

8.5 Ground Conditions and Contamination

Introduction

8.5.1 This section has been prepared by A-Squared Studio Engineers Ltd (A-Squared) on behalf of Expedition Engineering (Expedition) and presents an assessment of the baseline conditions and likely significant effects that should be scoped into the EIA. Based on the baseline conditions and likely significant effects, further assessment methodology to assess these likely effects have been included within this section.

Background Information

8.5.2 Previous correspondence and reports were provided by Expedition to inform this section, and these are summarised below.

8.5.3 The EA were contacted for pre-application advice in September 2014 (**Appendix 8.5.1**) in which environmental concerns were identified. These concerns were due to the explosion and fire at the Buncefield Oil Depot adjacent to the Site's western boundary in December 2005 that resulted in contamination of the surrounding area from Perfluorooctanoic sulphonate (PFOS) and hydrocarbons such as benzene and xylene. The EA response concluded that any development should avoid interfering with groundwater flow across the Site and that any soakaways as part of proposed developments are highly unlikely to be acceptable due to the potential to move plumes of contamination into areas of aquifers that are currently unaffected.

8.5.4 Geo-environmental based reporting which has been undertaken on Site which has been used to establish a baseline assessment include the following:

- Preliminary Opinion: residential, commercial and industrial development east of Hemel Hempstead (ref NE/2014/121110/01-L01) prepared by the Environment Agency (EA), dated 10th September 2014 (**Appendix 8.5.1**);
- Preliminary Groundwater Assessment (Job number: ST15083, Report Number GWA001) prepared by Wardell Armstrong LLP (Wardell Armstrong), dated November 2017;
- Ground Stability Desk Study (Job number: ST13903, Report Number 001) prepared by Wardell Armstrong, dated November 2017;
- Preliminary Ground Conditions Assessment (Job number: ST13903, Report Number 002A) prepared by Wardell Armstrong, dated December 2017;
- Factual Report, Land East of Hemel Hempstead Ground Investigation (C6515) prepared by CC Ground Investigation Ltd (CC), dated January 2020; and
- East Hemel: Land Quality Desk Study (P23552_R1) prepared by Yellow Sub Geo Ltd, dated March 2023.

8.5.5 The Wardell Armstrong Preliminary Ground Conditions Assessment includes a Phase I Preliminary Geo-environmental Qualitative Risk Assessment based on publicly available information and a Phase 2

Geo-Environmental Quantitative Risk Assessment based on information collected during a previous ground investigation. This investigation was undertaken between the 3rd November 2014 and the 2nd of December 2014 with a supplementary phase conducted on the 5th September 2017.

- 8.5.6 The Wardell Armstrong Preliminary Groundwater Assessment consists of a Phase 2 Geo-Environmental Quantitative Risk Assessment based on groundwater data collected as part of a ground investigation undertaken between the 9th January 2017 and the 27th February 2017.
- 8.5.7 The Wardell Armstrong Ground Stability Desk Study provided a desk-based appraisal of mining and ground risks stability risks associated with the Sites prevailing ground conditions.
- 8.5.8 The CC Factual Report presents the findings of a ground investigation undertaken on behalf of The Crown Estate under the technical direction of Wardell Armstrong. This investigation was undertaken between the 16th September 2019 and the 29th October 2019 and included 404 no. exploratory hole locations. No geo-environmental sampling or monitoring was included as part of these works.
- 8.5.9 The Yellow Sub Geo Land Quality Desk Study includes a Phase I Preliminary Geo-environmental Qualitative Risk Assessment based on publicly available information.

Summary Baseline Information and Key Issues

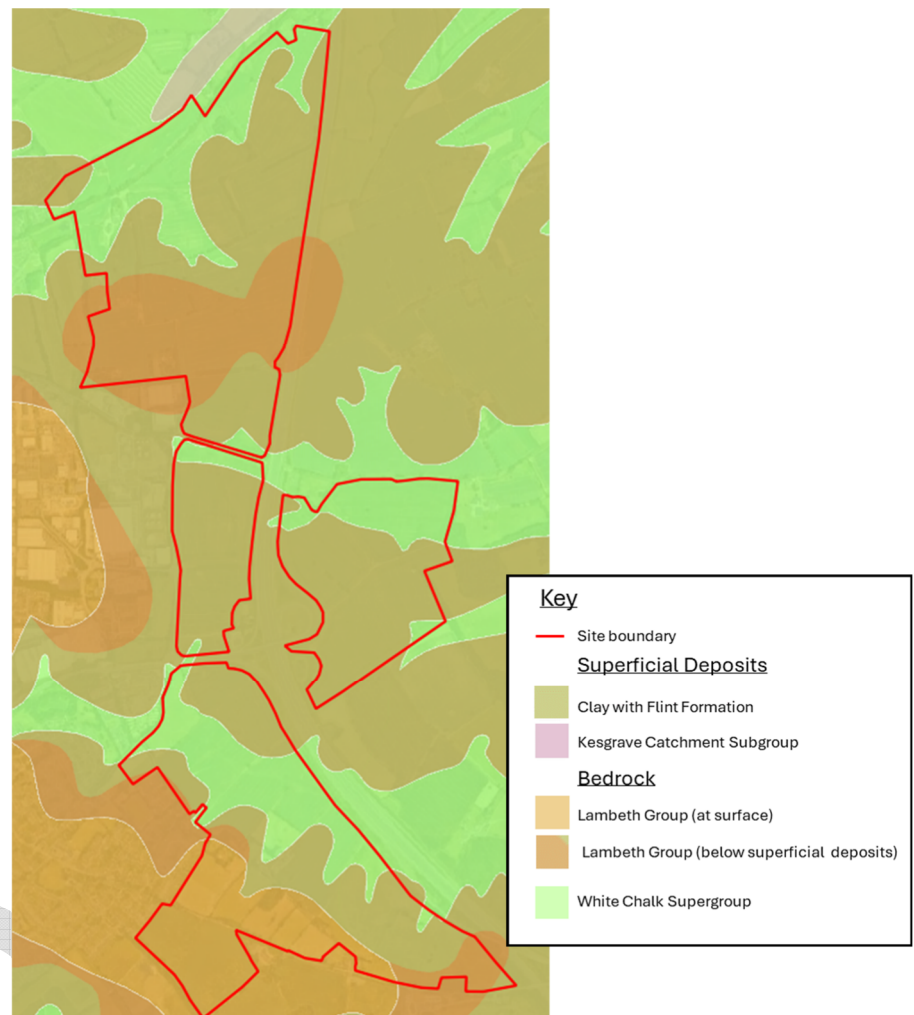
Baseline Conditions

- 8.5.10 The Site comprises agricultural land to the west of the M1 motorway, with the M1 and A414 junction crossing through the centre of the Site. The Site is bounded to the north by Hemel Hempstead Road, to the east by Brick Lane, to the south by the M1, agricultural fields, the A4147 and to the west by the residential area of Leverstock Green and Hemel Hempstead Industrial Estate.

Desk Based Risk Assessment

- 8.5.11 The anticipated ground conditions at the site comprise Topsoil overlying superficial deposits of the Clay-with-flints Formation. These superficial deposits are then expected to be underlain by the bedrock of the White Chalk Supergroup (Lewes Nodular Chalk Formation and Seaford Chalk Formation). The Lambeth Group has been geological mapped in the north and south regions of the Site above the Chalk bedrock. A geological map of the site with data supplied by the British Geological Society (BGS)¹ can be observed at **Figure 8.5.1**.

¹ British Geological Survey Geoindex Onshore (2024). Available at: https://mapapps2.bgs.ac.uk/geoindex/home.html?layer=BGSBoreholes&_ga=2.205161808.1585448766.1661440447-666512120.1661440447 (Accessed: 18th September 2024)

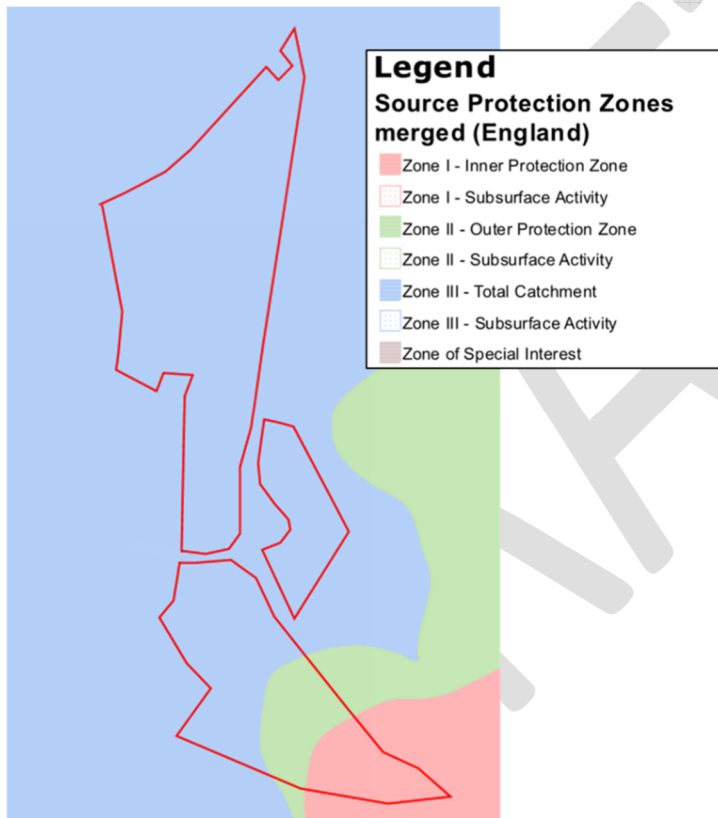
Figure 8.5.1: Geological Map of the Site and surrounding area

- 8.5.12 The Ground Stability Desk Study produced by Wardell Armstrong in 2017 concluded that it is unlikely for an underground mining setting to exist within the Study area. However, risk of unrecorded underground mining cannot be completely discounted. In addition, it is noted that the Site is at risk from ground dissolution stability particularly in areas in which the Lambeth Group overlies the Chalk. The predominant risk associated with ground stability hazards at the Site are solution pipes of which one has already been recorded at the location of E508640, N209550.
- 8.5.13 The Clay-with-flints Formation is designated as an Unproductive Aquifer and the Chalk bedrock is designated as a Principal Aquifer. A Principal Aquifer is defined by the Environment Agency as a layer of rock that have high intergranular and/or fracture permeability; meaning they usually provide a high level of water storage that may support water supply and/or river base flow on a strategic scale. The Lambeth Group is designated as a Secondary (A) Aquifer which is defined by the EA as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
- 8.5.14 No substantial surface water bodies are present on Site however, a few small ponds have been identified adjacent to the M1 and the A414 located in the central region of the Site, and adjacent to Redbourn Road and Three Cherry Tree Lane located in the northern portion of the Site. The nearest river is the River Ver, approximately 1.5km to the north-east of the Site.

8.5.15 Environment Agency mapping indicates the Site is located within Flood Zone 1, classed as having a low risk of flooding from fluvial (river) sources with small areas in the south and centre of the Site shown as having a high risk of surface water (pluvial) flooding. The BGS groundwater flooding susceptibility maps indicate that risk of groundwater flooding is either low or negligible across the Site.

8.5.16 The Development Site lies above the Mid-Chilterns Chalk groundwater body, within a Drinking Water Protected Area. The majority of the site is within a groundwater Source Protection Zone 3 (Total Catchment) with the southern portion of the site also being within a Source Protection Zone 2 (Outer Protection Zone) and Zone 1 (Inner Protection Zone). A Source Protection Zone map with data supplied by Defra's Multi-Agency Geographic Information for the Countryside (MAGIC) tool² can be observed as **Figure 8.5.2** below. The groundwater is currently classified as being of 'poor' chemical status under the Water Framework Directive.

Figure 8.5.2: Geological Map of the Site and surrounding area



8.5.17 There are various groundwater abstractions from the Chalk aquifer for public water supply in the area however, none of these are within a 1km radius of the Site. There are various licensed industrial groundwater abstractions into the west of the Site, although several of these relate to groundwater abstraction as part of remediation work after the Buncefield Incident. The closest groundwater abstraction point to Site not associated with the Buncefield Incident is located 327m north (according to Wardell Armstrong) and used for general farming purposes. As part

² Defra (2024) MAGIC Map. Available at: <https://magic.defra.gov.uk/MagicMap.aspx> (Accessed: 2nd October 2024)

of the Yellow Sub Geo Ltd Land Quality Desk Study, this abstraction point was listed as being 316m north of the Site.

8.5.18 The following potential sources of contamination have been identified in both the Land Quality Desk Study prepared by Yellow Sub Geo Ltd and the Preliminary Ground Conditions Assessment prepared by Wardell Armstrong:

- Historical railway sidings in the north;
- Made Ground;
- Adjacent M1 motorway and junction construction resulting in potential spills and leaks of chemical, fuel, lubricants etc;
- Depot and car park in the centre of the site adjacent to the M1 motorway resulting in potential spills and leaks of chemical, fuel, lubricants etc;
- On-Site buildings (including those previously demolished) and the potential for asbestos containing material;
- On-Site fly tipped material including potential Asbestos Containing Material (ACMs);
- Site's former use as agricultural land; and
- On-Site historical pollution incidents including biodegradable materials, inert materials, firefighting water/foam run-off and other pollutant.

8.5.19 The desk-based review identified the following as off-Site sources of contamination:

- Buncefield Fire Major Incident (2005) resulting in release of petroleum hydrocarbons and PFOS in firefighting foam run-off;
- Activities associated with off-Site industrial estate, potential for spills and leaks of chemicals, fuels and lubricants;
- Infilling of historical gravel pits and reservoirs with unknown materials; and
- Farms and the associated features (such as tanks) in the Site's vicinity.

8.5.20 The Yellow Sub Desk Land Quality Study and Wardell Armstrong Preliminary Ground Conditions Assessment indicated that the existing conditions at the Site represent a maximum 'moderate to high' risk from potential sources of contamination identified on Site and in the surrounding areas.

Quantitative Risk Assessment

8.5.21 During the previous Wardell Armstrong phases of intrusive investigation across the Site, ground conditions were noted to consist of Topsoil and Made Ground overlying superficial deposits of the Clay-with-flints Formation.

8.5.22 Topsoil was observed to have a maximum thickness of 1.2m (0.3m to 0.5m thick on average) and predominantly be comprised of soft, brown, slightly silty and gravelly clay with gravels of flint and rare man-made materials.

- 8.5.23 Made Ground was logged in only two locations (CPR05 and TP21) during the Wardell Armstrong 2014 investigation. The Made Ground encountered had recorded thickness ranging from 0.4m (TP21) to 0.9m (CPR05) and found to be composed of sandy clayey gravel fill with cobble sized fragments of bricks and rubble, and soft to firm, light brown, slightly gravelly clay with gravel of fine to coarse nodular flint and rare brick and charcoal.
- 8.5.24 During the CC 2019 investigation, Made Ground was logged (CPBH1024 to CPBH1029, CPBH038 to CPBH041, CPH1045, MP1001, MP1008 to MP1010, MP1022 and TP101 to TP1021) in the vicinity of the industrial estate located adjacent to the Site's western boundary and the road networks both on the Site and the M1 adjacent to the Site's eastern boundary. Made Ground encountered as part of the CC 2019 investigation was recorded as being from 0.15m to 0.6m thick and predominantly comprised of dark coloured (brown and black), slightly sandy, slightly silty and slightly gravelly clay. Gravel encountered was of sub-angular, fine to coarse brick and flint. This composition is similar to the Topsoil logged as part of the previous Wardell Armstrong investigations. Due to the current and historic uses of the Site, the Made Ground logged as part of the CC 2019 investigation and Topsoil logged as part of the Wardell Armstrong are likely to be the same material (i.e. Topsoil with inclusions of foreign objects).
- 8.5.25 The superficial geology of the Clay-with-flints Formation underlies the Topsoil and Made Ground and ranges in thickness between 0.5m and 12.8m across the Site. It generally comprised firm to stiff, mottled red, orange, grey or black, clay with gravel, cobbles and occasional small boulders of nodular flint. In some areas, the stratum is recorded as becoming a clayey gravel consisting of more rounded flints.
- 8.5.26 The Chalk of the White Chalk Super Group underlying the Clay-with-flints Formation generally comprised weathered chalk (CIRIA Grade Dm and Dc) overlying structured chalk bedrock. However, many of the borehole logs record 'putty chalk' i.e. comminuted chalk due to sample disturbance from the drilling methodology. This description is unlikely to reflect the actual grade of the chalk. Where sample and core recovery did allow logging of the chalk grade, the structured chalk bedrock comprised low to medium density, weak to extremely weak, white chalk with occasional orange staining and flint horizons. The base of the chalk bedrock was not encountered and was observed to extend down to depths of 68.0m bgl.
- 8.5.27 Ground conditions encountered during the 2014 and 2017 Wardell Armstrong investigations have been summarised as **Table 8.5.1**. The ground investigation report provided by CC was purely factual data and therefore a summary ground model was not produced. However, on review of the logs, ground conditions encountered were generally consistent with the ground model produced by the Wardell Armstrong.

Table 8.5.1: Ground conditions summarised from the 2014 and 2017 Wardell Armstrong investigations

Strata type	Depth from (m bgl)	Depth to (m bgl)	Thickness (m)
Topsoil	Ground level	0.10 to 1.20	0.10 to 1.20
Made Ground	Ground level	0.40 to 0.90	0.40 to 0.90
Superficial Deposits	0.10 to 1.20	0.80 to 13.00	0.50 to 12.80
Chalk	0.20 to 13.00	6.30 to 68.00*	1.80* to 50.90*

Strata type	Depth from (m bgl)	Depth to (m bgl)	Thickness (m)
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*Where base of superficial deposits encountered

- 8.5.28 As part of the Wardell Armstrong 2017 investigation, 27 no. groundwater monitoring standpipes were installed within the underlying Chalk aquifer. The topography of the Site varies from approximately 100m Above Ordnance Datum (AOD) at the northern most tip to 140m AOD at the south-western most area. Identified groundwater levels ranged from 84.56m AOD to 96.27m AOD (12.65m bgl to 53.77m bgl) with groundwater depth generally increasing to the south and east. Contouring of groundwater elevations identified an easterly groundwater flow in the north and centre of the Site and south-easterly flow in the southern portion of the Site.
- 8.5.29 As part of the Wardell Armstrong 2014 investigation, a geophysical trial survey was undertaken to test the efficacy of Ground Penetrating Radar (GPR) techniques in locating potential dissolution features. The trial survey was located to the north of the Site, near wood farm, in the vicinity of a possible historic dissolution pipe feature. The survey then covered approximately 1ha centred on this possible historic feature. The GPR survey did not locate any anomaly at the recorded position of the dissolution pipe however, a trial pitting exercise did identify 'pipe like' structures and dissolution features within the chalk which were filled with well consolidated clay. The trial pits in which these features were identified are recorded as TT2 and TT3.
- 8.5.30 Wardell Armstrong has concluded that the preliminary ground investigation carried out to date is limited given the size of the Site and therefore, in order to provide a thorough assessment and derive a foundation strategy, further intrusive investigation is required.
- 8.5.31 As part of the Wardell Armstrong 2014 investigation a total of 47 no. soil samples underwent laboratory testing for a range of contaminants which included asbestos, cyanide, petroleum hydrocarbons, metals, polycyclic aromatic hydrocarbons, pH, phenols, sulphate and sulphur along with common pesticides and herbicide. Samples were obtained from a range of depths (up to 2.5m) to allow for each material encountered to undergo analysis however the majority of them were taken from the top 1.0m.
- 8.5.32 Results were screened against the S4UL guidance values published by Land Quality Management currently in place at the time of assessment (2017) for a residential end use with plant uptake scenario. A soil organic matter content of 1% had been conservatively assumed for this assessment. Of the contaminates analysed, only nickel and asbestos were identified to have exceeded their respective criteria. In regard to nickel, just one sample taken from TP15 at a depth of 1.0m bgl exceeded the S4UL (180 mg/kg) with a concentration of 261mg/kg. This sample was retrieved from the Clay-with-flints Formation. In regard to asbestos, trace levels of chrysotile and amosite were recorded in the Made Ground at CPR05 with a laboratory quantification of <0.001%.
- 8.5.33 The soil data collected as part of the 2014 investigation generally indicates low contaminant concentrations, which would not be expected to be a significant source of contamination to groundwater. However, two locations (TP3/1 and CPR05) recorded potential localised hydrocarbon contamination. A sample collected from TP3/1 (at 1.0m bgl) recorded the presence of Gasoline Range Organics (GRO) with a total GRO concentration of 9,340 µg/kg, comprised predominantly of aliphatic >C6-C10 compounds (no Benzene, Toluene, Ethylbenzene, Xylenes [BTEX] recorded).

The Made Ground at CBR05 also may represent a second localised source of hydrocarbon contamination as a soil sample collected from this material recorded heavier hydrocarbons (>C12-C44) concentrations of 1,342 mg/kg.

- 8.5.34 One round of ground gas monitoring was undertaken which recorded no methane above the limit of equipment detection (<0.1%) and a maximum concentration of carbon dioxide of 1.1% v/v, with a flow rate below the limit of equipment detection (0.1l/hr). Though readings were low, prior to development, additional monitoring visits, to comply with the recommended minimum monitoring frequencies in published guidance should be undertaken.
- 8.5.35 Results of the Wardell Armstrong 2017 investigation concluded that permeabilities calculated for the chalk encountered ranged from 10⁻⁵ m/s to 6 x 10⁻⁷ m/s which correspond to medium to low permeability.
- 8.5.36 As part of the Wardell Armstrong 2017 investigation, groundwater samples were obtained during three return monitoring rounds undertaken between the 27th of February 2017 and the 14th of March 2017. A total of 68 no. samples were obtained using low flow sampling methods and tested for PFOS, perfluorooctanoic acid (PFOA), Volatile Organic Compounds (VOC), Semi-Volatile Compounds (SVOC), speciated petroleum hydrocarbons ('TPH-CWG' method), pH, and Biochemical Oxygen Demand (BOD).
- 8.5.37 PFOS was identified in 19 no. of the 25 no. boreholes monitored, with concentrations varying across three orders of magnitude. Results show a notable spatial distribution relative to the Buncefield Oil Depot site, with concentrations of >6,000 ng/l recorded in boreholes adjacent to Hogg End Lane, directly to the east of the Buncefield Oil Depot site (and west of the Site).
- 8.5.38 BTEX compounds were not recorded above laboratory detection limits in any groundwater sample collected, however, concentrations of heavier fuel hydrocarbons (>C12) were recorded across the Site. The >C12 hydrocarbons results show no clear spatial distribution and there is no evidence that they are distinctive of a plume of contamination from the Buncefield Incident.
- 8.5.39 Bis (2-Ethylhexyl) Phthalate (DEHP) is a plasticizer that is used in the manufacture of various plastics which can be released into the environment as a result of burning plastics. DEHP was recorded in groundwater at concentrations above laboratory limits of detection in boreholes south-east of the Buncefield Oil Depot however, it is noted that the spatial distribution of DEHP concentrations does not match the spatial distribution of elevated PFOS concentrations.
- 8.5.40 The study area history indicates a relatively low risk of soil contamination, and this is corroborated by the findings of the intrusive investigation undertaken to date. Whilst Made Ground has been identified at CPR05 it appears to affect only a small proportion of the study area, with the Made Ground being localised to a distinct mound around CPR05. The recorded contaminant concentrations across the remainder of the study area are low and would not be expected to present a potential human health risk. The primary risk to the Site and associated Proposed Development is the lateral migration of contaminated groundwater from the adjacent Buncefield Oil Depot with potential construction works or final Site operation uses having the potential to mobilise contamination plumes that may underly the Site.

8.5.41 Based on the above, a revised Conceptual Site Model (CSM) was produced by Wardell Armstrong that concluded that there are 'low to moderate' risk associated with the Made Ground around CPR05 that needs to be investigated further and 'moderate to high' risks associated with the Buncefield 2005 incident to controlled waters.

Future Baseline

8.5.42 The baseline conditions of the Site are unlikely to change significantly in the near future, without the implementation of the Development. The Site currently does not have any active uses which will generate substantial amounts of contamination. Without disturbance from construction activities or earthworks, the residual risk from the potential contamination is unlikely to be altered.

Likely Significant Effects to be Addressed in the ES

Assessment Scope

Likely Significant Effects

8.5.43 **Section 7.8** (Water Resources and Flood Risk) assesses the likely significant effects to Controlled Waters. As such, potential impacts relating to mobilisation of dissolved phase contaminants in groundwater due to changes in surface water drainage are assessed within **Section 7.8** (Water Resources and Flood Risk).

Non-Significant Effects

8.5.44 As a result of potentially contaminative land uses within the Site, standard mitigation measures will be required during the construction process in addition to contaminated land conditions raised by the local authority as part of the Sites overall planning application. With the implementation of the standard mitigation measures during the both the construction stage and once the Proposed Development is complete and operational, the likely effects on receptors are not considered to be significant, and therefore the topic of ground conditions can be scoped out of the EIA.

8.5.45 The mitigation measures as mentioned above would include standard construction controls and a site investigation (SI)/remediation works (if required) as follows:

- Standard control measures during demolition and construction will be adopted for the Proposed Development as well as good construction practices to reduce the contamination risks to construction workers and adjacent site users. These will be set out within the Construction Environmental Management Plan (CEMP).
- A detailed data review of the proposed finalised development plans and previous investigations undertaken across the site will be completed. Based on the finding of the previous investigation and development plans,

an updated CSM and GQRA in line with the Government's Land Contamination Risk Management (LCRM)³ guidance will be required. This data review would be required to support a planning application.

- Following the data review, the updated CSM and GQRA will then be used as a basis to design an additional or supplementary ground investigation in accordance with BS10175 to fill any potential data gaps that need further assessment. The ground investigation will be required and may be secured via condition(s).
- Further site investigation and ground investigation will be undertaken to assess the potential risks associated with chalk dissolution features and mining. This will develop a robust ground model to allow management of ground stability risks and derive strategies for ground improvement and/or engineering design (including foundations).
- The GQRA will be completed based on the previous and additional/supplementary ground investigation and will include refinement of the CSM with respect to contamination and geological conditions. The CSM and Risk Assessment will be produced in accordance with LCRM and BS10175⁴. The output will assist in assessing whether there are unacceptable risk of significant harm/pollution to the key receptors. The risk level classification system employed in the risk assessment is generally based upon those described in CIRIA Report C552⁵. This will be required for planning and may be secured via condition(s).
- The assessment of likely significant effects to sensitive receptors will consider the sensitivity of the receptor and the magnitude of change to gauge significance, on a scale of large/high, medium, small/low and negligible. Significant effects will be assessed through professional judgment. However, as a general rule major and moderate effects are considered to be significant, and minor and negligible effects are considered to be not significant.
- This work will inform a Remediation Options Appraisal and Outline Remediation Strategy which will set out the remediation and mitigation objectives to render the Development suitable for use. The Remediation Strategy would also outline the verification requirements to confirm that remediation/mitigation has been satisfactorily implemented. This will be required for planning and may be secured via condition(s).
- Remediation Method Statements will be required for each individual development area/phase to detail how the remediation will be completed and setting out a verification plan. This will be required for planning and may be secured via condition(s).
- The successful implementation of the RMS will be detailed in Remediation Verification Reports to demonstrate that remediation/mitigation has been satisfactorily implemented. This will be required for planning and may be secured via condition(s).

³ EA (2023) Land Contamination Risk Management. Available at: <https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm> (Accessed: 18th September 2024)

⁴ British Standards Institution (2017) *BS 10175:2011+A2:2017: Investigation of potentially contaminated sites – code of practise*. London: BSI.

⁵ Rudland, D J, Lancefield (January 2001) *Contaminated Land Risk Assessment: A guide to good practice (C552)*. ISBN: 978-0-86017-552-0.

8.5.46 In addition, throughout the demolition and construction works standard mitigation controls will be implemented to reduce the potential for ground conditions related impacts (and resulting effects) to arise. This will include (but not limited to) measures relating to waste minimisation, storage, handling and disposal, materials and chemicals storage, handling and disposal, use of Personal Protective Equipment (PPE), site inspections and auditing of processes and procedures

Study Area and Spatial Scope

8.5.47 The study area includes the Site and surrounding area within a 250m radius. Any features/contamination outside of this area are considered to have a negligible impact on the Site and will not be included in the assessment.

Cumulative Assessment

8.5.48 Consideration of Cumulative Schemes within the study area should be included. At the time of writing, due to the ES application date not being submitted until Autumn 2025, there is potential for schemes to become out of date prior to the ES being completed. Therefore, finalised Cumulative Schemes have not yet been agreed.

Key Receptors

8.5.49 When reviewing the baseline conditions of the Site as reported above, the following are considered to be the key sensitive receptors relating to the Site.

- Controlled Waters (as stated in **Section 7.8** (Water Resources and Flood Risk))

Summary Assessment Methodology

8.5.50 The summary assessment methodology for potential groundwater contamination has been included within **Section 7.8** (Water Resources and Flood Risk) of this EIA Scoping Report.

8.5.51 With the implementation of the standard mitigation measures discussed above, the likely effects on receptors in relation to ground conditions are not considered to be significant, and therefore the topic of ground conditions can be scoped out of the EIA.