WHITESTONE SOLAR FARM

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6.20 Appendix 9.9: Phase 1 Contaminated Land Report: Whitestone 3

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Glossary

Term	Meaning
Agricultural Land Classification (ALC)	A system of classification of agricultural resource value of soils in England devised by Natural England, from Grade 1 (best quality) to Grade 5 (poorest quality), and based on criteria including soil characteristics (depth, structure, texture, chemistry, stoniness) as well as climate and site aspects.
Aquifer	"Underground layers of water-bearing, permeable rock from which groundwater can be extracted" (British Geological Survey).
Best and Most Versatile (BMV)	Best and Most Versatile is agricultural land with an Agricultural land Classification of Grade 1, Grade 2 or Grade 3a (National Planning Policy Framework).
Cable Corridors	Corridors within which the high voltage cables would be constructed.
Conceptual Site Model	"A representation of the characteristics of a site which shows the possible relationships between contaminants, pathways and receptors" (Land Contamination Risk Management).
Environmental Statement (ES)	The Environmental Statement which presents the environmental information relating to the Proposed Development. The ES has been prepared to present information for formal consultation in accordance with current EIA regulation.
Made Ground	Land where the pre-existing ground surface is raised or replaced by artificial or man-made deposits.
Mineral Safeguarding Area	"An area designated by a Mineral Planning Authority which covers known deposits of minerals which are desired to be kept safeguarded from unnecessary sterilisation by non-mineral development" (Planning Practice Guidance).
Principal Aquifer	"Rocks that provide significant quantities of water and can support water supply and/or baseflow to rivers, lakes and wetlands on a strategic scale. They typically have a high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage" (Environment Agency).
Order Limits	Total area comprising the Site and Cable Corridors.
Secondary Aquifer	Rocks which "can provide modest amounts of water, but the nature of the rock or the aquifer's structure limits their use. They support water supplies at a local rather than strategic scale (such as for private supplies) and remain important for rivers, wetlands and lakes. They have a wide range of water permeability and storage" (Environment Agency). Secondary Aquifers may be further classified as 'A', 'B' or 'Undifferentiated' based on their permeability and ability to support local water supplies and/or base flow to rivers.
Source Protection Zone	Defined around large and potable groundwater abstractions sites with the purpose to "provide additional protection to safeguard drinking water quality through constraining the proximity of an

Term	Meaning
	activity what may impact upon a drinking water abstraction" (Environment Agency).
Study Area	The spatial extent within which environmental receptors may experience likely significant effects from the Proposed Development.
The Applicant	Whitestone Net Zero Ltd.
The Application	The Application submitted to the Secretary of State for a Development Consent Order.
The Proposed Development	The proposed Whitestone Solar Farm.
The Site	The land planned to be used for solar PV array and associated infrastructure, BESS, substation, and landscaping and habitat enhancement. The Site is split into W1, W2, and W3.
Whitestone 1 (W1)	The northern parcels of the Whitestone Solar Farm.
Whitestone 2 (W2)	The middle parcels of the Whitestone Solar Farm.
Whitestone 3 (W3)	The southern parcels of the Whitestone Solar Farm.

Acronyms

Acronym	Meaning
ALC	Agricultural Land Classification
AOD	Above Ordnance Datum
AoI	Area of Influence
AONB	Area of Outstanding Natural Beauty
BESS	Battery Energy Storage System
BGL	Below Ground Level
BGS	British Geological Survey
BMV	Best and Most Versatile
BOD	Below Ordnance Datum
BS	British Standards
CDC	City of Doncaster Council
CEMP	Construction Environmental Management Plan
DCO	Development Consent Order
DEFRA	Department for Environmental, Food and Rural Affairs
DEMP	Decommissioning Environmental Management Plan
EA	Environment Agency
EIA	Environmental Impact Assessment
ERM	Environmental Resources Management
ES	Environmental Statement
EU	European Union

Acronym	Meaning
HDD	Horizontal Directional Drilling
IEMA	Institute of Environmental Management and Assessment
LCRM	Land Contamination Risk Management
MRA	Mining Remediation Authority
NEDDC	North East Derbyshire District Council
NPPF	National Planning Policy Framework
oCEMP	Outline Construction Environmental Management Plan
oDEMP	Outline Decommissioning Environmental Management Plan
OEMP	Operational Environmental Management Plan
oOEMP	Outline Operational Environmental Management Plan
PBDE	Polybrominated Diphenyl Ethers
PCS	Power Conversion System
PLQRA	Preliminary Land Qualitative Risk Assessment
PPE	Personal Protective Equipment
PPG	Planning Practice Guidance
PPL	Potential Pollutant Linkages
PV	Photovoltaic
RMBC	Rotherham Metropolitan Borough Council
SAC	Special Areas of Conservation
SI	Site Investigations
SPA	Special Protection Area
SPZ	Source Protection Zone
W1	Whitestone 1
W2	Whitestone 2
W3	Whitestone 3
WFD	Water Framework Directive
ZoI	Zone of Influence

Units

Units	Meaning
ha	Hectares
km	Kilometres
kV	Kilovolt
m	Metres
MW	Megawatts

9.9 Phase 1 Contaminated Land Report: Whitestone 3

Introduction

Scope and Purpose

9.9.1 This Phase 1 Contaminated Land Report has been prepared on behalf of Whitestone Net Zero Ltd (the Applicant) to present a preliminary risk assessment of the potential ground quality effects in relation to the Development Consent Order (DCO) Application for the construction, operation, maintenance, and decommissioning of Whitestone Solar Farm (Proposed Development). This Report considers the Site history, geology, hydrogeology and land quality at the Proposed Development.

9.9.2 This Report was prepared in November 2025 to support the design process of the Proposed Development and provides information on specific areas which were removed following during Stage 4 design (see **ES Volume 1, Chapter 4: Alternatives and Design Evolution [EN0110020/APP/6.4]**). Consequently, in places this Report refers to areas of previous designs which have since been removed from the Proposed Development through design refinement. Relevant parts of this Report have been extracted for use in **ES Volume 2, Chapter 9: Ground Conditions and Land Quality [EN0110020/APP6.9]**, and the design referenced in the Report is the Stage 3 design shown in **ES Volume 3, Appendix 4.2 Design Evolution [EN0110020/APP/6.20]**.

The Order Limits

9.9.3 This extent of the Order Limits are shown in **ES Volume 3, Figure 3.1: Order Limits EN0110020/APP/6.19]** and the Proposed Development is described in full in **ES Volume 1, Chapter 5: The Proposed Development [EN0110020/APP/6.5]** and shown spatially on the **Works Plans [EN0110020/APP/2.3].**

9.9.4 This Phase 1 desktop study covers all areas where the ground is to be disturbed and focuses on areas with potentially contaminated land, as well as considering if any ground conditions exist that may affect the Proposed Development. It is designed to meet regulatory requirements and guidance, as outlined in the following sub-section.

9.9.5 This Report represents the full coverage for Whitestone 3 (W3), the southernmost section of the Whitestone Solar Farm. Whitestone 1 (W1) and Whitestone 2 (W2) are presented in **ES Volume 3, Appendix 9.6: Phase 1 Contaminated Land Report: W1 [EN0110020/APP/6.20]** and **ES Volume 3, Appendix 9.8: Phase 1 Contaminated Land Report: W3 [EN0110020/APP/6.20]**, respectively.

Regulatory Requirements and Guidance to the Approach

9.9.6 This Phase 1 contaminated land report is a desktop study that includes a preliminary risk assessment which has been undertaken in line with the following legislation, policy and guidance:

- The Environmental Protection Act 1990, and Part 2A of the Environmental Protection Act 1990 (and subsequent amendments)[1];

- Environment Agency (EA) / Department for Environmental, Food and Rural Affairs (DEFRA) Land Contamination Risk Management (LCRM) 2023[2];
- Environmental Permitting (England and Wales) Regulations 2016 (and subsequent amendments)[3];
- National Planning Policy Framework (NPPF) (2024)[4];
- NPPF Planning Practice Guidance (PPG) for Land affected by contamination (2019)[5];
- NPPF PPG for Land stability (2019)[6];
- BS 10175:2011 + A2:2017 Investigation of potentially contaminated sites - Code of practice[7];
- BS EN1997 (EC7) and BS 8004:2015+A1:2020 - Code of practice for foundations[8];
- Institute of Environmental Management & Assessment (IEMA) Land and Soil in Environmental Impact Assessment (EIA) Guidance (2022)[9];
- European Union (EU) Groundwater Directive (2006/118/EC) 2006[10];
- The Water Environment (Water Framework Directive (WFD)) (England and Wales) Regulations 2017[11]; and
- EU Water Framework Directive (2000/60/EC)[12].

9.9.7 The approach taken for this Phase 1 desktop study includes a description of the environmental setting for all areas of W3 where the ground is to be disturbed and focus on areas with potentially contaminated land. Baseline information has come from online sources, commercial geodata sources and from site walkovers undertaken by Environmental Resources Management (ERM) staff from February to May 2025. Data sources that were reviewed to establish the baseline included:

- British Geological Survey (BGS) Solid and Drift Geology, 1:50,000 England and Wales[13];
- BGS GeoIndex Onshore interactive map viewer, including borehole records[14];
- Defra's 'Magic' Map and Historical Landfills Sites database[15];
- The Mining Remediation Authority's (MRA, formerly the Coal Authority) interactive map viewer[16];
- EA Catchment Data Explorer[17];
- UK Radon Maps[18];
- Rotherham Local Plan Interactive Policies Map[19];
- **ES Volume 3, Appendix 9.4: Landmark Envirocheck® Report: W3 [EN0110020/APP/6.20]**;
- **ES Volume 3, Appendix 9.5: Landmark Envirocheck® Report for Cable Corridors [EN0110020/APP/6.20]**;
- The Coal Authority Consultants Coal Mining Report for W3 (see **ES Volume 3, Appendix 9.12: Phase 1 Coal Mining Risk Assessment: W3 [EN0110020/APP/6.20]**); and
- **ES Volume 3, Appendix 9.12: Phase 1 Coal Mining Risk Assessment: W3 [EN0110020/APP/6.20]**.

9.9.8 In line with the guidance above, the Phase 1 desk study includes a preliminary risk assessment framed within a conceptual site model developed for specific parts of W3, as well as general conditions, at the construction, operational and decommissioning phases of the Proposed Development. The preliminary risk assessment considers the potential pollutant pathways, land stability and ground conditions and will specify and assess the significance of sources (of pollution), pathways (that transmit the pollution) and receptors (such as controlled waters, humans and livestock) and potential pollutant linkages, in line with the approach in the Land Contamination Risk Management (2023) and the 2012 statutory guidance under Part 2A of the Environmental Protection Act (1990). Recent amendments (2023) to the Environmental Permitting (England and Wales) Regulations (2016) expanded the definition of pollutants in groundwater to include heat and so heat from buried high voltage cables affecting groundwater is also considered within this preliminary risk assessment.

9.9.9 A further purpose of the Phase 1 preliminary risk assessment is to determine if supplemental Phase 2 intrusive investigations are required to confirm or otherwise the quantum of land pollution in suspected source areas (by taking samples of soil and controlled waters), test the validity of potential pollution linkages, or characterise any significant geotechnical features that may affect W3. The objective of a Phase 2 investigation, if one is required, is to provide sufficient data to undertake a detailed, quantitative risk assessment which will inform the need for any remedial or design work to be undertaken prior to redevelopment.

Summary of the Proposed Development and Potential Effects on Land Quality

9.9.10 The Proposed Development is located to the east of Sheffield, South Yorkshire, within the administrative areas of the City of Doncaster Council (CDC), North East Derbyshire District Council (NEDDC) and Rotherham Metropolitan Borough Council (RMBC). At current scope, the Proposed Development involves the construction, operation and maintenance, and decommissioning of over 100 megawatts (MW) of solar photovoltaic (PV) array, Battery Energy Storage System (BESS), onsite substations and supporting infrastructure, and grid connection infrastructure. The grid connection infrastructure would connect the Proposed Development to the new 400 kilovolt (kV) National Grid substation proposed on land immediately east of Long Lane, Brinsworth, S60 4JJ (Long Lane 400kV Substation). National Grid are currently undergoing consultation on plans for the development of this new substation which is expected to be operational in time for the Proposed Development to connect in 2029.

9.9.11 The Area of Influence (AoI) considered in this Report is defined within **ES Volume 3, Figure 9.1: Study Area [EN0110020/APP/6.19]** and mainly focuses on the operational area of the Proposed Development for W3 only and immediately adjacent land. The W3 part of the Whitestone Solar Farm does not include a BESS, and so the specific effects of these facilities are not considered in this Report, although they do feature in the Reports for W2 and W3. A full description of the Site and the Proposed Development can be found in **ES Volume 1, Chapter 3: The Site and Surrounding Area [EN0110020/APP/6.3]** and see **ES Volume 1, Chapter 5: The Proposed Development [EN0110020/APP/6.5]**, respectively.

9.9.12 The solar PV modules would be mounted on metal racks, known as mounting structures. These mounting structures will be galvanised or bare metal frames which would be pile-driven or installed by helical screws to a maximum depth of

4m below ground level (BGL). Where ground conditions are considered to be unsuitable for piles or screws, a concrete ballast would be used.

9.9.13 Solar PV modules would be bifacial, meaning both faces of the modules would have the capacity to absorb sunlight. The solar PV modules would be installed in rows, with a minimum of 3m between each row.

9.9.14 Power Conversion Stations (PCS) manage the output generated by the solar PV modules. They consist of multiple components housed in a single enclosure. A PCS will be placed on a hardstanding foundation which would not typically exceed depths of 2m BGL but could also include piling to depths of up to 4m BGL.

9.9.15 Potential effects of the Proposed Development on geology, hydrogeology and land quality mostly occur in the construction and decommissioning phases, and comprise:

- Disturbance and / or removal of the ground and potentially groundwater which could potentially remove, relocate or mobilise pollutants;
- Use of plant and equipment which could accidentally leak fuels and oils, introducing contaminants to the ground;
- Use of horizontal drilling techniques to install cables which could accidentally leak drilling fluids, introducing pollutants to the ground and potentially into surface water;
- Installation of sub-surface structures, such as cables, piles and foundations, which could act as new pathways for mobilised pollutants that include heat in the case of cables;
- Storage and use of hazardous materials and substances (e.g. concretes, fuel, oils and drilling fluids) which could be mobilised to ground or controlled waters;
- Exposure of construction/decommissioning workers to dust during soil excavation activities; and
- Ground stability issues such as subsidence related to historic coal mining infrastructure.

9.9.16 Some of these effects could persist into the operational phase, and other land quality effects that could arise from site activities in operations are around storage of wastes, vehicular access and maintenance, as well as from the heat generated by the high-voltage cables that will be located in the Cable Corridors and are buried in the ground.

9.9.17 W3 could also be adversely affected by ground conditions during any phase from instability caused by compressible ground or subsidence, soluble bedrock or shrinking / swelling clays, that could be either naturally occurring or as a result of historic quarrying, landfilling and coal mining activity and infrastructure.

9.9.18 Considerations of agricultural land use, as graded by surveys for Agricultural Land Classification (ALC) to determine Best Most Versatile (BMV) land and to consider the potential impacts to that from the Proposed Development, are not included in this Report as they are subject to separate survey and baseline reporting.

Methodology for the Assessment of Effects

9.9.19 The normal procedure for assessing land, as detailed by the current LCRM guidance, dictates that potential contaminants, pathways, and receptors should be considered within the context of contaminant or contaminant linkages. An

evaluation of the risks associated with each linkage should drive decisions regarding the status of the land as contaminated and requiring remediation, uncontaminated or requiring further investigation. Where the Preliminary Land Qualitative Risk Assessment (PLQRA) indicates a low or negligible risk, no further investigation is recommended. The PLQRA methodology specific to this contaminated land assessment is outlined in the following sections and also incorporates relevant Environment Agency and British Standards (BS) guidance. The potential impacts for this topic are characterised on the basis of the potential harm to a receptor within a given source-pathway-receptor combination, or a pollutant linkage and graded with a level of magnitude. In order to evaluate whether the presence of a source of contamination could potentially lead to harmful consequences a source-pathway-receptor methodology is adopted, with the underlying principle that the identification of pollutant linkages consists of the following three elements:

- A source hazard (a substance or situation that has the potential to cause harm or pollution);
- A pathway (a means by which the hazard moves along); and
- A receptor/target (an entity that is vulnerable to the potential adverse effects of the hazard).

Sensitivity of Receptors

9.9.20 The sensitivity (value) of potential receptors can be described qualitatively according to the categories presented in **Table 9.9.1**.

Table 9.9.1 Sensitivity of Receptors

Sensitivity	Receptor
High	• Human health: onsite residential developments, onsite construction workers; and • Controlled waters (groundwater): Source Protection Zone (SPZ) or highly productive aquifer.
Medium	• Human health: onsite commercial developments, off-site residential developments; and • Controlled waters (groundwater): Moderately productive aquifer.
Low	• Human health: transient or limited access, off-site commercial development; and • Controlled waters (groundwater): Low productivity aquifer or rocks essentially with no groundwater.

Magnitude of Impact

9.9.21 The magnitude of impacts is determined by considering the intensity (or scale), spatial coverage and longevity of an impact. The magnitude of impact on the receptors is presented in **Table 9.9.2**.

Table 9.9.2 Magnitude of Impact

Magnitude	Description	Example
Large	• Results in loss of attribute and/or likely to	• Impact of the health of a large number of human receptors,

	cause exceedance of statutory objectives and/or breach of legislation.	including off-site. Contamination of a highly productive aquifer; • Loss or isolation of a strategic mineral resource; and • Permanent or irreversible loss of soil functions over an area of >20ha, or loss or isolation of strategic mineral resource.
Medium	• Results in impact on integrity of attribute/or loss of part of attribute, and/or possibly cause exceedance of statutory objectives and/or breach of legislation.	• Loss or isolation of a regional/local mineral resource; • Contamination of a moderately productive aquifer; • Reduction in the value of a feature, permanent or irreversible loss of soil functions over an area of 5 – 20ha, or loss or isolation of regional/local mineral resource; and • Impact on the health of on-site human receptors (i.e. the workforce).
Small	• Results in minor impacts on receptor.	• Measurable change in receptor, but of limited size/proportion; • Contamination of a poor yielding aquifer; and • Reduction in the value of a feature, permanent or irreversible loss of soil functions over an area of <5ha, or a temporary, reversible loss.
Negligible	• No loss or alteration of characteristics, features or elements, no observable impact in either direction.	• No significant loss in quality of receptor.

Significance of Effect

9.9.22 The significance of effect is determined by assessing the potential magnitude of impact on the receptors against the sensitivity of the receptor. **Table 9.9.3** presents the matrix for evaluation of the significance of effects. Moderate or major effects are considered significant in EIA terms.

Table 9.9.3 Significance of Effect

Sensitivity	Magnitude of Impact			
	Negligible	**Small**	**Medium**	**Large**
High	Not Significant	Moderate – Significant	Moderate – Significant	Major – Significant

Medium	Not Significant	Minor – Not Significant	Moderate – Significant	Moderate – Significant
Low	Not Significant	Not Significant	Minor – Not Significant	Minor – Not Significant

Likelihood of Occurrence

9.9.23 The significance of effects is determined as if the impact has actually happened. However, in the context of land quality and ground conditions it is also important to consider the likelihood of the impact occurring when assessing the overall significance of effects. The likelihood of occurrence is defined as follows:

- **High:** Occurrence of an impact is very likely in the short-term and is almost certain to occur in the long term, or a complete pollutant pathway is known to already exist.
- **Medium:** An impact may occur, either due to an unplanned event or the presence of a complete pathway, and it is probable that it will do so over the long term.
- **Low:** An impact may occur, either due to an unplanned event or the presence of a complete pathway, and it is possible that it will do so over the long term but there is no certainty that it will do so.
- **Unlikely:** The potential for an impact to occur may be present, but the circumstances under which an adverse effect would materialise, even in the long-term, are improbable.

Site and Surrounding Area

9.9.24 This section provides a description of the key characteristics of W3. This description is derived from online public databases and gathered during the ERM site visits which were undertaken in February to May 2025.

Site Description

9.9.25 W3 is located within the administrative area of RMBC, with a southern boundary extending slightly into the administrative area of NEDDC. W3 is located approximately 14km to the east of Sheffield and Rotherham and covers approximately 200ha. There are three distinct sections to W3, all located within the vicinity of Woodall Services on the M1 motorway. The western most section is located between the village of High Moor to the west and Woodall Services to the east. The eastern section is located opposite on the eastern side of the M1 and Woodall services, south of Woodall. The northern section is located in the area between Woodall and Kiveton Park to the north. **ES Volume 3, Figure 3.2: Site Referencing [EN0110020/APP/6.19]** show the extent of W3.

9.9.26 There are currently four proposed Cable Corridor Options, which are considered part of W3. The four Cable Corridor Options currently include:

- **CR 3a**: connects to the northeast of W3, running between Kiveton Park and Kiveton Park Industrial Estate, to connect with the southeast of W2;
- **CR 3b**: connects to the east of W3, running east of Kiveton Park Industrial Estate to connect to the southeast of W2;

- **CR 3c**: connects the eastern parcels of W3; and
- **CR 3d**: connects the southern parcels of W3.

9.9.27 W3 almost entirely consists of agricultural land, with the exceptions being overlapping infrastructure, such as roads. The Order Limits of W3 are defined by field boundaries as well as major roads in the area. These include the M1, which defines the western boundary for the areas surrounding Woodall, the A618, which runs adjacent to the southern boundary and Hard Lane, which defines the northeastern most boundary. Killamarsh Lane crosses the W3 in the west.

Surrounding Area Description

9.9.28 W3 is located in a predominantly rural area with a variety of surrounding land uses. Most of the surrounding land is used for agricultural purposes, primarily arable with some farms used for livestock rearing, including horse farming. There are five significant residential areas located directly adjacent to or within 250m of W3 and the Cable Corridor Options. These are High Moor (adjacent west), Woodall (adjacent centrally), Harthill (~250m east), Kiveton Park (~100m west of CR 3a) and South Anston (~100m east of CR 3b). Woodall Services are also located adjacent to the W3 in the south. There are also a number of isolated residential and farm buildings located adjacent, and within close proximity to W3. Other surrounding land uses include areas of woodland, Harthill Reservoir to the east and Killamarsh Pond north of Killamarsh Lane. There is a sewage works located south of Killamarsh Lane adjacent to W3.

Physical Setting

Topography

9.9.29 The topography of W3 is variable, with the elevation difference across the Site reaching 50m. The greatest elevation in the south/southwest is approximately 145m Above Ordnance Datum (AOD). The topography slopes to the north/northeast, reaching a low point of approximately 95m AOD, south of Kiveton Community Woodland.

Geology

9.9.30 According to the BGS Geoindex (Onshore) and the Landmark Envirocheck Report, the bedrock geology which underlays W3 is dominated by Upper Carboniferous Pennine Middle Coal Measures of mudstone, siltstone and sandstone, including the members Oaks Rock of sandstone in the west and Mexborough Rock of sandstone in the northeast. There are no superficial deposits recorded within the western or southern sections, while the northeastern section has deposits of Head and Alluvium of clay, silt, sand and gravel.

9.9.31 The Cable Corridor Options are underlain by the same geology, with the exception of the eastern extents of CR 3b and a small section of CR 3a between Kiveton Park and Kiveton Park Industrial Estate, where they are both underlain by dolostone of the Cadeby Formation. Superficial deposits of Till of diamicton (boulder clay) underlay the northern extents of CR 3a and CR 3b.

9.9.32 In approximately 17 hectares of W3, primarily the southern section and the most northwestern section, the BGS Geoindex (Onshore) indicates the presence of Made Ground. Borehole SK48SE196 located at Woodall Services details the

Made Ground as a mixture of mudstone and sandstone pieces with occasional coal fragments.

9.9.33 According to the BGS Geoindex (Onshore), there are numerous recorded boreholes within the vicinity of W3, and five directly within the boundaries of the W3. Four of these are located in the eastern section, and one in the northern section.

- In the eastern section, boreholes SK48SE26 and SK48SE263 are both recorded as being constructed for High Moor Colliery No. 1, although there are no available log records establishing their geology;
- Borehole SK48SE46 is located ~200m east of Woodall Services. According to BGS Geoindex, it was drilled as part of a section of High Moor Colliery, Clowne to Two Foot Intake Drift, with the goal of accessing the two-foot seam. The log indicates interbedded siltstone, mudstone and sandstone up to a depth of 22m BGL, where there was a 2m thick layer of Main Bright Coal. At 33.7m BGL, the Two Foot coal seam was encountered with a thickness of ~1m;
- Borehole SK48SE11, located west of Harthill Reservoir was drilled from an underground location as part of the development of Westhorpe Colliery No. 7 with the aim of proving reserves in the Chavery seam. The log indicates two directions of drilling as the operations began underground at approximately 86m BGL at the floor of the Flockton seam. The upbore was drilled to prove the Chavery seam, while the downbore was drilled to investigate deeper coal measures. The upbore indicates interbedded sandstones and siltstones up to 16.5m above the drill starting depth, where the Chavery seam was encountered, with a thickness of ~1.5m. The downbore was drilled to a depth of 122m below the floor of the Flockton seam and recorded geology of interbedded siltstones, mudstones and sandstones with a number of coal seams also encountered at 8, 22.5, 31, 51 and 71m Below Ordnance Datum (BOD); and
- In the northern section of the W3, borehole SK48SE203 is located in the northwest, adjacent to the M1. The log records sandstone up to a depth of 4m BGL, where it becomes interbedded with coal seams up to 5.5m BGL. Below this, there are layers of sandstone and siltstone up to the final depth of 11.5m BGL.

9.9.34 There are many other boreholes recorded in the area around W3 and the Cable Corridor Options. They are of varying depth and purpose, with many centred on the M1, likely drilled during the construction of the motorway as fairly shallow boreholes less than 20m deep. Most of the other boreholes relate to historic coal mining, with several being underground boreholes drilled from existing underground adits.

Hydrology

9.9.35 W3 is located in close proximity to a number of surface water features, and there are a few locations for which they are present within the boundaries of the Site. The majority of these features are unnamed streams forming parts of the field boundaries. The most significant of these is Broad Bridge Dike, which runs north-south along the eastern boundary and across the northern section of W3. There are also several larger surface water features which are adjacent to W3. The largest of these is Harthill Reservoir, located adjacent to the southern section of W3. The reservoir is over 200 years old and was originally built to supply water to

the Chesterfield Canal. It is currently used for recreational activities such as fishing, swimming and occasional water sports. Other surface water features in the vicinity of W3 include Killamarsh Pond and several other unnamed ponds which are located adjacent to the western section of W3. Both CR 3a and CR 3b cross the Chesterfield Canal either side of Kiveton Park Industrial Estate.

9.9.36 According to **ES Volume 3, Appendix 9.4: Landmark Envirocheck® Report: W3 [EN0110020/APP/6.20]** and **ES Volume 3, Appendix Landmark Envirocheck® Report for Cable Corridor Options [EN0110020/APP/6.20]**, there are no recorded surface water abstractions within the boundaries of W3 or within 250m of the Order Limits (including the Cable Corridor Options).

9.9.37 According to the EA Catchment Data Explorer, W3 extends over two different catchments. The western section, including CR 3d, lies within the Rother, Doe Lea to Don water body, which is classified as having a moderate ecological status. The eastern and northern sections, including CR 3c, are situated within the Broad Bridge Dyke water body. This is the Harthill feeder to the Chesterfield Canal and sits within the Idle River operational catchment. The EA Catchment Data Explorer classifies Broad Bridge Dyke water body as having poor ecological status due to poor biological quality elements including Macrophytes and Phytobenthos. In 2019, Broad Bridge Dyke failed on hazardous chemical substance levels including mercury and its compounds and Polybrominated diphenyl ethers (PBDE). The northern extents of CR 3a and CR 3b are both situated in two further surface water bodies. In the area around Kiveton Park, the Cable Corridor Options are situated within the Ryton from Chesterfield Canal to Anston Brook Water Body. In 2022, the EA Catchment Data Explorer classifies this water body as having good ecological status. In the area west of South Anston, CR 3a and CR 3b are situated within the Anston Brook from Source to Ryton Water Body, which the EA Catchment Data Explorer classifies as having moderate ecological status.

Hydrogeology

9.9.38 According to DEFRA's Magic Map Tool as well as **ES Volume 3, Appendix 9.4: Landmark Envirocheck® Report: W3** and **ES Volume 3, Appendix 9.5: Landmark Envirocheck® Report for Cable Corridor Options [EN0110020/APP/6.20]**, the Pennine Middle Coal Measures underlying the majority of the W3 are classified as a Secondary A aquifer. The EA designates a Secondary A Aquifer as a permeable layer capable of supporting local water supplies and, in some cases, forming an important source of base flow to rivers. The Cadeby Formation dolostone, which underlies short stretches of CR1a and CR1b is classified as a Principal Aquifer. The EA designates a Principal Aquifer as rock layers that provide significant quantities of water and can support water supply and/or baseflow to rivers, lakes and wetlands on a strategic scale. They typically have a high intergranular and/or fracture permeability (the latter in the case of the Cadeby Formation), meaning they usually provide a high level of water storage.

9.9.39 The superficial deposits situated in the northeastern section of W3 are classified as a Secondary Undifferentiated Aquifer. A Secondary Undifferentiated Aquifer is designated as an aquifer where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type.

9.9.40 According to **ES Volume 3, Appendix 9.4: Landmark Envirocheck® Report: W3** and **ES Volume 3, Appendix 9.5: Landmark Envirocheck® Report for**

Cable Corridor Options [EN0110020/APP/6.20], both the bedrock aquifers and superficial aquifer are both deemed as having high groundwater vulnerability. W3 is not classified as having a soluble rock risk. There is additionally potential for groundwater flooding to occur in small areas across W3 and CR 3a and CR3b, corresponding to the outcrop of the sandstone Members of the Pennine Middle Coal Measures and the location of alluvium superficial deposits, as well as in close proximity to the Chesterfield Canal. According to the EA Catchment Data Explorer, W3 is within the Don & Rother Millstone Grit & Coal Measures Water Body. In 2019, it was classified as having poor overall status due to poor groundwater chemical status attributed to historic mining and quarrying, as well as natural mineralisation.

9.9.41 According to **ES Volume 3, Appendices 9.4 and 9.5: Landmark Envirocheck® Report: W3** and **Landmark Envirocheck® Report for Cable Corridor Options [EN0110020/APP/6.20]**, respectively, there are no recorded groundwater abstractions within the boundaries of W3 or the Cable Corridor Options. The nearest groundwater abstraction is located 185m southeast of the northern section at Oaklands Farm and is used for spray irrigation. There are three further groundwater abstraction points located within 500m of the W3 which are recorded in the Landmark Envirocheck Report. All three are located within the vicinity of Kiveton Park Industrial Estate and are used for industrial processes.

9.9.42 There are no Source Protection Zones located within W3 or the Cable Corridor Options, with the exception of the easternmost buffer of CR 3b, which passes through an SPZ 3, in a short section south of South Anston. The centerline of CR 3b, thought to be the most likely Cable Corridor Option, does not cross the SPZ.

9.9.43 An accurate assessment for depth to groundwater has not been established for W3 or the Cable Corridor Options. This is primarily due to the lack of recorded borehole data with groundwater depth or regional hydrogeological mapping in the area. It is expected that depth to groundwater will vary across W3 with shallower groundwater expected in valleys, especially where close to surface water bodies.

Ground Conditions

9.9.44 As the Proposed Development is in an area of historic coal mining, further information has been acquired from the Mining Remediation Authority (formerly known as the Coal Authority) with regard to the ground conditions at W3. This information is presented in more detailed **ES Volume 3, Appendix 9.12: Coal Mining Risk Assessment: W3 [EN0110020/APP/6.20]**), but information will also be presented in this Report to further describe the baseline.

9.9.45 According to the BGS Geoindex (Onshore) and the Landmark Envirocheck Report, there are two records of inferred geological faults present within W3. One is located in the eastern section, bisecting the Site in a southwest-northeast direction, while the second is located in the very northeast of W3, and is orientated in a northwest-southeast direction. There are two east-west faults which are present within CR 3a and CR 3b just south of Kiveton Park, and a further fault bisecting CR 3a in a northwest-southeast direction, north of Kiveton Park.

9.9.46 According to the MRA Map Viewer and the RMBC Local Plan, the entirety of W3 is located within a Shallow Coal, Fire and Brick Clay Mineral Safeguarding Area. The eastern and northern parts of the CR 3a and CR 3b buffer extend on to the Limestone Mineral Safeguarding Area, although again, the centerlines of these, thought to be the most likely Cable Corridor Option, do not cross into them.

9.9.47 The MRA Map Viewer also shows that the Proposed Development lies adjacent and within an area of past surface mining and past shallow coal mine workings. These areas overlap with W3 by approximately 7ha north of Woodall village, and around 12ha southeast of the Woodall Services. As such, these areas are designated by the MRA as Development High Risk Areas and are of note because the excavations were infilled with unknown materials that could potentially include waste or contaminating materials and could also pose geotechnical ground stability risks. This Made Ground is described in paragraphs 9.9.51 to 9.9.52.

9.9.48 According to the Consultants Coal Mining Report, provided by the MRA, there are eight recorded mine entries located within the northern section of W3, one in the eastern section and three in the western section. All of these refer to mine shafts and are detailed further in **ES Volume 3, Appendix 9.12: Coal Mining Risk Assessment: W3 [EN0110020/APP/6.20]**). The MRA designates that:

"Each mine entry has a zone of influence buffer around the mine entry. The Zone of Influence (ZoI) highlights the area on the surface that could potentially be affected in the unlikely event a collapse was to occur. The calculation takes into account the size of the mine entry entrance, the geological 'drift' deposits for the area and the original source from which the mine entry was captured. Where the calculated ZoI is less than 20m then a default value of 20m is used."

9.9.49 As such, for the mine entries recorded within W3, the ZoI is considered to be a 20m radius around each of the recorded entries.

Infilled Land

9.9.50 According to the Landmark Envirocheck Report, there are eight recordings of infilled land, both water and non-water within W3. Four of these are in the northern section of W3 and relate to historic coal mine shafts, as they also coincide with BGS recorded mineral sites. They are recorded as Potentially Infilled Land (Non-water), such as quarries or pits. A further potentially infilled land (non-water) is located approximately 500m south of the northern group, north of Woodall. This record likely coincides with Baugy Hill Quarry, which is also a BGS recorded mineral site. In the southeast of W3, just south of Woodall, is another potentially infilled land record. According to the historic mapping, this likely refers to a small, infilled clay pit. The two final records are for potentially infilled land (water), such as ponds, marshes, streams or rivers. One record is located in the eastern section of W3 and is likely an infilled field drain, while the other is located in the west of W3 and is likely an infilled pond or marsh.

Made Ground

9.9.51 According to the Landmark Envirocheck Report as well as BGS Geoindex, there are large areas (approximately 19ha) of artificial ground identified within the central sections of W3, corresponding to historical coal mining activities described above. The BGS describes these infilled ground units as an area where the pre-existing land surface has been excavated (Worked Ground) and subsequently partially or wholly backfilled (Made Ground). As described above, these areas are of note because the excavations were infilled with unknown materials that could potentially include waste or contaminating materials and made ground may present a geotechnical risk due to its potential heterogeneous and compressible nature.

9.9.52 Other areas of infilled ground within the vicinity of W3 include Kiveton Community Woodland, an area of remediated land adjacent to the north of W3, and the historic landfills and quarries within the vicinity of Kiveton Park Station, adjacent to Cable Corridor Options CR 3a and CR 3b.

Ground Stability

9.9.53 The Landmark Envirocheck Report defines the ground stability through five different potential hazards: Collapsible Ground, Compressible Ground, Ground Dissolution, Landslide Ground Stability, and Shrinking or Swelling Clay.

9.9.54 Each of these potential hazard classifications is rated with a risk value ranging from no hazard to very high. The Landmark Envirocheck Report lists multiple records across the Site which are typically no or very low hazard, ranging up to a moderate hazard of Compressible Ground Stability in the southern section, east of Woodall Services, as well as the northwestern most section. As such, a range of risk levels as been presented for each hazard category. For the Site at W3, these are as follows:

- *Potential for Collapsible Ground Stability Hazards*: **Very Low**, with deposits with potential to collapse when loaded and saturated unlikely to be present;
- *Potential for Compressible Ground Stability Hazards*: **No Hazard – Moderate**, with compressible strata absent across most of the Site. The areas with moderate risk are mapped where there were past shallow coal mine workings;
- *Potential for Ground Dissolution Stability Hazards*: **No Hazard**, with soluble rocks not present;
- *Potential for Landslide Ground Stability Hazards*: **Very Low – Low**, with slope instability problems not thought to occur; and
- *Potential for Shrinking or Swelling Clay Ground Stability Hazard*: **No Hazard - Very Low**, with ground conditions predominately non-plastic.

9.9.55 For the Cable Corridor Options, the risk ratings are defined as follows:

- *Potential for Collapsible Ground Stability Hazards*: **Very Low** with deposits with potential to collapse when loaded and saturated unlikely to be present;
- *Potential for Compressible Ground Stability Hazards*: **No Hazard - Moderate** with compressible strata absent across most of the Site. The areas with moderate risk are mapped where there were past shallow coal mine workings and other historic and present quarrying activities in the vicinity of Kiveton Park Station;
- *Potential for Ground Dissolution Stability Hazards*: **No Hazard** with soluble rocks not present;
- *Potential for Landslide Ground Stability Hazards*: **Very Low** with slope instability problems not thought to occur; and
- *Potential for Shrinking or Swelling Clay Ground Stability Hazards*: **Very Low** with ground conditions predominately non-plastic.

Other Protected Areas / Sensitive Land Uses

9.9.56 According to the Landmark Envirocheck Report, there are no Areas of Outstanding Natural Beauty (AONB), Environmentally Sensitive Areas, Forest Parks, Local Nature Reserves, Marine Nature Reserves, National Nature

Reserves, National Parks, Nitrate Sensitive Areas, Ramsar Sites, Sites of Special Scientific Interest, Special Areas of Conservation (SAC), Special Protection Areas (SPAs) or World Heritage Sites located within the boundaries of the Proposed Development or within 500m.

9.9.57 According to the Landmark Envirocheck Report, the Proposed Development is located within an Area of Adopted Green belt (Rotherham Metropolitan Borough Council) and within and Nitrate Vulnerable Zone. An Ancient Woodland is located approximately 200m north of the western section of the Proposed Development.

Radon

9.9.58 The UK Maps of Radon indicate that the Proposed Development is in an area where there is an elevated radon potential. The majority of W3 and Cable Corridor Options are located within a band where the maximum radon potential is between 1-3% of homes above the action level. In the southern portions of W3, namely south of Woodall Services, the maximum radon potential is between 3–5% of homes above the action level.

Historical Use Information

Approach

9.9.59 The historical development of W3 and surrounding area has been assessed through a review of available historical maps from the 1850s onwards, presented in **ES Volume 3, Appendix 9.4: Landmark Envirocheck® Report: W3 [EN0110020/APP/6.20]**, **ES Volume 3, Appendix 9.5: Landmark Envirocheck® Report for Cable Corridor Options**, aerial photographs and Google Earth. A summary of the key historical land uses and developments in the surrounding area is presented below.

Land Use History

9.9.60 The vast majority of W3 has been agricultural and undeveloped land since first mapped in the 1850s. In 1854, the western section of W3 is shown to be part of ‘Woodall Common’ and shows a number of agricultural fields within the Site boundaries. There are two marked plantations (‘High’ and ‘Low’) which are located in the centre of the Site, southerly adjacent to Killamarsh Lane. The nature of these plantations is unknown. Killamarsh Lane exists in the same location as the present day. From the same dates, the eastern section of the W3 also is shown as being entirely comprised of agricultural fields. A singular clay pit is labelled in the northwest corner of the Site. The northern section is much the same, with the majority of it being comprised of agricultural fields. Walseker Lane exists in its present location, running north-south through the Site, with a bridleway abutting perpendicular in an easterly direction. In the northwest of the Site, there are four shafts marked, all part of Wales Collieries. In the southwest of the Site, next to Baugy Hill is marked an old quarry. The nature of this quarry is unknown.

9.9.61 The Cable Corridor Options have much the same historic land use. CR 3a and CR 3b both are mainly located within historic agricultural land from at least 1854 to the present. In 1854, both Cable Corridor Options cross the Manchester-Sheffield-Lincolnshire Railway either side of Kiveton Park Station. Both Cable Corridor Options also cross the Chesterfield Canal. Also present within the vicinity of Kiveton Park Station are a number of quarries and plantations. CR 3a directly

crosses through “Red Hill Quarry” and “Red Hill Plantation” approximately 500m west of Kiveton Park Station. CR3B does not appear to pass through any named quarries in 1854 mapping. There are further quarries such as “Dog Kennels Quarry” present 500m west of CR 3b, and another unnamed old limestone quarry 100m east of CR 3b. This old quarry is no longer present in the 1893 map. The mapped land use of CR 3c has been agricultural from 1854 to the present.

9.9.62 Through the late 1800s and into the mid-20th century, W3 land use remained largely unchanged. By 1894, the clay pit in the eastern section, and the Wales Colliery shafts in the northern section are no longer present. The old quarry adjacent to Baugy Hill is also no longer marked, however there is now a spring within the vicinity of the quarry, located on Walseker Lane. In the 1899 map, the spring is labelled as ‘Old Quarry Spring’.

9.9.63 By 1967, there is a drain present in the southeast of the eastern section of W3, which flows into Harthill Reservoir. Further drains are present in the northern section, focused on the western and northern Site boundaries. The old quarry spring is no longer marked as a well. By 1978, High Plantation in the western section of W3 is no longer present. From 1978 up to the present day, there are few changes to the Proposed Development, including the Cable Corridor Options. The surrounding land use shows few changes since the early 20th century, most notably being the surrounding quarries and limekilns becoming disused by the 1960s. By 1978, more residential buildings are present 250m east of CR 3a and 250m north of CR 3b. Other changes include Stonehill Farm appearing by 2000, 100m southeast of CR 3b, and Oaklands Farm 150m south of CR 3b by the same year.

Surrounding Area History

9.9.64 Historically, the area surrounding W3 has also been used for agricultural purposes, along with coal mining. In the mid-1850s, the area surrounding W3 was dominated by agricultural land. The village of Woodall is present, located centrally between the sections of W3 and adjacent to the northern and eastern sections. By this date, Woodall comprised residential properties and farm buildings, which were mainly in the north of the village. South of W3 are further agricultural fields and isolated farm buildings. Pebley Inn is approximately 200m south of the eastern section. 250m south of the northeastern most section of W3 is the northern extents of the village of Harthill. This includes several residential and farm buildings. The village of High Moor is present 200m west of the western section of W3. In the mid to late 1800s, High Moor consisted of only a few residential and farm buildings. Highmoor Colliery and Newland Colliery were both present in 1882, including a at least four shafts, coal pits and a brick yard. They are located approximately 400m west of W3. There are also two wells marked in fields adjacent to the W3, south of High Moor. Other significant land uses within the surrounding area of W3 include Harthill Reservoir, adjacent to the east of the Site, Killamarsh Pond, adjacent to the northwest, north of Killamarsh Lane, and Woodall Pond, 200m north of W3 and west of Woodall.

9.9.65 Historic land use surrounding the Cable Corridor Options is dominated by agriculture, the most significant other features are quarries, limekilns and plantations focused around Kiveton Park Station, located between CR 3a and CR3B. Industrial activities are present in this area from 1854 and become more significant by the early 1900s. By 1892, approximately 500m west of CR 3a is the Kiveton Park Colliery including several associated buildings and infrastructure.

9.9.66 Towards the end of the 1800s, the surrounding land use largely remained agricultural. The most significant change came in the form of the Killamarsh Branch and Extension to the Midlands Railway. Constructed at some point before 1894 and located approximately 200m north of W3 and running along an east-west direction, the railway connected the West Kiveton Colliery and the Norwood Colliery to the rest of the Midlands Railway network. The railway passes through a tunnel, 100m north of W3. The West Kiveton Colliery itself is located approximately 500m northwest of the norther section of W3. The Norwood Tunnel runs parallel to the Killamarsh Railway Branch and is a canal tunnel for the Chesterfield Canal. Research indicates that the tunnel was constructed in the 1700s however it was not shown on the earlier historical maps. By 1894, a quarry is located approximately 100m east of the northern section of W3.

9.9.67 Few changes are observed in the early 1900s, with agriculture remaining the predominant land use. By 1924, High Moor had seen some expansion with the addition of Chesterfield Council Water Works, and a sewage works, bot adjacent to the west of W3. A further sewage works is also located adjacent to the northwest of the northern section of W3. High Moor Colliery is now marked as disused.

9.9.68 Through the early 1900s, there were further expansions to the works around Kiveton Park and Kiveton Park Station. The Kiveton Park Colliery had seen more established infrastructure and construction of cooling ponds, a reservoir and sewage works. Kiveton Park Station had seen further additions including a malthouse, miner's welfare and other lodgings.

9.9.69 The area surrounding W3 remains consistent up to 1967. By this date the West Kiverton Colliery is marked as disused. Between the western and eastern sections, there is an area marked as 'Active Workings'. The M1 has been constructed in the mid-1960s and the section around W3 opened in December 1967, with the Woodall Services opening in 1968. Other significant changes include a new sewage works, south of Killamarsh Lane and adjacent to the western section of W3. The previous Killamarsh Railway Branch had been dismantled, and further residential buildings had been constructed in the north of Harthill, adjacent to the northeast of W3.

9.9.70 The area surrounding the Cable Corridor Options saw more significant change from the mid 1900s up to the present day. Kiveton Park and Colliery (~500m west of CR 3a) saw expansion of the industrial works as well as residential buildings in the second half of the 20th century. By 2000, the colliery was no longer active, although some of the historic infrastructure remains. Kiveton Park Station also saw developments during this time period. By 1967, there were several industrial works buildings present approximately 400m east of CR 3a, including a wireworks. By 1982, these works had expanded both north and south of the railway line. By this date, all of the surrounding quarries and limekilns had become disused. The works buildings underwent further expansions in the late 1900s and early 2000s. At present, Kiveton Park Industrial Estate is located 250m east of CR 3a and further factories are located approximately 500m east of CR 3a. North of the northern section of W3 and west of CR 3a and CR 3b, where Kiveton Park Colliery was located is now parkland and lakes. This land was previously a colliery tip which was subsequently remediated.

Soil and Groundwater Conditions

Potential Baseline Contamination Sources

9.9.71 The land use history and baseline knowledge described above has identified potential sources of soils at W3 as follows. **ES Volume 3, Figure 9.7.1: Map of Potentially Contaminated Sites [EN010020/APP/6.19]** shows all identified Potential Sources of Contamination within the W3 and 250m buffer.

On Site

- Infilled historic surface coal mine workings. Around 17ha of W3, in one borehole the made ground is composed of grey silty clay with gravel of sandstone, coal and mudstone. Without further ground investigation, the make-up of this material with regard to other wastes and potential for contamination and adverse ground conditions is unknown;
- Potentially infilled land attributed to eight historic coal mining shafts in the north of W3;
- Baugy Hill Quarry (potentially infilled land) north of Woodall;
- Historic unnamed clay pit (1854 – 1898) potentially infilled land east of Woodall;
- Potentially infilled historic land drain (southern W3);
- Potentially infilled land (water e.g. marsh, pond etc.) southwest W3;
- Plantation Hill/Red Hill historic landfill and quarry, CR 3a. The Site is located south of the B6059. Red Hill Quarry is a BGS recorded mineral site at the same location, which is described as an opencast dolomite mine. The Site operated under the license of Alan S Denriff Limited. Waste deposited at the Site included industrial waste;
- Steetley Quarry Historic, Registered, and Local Authority Recorded Landfill, CR 3a. The Site is located north of the B6059. Operated by the Rotherham Metropolitan Borough Council, deposited waste included industrial, commercial and household Waste;
- Potentially Infilled Land at Stonehill Farm CR 3b;
- Recorded Mineral Site Lady Field CR 3b;
- Recorded Mineral Site Thorpe Bridge Quarry CR 3b; and
- Recorded Mineral Site Peck Mill Bottoms Quarry CR 3b.

Off Site

- Woodall Road (High Moor) Historic and registered Landfill, 27m southwest. The Site is located at High Moor, Killamarsh. The Site operated under Parsons Group (High Moor) Limited. Waste deposited at this site include inert waste and industrial waste;
- Railway Cutting Historic and Recorded Landfill, 196m north. The Site is located off Mansfield Road, Norwood. Site operated under Mr W Richardson. Waste deposited at this site include inert waste and industrial waste;

- BGS Recorded mineral sites attributed to coal shafts, potentially infilled with unknown material, up to 200m north;
- Shell Petrol Stations at Woodall Services adjacent east and west;
- Low Plantation Sewage works and sludge beds, adjacent east;
- Kiveton Park Steel & Wire on Dog Kennel Lane Registered Landfill. The Site is located north of the B6059 and is approximately 100m east of CR 3a. License holder listed as Kiveton Park Steel & Wire Ltd. and authorised waste includes household and commercial waste, industrial non-hazardous and inert waste; and
- Dog Kennel Quarry BGS Recorded and Historic Landfill, approx. 250m west of CR 3b. The Site is east of the B6059. Authorised waste included inert, commercial and household waste.

Potential Baseline Pollutant Linkages and Receptors

9.9.72 The potential pathways and sensitive receptors associated with the baseline conditions (i.e. before the effects of the Proposed Development are taken into account) are described below.

Pathways

Human Health

- Inhalation of airborne dust and volatile vapours, ingestion of soil through handling and / or dermal absorption through skin from handling or working any contaminated soils present during construction works or farming activities (e.g. ploughing);
- Ground gases, such as methane and carbon dioxide, that could form from natural deposits (e.g. peat), organic matter in landfills and infilled land, or from underground coal mine workings (mine gas), accumulation of which could lead to a risk of explosion or asphyxiation to construction workers and nearby residents; and
- Inhalation of airborne dust by nearby residents.

Environmental

- Lateral migration of contaminants within perched waters to potentially affect surface water features present directly within W3 and the Cable Corridor Options including Broad Bridge Dike and on to Chesterfield Canal. Other potentially affected surface water features include multiple unnamed drains and streams bordering W3 and the Cable Corridor Options, several ponds, lakes and reservoirs within the Study Area, such as Harthill Reservoir and Killamarsh Pond, and regional water bodies such as the River Rother (west) and River Ryton (east);
- Vertical percolation of contaminants to affect the underlying aquifers including the predominant bedrock Secondary A Aquifer (Middle Coal Measures), the section of Principal Aquifer (Cadeby Formation dolostone) underlying buffer extents of CR 3a and CR 3b, and Secondary Undifferentiated Aquifers (shallow superficial deposits) potentially via pathways created by historical

foundation / piling works during construction, at pylons and wind turbines, or along boreholes and water wells;

- Lateral migration of contaminants within perched waters or from surface water runoff to potentially affect water-dependent habitat and ecology associated with surface water features adjacent to and within W3;
- Lateral migration of ground gasses along natural pathways and along man-made features such as utilities trenches, under foundations and along pilings, as well as former coal mining structures;
- Airborne migration of potentially contaminated soils by dusts generated by during construction works or farming activities (e.g. ploughing) to surface waters, designated habitats and adjacent agricultural land / soil resource and
- Lateral migration of contaminants to potentially affect quality of adjacent agricultural land / soil resource.

Receptors

Human Health

- Future Site users;
- Future construction and maintenance workers; and
- Local residents via potential migration of contamination and gasses offsite in the zone of influence.

Environmental

- Underlying bedrock aquifers of Secondary A (Middle Coal Measures) and the small area of Principal Aquifer (Cadeby Formation dolostone) within the buffer zone of a Cable Corridor Option; and
- Surface water bodies including streams and lakes/ponds located on and near the Site and the aquatic habitats they support.

Preliminary Conceptual Site Model

9.9.73 The main potential sources of pollutants are likely to arise from the presence of historic mineral sites, landfills and quarries which have subsequently been infilled with material of unknown composition. This is particularly prevalent in the area where CR 3a and CR 3b transect either side of Kiveton Park Station, where there has been significant historical industrial activity. The remaining landfills, which some of which are directly located within the Cable Corridor Options, have the potential to contain contaminated materials, which could be encountered by groundworkers, or mobilised into shallow groundwaters or surface waters during the construction activities of the Proposed Development. Another significant potential source of pollutants is the historic use of small parts of W3 for coal mining activities, with approximately 17ha of land mapped in W3 as surface mine workings that have been backfilled with unknown material. Although the vast majority of mining activities took place well beneath the surface within the Study Area, some historic surface infrastructure remains. This includes the eight recorded mine entries clustered in the northern section of W3, and further three in the western section of W3. According to the Coal Authority Consultants Coal Mining Report some of these have been recorded as filled and capped with

concrete, although several have no recorded treatment details, and whilst these are not associated with records of coal gas risk, an entry 400m to the north has a mine gas incident recorded. As such, it cannot be ruled out that these mine entries were infilled with potentially contaminated material and could also present a ground gas risk, which could be re-mobilised if disturbed during the construction phase.

9.9.74 Another potential source of pollutants arises from the current and historic agricultural land uses, including the use of pesticides, herbicides and storage of wastes and chemicals in and around farm buildings adjacent to W3. If elevated concentrations of polluting chemicals were present in the ground then they could pose a threat to the waters of Broad Bridge Dike and the Chesterfield Canal, as well as regional water bodies if disturbed during the construction phase. It is notable that the Broad Bridge Dyke Surface Water Catchment in W3 has poor ecological status due to recorded measurements of PBDE (polybrominated diphenyl ether) and mercury compounds – the latter could be due to historical agricultural usage as pesticide. The origin of PBDE (a flame retardant) is less clear, although due to its propensity to bioaccumulate, sewage may contain traces of PBDE and runoff from soils on farmland that have been fertilised with sewage may enter watercourses in this way. It is possible this is the origin of mercury occurrences as well.

9.9.75 Polluting chemicals could also potentially pose a threat to the underlying aquifers under current, undisturbed conditions, as well as in the event of disturbance caused by encountering contaminated soils during the construction phase. A potential pathway may be created between perched shallow groundwater and aquifers from associated foundation / piling works during construction, for each of the solar panels and for other foundations, up to 4m depth. The remaining bedrock Secondary A aquifers underlying the majority of W3 also could be impacted by vertically migrating pollutants as the bedrock is also encountered at shallow depths.

9.9.76 Adjacent land uses may already affect land quality within W3, in terms of current ground quality and potential additive or cumulative effects via groundwater migration or soil-dust generation. Adjacent land uses with migration potential include agricultural activities, railway land, storage of agricultural chemicals, historic industrial and coal mining activities and infilled land with unknown material from off-site sources.

9.9.77 Finally, recent changes in legislation identify heat as a pollutant in groundwater, and there is potential for heat generated along powered high voltage cables to heat groundwater where the groundwater is very shallow (<1.2m BGL), possible in topographic lows (e.g. valleys) close to surface water bodies. Heated groundwater could migrate laterally or vertically to aquifers or surface water bodies.

Assessment of Potential Effects

Introduction

9.9.78 Screening of potential effects has been informed by currently available baseline data for W3. Qualitative assessment of risk from potentially contaminated land is covered under guidance documents, the approach of which has been combined with impact assessment methodologies in the following sub-sections with a view

to identify mitigation that may be required during construction, operation or decommissioning.

9.9.79 The purposes of the following sections are to assess possible and probable effects and mitigation for the three phases of the Proposed Development.

9.9.80 Overall, it is not anticipated that contaminated land is likely to present a significant source of potential effects, particularly as the majority of the Site has historically been used as agricultural land. The only likely sources of pollution at W3 are the landfills that are intersected by Cable Corridor Options, although it is not the intention that the final route choice would be such that a trench would actually excavate through known licenced waste landfill material.

9.9.81 As described above we consider the following potential sources may be present within W3:

- Potentially infilled land from historic coal mining activities, with approximately 17ha of land mapped in W3 as surface mine workings backfilled with unknown material (although one record showed mine waste backfill without other waste material), at the infilled mine entries, as well as at the much smaller areas of historic quarrying (Baugy Hill Quarry) and other records of infilled land drains;
- Current and historic agricultural use of land with potential for diffuse pollutants across fields at lower concentrations (e.g. herbicides and pesticides, reduced nitrogen compounds); and
- Current and historic landfills located on or within 250m of W3.

Assessment of Potential Effects During Construction

9.9.82 Effects during construction have the potential to result from changes in contamination sources, pathways and receptors (construction workers and visitors) compared to baseline conditions. Construction of the Proposed Development may be expected to include potential activities which could, in the absence of mitigation, influence contamination sources and pathways.

9.9.83 It should be noted that ‘an effect’ would only be expected where a pollutant linkage exists (i.e. a defined source was connected via a defined pathway to a defined receptor). In the majority of cases, potential effects during construction can be avoided and minimised through standard construction management practices (e.g. those in the **Outline Construction Environmental Management Plan (oCEMP) [EN0110020/APP/5.9]**). In addition, other specific additional mitigation, such as method statements and pollution prevention measures, are identified where required.

9.9.84 Potential effects of the Proposed Development in the construction phase are:

- Disturbance and / or removal of polluted ground and potentially groundwater which could potentially remove, relocate or mobilise pollutants, including ground gasses;
- Use of plant and equipment which could accidentally leak fuels and oils, introducing contaminants to the ground;
- Use of horizontal drilling techniques to install cables which could accidentally leak drilling fluids, introducing pollutants to the ground and potentially into surface water;

- Installation of sub-surface structures, such as cables, piles and foundations, which could act as new pathways for mobilised pollutants (including heat in groundwater and ground gasses);
- Storage and use of hazardous materials and substances (e.g. concretes, fuel, oils and drilling fluids) which could accidentally escape to ground or controlled waters; and
- Exposure of construction workers to soil excavation activities via dust inhalation, ingestion and dermal contact.

9.9.85 A schematic cross-section of the Conceptual Site Model (**Plate 1**) has been developed to visualise the potential contaminant pathways and receptors described in the following tabulations.

Plate 1 Cross Section Of Conceptual Site Model

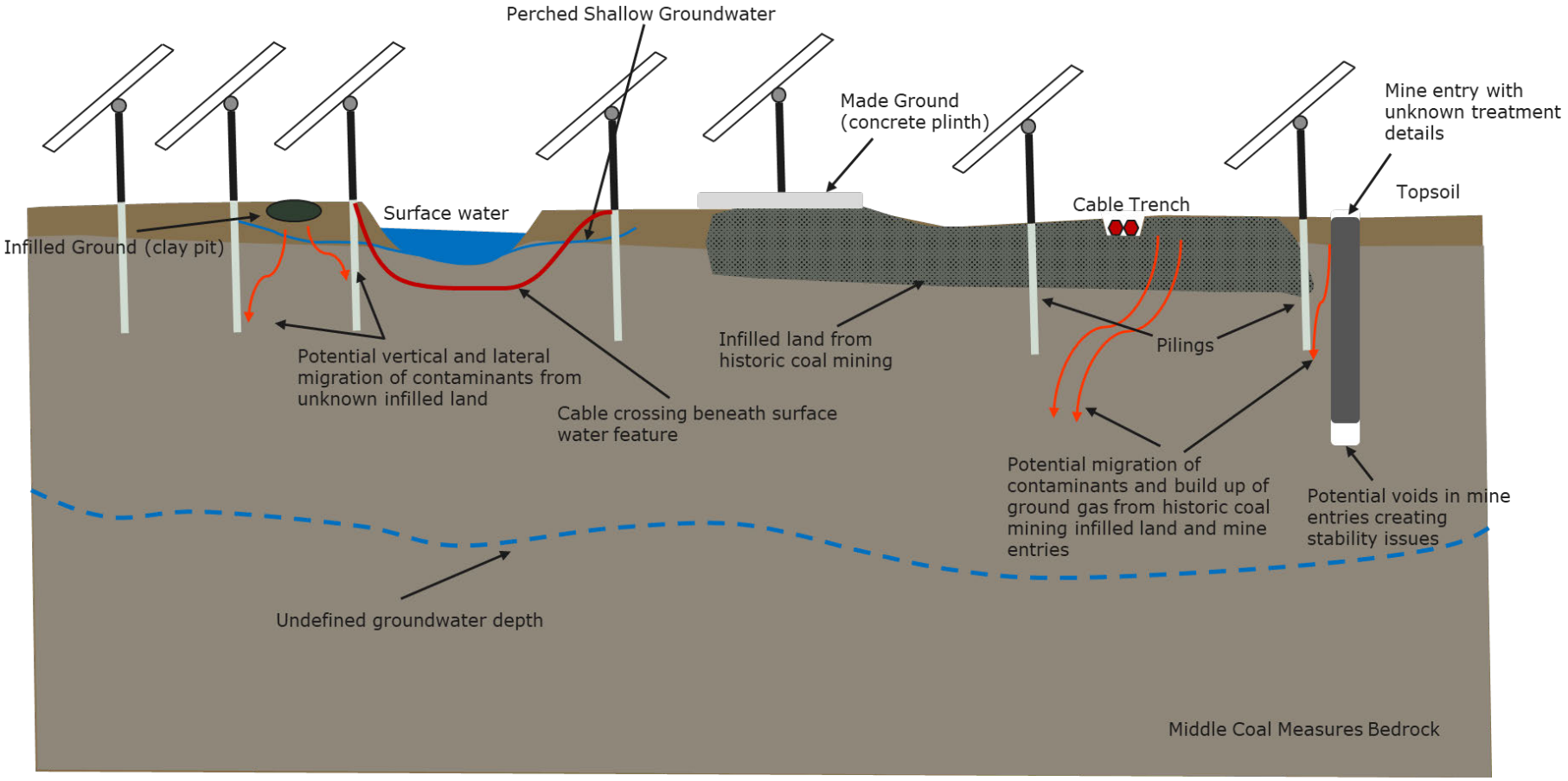

Table 9.9.4 Assessment of Potential Effects During Construction

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
Human Health							
Excavation of soils for cable laying in areas of surface mine workings backfilled with unknown material or other infilled land	Construction workers exposed to historic contaminated soil	Inhalation, ingestion and dermal contact	High	Small	Very Low	Low	No – mitigation from Construction Environmental Management Plan (CEMP) (e.g. Personal Protective Equipment (PPE)) (outline version provided in **oCEMP [EN0110020/APP/5.9]**)
Trenching and piling for the installation of cables, solar panels and foundations producing new pathways for ground gas migration	Construction workers and nearby residents / workers exposed to ground gas accumulation with risk of explosion or asphyxiation	Introducing new pathways between ground gas sources / accumulations (mine entries) and receptors	High	Moderate	Very Low	Moderate-Low	Yes – avoid subsurface installations in or adjacent to mine ZoIs, or else Phase 2 Site Investigation (SI) to assess conditions
Excavation of soils for cable laying in areas affected by accidental spillages	Construction workers exposed to accidentally contaminated soil	Inhalation, ingestion and dermal contact	High	Small	Very Low	Low	No – mitigation from CEMP (outline version provided in **oCEMP [EN0110020/APP/5.9]**)

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
during construction (e.g. fuels)							
Traffic movement, creation of contaminative dust from historical, agricultural or accidental sources	Construction workers and nearby residents / workers exposed to potentially contaminated dust	Inhalation of airborne dust	High	Small	Low	Moderate-Low	No – mitigation of dust management within CEMP (outline version provided in **oCEMP [EN0110020/APP/5.9]**)
Environment							
Earthworks and piling activities, the excavation of cable trenches and / or removal of the made ground / topsoil, in areas where there was historical landfilling (mainly former surface coal mined areas)	Potential to remove, relocate or mobilise contaminants (if present) to adjacent agricultural land, underlying Secondary A aquifer and nearby surface waters.	Migration of leaching contaminants to the underlying aquifer.	High	Medium in in areas with worked ground, Low elsewhere	Very Low	Low in areas with worked ground, Very Low elsewhere	No – low to very low risk overall. Include encountering potential contaminated soils procedure in CEMP (outline version provided in **oCEMP [EN0110020/APP/5.9]**)
		Migration of contaminants from surface run-off to surface water features, field drains and adjacent land					No – mitigation from CEMP (outline version provided in **oCEMP [EN0110020/APP/5.9]**)

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
Use of plant and equipment during construction	Potential of accidental leakage of fuels and oils, introducing contaminants to the ground	Migration of leaching contaminants from spills to soils and groundwater, with potential run-off to surface water features	High	Small	Low	Low	No – mitigation from CEMP (outline version provided in **oCEMP [EN0110020/APP/5.9]**)
Storage and use of materials and substances with polluting potential (e.g. concrete, fuel, oils and soils)	Potential for mobilisation to ground and surface waters or Secondary A aquifer if leak occurs.	Migration of leaching contaminants from spills, with potential for run-off to surface waters or infiltration into Secondary A aquifer.	High	Small	Low	Low	No – mitigation from CEMP (outline version provided in **oCEMP [EN0110020/APP/5.9]**)
Cable installation under surface waters and roads using horizontal directional drilling (HDD)	Accidental break-out of HDD fluids into surrounding ground, which may include Secondary A Aquifer, or to	Direct release into Secondary A Aquifer, or to surface waters, or migration via baseflow to them.	High	Small	Low	Low	No – mitigation from CEMP (outline version provided in **oCEMP [EN0110020/APP/5.9]**)

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
	surface waters.						
Ground Conditions							
Installation of solar array piles or cable trenching over mine entries (capped or uncapped)	Excavation instability, leading to potential for death or injury to construction workers and/or damage to equipment	Geotechnical failure of cap or in the case uncapped mine entries	High	Medium	Low	Moderate	Yes – avoid cable laying, piling & foundations across areas over mine entries, or else Phase 2 SI to assess conditions

Assessment of Potential Effects During Operation

9.9.86 Potential effects during the operational phase of the Proposed Development may result from:

- Changes to receptors which will now compromise any site maintenance workers, potential new nearby residents and visitors;
- Changes to the amount and nature of wastes produced;
- Storage and handling of site maintenance materials such as fuels and other chemicals, which could leak and/or spill, introducing contaminants to the ground and/or groundwater;
- Ground stability on infilled land; and
- Heat generated by the buried high voltage cables through the Cable Corridors.

9.9.87 As with the construction-related effects identified in **Table 9.9.4**, it is envisaged that the majority of potential effects can be avoided and /or minimised through good operational management practice. The potential effects during operation are summarised in **Table 9.9.5**.

Table 9.9.5 Assessment of Potential Effects During Operation

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
Human Health							
Site activities and facilities including handling and containment of any generated waste and potential chemical and oil storage areas	Handling of wastes, any accidental spills or soils impacted by them by site workers	Inhalation, ingestion and dermal contact of wastes or accidentally introduced contaminated soils	High	Small	Low	Low	No – will be covered in operational environmental management plans (outline version provided in **outline Operational Environmental Management Plan (oOEMP) [EN0110020/APP/5.10]**)
Environment							
High voltage buried Cable Corridor (note low voltage routes have negligible effect)	Heating of surrounding soils that may include underlying Secondary A aquifer.	Heat transfer and groundwater migration	High	Small – cable trench likely to be above Secondary A Aquifer in most places	Moderate	Moderate-Low	Yes – consider thermally insulated cables and, measures to minimize lateral groundwater flow in areas it is present
Site activities and facilities including handling and containment of any generated	Spills and leaks of oil, fuel and other polluting substances entering surface	Spill of materials followed by leaching or lateral migration from	High	Small	Low	Low	No – will be covered in operational environmental management plans (outline version provided in **oOEMP [EN0110020/APP/5.10]**)

waste and potential chemical and oil storage areas.	watercourses, or infiltrating soils into shallow groundwater.	surface run-off					
Ground Conditions							
Installation of solar array piles over ground with moderate risk of compressible soils (e.g. in the areas of backfilled surface mining)	Excessive and differential settlement causing damage to pile structures and cables. Increased costs for maintenance / remedial works.	Settlement and subsidence	Low	Moderate	Low	Low	No – will be covered in operational environmental management plans (outline version provided in **oOEMP [EN0110020/APP/5.10]**)

Assessment of Potential Effects During Decommissioning

9.9.88 Decommissioning is anticipated to involve the removal of all above surface structures and possibly some of the buried cables, followed by reinstatement of ground to a condition suitable for whatever after use is proposed, most likely agriculture. A laydown area will also be involved.

9.9.89 Potential effects during the decommissioning phase will be broadly similar to those during the construction phase in that there will be an influx of new contractors to deconstruct the plant and equipment.

9.9.90 Potential effects during the decommissioning phase of the Proposed Development may result from:

- Changes to receptors, which comprise decommissioning contractors, nearby residents and visitors;
- Storage and handling of materials (oil, fuel and others) which could leak and/or spill, introducing contaminants to the ground and/or groundwater; and
- Possible disturbance of contamination sources through ground disturbance.

9.9.91 As with the earlier phase effects identified, it is envisaged that the majority of potential effects can be avoided and /or minimised through good operational management practice, including those to be developed in the future (e.g. Decommissioning Environmental Management Plan (DEMP)). The potential effects during decommissioning are summarised in **Table 9.9.6**.

Table 9.9.6 Assessment of Potential Effects During Decommissioning

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
Human Health							
Excavation of soils for the removal of cables in areas affected by accidental spillages or historical contamination	Construction workers exposed to accidentally contaminated soil	Inhalation, ingestion and dermal contact	High	Small	Very Low	Low	No – mitigation from DEMP (outline version provided in **outline Decommissioning Environmental Management Plan (oDEMP) [EN0110020/APP/5.11]**)
Traffic movement, creation of contaminative dust from historical, agricultural or accidental sources	Construction workers and nearby residents / workers exposed to potentially contaminated dust	Inhalation of airborne dust	High	Small	Very Low	Low	No – mitigation of dust management within DEMP (outline version provided in **oDEMP [EN0110020/APP/5.11]**)
Environment							
Excavation of soils for the removal of cables in areas affected by accidental spillages or	Potential to remove, relocate or mobilise contaminants (if present) to adjacent agricultural	Migration of leaching contaminants vertically and laterally from contaminants in soils and underlying	High	Low	Very Low	Low	No – mitigation from DEMP (outline version provided in **oDEMP [EN0110020/APP/5.11]**)

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
historical contamination	land, underlying Secondary A aquifer, and nearby surface waters	aquifers with potential run-off to surface water features					
Use of plant and equipment during decommissioning	Potential of accidentally leakage of fuels and oils, introducing contaminants to the ground	Migration of leaching contaminants from spills in soils and underlying aquifers with potential run-off to surface water features	High	Small	Very Low	Low	No – mitigation from DEMP (outline version provided in **oDEMP [EN0110020/APP/5.11]**)
Storage and use of materials and substances with polluting potential (e.g. concretes, fuel, oils and soils)	Potential for mobilisation to ground and controlled waters or Secondary A aquifer if leak occurs.	Migration of leaching contaminants from spills, with potential for run-off to surface water features or infiltration to Secondary A aquifer.	High	Small	Low	Low	No – mitigation from DEMP (outline version provided in **oDEMP [EN0110020/APP/5.11]**)

Activity	Potential Effect / Receptor	Pathway	Sensitivity / Vulnerability of Receptor	Magnitude of impact	Likelihood of PPL / effect	Potential Risk Rating	Mitigation Required?
Removal of shallow to moderate depth foundations at buildings, cables (1.2m) and panel frame posts (up to 4m), in areas where there was historical landfilling (mainly former surface coal mined areas)	Potential to remove, relocate or mobilise contaminants (if present) to adjacent agricultural land, underlying Secondary A aquifer and nearby surface waters.	Migration of leaching contaminants to the underlying aquifer.	High	Medium in in areas with worked ground, Low elsewhere	Very Low	Low in areas with worked ground, Very Low elsewhere	Yes – was avoided or assessed by Phase 2 SI in the construction phase.

Summary and Conclusions

9.9.92 This Report presents a preliminary qualitative risk assessment of land quality and ground conditions in relation to the Whitestone Solar Farm, located in South Yorkshire, approximately 14km east of Sheffield and Rotherham. The assessment covers the 200ha W3 site and associated Cable Corridor Options, forming the southernmost section of the wider Whitestone Solar Farm. This Phase 1 desktop study focuses on all areas where ground disturbance is anticipated, with particular attention to potentially contaminated land and ground conditions that may influence the Proposed Development. The assessment is undertaken in accordance with relevant regulatory requirements and guidance.

9.9.93 The W3 site comprises predominantly agricultural land, with boundaries defined by field edges and major roads, including the M1 and A618. The area is characterised by variable topography (95–145m AOD), intersected by streams and drains, and is adjacent to several residential areas, woodlands, and water bodies such as Harthill Reservoir. The underlying geology is dominated by Upper Carboniferous Pennine Middle Coal Measures (mudstone, siltstone, sandstone), with localised superficial deposits of Head and Alluvium. The underlying aquifer is the Pennine Middle Coal Measures (Secondary A) considered to have high groundwater vulnerability. The outer buffers of the Cable Corridor Options extend over small areas of dolostone (Cadeby Formation), although the actual Cable Corridor Option selected will avoid this, and, glacial till.

9.9.94 The Site and its surroundings have a long history of agricultural use, with small areas of historic coal mining, quarries, and landfilling activities. There are multiple records of infilled land, including 11 recorded former mine entries, quarries, and land drains, as well as around 17ha, mapped as artificial ground associated with historic surface coal mining. Several historic and registered landfills are located within 250m of W3 and within the Cable Corridor Options, with waste types including inert, industrial, and household materials. Adjacent land uses include sewage works, petrol stations, and industrial estates.

9.9.95 Potential sources of contamination include infilled land from historic mining and quarrying, diffuse agricultural pollutants (e.g., pesticides, herbicides), and nearby landfills. High voltage cables can produce heat that is regarded as a pollutant in groundwater. Pathways for potential pollutant migration include direct contact, inhalation of dust, ground gas migration, leaching to groundwater, and migration of groundwater (lateral and vertical) to aquifers and surface waters. Sensitive receptors identified are future site users and visitors, construction and maintenance workers, local residents, underlying aquifers, and adjacent surface water bodies.

9.9.96 The Proposed Development will involve ground disturbance through pile driving (up to 4m depth), trenching for cable installation (typically 1.2m depth), and construction of foundations for substations and supporting infrastructure (up to 4m depth). The risk assessment considers potential pollutant linkages (PPLs) for construction, operation, and decommissioning phases, evaluating the sensitivity of receptors, magnitude and likelihood of effects, and the need for mitigation.

9.9.97 In most cases, potential effects can be avoided or minimised through standard construction and operational management practices (e.g., CEMP, Operational Environmental Management Plan (OEMP), DEMP). Moderate and some low risk PPLs during construction include:

- Excavation in areas of mine entries, with potential exposure of workers to unstable ground, contaminated soils and ground gasses;
- Mobilisation of contaminants through soil handling, potentially affecting adjacent land, aquifers, and surface waters;
- Creation of preferential pathways for contaminant migration, including ground gasses, via foundations and cable trenches, in areas of mine entries; and
- Accidental release of drilling fluids during HDD for cable installation.

9.9.98 During operation, the primary PPL requiring further mitigation is the potential heating of groundwater by high-voltage buried cables, particularly where these intersect shallow aquifers. Mitigation may include the use of thermally insulated cables and measures to minimise lateral groundwater flow. There is a low risk of ground stability issues due to differential settlement causing damage to pile structures and cables that may lead to increased costs for maintenance / remedial works.

9.9.99 Decommissioning effects are expected to be similar to those during construction, with risks managed through appropriate environmental management plans and by avoiding disturbance of historically infilled land where possible.

9.9.100 In conclusion, while the W3 site includes areas of potential contamination where there is historic infilled land, surface coal workings and other infilled features, coal mining with mine entries, the majority of the land is agricultural with no proven significant sources of pollution. Ground stability and mine gas are rated as moderate risks in the areas of the mine entries. Adherence to standard management plans and targeted mitigation, such as further Phase 2 intrusive investigation ahead of ground disturbance during construction in mine entry zones of influence, and providing thermal shielding for high-voltage cables, will reduce overall risks to low. No further Phase 2 intrusive investigation, remediation, or special measures are considered necessary for land quality and ground conditions at this stage.

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