the site. Spoil heaps, which appear to be associated with Milton Iron Works, are indicated to have spread to within around 180 m of the western extent of the site by this time. An air shaft is labelled around 250 m south west, and a colliery tramway (incline) is around 200 m to the south, running east to west between the local collieries.

By around 1903, the spoil heaps have continued grown in size to the west of the site. Additional housing has been built to the south east and north west of the site, and Stubbin (as it is now labelled) now practically links Elsecar to the south east with Hoyland Nether to the north west. The Chapeltown Branch railway extension now runs from north east to south west along the northern side of the site, with Elsecar station being on the site boundary, and sidings entering the site from the west. The railway is shown within a cutting for much of its length, but is atop an embankment as it passes the site and as it crosses the spoil heaps to the west.

The map dated 1930 shows a school, picture theatre, tennis courts and a bowling green to have been constructed on the land immediately north of the railway line. A small gravel pit is shown around 200 m south west of the site at this time. The land west of the site is indicated to have been plateaued, with the edge of the railway embankment having been pushed out towards the south. Milton Iron works is no longer shown to the west of the site, with new housing having replaced the works buildings. The colliery incline has been removed, although several air shafts are still labelled in the area south of the site. Elsecar Main Colliery is now present around 750 m east of the site.

During the late 1950s and early 1960s, significant housing development took place to the north of the site. The gravel pit is no longer shown by 1956, and the area has undergone additional filling by spoil heaps to create a level plateau. The area north of the railway line has also had additional material placed, and appears to be a recreation ground by the late 1960s. A surface water drain or small stream is indicated at the base of the embankment to the south of the site by 1956, which connects into a series of other drains/watercourses from the former spoil heaps to the west of the site. By 1968, the railway sidings had been removed. Cardigan (iron and aluminium) Works has been developed around 90 m south of the site, adjacent to the previous foundry, which remains.

Since the late 1960s, no significant changes are indicated in the immediate vicinity of the site. Infill development has occurred with new houses and community buildings. Elsecar Main Colliery was removed by 1989. The foundry buildings to the south of the site partly remain to the present day, with a number of the buildings having been demolished in the late 1990s it appears. The buildings which do remain are currently unused.

3.3 Geology

The geological map for the area, Sheet SE 30 SE (1:10,000 scale), shows the solid geology below the site to comprise strata of the Pennine Middle Coal Measures. Undifferentiated mudstones or shales are indicated beneath the majority of the site, with sandstone potentially beneath the northern most corner. The strata are indicated to dip towards the north east, at angles of around 4°.

No alluvial or other recent deposits are indicated to be present on the site, although the historical maps do indicate some change in level to have taken place around 100 years ago. Therefore, made ground is expected in parts of the site.

No faults or other lines of weakness are indicated to cross the site at surface, although the Elsecar Fault is conjectured around 30 m the north east. Interconnected minor faults are also recorded around the area.

3.4 Hydrogeology

Under the Environment Agency's aquifer designations, the solid geology below the site is classified as a Secondary A Aquifer. This is defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

Information within the Envirocheck Report also states that the site does not lie within a groundwater Source Protection Zone.

3.5 Hydrology

The nearest surface water feature listed in the Envirocheck is located 4 m to the south east of the site. This is indicated to be the open drain/stream at the base of the former railway embankment, which flows towards the south west. This watercourse was not noted during the site walkover visit, and it is therefore assumed that it is either dry, or culverted.

No groundwater abstraction licences are recorded within a 250 m radius of the site.

3.6 Coal Mining

The site overlies Coal Measures strata and therefore there is potential for coal seams of a workable quality and thickness to be present below the site. According to the geological map, the Kents Thick Coal sub-crops across the northern corner of the site. The coal is therefore likely to be present at shallow depth, below any fill that has subsequently been placed, although this is only likely to be relevant to a very limited area of the site. The seam is recorded to be between 2.5 feet and 3 feet

(0.75 to 0.9 m) thick. However, the geological memoirs for Barnsley state that the seam is a 'worthless mass of coal streaks in black shale' in the area south of Barnsley, although the seam is commonly worked to the north of Barnsley. The seam is therefore not expected to have been worked below the site. Should any workings been attempted, these are likely to be via surface extraction, given the shallow depth at which the seam will lie.

A thin seam of coal is also conjectured to outcrop across south western most corner of the site., which will then dip beneath the remainder of the site. This may be up to about 300 mm thick, but is not expected to have been worked in the past.

The next shallowest seam of coal expected is the Barnsley Rider Coal, which may be up to around 600 mm thick in this area, but contains numerous dirt partings. This seam is therefore unlikely to have been of economic interest in the past, and is likely to be at a depth of around 30 m bgl. Any

workings that are present within this seam are unlikely to affect developments at surface.

The next worked seam of coal is expected to be the Barnsley coal. Several historical shafts shown on the geological maps to the south of the site indicate this seam to lie at a depth of around 40 m and therefore the Barnsley Coal is expected to be at least this deep below the site. The Barnsley Coal is a major seam within the former south Yorkshire coalfield, and as such, the seam is widely worked. As the seam was noted in the local shafts, it can be assumed that extraction has been undertaken below the site. The seam has an average thickness of around 2.4 m. Therefore there is expected to be a sufficient thickness of competent ground between the seam and the underside of foundations for the proposed development, and remedial works such as drilling and grouting are not expected to be required.

A Coal Authority mining report has been obtained and is included in the Appendix. This states that the site is within a surface area that could be affected by past underground mining in eight seams of coal at depths of between 50 m and 400 mm depth, last worked in 1979. The sallowest workings are anticipated to be within the Barnsley Coal.

The report does also state that the site is within an area where the Coal Authority believe there to be coal at shallow depth, which could have undergone unrecorded workings in the past. This is expected to relate to the Kent's Thick Coal below the northern edge of the site, and the unnamed thin coal below the south. Neither of these seams are expected to have been worked in the past, but it may be prudent to undertake some intrusive investigation to confirm the depth, thickness and condition of these two coal seams.

The site is not in an area of present coal mining, and a licence has not been granted to remove or otherwise work coal using underground methods in the area in future. However, reserves of coal exist in the local area which could be worked at some time in the future, although this is considered unlikely due to the decline of the UK coal industry and due to the site's location within a highly urbanised area.

There are no known coal mine entries within, or within 20 metres of, the site boundary. However records may be incomplete and there may be nearby mine entries of which the Coal Authority has no knowledge.

There is no record of any mine gas emission requiring action by the Coal Authority within the boundary of the site, and no claims for alleged mining related subsidence have been made on any property within the site boundary or within 50 m of it.

Precautions against the effects of shallow coal mining are therefore not expected to be necessary. However, it may be prudent to undertake a borehole investigation to prove the depth and thickness of the thin coal below the site, and also of the Kents Thick coal below the northern most corner of the site. Any mine workings that are present would need to be drilled and grouted.

3.7 Ground Gas

3.7.1 Radon

The site is partly within an intermediate probability radon area (1 to 3% of homes estimated to be at or above the action level) and partly within a lower probability radon area (less than 1% of homes estimated to be at or above the action level) according to the Envirocheck report. The Envirocheck report confirms that no radon precautions would be necessary for new dwellings constructed at this site.

3.7.2 Landfills

According to the Envirocheck report there are two entries for historical/registered landfill sites located within 250 m of the site. Both relate to the same area within the former spoil heaps associated with Milton Iron Works, from around 152 m to the west of the site. The landfill is recorded a accepting inert, commercial and industrial waste from August 1972. No end date of waste inputting has been supplied.

As the spoil heaps are predominantly above ground features, a significant risk of gases entering the ground beneath the heaps and migrating through the mudstone strata towards the site is not considered to be presented. Any gases which are being generated in any of these landfills are likely

to take the path of least resistance, and will therefore tend to migrate towards the top or towards the faces of the former spoil heaps and will therefore be vented to atmosphere before reaching the development site. As the heaps have been in place for many, many years, it is not expected that significant volumes of gas will still be being generated.

An area of potentially infilled ground is also recorded around 194 m south west of the site. This appears to be the former gravel pit noted on the historical maps. This was a relatively small pit, and appears to have been filled over by the 1960s, potentially with colliery spoil (on the basis of information gained in other, previous investigations in that area). Again, a significant risk of gas generation for this localised feature is not generally expected.

3.7.3 Ground Gases

It is possible that made ground that is in excess of 2 m deep will be present on site due to the past development across the area. From a surface inspection, it appears that any made ground will comprise clay and granular materials, which are not expected to produce significant volumes of gas. However past investigation by Eastwood & Partners in the area west of the site recorded significant depths of made ground where the former railway embankments were located, comprising black ash over colliery spoil. We understand that the ash has since been removed, but anticipate that the colliery spoil will remain.

At this stage, we expect that a programme of gas monitoring is likely to be necessary to determine if a gas risk is present. This will require monitoring wells to be installed on the site, and visits being made by an engineer on a minimum of six occasions to undertake readings from the wells.

At this stage, allowance should be made for installing gas resisting measures (including a fully lapped and sealed carbon dioxide and methane resistant membrane) within the substructure of the proposed houses.

3.8 Pollution Incidents to Controlled Waters

The Envirocheck Report does not records any pollution incidents to controlled waters within 250 m of the site.

3.9 Discharge Consents

The Envirocheck report lists only one discharge consent within 250 m of the site. This is located 163 m south west of the site and comprises a sewage storm water overflow discharge into a tributary of the Knoll Beck. This is not expected to affect the proposed development.

3.10 Flooding

The Envirocheck indicates the site to lie within a Flood Zone 1 , that is that it is not within an area at risk from flood events from rivers.

The site is not mapped as being at risk from surface water flooding. The nearest area susceptible to surface water flooding is located on the railway lines within the cutting to the north of the site.

The entirety of the site is recorded as being within an area of limited potential for groundwater flooding to occur.

3.11 Soil Geochemistry

The Envirocheck estimates the following concentrations of arsenic, cadmium, chromium, nickel and lead to be present in the natural soil at the site:

Contaminant	Estimated Concentration (mg/kg)	Assessment Value (mg/kg)*
Arsenic	<15 to 25	37
Cadmium	<1.8	11
Chromium	60 to 90	910
Lead	<100	200
Nickel	15 to 30	180

*Human Health Threshold. Other receptors may use lower threshold values.

The concentrations of these contaminants are not therefore expected to be elevated above commercial/industrial end use assessment values within the natural ground at the site. The concentrations within any made ground that is present may be higher, however.

4.0 EXPECTED GROUND CONDITIONS

4.1 Surface Covering

The site is currently surfaced with gravel and locally with hardstanding of macadam. The surfacing is not expected to be of significant thickness.

4.2 Made Ground

Reference to the historical maps in the Envirocheck indicates that ground levels are likely to have been raised in the past, and therefore made ground may be expected to underlie the site. This may comprise colliery spoil, demolition type rubble or ash, as is commonly encountered in this area from the local industry. Previous investigations found significant depths of made ground in the area immediately west of the site, although we note from the site walkover that some of this has now been removed by a recent regrading of the land.

The made ground may be of significant thickness(in excess of 2 m thick), especially in the southern part of the site where the natural slope of the ground is to fall, and therefore an excess build-up of fill may have been placed to create the current level plateau.

4.3 Natural Ground

The natural ground is generally expected to comprise firm to stiff sandy clay, becoming mudstone bedrock with depth. Sandstone may be present in the very north of the site.

Coal may be present beneath the northern corner of the site, and also a thin seam may be present at shallow depth in the south, dipping below the site.

4.4 Groundwater

Groundwater is not expected at shallow depth beneath the site. The water courses indicated along the southern edge of the site and to the west are expected to be drains, collecting surface water from the former embankments and spoil heaps.

5.0 OUTLINE CONCEPTUAL MODEL

The site is being considered for residential development, with detached houses each with private gardens and associated areas of communal and private hard and soft landscaping.

5.1 Potential Sources of Contamination

At this stage, made ground is expected to be present below the site, and the nature of this will need to be confirmed. The material may comprise industrially derived materials, such as ash, or may include demolition rubble arisings. Any made ground that is present may contain some elevated concentrations of heavy metals/metalloids such as arsenic, lead, nickel, copper or zinc, as well as elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and sulphates, particularly if ashy materials are present.

Asbestos containing materials could also be present in made ground containing demolition type materials.

5.2 Ground Gas

No radon precautions are required in new dwellings constructed on the site.

The site is not expected to be influenced by historical landfills in the local area. However, made ground in excess of 2 m thick may exist on the site, and therefore a risk of ground gas generation from on site may be present. Gas monitoring will be required if deep made ground is present, and at this stage, it is recommended that allowance is made for installing gas protective measures within the plots, comprising a gas resistant membrane, which is fully lapped and sealed across the plot to the external leaf of blockwork, and for the use of precast concrete beam and block floors with a passively ventilated void below.

5.3 Potential Pollutant Linkages

The table below details the possible sources and associated contaminants of concern, pathways and receptors:

Source	Potential Contaminants	Potential Pathways	Potential Receptors
• Made Ground.	• Heavy metals/metalloids, PAHs, sulphates, hydrocarbons	• Ingestion, inhalation, direct contact • Migration through ground	• Future residents and visitors to the site • Site construction workers • Water supply pipes • Secondary A Aquifer. • Subsurface concrete
	• Asbestos	• Inhalation of fibres	
• Natural ground.	• Sulphates	• Direct contact	
• Ground Gases	• Carbon dioxide or methane if deep made ground or soils with high organic content are present.	• Upward migration into buildings	• Future residents and visitors to the site • Buildings

5.4 Remedial Measures

At this stage it is considered that you make allowance for the following:

- A 600 mm thick clean capping is likely to be required for gardens and landscaped areas wherever made ground is to remain;
- A minimum DS-2 AC-2 level of sulphate precautions should be allowed for, applying to below ground concrete structures;
- Protective potable water supply pipes in made ground;
- Any macadam surfacing may contain coal tar and this should be tested at an early stage to ensure that it can be dealt with; and
- Amber 1 gas precautions across the site.

6.0 GEOTECHNICAL APPRAISAL

6.1 General

Made ground is anticipated to underlie the existing hard covering across the site. This may be in excess of 2 m thick. The composition of the made ground is unknown, but it is unlikely that it will be suitable to support foundation loadings.

The natural clay beneath the site is expected to be competent, and should be a suitable founding medium.

A thin seam of coal is expected to be present at shallow depth beneath the site, with a thicker seam below the northern most corner. Workings are not expected in either seam, but a borehole investigation is recommended to confirm this. Any mine workings that are present would need to be drilled and grouted. Any footings that encounter coal in the base should be extended until competent clay/mudstone is exposed. Coal in the sides of excavations should be blinded off using a lean mix of concrete.

6.2 Foundations

At this stage, it is expected that trench fill footings can be considered where the depth of made ground is less than around 2.5 m from proposed finished floor level. These should be taken through the made ground into the natural ground. A minimum footing depth of 900 mm bgl should be adopted in areas where significant fill is not present.

Any footings in clay would need to be deepened in accordance with NHBC Standards wherever past, present or proposed trees will have an effect. Precautions against lateral soil heave will be required in footings in clay with a calculated founding depth greater than 1500 mm due to the influence of past or existing trees. This would however, only apply where the ground is considered to be medium or high volume change potential. Geotechnical testing will be required to determine the shrinkability of any cohesive soils that are present.

For areas where the depth of made ground exceeds 2.5 m, piled foundations may be more appropriate with reinforced ground beams spanning between the pile caps.

6.3 Ground Slabs

It is anticipated that precast concrete beam and block floors with a 200 mm minimum height passively ventilated void below will be required for all plots due to the depth of made ground beneath the plot and the need for gas protection measures.

6.4 Superstructure Precautions

No additional superstructure precautions are expected to be required based upon the ground conditions expected below the site at this stage.

6.5 Excavation Problems

Significant excavation issues are not expected to be encountered on the site at this stage.

Temporary support will be required in accordance with current Health & Safety Regulations wherever access is required to trenches deeper than 1.2 m or less where there is risk of collapse.

6.6 Obstructions

Significant obstructions are not expected to be encountered on the site. Some relic foundations may remain from the former railway goods shed that was present in the centre of the site. However, it is expected that these can be easily broken out where necessary.

6.7 Roads

A CBR value of at least 2% is expected to be appropriate for road design at this stage.

The ground should be assumed to be frost susceptible and a minimum construction thickness of 450 mm will therefore apply. It is recommended that CBR tests are undertaken along any proposed roads or service yards prior to construction so that accurate CBR values can be obtained.

6.9 Surface Water Drainage

It is expected that the site is underlain by made ground with cohesive soils below this. It is not expected that soakaway drainage will be appropriate for this development. Due to the potential for unacceptable levels of inundation settlement within the made ground around the soakaway chambers.

It is likely that a piped drainage connection will be required, subject to approval by the water company and Local Authority.

7.0 RECOMMENDATIONS FOR FURTHER WORK

Before more definite information regarding the properties of the ground and any contamination present can be given, an intrusive ground investigation will be required. Investigation by trial pit, excavated by a mechanical excavator, is considered to be the most appropriate method of investigating the site as this will allow a larger volume of soil to be viewed.

It is considered prudent to undertake a borehole investigation to determine the depth and thickness of the coal seams at shallow depth below the site, and to install gas monitoring wells if deep made ground is proven. If gas monitoring is required, a minimum of six rounds, undertaken over a period of at least three months is likely to be required, depending o the nature of the made ground encountered on the site.

The potential pollutant linkages presented in Section 5.3 will need to be investigated by means of soil analysis. The chemical testing suite should be chosen to cover the range of potential contaminants indicated. Geotechnical testing should be carried out on clay soils, if encountered, to determine their volume change potential.