on site investigation.

Soil was collected for onsite testing. A plastic bag was half filled with soil allowing a suitably sized headspace. The bag was sealed and stored for at least 20 minutes before being tested for Total Volatile Organic Compounds (TVOCs) using a Photo Ionisation Detector (PID). Results of the PID readings are presented on the exploratory hole logs.

The onsite monitoring was carried out in line CIRIA C6658 to aid targeting samples for VOC laboratory analysis.

4.0 GROUND MODEL

4.1 Made Ground

Surfacing encountered in all locations across the site consisted of grass over dark grey brown sandy clayey topsoil with gravel of ash, sandstone, quartzite, ceramic, coal, brick, glass, concrete and limestone to depths between 0.2m and 0.42m bgl.

A single main Made Ground population was encountered during the investigation consisting of soft to stiff grey brown sandy gravelly clay with a low cobble content of concrete and brick and gravel of brick, wood, concrete, steel, sandstone, coal and plastic. The above was encountered in locations TP101, TP102, TP104, TP106 and TP107 in the north of the site from a minimum depth of 0.23m to a maximum depth of 1.6m bgl.

Made Ground was generally deepest in the north of the site. Shallow made ground consisting of topsoil was present across the majority of the site.

Black sandy gravel of ash, clinker and coal was present in TP112 between 0.42m and 0.53m bgl.

Firm orange brown slightly gravelly very sandy friable clay, which was possibly reworked, was present in RC104 between depths of 0.21m and 1.6m bgl.

4.2 Mine Shaft

In TP110 in the south west of the site, a suspected mine shaft was encountered with the Made Ground consisting of dark grey to black sandy gravelly friable clay with a low cobble content of sandstone and gravel of coal, ironstone, sandstone and ceramic between depths of 0.33m and 3.1m bgl. The lateral extent of the shaft was observed with natural ground either side of the infilled material which measured c.2.5m wide. Photographs of the ground conditions are presented in *Appendix 2 - Photos 36 to 39.*

Exploratory Hole Locations

4.3 Natural Ground

A single main natural stratum was encountered during the investigation consisting of firm to very stiff medium to high strength orange brown mottled grey sandy gravelly silty Clay which was encountered in all locations except for TP105, RC101 and RC102 from a minimum depth of 0.2m to a maximum depth of 3.2m bgl. This is likely residually weathered bedrock from the Pennine Middle Coal Measures Formation.

Dark brown sandy clayey Gravel of coal, sandstone and mudstone was encountered in RC104 between 1.6m and 2.4m bgl.

4.4 Bedrock

Bedrock was encountered in all locations from depths between 0.2m (TP105) and 3.2m bgl (TP101) and generally consisted of extremely weak to weak orange brown Sandstone in varying states of weathering underlying the Made Ground or natural soils.

Extremely weak grey to brown residually weathered Mudstone was observed underlying the natural soils in TP109 and RC103 in the east and north east of the site from depths of 1.4m and 1.5m bgl respectively.

In the borehole locations, Sandstone was the main stratum encountered to depths between 3.94m and 7.16m bgl. This was in turn generally underlain by extremely weak grey Siltstone to the base of the boreholes.

Mudstone was encountered in RC101 between depths of 10.9m and 12.5m bgl and RC102 between 7.02m and 13.0m bgl and as bands in RC103 and RC104.

Black anthracite Coal was present in TP103 in the north of the site between 2.45m and 2.85m bgl and the base of the seam was not determined. Black anthracite Coal was also encountered in RC101, in the north of the site, between 10.5m and 10.9m bgl and in RC103, in the north east of the site, between 19.50m and 22.0m bgl.

4.5 Groundwater

Groundwater strikes were not observed during the investigation.

4.6 Watching Brief

A watching brief was maintained during the Ground Investigation for visual and olfactory evidence of contamination.

Made Ground was generally shallow across the site consisting predominantly of topsoil. Visual evidence of potential contamination was observed within the topsoil at TP110 and TP112, in the south west of the site, where ash was observed. Furthermore, a band of black ash and clinker was observed in TP112 between 0.42m and 0.53m bgl.

The suspected mine shaft encountered in TP110 was backfilled with colliery spoil.

No olfactory evidence of contamination was noted during the investigation and PID readings across the site were low.

4.7 Mine Workings

Evidence of historical mine workings was encountered at the site as outlined below:

- *TP110 – Suspected mine shaft encountered measuring c.2.5m wide and present to the base of trial pit which was terminated at 3.1m bgl due to instability within the backfilled material.*
- *RC101 – Broken ground was encountered between 8.0m and 10.5m bgl and water flush lost.*
- *RC102 – Broken ground was encountered between 8.0m and 9.5m bgl and water flush lost. Void encountered between 9.5m and 10.5m bgl.*
- *RC104 – Void encountered between 15.4m and 16.8m bgl.*

Voids were backfilled using a bentonite grout and gravel mix to create a cone until the void was sealed in accordance with CIRIA C758D.

4.8 Excavation Stability

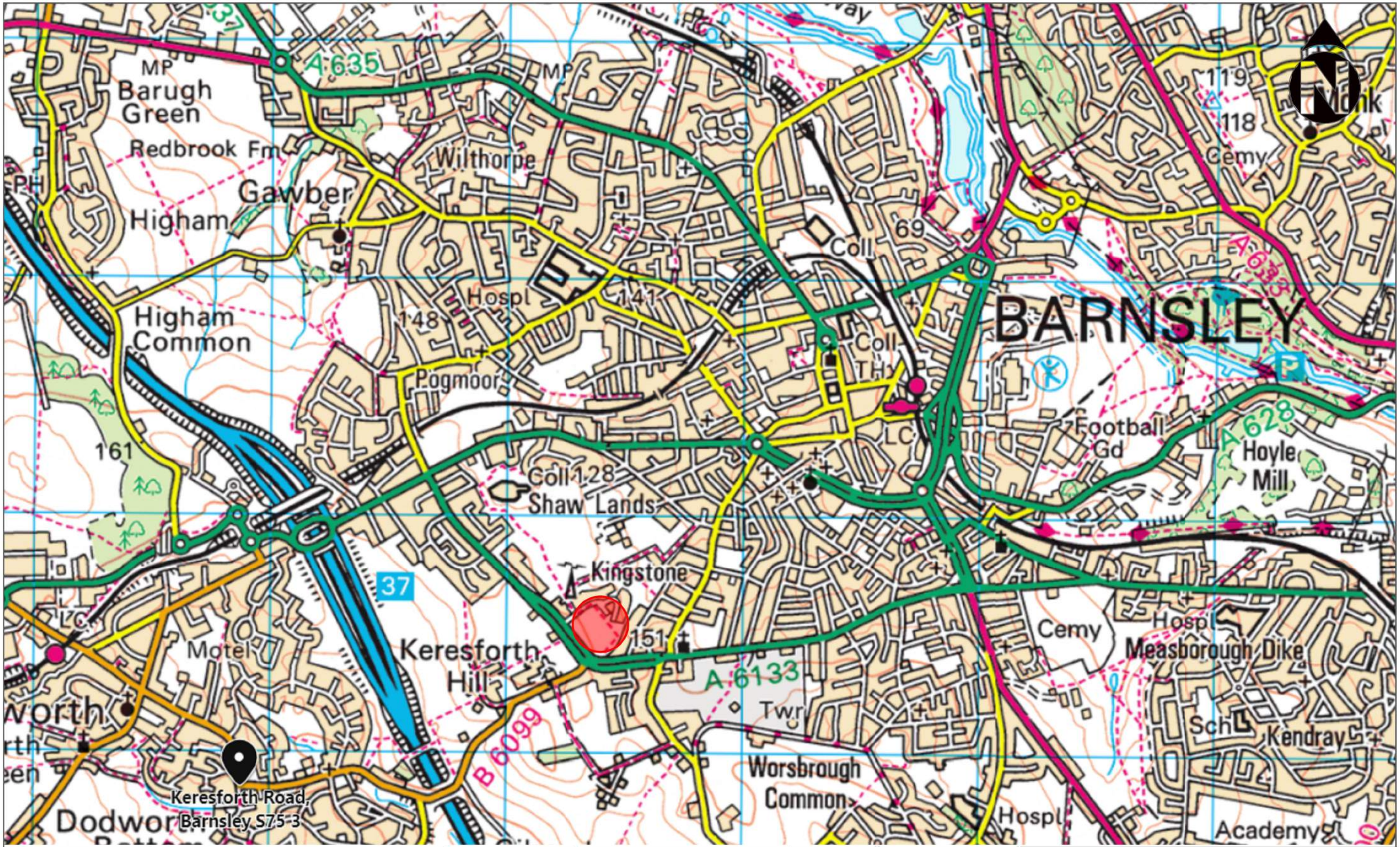
The trial pit sides were unstable and collapsing within the backfilled material in the suspected mine shaft encountered in TP110.

4.9 Excavation Progress

TP101, TP103, TP105, TP106, TP108, TP109 and TP111 all terminated before their scheduled depth due to competent bedrock at depths between 0.9m and 3.8m bgl. TP103 specifically terminated within a coal seam through which the excavator could not make reasonable progress.

Competent Sandstone bedrock was also encountered at shallow depths in RC101 and RC102 meaning the hand dug pits could not be advanced to 1.2m bgl prior to drilling commencing.

APPENDIX 1 - Plans



GROUNDTECH CONSULTING

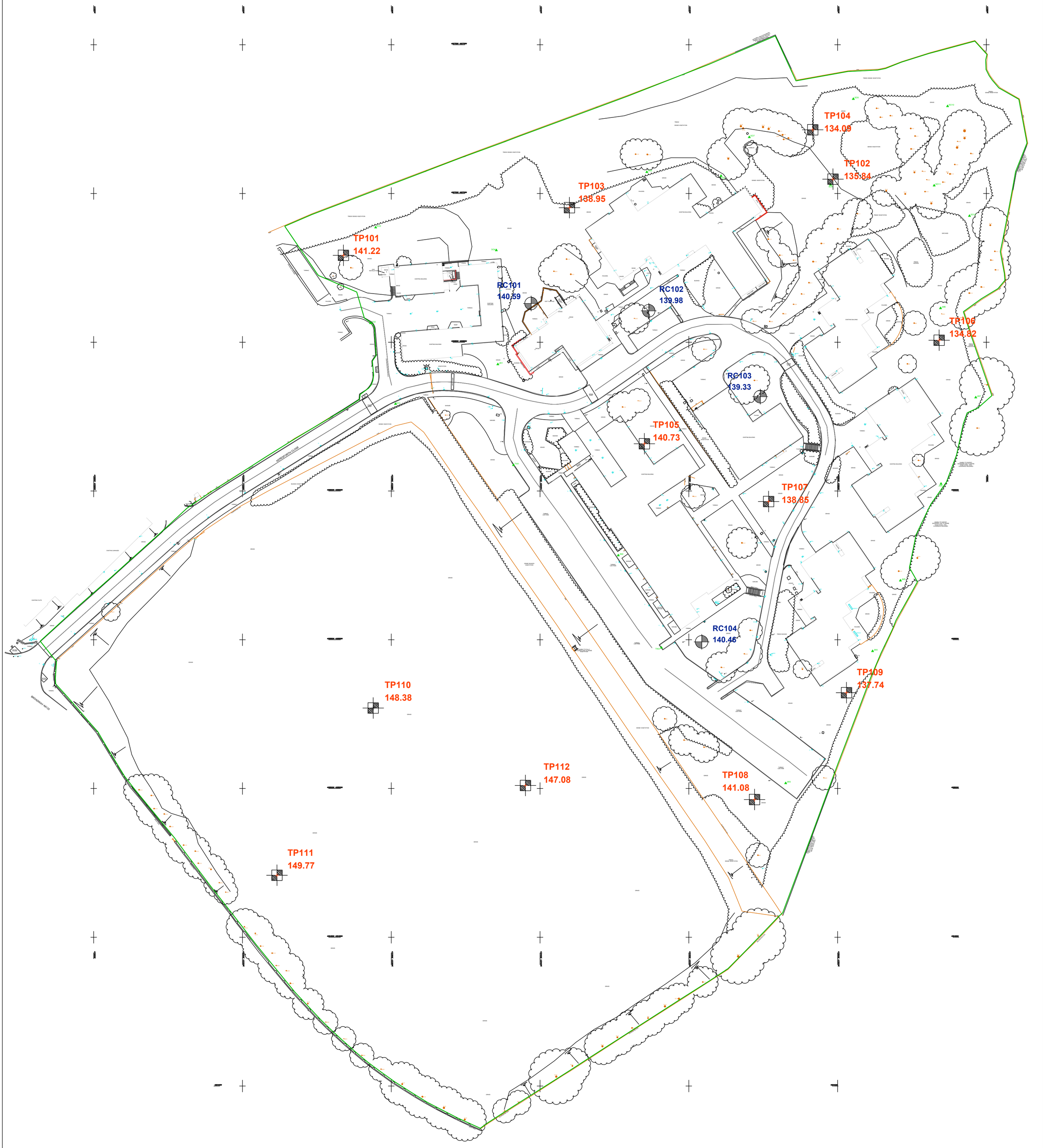
CLIENT	WATERMAN I&E
PROJECT TITLE	TRINITY ACADEMY, BARNSLEY
PLAN TITLE	PROJECT LOCATION PLAN
DATE	OCTOBER 2020
SCALE	NTS
PLAN NUMBER	GRO-20063-P01

Rev.	Details	Date

Status	
Preliminary	
Draft	
Issued	●
For Comment	
Approved	

Notes

Location of Site



GROUNDTECH CONSULTING	CLIENT: WATERMAN I&E	DATE: OCTOBER 2020				Status	
	PROJECT TITLE: TRINITY ACADEMY, BARNSLEY	SCALE: 1:1000 @ A1				Preliminary	
	PLAN TITLE: EXPLORATORY HOLE LOCATION PLAN	PLAN NUMBER: GRO-20063-P02				Draft	
						Issued	●
						For Comment	
			Rev.	Details	Date	Approved	

Notes

- Trial Pit Location
- Rotary Borehole Location

APPENDIX 2 - Site Photographs

Photograph 1 – RC101 1.5m to 4.5m

Photograph 2 – RC101 4.5m to 7.5m

Photograph 3 – RC101 7.5m to 10.5m

Photograph 4 - RC102 1.5m to 4.5m

Photograph 5 – RC102 4.5m to 7.5m

Photograph 6 – RC102 7.5m to 10.5m

Photograph 7 – RC104 3.0m to 6.0m

Photograph 8 – RC104 6.0m to 9.0m

Photograph 9 – RC104 9.0m to 10.5m

Photograph 10 – TP101

Photograph 11 – TP101