

A47 North Tuddenham to Easton Dualling

Scheme Number: TR010038

Volume 6

6.1 Environmental Statement **Chapter 9 - Geology and Soils**

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed
Forms and Procedure) Regulations 2009

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Infrastructure Planning

Planning Act 2008

**The Infrastructure Planning
(Applications: Prescribed Forms and
Procedure) Regulations 2009**

The A47 North Tuddenham to Easton
Development Consent Order 202[x]

**ENVIRONMENTAL STATEMENT CHAPTER 9
GEOLOGY AND SOILS**

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Author:	A47 North Tuddenham to Easton Dualling Project Team, Highways England

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9. Geology and soils

9.1. Introduction

- 9.1.1. Highways England (the Applicant) has submitted an application for an order to grant a development consent order (DCO) for the North Tuddenham to Easton Dualling Scheme (hereafter referred to as ‘the Proposed Scheme’). The Proposed Scheme comprises the dualling of a section of the A47 between North Tuddenham and Easton, including the creation of two grade separated junctions (Wood Lane junction and Norwich Road junction), associated side road alterations and walking, cycling and horse-riding connections. This section of A47 road is currently unable to cope with the high traffic volume and there are limited opportunities to overtake slower moving vehicles on the single carriageway. This section of the A47 also has a poor safety record. The Proposed Scheme aims to reduce congestion related delay, improve safety, improve journey time reliability and increase the overall capacity of the A47. Full details of the Proposed Scheme are provided in Environmental Statement Chapter 2 (The Proposed Scheme) **(TR010038/APP/6.1)**.
- 9.1.2. Under the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017, the Proposed Scheme is an Environmental Impact Assessment (EIA) development and as such requires submission of an Environmental Statement (ES) presenting the likely significant environmental effects of the Proposed Scheme.
- 9.1.3. As part of the EIA process, this ES chapter reports the potential significant effects for Geology and Soils as a result of the Proposed Scheme. This assessment includes a review of the existing baseline conditions, consideration of the potential impacts and identification of proportionate mitigation and enhancement.
- 9.1.4. The approach to this assessment follows the Scoping Report (September 2019) **(TR010038/APP/6.5)** and subsequent agreed Scoping Opinion (November 2019) for the Proposed Scheme **(TR010038/APP/6.6)**.
- 9.1.5. This chapter text is supported by the following appendices:
- Appendix 9.1 - Hierarchy of Screening Criteria for Generic Quantitative Risk Assessment **(TR010038/APP/6.3)**
 - Appendix 9.2 - Agricultural Land Classification report **(TR010038/APP/6.3)**

9.2. Competent expert evidence

- 9.2.1. The competent expert is a contaminated land specialist (BSc, MSc, SoBRA Accredited Risk Assessor, Chartered Waste Manager, Member Royal Society

Chemistry) with 19 years of experience in environmental protection, contaminated land, risk assessment and EIA. They have experience of several large-scale Highways England Schemes including the A1 in Newcastle, M25 and the A63 in Hull.

- 9.2.2. A second competent expert is also a Fellow of the Royal Society of Chemistry and Specialist in Land Condition (SILC) with over 30 years' experience with environmental advice.
- 9.2.3. The agricultural land sections and appendix have been prepared by an Agricultural Land Classification Consultant and an EIA Consultant. The Agricultural Land Classification Consultant is qualified as a Master of Science in Soil Science and over five years' experience. The EIA Consultant is qualified as a Master of Science in Environmental Assessment and Management and over five years' experience producing agricultural chapters for EIA's.
- 9.2.4. They have used their knowledge and professional judgement in identifying the likely significant impacts associated with the Proposed Scheme and providing technical guidance through the assessment process.

9.3. Legislation and policy framework

- 9.3.1. The main legislative framework for the geology and soils chapter (including contaminated land and soils as a national resource) includes the following regulations, guidance, standards and best practice:

Table 9-1: Summary of legislation, regulations, standards and best practice

Legislation or regulation	Summary
Environmental Protection Act 1990 (as amended by the Environment Act 1995)	<p>Part IIA of this Act provides a framework for the definition, identification and remediation of contaminated land.</p> <p>Central to the assessment of potentially contaminated land is the concept of a Significant Pollutant Linkage, i.e. a significant connection between a source of contamination and a sensitive receptor via an appropriate environmental pathway.</p> <p>The Part IIA regime is underpinned by the core principles of the 'polluter pays' and that land must be suitable for use.</p>
Environmental Protection (Duty of Care) Regulations 1991 (as amended 2003)	<p>These regulations impose a duty of care on persons who produce, store, carry, treat or dispose of controlled waste or, as a broker, has control of such waste. The duty requires such persons to ensure that there is no unauthorised or harmful deposit, treatment or disposal of the waste, to prevent the escape of the waste from their control or that of any other person, and on the transfer of the waste to ensure that the transfer is only to an authorised person or to a person for authorised transport purposes and that a written description of the waste is also transferred.</p>

Legislation or regulation	Summary
<p>Land contamination: risk management. Environment Agency, October 2020</p>	<p>The Land Contamination Risk Management guidance details how to assess and manage risks from land contamination. The guidance covers the use of a tiered approach to risk assessment:</p> <p>Stage 1: Risk assessment</p> <p>Stage 2: Options appraisal</p> <p>Stage 3: Remediation and verification</p> <p>The guidance applies to risks to human health, drinking water supplies, groundwater and surface water, soils ecosystems and property.</p>
<p>Contaminated Land Risk Assessment – A Guide to Good Practice C552 (CIRIA, 2001)</p>	<p>The C552 report examines risk assessment of contaminated land and the key elements of risk assessment practices and procedures. The guide describes the stages involved in identifying risks and assessing their significance.</p>
<p>The Contaminated Land (England) (Amendment) Regulations 2012</p>	<p>This regulation amends the contaminated land (England) regulations 2006 to provide stronger protection of controlled waters. This is an extension of the existing regulations which is designed to prevent land from being contaminated and to tackle existing contamination.</p>
<p>The Environmental Damage (Prevention and Remediation) (England) Regulations 2015</p>	<p>This regulation covers environmental liability with regard to the prevention and remedying of environmental damage. It specifies the types of damage to a protected species or natural habitat, a site of special scientific interest, water or land which constitute environmental damage.</p> <p>The regulation also deals with prevention of environmental damage, remediation of damage, and recovery of costs.</p>
<p>The Environmental Permitting (England and Wales) Regulations 2016 as amended</p>	<p>The environmental permitting regime requires those carrying out activities that release emissions to land, air and water, or that involve certain waste types, to hold an environmental permit.</p>
<p>Code of Practice for the Sustainable Use of Soils on Construction Sites, (Department for Environment, Food and Rural Affairs (Defra), 2009)</p>	<p>Comprises a code of practice for the sustainable use of soils on construction sites, to assist anyone involved in the construction industry to protect the soil resources with which they work. Outlines current guidance and legislation concerning the use of soil in construction projects, offering stage by stage guidance on the use, management and movement of soil on site.</p>
<p>Guide to assessing development proposals on agricultural land (Natural England, 2018)</p>	<p>This guide explains how local planning authorities can assess proposals to protect the best and most versatile (BMV) agricultural land from inappropriate and unsustainable development.</p>
<p>Agricultural Land Classification: protecting the best and most versatile agricultural land. (TIN049). Second edition (Natural England, 2012)</p>	<p>This note explains the Government Policy to protect agricultural land and the Agricultural Land Classification system and uses.</p>

Legislation or regulation	Summary
The Infrastructure Planning (EIA) Regulations 2017	These regulations implement the requirements of the Environmental Impact Assessment (EIA) Directive (85/337/EEC) for EIA procedures in the context of the nationally significant infrastructure regime.
Design Manual for Roads and Bridges (DMRB) LA 104 Environmental assessment and monitoring, Highways England 2019 (Revision 1)	DMRB LA 104 sets out the requirements for environmental assessment of projects, including reporting and monitoring of significant adverse environmental effects, applying a proportionate and consistent approach using best practice and ensuring compliance with relevant legislation. The approach to deriving impact significance from receptor value and magnitude of effects in DMRB LA 109 is undertaken in accordance with LA 104.
Design Manual for Roads and Bridges (DMRB) LA 109 Geology and Soils (and associated supporting standards), Highways England	DMRB LA 109 sets out the requirements for assessing and reporting the effects of highway projects on geology and soils, applying a proportionate and consistent approach using best practice and ensuring compliance with relevant legislation.

9.3.2. The Proposed Scheme will adhere to guidance detailed in the Planning Policy documents summarised in Table 9-2:

Table 9-2: Summary of planning policy

Legislation or regulation	Summary
National Policy Statement for National Networks (NPS NN) (Department for Transport, 2014)	NPS NN sets out the Government's vision and policy for the future development of the Nationally Significant Infrastructure Projects (NSIP) on the national road and rail networks in England, and provides the basis for the examination by the Examining Authority and decisions by the Secretary of State.
National Planning Policy Framework (Ministry of Housing, Communities & Local Government, 2019)	The National Planning Policy Framework sets out the Government's planning policies for England and how these are expected to be applied. It provides a framework within which locally-prepared plans for housing and other developments can be produced.
South Norfolk Local Plan Development Management Policies Document. South Norfolk Council, 2015.	The Development Management Policies document forms part of a set of documents that together constitute a local plan for the future development of the South Norfolk area. It sets out policies which will help the local authority promote sustainable development and help determine planning applications. Policy DM 2.8 Equestrian and other changes of use of agricultural land seeks to ensure that development of agricultural land is appropriate and necessary. Policy DM 3.14 Pollution and, health and safety includes the following guidance on contaminated land; <ul style="list-style-type: none"> • Land should be suitable for the new use, ensuring that both human health and the environment are safeguarded from unacceptable risk. Sites which are known or suspected to be contaminated should be identified at an early stage. • For such sites, an assessment by a competent person should be submitted with the application determining whether or not the site is contaminated and demonstrating adequate remediation as appropriate for the proposed use. Where the extent or existence of contamination is unclear a precautionary approach should be taken.

9.4. Assessment methodology

- 9.4.1. The following section describes the methodology used to determine the likely significant effects on geology and soils as a result of the Proposed Scheme.
- 9.4.2. The assessment has been undertaken in accordance with the methodology presented in LA 109 Geology and soils.
- 9.4.3. The guidance provides a framework for assessing and managing the effects on geology and soils as a result of the Proposed Scheme. These include consideration of the:
- effects on bedrock and superficial geology including geological designations and sensitive or valuable non-designated features
 - effects on soil resources
 - effects on agricultural land
 - effects from contamination in soils on human health and surface water and groundwater
- 9.4.4. As part of the scoping exercise, impacts to bedrock and superficial geology have been scoped out of this geology and soils assessment as the function or quality of the soils as a resource, outside of their function for agriculture, is not likely to be affected by the Proposed Scheme (see Table 9-3). This is in line with guidance in DMRB LA 109.

Update to guidance and scope of assessment

- 9.4.5. This chapter follows the latest DMRB LA 109 guidance issued in October 2019, which was published after the date of the Scoping Report (September 2019) (**TR010038/APP/6.5**). A Preliminary Environmental Information Report (PEIR) was produced (Sweco, February 2020)¹ updating geology and soils information in light of the new guidance and a summary of the revised scope is presented in Table 9-3.

Table 9-3: Summary of proposed scope

Scoping question	Comment	Scope in?
Is the project likely to affect designated geological sites (statutory or non-statutory)?	No statutory or non-statutory sites recorded within the proposed construction boundary.	No

¹ https://highwaysengland.citizenspace.com/he/a47-north-tuddenham-to-easton-february/supporting_documents/A47%20North%20Tuddenham%20to%20Easton%20%20Preliminary%20Environmental%20Information%20Report%20PEIR.pdf

Scoping question	Comment	Scope in?
Is the project likely to affect the function or quality of soil as a resource?	<p>According to DMRB LA 109, soil function is defined as ‘<i>The ability of soil to provide a range of environmental services, such as the support of vegetation growth, ecological habitats and biodiversity</i>’</p> <p>The primary function of the soils within the study area is considered to relate to its use for agriculture purposes, although soils within the study area also provide some other environmental services as there are also wooded areas within the study area. The large majority of the land however is agricultural.</p>	Yes
Is the project likely to affect agricultural land classified as best and most versatile (BMV) or prime land?	The Proposed Scheme impacts areas of agricultural land classified as BMV (that is land that can best deliver future crops for food and non-food uses). This includes agricultural land classified as Grade 2 and Grade 3a agricultural land under the Agricultural Land Classification (ALC) system.	Yes
Is the project likely to disturb historical contamination?	<p>Historical mineral working pits are considered as the predominant former land use with a potential to give rise to localised soil and groundwater contamination. Other plausible sources comprise residues of petroleum hydrocarbons and chemicals accidentally released from vehicles although the Envirocheck report records no pollution incidents associated with spillage of vehicle fuel or chemical loads.</p> <p>Localised potential contamination sources comprise the graveyard’s at St. Andrew Church, Honingham and St. Peter’s Church, Easton, a timber yard, sewage treatment works, and Mooney’s plant hire and building material reclamation yard. It is also possible that minor leaks and spillages of fuel at off-site farms and works, where stored in bulk tanks, may have locally impacted soil and groundwater without giving rise to reported pollution incidents.</p> <p>No significant sources of historical contamination have been identified, however, there is the possibility of unidentified contamination to be present.</p>	Yes
Is the project likely to introduce significant sources of contamination?	No significant sources of contamination are likely to be introduced as part of the Proposed Scheme’s construction.	No

9.4.6. Given the above, the assessment in this chapter will concentrate on contamination and the effects on human health, surface water and groundwater from historical and ongoing potential sources of contamination and impacts to agricultural land as a soil resource and BMV or prime land.

9.4.7. The DMRB LA 109 provides specific guidance on assessing the effects of the Proposed Scheme on agricultural land. The sensitivity and magnitude criteria has therefore been updated since issue of the Scoping Report (TR010038/APP/6.5) in line with the DMRB LA 109 guidance.

Consultation

9.4.8. Consultee comments were received in response to the Scoping Report (2019) (TR010038/APP/6.5). Following changes to DMRB the comments have been

reassessed in light of this update. There are no significant changes to the scope outlined in the Scoping Report therefore no new consultation was undertaken.

- 9.4.9. The consultation comments included requests to include the new Groundwater Source Protection Zone (SPZ) and to assess risks to groundwater, abstractions and surface water given the proximity of construction works to the River Tud and aquifers.
- 9.4.10. Further details of risk mitigation measures for unexploded ordnance (UXO) were also requested as part of the consultation as a medium risk was presented in the specialists' report.
- 9.4.11. The Environment Agency have been contacted with respect to controlled water risks with the details provided in ES Chapter 13 (Road drainage and the water environment) (**TR010038/APP/6.1**).
- 9.4.12. The potential contaminated land risks are addressed through assessment of the ground investigation results against standards from published guidance and regulations. No specific consultation is therefore required for this aspect of the assessment.

Assessment criteria

Sensitivity of receptors

- 9.4.13. Within DMRB LA 109, impacts on geology and soils are assessed by a qualitative comparison, evaluating the sensitivity of particular receptors impacted by the Proposed Scheme and assessment of the magnitude of that impact. The sensitivity of receptors, classes and the range of magnitude criteria are set out in DMRB LA 109.
- 9.4.14. The assessment of the effects of contamination on the identified receptors has been informed by a ground investigation completed in 2020. Effects on groundwater are assessed in ES Chapter 13 (Road drainage and the water environment) (**TR010038/APP/6.1**).
- 9.4.15. The criteria for assessing sensitivity of receptor and magnitude of impact to these receptors is presented in Table 9-4 and Table 9-5 in accordance with LA 109 Geology and soils and LA 113 Road drainage and water environment.

Table 9-4: Sensitivity of receptor

Receptor value (sensitivity)	Description
Very high	Human health: Very high sensitivity land use such as residential or allotments Surface water: Watercourse having a Water Framework Directive (WFD) classification shown in a River Basin Management Plan (RBMP) and $Q_{95} \geq 1.0\text{m}^3/\text{s}$. Site

Receptor value (sensitivity)	Description
	<p>protected/designated under EC or UK legislation (Special Area of Conservation (SAC), Special Protection Area (SPA), Sites of Special Scientific Interest (SSSI), Ramsar site, salmonid water)/Species protected by EC legislation</p> <p>Groundwater: Principal aquifer providing a regionally important resource and/or supporting a site protected under EC and UK legislation. Groundwater locally supports Groundwater dependent terrestrial ecosystems (GWDTE). SPZ 1</p> <p>Soils: ALC grade 1 & 2 or Land Classification for Agriculture (LCA) grade 1 & 2</p>
High	<p>Human health: high sensitivity land use such as public open space</p> <p>Surface water: Watercourse having a WFD classification shown in a RBMP and $Q_{95} < 1.0\text{m}^3/\text{s}$. Species protected under EC or UK legislation</p> <p>Groundwater: Principal aquifer providing locally important resource or supporting a river ecosystem. Groundwater supports a GWDTE. SPZ 2</p> <p>Soils: ALC grade 3a, or LCA grade 3.1</p>
Medium	<p>Human health: medium sensitivity land use such as commercial or industrial</p> <p>Surface water: Watercourses not having a WFD classification shown in a RBMP and $Q_{95} > 0.001\text{m}^3/\text{s}$.</p> <p>Groundwater: Aquifer providing water for agricultural or industrial use with limited connection to surface water. SPZ3</p> <p>Soils: ALC grade 3b or LCA grade 3.2</p>
Low	<p>Human health: low sensitivity land use such as highways and rail</p> <p>Surface water: Watercourses not having a WFD classification shown in a RBMP and $Q_{95} \leq 0.001\text{m}^3/\text{s}$.</p> <p>Groundwater: Unproductive strata</p> <p>Soils: ALC grade 4 & 5 or LCA grade 4.1 to 7</p>
Negligible	<p>Human health: undeveloped surplus land / no sensitive land use proposed</p> <p>Surface water: not applicable for this sensitivity</p> <p>Groundwater: not applicable for this sensitivity</p> <p>Soils: previously developed land formerly in 'hard uses' with little potential to return to agriculture.</p>

Magnitude of impact

9.4.16. The magnitude of impact is a predicted determination of the potential scale of effects and deviation from baseline conditions as a result of the Proposed Scheme. The qualitative impact is determined according to the criteria provided in Table 9-5.

Table 9-5: Magnitude of impact

Magnitude	Description
Major	<p>Human health: Significant contamination identified. Contamination levels significantly exceed background levels and relevant screening criteria (e.g. category 4 screening levels) with potential for significant harm to human health. Contamination heavily restricts future use of land.</p> <p>Surface water: Loss or extensive change to a fishery. Loss of regionally important public water supply. Loss or extensive change to a designated nature conservation site. Reduction in water body WFD classification.</p> <p>Groundwater: Loss of regionally important water supply. Reduction in water body WFD classification.</p> <p>Soils: physical removal or permanent sealing of >20ha of agricultural land</p>
Moderate	<p>Human health: Contaminant concentrations exceed background levels and are in line with limits of relevant screening criteria (e.g. category 4 screening levels). Significant contamination can be present. Control / remediation measures are required to reduce risks to human health / make land suitable for intended use.</p> <p>Surface water: Degradation of regionally important public water supply or loss of major commercial/industrial/agricultural supplies. Contribution to reduction in water body WFD classification.</p> <p>Groundwater: Degradation of regionally important public water supply or loss of significant commercial/ industrial/ agricultural supplies.</p> <p>Soils: physical removal or permanent sealing of 1ha – 20ha of agricultural land; or permanent loss / reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource).</p>
Minor	<p>Human health: contaminant concentrations are below relevant screening criteria (e.g. category 4 screening levels). Significant contamination is unlikely with a low risk to human health. Best practice measures can be required to minimise risks to human health.</p> <p>Surface water: Minor effects on water supplies.</p> <p>Groundwater: Minor effects on an aquifer, GWDTEs and abstractions.</p> <p>Soils: temporary loss / reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource.)</p>
Negligible	<p>Human health: contaminant concentrations substantially below levels outlined in relevant screening criteria (e.g. category 4 screening levels). No requirement for control measures to reduce risks to human health / make land suitable for intended use.</p> <p>Groundwater: No measurable impact upon an aquifer and/or groundwater receptor.</p> <p>Soils: no discernible loss / reduction of soil function(s) that restrict current or approved future use</p>

9.4.17. In assessing whether contaminants in soils or groundwater have potential to cause harm to health or controlled waters requires that a contaminated land risk assessment is undertaken. This is a process by which the actual or potential risks posed by identified hazards to specific receptors are estimated. In the context of evaluation of contaminated land, hazards relate to sources, or potential sources of contamination capable of causing harm. The process of estimating risk from soil contamination is described in guidance documents set out in Land Contamination: Risk Management (LCRM) and related guidance documents. For

the Proposed Scheme a quantitative risk assessment of the measured potential ground contaminants has been undertaken. The findings of the quantitative risk assessment have been used to inform the risk assessment in this Chapter.

- 9.4.18. Generic assessment criteria have been sourced from current published guidance protective of human health and the environment. Appendix 9.1 (TR010038/APP/6.3) provides details on the source and application of these criteria.

Significance of effects

- 9.4.19. The significance of effects will be determined in accordance with Table 3.7, Table 3.8.1 and Section 3.9 of DMRB LA 104.
- 9.4.20. Residual effects that are of moderate, large or very large significance will give rise to significant effects in accordance with Note 3 of the DMRB LA 104.
- 9.4.21. The significance of effects of the Proposed Scheme on receptors is reported in Section 9.10 Assessment of likely significant residual effects.

9.5. Assessment assumptions and limitations

- 9.5.1. Information has been obtained from a number of statutory and non-statutory bodies and reports and external subcontractors.
- 9.5.2. Previous reporting used in this assessment includes the Preliminary Sources Study Report (PSSR) (Amey, 2017), PSSR Addendum (MMSJV, 2018) and Scoping Report (TR010038/APP/6.5).
- 9.5.3. Reported baseline conditions in line with the ground investigation (Soiltechnics, 2020) have been used in this assessment.
- 9.5.4. The ground investigation information is limited to the locations investigated and there is the potential for unidentified contamination to be present outside of investigated locations. Laboratory analysis has been completed to relevant standards.
- 9.5.5. The Environmental Management Plan (EMP) will set out controls to ensure identified risks associated with contamination are appropriately managed and minimised during construction. Additionally, this will set out appropriate measures for dealing with unidentified contamination. Mitigation measures within the EMP shall include best practice environmental management procedures and appropriate waste management.
- 9.5.6. The agricultural baseline is based on an Agricultural Land Classification (ALC) survey carried out in June and August 2020. A small area of land could not be

surveyed because permission to access it was not provided, however, this only constitutes a very small part of the study area (approximately 0.5%) and is unlikely to be subject to permanent land take. Therefore, the absence of access to this area is not considered to act as a limitation to the completion of this assessment.

9.5.7. Due to dry conditions and very firm ground during the ALC survey, some of the soil augers could not be taken to their full depth. In these cases, assumptions were drawn from nearby deeper augers and/or comparable soil description pits. It is considered that there was still sufficient data to provide an accurate grading of the agricultural land.

9.6. Study area

9.6.1. According to Section 3.5 of DMRB LA 109, the study area shall be identified on a project by project basis and using professional judgement. The study area has therefore been defined as:

- The study area for the contamination assessment considers all locations where physical works and ground disturbance would take place (the construction boundary (DCO boundary)).
- The study area also extends to 1km beyond this construction boundary in order to identify any past pollution incidents which may have affected geology and soils within the area and sensitive off-site receptors that could be affected by the Proposed Scheme.
- In terms of agricultural land, the main focus of the assessment is the construction boundary as this covers the temporary and the permanent land take areas.

9.6.2. The assessment of effects therefore considers an appropriate extent from the construction boundary/project boundary including compounds and temporary land take and the gas pipe diversion for the Proposed Scheme as further described in ES Chapter 2 The Proposed Scheme (**TR010038/APP/6.1**). The extents of the study area are shown on Figure 9.1 (**TR010038/APP/6.2**). The Proposed Scheme covers a land area of approximately 299ha.

9.7. Baseline conditions

9.7.1. The majority of the Proposed Scheme lies within undeveloped agricultural land which is currently in use by a number of farms. The existing A47 road infrastructure is the most prominent man-made feature present in the study area.

9.7.2. Baseline conditions for the study area are summarised in Table 9-6 and on Figures 9.2 and 9.3 (**TR010038/APP/6.2**).

Table 9-6: Baseline Data

Aspect	Details
Geology	<p>A basic summary of the geological sequence in the area of the Proposed Scheme is as follows, further details in paragraph 9.7.15 of this chapter.</p> <p>Details on the geology have been obtained from the ground investigation and with reference to the British Geological Survey (BGS) published mapping and lexicon.</p> <p>Superficial Geology</p> <ul style="list-style-type: none"> • Topsoil recorded extensively across the Proposed Scheme • Made ground • Alluvium – clay/silt, sand, gravels and peat • River Terrace Deposits – sand and gravels • Alluvial Fan Deposit – sand • Lowestoft Formation – clay, silt, sand and gravels • Sheringham Cliffs Formation – clay and silt • Happisburgh Glaciogenic Formation – clay, sand and gravelly <p>Bedrock Geology</p> <ul style="list-style-type: none"> • Chalk
Sites of Geological Interest	<p>Historic Quarrying</p> <p>Many disused marl, sand, and gravel pits close to the route alignment are shown on historical Ordnance Survey (OS) maps. A former brick field and associated kiln was previously located close to what is now Fox Lane. Similar features may be present which are not shown on the available historical maps. There are none known of geological interest.</p>
Hydrogeology	<p>The study area is underlain by a Principal Aquifer (Chalk) which is highly permeable.</p> <p>The White Chalk Subgroup has been classified by the BGS aquifer designations as a Principal Aquifer. Principal Aquifers are defined as aquifers that “support water supply and/or river base flow on a strategic scale.” Within the bounds of the proposed site, the aquifer likely provides base flow to the River Tud. The Chalk Principal aquifer provides strategic public water supply, local private water supplies (agricultural purposes) and significant baseflow to rivers.</p> <p>The alluvium, Lowestoft Formation sand and gravels and Sheringham Cliffs Formation sand and gravels are classified by the BGS aquifer designations as Secondary ‘A’ aquifers.</p> <p>Secondary ‘A’ aquifers are defined as “permeable layers capable of supporting water supplies at local rather than strategic scale”. These formations are in good hydraulic connectivity with the underlying bedrock aquifer. Base flow to the River Tud may occur from these aquifers.</p> <p>The Lowestoft Formation (glacial till) is classified by the BGS aquifer designations as a Secondary (undifferentiated) aquifer. Secondary (undifferentiated) aquifer designations are assigned where “the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type”. It is considered that this formation may partially confine the underlying aquifer where thick and less permeable zones occur.</p> <p>Groundwater Vulnerability</p> <p>Groundwater vulnerability varies across the study area. The majority of the Proposed A47 mainline dual carriageway is classified in terms of aquifer vulnerability as “Principal Aquifer Intermediate” and is generally associated with superficial cover of glacial till and alluvium.</p> <p>The eastern section of the Proposed A47 mainline dual carriageway, approximately from Honingham, is classified as “Principal Aquifer High”, and is associated with the higher permeability of the Lowestoft Formation, and the Sheringham Cliffs Formation.</p>

Aspect	Details
	<p>The Proposed A47 mainline dual carriageway is within a groundwater Nitrate Vulnerable Zone (NVZ) at the route's eastern extent, and locally around Honingham.</p> <p>Water Framework Directive</p> <p>Groundwater within the study area is classified under the Broadland Rivers Chalk and Crag groundwater body, which has Poor Chemical and Quantitative status (2016 cycle 2). Objectives are to achieve Good Quantitative status by 2021, and Good Chemical Status by 2027. The waterbody is protected under the Nitrates Directive and is a Drinking Water Protected Area.</p> <p>Water Abstraction and Source Protection Zones</p> <p>The Proposed Scheme crosses a source protection zone (SPZ) 3 (Total Catchment) generally west of Oak Farm, south of Hockering and east of Honingham (Figure 9.3) (TR010038/APP/6.2). This SPZ is associated with major strategic water abstractions at Costessey to the east-northeast of the Proposed Scheme. Any groundworks within the SPZ3 have the potential to affect this abstraction.</p> <p>Another SPZ 3 is present within the 1km study area boundary, located approximately 250m to 1000m north of the Proposed Scheme. This SPZ is associated with public water supply abstractions 4km north of the study area at Lyng and includes a drinking water safeguard zone for groundwater.</p> <p>A new Anglian Water Services public groundwater supply is currently being developed in North Tuddenham. Specific details of this abstraction are unknown, although the assumed SPZ 1 (Inner Zone) spans a 1km stretch directly to the north of the abstraction.</p> <p>There are a number of small and medium private licenced groundwater abstractions within the study area. These are for agricultural and industrial purposes. See ES Chapter 13 (Road drainage and the water environment) (TR010038/APP/6.1) for more information.</p>
Hydrology	<p>Surface Water Features</p> <p>The Proposed Scheme crosses the River Tud, a main river and tributary of the River Wensum Site of Special Scientific Interest (SSSI) and two of its tributaries. There are a number of small ponds within the vicinity of the Proposed Scheme.</p> <p>Surface water features within the vicinity of the Proposed A47 mainline dual carriageway may be partially groundwater dependent and receive base-flow from underlying aquifers. The route option is entirely within a surface water NVZ.</p> <p>Water Framework Directive</p> <p>The entire route option is within the Tud surface waterbody, which is designated as heavily modified. The Tud waterbody achieved its 2015 objectives for Good Chemical Potential and Moderate Ecological Potential, has two linked protected areas (Norfolk Valley Fens and the River Wensum), and is protected under the Nitrates Directive.</p> <p>Surface Water Abstractions</p> <p>There are 6 licenced surface water abstractions within the study area.</p> <p>See Chapter 13 (Road drainage and the water environment) (TR010038/APP/6.1) for more information.</p>
Landfill Records	<p>One historical landfill site has been identified located approximately 400m south of the Proposed A47 mainline dual carriageway at a location within 500m south west of Hockering, accessed from Mill Close. The landfill is Mattishall Landfill, operated by Thomson Brothers, with the licence commencing 31 December 1968. The closure date is not provided. The specified accepted waste type is 'inert'.</p>
Current Land Use and Man-Made Features	<p>The existing A47 road infrastructure is the most prominent man-made feature within Proposed A47 mainline dual carriageway. Most of the route lies within agricultural land.</p> <p>The Proposed A47 mainline dual carriageway follows the existing A47 road for approximately 1km from the start of the alignment to the east of Oak Farm, where it deviates into fields. It then crosses the existing A47 at three locations before re-joining the A47 at the roundabout at Easton.</p>

Aspect	Details
	<p>The Proposed A47 mainline dual carriageway crosses and realigns local roads and tracks, such as; Low Road, Mattishall Lane, Mill Lane, Church Lane, Wood Lane and Blind Lane. There are likely to be underground utility services associated with these roads, however, their exact position is currently unknown.</p> <p>Industrial land use was dominated by local extraction of gravel, clay, marl and sand by quarrying. The scale of this industry meant that many pits have been excavated both along and close to the route. Many of these pits have been infilled as the industry has declined, some have flooded, creating ponds.</p> <p>There is still residential and commercial development in North Tuddenham, Honingham, Hockering and Easton. Additional land uses include a sewage treatment works, two grave yards (St. Andrew's Church Honingham and St. Peter's Church Easton), a scrap yard (Thomson's), garage / fuel station (Hockering Motor Services), a timber yard and a building material reclamation and plant hire firm (Mooney's).</p>
Agricultural	<p>The agricultural land quality within the Proposed Scheme study area is a mixture of Grade 2 (very good quality), Grade 3a (good quality), Grade 3b (moderate quality) and Grade 4 (poor quality) agricultural land. Grade 2 and Grade 3a is considered to be BMV agricultural land. Further information on agricultural soils is provided below and in Appendix 9.2 (TR010038/APP/6.3).</p>
Route History	<p>The historical development of the area had been summarised from historical OS mapping contained within the Envirocheck Report (Amey, 2017).</p> <p>It is understood that a road has been in existence on this alignment since Roman times and has had numerous upgrades, notably in the 1970s and 1980s.</p> <p>The available historical OS maps indicate that the off-line route comprised agricultural fields, rough pasture and woodland with several gravel, clay, marl and sand pits. A brick field with kiln and well were present to the south of the route at Field Lane prior to 1883 and had become disused by circa 1906.</p> <p>Hockering Wood located 500m to the north of the Proposed Scheme was developed as a former WWII munitions store with purpose-built roads and bomb stores. This is now a SSSI.</p> <p>The UXO Threat and Risk Assessment report by 6 Alpha Associates for the study site has rated the overall risk to the Proposed Scheme as 'medium'. This category does not require any risk mitigation measures such as surface clearance or downhole clearance, however, an explosive ordnance disposal engineer should be on call and UXO safety and awareness briefings provided. Therefore, this is not considered further.</p>
Potential Contamination Sources	<p>Historical mineral working pits are considered as the predominant former land use with a potential to give rise to localised soil and groundwater contamination. Other plausible sources comprise residues of petroleum hydrocarbons and chemicals accidentally released from vehicles although the Envirocheck report records no pollution incidents associated with spillage of vehicle fuel or chemical loads.</p> <p>Localised potential sources comprise the graveyards at St. Andrew's Church, Honingham and St. Peter's Church, Easton, a timber yard, sewage treatment works, and Mooney's plant hire and building material reclamation yard. It is also possible that minor leaks and spillages of fuel at off-site farms and works, where stored in bulk tanks, may have locally impacted soil and groundwater without giving rise to reported pollution incidents.</p> <p>Hockering Motor Services, and Mattishall former landfill site are considered to be located at a suitable distance away from the proposed improvements work and, therefore, unlikely to represent a plausible risk.</p> <p>Therefore, the potential sources of contamination which may be present at or near the Proposed Scheme comprise of:</p> <ul style="list-style-type: none"> • former/current industrial/commercial uses • graveyards • residual hydrocarbon contamination from any accidental releases of vehicle fuel or loads

Aspect	Details
	<ul style="list-style-type: none"> • agricultural chemicals within the construction boundary and adjacent land (off-site) • hazardous ground-gas derived from organic alluvial deposits including peat • potentially contaminated groundwater • general made ground • residual contamination from unspecified ground workings <p>These potential sources present theoretical risks to construction materials, ground conditions, site workers, site users, groundwater and the River Tud.</p>

Conceptual Site Model

- 9.7.3. The desk-based information has been used to develop the Conceptual Site Model (CSM) which forms the basis to investigate potential contaminant linkages for the Proposed Scheme via a source-pathway-receptor model. For a source of contamination (or hazard) to present a risk to a receptor (such as construction workers or groundwater), there must be a viable exposure pathway.
- 9.7.4. This source-pathway-receptor model is considered best practice methodology to evaluate environmental risk arising from potential land contamination, according to Department of Environment, Food and Rural Affairs (DEFRA) and Environment Agency guidance documentation (Environment Agency, 2020).
- 9.7.5. This assessment utilises information from the 2020 ground investigations.
- 9.7.6. A risk evaluation has been undertaken by considering the source-pathway-receptor relationship in terms of both the probability (likelihood) that a source-pathway-receptor linkage will occur and the potential consequences of occurrence.

Potential Sources

- 9.7.7. In the context of this study, hazards relate to sources, or potential sources of contamination capable of causing harm. Table 9-7 lists the sources that have been identified.

Table 9-7: Potential Sources

Potential Source	Description
Source 1: Infilled land	<p>The location of the new road extends over and within close proximity to potential small areas of infilled land (ponds, extraction pits and quarries etc).</p> <p>Potential for hydrocarbons, metals, inorganics, asbestos</p>
Source 2: Made ground	<p>Associated with the existing A47 carriageway and associated side roads including vehicle fuels, brake and exhaust products.</p>

Potential Source	Description
Source 3: Commercial/industrial land use	Potentially contaminated materials associated with former and current land uses include a sewage treatment works, two grave yards (St. Andrew's Church Honingham and St. Peter's Church Easton), a scrap yard (Thomson's), garage / fuel station (Hockering Motor Services), a timber yard and a building material reclamation and plant hire firm (Mooney's).
Source 4: Ground Gas	Hazardous ground-gas derived from organic alluvial deposits including peat.

Receptors

9.7.8. Receptors that could be adversely affected by a contaminant are listed in Table 9-8.

Table 9-8: Potential Receptors

Potential Receptor	Description
Human Health	Construction workers – short term duration but potential for higher exposure – medium sensitivity Future site users – A47 users (motorised), pedestrians and cyclists – low sensitivity Off-site receptors – users/occupiers of adjacent land areas; agricultural fields, paths, off-site residents/workers – high to very high sensitivity
Surface Water	The Proposed Scheme crosses the River Tud, a main river and tributary of the River Wensum and two of its tributaries – high sensitivity Land drainage channels present in the locality – high sensitivity Ponds – high sensitivity
Groundwater	Principal aquifer – White Chalk Subgroup – very high sensitivity Secondary A Aquifers – Lowestoft Formation and Sheringham Cliffs Formation – very high sensitivity Secondary undifferentiated aquifer – very high sensitivity Groundwater abstractions – Proposed Scheme crosses a source protection zone (SPZ) 3 (Total Catchment) between Honingham and Easton. Another SPZ 3 is present within the 1km study area boundary, located approximately 250m to 1000m north of the Proposed Scheme – very high sensitivity
Agricultural land	Agricultural land ALC grades 2 to 5 within and in proximity of the Proposed Scheme - Low to very high sensitivity based on land quality.
Ecological	Flora and fauna (including livestock) – low sensitivity* Chapter 8 (Biodiversity) assesses the impacts on these receptors in depth

*There are no ecological designations effected. Therefore soils supporting ecology have been assigned a low sensitivity

Pathways

9.7.9. For a hazard to present a risk to a receptor they must be linked by an exposure pathway. Potential plausible pathways identified include:

- Direct contact with or ingestion of contaminated soils and dusts by humans.
- Inhalation of dusts (including asbestos fibres) by humans.
- Inhalation of ground gas/vapours by people.
- Migration of ground gas/vapours into buildings.
- Leaching/dissolution and migration of contaminants through permeable strata in the unsaturated zone towards the saturated zone.
- Migration of contaminants in the saturated zone towards surface water. Surface run-off towards surface waters, including via local drainage systems.
- Lateral migration of contaminants via groundwater flow.
- Migration of contaminants in the saturated zone towards surface water.
- Surface run-off towards surface waters, including via local drainage systems.
- Uptake by plant roots, ingestion/inhalation of contaminated soil/dust by animals.

9.7.10. The potential active contaminant linkages for the Proposed Scheme are summarised in Table 9-9. Linkages between off-site sources and off-site receptors are not considered.

Table 9-9: Potentially Active Contaminant Linkages

Source	Pathway	Receptor
Source 1: Infilled land - Potential small areas of infilled land (ponds, extraction pits and quarries etc).	Direct contact with soils/dusts	Construction workers
	Inhalation or ingestion of soils/dusts	Future site users
	Inhalation of gas/vapours	Off-site human health receptors
		Agriculture
	Leaching/dissolution of contaminants from made ground	Surface water courses
	Migration of contaminants through permeable strata	(River Tud, tributaries, drainage channels and ponds)
	Migration of contaminants in saturated zone towards surface water	
	Leaching/dissolution of contaminants from made ground	Groundwater
	Migration of contaminants through permeable strata	(Principal aquifer, Secondary aquifers, groundwater abstractions)
	Migration to aquifers	
Source 2: Made ground - associated with the existing A47 carriageway and associated side roads	Direct contact with soils/dusts	Construction workers
	Inhalation or ingestion of soils/dusts	Future site users
	Inhalation of gas/vapours	Off-site human health receptors
		Agriculture

Source	Pathway	Receptor
	Leaching/dissolution of contaminants from made ground Migration of contaminants through permeable strata Migration of contaminants in saturated zone towards surface water	Surface water courses (River Tud, tributaries, drainage channels and ponds)
	Leaching/dissolution of contaminants from made ground Migration of contaminants through permeable strata Migration to aquifers	Groundwater (Principal aquifer, Secondary aquifers, groundwater abstractions)
Source 3: Commercial/industrial land use including graveyards	Direct contact with soils/dusts Inhalation or ingestion of soils/dusts Inhalation of gas/vapours	Construction workers Future site users Off-site human health receptors Agriculture
	Leaching/dissolution of contaminants from made ground Migration of contaminants through permeable strata Migration of contaminants in saturated zone towards surface water	Surface water courses (River Tud, tributaries, drainage channels and ponds)
	Leaching/dissolution of contaminants from made ground Migration of contaminants through permeable strata Migration to aquifers	Groundwater (Principal aquifer, Secondary aquifers, groundwater abstractions)
Source 4: Ground Gas	Migration via permeable strata	Construction workers Future site users Off-site human receptors

Agricultural soils

9.7.11. The ALC system provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. The principal factors influencing agricultural production are climate, site (including relief) and soil. By assessing these factors, it is possible to assign land into one of five land classification grades, Grade 1 land being the highest quality and Grade 5 the lowest quality agricultural land. Grade 3 is sub-divided into Subgrades 3a and 3b, to identify good quality

agricultural land from moderate quality agricultural land (see Appendix 9.2 (TR010038/APP/6.3) for further information on the ALC system).

- 9.7.12. ALC Grades 1, 2 and 3a are classified as Best and Most Versatile (BMV) land. BMV agricultural land is a finite national resource and is given special consideration in national policy and guidance. The Proposed Scheme passes through three districts, Breckland, Broadland and South Norfolk. Based on the Provisional ALC map, Grade 1 agricultural land makes up approximately 6%, Grade 2 approximately 24% and Grade 3 approximately 67% of the agricultural land within Broadland District (the Provisional ALC map does not subdivide Grade 3 land into Subgrades 3a and 3b). Breckland District has no Grade 1 agricultural land and approximately 10% of the agricultural land is Grade 2 and 68% is Grade 3. South Norfolk District similarly has no Grade 1 agricultural land and approximately 10% of the agricultural land is Grade 2, while approximately 82% is Grade 3.
- 9.7.13. An ALC survey was carried out on the Proposed Scheme study area in June and August 2020 in accordance with the MAFF guidelines and the TIN049 guidance. The survey was based on observations at intersects of a 100m grid, giving a sampling density of at least one observation per hectare. During the survey soils were examined via a combination of auger borings and a soil description pit to a maximum depth of 1.2m. The full results of the ALC survey including details on agricultural soils are provided in Appendix 9.2 (TR010038/APP/6.3).
- 9.7.14. The detailed field work carried out for the assessment indicated that the agricultural land quality within the Proposed Scheme footprint is a mixture of Grade 2, Grade 3a, Grade 3b and Grade 4 agricultural land as shown below in Table 9-10. The areas of Grade 2 and Grade 3a agricultural land are considered to be BMV agricultural land and make up approximately 65.7% of the study area.

Table 9-10: ALC grades within the study area

ALC Grade	Total (ha)	Total (%)
Grade 1 (excellent quality)	-	-
Grade 2 (very good quality)	54.3	19.0
Grade 3a (good quality)	133.0	46.7
Grade 3b (moderate quality)	18.4	6.5
Grade 4 (poor quality)	8.9	3.1
Grade 5 (very poor quality)	-	-

ALC Grade	Total (ha)	Total (%)
Non-agricultural (existing A47 road, residential properties, commercial buildings and wooded areas)	69.0	24.2
Urban	-	-
Not surveyed	13.9	4.6
Total	299	100

Contamination baseline

Ground Conditions

9.7.15. The ground investigation (Soiltechnics, 2020) encountered the following typical sequence of strata within the construction boundary:

- Topsoil (proven average of 0.4m thickness with a maximum of 0.9m in thickness).
- Made ground isolated locations (proven as up to 2m in thickness with a maximum of 3.6m).
- River Terrace Deposits are present at a location east of Mattishall Lane, associated with the River Tud proven to depths of between 5.7m and 9.6m.
- Alluvium up to a thickness of 19.5m (average 3.0m) is present at the River Tud and its tributaries, including between Mill Lane and Gypsy Lane.
- Sheringham Cliffs Formation has been proven to be present at the western extents and at the east of the Proposed Scheme.
- Lowestoft Formation is widespread across the route to a depth of up to 23.5m.
- Happisburgh Glaciogenic Formation is recorded east of Taverham Road and St Andrew's Church. It is proven above chalk bedrock.
- The Chalk bedrock is present across the Proposed Scheme and was proven from depths of between 1.8m and 25.0m below ground level at locations east of Hockering and towards Church Lane, and the River Tud respectively. The thickness was not proven, however a recorded maximum thickness of 36m was recorded during the ground investigation.

9.7.16. Occasional areas of made ground were encountered and made ground is proven to a maximum thickness of 2m (average 0.5m) which is limited to coincide with existing roads and infrastructure. Made ground comprises reworked superficial materials mixed with minor amounts of anthropogenic materials including brick, concrete, asphalt, ash and clinker.

- 9.7.17. 'Possible' and 'probable' made ground is described at discrete locations where, although anthropogenic constituents were absent, the in-situ test results and general composition suggest reworked soils associated with possible drain infill and culvert construction and landscaping/planting of trees.
- 9.7.18. Topsoil up to a maximum thickness of 0.9m (average 0.4m) is present across the extent of the Proposed Scheme alignment. It comprises predominantly sandy, gravelly, clay soils. It should be noted that ploughed and reworked topsoil across farmed land has not been recorded as Made Ground and is considered as 'Topsoil' unless visible anthropogenic materials are recorded.
- 9.7.19. Alluvium up to a thickness of 20m (average 3.4m) is present at the River Tud and its tributaries, including between Mill Lane and Gypsy Lane. The alluvium comprised both cohesive (clay/silt) and granular soils (gravelly sand) with cohesive, organic soils limited to near surface locations (<3.0m). Within the alluvial soils, organic soils and peat were recorded locally and to a maximum thickness of 1.4m (average 0.7m).
- 9.7.20. Granular soils associated with Alluvial Fan Deposits (AFD) were observed at a discrete location south of the proposed Wood Lane junction. The presence of AFD indicates that while the AFD extends beyond that indicated by the BGS maps the AFD does not extend as far as to intersect the Proposed Scheme.
- 9.7.21. River Terrace Deposits up to a thickness of 4m are present at a location east of Mattishall Lane, associated with the River Tud. The deposits comprise sand and gravel to depths of between 5.7mbgl and 9.6mbgl.
- 9.7.22. Lowestoft Formation is widespread across the route to a depth of up to 23.5m, occurring between topsoil, made ground and alluvium and the underlying chalk bedrock. Lowestoft Formation displays a full range of grain sizes comprising clay, silt, sand and gravel and is typically clayey near the surface becoming gravelly and chalky at depth. The formation becomes increasingly more interstratified with sands within exploratory holes located to the east of the River Tud.
- 9.7.23. Sheringham Cliffs Formation has been proven to be present at the western extents of the Proposed Scheme and as a 'wedge' at the east of the Proposed Scheme near Church Lane, in line with the available published mapping. It is present to a maximum depth of 13m. East of Church Lane, the Sheringham Cliffs Formation comprises predominantly sand with thin bands of clay and silt.
- 9.7.24. Happisburgh Glaciogenic Formation is recorded at a discrete location to the east of Taverham Road and St Andrew's Church, and is noted to comprise very clayey, very gravelly sand to a depth of 2.3m.

- 9.7.25. Chalk bedrock - The exploratory hole records indicate that the chalk bedrock is present across the entire Proposed Scheme extents with the boundary between the superficial deposits and the chalk bedrock present between elevations of 8m and 30m above ordnance datum (AOD) at locations immediately adjacent to the River Tud, and close to Mill Lane respectively. In general, the chalk profile varies roughly between elevations of 20mAOD to 30mAOD west of the River Tud, to between 10mAOD and 20mAOD eastwards of the River Tud. In depths below ground level, chalk is noted at 1.8m at locations east of Hockering and towards Church Lane, and from 25m at the River Tud. The average depth to the chalk rockhead is 12m. A maximum thickness of 36m was proven within the Proposed Scheme extents by the recent ground investigation at locations close to the River Tud. The base of the chalk was not proven. Chalk is described as completely weathered and structureless, and is recovered as variably clayey, and gravelly, silt and gravel.
- 9.7.26. Groundwater was encountered across the Proposed Scheme generally confined to granular strata and the chalk aquifer. Sub-artesian groundwater was frequently observed. Artesian groundwater conditions were present at locations within proximity to the River Tud crossing and at the proposed embankment approximately south east of Hockering. Groundwater levels in the chalk were reported as between 40.5m above ordnance datum (AOD) and 20.5mAOD. Groundwater levels within the superficial deposits range between 48 and 21.8mAOD. Full details of the hydrogeological regime are presented in ES Chapter 13 (Road drainage and the water environment) (TR010038/APP/6.1).

Human Health

- 9.7.27. Chemical analysis results have been compared with generic assessment criteria (GAC) protective of a commercial/industrial end use and a Public Open Space (park). These are considered the most appropriate assessment criteria to assess risks to future workers and site occupiers during the construction phase and subsequent future land use.
- 9.7.28. Concentrations exceeding the relevant criteria were not recorded for the commercial screening.
- 9.7.29. Concentrations exceeding the human health criteria were recorded in shallow samples located at the existing A47 junction with Taverham Road. The sample is described as a made ground with gravel of flint, chalk and asphaltic concrete. A hydrocarbon odour was recorded at 0.3mbgl from the asphaltic concrete and the hole was terminated on an asphaltic concrete obstruction. The exceedance is likely due to the presence of asphaltic concrete. The recorded concentrations were slightly elevated above the relevant criteria. Given the depth to the exceedances and the presence of material above which does not exceed the

criteria this location is not considered to pose an unacceptable risk to human health.

- 9.7.30. The remaining area within the construction boundary is considered to present a negligible risk to human health given the lack of concentrations exceeding the relevant assessment criteria.
- 9.7.31. Asbestos was not detected in any of the 22 made ground soil samples which were screened and therefore the risk from asbestos is considered to be very low.
- 9.7.32. Stockpiles of suspected asbestos cement sheeting were identified. These are potentially illegal fly tipped wastes and their presence and removal will be noted on the construction phase EMP.
- 9.7.33. The results of the assessment identified overall potential risks to human health to be low from existing materials present within the construction boundary.

Controlled waters - leachability

- 9.7.34. Risks to groundwater from the Proposed Scheme have been assessed through comparing the chemical laboratory data against appropriate generic assessment criteria. The UK Drinking Water Standards (DWS) and World Health Organisation (WHO) guidelines for drinking water quality (2011) have been used for protection of the identified potentially sensitive aquifer receptors.
- 9.7.35. Risks to surface water from the Proposed Scheme have been assessed through comparing the chemical laboratory data against appropriate generic assessment criteria. The Water Framework Directive criteria has been used for protection of the identified potentially sensitive receptor, the River Tud.
- 9.7.36. Elevated leachable concentrations of ammoniacal nitrogen as NH_4 above the criterion were recorded in limited samples. These exceedances were generally observed in topsoil and are likely to be as a result of agricultural activities. These concentrations are not considered to be derived from ground contamination related sources but maybe part of more general diffuse sources of agricultural impacts.
- 9.7.37. Negligible concentrations of metals exceeding the criteria were recorded in isolated locations. These are potentially reflective of elevated natural background soil concentration and are therefore not considered to pose an unacceptable risk to groundwater as a result of construction of the Proposed Scheme.
- 9.7.38. Concentrations of PAHs, TPH and EPH have been identified at elevated concentrations above the relevant criteria in one sample located at the existing A47 junction with Taverham Road. The sample is described as a made ground

with gravel of flint, chalk and asphaltic concrete. A hydrocarbon odour was recorded at 0.3mbgl from the asphaltic concrete. These elevated concentrations are likely to be related to the presence of the asphaltic concrete associated with the existing road construction. Management of existing roadway construction materials will be considered in the construction phase EMP and are not considered likely to present an impact to groundwater during the construction phase activities.

9.7.39. Considering the following site-specific factors, the potential for the identified exceedances to pose an unacceptable risk to controlled waters is considered Low:

- The raised concentrations (above laboratory limit of detection (LOD)) are generally slightly elevated above the relevant criteria and within one order of magnitude of the criteria.
- No significant amounts of made ground with elevated concentrations of contaminants have been identified.
- Visual and olfactory evidence of contamination was not recorded
- The majority of samples were from natural strata and are therefore likely to be reflective of natural background levels.
- Assuming the works are undertaken in an appropriate manner, with risks to controlled waters mitigated as detailed in the EMP. Mitigation measures shall include (but are not limited to) appropriate site management, for example; management of stockpiles of excavated soils, groundwater encountered in excavations and surface water drainage.

Controlled waters - groundwater

9.7.40. Concentrations of potential contaminants recorded in groundwater from samples obtained from eight monitoring boreholes across the Proposed Scheme were generally below the assessment criteria. Where concentrations exceeded these criteria (ammoniacal nitrogen as NH_4 and metals), the exceedances were negligible and therefore do not pose an unacceptable risk to controlled waters.

9.7.41. Protection of controlled waters must be maintained throughout site works. Protection measures may include but are not limited to:

- Appropriate environmental risk assessments.
- Suitable stockpile management (located on hardstanding, covered and bunded where applicable).
- Provision of suitable spill kits.
- Plant refuelling and storage of chemicals and fuels on drip trays away from watercourses, ditches and drains.
- Drain or ditch protection (sandbags, booms, boards etc).

- Management and appropriate disposal and or re-use of existing road construction materials.

Ground Gas

- 9.7.42. Ground gas monitoring was undertaken at 37 locations between March 2020 and May 2020 covering the construction boundary.
- 9.7.43. Based on the results from the 2020 ground investigations, no ground gas hazards have been identified associated within the construction boundary.

Future Baseline

- 9.7.44. The future baseline scenario outlines the likely evolution of the current state of the environment without the Proposed Scheme. This allows for the identification of effects and impacts of the Proposed Scheme against the baseline at both the commencement of construction and operation of the completed Scheme.

Construction year baseline (2023)

- 9.7.45. Potential changes to the identified baseline conditions for geology and soils, based on data in the Breckland Adopted Local Plan (Breckland, 2019), Broadland Local Plan (Broadland, 2016) and South Norfolk District (2014) are limited to planned developments near the DCO boundary. Planned development in the vicinity of the Proposed Scheme may result in changes to the soils or identification of contamination. Off-site developments would be required to adhere to current planning policy guidance and best practice such that any contamination identified would, if required, be subject to remediation or mitigation.
- 9.7.46. This assessment does not consider there to be any material or significant changes to the baseline ground conditions identified in this future construction year baseline assessment. This is because no developments have been identified that would affect the baseline conditions for geology and soils.

Operational year baseline (2025)

- 9.7.47. The Greater Norwich Local Plan (emerging) (2020) and adopted local plans detailed above identify potential development sites along the current A47. The Greater Norwich Local Plan is currently at consultation stage and therefore these potential development sites have not been assessed fully and should take into account the Proposed Scheme.
- 9.7.48. Given the locations of these potential development sites, this assessment does not consider there to be any material or significant changes to the baseline ground conditions identified in this future operational year baseline assessment.

9.8. Potential impacts

9.8.1. The following sections identify the potential impacts on geology and soils that may occur as a consequence of the Proposed Scheme. The potential effects are identified and assessed assuming no mitigation.

Construction

9.8.2. Potential negative construction impacts in terms of contamination include the following:

- potential emission / pollution from construction activities
- potential to mobilise contaminants in soils and groundwater as a result of ground disturbance. Elevated PAH and TPH concentrations identified at DP419 located at the existing A47 junction with Taverham Road
- generation of dust
- alteration of potential for contaminants to mobilise (leach) from soils during construction
- increased potential for contaminants to enter surface water through drainage or surface run-off
- introduction of fuels, chemicals and fluids relating to construction activities
- increased potential for exposure to contaminants to human health receptors due to exposure of contaminated materials during construction
- creation of preferential pathways such as piles penetrating through strata or via service corridors for migration of potential contaminants to groundwater

9.8.3. With regards to geology and soil resources the following construction activities have the potential for negative impacts:

- creation of temporary access tracks and traffic diversions resulting in compaction or sealing of soils
- land-take both temporary and permanent
- impacts from proposed new / removed facilities such as severance of a path or habitat
- stripping and storage of soils, topsoil and materials leading to damage of these resources
- loss of agricultural land

9.8.4. Table 9-11 shows the approximate permanent and temporary land take associated with the Proposed Scheme, based on the preliminary design.

Table 9-11: Agricultural land take

ALC grade	Approximate permanent land take (ha)	Approximate temporary land take (ha)	Approximate total construction land take (ha)
Grade 2	18.9	35.4	54.3
Grade 3a	32.2	100.8	133.0
Grade 3b	6.2	12.2	18.4
Grade 4	0.6	46.0	8.9

9.8.5. Not all of the permanent land take would be covered in hardstanding. Although this land would be lost to agriculture, the soil resources would still be used for landscaping as part of the Environmental Masterplan (**TR010038/APP/6.8**). However, as none of this land would be retained for commercial agriculture, it is all considered as lost agricultural land for the purpose of this assessment.

9.8.6. Compacted soil reduces water infiltration and can lead to increased rates of surface water run-off and associated soil erosion as well as reduced agricultural productivity. Poor reinstatement of any temporary land take would lead to a loss in agricultural land quality.

Operational

9.8.7. The loss of agricultural land occurs during the construction phase although it is acknowledged that some would be lost permanently to the Proposed Scheme. However, no additional loss of agricultural land is expected during the operational phase. Therefore, it is anticipated that the Proposed Scheme, once constructed will have limited future interaction with geology and soils.

Determination of magnitude of potential impact

9.8.8. The magnitude of potential impacts has been determined based on the baseline conditions identified and are presented in Table 9-12.

Table 9-12: Determination of the magnitude of potential impact

Receptor	Magnitude	Reasoning
Users/occupiers of A47	Negligible adverse	Users of the existing A47 will be present during construction and during operation. Concentrations of contaminants and ground gases on the Proposed Scheme are at levels unlikely to cause risk to human health.
Users/occupiers of adjacent land areas; agricultural fields, paths	Negligible adverse	Human health receptors will be present in the areas surrounding the Proposed Scheme. Concentrations of contaminants and ground gases on the Proposed Scheme are at levels unlikely to cause risk to human health.
Off-site residential receptors	Negligible adverse	Residential properties in close proximity to the Proposed Scheme. Concentrations of contaminants and ground gases on the Proposed Scheme are at levels unlikely to cause risk to human health.
Construction workers	Minor adverse	Construction workers will be present during the construction phase and potentially as maintenance workers during the operational phase. Potential for close contact with made ground materials. Concentrations of contaminants and ground gases on the Proposed Scheme are at levels unlikely to cause risk to human health.
Surface water River Tud, associated tributaries and ponds	Negligible adverse	The most sensitive controlled water surface water receptors is the River Tud. No potential risks have been identified from soils to controlled waters. Potential for emissions or pollution from construction activities, potential for contaminants to enter surface water through drainage or surface run-off.
Groundwater	Negligible adverse	Principal and Secondary A aquifers are present within the Proposed Scheme.
Agricultural soils Permanent take	ALC grade 2: Very high sensitivity, moderate adverse ALC grade 3a: High sensitivity, major adverse ALC grade 3b: Medium sensitivity, moderate adverse ALC grade 4: low sensitivity, negligible adverse	Stripping of soil across the Proposed Scheme footprint required for the permanent works (road, structures, drainage network, environmental bunds etc). Agricultural land would be removed and/or permanently sealed beneath new carriage ways which will be constructed as part of the Proposed Scheme. Permanent land take of between 1 - 20ha of ALC grade 2. Permanent land take of more than 20ha ALC grade 3a. Permanent land take of between 1 - 20ha of ALC grade 3b. Permanent land take of less than 1ha of ALC grade 4.
Agricultural soils Temporary take	ALC grade 2: Very high sensitivity, minor adverse ALC grade 3a: High sensitivity, minor adverse	Stripping of soil across the Proposed Scheme footprint required for the temporary works (construction compounds, haul roads etc). Temporary land take resulting in the potential for reduction of soil functions due to degradation, compaction and erosion of soil resource during the construction period.

Receptor	Magnitude	Reasoning
	ALC grade 3b: Medium sensitivity, minor adverse ALC grade 4: low sensitivity, minor adverse	

9.9. Design, mitigation and enhancement measures

- 9.9.1. Design and mitigation shall be applied to avoid, reduce and remediate effects on geology and soils following the design and mitigation hierarchy outlined in DMRB LA 104.
- 9.9.2. Impacts on geology and soil resources during the construction phase shall be managed and minimised through an EMP.
- 9.9.3. The EMP will set out controls to ensure identified risks associated with contamination are appropriately managed and minimised. Mitigation measures within the EMP will include best practice environmental management procedures and appropriate waste management, such as, but not limited to:
- ensuring adequate space for storage of topsoil and subsoil which must be segregated during excavation
 - protection of watercourses from entry of polluting matter
 - stripping, storing and reinstating of soils using best practice measures to minimise the risk of degradation to soils
 - controls for identification of unexpected contamination
 - suppression of odour and dust using best practice measures
- 9.9.4. The most applicable mitigation for reducing impacts on agricultural soils is through effective design and route selection. Given the surrounding lands are of similarly high agricultural quality, the overall effect on agricultural soils of alternatives would be very similar for other offline route options.
- 9.9.5. The key principle considered to minimise effects on soils is to ensure that the footprint of the Proposed Scheme is reduced as much as practicable, without adversely affecting the design.

Construction

- 9.9.6. Made ground and organic deposits including some peat soils underlie the Proposed Scheme. Management of the associated potential risks would be undertaken in accordance with good practice including:
- monitoring of potential ground-gases and vapours in confined spaces during construction
 - design of in-ground structures to appropriate concrete design class
 - suitable personal protective equipment (PPE) and hygiene practices for construction and maintenance workers
- 9.9.7. Stripping and storage of topsoil shall be managed with regard to BS 3882:2015 utilising best practice.
- 9.9.8. There are no measures that can mitigate the permanent land take required and therefore, the permanent loss of agricultural soils associated with the Proposed Scheme.
- 9.9.9. However, in order to mitigate impacts on temporary land take areas, a SMP, incorporating guidance provided by the *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites* (Defra, 2009), will be produced to ensure the use of best practice measures for soil handling. The SMP will ensure that soils in the areas subject to temporary land take are properly handled, stored and reinstated. The SMP will form part of the 2nd iteration EMP **(TR010038/APP/7.4)**.
- 9.9.10. The SMP will include a Soil Resource Plan and a Soil Handling Strategy, based on a soil resource survey. A Materials Management Plan (MMP) will be put in place to minimise over-excavation of soils and ensure that soils from permanent land take areas will be reused as much as possible within the Proposed Scheme and that areas of temporary land take are restored back to their former condition. The MMP will form part of the 2nd iteration EMP **(TR010038/APP/7.4)**.
- 9.9.11. The SMP and MMP shall outline areas of soil to be protected from earthworks and construction activities; the areas and types of topsoil and subsoil to be stripped, haul routes, stockpile locations; the methods for stripping, stockpiling, re-spreading and ameliorating landscape soils and restoring temporary land take areas, and a cut and fill balance to ensure as much material as possible is re-used in the Proposed Scheme. All affected soil will be stripped, including topsoil and subsoil, and stored separately.
- 9.9.12. Construction compound and working areas will include a clear demarcation (fence) of the construction area and prevent access onto adjacent areas of agricultural land that could result in further compaction or damage of soils.

Construction vehicles will be confined to designated haul routes to reduce the amount of compaction of soil.

- 9.9.13. Where there are excess soils generated, these will be saved and reused outside the Proposed Scheme where there are opportunities to do so.
- 9.9.14. Where necessary for protection from earthworks and construction activities, agricultural soils will be stripped, stored and replaced to their baseline condition, as far as possible.
- 9.9.15. Measures required for material reuse and disposal are detailed in ES Chapter 10 (Material assets and waste) (TR010038/APP/6.1).
- 9.9.16. Mitigation in relation to road drainage is included in ES Chapter 13 (Road Drainage and the water environment) (TR010038/APP/6.1).

Operation

- 9.9.17. No mitigation measures are proposed for operation of the Proposed Scheme.

9.10. Assessment of likely significant effects

- 9.10.1. Residual effects once mitigation measures are taken into consideration, which have been identified based on ground investigation data and the preceding sections are identified in Table 9-13. The methodology contained within DMRB LA 104 and DMRB LA 109 has been used to assign the sensitivity, magnitude and significance of the effects (summarised in Section 9.4).

Table 9-13: Determination of the significance of residual effects

Description of impact	Sensitivity	Magnitude of impact	Significance
Construction			
<i>Users/occupiers of A47:</i> Direct contact with, inhalation or ingestion of contaminated soils, dusts and inhalation of ground gases/vapours.	Low	Negligible adverse	Neutral
<i>Users/occupiers of adjacent land areas; agricultural fields, paths:</i> Inhalation or ingestion of dusts and inhalation of ground gases/vapours.	High	Negligible adverse	Slight adverse
<i>Off-site residential receptors:</i> Inhalation or ingestion of dusts and inhalation of ground gases/vapours.	Very High	Negligible adverse	Slight adverse

Description of impact	Sensitivity	Magnitude of impact	Significance
<p><i>Construction workers:</i></p> <p>Direct contact with, inhalation or ingestion of contaminated soils, dusts and inhalation of ground gases/vapours.</p>	Medium	Minor adverse	Slight adverse
<p><i>Surface water – River Tud, associated tributaries and ponds:</i></p> <p>Migration of contaminants in the saturated zone towards surface water. Surface run-off towards surface waters, including via local drainage systems.</p>	High	Negligible adverse	Slight adverse
<p><i>Groundwater:</i></p> <p>Principal and Secondary A Aquifers</p>	Very high	Negligible adverse	Slight adverse
<p><i>Agricultural soils</i></p> <p>Grade 2</p> <p>Stripping of soil across the proposed scheme footprint required for the permanent works (road, structures, drainage network, environmental bunds etc).</p> <p>Permanent land take of between 1 - 20ha</p>	Very high	Moderate	Large adverse
<p><i>Grade 2</i></p> <p>Stripping of soil across the proposed scheme footprint required for the temporary works (construction compounds, haul roads etc).</p>	Very high	Minor	Moderate adverse
<p><i>Grade 3a</i></p> <p>Stripping of soil across the proposed scheme footprint required for the permanent works (road, structures, drainage network, environmental bunds etc). Permanent land take of over 20 ha.</p>	High	Major	Very large adverse
<p><i>Grade 3a</i></p> <p>Stripping of soil across the proposed scheme footprint required for the temporary works (construction compounds, haul roads etc.).</p>	High	Minor	Slight adverse
<p><i>Grade 3b</i></p> <p>Stripping of soil across the proposed scheme footprint required for the permanent works (road, structures, drainage network, environmental bunds etc). Permanent land take of between 1 – 20 ha</p>	Medium	Moderate	Moderate adverse
<p><i>Grade 3b</i></p>	Medium	Minor	Slight adverse

Description of impact	Sensitivity	Magnitude of impact	Significance
Stripping of soil across the proposed scheme footprint required for the temporary works (construction compounds, haul roads).			
<i>Grade 4</i> Stripping of soil across the proposed scheme footprint required for the permanent works (road, structures, drainage network, environmental bunds etc). Permanent land take of less than 1 ha.	Low	Negligible	Neutral
<i>Grade 4</i> Stripping of soil across the proposed scheme footprint required for the temporary works (construction compounds, haul roads).	Low	Minor	Neutral
Operation			
<i>Users of Proposed Scheme:</i> Direct contact with, inhalation or ingestion of contaminated soils, dusts and inhalation of ground gases/vapours.	Low	No change	Neutral
<i>Off-site receptors:</i> Inhalation or ingestion of dusts and inhalation of ground gases/vapours.	Very High	No change	Neutral
<i>Surface water – River Tud and associated tributaries:</i> Migration of contaminants in the saturated zone towards surface water. Surface run-off towards surface waters, including via local drainage systems.	High	No change	Neutral
<i>Groundwater</i> Principal and Secondary A Aquifers	Very high	No change	Neutral
<i>Agricultural soils</i> No additional loss of agricultural land is expected during the operational phase.	Very high to low	No change	Neutral

9.10.2. It is predicted that the Proposed Scheme is unlikely to give rise to any significant effects upon geology or soils during the operational phase.

9.10.3. Residual effects to human health and controlled waters from disturbance and mobilisation of contamination in geology and soils during construction have been identified as Neutral to Slight adverse.

- 9.10.4. The proposed mitigation for agricultural soils outlined in Section 9.9 aims to maintain the quality of retained and excavated soils through best practice soil handling methods and techniques. The temporary land take areas would be restored to agriculture following the completion of the construction phase. The temporary loss of agricultural land during the construction phase is considered to be of minor magnitude and moderate adverse significance for Grade 2 agricultural land, slight adverse significance for Grade 3a agricultural land and slight adverse significance for Grade 3b agricultural land.
- 9.10.5. Provided that the mitigation measures are effective and areas of temporary land take are restored back to their former condition, the long-term residual effects on agricultural soils would be limited to the permanent loss of agricultural land:
- The permanent loss of 18.9 hectares of Grade 2 agricultural land is considered to be of moderate magnitude and large adverse significance.
 - The permanent loss of 32.2 hectares of Grade 3a agricultural land is considered to be of major magnitude and very large adverse significance.
 - The permanent loss of 6.2 hectares of Grade 3b agricultural land is considered to be of moderate magnitude and moderate adverse significance.
- 9.10.6. Residual effects have been identified to be Neutral from the operation of the Proposed Scheme.

9.11. Monitoring

- 9.11.1. No significant residual effects have been identified relating to contamination or geology and therefore physical monitoring through inground installations etc. is not considered necessary. No remediation due to contamination is required. Soils and other material assets will be handled according to the waste and materials asset requirements set out in the EMP. Monitoring of accordance with these requirements will be conducted via audit of the requirements.
- 9.11.2. Soil stripping, handling and storage will be monitored/audited to ensure that it follows the procedures outlined in the SMP. Following the reinstatement of the temporary land take, there would be a programme of monitoring of soil conditions to identify if there are soil problems which need to be remediated. This would include an assessment of the problem and design of a suitable remediation strategy such as subsoiling or drainage followed by crop establishment.

9.12. Summary

- 9.12.1. Only minor evidence of contamination from historical activities were recorded during the site investigation and no special remedial activities are recommended for the Proposed Scheme.

- 9.12.2. Minor impact from ground contamination was identified in the ground investigation work and hence there is limited potential for construction activities to mobilise contaminants within the underlying soils or introduce contaminants which may potentially harm human health or environmental receptors such as the River Tud. Potentially harmful construction activities will be identified, controlled and mitigated by measures set out in the EMP.
- 9.12.3. The delivery of the Proposed Scheme results in the permanent and temporary land take of Grade 2 and Grade 3a agricultural land, which is considered to be BMV land, as well as Grade 3b and Grade 4 agricultural land.
- 9.12.4. A SMP will be developed to help preserve land quality on the temporary land take areas and to make effective reuse of the soils taken from the areas of permanent land take. Provided that the mitigation and monitoring measures are effective and areas of temporary land take are restored back to their former condition, the long-term residual effects on agricultural soils would be limited to the permanent loss of agricultural land. The permanent loss of Grade 2 land is considered to be of large adverse significance, the permanent loss of Grade 3a agricultural land is considered to be of very large adverse significance, while the permanent loss of Grade 3b agricultural land is considered to be of moderate adverse significance of effect.
- 9.12.5. The operational phase of the Proposed Scheme results in a reduced potential for harm as the underlying soils are no longer exposed or disturbed effectively breaking potential pathways to receptors and presents no further impacts to agricultural soils.

9.13. References

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9.14. Glossary

ALC	Agricultural Land Classification
BMV	Best and Most Versatile
CLR	Contaminated Land Report
CSM	Conceptual Site Model
DWS	Drinking water standards
EMP	Environmental Management Plan

EPH	Extractable petroleum hydrocarbons
GAC	Generic assessment criteria
GI	Ground investigation
GIR	Ground investigation report
GWDTE	Groundwater dependent terrestrial ecosystems
LCA	Land Classification for Agriculture
LOD	Limit of detection
MMP	Materials Management Plan
PAH	Polycyclic aromatic hydrocarbon
PEIR	Preliminary Environmental Information Report
PPE	Personal protective equipment
PSSR	Preliminary Sources Study Report
Q ₉₅	The flow equalled or exceeded in a watercourse 95% of the time
RBMP	River Basin Management Plan
SMP	Soil Management Plan
SOM	Soil organic matter
SPZ	Source Protection Zone
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Sites of Special Scientific Interest
TPH	Total petroleum hydrocarbons
UXO	Unexploded ordnance
WFD	Water Framework Directive