Grand Union Canal Transfer

Appendix 14-PD-5: Ground Engineering Risk Assessment

Table of Contents

Tables

Appendix 14-PD-5: Ground Engineering Risk Assessment

1. Introduction

1.1 Purpose of this Appendix

1.1.1 This Preliminary Environmental Information (PEI) Report appendix provides a high-level desk-based qualitative risk assessment of ground engineering hazards which may be present within the Preliminary Order Limits of the proposed Grand Union Canal Transfer (the Proposed Development).

1.1.2 Hazards identified within the working areas of the Proposed Development are assigned a risk rating to identify those areas to be considered for further detailed investigation.

1.2 Context

1.2.1 The Proposed Development extends from the Minworth Wastewater Recycling Centre near Birmingham to an underground reservoir at Chaul End near Luton, following the alignment of the Coventry, Oxford and Grand Union Canal network. The route is underlain by a complex sequence of superficial deposits and variable bedrock geology. A detailed description of superficial and bedrock geology of the Proposed Development is provided in **Annex 14-1** of **Appendix 14-PD-2** in PEI Report **Volume 4**.

1.2.2 Historical industrial activity, canal construction, and alteration of natural drainage patterns have collectively influenced the existing ground conditions. A thorough understanding of the geological and hydrogeological setting is therefore essential to identify potential ground engineering hazards that may impact the existing canal infrastructure and the Proposed Development works.

1.2.3 Superficial and bedrock geology may present ground engineering hazards associated with dominant lithologies, depositional environments, presence and movement of groundwater, and historical resource exploitation. The significance of these hazards will depend on the proposed construction methods and sequencing, groundwater conditions and drainage, and interactions with existing infrastructure.

1.2.4 The worst-case consequences of triggering these hazards may be substantial ground and/or infrastructure failures, injuries and fatalities in the short or long term. The most likely expected consequences are long term, including cracking, tilting and other ground and infrastructure deformation due to settlement and subsidence, which may reduce serviceability over the design life of the Proposed Development. Early identification of the hazards and risks posed will aid in the development of appropriate control measures to ensure safety and serviceability.

1.2.5 Descriptions and explanations of the ground engineering hazards assessed in this Appendix are provided in **Annex 14-4**.

1.3 Scope

1.3.1 This assessment was undertaken to identify potential ground engineering hazards (including ground instability) in support of **Chapter 14: Ground Conditions** in PEI Report **Volume 2**, which presents the preliminary assessment of likely significant environmental effects arising from the Proposed Development in relation to ground conditions.

1.3.2 A summary of the study areas for the ground conditions assessment is provided in **Chapter 14: Ground Conditions** in PEI Report **Volume 2** and shown in **Figure 14-PD-1** provided in PEI Report **Volume 3**. In general, the study areas extend 250 m from the Preliminary Order Limits of the Proposed Development and include surface and subsurface ground conditions.

1.4 Limitations

1.4.1 This risk assessment is desk-based. No intrusive investigation, in-situ testing, site walkover, or geotechnical slope stability analyses have been undertaken.

1.4.2 The findings presented are therefore high-level and qualitative in nature. The findings are intended to provide an early indication of potential ground engineering hazards to support the environmental impact assessment and the early stages of design development. Site-specific ground investigations will take place prior to detailed design and construction.

2. Methodology

2.1 Sources of information

2.1.1 Geological, geographical and mining information used in this assessment included Geographical Information System (GIS) data from the following sources:

a. The British Geological Survey (BGS) (Ref 1);

b. The Mining Remediation Authority (MRA) (formerly Coal Authority) (Ref 2); and

c. Groundsure (Ref 3).

2.2 Assumptions

2.2.1 The section breakdowns of the Proposed Development are in line with that as described within the wider PEI report.

2.2.2 Only Indicative Works Areas of the Proposed Development form part of this assessment. The following Indicative Non-Works Areas have not been included in this assessment:

a. Part 2 Section C: Coventry Canal - Chilvers Rise, Nuneaton to Oxford Canal - Hawkesbury Pumping Station (‘Part 2 (Section C)’);
b. Oxford Canal – Crick Road (A428), Hillmorton to Junction of Oxford and Grand Union Canal (‘Part 2 (Section J)’);
c. Grand Union Canal - Camp Hill, Bugbrooke to Station Road, Blisworth (‘Part 2 (Section O)’);
d. Part 2 Section P: Grand Union Canal - Station Road, Blisworth to Stoke Road, Stoke Bruerne (‘Part 2 (Section P)’);
e. Part 2 Section R: Grand Union Canal - Bozenham Mill Lane, Grafton Regis to Station Road, Castlethorpe (‘Part 2 (Section R)’); and
f. Part 2 Section T: Grand Union Canal - Marsh Drive, Milton Keynes to Childs Way, Milton Keynes (‘Part 2 (Section T)’).

2.3 Risk Classification

2.3.1 For simplification of the risk assessment, the BGS GeoSure classifications (Ref 4) of A and B, broadly corresponding to ‘very low’ and ‘low’ risk respectively, are rated herein as ‘low’ risk. Classifications of D and E, broadly corresponding to ‘high’ and ‘very high’ risk respectively, are rated herein as ‘high’ risk. Classifications of C, corresponding to ‘moderate / medium’ risk, remains unchanged and are rated herein as ‘moderate’ risk.

2.3.2 The risk of the presence of shrink-swell clays has been assessed based on the BGS GeoSure classification (Ref 4) for ‘Shrink Swell Clays’, which identifies expected degrees of plasticity, in conjunction with superficial and bedrock geology (e.g. glaciolacustrine clays, mudstones) within the study areas.

2.3.3 The risk of the presence of running sands has been assessed based on the BGS GeoSure classification (Ref 4) for ‘Running Sands’ in conjunction with superficial geology (e.g. river terrace deposits, loose sands) within the study areas.

2.3.4 The risk of slope failure has been assessed based on plotting of slope profiles derived from GIS topography layers at 1 m intervals along the Proposed Development, in conjunction with superficial geology (e.g. soft clays, loose sands, and competent materials) and historical records of landslides. Engineering judgement has been applied to assign qualitative risk ratings of low, moderate and high.

2.3.5 The risk of the presence of collapsible ground has been assessed based on the BGS GeoSure classification (Ref 4) for 'Collapsible Deposits' in conjunction with superficial and bedrock geology within the study areas.

2.3.6 The risk of the presence of compressible deposits has been assessed based on the BGS GeoSure classification (Ref 4) for 'Compressible Deposits' in conjunction with superficial geology (e.g. alluvium, peat, silts and clays) within the study areas.

2.3.7 The risk of the presence of highly soluble rock has been assessed based on the BGS GeoSure classification (Ref 4) for 'Dissolution of Soluble Rocks' in conjunction with superficial and bedrock geology (identified chalk formations) within the study areas.

2.3.8 The risk of the adverse effects to the Proposed Development from surface and underground mining works has been assessed based on geological and geographical information from the BGS regarding mineral resources, surface landforms, features and infrastructure associated with mining, in conjunction with historical coal mining information from the MRA. Professional Engineering judgement was applied to assign qualitative risk ratings of low, moderate and high.

3. Summary Findings

3.1 Risk Assessment

3.1.1 The findings of this ground engineering risk assessment are provided below.

3.1.2 It should be noted that these findings are indicative only. Identified hazards within areas currently classified as low or moderate risk may escalate to high risk at later stages as more information becomes available and following detailed ground investigations.

3.1.3 **Table 1** highlights those sections of the Proposed Development in which one or more of the ground engineering hazards assessed are rated as 'high' risk.

3.1.4 **Table 2** to **Table 7** provide the risk ratings for each ground engineering hazard assessed for each part and section of the Proposed Development in full.

Table 1: Summary 'High' Risk Assessment

Segment ID	Ground Engineering Hazard/s (assessed as 'high' risk)	
Part 1a	Compressible deposits	Areas comprising made ground and superficial alluvium deposits are compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
Part 1b Section A	Shrink-swell clays	Ground comprising alluvium and glaciolacustrine silt and clay deposits is inferred to have predominantly medium to high plasticity, with a high shrink-swell potential.
	Compressible deposits	Ground comprising alluvium and glaciolacustrine silt and clay deposits are inferred to be compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
Part 1b Section B	Compressible deposits	Areas comprising infilled ground, superficial alluvium and head deposits are inferred to be compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
	Underground mining	The Proposed Development extends within 350 m of a proven mine shaft and crosses over underground workings related to Kingbury Colliery (workings are likely >100 m bgl). Subsidence and ground stability risks should be considered.
Part 1b Section C	Surface mining	Several ceased pits/quarries (marl, clay, sand) lie inside or within 50 m of the work area, mostly concentrated around Baxterley village and the southern edge of Atherstone. Extraction extents and restoration are unclear. Recorded past surface coal mine workings intersect the Proposed Development area to the east of Baxterley. Difficult ground conditions relating to ground stability should be considered.
	Underground mining	The Proposed Development extends within 50 m of one, and 130 m of five proven mine shafts, and within 300 m of two proven mine adits in the vicinity of Baxterley village. Coal outcrops and recorded and probable past shallow coal mine workings intersect the Proposed Development to the east of Baxterley and this area is classified as a 'Development High Risk Area' by the Mining Remediation Authority. Difficult ground conditions and subsidence should be anticipated.

Segment ID	Ground Engineering Hazard/s (assessed as 'high' risk)	
Part 2 Section A	Slope failure	Instability may be present on the northern aspects of slopes along the south side of the Coventry Canal near Atherstone where underlain by the Purley Shale Formation. Site investigation should consider specifically the slope stability of the site.
Part 2 Section B	Slope failure	Instability may be present on the northern aspects of the south banks of the Coventry Canal northwest of Nuneaton, the slopes of the Tuttle Hill quarrying area, and areas on the east and west sides of the canal in the west part of Nuneaton where underlain by shale bedrock. Site investigation should consider specifically the slope stability of the site.
	Surface mining	Numerous remnants of previous extraction work (sandstone, granite, quartzite, ironstone, clay) are present along the south and west banks of the Coventry Canal, including refuse heaps, unspecified pits, and ponds (tailings or flooded pits). Difficult ground conditions should be considered.
	Underground mining	West of Nuneaton, the Proposed Development extends within 130 m of recorded coal outcrops and probable past shallow coal mine workings, within 300 m of recorded past shallow to deep coal mine workings, and within 500 m of several proven mine shafts related to Nuneaton Colliery. Northwest of Nuneaton the proposed development intersects a location of recorded manganese mine workings with the potential for adits and stopes to be present. Difficult ground conditions in the form of recorded and unrecorded underground workings should be considered.
Part 2 Section D	Surface mining	Numerous remnants of previous extraction works are present around Hawkesbury Lock and the Oxford Canal, including refuse heaps, unspecified pits, and ponds (tailings or flooded pits). Difficult ground conditions should be considered.
	Underground mining	Several mine shafts are present within the working area around Hawkesbury Locks, the condition of these shafts is unknown and therefore is a risk to the works. The Proposed Development extends over an area of recorded and probable shallow to deep coal mine workings. Around Whitting's Bridge, six recorded mine shafts lie within the working area as well as recorded moderate to deep underground mine workings for coal. This area around Hawkesbury Locks is classified as a 'Development High Risk

Segment ID	Ground Engineering Hazard/s (assessed as 'high' risk)	
		Area' by the Mining Remediation Authority Difficult ground conditions and subsidence should be anticipated.
Part 2 Section E, F, G and H	Compressible deposits	Ground comprising Wolston Clay (Bosworth Clay Member) and alluvium deposits are compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
Part 2 Section F	Slope failure	Instability may be present on both banks of the Oxford Canal, in particular where the canal runs adjacent to the railway embankment and crosses beneath the M6 overpass.
Part 2 Section I	Compressible deposits	Ground comprising peat deposits are highly compressible. There will be engineering constraints on land use depending on peat thickness.
Part 2 Section U	Compressible deposits	Ground comprising glaciolacustrine silt and clay deposits are compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
Part 2 Section V	Shrink-swell clays	Ground comprising the Peterborough Member Mudstone and Oxford Clay Formation is predominantly high plasticity, with high shrink-swell potential.
	Compressible deposits	Ground comprising alluvium and glaciolacustrine silt and clay deposits are compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
Part 3	Compressible deposits	Ground comprising alluvium deposits around the Daventry Reservoir are compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
Part 4a	Shrink-swell clays	Ground comprising the Oxford Clay and West Walton formations is predominantly high plasticity, with high shrink-swell potential.
Part 4b Section A	Shrink-swell clays	Ground comprising the West Walton Formation (mudstone) is predominantly high plasticity, with high shrink-swell potential.

Segment ID	Ground Engineering Hazard/s (assessed as 'high' risk)	
Part 4b Section B	Compressible deposits	Ground comprising alluvium deposits are compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
Part 4b Section C, D and E	Shrink-swell clays	Ground comprising the Gault Formation (mudstone) is predominantly high plasticity, with high shrink-swell potential.
Part 4b Section E	Compressible deposits	Ground comprising alluvium deposits are compressible and liable to uneven settlement. Land use should consider specifically the compressibility and variability of the site.
	Underground mining	There is recorded underground pillar and stall mine workings for chalk to the west of Totternhoe. There is also the potential for related shafts and adits to be in the vicinity of the working area. Difficult ground conditions should be considered, and potential subsidence may be considered.
Part 4b Section F and G	Dissolution of soluble materials	Ground comprising the Lewes Nodular and Seaford Chalk formations is soluble, and many dissolution features may be present. Difficult ground conditions should be considered, and potential subsidence may be considered.

Table 2: Ground Engineering Risk Assessment – Part 1a

Segment ID	Ground Engineering Risk Rating							
	Shrink-swell clays	Running sands	Slope failure	Collapsible deposits	Compressible deposits	Dissolution of soluble rocks	Surface mining	Underground mining
Part 1a	Low	Moderate	Low	Low	High	Low	Low	Low

Table 3: Ground Engineering Risk Assessment – Part 1b

Segment ID	Ground Engineering Risk Rating							
	Shrink-swell clays	Running sands	Slope failure	Collapsible deposits	Compressible deposits	Dissolution of soluble rocks	Surface mining	Underground mining
Section A	High	Low	Low	Low	High	Low	Low	Low
Section B	Low	Moderate	Low	Low	High	Low	Moderate	High
Section C	Moderate	Moderate	Low	Low	Moderate	Low	High	High

Table 4: Ground Engineering Risk Assessment – Part 2

Segment ID	Ground Engineering Risk Rating							
	Shrink-swell clays	**Running sands**	**Slope failure**	**Collapsible deposits**	**Compressible deposits**	**Dissolution of soluble rocks**	**Surface mining**	**Underground mining**
Section A	Low	Moderate	High	Low	Moderate	Low	Moderate	Low
Section B	Low	Moderate	High	Low	Moderate	Low	High	High
Section D	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate	High
Section E	Moderate	Moderate	Moderate	Low	High	Low	Low	Low
Section F	Moderate	Moderate	High	Low	High	Low	Moderate	Low
Section G	Moderate	Low	Moderate	Low	High	Low	Moderate	Low
Section H	Moderate	Moderate	Moderate	Low	High	Low	Moderate	Low
Section I	Moderate	Moderate	Moderate	Low	High	Low	Low	Low
Section K	Moderate	Moderate	Moderate	Low	Moderate	Low	Low	Low
Section L	Moderate	Moderate	Low	Low	Moderate	Low	Low	Low
Section M	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate	Low
Section N	Moderate	Moderate	Low	Low	Moderate	Low	Low	Low
Section Q	Moderate	Low	Low	Low	Moderate	Low	Low	Low
Section S	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Low
Section U	High	Low	Low	Low	High	Low	Low	Low
Section V	High	Moderate	Low	Low	High	Low	Low	Low

Notes: Risk ratings are based on assessment of only the working areas along Part 2 of the Proposed Development. Therefore, Sections C, J O, P, R and T are omitted.

Table 5: Ground Engineering Risk Assessment – Part 3

Segment ID	Ground Engineering Risk Rating							
	Shrink-swell clays	Running sands	Slope failure	Collapsible deposits	Compressible deposits	Dissolution of soluble rocks	Surface mining	Underground mining
Part 3	Moderate	Low	Low	Low	High	Low	Moderate	Low

Table 6: Ground Engineering Risk Assessment – Part 4a

Segment ID	Ground Engineering Risk Rating							
	Shrink-swell clays	Running sands	Slope failure	Collapsible deposits	Compressible deposits	Dissolution of soluble rocks	Surface mining	Underground mining
Part 4a	High	Moderate	Low	Low	Low	Low	Low	Low

Table 7: Ground Engineering Risk Assessment – Part 4b

Segment ID	Ground Engineering Risk Rating							
	Shrink-swell clays	**Running sands**	**Slope failure**	**Collapsible deposits**	**Compressible deposits**	**Dissolution of soluble rocks**	**Surface mining**	**Underground mining**
Section A	High	Moderate	Moderate	Low	Low	Low	Low	Low
Section B	Moderate	Moderate	Moderate	Low	High	Low	Moderate	Low
Section C	High	Low	Moderate	Low	Low	Low	Low	Low
Section D	High	Low	Moderate	Low	Low	Low	Low	Low
Section E	High	Low	Low	Low	High	Low	Low	High
Section F	Moderate	Low	Low	Low	Low	High	Moderate	Moderate
Section G	Moderate	Low	Low	Low	Low	High	Moderate	Low

3.2 References

Ref 1 British Geological Survey (BGS), GeoIndex Onshore (2020). Available at: https://mapapps2.bgs.ac.uk/geoindex/home.html [Accessed 20/10/25].

Ref 2 Mining Remediation Authority Map Viewer. Available at: https://datamine-cauk.hub.arcgis.com/ [Accessed 20/10/2025].

Ref 3 Groundsure Site Sensitivity Data (GIS format), Ref. GS-L4D-PCR-CHS-QF9, September 2025. Available at: https://www.bgs.ac.uk/ [Accessed 20/10/2025].

Ref 4 British Geological Survey. BGS GeoSure User Guide v8, Report OR/17/050, Appendix 1 GeoSure Legends (2018). Available at: BGS GeoSure User Guide - British Geological Survey [Accessed 30/10/2025].

Ref 5 British Geological Survey, UK Geohazard Note. Ground shrinking and swelling (2012) Available at: Geohazard note - Ground shrinking and swelling - British Geological Survey [Accessed 30/10/2025].

Ref 6 British Geological Survey, BGS GeoSure: running sand Available at: BGS GeoSure: running sand - British Geological Survey [Accessed 30/10/2025].

Ref 7 British Geological Survey, UK Geohazard Note. Landslides (2012) Available at: Geohazard note - Landslides - British Geological Survey [Accessed 30/10/2025].

Ref 8 British Geological Survey, UK Geohazard Note. Collapsible Ground (2014) Available at: Geohazard note - Collapsible ground - British Geological Survey [Accessed 30/10/2025].

Ref 9 British Geological Survey, UK Geohazard Note. Compressible Ground (2014) Available at: Geohazard note - Compressible ground - British Geological Survey [Accessed 30/10/2025].

Ref 10 British Geological Survey, UK Geohazard Note. Soluble rocks (2014) Available at: Geohazard note - Soluble rocks - British Geological Survey [Accessed 30/10/2025].

Annex 14-4: Ground Engineering Hazards

1.1 Shrink-swell clays

1.1.1 Clay type soils of certain compositions can generate significant omni-directional ground movements through the rapid absorption or loss of water. Introduction or removal of water from between the sheet silicate layers of the clay particles will increase or decrease their volume (Ref 5).

1.1.2 Near-surface water content is the primary control, affected by changes in drainage regimes, heavy rain/flooding, hot and dry spells, vegetation growth, die-back, planting, and removal, and leaking/burst water pipelines or tanks. This will manifest as surface heave and bulging when the clay is wet, and subsidence and cracking (desiccation) when dry. At depth, increased moisture will generate higher ground pressures and increased forces on buried infrastructure.

1.1.3 Damage may occur to rigid structures (such as foundations to structures) where there is uneven shrink-swell behaviour within their footprints during single events or over long-term repeated shrink-swell cycles, resulting in cracking, sinking, strains and breaks along services and reduction in serviceability.

1.1.4 Susceptible superficial deposits are alluvium, peat, and laminated clays, as well as notable clay units (London, Gault, Kimmeridge, Oxford), present across the UK. Shrink-swell clays are one of the costliest ground stability hazards in the UK, and are likely to worsen with the effects of climate change.

1.2 Running sands

1.2.1 Deposits containing loosely packed sandy layers may become fluidised by water flowing through them, destabilising the structure and strength of the soil so that it becomes a liquid (Ref 6).

1.2.2 Where water is introduced to a sand, such that the pore pressures equal or exceed the interstitial forces between the sand grains holding the structure together, the structure will collapse on its own or under loading and the material flows. Excavations below the water table, underground springs, soakaways and leaking drains may all be triggers. Seismic activity may also induce liquefaction to the same effect. This may occur at the surface or within a buried layer and removes the support for all overlying materials and structures.

1.2.3 Failures may present gradually or suddenly, and damage to infrastructure may be potentially destructive, from road or service connection breaks to structural cracking, tilting, sinking and collapse. If material can flow away, the affected zone may increase in size through progressive failures.

1.2.4 Superficial sand and gravel deposits, river terrace deposits and granular alluvium may all be prone to running conditions.

1.3 Slope failure

1.3.1 Slope failures (landslides) are the mass movement of rock, soil and debris down-slope under the force of gravity, and can occur as falls, topples, slides, flows and spreads depending on the material type and triggering mechanism (Ref 7).

1.3.2 They are caused when the driving force of gravity exceeds the resisting forces holding the slope together. Triggers may be gradual environmental weathering and weakening, changes to the slope profile such as undercutting or oversteepening, additional loading from structures, vegetation or precipitation, and poor drainage. Earthquakes and floods may also trigger landslides.

1.3.3 Risk and potential level of damage is dependent on the size, speed, material type, and proximity of the slope failure to assets or people.

1.3.4 Extent of damage is dependent on speed, location, and proximity. Shallower angle spreads and soil creep may cause structural damage, strains and breaks of utility lines, and reduce long term serviceability. Steeper slope failures release large amounts of energy quickly and can be destructive, able to knock down structures or bury them. The resulting landslide mass may present additional ground stability hazards depending on its composition.

1.3.5 Though many are degraded and stabilised, climate change is increasing the risk of re-activating currently dormant slides as well as creating conditions for new landslides to occur. Riverbanks and the slopes above canals comprised of unconsolidated superficial soils present the most acute risk for development.

1.4 Collapsible ground

1.4.1 Collapsible ground refers to those ground materials with the potential to experience a sudden and permanent reduction in volume as a result of the internal mineral structures collapsing (Ref 8).

1.4.2 The hazard is triggered where loads applied during construction occurs in partially saturated ground comprised of such materials, which is then weakened by an increase in saturation due to rising groundwater, flooding, leaking pipework or changes in drainage regimes.

1.4.3 This may result in differential settlement, leading to structural damage and reduction in serviceability of buildings and infrastructure. In the UK, superficial wind-blown silts (loess) silts found mainly in southeast Essex and Kent are the main deposits of concern.

1.5 Compressible deposits

1.5.1 Some types of unconsolidated superficial soils are likely to undergo permanent volume reduction (settlement) under applied loads and/or changes in moisture content as water filled pore spaces are compressed (Ref 9).

1.5.2 Primary settlement occurs during and shortly after construction as the moisture content is lowered through increases in applied load squeezing pore water out, and where the surrounding water level drops (dewatering), allowing the soil to drain. Drainage may occur naturally, as may decomposition in organic soils. Secondary settlement occurs much later, as the soil structure is altered.

1.5.3 Settlement shows as ground subsidence at the surface or beneath structures, which may be non-uniform depending on the type, thickness, distribution and moisture content of compressible soils and differences in applied loads upon them. Resultant damage to buildings and infrastructure may manifest as cracks, tilting, strains and breaks along services and reduction in serviceability.

1.5.4 Superficial deposits where significant settlement is considered are peat, alluvium, laminated clays, some silts and sands, and made ground (infilled quarries, landfills), and are found UK wide. Climate change is expected to adversely impact settlement issues.

1.6 Dissolution of soluble materials

1.6.1 Geological materials comprised of, or containing soluble minerals are susceptible to the dissolution through the infiltration of water, leading to the formation of voids, cavities and caves. The loss of material reduces strength and support to the overlying ground and provides space for overlying materials to funnel into (Ref 10).

1.6.2 Triggers of increased dissolution may be natural (heavy rain or flooding), or more often the result of human influences on the groundwater regime, such as leaking/burst water pipelines, poorly designed drainage and local abstractions.

1.6.3 Failures are generally localised and may present on the surface as gradual subsidence (dolines) or sudden and catastrophic collapses (sinkholes). Resulting infrastructure damage is potentially destructive and fatal, particularly in the case of building, bridge or road collapse, or rupturing of high-pressure gas pipelines.

1.6.4 Rock types associated with dissolution hazards are the extensive carbonate formations (limestones, dolomites and chalk) found throughout the UK and highly soluble gypsum and salt deposits present in many parts on northern and central England.

1.7 Surface and underground coal mining

1.7.1 The Pennine Coal Measures are recorded extending roughly parallel along the south side of Part 2 of the Proposed Development. Evidence of surface and underground coal mining is present within and around Part 1b Sections B and C. and Part 2 Sections B and D of the Proposed Development. Evidence of chalk mining is also present near to Part 4B Section E.

1.7.2 Legacy surface and underground coal mining of these measures is recorded in this region, evidence of which is present underlying and in close proximity to the Proposed Development. It is understood that there is a possibility of unrecorded or unmapped workings which should be considered.

1.7.3 Recorded or unrecorded mine workings may result in ground instability leading to collapse and subsidence as well as hazardous gas emissions such as methane, leading to reduction of asset serviceability.

1.7.4 Recorded or unmapped surface pits and spoil heaps or tips may also present additional subsidence or slope stability hazards, where is close proximity to the Proposed Development.

1.8 Surface and underground mineral extraction

1.8.1 Exploitation of regionally significant sand and gravel resources, clay for brick firing, chalk and limestone is recorded along the majority of the Proposed Development, together with a number of small landfills and ponds.

1.8.2 Evidence of underground mineral extraction (manganese ore) recorded in the area (Purley Chase Manganese Mine), and the lithologies in which ore has been mined are present within the Proposed Development. An operational chalk quarry (Keyworth Chalk Pit) lies close to the eastern extent of the Proposed Development (Part 4b Section E), and evidence of former chalk pits is present in the area.

1.8.3 Former surface aggregate workings, quarries and pits may represent increased ground stability risk due to unknown compressibility or shrink-swell potential of infill/capping materials, and slope failures where not infilled. Subsidence may be considered when developing in or near these areas.

1.8.4 Recorded or unrecorded mine workings may result in ground instability leading to collapse and subsidence as well as hazardous gas emissions such as methane, leading to reduction of asset serviceability.

1.8.5 Influences of former of current workings beyond their recorded site extents should be considered, such as alterations to the groundwater regime, weakened ground, slope stability, and unrecorded disposal of waste

1.8.6 Partially or unrecorded workings may result in difficult ground conditions during construction and/or longer-term ground subsidence and reduction of asset serviceability. Recorded surface pits and heaps may also represent additional subsidence or slope stability hazards.