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TABLES

12.0 GEOLOGY, HYDROGEOLOGY AND LAND CONTAMINATION

12.1 Introduction

12.1.1 This chapter identifies and addresses the potential impacts and effects of the construction, operation (including maintenance) and decommissioning of the Proposed Development on ground conditions and land quality. It should be read with reference to the description of the Proposed Development in Chapter 4.

12.1.2 The assessment has been prepared in accordance with the methodology described in Section 12.3 and is largely based on the information obtained following the completion of the Phase 1 Geo-environmental and Geotechnical Desk Study report prepared by AECOM (August 2018), provided in Appendix 12A in ES Volume III.

12.2 Legislation and Planning Policy Context

12.2.1 The European Union (EU) Directives and United Kingdom (UK) Acts considered the key legislative drivers for the geology, hydrogeology and land contamination assessment, including risks to human health and the environment from ground conditions, are summarised in the following paragraphs.

The Building Act 1984 and The Building Regulations & c (Amendment) Regulations 2015

12.2.2 The Building Act 1984 and in particular the associated Building Regulations &c (Amendment) Regulations 2015 are key when considering structural and design aspects of a development in terms of the geotechnical properties of the ground. The Building Act 1984 requires that buildings are constructed so that ground movement caused by swelling, shrinkage, freezing, landslip or subsidence of the sub-soils will not impair the stability of any part of the building.

The Environmental Protection Act 1990 (EPA) Part 2A - the Contaminated Land Regime

12.2.3 Current legislation relating to contaminated land in the UK is contained within Part 2A of the EPA, which was inserted by Section 57 of the Environment Act 1995 and by Section 86 of the Water Act 2003 (see below), and implemented by the Contaminated Land (England) Regulations 2006 [S.I. 2006/1380] (amended 2012 [S.I. 2012/263]). Under Part 2A, sites are identified as 'contaminated land' if they are (i) causing harm; (ii) if there is a significant possibility of significant harm; or (iii) if the site is causing, or could cause, pollution of controlled waters (i.e. both surface and groundwater).

The Water Resources Act 1991

12.2.4 The Water Resources Act 1991 provides statutory protection for controlled waters (i.e. streams, rivers, canals, marine environment and groundwater) and makes it an offence to discharge to controlled waters without the permission or consent of the regulators of these areas.

The Water Act 2003

12.2.5 The Water Act 2003 introduced a revision to the wording of the EPA, which requires that if a site is causing or could cause significant pollution of controlled waters, it may be determined as contaminated land. Once a site is determined to be contaminated land then remediation is required to render significant pollutant linkages insignificant (i.e. the source-pathway-receptor relationships that are associated with significant harm to human health and/or significant pollution of controlled waters), subject to a test of reasonableness.

Other Legislation

12.2.6 Other legislation of relevance to this Chapter includes:

- Anti-Pollution Works Regulations 1999;
- Environmental Damage (Prevention and Remediation) Regulations 2009;
- The Contaminated Land (England) (Amendment) Regulations 2012;
- The Control of Asbestos Regulations (2012);
- Environmental Permitting (England and Wales) Regulations 2016;
- Hazardous Waste (England and Wales) (Amendment) Regulations 2016;
- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017;
- The Water Framework Directive (2000/60/EC);
- The Groundwater Directive (2006/118/EC);
- The Environmental Quality Standards (EQS) Directive (2008/105/EC); and
- The Environmental Liability Directive (2004/35/EC).

Guidance on Assessment of Contaminated Land

12.2.7 Contaminated land, as defined in Part 2A of the EPA, is assessed through the identification and assessment of pollutant linkages (contaminant-pathway-receptor relationships). Implicit in EPA 1990: Part 2A Contaminated Land Statutory Guidance (Department for Environment, Food and Rural Affairs (Defra), 2012) is the application of risk assessment to assess whether potential pollutant linkages may be significant.

12.2.8 The risk-based methodology adopted in this report is based upon the Environment Agency's Model Procedures for the Management of Land Contamination (CLR11) (Environment Agency, 2004) together with the supporting guidance referenced within CLR11. The methodology relies on the development of a site specific Conceptual Site Model (CSM) consisting of three components:

- a source of contamination: for example due to historical site operations;
- a pathway: a route by which receptors can become exposed to contaminants (examples include vapour inhalation, soil ingestion and groundwater migration); and
- a receptor: a target that may be exposed to contaminants via the identified pathways (examples include human occupiers/users of the site, surface water, groundwater, property or ecosystems).

12.2.9 For a potential risk to either environmental and/or human health receptors to exist, a plausible pollutant linkage involving each of these components must exist. If one of the components is absent then a pollutant linkage, and thereby potentially unacceptable risk, is also unlikely to exist. Where all three components are or may be present, a potentially complete pollutant linkage can be considered to exist. This does not automatically imply the presence of unacceptable risk but further investigation of the potential pollutant linkages is required.

Planning Policy Context

12.2.10 Planning policy of relevance to the geology, hydrogeology and land contamination assessment is provided in Tables 12.1 and 12.2.

Table 12.1: The National Planning Policy Framework (Ministry for Housing, Communities and Local Government, 2018)

POLICY REFERENCE	SUMMARY
Paragraph 117	Planning policies and decisions should promote an effective use of land in meeting the need for homes and other uses, while safeguarding and improving the environment and ensuring safe and healthy living conditions. Strategic policies should set out a clear strategy for accommodating objectively assessed needs, in a way that makes as much use as possible of previously-developed or 'brownfield' land.
Paragraph 118 c)	Planning policies and decisions should:give substantial weight to the value of using suitable brownfield land within settlements for homes and other identified needs, and support appropriate opportunities to remediate despoiled, degraded, derelict, contaminated or unstable land.
Paragraph 170 a)	Planning policies and decisions should contribute to and enhance the natural and local environment by: …. protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan).
Paragraph 170 e)	Preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans.
Paragraph 170 f)	…by…remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.
Paragraph 171	Plans should: distinguish between the hierarchy of international, national and locally designated sites; allocate land with the least environmental or amenity value, where consistent with other policies in this Framework…...
Paragraph 178 a)	Planning policies and decisions should ensure that: …a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation)
Paragraph 178 b)	Planning policies and decisions should also ensure that:… after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990
Paragraph 178 c)	Planning policies and decisions should also ensure that:… adequate site investigation information, prepared by a competent person, is presented.
Paragraph 179	Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.

POLICY REFERENCE	SUMMARY
Paragraph 180	Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development.
Paragraph 183	The focus of planning policies and decisions should be on whether proposed development is an acceptable use of land, rather than the control of processes or emissions (where these are subject to separate pollution control regimes). Planning decisions should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a particular development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities.

Table 12.2: North East Lincolnshire Local Plan (North East Lincolnshire Council, 2018)

POLICY REFERENCE	SUMMARY
Policy 5 Paragraph 1	**Development Boundaries** Development Boundaries are identified on the Policies Map. All development proposals located within or outside of the defined boundaries will be considered with regard to suitability and sustainability, having regard to: – the quality of agricultural land; – measures to address any contamination of the site; and – impact on areas of heritage, landscape, biodiversity and geodiversity value, including open land that contributes to settlement character.
Policy 31 Paragraph 3	**Renewable and Low Carbon Infrastructure** Proposals for renewable and low carbon energy generating systems will be supported where any significant adverse impacts are satisfactorily minimised and the residual harm is outweighed by the public benefits of the proposal. Developments and their associated infrastructure will be assessed on their merits and subject to the following impact considerations, taking account of individual and cumulative effect: – biodiversity, geodiversity and nature conservation, with regard given to the findings of the site and project specific HRA and potential impacts on SPA birds where appropriate; – the land, including land stability, contamination, soils resources and loss of agricultural land.

12.3 Assessment Methodology and Significance Criteria

Baseline Conditions and Sensitive Receptors

12.3.1 The assessment of impacts to and from the existing ground conditions as a result of the Proposed Development has been undertaken using importance and significance criteria that have been developed and successfully applied to other Environmental Impact Assessments (EIAs). The methodology considers the potential presence of land and groundwater contamination as well as sites of geological/ geomorphological significance such as geological conservation features or mineral resources. Geotechnical constraints (e.g. differential settlement, subsidence and the potential for ground gas accumulation) are also discussed within this Chapter with the Proposed Development infrastructure identified as a receptor.

12.3.2 Information obtained from the following sources mentioned in Section 12.4 below have been used to establish the baseline conditions. The Conceptual Site Model (CSM) presented in the Phase 1 Geo-environmental and Geotechnical Desk Study Report within Appendix 12A in ES Volume III, is integrated into the assessment of baseline conditions. All supporting information is consistent with the risk-based framework adopted in the Environment Agency document Model Procedures for the Management of Land Contamination - CLR11 (Environment Agency, 2004). Guidance within British Standard (BS) 10175: 2011 Investigation of Potentially Contaminated Sites – Code of Practice (British Standards Institute (BSI), 2011) has also been followed.

12.3.3 The geology, hydrogeology and land contamination assessment initially entailed defining the importance/ sensitivity of identified receptors which takes into consideration the following:

- surrounding land uses, based on mapping, site visits and existing planning designations;
- proposed end-use, based on the nature of the Proposed Development;
- soil resource losses as associated with the Proposed Development;
- construction activities that are necessary for the Proposed Development;
- details of geological and/or nature conservation importance; and
- geology, hydrogeology and hydrology of the Site and the Study Area (which is defined in Section 12.4 below).

12.3.4 Potential sources of contamination associated with the Site are identified considering the current and previous land use from study of existing reports, current and historic maps, photographs, local history sources, environmental database information and a Site inspection.

12.3.5 Where a significant contamination source has been identified and the sensitivity of receptors considered, then the potential effects can be determined by consideration of the pathways through which the source or hazard may affect the receptors. The magnitude of impact and the significance of effect is then determined taking due account of strength of pathway between a source and a receptor.

Assessment of Significance of Effects

12.3.6 This section describes the framework of the assessment in identifying the magnitude of impact, sensitivity of receptor, and classification of effect. The impact assessment methodology applied will take account of technical guidance that has been produced in the UK for the assessment of ground conditions and water resources by the government (i.e. Defra), the Environment Agency document Model Procedures for the

Management of Land Contamination - CLR11 (Environment Agency, 2004), Contaminated land: Applications in Real Environments (CL:AIRE, 2010); and BS 10175: 2011 Investigation of Potentially Contaminated Sites – Code of Practice (BSI, 2011).

12.3.7 The effects are assessed in terms of the sensitivity or importance of a receptor or feature, and the magnitude of change or scale of impact due to the Proposed Development.

12.3.8 The sensitivity of a receptor reflects the quality of the receptor and its ability to absorb an impact without perceptible change. Sensitivity is defined in Table 12.3. The importance of potentially affected geological/ geomorphological features and the sensitivity of receptors that may be affected by land contamination impacts, have been assessed on this basis.

Table 12.3: Importance /Sensitivity Criteria of Geology, Hydrogeology and Land Contamination Resources / Receptors

SENSITIVITY/ VALUE OF RECEPTOR	RECEPTORS SUSCEPTIBLE TO LAND CONTAMINATION AND GROUND HAZARD IMPACTS	SOIL GEOLOGICAL AND HYDROGEOLOGICAL RESOURCES
Very High	Attribute has a high quality and rarity on a regional or national scale	Principal Aquifer providing a regionally important resource. Groundwater supporting a site protected under European and UK habitat legislation. Groundwater Source Protection Zone (SPZ) 1.
High	Future site users (residential development). Residential areas or schools within 50 m of construction works. Water features deemed to be of high value Ecological features deemed to be of high value. Allotments, arable farmland, livestock or market gardens on or adjacent to the site.	Principal Aquifer. Secondary A Aquifer providing locally important resource or supporting river ecosystem. Groundwater SPZ 2 or 3. Internationally and nationally designated sites. Regionally important sites with limited potential for substitution. High quality agricultural soils (Grade 1 and 2) or soils of high nature conservation or landscape importance. Presence of significant mineral reserves and within a Mineral Consultation Area. Soil/ materials disposal required following earthworks resulting in a significant increase in demand on waste management infrastructure.
Medium	Future site users (commercial development). Residential areas or schools within 50 to 250 m of construction works.	Secondary A and B Aquifers. Secondary A Aquifer providing source of water for agricultural or industrial use with limited connectivity with surface water features.

SENSITIVITY/ VALUE OF RECEPTOR	RECEPTORS SUSCEPTIBLE TO LAND CONTAMINATION AND GROUND HAZARD IMPACTS	SOIL GEOLOGICAL AND HYDROGEOLOGICAL RESOURCES
	Commercial areas within 50 m of construction works. Water features deemed to be of medium value. Ecological features deemed to be of medium value. The built environment including buildings and infrastructure.	Regionally important sites with potential for substitution. Locally designated sites with limited potential for substitution. Good quality agricultural soils (Grade 3a) or soils of medium conservation or landscape importance. Site within a Mineral Consultation Area. Soils/materials disposal required following earthworks resulting in a moderate increase in demand on waste management infrastructure.
Low	Future site users (car park, highways and railway related development). Residential areas >250 m from construction works. Commercial areas within 50 to 250 m of construction works. Water features deemed to be of low value. Ecological features deemed to be of low value.	Secondary B Aquifers. Secondary B Aquifer providing source of water for agricultural or industrial use with limited connectivity with surface water features. Undesignated sites of some local earth heritage interest. Moderate or poor quality agricultural soils (Grade 3b or 4) or soils of low nature conservation or landscape importance. Limited potential for mineral reserves and site not within a Mineral Consultation Area. Soil/materials disposal required following earthworks resulting in a minor increase in demand on waste management infrastructure.
Very Low	Attribute has a negligible quality or rarity on a local scale Other sensitive receptors susceptible to soil or groundwater contamination	Unproductive groundwater strata. No mineral extraction potential. No geological or geomorphological features of interest. No developed land uses other than transport infrastructure within 250m. Surface water feature deemed to be of negligible quality/ value.

Magnitude of Impacts

12.3.9 The magnitude of a potential impact considers the scale of the predicted change to the baseline condition taking into account its duration (i.e. the magnitude may be moderated by the impacts being temporary rather than permanent, short term rather than long term). Definitions for impact magnitude are described in Table 12.4. It is

generally unlikely that impacts on geology, hydrogeology and land contamination due to new developments are beneficial, so the examples of magnitude all relate to negative/ adverse impacts.

Table 12.4: Impact Magnitude Criteria (Geology, Hydrogeology and Land Contamination)

MAGNITUDE	DESCRIPTION	EXAMPLES
High	Total loss or major alteration to key features of the baseline conditions such that post development character/ composition of baseline condition will be fundamentally changed	Pollution of potable sources of water abstraction. Loss of, or extensive change to, an aquifer or groundwater supported designated wetland. Loss of, or extensive change to, nationally important geological/ geomorphological features.
Medium	Loss or alteration to one or more key features of the baseline conditions such that post development character/ composition of baseline condition will be materially changed.	Partial loss or change to an aquifer. Partial loss of the integrity of groundwater supported designated wetlands. Permanent loss of regionally important geological features or substantial changes to nationally important geological/ geomorphological features.
Low	Results in some measurable change in attributes quality or vulnerability compared to baseline conditions. Changes arising from the alteration will be detectable but not material; the underlying character/ composition of baseline condition will be similar to the pre-development situation.	Measurable effect on aquifer but of limited size or proportion, which does not lead to a reduction in the aquifer status; Minor effects on groundwater supported wetlands; and, Minor changes to regionally important geological/ geomorphological features or small changes to nationally important geological/ geomorphological features.
Very Low	Very little change from baseline conditions. Change is barely distinguishable, approximating to a “no change” situation.	No measurable effect upon groundwater, or geology/ geomorphology.

Assessment of Significance of Effects

12.3.10 The classification and significance of a potential effect is derived from both the sensitivity of the feature and the magnitude of the impact, and can be then determined using the matrix presented in the Table 12.5. Effects can be beneficial, adverse or negligible and their significance major, moderate, minor or negligible.

Table 12.5: Classification of Effects

MAGNITUDE OF IMPACT	SENSITIVITY OF RECEPTOR			
	High	**Medium**	**Low**	**Very Low**
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible
Very Low	Minor	Negligible	Negligible	Negligible

12.3.11 The EIA Regulations require the likely significant effects to be identified. Any effect predicted to be minor or negligible is considered to be not significant. Effects assessed as moderate or major are considered to be significant.

12.3.12 The classification of effect is further explained in Table 12.6.

Table 12.6: Explanation of Significance Classifications

CLASSIFICATION	GENERAL DESCRIPTION	SIGNIFICANT?
Major (adverse or beneficial)	A large and/or detrimental change to a valuable/sensitive receptor; likely or apparent exceeding of accepted (often legal) threshold or a major departure from national targets. A large and beneficial change, resulting in improvements to baseline conditions whereby previously poor conditions are replaced by compliance with accepted (often legal) thresholds or a major contribution is made to national targets. These are effects which may represent key factors in the decision making process. Potentially associated with sites and features of national importance or likely to be important considerations at a regional or district scale. Major effects may relate to impacts on resources or features which are rare and cannot be relocated, or if lost, cannot be replaced.	Yes

CLASSIFICATION	GENERAL DESCRIPTION	SIGNIFICANT?
Moderate (adverse or beneficial)	A medium scale change which, although not beyond an accepted (often legal) threshold, is still considered to be generally unacceptable, unless balanced out by other significant positive benefits of the development. Likely to relate to departure from relevant planning policy, rather than legal compliance. A positive moderate effect is a medium scale change that is significant in that the baseline conditions are improved to the extent that guideline targets are contributed to. These effects, if adverse, are likely to be important at a local or district scale and on their own could have a material influence on	Yes
Minor (adverse or beneficial)	A small change that, whilst adverse, does not exceed accepted thresholds, legal or guideline standards. Unlikely to be a departure from planning policy. A small positive change, but not one that is likely to be a key factor in the overall balance of issues.	No
Negligible	A very small change that is so small and unimportant that it is considered acceptable to disregard. Effects which are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error, these effects are unlikely to influence decision making, irrespective of other effects. unlikely to influence decision making, irrespective of other effects.	No

Development Scenarios

12.3.13 As described in Chapter 4: The Proposed Development, there are a number of possible development scenarios – a single stream plant, a two stream plant built in a single phase, or a two stream plant built in two phases.

12.3.14 The assessment of impacts presented in this chapter considers the activities that would be required for the construction and operation of any of the development scenarios, so the assessment is relevant to all development scenarios.

Consultation

12.3.15 The EIA Scoping Opinion (see Appendix 1B in ES Volume III) confirmed that an assessment of impacts on ground conditions (including ground waters and contamination) during construction, operation (including maintenance) and decommissioning should form part of the EIA. This assessment is reported in this chapter.

12.4 Baseline Conditions

12.4.1 Baseline conditions are set out in the Phase I Geo-environmental and Geotechnical Desk Study Report (Appendix 12A in ES Volume III).

Study Area

12.4.2 The Study Area for the geology, hydrogeology and land contamination assessment is the boundary of the Site and up to 500 m from the Site boundary. Where necessary, the assessment of impacts will be extended outside the Study Area to include important off-Site features within the vicinity of the Site.

12.4.3 Whilst the review of baseline conditions focuses on the geological and hydrogeological setting, it also considers the wider environment in terms of identifying potential receptors that could be impacted upon by any existing or resulting soil and/or groundwater contamination. There is therefore some reference made to hydrological and ecological features in this chapter. These are also discussed in more detail within Chapter 14: Water Resources, Flood Risk and Drainage and Chapter 10: Ecology and Nature Conservation.

Geology

12.4.4 The Proposed Development is not situated within any identified areas of Artificial Ground. However, the uneven surfaces of the Main Development Area and the presence of a mound noted during the Site walkover indicate the presence of Made Ground. The underlying geology comprises superficial deposits of Tidal Flat (Clay and Silt) normally a consolidated soft silty clay, with layers of sand, gravel and peat. The Tidal Flat deposits are underlain by Glacial Deposits of Devensian age. The bedrock geology underlying the Tidal Flats is the Flamborough Chalk Formation, described by the British Geological Survey (BGS) Lexicon (BGS 'GeoIndex Onshore' website accessed 16/07/2018) as being "*White, well-bedded, flint-free chalk with common marl seams (typically about one per metre). Common stylolitic surfaces and pyrite nodules*."

12.4.5 No geological faults have been identified at the Site either on BGS 1:50,000 or 1:10,560 scale maps.

12.4.6 There are four BGS boreholes within 250 m of the Main Development Area; TA21SW119, TA21SW347, TA21SW346 and TA21SW345. Made Ground was identified between ground level and 0.30 m below ground level (bgl) in borehole TA21SW119. From approximately 0.30 m bgl to 7.48 m bgl, the geology was described as mudflat intertidal channel comprising of layers of clayey silt and sandy silts. Underlying the mudflat intertidal channel to 9.00 m bgl (base of borehole) was low salt marsh which comprised of silty clay with peat, wood fragments, pebbly sandy silt with chalk pebbles. No groundwater strike was recorded. The three remaining boreholes recorded alluvium from ground level at depths of between 6.60 m and 9.30 m bgl. Underlying the alluvium glacial deposits was described comprising of layers of clay and sand to depths of 23.00 m bgl overlying the Flamborough Chalk. Groundwater was encountered in these three boreholes between depths of 9.70 m bgl and 11.40 m bgl.

12.4.7 The Site is not within an area affected by coal mining and there are no BGS Recorded Mineral Sites within the Study Area.

Hydrogeology

12.4.8 The superficial deposits within the Site are classified by the Environment Agency as an Unproductive Aquifer. The bedrock geology is designated as a Principal Aquifer, i.e. exhibiting high permeability and/or provides a high level of water storage. Principal Aquifers may support water supply and/or river base flow on a strategic scale.

12.4.9 The Site is not located within a Groundwater Source Protection Zone and there are no groundwater abstractions within the Study Area.

Hydrology

12.4.10 To the east of the Site is the Humber Estuary. 'High Water Tide' mark is noted on the Ordnance Survey (OS) maps as approximately 175 m from the eastern boundary of the Main Development Area.

12.4.11 There is a system of drainage channels around the majority of the perimeter of the Site. The Oldfleet Drain is located approximately 140 m south of the Site boundary (at its closest point) and it connects to the Mawbridge Drain approximately 1 km south of the Site.

12.4.12 There are two surface water bodies (ponds) on the Site. A large pond lies off-Site approximately 250 m south of the Site to the south of the Oldfleet Drain.

12.4.13 The Environment Agency Catchment Data Explorer (https://environment.data.gov.uk/catchment-planning/ accessed online on 16/07/2018) indicates the north-eastern area of the Site is within the 'North Beck Drain' catchment area and the south-western area is within the 'Mawbridge Drain' catchment area. The chemical qualities of both catchments are classified as 'Good' in the 2016 classification, indicating the Water Framework Directive (WFD) objective has been met. The ecological qualities of both catchments are designated as 'Moderate' in the 2016 classification, with an objective of 'Good' classification set for 2027.

12.4.14 The Environment Agency's flood map for planning (accessed https://flood-map-for-planning.service.gov.uk/ online on 16/07/2018) indicates that the Site is within Flood Zone 3. These are areas assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. The flood zone does not take into account the presence of any flood defences in the area.

12.4.15 Water quality and flood risk as discussed further in Chapter 14: Water Resources, Flood Risk and Drainage.

Designated and Non-Designated Geology Sites

12.4.16 There are no geologically designated sites identified within the Study Area.

Site History

12.4.17 Historical mapping from 1887 until 1999 depicts the Site and the Study Area as agricultural fields with drainage channels, with the Humber Estuary lying to the east of the Site.

12.4.18 During the late 1990s the South Humber Bank Power Station (SHBPS) was built within the Site, to the west of the Main Development Area, with an attenuation lagoon in the south of the Main Development Area. By 2006 a pond is depicted on the historical mapping situated in the north-eastern corner of the Main Development Area.

12.4.19 From 1965 until the 1980s the most significant changes were the development of works buildings on the south-eastern boundary of the Site with further development on the north-east corner of the Site boundary, appearing in 1968 and by 1978 further works had been developed on the outskirts of the north-eastern and eastern Site boundaries.

12.4.20 In 2006 an underground pipeline is depicted on the historical mapping, 270 m north from the eastern boundary of the Site which extends from the headland towards the sea.

Potentially Contaminative Land Uses

12.4.21 The SHBPS, which lies directly to the west of the Main Development Area, is considered as a potentially contaminative land use.

12.4.22 No landfill sites or waste management facilities are listed within 250 m of the Site. One Permitted Waste Management Facility is located within 500 m of the Proposed Development Boundary – the NEWLINCS waste management facility, for which a Permit was issued in May 2012.

12.4.23 Just outside the Study Area there are:

- seven Licensed Waste Management Facilities located between 500 m and 1 km of the Site;
- one BGS Recorded Landfill Site located 825 m south-east of the Site; and
- four Historic Landfills listed between 500 m to 1 km south-east of the Site (Stallingborough Landfill located c. 750 m to the north-west and Landfills No2, No3 and No4 at Greatcoates Works located c. 800 m to the south-east of the Site).

Contemporary Trade Uses

12.4.24 Two active Contemporary Trade Uses are listed on Site: a waste disposal service and a power transmission service.

12.4.25 There are a further two entries within 250 m of the Site; one classified as a rubber and plastic products manufacturer, which is active, and the other a chemicals and allied products manufacturer which is listed as inactive.

12.4.26 Just outside the Study Area between 500 m and 1 km, there are two Contemporary Land Uses entries which are both active; one classified as a Recycling Centre and the other as a Gas Supplier.

Previous Ground Investigation

12.4.27 In 2006, RSK Group was commissioned by Centrica to design a Site Protection and Monitoring Program for SHBPS, which included a ground investigation and installation of monitoring wells in the western part of the Site and a monitoring programme.

12.4.28 The intrusive ground investigation recorded variable thicknesses of Made Ground overlying superficial alluvial clay deposits comprising very soft or soft black to grey brown or dark grey clay with a slight organic reducing odour. The alluvial clay was observed as becoming very sandy at 4.0 m bgl along with groundwater seepages. During the ground investigation groundwater was encountered across the monitoring well network with resting groundwater elevations ranging from 9.88 mAD (above site datum) to 10.24 mAD. RSK inferred that groundwater flowed towards the south-east.

12.4.29 Analysis of the soils undertaken during the investigation indicated the presence of localised, trace concentrations of heavy fractions (C21 – C25) aromatic and aliphatic Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAH) at shallow depths. Groundwater chemical analysis results recorded TPH concentrations below the method detection limit and aqueous PAH concentrations of 0.129 µg/l and 0.29 µg/l. RSK's report noted that the groundwater pH and chloride concentrations suggested alkaline freshwater conditions beneath the Site, with no evidence of saline intrusion from the Humber Estuary.

12.5 Development Design and Impact Avoidance

12.5.1 This section considers how potential environmental impacts have or will be avoided, prevented, reduced or offset through design and/ or management of the Proposed Development with respect to ground conditions and contamination.

12.5.2 A ground investigation will be undertaken before construction to more accurately quantify potential hazards and a risk assessment carried out to define potential remediation objectives to narrow the degree of uncertainty in the risk rankings. This is proposed to be secured by planning condition. The ground investigation will comprise the following:

- investigation of the nature and extent of the Made Ground across the Site;
- investigation of the nature of the underlying natural strata, where present, including determination of in-situ soil properties;
- investigation of depths to rockhead;
- chemical and geotechnical testing of soil and groundwater samples;
- installation of gas and groundwater monitoring wells and monitoring of ground gas concentrations and groundwater levels; and
- testing of a range of suitable soil, leachate and groundwater chemicals, including Building Research Establishment (BRE) sulphate tests.

12.5.3 A Construction Environmental Management Plan (CEMP) will be prepared and implemented by the selected construction contractor. This CEMP will include a range of measures associated with mitigating potential impacts associated with land contamination as detailed below. Such measures accord with legal compliance and best practice guidance when working with or around contaminated materials. A Framework CEMP is presented within Appendix 5A in ES Volume III.

12.5.4 Before construction, a remediation and/or earthworks strategy may be required and is dependent on the findings of the ground investigation. If required, the remediation strategy will set out how the earthworks/ excavation stage of the Proposed Development will be undertaken. Where necessary, the strategy will consider what materials, if any, can be reused and what materials are surplus and require either disposal or onward management to ensure appropriate re-use. The strategy will also define whether any treatment may be required, prior to reuse or disposal as well as establishing risk-based compliance criteria for soils to be screened against. The strategy will cover the clearing of the Site and the works required to prepare it for development. A remediation strategy will be prepared if significant contamination is encountered during any future ground investigation.

12.5.5 A Materials Management Plan (MMP) will be prepared alongside any earthworks/ excavation/ reclamation strategy. The MMP will detail the procedures and measures that will be taken to classify, track, store, dispose of and possibly re-use all excavated materials that are expected to be encountered during the development works.

12.5.6 The disposal of soil waste, contaminated or otherwise to landfill sites will be best mitigated by minimisation of the overall quantities of waste generated during construction and by ensuring that excavated material consigned to landfill cannot, as an alternative, be put to use either on Site or on other sites (see Chapter 16: Waste Management).

12.5.7 The Flamborough Chalk formation is known to contain pyritic minerals. Therefore, upon completion of an additional ground investigation, chemical analysis of soil samples will

be required to determine the appropriate design sulphate concrete classification to prevent chemical attack on concrete.

Construction Phase

Impacts on Soil Resources

12.5.8 The potential impacts on soil resources will be managed by minimising trafficking over topsoil materials and undertaking soil stripping during appropriate weather conditions, such that the soils are not wet. Once stripped the soils will be stored in soil bunds to an agreed height so that the materials own weight does not damage the structure of the soil. The topsoil will be reused in areas of landscaping within the Site or off-Site if it cannot be re-used on Site.

Impacts on Human Receptors

12.5.9 The potential impacts specific to construction workers during construction of the Proposed Development will be managed by adherence to the working practices in accordance with Construction Industry Research and Information Association (CIRIA) C741 Environmental Good Practice on Site 4th Edition (CIRIA, 2015), including:

- measures to minimise dust generation;
- provision of personal protective equipment (PPE), such as gloves, barrier cream, overalls etc. to minimise direct contact with soils;
- provision of adequate hygiene facilities and clean welfare facilities for all construction site workers;
- monitoring of confined spaces for potential ground gas accumulations, restricting access to confined spaces i.e. by suitably trained personnel, and use of specialist PPE, where necessary; and
- preparation and adoption of a Site and task specific health and safety plan.

Impact on Controlled Waters

12.5.10 To manage the potential impact on controlled waters, the pre-construction ground investigation for the Proposed Development will include installation of monitoring wells with targeted response zones, groundwater level monitoring and chemical testing to determine the presence of any contaminants in groundwater.

12.5.11 The management measures implemented through the CEMP will minimise the risk of any contaminated surface water runoff from the Site during the site preparation, earthworks and construction phase so that it does not have a detrimental effect on the receiving watercourse and the underlying aquifers. The surface water runoff will be controlled using appropriate drainage measures and segregating uncontaminated surface water from any process effluent streams, as well as impermeable surfacing to minimise infiltration into the ground This will minimise the potential for potential contaminants to migrate to controlled waters.

12.5.12 If dewatering of the Site is required during the construction phase a permit from the Environment Agency to discharge to surface water or a consent to discharge to foul sewer will be obtained, and arrangements will be made to store any waters collected during dewatering to determine whether contamination is present before deciding on where to discharge the waters.

12.5.13 A piled foundation is proposed for the Proposed Development. Therefore, a piling risk assessment will be undertaken in accordance with Environment Agency guidance. This will be used to establish the means of mitigating any risks of causing new pollutant

linkages and/ or worsening existing ones with respect to risks to controlled waters at the construction stage.

12.5.14 In addition, the prevention of pollution of surface water and/ or groundwater will comply with the requirements of the following Environment Agency Pollution Prevention Guidelines (PPG) documents:

- PPG1 Basic Good Environmental Practices (2013);
- PPG5 Works in, near or over Watercourses (2014);
- PPG6 Construction and Demolition Sites (2014); and
- PPG21 Incident Response Planning (2009).

12.5.15 These PPG have been withdrawn and are currently being updated by the Environment Agency. However, they still provide good practice guidance to avoid pollution during the activities undertaken as part of a ground investigation.

Impact on Development Infrastructure

12.5.16 Materials used in infrastructure will be designed and specified accordingly taking due account of the potential for aggressive ground conditions, if these are identified through the pre-construction ground investigation. The assessment methodology set out in BRE Special Digest 1 (2005) will be adopted to determine the appropriate concrete classification in relation to the protection of buried concrete against sulphate attack.

12.5.17 The design specification may include the import of engineered fill to improve the bearing capacity of the soil if required following ground investigation.

Operation Phase

Impact on Maintenance Workers

12.5.18 For maintenance workers during the operation phase, any maintenance works will be carried out in accordance with CIRIA (2015) C741 Environmental Good Practice on Site 4th Edition. Maintenance workers will be provided with appropriate PPE such as gloves and overalls to minimise direct contact with soils. Entry into excavations or confined spaces will comply with confined space legislation and assessed prior to entry. Should the detailed design of the Proposed Development incorporate any confined spaces such as ducts, manholes and inspection chambers, a gas monitoring programme and gas risk assessment will be undertaken to determine the site Characteristic Situation in accordance with CIRIA Report C665 (CIRIA, 2007).

Impact on Off-Site Receptors and Future Site Users

12.5.19 The risk to future site users from direct contact with the underlying soils is considered very low. The Proposed Development will maintain an area of hardstanding across the majority of the Main Development Area, which will break the potential contaminant linkage and therefore reduce the likelihood of contact further.

12.5.20 The risk to future site users from direct contact with contaminated leachate or groundwater is considered low. It is considered the probability that future site users will come into contact with contaminated leachate or groundwater at the site is unlikely due to the majority of the area being covered by hardstanding.

Impact on Controlled Waters

12.5.21 The Proposed Development will include activities that are likely to generate contaminants that could pose risks to controlled waters if not managed. In addition there is potential for environmental risks associated with spillages due to road accidents or faulty vehicles. To manage potential impacts on controlled waters during the

operational stage of the Proposed Development, suitable drainage systems will be employed during construction and maintained during operation to prevent infiltration of surface water or potential contaminants into the ground during the operation phase. The operator of the Proposed Development will comply with the requirements of any permits and/ or will handle and store materials such as chemicals and fuels as recommended by the manufacturer.

Impact on Development Infrastructure

12.5.22 In order to mitigate potential risks to sub-surface concrete structures from aggressive ground conditions associated with the presence of sulphate, the following options will be considered on a case by case basis:

- the specification of materials to be used for the construction of the Proposed Development will be specific to the ground conditions into which they will be placed;
- the modification of concrete mix to resist sulphate attack;
- bitumen coating of sub-surface structures; and
- additional sacrificial thickness of sub-surface concrete.

12.5.23 A pre-construction ground investigation will determine the suitable founding material which will be required across the Main Development Area. Any residual risks relating to soft ground will be addressed during the detailed design stage, taking into account the ground investigation results. The specification design can be determined following an additional ground investigation and chemical analysis of soil samples analysing the BRE Sulphate suite.

Decommissioning Phase (including demolition)

Impacts on Soil Resources

12.5.24 During the decommissioning phase the potential impacts on soil resources will be managed by minimising trafficking over topsoil.

Impacts on Human Receptors

12.5.25 The potential impacts specific to demolition workers during decommissioning phase will be mitigated by adherence to the working practices in accordance with CIRIA (2015) C741 Environmental Good Practice on Site 4th Edition, including:

- measures to minimise dust generation;
- provision of PPE such as gloves, barrier cream, overalls etc. to minimise direct contact with soils;
- provision of adequate hygiene facilities and clean welfare facilities for all demolition workers;
- monitoring of confined spaces for potential ground gas accumulations, restricting access to confined spaces i.e. by suitably trained personnel, and use of specialist PPE, where necessary; and
- preparation and adoption of a site and task specific health and safety plan.

Impact on Controlled Waters

12.5.26 Mitigation measures similar to those employed for the construction phase will be implemented to minimise the risk of any contaminated surface water runoff from the Site during the decommissioning phase so that it does not have a detrimental effect on the receiving watercourse and the underlying aquifers. The surface water runoff will be

controlled using appropriate drainage measures and segregating uncontaminated surface water from any process effluent streams, as well as impermeable surfacing to minimise infiltration into the ground. This will minimise the potential for potential contaminants to migrate to controlled waters.

12.5.27 If dewatering of the Site is required during the decommissioning phase a permit from the Environment Agency to discharge to surface water or a consent to discharge to foul sewer will be obtained, and arrangements will be made to store any waters collected during dewatering to determine whether contamination is present before deciding on where to discharge the waters.

12.6 Likely Impacts and Effects

Conceptual Site Model (CSM)

12.6.1 The CSM defines the plausible contaminant source, pathway and receptor linkages, which is integral to defining the baseline conditions. The CSM presents potential sources of contamination, potential receptors and potential sources of contamination migration pathways that have been identified for the Proposed Development.

12.6.2 The topography, geology, hydrogeology and hydrology of the Site are the main factors that influence the way in which potential contaminants in the soil or groundwater can be transported on or off-Site, and the ways in which contamination can affect different receptors. Potential receptors are first summarised in this section, and where applicable references are made to the other relevant chapters within the ES. Potential sources and pathways linking any sources to the defined receptors are then identified.

Table 12.7: Sources of potential contamination for the Main Development Area (including a 250 m buffer).

POTENTIAL SOURCE	POTENTIAL PATHWAY	POTENTIAL RECEPTOR
Diffuse metal, inorganic and organic contamination within the Made Ground at the Site and from off-Site sources (if present).	Ingestion of contaminated soil Inhalation/ingestion of soil derived dust Inhalation of organic vapours Direct contact with soils/ dusts	Future site users Construction/ maintenance workers Development infrastructure Flora and fauna Off-Site receptors
Asbestos containing materials (ACM) within the Made Ground (if present)	Inhalation of soil derived dust Direct contact with soils/dusts	Future site users Construction/ maintenance workers Off-Site receptors
Generated leachate from Made Ground and spills/ leaks into natural ground (if present)	Leaching into groundwater and migration to surface watercourses Plant uptake	Surface watercourses Perched groundwater Off-Site flora and fauna
Contaminants in groundwater (e.g. from on or off-Site spills and leaks) (if	Migration and diffusion	Middle Drain and Oldfleet Drain Shallow groundwater (in Principal Aquifer)

present)		
Ground gases (if present)	Migration and diffusion via permeable strata	Future site users Construction / maintenance workers Flora and fauna Development infrastructure Off-Site receptors

12.6.3 The assessment considers the potential impacts upon identified receptors prior to design and impact avoidance measures (initial classification). The residual effects when the embedded mitigation and best practice measures as outlined in Section 12.5 are included are described in Section 12.9.

12.6.4 The following assessment is based on the methodology set out in Section 12.3. The assessment considers the impacts of the construction, operation (including maintenance) and decommissioning of the Proposed Development on identified receptors.

Construction Phase

Table 12.8: Summary of Impacts and Effects during Construction Phase (in the absence of development design and impact avoidance measures)

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT
Soil resource	Topsoil: loss / deterioration of soil resource	Medium	Low	Minor adverse (not significant)
Made Ground and soil derived leachate	Construction workers: exposure to contaminants, dust and vapours	High	Very low	Minor adverse (not significant)
	Controlled waters (surface water): reduction in ground water / surface water quality due to uncontrolled release of pollutants	High	Medium	Major adverse (significant)
	Controlled waters (groundwater): migration of contaminated water through preferential pathways (such as piling) to groundwater in underlying aquifer.	High	Low	Moderate adverse (significant)

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT
	Development infrastructure: chemical attack on buried structures such as concrete; permeation of water pipes by contaminants.	Medium	Medium	Moderate adverse (significant)
	Off-Site receptors: exposure to contaminants, dust and vapours.	Medium	Low	Minor adverse (not significant)
	Flora and fauna: migration of contaminants to ecological receptors	Medium	Medium	Moderate adverse (significant)
Ground water	Controlled waters (surface water): migration to surface watercourses	High	Medium	Moderate adverse (significant)
	Controlled waters: lateral migration through aquifer	High	Low	Moderate adverse (significant)
	Off-Site receptors: migration of groundwater vapours	Medium	Low	Minor adverse (not significant)
Ground gas	Construction workers: accumulation of ground gas in confined spaces – asphyxiation and explosion risks	High	Medium	Major adverse (significant)
	Development infrastructure: explosion risk	Medium	Low	Minor adverse (not significant)
	Off-Site receptors: ground gas migration caused by ground disturbance during construction works	Medium	Low	Minor adverse (not significant)

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT
Ground instability	Development infrastructure (e.g settlement):	Medium	Low	Minor adverse (not significant)

Impacts on Soil Resources

12.6.5 During construction of the Proposed Development topsoil will be stripped and stored on Site. On completion of construction, stored topsoil will be re-used where possible in on-site landscaping. Any excess topsoil may need to be removed from Site for re-use elsewhere but it is expected that it will be retained and reused beneficially on Site.

12.6.6 The sensitivity of the soil on the Site is considered to be medium and the magnitude of the impact is considered to be low. The effect to soil resources is therefore considered to be minor adverse (not significant).

Impacts on Construction Workers

12.6.7 During the construction phase of the Proposed Development, the construction workers are potentially at risk of short term exposure to potential contaminants in Made Ground via dermal, inhalation and ingestion pathways. Asbestos could be encountered during the construction phase although none has been identified in previous ground investigations. Chemical testing of soils undertaken in the previous investigations reported by RSK (see Section 12.4 Baseline Conditions (Previous Ground Investigation) above) indicated the presence of localised, trace concentrations of heavy fractions (C_{21} – C_{25}) aromatic and aliphatic TPH and PAH.

12.6.8 During the construction phase of the Proposed Development, the use of heavy equipment and activities such as excavation, backfilling and compaction may disturb the soil and mobilise potentially contaminated materials and asbestos containing materials if found to be present.

12.6.9 In addition construction workers may be exposed to ground gases when working in confined spaces from on-Site sources (e.g. Made Ground material) or via migration from off-Site sources (if their presence is confirmed by future ground investigation).

12.6.10 The sensitivity of construction workers has been classed as high but as the magnitude of the impact is very low except for workers in confined spaces at risk of asphyxiation and explosion due to accumulations of ground gas (if present). The effect on construction workers during the construction phase of the Proposed Development is considered to be minor adverse (not significant) for all except workers in confined spaces where the construction effect is major adverse (significant) without mitigation if ground gases are present.

Impacts on Controlled Waters

12.6.11 The groundwater underlying the Site is considered to be of high sensitivity. The superficial Tidal Flat Deposits are designated by the Environment Agency as an Unproductive Aquifer with the Flamborough Chalk designated as a Principal Aquifer. The Tidal Flat Deposits may provide some protection to the underlying Principal Aquifer, limiting migration of contaminants from the surface.

12.6.12 No groundwater abstractions have been identified within the Study Area and the Site is not located within a Groundwater Source Protection Zone.

12.6.13 Due to shallow groundwater depths recorded during RSK's previous ground investigation in 2006, dewatering of excavations for the Proposed Development may be required during the construction phase. Storage and disposal of the water will comply with current regulations. The findings of the pre-construction ground investigation will confirm whether dewatering is required.

12.6.14 The main surface water features which may be impacted by the Proposed Development are:

- the Humber Estuary approximately 175 m east of the Proposed Development;
- drainage ditches around the majority of the perimeter of the Site;
- two surface water bodies (ponds) within the Main Development Area which will be removed during construction. A new attenuation pond will be constructed within the Main Development Area and a new ecological mitigation pond will be constructed to the west of the SHBPS).

12.6.15 The sensitivity of surface water resources is classed as high and the magnitude is low. The sensitivity of groundwater resources is classed as high and the magnitude low. Therefore the effects on controlled waters during the construction phase are considered to be moderate adverse (significant) in relation to surface waters and groundwater, in the absence of mitigation measures.

Impacts on Development Infrastructure

12.6.16 Development and building infrastructure can be impacted upon by the ground conditions. Where adequate mitigation is not incorporated during the design and construction of a development, the impacts would be realised during the operational phase.

12.6.17 It is recommended that the specification of materials to be used during construction of a development are specific to the ground conditions into which they will be placed. For example, in the case of the Proposed Development, there is potential for aggressive ground conditions to be present, which can cause damage to concrete. If ground investigation finds that ground gas concentrations are elevated then these could present a risk of asphyxiation or explosion if allowed to accumulate in confined spaces withouth adequate mitigation. As such, appropriate mitigation will be incorporated during construction of the Proposed Development following suitable ground investigation..

12.6.18 The sensitivity of development infrastructure to the impacts has been classed as medium, with the magnitude being classed as low to medium. The effect on development infrastructure during the construction phase of the Proposed Development is considered to be minor adverse (not significant) to moderate adverse (significant), in the absence of mitigation measures.

Impacts on Off-site Receptors

12.6.19 The main off-Site human receptors are considered to be commercial/ industrial workers in the Study Area.

12.6.20 Workers and visitors to these areas are at risk from wind-blown dust and subsequent inhalation or direct contact with dusts of vapour generated by the construction activities.

12.6.21 The sensitivity of the receptors is medium and the magnitude of impact is low, and in the absence of mitigation measures, the effect on off-site receptors is considered to be minor adverse (not significant).

Impacts on Flora and Fauna

12.6.22 In the absence of mitigation, there is potential for impacts on flora and fauna in or adjacent to the Site due to uptake/ ingestion of water from the ground that is contaminated by spills/ leaks on Site or migration of contaminants from Made Ground. The sensitivity of receptors is low and the magnitude of impact is low, so the effect is considered to be negligible adverse (not significant) without mitigation.

Operation Phase

Table 12.9: Summary of Impacts and Effects during the Operation Phase (in the absence of development design and impact avoidance measures)

SOURCE	DESCRIPTION OF RESOURCE / RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT
Made Ground and soil derived leachate	Future site users (workers and visitors): exposure to contaminants, dust and vapours	Medium	Low	Minor adverse (not significant)
	Maintenance workers: exposure to contaminants, dust and vapours	High	Very low	Minor adverse (not significant)
	Controlled waters (surface water): reduction in groundwater / surface water quality due to uncontrolled release of pollutants	High	Low	Medium adverse (significant)
	Controlled waters (groundwater): migration of contaminated water through preferential pathways (such as piled foundations) to groundwater in underlying aquifer.	High	Low	Moderate adverse (significant)

SOURCE	DESCRIPTION OF RESOURCE / RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT
	Development infrastructure: chemical attack on buried structures such as concrete; permeation of water pipes by contaminants	Low	Medium	Minor adverse (not significant)
	Off-Site receptors: exposure to contaminants, dust and vapours	Medium	Very low	Negligible adverse (not significant)
	Flora and fauna: migration of contaminants to other ecological receptors	Low	Low	Negligible adverse (not significant)
Ground water	Controlled waters (surface water): migration to surface watercourses	High	Low	Moderate adverse (significant)
	Controlled waters: lateral migration through aquifer	High	Low	Moderate adverse (significant)
	Off-Site receptors: migration of groundwater vapours	Medium	Very low	Negligible adverse (not significant)
Ground gas	Future site users (site workers and visitors): Accumulations of ground gas in confined spaces	Medium	Very low	Negligible adverse (not significant)
	Development infrastructure: explosion risk	Low	Low	Negligible adverse (not significant)

SOURCE	DESCRIPTION OF RESOURCE / RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT
	Off-Site receptors: migration of ground gas	Medium	Very low	Negligible adverse (not significant)
Ground instability	Development infrastructure (e.g. settlement):	Medium	Medium	Moderate adverse (significant)

Impacts on Future Site Users

12.6.23 It is considered that there is the potential for ground contamination to occur during operation (due to leaks or spillages for example) and for ground gas to accumulate in confined spaces that could pose risk to future site users during the operational phase (if confirmed by future ground investigation).

12.6.24 The Main Development Area is proposed to be largely covered in one or more buildings and hardstanding, but areas of top-soiled landscaped land would be present around the margins of the Site.

12.6.25 Potentially hazardous materials (including those which represent a risk to controlled waters) will be stored in compliance with the requirements of any permits and/ or will handle and store such materials as recommended by the manufacturer.

12.6.26 Therefore, based on the proposed use of the Main Development Area the sensitivity of future site users is classed as medium and the impacts are considered to have a low magnitude. The overall effect on future site users during the operational phase is considered to be minor adverse (not significant) in relation to soil or groundwater contamination and ground gas.

Impacts on Future Maintenance Workers

12.6.27 Maintenance workers could be more directly exposed to soil or groundwater contaminants than future site users (during excavation works for example). However, it is expected that the duration of exposure would be very short and and that appropriate protective equipment and safe working procedures would be used.

12.6.28 Consequently the effect on maintenance workers during the operational phase is considered to be minor adverse (not significant).

Impacts on Controlled Waters

12.6.29 The Proposed Development will include activities during the operational phase that could generate contaminants that could pose risk to surface water (the Humber Estuary, drainage channels within the Site, the proposed ecological mitigation pond and the proposed attenuation lagoon) and/ or groundwater. The Main Development Area will be largely covered in hardstanding with other areas of top-soiled landscaping which will reduce infiltration potential. In addition, the operator of the Proposed Development will comply with the requirements of any permits and/ or will handle and store materials such as chemicals and fuels as recommended by the manufacturer. However, there could be potential for environmental risks associated with spillages due to road accidents or faulty vehicles.

12.6.30 The sensitivity of controlled waters during the operational phase of the Proposed Development has been classed as high to high for surface water and groundwater. The magnitude of the impacts to controlled waters is classed as low. Therefore the effect on controlled waters during the operational phase of the Proposed Development is considered to be moderate adverse (significant) in relation to soil and groundwater contamination, in the absence of mitigation measures.

Impacts on Development Infrastructure

12.6.31 Materials such as concrete, metals and plastic will be employed during the construction of the Proposed Development. These materials could be used underground or above ground level. Development/ building infrastructure can be impacted where materials have been incorrectly specified at the design/ construction stage. Buried concrete could be exposed to chemical attack especially from acidity associated with the presence of sulphate and this could compromise the structural integrity of the underground structures.

12.6.32 The sensitivity of the development infrastructure is considered low to medium. The magnitude of impact prior to the implementation of the mitigation measures is considered to be medium to low.

12.6.33 Therefore, the effect on development infrastructure during the operational phase is considered to be minor adverse (not significant) in relation to soil or groundwater contamination, negligible adverse (not significant) in relation to ground gas, and moderate adverse (significant) in relation to ground instability in the absence of mitigation measures.

Impacts on Off-site Receptors

12.6.34 The Proposed Development could potentially include activities during the operational phase that are likely to impact off Site receptors, for example fuel/ chemical spillages that could run off and infiltrate into the ground and surface water.

12.6.35 The sensitivity of the off-Site receptors is considered to be medium. The magnitude of impact prior to the implementation of the mitigation measures is considered to be very low. Therefore the effect on off-Site receptors during the operational phase of the Proposed Development is considered to be negligible adverse (not significant) for commercial/ industrial workers and visitors to the Proposed Development in relation to migration of soil or groundwater contamination.

Impacts on Flora and Fauna

12.6.36 The Proposed Development includes areas of landscaping around the margins of the Site. Whilst Site operations are not anticipated to be undertaken in the areas of landscaping, spillages could potentially occur and runoff into the areas of soft landscaping or to surrounding habitats and infiltrate into the ground.

12.6.37 The sensitivity of the flora and fauna is considered to be low. The magnitude of impact prior to the implementation of the mitigation measures is considered to be low. Therefore the effect on flora and fauna during the operational phase of the Proposed Development is considered to be negligible adverse (not significant) in relation to soil contamination.

Decommissioning Phase

Table 12.10: Summary of Impacts and Effects during the Decommissioning Phase (in the absence of development design and impact avoidance measures)

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT
Made Ground and soil derived leachate	Demolition workers: exposure to contaminants, dust and vapours	High	Very low	Minor adverse (not significant)
	Controlled waters (surface water): reduction in ground water / surface water quality due to uncontrolled release of pollutants	High	Medium	Major adverse (significant)
	Controlled waters (groundwater): migration of contaminated water through preferential pathways to groundwater in underlying aquifer.	High	Very low	Minor adverse (not significant)
	Off-Site receptors: exposure to contaminants, dust and vapours.	Medium	Low	Minor adverse (not significant)
	Controlled waters (surface water): migration to surface watercourses	High	Medium	Major adverse (significant)
Ground water	Controlled waters: lateral migration through aquifer	High	Low	Moderate adverse (significant)
	Off-Site receptors: migration of groundwater vapours	Medium	Low	Minor adverse (not significant)
Ground gas	Off-Site receptors: ground gas migration caused by ground disturbance during decommissioning works	Medium	Low	Minor adverse (not significant)

Impacts on Demolition Workers

12.6.38 During the decommissioning phase of the Proposed Development, the demolition workers are potentially at risk of short term acute exposure to potential contaminants in Made Ground via dermal, inhalation and ingestion pathways.

12.6.39 During the decommissioning phase of the Proposed Development, the use of heavy equipment and activities such as excavation, backfilling and compaction may disturb the soil and mobilise potentially contaminated materials if found to be present.

12.6.40 In addition demolition workers may be exposed to ground gases when decommissioning in confined spaces, from on-Site sources (e.g. Made Ground material).

12.6.41 The sensitivity of construction workers has been classed as high and the magnitude of the impact is very low as mandatory PPE will be worn. Therefore, the effect on construction workers during the decommissioning phase of the Proposed Development is considered to be minor adverse (not significant).

Impacts on Controlled Waters

12.6.42 The groundwater underlying the Site is considered to be of high sensitivity. The superficial Tidal Flat Deposits are designated by the Environment Agency as an Unproductive Aquifer with the Flamborough Chalk designated as a Principal Aquifer. The Tidal Flat Deposits may provide some protection to the underlying Principal Aquifer, limiting migration of contaminants from the surface.

12.6.43 Should any dewatering of excavations for the Proposed Development be required during the decommissioning phase, storage and disposal of the water will comply with current regulations.

12.6.44 The main surface water features which may be impacted by decommissioning of the Proposed Development are:

- the Humber Estuary approximately 175 m east of the Main Development area;
- drainage channels around the majority of the perimeter of the Site;
- the two surface water bodies within the Main Development Area (the new attenuation pond constructed within the Main Development Area and the new ecological mitigation pond constructed to the west of the South Humber Bank Power Station).

12.6.45 The sensitivity of surface water resources is classed as high and the magnitude is medium. The sensitivity of groundwater resources is classed as high and the magnitude very low to low. Therefore, in the absence of mitigation, during the decommissioning phase, the effects on controlled waters are considered to be moderate adverse (significant) in relation to surface waters and minor adverse (not significant) to moderate adverse (significant) in relation to groundwater.

Impacts on Off-site Receptors

12.6.46 The main off-Site human receptors are considered to be commercial/ industrial workers in the Study Area.

12.6.47 Workers and visitors to these areas are at risk from wind-blown dust and subsequent inhalation or direct contact with dusts of vapour generated by the decommissioning activities.

12.6.48 The sensitivity of the receptors is medium and the magnitude of impact is low. Therefore, the effect on off-Site receptors is considered to be minor adverse (not significant).

12.7 Mitigation and Enhancement Measures

12.7.1 Mitigation measures for geology, hydrogeology and land contamination required for the Proposed Development are described in Section 12.5 Development Design and Impact Avoidance. Residual effects after these measures are adopted are set out in Section 12.9

12.8 Limitations or Difficulties

12.8.1 This chapter relies on the information contained in previous desk study (AECOM, 2018) and the Site Protection and Monitoring Programme (SPMP) for South Humber Bank Power Station (RSK, 2007) and Site Protection and Monitoring Programme Review for South Humber Bank Power Station (Ford Consulting Group, 2011).

12.8.2 Additional ground investigation works will be undertaken prior to detailed design and construction to provide the additional site specific data required to inform foundation design and site specific human health risk assessment and controlled waters risk assessments.

12.9 Residual Effects and Conclusions

12.9.1 Tables 12.11, 12.12 and 12.13 provide a summary of residual effects for the construction, operational and decommissioning phases of the development respectively following the implementation of the design and impact avoidance measures set out in Section 12.5. No significant residual effects are anticipated as a result of the Proposed Development.

Table 12.11: Summary of Residual Effects during Construction Phase following Adoption of Mitigation/Impact Avoidance

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
Soil resource	Topsoil: loss / deterioration of soil resource	Medium	Low	Minor adverse (not significant)	See Section 12.5	Minor adverse (not significant)
Made Ground and soil derived leachate	Construction workers: exposure to contaminants, dust and vapours	High	Very low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters (surface water): reduction in ground water / surface water quality due to uncontrolled release of pollutants	High	Medium	Major adverse (significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters (groundwater): migration of contaminated water through preferential pathways (such as piling) to groundwater in underlying aquifer.	High	Low	Moderate adverse (significant)	See Section 12.5	Minor adverse (not significant)
	Development infrastructure: chemical attack on buried structures such as concrete; permeation of water pipes by contaminants.	Medium	Medium	Moderate adverse (significant)	See Section 12.5	Minor adverse (not significant)

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
	Off-Site receptors: exposure to contaminants, dust and vapours.	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Flora and fauna: migration of contaminants to ecological receptors	Medium	Medium	Moderate adverse (significant)	See Section 12.5	Negligible adverse (not significant)
Ground water	Controlled waters (surface water): migration to surface watercourses	High	Low	Moderate adverse (significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters: lateral migration through aquifer	High	Low	Moderate adverse (significant)	See Section 12.5	Minor adverse (not significant)
	Off-Site receptors: migration of groundwater vapours	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
Ground gas	Construction workers: accumulation of ground gas in confined spaces – asphyxiation and explosion risks	High	Medium	Major adverse (significant)	See Section 12.5	Negligible adverse (not significant)

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
	Development infrastructure: explosion risk	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Off-Site receptors: ground gas migration caused by ground disturbance during construction works	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
Ground instability	Development infrastructure (e.g settlement):	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)

Table 12.12: Summary of Residual Effects during the Operational Phase following Adoption of Mitigation/Impact Avoidance

SOURCE	DESCRIPTION OF RESOURCE / RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
Made Ground and soil derived leachate	Future site users (workers and visitors): exposure to contaminants, dust and vapours	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Maintenance workers: exposure to contaminants, dust and vapours	High	Very low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters (surface water): reduction in surface water quality due to uncontrolled release of pollutants	High	Medium	Major adverse (significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters (groundwater): migration of contaminated water through preferential pathways (such as piled foundations) to groundwater in underlying aquifer.	High	Low	Moderate adverse (significant)	See Section 12.5	Minor adverse (not significant)

SOURCE	DESCRIPTION OF RESOURCE / RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
	Development infrastructure: chemical attack on buried structures such as concrete; permeation of water pipes by contaminants	Low	Medium	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Off-Site receptors: exposure to contaminants, dust and vapours	Medium	Very low	Negligible adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Flora and fauna: migration of contaminants to other ecological receptors	Low	Low	Negligible adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
Ground water	Controlled waters (surface water): migration to surface watercourses	High	Medium	Major adverse (significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters: lateral migration through aquifer	High	Low	Moderate adverse (significant)	See Section 12.5	Minor adverse (not significant)
	Off-Site receptors: migration of groundwater vapours	Medium	Very low	Negligible adverse (not significant)	See Section 12.5	Negligible adverse (not significant)

SOURCE	DESCRIPTION OF RESOURCE / RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
Ground gas	Future site users (site workers and visitors): accumulations of ground gas in confined spaces	Medium	Very low	Negligible adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Development infrastructure: explosion risk	Low	Low	Negligible adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Off-Site receptors: migration of ground gas	Medium	Very low	Negligible adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
Ground instability	Development infrastructure (e.g. settlement):	Medium	Medium	Moderate adverse (significant)	See Section 12.5	Negligible adverse (not significant)

Table 12.13: Summary of Impacts and Effects during the Decommissioning Phase following Adoption of Mitigation/Impact Avoidance

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
Made Ground and soil derived leachate	Demolition workers: exposure to contaminants, dust and vapours	High	Very low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters (surface water): reduction in ground water / surface water quality due to uncontrolled release of pollutants	High	Medium	Major adverse (significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters (groundwater): migration of contaminated water through preferential pathways to groundwater in underlying aquifer.	High	Very low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Off-Site receptors: exposure to contaminants, dust and vapours.	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
	Controlled waters (surface water): migration to surface watercourses	High	Medium	Major adverse (significant)	See Section 12.5	Negligible adverse (not significant)

SOURCE	DESCRIPTION OF RESOURCE/ RECEPTOR AND IMPACT	SENSITIVITY/ IMPORTANCE OF RESOURCE/ RECEPTOR	MAGNITUDE OF IMPACT	INITIAL CLASSIFICATION OF EFFECT	IMPACT AVOIDANCE MEASURES	RESIDUAL EFFECTS
Ground water	Controlled waters: lateral migration through aquifer	High	Low	Moderate adverse (significant)	See Section 12.5	Negligible adverse (not significant)
	Off-Site receptors: migration of groundwater vapours	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)
Ground gas	Off-Site receptors: ground gas migration caused by ground disturbance during decommissioning works	Medium	Low	Minor adverse (not significant)	See Section 12.5	Negligible adverse (not significant)

12.10 References

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