A303 Amesbury to Berwick Down

TR010025

Volume 6

6.1 Environmental Statement

Chapter 10: Geology and soils

APFP Regulation 5(2)(a)

Planning Act 2008

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

October 2018

10 Geology and soils

10.1 Introduction and competent expert evidence

10.1.1 This chapter assesses the potential impacts of the construction and operation of the Scheme, following the methodology set out in Design Manual for Roads and Bridges ("DMRB") Volume 11, Section 3, Part 11 and associated Interim Advice Notes ("IANs") (Ref 10.1). This chapter details the methodology followed for the assessment, summarises the regulatory and policy framework related to geology and soils and describes the existing environment in the area surrounding the Scheme. Following this, the design, mitigation and residual effects of the Scheme are discussed, along with the limitations of the assessment.

10.1.2 This chapter of the ES has been undertaken by competent experts with relevant and appropriate experience. The technical lead for the geology and soils assessment is Phil Hough and his professional qualifications and experience are summarised in Appendix 1.1.

10.2 Legislative and policy framework

10.2.1 As discussed in Chapter 1, the primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the National Policy Statement for National Networks (NPSNN) which, at Sections 4 and 5, sets out policies to guide how DCO applications will be decided and how the impacts of national networks infrastructure should be considered. Table 10.1 identifies the NPSNN policies relevant to geology and soils and where in the ES chapter information is provided to address the policies.

Table 10.1: Relevant NPSNN policies for geology and soils assessment

Relevant NPSNN paragraph reference	Requirement of the National Policy Statement for National Networks (NPSNN)	Where in the ES Chapter is information provided to address this policy.
5.117 – 5.119	Where necessary, land stability should be considered in respect to new development … A preliminary assessment of ground instability should be carried out at the earliest possible stage before a detailed application for development consent is prepared … This could be in the form of a land stability or slope stability risk assessment report.	Section 10.6: Land Instability includes a summary of the land instability risk assessment report which is included at Appendix 10.6

Relevant NPSNN paragraph reference	Requirement of the National Policy Statement for National Networks (NPSNN)	Where in the ES Chapter is information provided to address this policy.
5.168	…applicants should seek to use areas of poorer quality land in preference to that of a higher quality. Applicants should also identify any effects, and seek to minimise impacts, on soil quality, taking into account any mitigation measures proposed. Where possible, developments should be on previously developed (brownfield) sites provided that it is not of high environmental value. For developments on previously developed land, applicants should ensure that they have considered the risk posed by land contamination and how it is proposed to address this.	Section 10.6: Soil and Groundwater Contamination Potential identifies current and historical potential sources of land contamination within the study area. Section 10.7: Potential Impacts considers potential pollutant linkages during construction and operation of the Scheme without mitigation. Section 10.8: Design, Mitigation and Enhancement Measures sets out headline actions, principles and mitigation in relation to prevention and control of contamination and how effects on soil resources would be mitigated. These are also presented in the OEMP (Appendix 2.2). Section 10.9: Assessment of Effects assesses contamination risks during construction and operation of the Scheme.

10.2.2 In accordance with the NPPF (Ref 10.2), the NPSNN policies relating to the applicant's assessment are the primary source of policy guidance regarding this assessment. The NPPF was revised in 2018, but the requirements which relate to this assessment have not substantively changed, and the NPSNN remains the primary source of policy guidance.

Policy

10.2.3 Other relevant policies and guidance have been considered as part of the geology and soils assessment where these have informed the identification of receptors and resources and their sensitivity; the assessment methodology; the potential for significant environmental effects; and required mitigation. These policies include:

a) Wiltshire Council Core Strategy Development Plan Document (Ref 10.3) – core policy 50 (geodiversity) and core policy 68 (water resources);

b) Part 2A of the Environmental Protection Act (EPA) 1990 (the Contaminated Land Regime) (Ref 10.4);

c) Department of the Environment, Transport and the Regions guidance 'Soil Strategy for England' (Ref 10.5).

10.2.4 National objectives for the sustainable management of soil are set out in the guidance paper, entitled 'Soil Strategy for England' (Department of the Environment, Transport and the Regions, 2009) (Ref 10.5). The four key objectives detailed in that strategy, which have been taken into account in this assessment are:

a) agricultural soils will be better managed and threats to them will be addressed;

b) soils will play a greater role in the fight against climate change and in helping us manage our impacts;

c) soils in urban areas will be valued during development and construction practices will ensure vital soil functions can be maintained; and

d) pollution of our soils is prevented, and our historic legacy of contaminated land is being dealt with.

10.2.5 After remediation, land should not be in a condition such that it could be determined as 'contaminated land' under Part 2A of the Environmental Protection Act 1990 (Ref 10.4). Water resources must be protected throughout the construction and operational phases of development and the quality and quantity must be maintained.

10.2.6 Local strategic objectives for sustainable minerals development are outlined in the policy document titled 'Wiltshire and Swindon Waste Core Strategy 2006 - 2026' (Swindon Borough Council and Wiltshire Council, adopted June 2009) (Ref 10.6). Policy MSC 6: *Safeguarding Mineral Resources, Rail-head Facilities and Mineral Recycling Facilities* identifies the need to safeguard mineral sites from potential sterilisation by development through the application of Mineral Safeguarding Areas (MSAs).

10.3 Assessment methodology

Geology and soils

10.3.1 Geology has been assessed using published information, existing information from historical investigation and assessment reports including the Preliminary Sources Study Report (PSSR) (Ref 10.7, presented in Appendix 10.4) undertaken as part of the previous phase of works and the Preliminary Ground Investigation Report (GIR) (Ref 10.8) completed in 2018 as part of the design

process. The GIR is based on information from available historical ground investigations and a recent ground investigation carried out in 2017 (Ref 10.9) and is provided in Appendix 10.1.

10.3.2 A land instability assessment report has been produced (Ref 10.10) as part of the design process and is included at Appendix 10.6. The objective of the assessment is to identify and assess potential ground instability risks in relation to the construction of the Scheme in order to assist in determining its technical feasibility and mitigation strategies.

10.3.3 No geological sites of Special Scientific Interest (SSSI), Local Geological Sites (LGS) or designated mineral resources have been identified within the study area. Therefore effects on geology and soils receptors from land instability are not considered significant.

10.3.4 The baseline agricultural land classifications within the study area have been reviewed and summarised using mapping published by the Soil Survey of England (Ref 10.11) and information from an agricultural land classification survey undertaken in May 2018. The potential impacts on agricultural soil grade in relation to the construction of the Scheme are assessed in Chapter 13 (People and Communities).

Land contamination

10.3.5 Areas of potential contamination have been identified within the study area of the Scheme. In line with the Environment Agency Contaminated Land Report CLR11 (Ref 10.12), the assessment of land contamination has taken the form of a tiered, risk-based approach, as summarised below:

a) Tier 1: qualitative risk assessment based on a desk top study of available information to identify potential sources of contamination, receptors to contamination and potential pathways between them. The identified sources, pathways and receptors are presented in the form of a Conceptual Site Model (CSM) showing the potential contaminant linkages (PCL);

b) Tier 2: If PCLs are identified, this means there is a theoretical risk to receptors from contamination and intrusive investigation should be used to provide data to inform a generic quantitative risk assessment (GQRA). The GQRA involves comparison of site-specific, laboratory analytical data against appropriate generic assessment criteria (GAC) for human health and/or controlled waters which represent minimal or tolerable risk; and

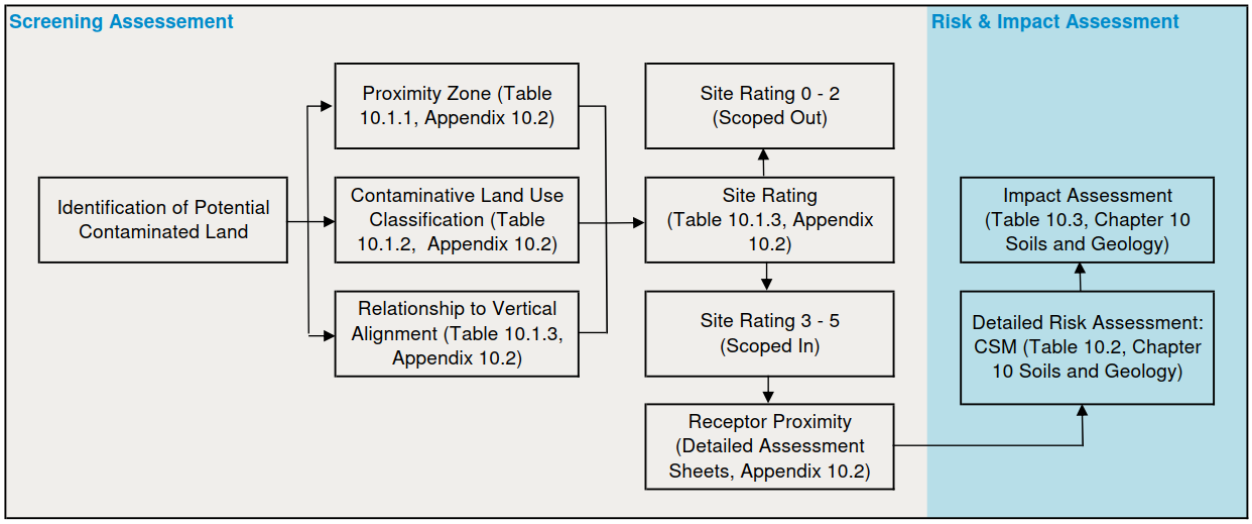
c) Tier 3: detailed quantitative risk assessment to identify whether contamination identified above minimal or tolerable risk levels represents an unacceptable risk and therefore requires remediation.

Screening assessment

10.3.6 A qualitative assessment of the risks posed by land contamination within the geology and soils study area, which is defined in Section 10.5, has been undertaken by first assigning a 'site rating' to each identified historical or current area of potential land contamination identified in the baseline review. The site rating has been determined using the tables provided in Appendix 10.2. The site rating is based partly on the relationship between the identified area of potential land contamination and its proximity to the Scheme (Appendix 10.2, Table 10.1.1) together with the vertical alignment of the Scheme design at its closest point (Appendix 10.2, Table 10.1.3). The site rating also considers the nature of the current and/or historical land use, as certain land uses typically result in a greater potential for contamination of the ground to have occurred (Appendix 10.2, Table 10.1.2). The lower the site rating then the lower the risk. Professional judgement has been applied in reviewing the generated site ratings. Generally, site ratings of two or less are considered not to pose a significant risk and will not be considered for further assessment. Site ratings of three or more will be considered for further risk and impact assessment as described below. A flow chart summarising the screening, risk and impact assessment steps is presented in Figure 10.1.

10.3.7 In addition, a desk study (Ref. 10.7), intrusive ground investigation and quantitative risk assessment (Ref. 10.8) have also been undertaken along the Scheme alignment to support the design development. The findings of these assessments have been used to inform the environmental assessment that is reported in this chapter.

Figure 10.1: Land contamination assessment flow chart



Risk and impact assessment

10.3.8 The approach to assessing the potential impacts of the Scheme has been undertaken by comparing the risk levels at baseline with the CSM and the risk

levels for the construction and post-construction stages respectively, to determine any change in risk at each stage.

10.3.9 Potential risks are determined and assessed based on the likelihood (or probability) and consequence using the principles given in the National House Building Council (NHBC) and Environment Agency report R&D66 (Ref 10.13). This provides guidance on development and application of the consequence and probability matrix to risk assessment and broad definitions of consequence. The risk matrix is presented in Table 10.2.

Table 10.2: Estimation level of risk

Probability	Consequence			
	Severe	Medium	Mild	Minor
High likelihood	Very high risk	High risk	Moderate risk	Low risk
Likely	High risk	Moderate risk	Moderate/low risk	Low risk
Low likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

10.3.10 The significance of the effects of land contamination has been assessed by comparing the difference in risk for each contaminant linkage at baseline to those at construction and at post construction stages. Where there is shown to be a decrease in contamination risk the Scheme is assessed as having a beneficial effect on the environment in the long term.

10.3.11 The definitions of the significance criteria used are presented in Table 10.3 below. This provides details of how increases and decreases in the contamination risks identified are related to the significance criteria adopted. Potential effects that are determined as being moderate or major are classed as 'significant' effects. Where an effect has been anticipated to be neutral or minor, these effects are classed as 'not significant'.

Table 10.3: Significance criteria

Significance Criteria	Definition
Major adverse effect	An increase in contamination risk of 4 or 5 risk levels in the risk matrix, e.g. from land that has a very low contamination risk in the baseline becomes a high or very high risk
Moderate adverse effect	An increase in contamination risk of 2 or 3 risk levels in the risk matrix, e.g. land that has a low contamination risk in the baseline becomes a moderate or high risk
Minor adverse effect	An increase in contamination risk of 1 risk level in the risk matrix, e.g. land that has a low contamination risk in the baseline becomes a moderate/low risk

Significance Criteria	Definition
Neutral effect	No change in contaminated land risks
Minor beneficial effect	A reduction in contamination risk of 1 risk level in the risk matrix, e.g. land that has a moderate/low contamination risk in the baseline becomes a low risk
Moderate beneficial effect	A reduction in contamination risk of 2 or 3 risk levels in the risk matrix, e.g. land that has a high contamination risk in the baseline becomes a moderate/low or low risk
Major beneficial effect	A reduction in contamination risk of 4 or 5 risk levels in the risk matrix, e.g. land that has a very high contamination risk in the baseline becomes a low or very low risk

Scoping

10.3.12 A request for an EIA Scoping Opinion was sent to the Planning Inspectorate in relation to the Scheme in October 2017, presenting the proposed scope of work and methodology for the ES. Comments relating to geology and soils are shown in Table 10.4 below, along with references to where these have been addressed within the ES. Where assessment has been undertaken in accordance with the Scoping Opinion point, a response and the relevant ES Section is provided; where an alternative approach has been agreed with the relevant stakeholder, an explanation is provided. The Scoping Opinion as received is provided in Appendix 4.1.

Table 10.4: Scoping opinion and response

Scoping Opinion	Where addressed within the ES
Planning Inspectorate	
The Inspectorate agrees that an assessment of effects on Local Geological Sites can be scoped out on the basis that there are none located within the study area or surroundings.	Section 10.6: Geological and ecological designations, confirms that there are no Local Geological Sites within the study area.
The Inspectorate agrees that an assessment of effects on Mineral Safeguard Areas can be scoped out due to none being located within the study area.	10.6: Mining and mineral resources, confirms the absence of Mineral Safeguarding Areas within the study area.
The Inspectorate does not agree that structural/engineering geology should be scoped out of the assessment. The Inspectorate notes the proposal of an additional structural/engineering geology report; however, it is unclear how this report addresses the issues identified in paragraphs 6.6.33 - 6.6.35, which appear to go beyond the scope of that assessment. The Inspectorate considers that the ES should assess the impacts applicable to the presence of Phosphatic Chalk. The ES should also include an assessment of the related options (if they are necessary) and explain where uncertainties exist or are addressed.	Section 10.6: Land instability includes a summary of the land instability risk assessment report included at Appendix 10.6. Section 10.6: Additional Phosphatic Chalk assessment reports on the leachate and radon potential of the Phosphatic Chalk and associated impacts. Appendix 10.1 Ground Investigation Report provides an assessment of engineering and structural geology, including a detailed assessment of the engineering and geochemical properties of the Phosphatic Chalk.

Scoping Opinion	Where addressed within the ES
The ES should explain and justify the chosen study areas for each of the strands of assessment as outlined in paragraph 6.6.3. Whilst paragraph 6.6.2 notes that Volume 11 of DMRB has been used in the preparation of the assessment method for this aspect; it is not stated as to whether the study area is derived from such guidance.	Section 10.5: Study area explains that the chosen study area aligns with established industry practice for defining land contamination study areas for EIA.
To enable clear understanding of impacts, the ES should include figures to depict (visually) the geographic locations of the varying risks of landslides and compressibility across the study area. This information will aid the understanding of risks which the Scoping Report identifies as varying from negligible to high.	Section 10.6: Land instability summarises the land instability risk assessment and cross references a plan depicting the geographical locations of the ground instability risks included within the report, presented in Appendix 10.6.
The Scoping Report notes that mitigation requirements are needed to prevent interaction with the Esso Oil Pipeline. The mitigation measures referred to are not specifically defined. These mitigation measures should be clearly set out in the ES along with consideration of how they are proposed to be secured as part of the design. The ES should also consider the potential for existing contamination in and around the area of the Esso Oil Pipeline.	Section 10.8: Design, mitigation and enhancement measures sets out the mitigation to protect the pipeline against construction impact and effects of ground settlement of the new road. The OEMP cross-referenced in this section provides further details and sets out the mechanism for securing all mitigation measures. Appendix 10.2 Contaminated Land Assessment Methodology and Detailed Risk Assessment includes a Conceptual Site Model and risk assessment specifically for the Esso Oil Pipeline.
Paragraph 6.6.33 describes “significant uncertainties” regarding the engineering properties of Phosphatic Chalk that is known to be present in the study area which could present constraints to the scheme design and construction methods. There is also an increased radon potential from Phosphatic Chalk. These matters should be assessed in sufficient detail in the ES including as part of the Proposed Development’s vulnerability to and from accidents and disasters (particularly in relation to ground stability) and the potential risks posed to contamination of controlled waters.	Appendix 10.1: GIR provides an assessment of the engineering properties of the Phosphatic Chalk. Geotechnical risks associated with uncertainties in the characteristics and extents of the material along the tunnel are evaluated in the Geotechnical Risk Register included in the GIR along with proposed mitigation. Section 10.6: Phosphatic Chalk assessment summarises the assessment undertaken to quantify the radon and phosphorus leachate potential of the Phosphatic Chalk and cross-references Appendix 10.1 GIR where further details are provided.

Scoping Opinion	Where addressed within the ES
Specific consideration should be given to the risks of contamination being introduced as a consequence of the construction and operation of the bored tunnel, including hazardous materials that may be required as part of the design. The EIA should also include specific consideration of the energy, material and natural resource use associated with the Tunnel Boring Machine itself including the use of any potentially hazardous substances or materials that are inherent in the process.	Section 10.7: Construction has considered the potential impact from introducing new sources of contamination during construction of the proposed tunnel. Section 10.7: Operation outlines potential for impacts arising from pollutants during operation of the proposed tunnel. Section 10.8: Construction cross references the OEMP where mitigation measures are contained to limit the possibility for dispersal and accidental releases of potential contaminants during construction. Section 10.8: Operation outlines how drainage control measures would contain and control any releases of contaminants along the highway and its associated infrastructure. The assessment of effects, Section 10.9, has concluded that no significant construction or operational stage effects are predicted in relation to geology and soils.
The Applicant explains that the de-watering risk assessment will require a “wider study area”. The assessment should be undertaken in accordance with a wider study where this is necessary, explaining the extent and need for the wider areas.	Section 10.5: Study area Chapter 11: Road Drainage and the Water Environment describes the wider study area applied to controlled waters receptors. Appendix 11.4 Groundwater Risk Assessment includes an assessment of dewatering impacts considering a study area up to 5km.
Environment Agency	
The investigations of the radial influence of any contamination resulting from construction or operation of A303 route or tunnel should not be limited in distance.	Section 10.5: Study Area provides clarification that there is no distance or limit specified for potential impacts arising from the construction or operation of the Scheme.

Scoping Opinion	Where addressed within the ES
Method of works for the construction of the road, bridge and tunnel will need to identify actions that will be taken in the event of intercepting contamination. The Esso Pipeline will need to continue to be considered as a potential source if such works identify contamination in this area.	Section 10.8: Design, Mitigation and enhancement measures sets out headline actions, principles and mitigation in relation to prevention and control of contamination. These are presented further in the OEMP. Appendix 10.2 Contaminated Land Assessment Methodology and Detailed Risk Assessment includes a Conceptual Site Model and risk assessment specifically for the Esso Oil Pipeline.
Groundwater Risk Assessment should consider the risk of the proposals (construction and operation) on water interests in and around A303.	Controlled waters receptors are identified within Section 10.6: Baseline conditions and the risk of the Scheme in relation to contamination on water interests is described in Section 10.7: Potential impacts and Section 10.9: Assessment of Effects. A detailed groundwater risk assessment is provided in Chapter 11 Road Drainage and the Water Environment

Consultation

10.3.13 To inform the development of the geology and soils assessment, discussions have taken place with Wiltshire Council and the Environment Agency. These discussions have been centred on the environmental aspects of the Scheme, in particular in relation to land contamination and the assessment methodology. Key potential land contamination sites were also discussed and further information was provided from Wiltshire Council's records.

10.3.14 Liaison has also been undertaken with Wiltshire Council and the Environment Agency to obtain records of licensed private and commercial groundwater abstractions within the study area. Further details are provided in Chapter 11 (Road Drainage and the Water Environment).

10.3.15 The Wiltshire Geological Society (WGS) were contacted and their opinion sought on any local geological features located within the study area. The WGS confirmed that there was currently nothing of specific geological importance to comment upon linked to the proposals.

10.4 Assessment assumptions and limitations

10.4.1 The assessment undertaken for geology and soils has been based on the collation and evaluation of available documentation provided by the Environment Agency, British Geological Survey (BGS), Envirocheck historical mapping (Ref 10.14), Groundsure Geo and Enviro Reports (Ref 10.15 and 10.16 respectively), 2018 Envirocheck Report (Ref 10.17) and other data

sources made available including the PSSR (Ref 10.7) and the GIR (Ref 10.8). Unless stated otherwise, the data presented in other consultant's reports has not been independently verified.

10.4.2 Baseline information on ground stability is included in this chapter, although the assessment of structural and engineering geology has been undertaken as part of the GIR (Appendix 10.1). An additional and separate land instability report (Ref 10.10) has been prepared that assesses ground stability with a particular focus on slope stability, Chalk dissolution and also tunnel movement and the impact on infrastructure, structures and heritage assets which is summarised in this chapter.

10.5 Study area

10.5.1 The study area for the land contamination assessment comprises the Scheme boundary, which includes the proposed east of Parsonage Down habitat creation area, Rollestone Junction and the new link between Allington Track and Amesbury Road, and an additional buffer of 250m. This area is considered appropriate for the consideration of historical and current potentially contaminative land uses which could be impacted by, or impact on the Scheme, and it aligns with established industry practice for defining land contamination study areas for EIA. This was agreed with the Environment Agency and Wiltshire Council in May 2018. In the event of contamination arising from the Scheme construction or operation there is no distance or limit specified as to its potential impact.

10.5.2 An extended buffer of 1km has been considered for groundwater, surface water and potable water abstractions as potential receptors to any land contamination.

10.5.3 For the remainder of the topic and other receptors e.g. minerals and geological sites, the study area comprises the Scheme boundary; since these receptors are only likely to be impacted where the Scheme directly crosses, or interfaces with them.

10.5.4 Groundwater risk assessments have taken into account a larger study area, to encompass areas to be used for construction, and the zone of influence of Water Framework Directive (WFD, 2000/60/EC) (Ref 10.18) groundwater bodies and groundwater Source Protection Zones (SPZ) from de-watering required for construction. Further details are provided in Chapter 11 (Road Drainage and the Water Environment).

10.5.5 The study area for geology and soils is illustrated in Figure 10.2 and for groundwater is illustrated on Figure 11.1.

10.6 Baseline conditions

10.6.1 This section presents the baseline conditions for geology and soils. It also considers potential receptors that could be impacted upon by any existing or resulting ground contamination. There is therefore reference made to surface water, groundwater and ecological features in this section which are discussed

in more detail in Chapter 11 (Road Drainage and the Water Environment) and Chapter 8 (Biodiversity).

Current Baseline

Geology

Published geology

10.6.2 Made Ground is not mapped within the study area. However, it is anticipated to be present in areas of previous and existing development and along existing highways. There is also the possibility for Made Ground associated with infilled ground. Based on information contained in the Groundsure Geo Insight Report (Ref 10.15), it is known that there are chalk pits, gravel pits, ground workings, cuttings, covered reservoirs, and infilled ponds within the study area.

10.6.3 Localised superficial deposits are present underlying the Scheme. River Terrace Deposits, Alluvium and Peat associated with the River Avon are present in the eastern part of the Scheme. Alluvium surrounds the channel of the River Till towards the west of the Scheme. Head Deposits are present within the study area, typically following the dry valley bottoms which are associated with former/seasonal surface water bodies and/or groundwater discharges.

10.6.4 The bedrock underlying the study area comprises a succession of the Upper Cretaceous Chalk group, including the Newhaven and Seaford Chalk Formations. The majority of Chalk strata exposed in the study area belongs to the Seaford Formation. An area in the vicinity of Stonehenge Down is underlain by the Newhaven Chalk Formation (which is known to contain distinct Phosphatic Chalk of limited lateral extent). A fault line forms the eastern boundary of the Newhaven Chalk Formation and trends in a north south direction, located approximately 500m to the east of the Stonehenge Monument (hereafter referred to as ‘the Stones’). The fault crosses the existing A303 immediately east of the junction of the A303 and the former A344 which was closed in June 2013.

Ground investigation

Existing ground investigations

10.6.5 A GIR was produced in April 2018 for the Scheme (Ref 10.8) and provided in Appendix 10.1. The GIR is based on all information from available historical ground investigations together with data from a recent ground investigation carried out in early 2017 (Ref 10.9). These ground investigations were based on the route options that were under consideration at the time and the relevance of the information was appraised in the GIR in the context of the Scheme.

10.6.6 The earliest ground investigation information is dated 1965 and was carried out for a proposed bypass in the area of the existing Countess Roundabout. A series of ground investigations were subsequently undertaken to support the design development of the previous published scheme including a main investigation carried out in two phases in 2001 and a supplementary

investigation undertaken in three phases between 2002 and 2004. In addition, two separate ground investigations were undertaken for improvement works at the Countess and Longbarrow Roundabouts between 2009 and 2010.

10.6.7 A total of 296 exploratory holes extending up to 51m deep were completed as part of the historical investigations between 2001 and 2010. The combined two phases of the 2001 main investigation are considered to contribute the majority of the available ground conditions information in terms of the number of exploratory holes and the area that they covered. The majority of these historical exploratory holes generally follow the alignment of the Scheme.

10.6.8 The most recent ground investigation concerns a programme of ground investigation that took place between the 9th January and the 16th April 2017 (Ref 10.9). This was referred to as the "Early Phase" Ground Investigation (EP GI). The scope of work included for five rotary cored boreholes to a maximum depth of 48.4m, 22 rotary open-hole boreholes to a maximum depth of 78.8m, 15 hand-dug inspection pits and 11 machine excavated trial pits.

Encountered ground conditions

10.6.9 A summary of the encountered ground conditions based on a review of the available and relevant historical and recent exploratory holes within the study area is provided in Table 10.5. The exploratory-hole locations are shown on Figure 10.3 and Figure 10.4 (Sheets A and B) and geological sections prepared along the Scheme alignment are included in the GIR (Ref 10.8).

Table 10.5: Summary of proven geology where relevant within the study area

Stratum	No. Exploratory Holes Encountered	Depth to top of Strata (m bgl*)	Stratum Thickness (m)	Location
Topsoil	186	0.0	0.09 – 1.50	Throughout the study area.
Made Ground	26	0.0 – 0.5	0.10 – 3.50(1)	Encountered in the area of the existing Longbarrow and Countess roundabouts and locally in borehole 16174-STP12 located in the western extent of the study area, south of Parsonage Down.
Head Deposits	32	0.0 – 1.9	0.15 – 4.15	River Till valley, River Avon valley and Stonehenge Bottom. Most significant presence found in the valley of the River Till.
Alluvium	49	0.0 – 3.0	0.20(1) – 3.90	Identified in the River Till and River Avon valleys.
River Terrace Deposits	38	0.3 – 4.2	0.20(1) – 4.42	Underlying Alluvium in the River Avon valley.
White Chalk Subgroup	211	0.0 – 6.7	0.40(1) – 50.65(1)	Throughout the study area.

Stratum	No. Exploratory Holes Encountered	Depth to top of Strata (m bgl*)	Stratum Thickness (m)	Location
Phosphatic Chalk	13	1.8 – 43.6	2.15 (2) – 34.60(1)	West of Stonehenge Bottom.

(1) Full thickness was not proven due to termination of exploratory hole

(2) The thickness range does not include the possible phosphatic nodules (<10mm) noted in boreholes 16175-R15A and 21762-R149.

**m bgl = meters below ground level*

Superficial geology

10.6.10 Made Ground was identified near to the existing Longbarrow and Countess Roundabouts. In the area of the Longbarrow Roundabout, four trial pits proved Made Ground which was generally described as brown sandy gravelly silt up to 1.25m in thickness. In the area of the existing Countess Roundabout Made Ground was proved in all 13 exploratory holes to depths of between 1.8m and 3.2m below ground level (m bgl). The Made Ground was found to be variable, comprising silt, clayey sand, gravel, clay and highly weathered Chalk; although silt and sand were the dominant lithology. Gravel of ash and clinker with a strong hydrocarbon odour was noted locally in trial pit TP4 (north west part of the roundabout) between 0.60m and 0.80m bgl which extended horizontally for approximately 1.20m. No olfactory evidence of hydrocarbon impact was observed in the underlying Alluvium in trial pit TP4. This was attributed to a localised fuel spillage (Ref 10.7).

10.6.11 Head deposits are not present across the entire study area but have been identified at several locations where the Scheme crosses fluvial and ephemeral valleys. The most significant presence of Head Deposits was found in the River Till valley. Head deposits have been generally described as silty, sandy, gravel of flint and occasional Chalk, with rare cobbles of flint and with typical thickness ranges from between 1.7m to 3m. Head deposits have also been encountered along a tributary valley which lies to the west of the River Till. In this area it has been described as silty, sandy gravel with occasional flint cobbles. Typical thicknesses ranged from 0.2m to 1.75m. More cohesive Head deposits have been identified to the west of Stonehenge Bottom where they have been described as sandy, gravelly clay or silt.

10.6.12 Alluvium has been identified in the River Avon valley, and is generally overlain by Made Ground around the area of the Countess Roundabout. Alluvium is also present in the River Till valley at Winterbourne Stoke. Alluvium around the River Till valley is predominantly granular (very clayey, occasionally gravelly sand), with a thickness ranging from 0.9m to 2.1m. Alluvium around Countess Roundabout and the River Avon has generally been noted to be more cohesive. Cohesive Alluvium has been identified to be approximately 0.4m to 2.25m in thickness, and typically described as silty, slightly sandy, gravelly organic clay or silt, with occasional pockets of peat and organic matter.

10.6.13 River Terrace Deposits that are predominantly granular in nature have been recorded in the River Avon valley up to 4.4m in thickness. This stratum is found underlying the Alluvium and has been described as loose to medium dense, brown to brownish-grey, silty sand and/or gravel with occasional flint cobbles.

Bedrock geology

10.6.14 The Newhaven Chalk Formation is the youngest formation of the White Chalk Subgroup identified within the study area, and crops out over higher ground in the interfluve regions either side of Stonehenge Bottom. The Seaford Chalk Formation has been identified either at outcrop or underlying the Newhaven Chalk Formation. The Lewes Nodular Chalk Formation is the oldest Chalk formation and has been proved only in the deepest exploratory-hole locations.

10.6.15 Structureless Chalk has been identified overlying structured Chalk throughout the study area and is typically present at the upper horizons. The structureless Chalk is typically 1m in thickness on the higher elevations in the interfluve zones but deeper and thicker in the areas of the River Till valley (up to 10m thick), the Stonehenge Bottom dry valley (up to 7m thick) and the Countess Roundabout/River Avon valley (up to 10m thick).

10.6.16 Phosphate-containing Chalk has been identified in the area to the west of Stonehenge Bottom based on the description of the recovered cores, samples and results from down-hole natural gamma logging carried out in the historical and recent ground investigations.

10.6.17 The Phosphatic Chalk is described as a variably, and often weakly, cemented brown sandy Chalk with pelletal phosphatic grains. The top of the Phosphatic Chalk has been logged at depths ranging from 1.8m bgl to 43.6m bgl. Due to the apparent interbedded nature of the Phosphatic Chalk, its thickness can be considered in terms of both interbedded and absolute thicknesses. Typical interbedded thicknesses[1] logged for Phosphatic Chalk range from 0.1m to more than 23.5m, with logged absolute thicknesses[2] ranging between 0.1m and 34.6m. The maximum thickness of Phosphatic Chalk was not proven during the ground investigation.

Land instability

10.6.18 Information contained within the Groundsure Geo Insight Report (Ref 10.15) and Envirocheck Report (Ref 10.17) indicates that the following natural ground hazards may exist across the Scheme study area:

a) there is a negligible to very low potential for shrinkage/swelling of clays;

b) there is a negligible to moderate potential for landslides;

1 Interbedded thickness is the thickness of each continuous Phosphatic Chalk occurrence
2 Absolute thickness is the difference between the top depth of first Phosphatic Chalk occurrence and the base depth of the last Phosphatic Chalk occurrence in a borehole

c) there is a very low to low potential for ground dissolution of soluble rocks;

d) there is a negligible to high potential for compressible deposits associated with the Chalk bedrock and superficial Alluvium respectively;

e) there is a negligible to very low potential for collapsible deposits; and

f) there is a negligible to low potential for running sands.

10.6.19 A land instability risk assessment has been produced for the Scheme (Ref 10.10) and is presented at Appendix 10.6. The assessment included a description of the receptors potentially affected by ground movement, description of potential sources of ground movement, a qualitative and quantitative analyses of ground movements potentially resulting from construction followed by an assessment of effects on the receptors. A plan depicting the geographical locations of the ground instability risks is included in the Land Instability Risk Assessment report (Ref 10.10). A brief summary of the potential sources of ground movement is provided as follows.

Natural cavities

10.6.20 Natural cavities can often be found present within Chalk in the form of dissolution features which can be present as sinkholes, dissolution pipes and swallow holes. Four known sinkholes have been identified within the study area. These are the Wilsford Shaft (a sinkhole incorporated into a Bronze age monument) which is located approximately 90m south of the proposed tunnel alignment, and 200m south west of the proposed Western Tunnel Portal; two sinkholes in the footprint of the northern A360 link road; and one within the footprint of the Western Tunnel Portal cutting.

10.6.21 The Land Instability Risk Assessment Report (Ref 10.10) states that the Wilsford Shaft is sufficiently far away from the proposed alignment, so is not likely to cause, or be impacted on by ground movements during construction. The additional dissolution features were identified during archaeological trial trench excavations. These features would not pose land instability issues to the Scheme, as they appear to be positioned above the proposed carriageway level, so would be excavated out during construction. Any residual dissolution piping that remains below carriageway would be grouted prior to placing the sub-base and road construction.

10.6.22 The discovery of the three additional features during archaeological excavations does infer that the risk of discovering further solution features is higher than previously anticipated. The risks presented have been captured in the Geotechnical Risk Register presented in the GIR (Ref 10.8, Appendix 10.1). Mitigation against these risks is to undertake further geophysical surveys. The potential impact of discovering solution features during construction would be delays to construction whilst grouting/infilling took place.

Faults and fractures

10.6.23 Faulting and fractures occur naturally within Chalk, largely due to tectonic activity and the effects of groundwater on the sedimentary rock. In the vicinity of the Scheme alignment, a north south trending fault is indicated to be present crossing the existing A303 within Stonehenge Bottom. At this point the Scheme alignment passes at a sub-surface level. Potential faulting has been logged during the previous ground investigations and discontinuities have been identified around the proposed tunnel area, which typically vary in nature. Existing information also suggests that faulting may be present around the Amesbury Conservation Area and associated buildings in the east of the study area.

10.6.24 The risk from faulting has been assessed in the Geotechnical Risk Register presented in the GIR (Ref 10.8, Appendix 10.1) (risk reference Geo8).

Proposed tunnel construction

10.6.25 Tunnel construction results in ground movement at surface and sub-surface levels due to ground volume loss during installation. The proposed tunnel runs in close proximity to the three cottage buildings at Stonehenge Cottages, situated east of Stonehenge. Based on ground movement analyses undertaken in the Land Instability Risk Assessment (Ref 10.10), it is considered that ground movements caused by tunnel construction will not have a significant impact on settlement around the cottages.

Radon

10.6.26 Radon is a radioactive gas formed by the radioactive decay of naturally occurring uranium in rocks and soils. The occurrence of radon gas is described in Public Health England's UK radon online maps (Ref 10.19). The study area does not lie within a radon affected area since it is estimated that less than 1% of homes are indicated to be above the radon action level of 200 becquerels per cubic meter of air for residential properties.

Mining and mineral resources

10.6.27 The Wiltshire and Swindon Aggregate Minerals Site Allocations Local Plan (2013) (Ref 10.20) identifies no Mineral Consultation Areas (MCA), Mineral Safeguarding Areas (MSA) or Preferred Areas (PA) within the study area. Similarly, there are no active mines, quarries or designated mineral resources in the study area. These features are therefore scoped out of the assessment.

Soils

10.6.28 The 1:250,000 soil map of South East England published by the Soil Survey of England and Wales in 1983 (Ref 10.11) shows the soils to be mainly shallow, calcareous soils over Chalk. Most widespread on the gently rolling downland is the Andover 1 association of calcareous silty soils over Chalk at shallow depth. Almost as extensive is the Icknield association of soils distinguished from the Andover by their blackish humose topsoils. On steeper slopes is the Upton 1 association of shallow, well drained, silty soils over Chalk. In the valley of the

River Till at Winterbourne Stoke is the Coombe 1 association of deep calcareous silty soils in colluvium (soil material deposited by hillwash and soil creep).

10.6.29 The nature and quality of the agricultural land and soil affected by the Scheme has been assessed following detailed field surveys. The total area surveyed extends to about 352ha of which most is agricultural land mainly under arable cultivation growing winter cereals or under grass used for grazing sheep and cattle.

Soil parent materials and natural drainage

10.6.30 There is one main soil parent material across the Scheme area, the Cretaceous Middle and Upper Chalk of the Seaford Chalk Formation, which is covered by varying thicknesses of flinty and chalky silty and loamy drift. The most extensive soil profiles within the Scheme boundary typically comprise dark brown or greyish brown, extremely calcareous, silty or loamy upper layers overlying Chalk at shallow depth. On land to the east of Longbarrow Roundabout and locally to the west and north west of Winterbourne Stoke, soil profiles typically comprise very dark greyish brown, organic, silty upper layers overlying Chalk at shallow depth.

10.6.31 Locally, in dry valleys, there are deeper soils which typically comprise dark brown, calcareous, silty or fine loamy upper layers over brownish, calcareous, silty and fine loamy lower layers, commonly over Chalk at moderate depth or over flinty gravelly lower layers. Within the flood plain of the River Till, soils are developed in gravelly drift and typically comprise dark greyish brown, calcareous, moderately stony, silty upper layers over calcareous gravelly lower layers.

10.6.32 Natural drainage of all of these soil types is mainly by vertical percolation down through the soil profile layers then through the permeable Chalk or gravelly layers below.

Agricultural Land Classification (ALC)

10.6.33 Agricultural Land Classification and associated soils is addressed in Chapter 13 (People and Communities).

Groundwater

10.6.34 The Chalk bedrock is classified by the Environment Agency as a Principal aquifer. The Head deposits are classified as a Secondary (undifferentiated) aquifer where they comprise clay, silt, sand and gravel and a Secondary A aquifer where they consist of gravel. The Environment Agency classifies the Alluvium, River Terrace Deposits and rare peat associated with fluvial channels also as Secondary A aquifers. Further details are provided in Chapter 11 (Road Drainage and the Water Environment).

10.6.35 Environment Agency information indicates that there are five active licensed groundwater abstractions within 1km of the Scheme, which are all understood

to be sourcing groundwater from the Chalk. Three of these abstractions are for general farming or commercial use and one relates to a potable, private water supply abstraction.

10.6.36 A summary of the groundwater abstraction licence details is provided in Table 10.6 below and the locations are shown on Figure 10.5.

Table 10.6: Licensed groundwater abstractions within 1km of the Scheme

Abstraction Borehole Name	Type of Use	Licence Number	Location (approx.)
Borehole 'B' at Airman's Corner	Private water supply: drinking, cooking, sanitary, washing, (small garden) - commercial/industrial/public services	SW/043/0021/003	10m north of the Scheme boundary (adjacent to Stonehenge Visitor Centre)
Borehole 'A' at Airman's Corner	Energy – heating pump	SW/043/0021/003	200m east of the Scheme boundary (adjacent to Stonehenge Visitor Centre)
Druids Lodge Borehole 1	General agriculture	13/43/021/G/251	270m south of the southern area of the Scheme boundary, adjacent to the A360, and south of Longbarrow Roundabout
Oatlands Hill, Winterbourne Stoke Well Point B	General farming and domestic	13/43/023/G/065	In the vicinity of Oatlands Hill, west of the A360 and 520m south of the Scheme boundary.
WISMA Farm Borehole Point A	General agriculture	13/43/023/G/246	650m south of the western area of the Scheme boundary, off Berwick Road south of Winterbourne Stoke

10.6.37 Borehole 'B' at Airman's Corner is located approximately 10m north of the Scheme boundary, to the east of the existing A360. This is a receptor of high sensitivity given its proximity to the Scheme and its use for potable water supply.

10.6.38 There are four licensed public drinking water supply sources located beyond the scheme boundary but within 1 km of the Scheme. The groundwater Source Protection Zones (SPZ) for these public drinking water supply abstractions are applicable to the study area. These are described below and presented on Figure 10.5:

a) one located north of Amesbury at Durrington (SPZ1, SPZ2 with the SPZ1 located within the study area);

b) one located north of Amesbury at Bulford (SPZ1 and SPZ2, located approximately 400m north of the Scheme boundary);

c) one located at Shrewton, north of Winterbourne Stoke (SPZ1, SPZ2, SPZ3 approximately 600m to 830m from the Scheme boundary); and

d) SPZ3 located within the eastern extent of the study area east of Amesbury, for a source at Little Durnford, approximately 4.2 miles (6.7km) south of the Scheme boundary.

10.6.39 Further information on the groundwater conditions in the study area is provided in Chapter 11 (Road Drainage and the Water Environment).

Surface waters

10.6.40 Two main rivers are located in the study area as shown in Figure 10.5; the River Avon at the eastern extent of the study area flowing southwards and the River Till flowing southwards through Winterbourne Stoke at the western extent of the study area. Both rivers are designated as Main Rivers by the Environment Agency.

10.6.41 There are a number of surface water features that have been identified to be fed mainly, or entirely, by groundwater discharges from the Chalk aquifer and are therefore vulnerable to changes in groundwater level and quality. These include a spring system at West Amesbury and Amesbury Springs within the grounds of Amesbury Abbey. More detail on these features is provided in Chapter 11 (Road Drainage and the Water Environment).

10.6.42 Information provided by the Environment Agency (Ref 10.21) indicates that there is one licensed surface water abstraction within 1km of the Scheme. This is located approximately 750m to the south of the Scheme boundary in West Amesbury and is associated with the abstraction of surface water from the River Avon for wetland support. The study area does not lie within a surface water Drinking Water Safeguard Zone or Drinking Water Protected Area.

Geological and ecological designations

10.6.43 There are no geological Sites of Special Scientific Interest (SSSI) or Local Geological Sites (LGS) within the study area (Ref 10.22). These features are therefore scoped out of the assessment.

10.6.44 The study area is located within a groundwater Nitrate Vulnerable Zone (NVZ). These are designated areas of land draining into waters polluted by nitrates from agriculture. The European Nitrates Directive requires NVZ to be designated and for farmers with land in NVZ to follow mandatory rules to tackle nitrate loss from agriculture.

10.6.45 There are five internationally or nationally significant ecological designated sites within the study area (Ref 10.22), as follows:

a) The River Till in the west of the study area is designated as a SSSI and located within a Special Area of Conservation (SAC);

b) The River Avon in the east of the study area is designated as a SSSI and located within a SAC;

c) Parsonage Down is designated as an SSSI and National Nature Reserve (NNR) and is located within the western part of the Scheme boundary;

d) Salisbury Plain is designated as a SAC and Special Protected Area (SPA) and lies within the Scheme boundary in the northern and eastern extents of the study area; and

e) Yarnbury Castle is designated as a SSSI and is located at the western extent of the study area.

Underground structures

10.6.46 A number of underground assets are located beneath the study area associated with supplying utilities such as water, electricity, gas and telecommunications to the settlements of Winterbourne Stoke, Amesbury and Ratfyn. The route of a high pressure Esso oil pipeline, aligned south east to north west, is intersected by the Scheme alignment in the vicinity of Berwick St James and Winterbourne Stoke. In addition, the potential also exists for networks of agricultural land drains within agricultural fields, crossing and running adjacent to the Scheme.

Soil and groundwater contamination potential

Current land use

10.6.47 Current Ordnance Survey (OS) Mapping (Ref 10.23), aerial imagery (Ref 10.24), Groundsure (Ref 10.16) and Envirocheck (Ref 10.17) data have been reviewed alongside observations from site visits in order to identify the present land uses within the study area.

10.6.48 The current land use within the study area is characterised by rural land use, with a number of villages, and the town of Amesbury. The majority of the land within the study area is in arable use, though some land alongside the River Till and around the major archaeological monuments is permanent grassland. Two pig farms currently exist in the western area and directly south east of Longbarrow Roundabout.

10.6.49 Current light industrial land uses within the study area include a goods yard, a motor garage and sewage works located in Ratyfn, and an engineering services located in Amesbury. In addition a small operational army barracks named Rollestone Camp is located adjacent to the northern section of the Scheme boundary. There are no current industrial uses located within the Scheme boundary.

10.6.50 There are four current fuel stations located in the study area, the closest is situated to the north east of Countess Roundabout adjacent to the Scheme boundary. During the 2009 Countess Roundabout ground investigation (Ref 10.25), no visual or olfactory evidence of contamination impact was observed in the saturated zone (which would have been indicative of off-site contamination). However, there is potential for leaks and/or spills to have occurred at the fuel station since 2009.

Historical land use

10.6.51 Historical OS maps (Ref 10.14 and 10.17) along with further documentary information within the PSSR (Ref 10.7) (including aerial photographs) and the GIR (Ref 10.8) have been reviewed to identify historical land uses within the study area. The dominant historical land use along the Scheme and within the study area is agricultural.

10.6.52 Key potentially contaminative historical land uses within the study area are shown on Figure 10.6 and presented in Table 10.7. Available supplementary information from other sources of information is provided in Appendix 10.3.

Table 10.7: Key historical potentially contaminative land use sites within the study area

Name and area reference[1]	Location	Description
Former RAF Oatlands Hill (CL018)	South west of Longbarrow Roundabout and would be intersected by the Scheme.	Comprised a grass airfield, hangars and underground fuel storage. Operational during World War II (1941 to 1946). Cut earthworks are proposed in the footprint of the former RAF Oatlands Hill associated with the proposed new Longbarrow Junction construction.
Former Larkhill Military Light Railway (CL025)	East of Longbarrow Roundabout and would be intersected by the Scheme.	The railway line is shown on the 1924 OS map but is labelled as having already been dismantled. Cut earthworks are proposed associated with Green Bridge Four and the cutting approach to the western portal.
Former Royal Flying Corps (RFC) Lake Down (CL023)	Located to the south of Longbarrow Roundabout and intersected by the southern extent of the Scheme boundary (existing A360 south from Longbarrow Roundabout).	World War I airfield (1917 to 1924) understood to have been used for day bombing run training.

Name and area reference[1]	Location	Description
Former RAF Stonehenge (CL035)	West of the Stones and intersected by the Scheme tunnel alignment.	Comprised a World War I military airbase and airfield. Understood to have entered into operation in 1917 and was earmarked for disposal by 1921. The western section of the proposed tunnel would intersect the domestic area of the former main camp.
Former RAF Stonehenge sewage works (CL038) and sewage outfall (CL037)	South of the Stones and 50m to the south of the Scheme boundary.	The OS map dated 1924 shows a disused sewage works that is understood to have been associated with the former RAF Stonehenge. Aerial photos indicate that this was dismantled sometime between 1943 and 1970.
Former Quarry (CL041)	North west of Amesbury and intersected by the Scheme.	The feature is labelled as an old quarry on the 1901 OS map and remains on mapping until at least 1961. The location of the former quarry corresponds with the proposed Amesbury cutting.
Former Gas Works (CL045)	Located in Amesbury adjacent east of the A345. The site is adjacent to the Scheme boundary however no excavation is proposed in this area.	Historical maps dated 1877 to 1901 show a gas works located to the south of the River Avon in Amesbury. The facility comprised a gasometer and an associated building.
Former SR Bulford Extension Railway (CL057)	Located in Amesbury/Ratfyn and partially within the boundary of the proposed corridor for utility connection.	Former Amesbury and Military Camp Light Railway shown on the 1924 and 1937 OS maps. Historically passed beneath the existing A303 in a cutting east of Amesbury.
Historic engine sheds and above ground tank (CL055)	Located in Ratfyn and intersected by the eastern proposed corridor for utility connection.	Two engine sheds and an above ground tank are shown on the 1926 OS Map off a spur of the Amesbury and Military Camp Light Railway.

[1]*Each potentially contaminated site is allocated a unique reference number*

Regulatory data

10.6.53 The Groundsure Enviro Insight (Ref 10.15) and Envirocheck Report (Ref 10.17) show the following features to be absent from the Scheme study area:

a) authorised landfills;

b) recorded historical landfills;

c) industrial facilities with Integrated Pollution Prevention and Control;

d) Control of Major Accident Hazards facilities; and

e) hazardous substance consents.

10.6.54 The Groundsure Report Enviro Insight Report (Ref 10.15) shows there is one isolated recorded pollution incident to controlled waters within the study area. The incident was reported on 29th October 2002 and relates to a release of oils and fuel to ground, approximately 140m south of the Scheme (south west of Countess Roundabout). This was reported as a Category 3 – Minor Incident. Given the date of the incident, its significance as a potential source of contamination is considered to be low.

10.6.55 The route of a high pressure Esso oil pipeline, aligned south-east to north-west, is intersected by the Scheme alignment in the vicinity of Berwick St James and Winterbourne Stoke. Although this is considered as a possible source of contamination, there are no recorded pollution incidents on or around the route of this pipeline within the study area.

10.6.56 According to the Groundsure Enviro Insight Report (Ref 10.15) and Envirocheck Report (Ref 10.17) there are four current fuel stations located within the study area:

a) Shell Countess, Countess Road, Amesbury, SP4 7AS (located adjacent to the Scheme boundary). The status is identified as Open.

b) Co-Op Amesbury located at Mid Summer Place, Amesbury Solstice Park, Salisbury, SP4 7SQ (located 60m south of the Scheme boundary). The status is identified as Open.

c) Stonehenge Filling Station located at High Street, Winterbourne Stoke, SP3 4SZ (located 110m south of the Scheme boundary). The status is identified as Open.

d) Amesbury Filling Station located at 2 London Road, Amesbury, SP4 7DY (located 240m south of the Scheme boundary). The status is identified as Open.

10.6.57 According to the Groundsure Enviro Insight Report (Ref 10.15) and Envirocheck Report (Ref 10.17) there are eight registered discharge consents within the study area. Four of these discharge consents have been revoked. The consents relate to the discharge of site drainage water, cooling water or sewage effluent (final/treated) to the River Avon or groundwater via a soak away. The closest active consent is registered to Stonehenge Visitor's Centre within the Scheme boundary for the discharge of cooling water into land. Further details are provided in Chapter 11 (Road Drainage and the Water Environment).

Ground Investigation – Soil and Groundwater Chemical Analysis

10.6.58 As part of the GIR provided in Appendix 10.1 (Ref 10.8) a contamination assessment in the form of a Generic Quantitative Risk Assessment (GQRA) was undertaken. The GQRA was based on soil and groundwater chemical data

obtained from the EP GI as well as a limited amount of relevant chemical data from historical ground investigations carried out between 2001 and 2010.

10.6.59 As part of the EP GI a total of 28 soil samples, 11 soil leachate samples and three groundwater samples were recovered and submitted for laboratory analysis for a suite of inorganic and organic determinands. During the historic ground investigations 14 soil samples were collected at Longbarrow and Countess roundabouts and four groundwater samples were collected in the Stonehenge Bottom area (in the vicinity of the proposed tunnel) for geo-environmental analysis.

10.6.60 Geo-environmental data is available from a total of 32 sampling points, all located within the study area except for two of the EP GI points which were positioned 70m to 120m south of the study area within Stonehenge Bottom. Four of the soil sampling locations and one of the groundwater locations are within 50m of the Scheme alignment. All of the EP GI exploratory positions sampled were located in agricultural fields. The 16 historic geo-environmental sampling points were all positioned within 50m of the Scheme. Whilst the completed geo-environmental sampling undertaken does not specifically target the identified current and historical potential sources of contamination identified, the data does provide a quantified measure of baseline soil and groundwater quality in the study area.

10.6.61 A plan showing the geo-environmental testing locations is presented in Figure 10.7 and the tabulated chemical results are provided in the GIR (Ref 10.8). A summary of the key findings of the GQRA undertaken on the data is provided as follows.

Summary of soil results

10.6.62 In order to evaluate potential risks to human health, the available soil data was screened against Generic Assessment Criteria (GAC) for an open space (parks) land use, which is consistent with the end use criteria adopted in previous recent assessments e.g. the PSSR (Ref 10.7). All of the soil samples collected during the EP GI recorded concentrations below the adopted GAC.

10.6.63 The 14 soil samples collected during the historical Longbarrow and Countess Roundabout investigations all relate to samples from shallow Made Ground. The results showed that concentrations of Polycyclic Aromatic Hydrocarbons (PAH) in two samples taken from trial pits located on the north western side of Countess Roundabout (TP2 and TP4) exceeded their adopted screening criteria. The sample from TP4 also reported a strong hydrocarbon odour with concentrations of Total Petroleum Hydrocarbon (TPH) of 13,900mg/kg which was considered to likely be associated with a fuel spillage (Ref 10.25). TPH analysis was undertaken for combined aliphatic and aromatic bands and therefore no direct comparison to a GAC was possible. However, a comparison of the combined concentrations against the aromatic TPH GAC (the lower of the two criteria) indicates that there are no exceedances.

10.6.64 Based on the results of the human health risk assessments undertaken on soil samples obtained from the EP GI and available historic investigations, it was concluded that there is unlikely to be a significant risk to human health based on the areas investigated.

Summary of leachate and groundwater results

10.6.65 To assess the baseline groundwater quality and potential risks to groundwater or surface water, a comparison of the maximum concentrations recorded in groundwater and soil leachate samples was made against published limits. The results were screened against Environmental Quality Standards (EQS – freshwaters) and drinking water standards (DWS) that are protective of the environment and also drinking water supplies.

10.6.66 The screening assessment identified that no phenols, TPH, Volatile Organic Compounds (VOC) or Semi Volatile Organic Compounds (SVOC) were detected greater than the test method limit of detection. All PAHs were also detected less than the limit of detection of the test method for the groundwater samples taken. No soil leachate or groundwater chemical analysis was undertaken in trial pit TP4 where a strong hydrocarbon odour and elevated TPH concentrations were recorded in shallow Made Ground during the 2009 investigation. No free product was noted and no impact was observed in the underlying Alluvium in TP4 or in the other 13 exploratory holes within Countess Roundabout. Based on the isolated nature of the observed impact, and its presence being limited to shallow Made Ground, no unacceptable risk to controlled waters was identified.

10.6.67 The PAH fluoranthene was detected in excess of the EQS screening value in three out of 11 soil leachate samples. These samples all related to natural soils and PAH were not detected above the limit of detection within the corresponding soils solid state analysis. In addition, no obvious source for PAH is evident. Given the relatively isolated nature of the exceedances they were not considered to represent an unacceptable risk to controlled waters.

10.6.68 The metals copper, lead and zinc were detected in the groundwater samples at concentrations greater than the EQS screening value. Copper was recorded above the EQS value in all seven groundwater samples by factors of between 2 and 20. The detected exceedances for lead and zinc were limited to two boreholes sampled in 2001. The concentrations of copper and zinc recorded in groundwater fall within BGS published natural groundwater quality baseline range (Ref 10.26). Concentrations of metals detected in the eleven soil leachate samples were generally reported below the corresponding screening criteria.

10.6.69 Elevated total cyanide concentrations were detected in one groundwater sample collected from the historical borehole R13 (located approximately 45m south of the proposed tunnel alignment) when compared to the EQS (exceeds by two orders of magnitude) and DWS (exceeds by one order of magnitude) values. Cyanide was not detected in any of the soil samples tested or any of the soil leachability tests undertaken. Based on the isolated nature of the exceedance, no unacceptable risk to controlled waters was identified.

10.6.70 One minor exceedance of the DWS value for nitrate was detected in the groundwater sample taken from borehole PX505A located in the Stonehenge Bottom area. Marginally elevated concentrations of nitrite were detected in three soil leachate samples collected from topsoil in the same area (P502B, P505 and R506A) compared to the DWS value. In addition, concentrations of ammoniacal nitrogen were detected above the EQS value in one soil leachate sample collected from topsoil. It was acknowledged that given the agricultural use of the area, the presence of nitrogen compounds within groundwater and soil leachate would not be an uncommon or surprising finding.

10.6.71 Given the generally minor level of metals and nitrogen compounds identified within the groundwater and the low soil leachability concentrations, the isolated detections of fluoranthene in soil leachate and cyanide in groundwater and the field observations (natural soils and no olfactory evidence of chemical impact), the measured concentrations were not considered to represent an unacceptable risk to water quality. Where exceedances against adopted screening values have been noted, this is generally considered to be attributable to background soil and groundwater conditions.

Phosphatic Chalk Assessment

10.6.72 Phosphatic Chalk is known to be present within the Stonehenge Bottom area of the study area and these deposits are likely to be intercepted during tunnel boring. This material is expected to have a higher phosphorus content compared to normal Chalk. The key environmental risk is considered to be the potential adverse effect on water quality of the River Till or Avon through eutrophication as a result of nutrient loading, should the material be re-used as part of the Scheme.

10.6.73 There are also uranium-bearing minerals within the Phosphatic Chalk which could give rise to increased radon emissions. However, since radon is a noble gas, it does not absorb to air particulates and in an outside environment, it is dispersed to such an extent that it represents no significant risk. The study area does not lie within a radon affected area.

10.6.74 In order to establish the leachate potential of phosphorus in the Phosphatic Chalk at Stonehenge Bottom and the possible risks posed to controlled waters should the material be excavated and re-used within the study area, supplementary chemical testing and assessment was undertaken in February 2018 as part of the GIR (Ref 10.8). The Phosphatic Chalk cores were also screened for radiation to quantify the radon potential and level of potential risk to human health. A summary of the findings is presented below and the full assessment and laboratory certificates are presented in the GIR.

Phosphatic Chalk leachate potential

10.6.75 As part of the EP GI completed between January and April 2017, a limited amount of phosphorus testing was undertaken on samples of the Phosphatic Chalk present to the west of Stonehenge Bottom. One sample collected from the Chalk with occasional pockets of Phosphatic Chalk nodules (borehole

R503B, 6.2m bgl) was analysed for leachable total phosphorus. Five samples of Phosphatic Chalk in borehole R501 were tested for water soluble phosphorus. In addition, one groundwater sample obtained from R503B was tested for total phosphorus, although in this borehole groundwater was not in direct contact with the Phosphatic Chalk nodules. The reported concentrations were all below the corresponding laboratory level of detection of 2.5mg/l. The EP GI exploratory hole locations are presented in Figure 10.3.

10.6.76 While the testing completed suggested the solubility of phosphorus in the Phosphatic Chalk is low, the data set was considered to be limited. Consequently, additional phosphorus leachate testing was undertaken in February 2018 on the Phosphatic Chalk cores obtained during the EP GI and held in storage.

10.6.77 The rationale of the additional Phosphatic Chalk leachate testing is reported in the GIR (Ref: 10.8). A summary is provided as follows:

a) Cores from boreholes R501, R503B and P505 where Phosphatic Chalk had been logged were selected for additional sampling. These boreholes were located to the west of Stonehenge Bottom which corresponds with the western part of the proposed tunnel alignment.

b) A total of 16 Phosphatic Chalk samples were collected at depths ranging between 8.45m bgl and 32.6m bgl and corresponding with the proposed tunnel vertical alignment; with some flexibility for adjustments that might be made at later design stages. The majority of these samples (14) were from borehole R501 based on its proximity to the tunnel alignment and the relative prevalence of logged Phosphatic Chalk.

c) The 16 samples were submitted for leachate analysis for a suite comprising reactive phosphorus (also known as orthophosphate) and selected major ions. The reactive phosphorus leachate analysis was undertaken using an automated colorimetric method (discrete analyser) in accordance with the recommendations in the UK Water Framework Directive (2013) guidance (Ref 10.27).

10.6.78 The results of the additional leachate analyses reported concentrations of reactive phosphorus below the laboratory level of detection of 0.05mg/l in all 16 samples. Concentrations of leachable total phosphorus were also recorded below the laboratory level of detection of 1mg/l. The reported concentrations of reactive phosphorus were better than the ‘good’ water quality standard recommended in the UK Water Framework Directive guidance (0.052 - 0.09mg/l) for a lowland high alkalinity river (i.e. high quality).

10.6.79 The leachate test results suggest that the dominant calcium carbonate chemistry of the Chalk is likely to generate a precipitation (mineral formation) rather than a dissolution environment, such that the rock is unlikely to yield large concentrations of dissolved phosphorus. Based on the findings of the additional leachate testing, the re-use of Phosphatic Chalk excavated material

at ground surface is not considered to pose an unacceptable risk to the phosphate element of water quality of the River Till or River Avon through groundwater migration and/or direct surface water runoff. This risk is therefore scoped out of the assessment.

Naturally occurring radiation of materials

10.6.80 In order to quantify the Phosphatic Chalk radon potential, the cores from the EP GI boreholes R501, P503B and P505 throughout the Phosphatic Chalk were screened using a Tracerco NORM Monitor on 12th February 2018. The full results from the scanned cores are provided in the GIR (Ref 10.8) and the EP GI borehole locations are shown on Figure 10.3.

10.6.81 Background levels were established by the collection of five integrated 100 second counts from two locations one of which was the core stores in Bristol. These readings provided a threshold for statistically identifiable radioactivity (three times background). The entire length of the cores was screened and each of the readings taken was recorded to be below the threshold for determining the presence of measurable radioactivity. Based on these measurements it is therefore considered that radioactivity is not a factor in determining the fate of rock removed as part of the excavation. This risk is therefore scoped out of the assessment.

Conceptual site model

10.6.82 In order to identify the potential contaminant linkages, a conceptual model of the Scheme has been developed. The topography, geology, hydrogeology and hydrology of the Scheme 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 other relevant chapters within this ES. Potential sources and pathways linking any sources to the defined receptors are then identified.

Receptors

10.6.83 The site specific receptors were identified based on the proposed land use as well as the environmental setting of the study area. Table 10.8 presents the identified potentially sensitive receptors that have been considered within the assessment.

Table 10.8: Summary of potentially sensitive receptors

Receptor type	Receptor description	Receptor Sensitivity
Human Health	Residents of existing properties, closest located adjacent to the Scheme boundary in the areas of Winterbourne Stoke, Oatlands Hill, Amesbury and Ratfyn.	High
	Workers in and visitors to commercial properties	Moderate

Receptor type	Receptor description	Receptor Sensitivity
	Users of public open space including the Stones, Amesbury Park and ecologically sensitive sites such as the Parsonage Down NNR which is located within the Scheme boundary.	Moderate
Groundwater	Principal aquifer – Chalk Group	High
	Secondary A aquifer – Alluvium, River Terrace Deposits, Peat and Head Deposits (where these consist of gravel)	Moderate
	Secondary (undifferentiated) aquifer – Head Deposits (comprising clay, silt, sand and gravel)	Low
Surface water	River Till and River Avon	High
Built Environment	Underground structures and buried services	Low
Natural Environment	River Till and River Avon (SSSI and SAC), Parsonage Down (SSSI and NNR), Salisbury Plain (SAC and SPA) and Yarnsbury Castle (SSSI).	High

Potential sources of contamination

10.6.84 A summary of the potential sources of land contamination within the study area identified following the baseline review is presented in Table 10.9 and sites taken identified for further assessment are shown on Figure 10.6.

Table 10.9: Summary of potential sources of land contamination within the study area

Possible sources within the study area	Number of features within the Scheme boundary
Military Land Use: a. Former RAF Oatlands Hill (1941–1946) (CL018); b. Rollestone Camp (CL028); c. Larkhill (Former Aerodrome and Current Royal School of Artillery) (CL028) and ; d. Former RAF Stonehenge (1917–1921) (CL035). e. Former RAF Lake Down (1917 – 1924) (CL023)	Three within the Scheme boundary: a. RAF Oatlands Hill (CL018); b. RAF Stonehenge (CL035); and c. RAF Lake Down (CL023).
Fuel Filling Stations: a. Winterbourne Stoke Filling Station (CL009); b. Amesbury Filling Station (CL046); c. Countess Filling Station (CL055); d. Coop Filling Station (CL071); and e. High Pressure Esso Oil Pipeline (CL080)	High Pressure Esso Oil Pipeline crosses the Scheme boundary (CL080).
Industrial Uses (current and former) including: a. Former Larkhill Military Light Railway (CL025); b. Former RAF Stonehenge Sewage	Eight within the Scheme boundary: a. Former Larkhill Military Light Railway (CL025); b. Former sewage outfall associated with

Possible sources within the study area	Number of features within the Scheme boundary
Works (CL038) and outfall (CL037); c. Former Gas Works (CL045); d. Historic Engine Sheds (1926) (CL055); e. Six current and historical Vehicle Repair Garages (CL056, CL065, CL102, CL0109, CL0110 and CL112) f. Former SR Bulford Extension Railway (1924–1937) (CL057); g. Two areas of Former Railway land and sidings complexes along route of SR Bulford Extension Railway (1924–1937 (CL065 and CL057); h. Current goods yard (CL113); i. Industrial Repairs and Servicing (CL059); j. Precision Engineers (Engineering Services) (CL064); k. Distribution Depot and Warehousing (CL066); l. Historic Barn and Above Ground Tank (1877–1961) (CL016); m. Former Stonehenge Pedigree Stock Farm (1924–1926, on the site of the former RAF Stonehenge) (CL036); n. Two sites of current unknown industrial/goods yard use (CL091 and CL113); o. Painting Contractors (CL069); p. Laundry (CL070); q. Dry Cleaners (CL112); and r. Ready Mix Concrete Plant (CL103).	RAF Stonehenge Sewage works (C038); c. Former Gas Works (CL045); d. Former SR Bulford Extension Railway (1924 –1937) (CL057); e. Former Railway land along route of SR Bulford Extension Railway (1924 –1937 (CL057)); f. Historic barn and above ground tank (1877–1961) (CL016); and g. Former Stonehenge Pedigree Stock Farm (1924 –1926, on the site of the former RAF Stonehenge) (CL036).
Thirteen Farms/Farm Buildings (Multiple Site ID's)	Three within the Scheme boundary (CL003, CL012 and CL044).
Nine Electricity Substations (CL011, CL043, CL049, CL053, CL054, CL061, CL081, CL088 and CL097)	None within the Scheme boundary.
Three Pumping Houses/Stations (CL005, CL021 and CL050)	Three within the Scheme boundary (CL005, CL021 and CL050).
Twenty-Four areas of potential infilled ground including former pits, former reservoirs, infilled cuttings, ponds, quarries and tips (Multiple Site ID's).	Eight within the Scheme boundary (CL010, CL014, CL015, CL020, CL041, CL058, CL098 and CL111).

Potential pathways

10.6.85 The human health exposure pathways that are considered viable based on the proposed highways end use but also accounting for neighbouring properties and people during the construction are listed below:

a) dermal contact with soil, dust and groundwater;

b) ingestion of soil, dust and groundwater;

c) inhalation of dust;

d) inhalation of vapours (from soils and groundwater); and

e) inhalation of ground-gas in confined spaces.

10.6.86 The controlled waters (surface water and groundwater) pathways considered viable are as follows:

a) mobilisation of soluble contaminants exposed during construction works;

b) vertical and lateral migration of leachate through the unsaturated zone to groundwater;

c) vertical and lateral groundwater migration; and

d) surface water run-off.

10.6.87 The built environment (underground structures and buried services) pathways that are considered viable are as follows:

a) ingress and/or accumulation of ground gas/vapours in the proposed tunnel; and

b) direct contact of ground with in-ground structures: sulphate attack on concrete foundations and/or permeation of hydrocarbons through plastic potable water supply pipes.

10.6.88 The natural environment (ecological designations) pathways that are considered viable are as follows:

a) vertical and lateral groundwater migration to the River Till and River Avon; and

b) migration of dust and direct contact with statutory sites for nature conservation.

Conceptual site model summary

10.6.89 The results of the leachate analyses undertaken on Phosphatic Chalk indicate that this material is unlikely to pose an unacceptable risk to controlled waters should the material be excavated, stored and re-used within the Scheme boundary. Furthermore, screening of the Phosphatic Chalk cores for naturally occurring radioactive material (NORM) showed that the readings taken were below the threshold for determining the presence of measurable radioactivity.

10.6.90 A review of desk study data indicates there is generally a low potential for ground contamination to exist along the Scheme. Potentially contaminated sites which could interact directly with the Scheme and where excavations would be

required, includes the former RAF Oatlands Hill, the former Larkhill Military Light Railway, a current pig farm, the former RAF Stonehenge, a former quarry, former SR Bulford Extension Railway and former railway land. Based on the CSM, potential contaminant linkages have been identified and these have been discussed in Appendix 10.2.

10.6.91 The findings of the GQRA undertaken on limited available soil and groundwater chemical data (Ref 10.8) indicated that there is unlikely to be an unacceptable risk to human health or controlled waters based on the areas investigated. It was acknowledged that whilst the chemical results are considered to be broadly representative of general ground conditions across the Scheme, the assessment was based on limited sampling data and no site specific sampling was completed to target all of the potential sources identified in Table 10.9, particularly the former military sites.

Future baseline

Construction Year Baseline (2021)

10.6.92 The potential for the baseline ground conditions to change in the lead up to the construction of the Scheme is limited to the extent to which any new development necessitates remediation or mitigation measures to control potential contamination releases. Any new development in the study area on potentially contaminated land would need to be suitable for its intended use as set out in the NPPF (Ref 10.2). To meet this requirement new development sites may require remediation to be undertaken. This wouldmean that some areas described as having potentially contaminative current and/or historical land use, may no longer be of significance at the time of construction of the Scheme. There are two known application sites within the study area where this may apply:

a) Construction of a fuel filling station at the Tesco Superstore in Amesbury, approximately 170m south of the Scheme boundary. This development lies within the footprint of an area of potentially infilled land associated with the SR Bulford Extension Railway which is identified as a potential source of contamination in Table 10.9.

b) The construction of an agricultural machinery store to replace the existing store building at Ratfyn Farm, adjacent to the Scheme boundary.

10.6.93 The potential for the baseline conditions to change would also depend on whether any land has been classified as contaminated land (none classified currently) by the Local Authority under Part 2A of the Environmental Protection Act 1990 (Ref 10.4). A number of mechanisms drive these determinations therefore they are difficult to predict. Where Part 2A determinations are made, the potential baseline change would occur where remediation works are subsequently undertaken.

10.6.94 Based on the above, the land quality assessment does not consider these proposed developments would result in significant future changes to the baseline ground conditions.

Opening Year Baseline (2026)

10.6.95 The potential for the baseline to have changed by the time the Scheme is operational is limited to the extent to which any new development (between 2021 and 2026) necessitates remediation or mitigation measures to control potential contamination. No committed developments have been identified in this local area that would materially alter the baseline conditions in 2026 for land quality.

10.7 Potential impacts

10.7.1 Mitigation measures incorporated in the design and construction of the Scheme are set out in Section 10.8. Prior to implementation of the mitigation measures, the Scheme has the potential to affect geology and soils (positively or negatively), both during construction and once in operation. Details are provided in the sections below.

Construction

10.7.2 In the locations of the identified land uses in Table 10.9, and in the event of disturbance of contaminated soils/groundwater, there is the possibility, in the absence of any mitigation measures, that construction may affect human, ecological or controlled waters receptors, and for the ground conditions to impact on the design of the Scheme. Excavated material is expected to comprise inert Chalk with no potential contamination (including the Phosphatic Chalk), therefore the main risks relate to excavations for cuttings, the proposed tunnel portals in the areas of the current pig farm and former RAF Stonehenge, proposed utilities corridor and bridge foundations.

10.7.3 Potential impacts include but are not limited to:

a) mobilising existing contaminants in soil and groundwater as a result of exposure following ground disturbance and de-watering during construction;

b) increasing the potential for contaminants in unsaturated soils to leach to groundwater in open excavations during construction, for example, any ground contamination that may be present at the tunnel portals from the pig farm (CL034) and former RAF Stonehenge (CL035);

c) increasing the potential for contaminated surface run-off to migrate to surface water and groundwater receptors as a result of contaminant mobilisation from uncovered stockpiles;

d) introducing new sources of contamination, such as fuels and oils used in construction plant and fluids and chemicals used in tunnel boring;

e) creating preferential pathways for the migration of soil contamination and ground gases, for example, along new below ground service routes, service ducts and as a result of de-watering; and

f) introducing new human health receptors such as site staff/construction workers during construction.

10.7.4 Construction activities can also result in physical damage to soil, including the excavation process for the proposed cuttings and tunnel portals, the tunnelling process, soil compaction as a result of heavy construction vehicle movements and the exacerbation of soil erosion through handling and storage of soils.

10.7.5 Potential impacts associated with temporary dewatering, if required during construction, are assessed in Chapter 11 (Road Drainage and the Water Environment).

Operation

10.7.6 During the operational stage of the Scheme, conditions may have altered from the baseline as a result of, but not limited to:

a) introducing road users, operational maintenance staff and the road infrastructure as new receptors;

b) contamination which has been encountered having been removed or remediated;

c) revised road drainage and discharge routes compared to the existing A303 road drainage system and the potential for polluted highway run-off and drainage to be directed towards groundwater and surface water receptors with the new highways drainage system acting as a rapid pollutant pathway;

d) the potential for impacts arising from pollutants e.g. fuel spillages, to pass directly into the aquifer, bypassing the drainage system such as in the proposed tunnel where the invert would sit directly onto the Chalk; and

e) reduction in soil erosion through improved drainage design and improvement in surface water runoff quality as a result of additional treatment compared to existing conditions.

10.8 Design, mitigation and enhancement measures

Construction

Embedded mitigation measures

10.8.1 Mitigation by design has been the primary consideration in the route chosen for the Scheme. Opportunities have been taken to avoid geological, geomorphological and hydrogeological receptors. The topic has been considered in design options developed to date, for example, the design of the

Countess Junction has a reduced construction footprint, and hence more constrained earthworks, relative to alternative options considered. This is expected to reduce the extent of ground disturbance in this area.

10.8.2 Further ground investigation would be undertaken prior to construction in order to inform the detailed design. These further studies would enable further consideration of risks from possible historical contamination areas, notably within the former RAF Oatlands Hill and RAF Stonehenge, and also the potential for migration of possible contaminants from the current Countess Service Station. Where risks are deemed to be significant, remediation options and strategies would be developed accordingly, pursuant to the process set out by the DCO requirement.

10.8.3 The Scheme passes over an existing Esso oil pipeline, to the north west of Winterbourne Stoke. At this point, the pipeline is currently 1.2m below ground level and the proposed carriageway is intended to be on an embankment up to 18m in height, with additional landscaping using exacavated materials in order to taper slopes into the surroundings. A protective structure would be installed to protect the pipeline in this location against construction impact and effects of ground settlement of the new road.

10.8.4 North of the new A303 alignment and east of Parsonage Down, the pipeline would be diverted. The alignment would be located within the area between the existing pipeline and the A3083 as shown in Chapter 2.

10.8.5 The results of the screening undertaken on three Phosphatic Chalk cores in February 2018 showed no measurable radioactivity activity was detected.

10.8.6 Construction techniques would be used which minimise the need for dewatering as far as reasonably practical. Further details including the findings of a Groundwater Risk Assessment are provided in Chapter 11 (Road Drainage and the Water Environment).

10.8.7 Piles for Green Bridges Two to Four and those for the Countess Flyovers would extend below the groundwater level. To reduce the risk of creating preferential pathways from the surface to the underlying Chalk groundwater body non-displacement construction methods would be used. Further details are provided in Chapter 11 (Road Drainage and the Water Environment), Appendix 11.4 Groundwater Risk Assessment.

10.8.8 An Outline Environmental Management Plan (OEMP) has been developed that contains measures to ensure compliance with relevant standards and legislation, see Appendix 2.2. The OEMP sets out the environmental mitigation requirements and also the project level expectations on how the Scheme would be constructed, as proposed in the rest of this section.

10.8.9 Measures contained within the OEMP are designed to limit the possibility for dispersal and accidental releases of potential contaminants, soil derived dusts and uncontrolled run-off to occur during construction. For example the OEMP

sets out how material is to be excavated, segregated and stockpiled to minimise the possibility for run-off, soil quality degradation and wind dispersal of dusts. The OEMP also establishes procedures for dealing with unexpected soil or groundwater contamination that may be encountered.

10.8.10 The successful Contractors would develop a detailed Construction Environmental Management Plan (CEMP) for their part of the construction works in conjunction with stakeholders (as set out in the OEMP) to ensure compliance with the environmental requirements set out in the OEMP.

10.8.11 Defra (Department for Environment, Food and Rural Affairs) has worked with the Department of Trade and Industry to develop a Code of Practice for Sustainable Use and Management of Soils on Construction Sites (2009) (Ref 10.28). The code of practice, which would be adopted for the construction of the Scheme, encourages the following:

a) identification of soil resources at an early stage in the development process;

b) improved planning of soil use;

c) a better level of soil management during project implementation, including sustainable use of surplus soil;

d) maintenance of soil quality and function both on and off site;

e) avoidance of soil compaction and erosion (with a consequent reduction in flooding and water pollution); and

f) an improved knowledge and understanding of soil at all levels in the construction industry, including soil amelioration techniques.

10.8.12 Topsoil would need to be removed during construction in order to prevent permanent burial beneath other earthworks. Such soils would be stockpiled and re-used, subject to acceptability, in the general earthworks for the Scheme such as landscaping and noise bunds. In particular, topsoil excavated from areas of known high quality agricultural land would be stored separately and, where possible, would be reused on-site in areas that would be returned to agricultural use.

10.8.13 The effects on soil resources would be mitigated by employing high standards of soil handling and management during construction, and by avoiding the creation of bare areas of exposed soil that would be vulnerable to erosion processes.

10.8.14 Topsoil stripped during the construction of the Scheme would be re-used as soon as is practicable and stored in such a way as to minimise structural damage from weathering, construction traffic movements, and multiple handling. This would also minimise the potential for leaching of nutrients from soils.

10.8.15 All materials proposed for re-use would be required to meet risk-based acceptability criteria. Soils would be protected from accidental contamination during storage and transit. Methods of soils handling and storage, including measures to prevent erosion by wind and surface water, would be detailed in method statements that would be prepared prior to the commencement of construction activities.

10.8.16 The re-use of excavated material would be governed by a Materials Management Plan developed in accordance with the CL:AIRE Code of Practice(Ref 10.29). The CL:AIRE Code of Practice is a voluntary framework for excavated materials management and re-use. Following this framework results in a level of information being generated that is sufficient to demonstrate that excavated material has been re-used appropriately and is suitable for its intended use. It demonstrates that unsuitable material or waste has not been used in the development. The Materials Management Plans would detail the procedures and measures that would be taken to classify, track, store, reuse and dispose of all excavated materials that would be encountered during the development/construction works.

10.8.17 There is not anticipated to be a requirement for off-site disposal of excavated soils and waste. However should the requirement arise, the material would be characterised to determine firstly whether it is Hazardous or Non-Hazardous waste in accordance with the EA's Technical Guidance WM3 (Ref 10.30). Once this is established the appropriate disposal facility would be determined through Waste Acceptance Criteria (WAC) analysis, as required.

10.8.18 Potential impacts specific to construction workers during site preparation and construction would be mitigated by the following measures and through working in accordance with CIRIA C741 4th Edition 'Environmental Good Practice On Site' (2015) (Ref 10.31), included in the OEMP.

a) measures to minimise dust generation;

b) provision of PPE, such as gloves, barrier cream, overalls etc. to minimise direct contact with soils;

c) provision of adequate hygiene facilities and clean welfare facilities for all construction site workers;

d) monitoring of confined spaces for possible ground gas accumulations, restricting access to confined spaces, i.e. to suitably trained personnel only, and use of specialist Personal Protective Equipment (PPE), where necessary; and

e) preparation and adoption of site and task specific health and safety plans as is required under Health and Safety legislation.

10.8.19 The OEMP sets out the geology and soils-related construction phase monitoring requirements. These are that the contractor shall prepare and implement a gas

monitoring procedure based on the potential for presence of underground gases; the contractor would undertake monitoring of the atmosphere within excavations to assess the development of any potentially explosive and / or asphyxiant conditions; and that any land restored to agriculture would be subject to a 5-year period of condition monitoring.

Enhancement mitigation measures

10.8.20 Any remediation works applied to the existing ground or groundwater, and / or the removal of contaminated soils associated with the construction of the Scheme would be expected to result in the enhancement of the local environment.

10.8.21 The construction of the Scheme has the potential to expose geology of interest and to work with the geological community during construction. Ground investigations for the proposed tunnel have revealed a unique and complex Chalk geology including the presence of the thickest (>20 m thick), and previously unknown Phosphatic Chalks in England.

Operation

10.8.22 The design of the Scheme includes measures that would contain and control any releases of contaminants along the highway and its associated infrastructure such as drainage control. The drainage proposals for the Scheme set out in the drainage strategy include measures to contain and control surface water runoff from the highway. Road edge channels would intercept the runoff and outfall to a carrier pipe network which conveys the flows to drainage treatment areas.

10.8.23 There are two types of drainage treatment areas proposed within the scheme. To the west of the proposed tunnel, infiltration basins would be used to store and treat the runoff before discharging to ground. The basins would be lined with a proprietary treatment system which absorbs and contains potential contaminants. At Countess Roundabout a series of permanently wet linear ponds planted with reeds would be used to attenuate and treat the highway runoff before outfalling to existing ditches which convey the runoff to the River Avon. Penstocks would be specified upstream of the treatment areas to provide a cut off mechanism to contain spillages of contaminants on the highway.

10.9 Assessment of effects

10.9.1 An assessment of potential effects of the Scheme on agricultural soils is presented in Chapter 13 (People and Communities). Potential effects of land instability associated with construction of the proposed are discussed in the Land Instability Risk Assessment report (Ref 10.6).

10.9.2 In line with the assessment methodology set out in Section 10.3 and Appendix 10.2, an initial screening process has been undertaken on the potential land contamination sites identified in the baseline review (Table 10.9). The screening process seeks to identify areas of current or historical contaminative use that

might pose contamination risks during construction and operation of the Scheme.

10.9.3 The following factors have been used to generate risk scores for the sites listed in Table 10.9 as part of the screening process. Further information on the criteria used is provided in Appendix 10.2:

a) the location of the potential land contamination site in relation to the Scheme and associated off line works;

b) the vertical profile of the Scheme at the closest point to the potential land contamination site e.g. whether this is a cutting, viaduct, embankment or at grade; and

c) the presence of sensitive receptors e.g. underlying sensitive groundwater aquifers (Principal or Secondary A aquifers), watercourses, human and ecological receptors.

10.9.4 Sites that present a low risk (site ratings of zero to two) in accordance with Appendix 10.2, Table 10.1.3 have not been taken further in the assessment. Site ratings of three or more (moderate to higher risk sites) are described in Table 10.1.5 in Appendix 10.2 and indicated on Figure 10.6 and have been assessed further. A total of 43 sites have been scoped out of the further assessment, with a total of 46 sites scoped in.

10.9.5 For the sites identified for further assessment, site-specific conceptual site models have been produced: one for the baseline conditions; one for the construction phase; and one for the post construction (operational) phase. Sites of similar land use and history have been grouped where appropriate. Conceptual site models have been prepared for fuel filling stations, farms, infilled land, industrial land, light industrial land, railway land, military land, the former gas works, and the high pressure Esso oil pipeline.

10.9.6 The CSMs are presented in Appendix 10.2.

Temporary effects

10.9.7 To determine whether there are any potential temporary effects on human health, groundwater, surface water, buildings or ecological receptors during the construction phase, the baseline and construction risk levels (see Table 10.2 and Table 10.3), as defined in their respective CSM have been compared. Further information on this assessment is presented in Appendix 10.2.

10.9.8 Where there is no predicted change between the main baseline risk and the main construction risk, the temporary effect significance is deemed to be neutral.

10.9.9 An increase in risk at the construction stage compared to baseline would result in an adverse effect and conversely, any improvement resulting from construction, for example where remediation is undertaken or a contaminant

linkage is removed, would result in a beneficial effect. Whilst adoption of the measures in the OEMP would make it unlikely that there would be adverse effects during construction e.g. through the control of surface run off and dust, it is considered that there may still be some temporary minor adverse effects during construction from ground disturbance or groundwater control.

10.9.10 The assessment of temporary effects has shown that whilst there are predicted minor adverse impacts associated with the construction stage, none of these would be regarded as significant following adoption of the measures in the OEMP. A summary of the key considerations is provided as follows and details of the full assessment are presented in Appendix 10.2:

a) The greatest risk to controlled waters is associated with the petrol filling stations (moderate risk during baseline conditions), the former railway land, former gas works and light industrial uses posing a moderate/low risk under current baseline conditions. The impact at these locations has been assessed as either a neutral or minor adverse effect due to the potential for ground disturbance during construction and contaminant mobilisation/migration.

b) The assessed risks to receptors associated with the former and current military sites are generally low to very low with a neutral impact during construction of the Scheme. This is due to the low likelihood that contamination is present, or if present very limited, associated with these land use sources.

c) During construction, human health receptors outside the Scheme boundary have the potential to be impacted by the construction works. The impact during construction for human health receptors outside the Scheme boundary has been assessed as either a neutral or minor adverse effect due to the potential for ground disturbance and contaminant mobilisation/migration. This is due to the potential impacts specific to construction workers being mitigated through working in accordance with CIRIA C741 4th Edition ‘Environmental Good Practice On Site’ (2015) (Ref 10.31) and adhering to specific health and safety plans, as required under Health and Safety legislation.

d) The High Pressure Esso Oil Pipeline is considered to pose a moderate risk to controlled waters and a moderate/low risk to human health at baseline due to the severity of potential impact that would occur should a leak occur. However, this risk is not anticipated to change during construction of the Scheme due to the proposed mitigation measures that avoid interaction with the pipeline.

10.9.11 Construction compounds located in the study area would include the storage of potentially hazardous substances, such as fuels and lubricating oils and may also be used for temporary storage of potentially contaminated soils. Mitigation measures set out within the OEMP include a Control of Substances Hazardous to Health (COSHH)/fuel inventory, storage of COSHH in accordance with

relevant Environment Agency Pollution Prevention Guidance notes[3] and storing any hazardous materials in designated locations with specific measures to prevent leakage and release of their contents. No significant temporary effects are identified.

Permanent effects

10.9.12 To determine whether there are any potential permanent effects, the baseline and post-construction CSM have been compared. The details of these comparisons are presented in Appendix 10.2.

10.9.13 The assessment has shown that whilst there are a number of minor beneficial impacts at the post construction stage, none of these would be regarded as significant in line with the methodology followed in Appendix 10.2. Minor beneficial effects relate to where the Scheme may remove a potential contaminant source either through physical removal of that source, ground or groundwater remediation or the introduction of a break in a contaminant linkage. There are minor beneficial effects for controlled waters post construction for those CSMs for Railway Land, Military Land and Infilled land sites that are inside the Scheme boundary as a result of remediation taking place should contamination be encountered, thus the risk to the aquifer and where relevant the River Till and River Avon is reduced. No significant permanent effects are identified.

Operational effects

10.9.14 There are not expected to be any significant operational effects on geology and soils as the design of the Scheme includes measures that would contain and control any releases of contaminants along the highway and its associated infrastructure during the operational period. These include measures in the drainage design to prevent/minimise the risk of discharging pollutants into the Chalk aquifer via drainage pathways.

Summary

10.9.15 In summary, it is considered that there are no significant construction or operation stage effects in relation to geology and soils as defined in Table 10.2 and Table 10.3.

Future baseline (2021 and 2026)

10.9.16 There is one known application site within the study area for which development could occur at the time of construction of the Scheme (2021). This relates to the development of a small scale fuel filling station at the Tesco Superstore in Amesbury which was granted planning permission in March 2018. This development lies within the footprint of an area of potentially infilled land associated with the SR Bulford Extension Railway (CL057). However, it is

[3] Now withdrawn but widely considered good practice

located approximately 170m south of the Scheme boundary and excavations would not interact directly with the Scheme.

10.9.17 The construction of the fuel station is not expected to result in material changes to the future baseline ground conditions within the study area (see Section 10.6). On this basis, no changes to the assessed effects on geology and soils have been reported with respect to the future baseline (2021 and 2026).

10.10 Monitoring

10.10.1 As no significant effects have been identified for the geology and soils assessment, no monitoring of significant effects is proposed.

References

Ref 10.1: Highways Agency, Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 11 Geology and Soils, 1999

Ref 10.2: Department for Communities and Local Government, National Planning Policy Framework, 2018

Ref 10.3: Wiltshire Council, Wiltshire Core Strategy, Adopted January 2015

Ref 10.4: Her Majesty's Stationery Office (HMSO), Part 2A of the Environment Protection Act 1990 Contaminated Land Statutory Guidance, April, 2012

Ref 10.5: Soil Strategy for England (Department of the Environment, Transport and the Regions), 2009

Ref 10.6: Swindon Borough Council and Wiltshire Council, Wiltshire and Swindon Minerals Core Strategy 2006 – 2026, Adopted June 2009

Ref 10.7: AAJV, Preliminary Sources Study Report, (HAGDMS Ref. 29300), 2016

Ref 10.8: AmW, A303 Amesbury to Berwick Down, Preliminary Ground Investigation Report, Document Ref HE551506-AMW-HGT-SW_GN_000_Z-RP-CE-0005, August 2018

Ref 10.9: Structural Soils, A303 Amesbury to Berwick Down – Factual Report on Ground Investigation, 2017

Ref 10.10: AmW, A303 Amesbury to Berwick Down, Land Instability Risk Assessment, 2018

Ref 10.11: Soil Survey of England and Wales (1983) - 1:250,000 scale Soil Map of South East England. Rothamsted Experimental Station, Harpenden

Ref 10.12: Environment Agency, Contaminated Land Report (CLR11) Model Procedures for the Management of Land Contamination, 2004

Ref 10.13: National House Building Council (NHBC), Environment Agency and Chartered Institute of Environmental Health, Guidance for the Safe Development of Housing on Land Affected by Contamination, R&D Publication 66, 2008

Ref 10.14: Historical Ordnance Survey mapping - Landmark Envirocheck Report (References 95704268_1_1, 95704374_1_1 and 95704420_1_1, ordered 31 August 2016

Ref 10.15: Groundsure Enviro Geo Insight Report, December 2016

Ref 10.16: Groundsure Enviro Insight Report, December 2016

Ref 10.17: Landmark Envirocheck Report (References 163066221_1_1, 163066403_1_1, 163058397_1_1, 163067050_1_1, 163060021_1_1, 163067169_1_1 and 163059581_1_1, ordered 17 April 2018)

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Ref 10.24: Google, Aerial imagery sourced from Infoterra Ltd and Bluesky, 2017

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