A303 Amesbury to Berwick Down

TR010025

6.1 Environmental Statement

Chapter 11: Road drainage and the water environment

Volume 6

APFP Regulation 5(2)(a)

Planning Act 2008

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

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11 Road drainage and the water environment

11.1 Introduction and competent expert evidence

11.1.1 This chapter assesses the potential road drainage and water environment impacts of the construction and operation of the Scheme, following the methodology set out in the Design Manual for Roads and Bridges ("DMRB") Volume 11, Section 3, Part 10 HD45 (Ref 11.1), amended to reflect best practice. This chapter details the methodology followed for the impact assessment, summarises the regulatory and policy framework related to road drainage and the water environment and describes the existing water 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.

11.1.2 This chapter of the ES has been prepared by a competent expert with relevant and appropriate experience. The technical lead for the road drainage and water environment assessment is Will Rogers and his professional qualifications and experience are summarised in Appendix 1.1.

11.2 Legislative and policy framework

11.2.1 As discussed in Chapter 1, the primary basis for deciding whether or not to grant a Development Consent Order (DCO) for the Scheme 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 11.1 identifies the NPSNN policies relevant to the road drainage and the water environment assessment and where in the ES information is provided to address the policy.

Table 11.1: Relevant NPSNN policies for road drainage and the water environment assessment

Relevant NPSNN paragraph reference	Requirement of the National Policy Statement for National Networks (NPSNN) (paraphrase)	Where in the ES is information provided to address this policy.
4.38, 4.40, 4.42	Adaptation to impacts arising from climate change. Consideration of the impacts of climate change. Take into account the potential impacts of climate change and appropriate mitigation or adaptation measures.	Climate change is considered in ES section 11.8 and Appendix 11.5
4.44	Adaptation measures should be based on the latest set of UK Climate Projections and consultation with statutory consultation bodies.	The climate change projections used were discussed with the Environment Agency and Wiltshire Council as described in ES sections 11.3, and Appendix 11.5

Relevant NPSNN paragraph reference	Requirement of the National Policy Statement for National Networks (NPSNN) (paraphrase)	Where in the ES is information provided to address this policy.
4.45 - 4.47	The impact of adaptation measures themselves should be considered in relation to the application as a whole. Timing of adaptation measures. Ensure adaptation measures could be implemented should the need arise.	These are considered in Section 11.8 and Appendices 11.3 and 11.5
4.48 – 4.56	Considering the need for pollution control as required by the pollution control framework or other consenting and licensing regimes and the potential for a cumulative effect.	This is considered in ES sections 11.8, 11.9 and Appendices 11.2 and 11.3
5.92 - 5.95	Consider all forms of flooding, climate change impacts, safe access and egress and residual risk in a Flood Risk Assessment as in NPPF and guidance	All forms of flooding are considered. See ES sections 11.6, 11.7 and Appendix 11.5
5.96	Seek pre-application discussions with the Environment Agency, and, where relevant, other flood risk management bodies	Discussions were held with the Environment Agency and Wiltshire Council as described in ES sections 11.3, and Appendix 11.5
5.110	The use of sustainable drainage systems to manage flood risk	These are described in Appendices 11.3 and 11.5
5.111	The range of sustainable approaches to surface water drainage management	These are described in Appendix 11.3
5.220	Requirements for a plan with accompanying information identifying water bodies in a River Basin Management Plan.	Sections 11.5, 11.6 and Appendix 11.2
5.221	Early contact with the relevant water regulators and water supply companies. Requirements for an assessment of the impacts on water quality, water resources and physical characteristics as part of the environmental statement.	Section 11.3 and Appendices 11.1, 11.2 and 11.4
5.222	Opportunities should be taken to improve upon the quality of existing discharges where these are identified and shown to contribute towards Water Framework Directive commitments.	Appendices 11.1 and 11.2
5.223	Describe the existing water quality, water quantity and dynamics of flow, and physical characteristics of the water environment affected by the proposed project. Describing any impacts of the proposed project on water bodies or protected areas under the Water Framework Directive and source protection zones around potable groundwater abstractions; and any cumulative effects.	Sections 11.3, 11.6, 11.9 and Appendices 11.1, 11.2, 11.4 and 11.5

11.2.2 In accordance with the National Planning Policy Framework (NPPF), the NPS NN 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 NPS NN remains the primary source of policy guidance.

Policy

11.2.3 Other relevant policies have been considered as part of the road drainage and the water environment assessment where these have informed the identification of receptors, including sensitive receptors and resources and their sensitivity; the assessment methodology; the potential for significant environmental effects; and required mitigation. These policies include:

a) NPPF – paragraphs 150, 155, 157-161, 163 and 165 in relation to flood risk and sustainable drainage, paragraph 170 regarding water quality, and supporting Planning Practice Guidance sections on “flood risk and coastal change” (2014) and “water supply, wastewater and water quality” (2015) which support the application of NPPF policies.

b) Wiltshire Council Core Strategy Development Plan Document – core policy 67 (flood risk), core policy 68 (water resources) and core policy 69 (River Avon SAC).

11.2.4 With regard to flood risk, these policies identify the need to apply the Sequential Test and undertake a site specific Flood Risk Assessment (FRA) to inform the assessment of flood risk from all types of flooding to and from the development. They require the assessment to consider the vulnerability of users of the Scheme, consider the impacts of climate change and confirm whether flood risk is increased elsewhere. In addition, local flood risk management strategies and surface water management plans should be considered when assessing local flood risk. The policies also identify measures to mitigate flood risk through sustainable surface water management. These are presented in Appendix 11.5.

11.2.5 With regard to water quality and water resources, these policies require consideration of the impacts of pollution from development on the water environment by assessing water bodies, protected areas under the Water Framework Directive (WFD), safeguard zones, water protection zones, source protection zones around potable groundwater abstractions and ecological sites. Specifically, Wiltshire Core Strategy core policy 69 identifies the River Avon Special Area of Conservation (SAC) as a potential sensitive receptor which requires protection from adverse pollution impacts resulting from development. These policies also encourage mitigation of pollution on the water environment through careful design to facilitate good pollution control practice.

11.3 Assessment methodology

11.3.1 In order to assess the potential impacts of the Scheme on road drainage and water, risk assessments were undertaken using the source-pathway-receptor approach promoted by Defra and the Environmental Agency. For there to be an identifiable risk, there must be a source, i.e. a contaminant/activity and a

receptor and a pathway, which allows the source to impact on a receptor. All three elements must be present before a linkage can be realised.

11.3.2 The Highways England Water Risk Assessment Tool (HEWRAT) was utilised for the water quality risk assessments. The methodology for assessing the impacts of routine runoff on surface waters was developed by Highways England and the Environment Agency to determine toxicity thresholds which are designed to prevent adverse ecological effects in the receiving water. The thresholds are consistent with the requirements of the WFD. The Environment Agency has approved the method of assessment used by HEWRAT and has agreed that the outputs from the tool can be used in EIA.

11.3.3 The method for assessing the importance, magnitude and significance of effects is based on DMRB Volume 11, Section 3, Part 10 HD45 – Road Drainage and the Water Environment. It has been amended to reflect best practice. This was done to incorporate an updated methodology for assessing the effects on groundwater quality and new methodologies for assessing the effects on groundwater flows, groundwater-dependent terrestrial ecosystems and the local hydromorphology. Appendices A, B, C and E detail these methodologies (Appendix 11.1).

11.3.4 The following has been undertaken as part of the assessment:

a) data requests to consultees including the Environment Agency, Wiltshire Council, and Wessex Water to gather further details on the baseline groundwater and surface water conditions;

b) an assessment of potential effects on groundwater flow from the construction of the tunnel and cuttings through use of the Wessex Basin Groundwater Model, jointly developed by the Environment Agency and Wessex Water;

c) an assessment of potential effects of routine road runoff on groundwater and surface water quality;

d) an assessment of spillage risk on receiving water bodies;

e) an assessment of existing and potential flood risk associated with the preferred route alignment, including the use of fluvial and pluvial hydraulic modelling;

f) an assessment of potential effects on water-dependent ecological species as part of the assessments for both surface water and groundwater;

g) an assessment of the potential effects on the archaeological site at Blick Mead in line with guidance from Historic England as changes to the water environment could potentially affect the conditions of the archaeological preservation at the site; and

h) an assessment of the potential effects of the chalk processing and placement for habitat creation at the area east of Parsonage Down as changes to the local topography could alter overland flow routes.

11.3.5 A Water Quality Compliance Assessment has been undertaken and is presented in Appendix 11.1. A separate WFD Impact Assessment has been undertaken and is presented in Appendix 11.2. The objective of the WFD Impact Assessment is to establish the nature and anticipated magnitude of the effects of the relevant scheme components on the WFD quality elements of the surface water and groundwater bodies affected by the Scheme. For the surface water bodies this has assessed biological, hydromorphological and physio-chemical quality elements. For the groundwater body this has assessed quantitative and chemical quality elements. These effects are considered in terms of the potential for deterioration of current water body status and/or the prevention of water body status objectives. These water quality and WFD Compliance Assessments have taken account of the Scheme's road drainage strategy, summarised in Appendix 11.3.

11.3.6 All sources of risk to groundwater receptors from the proposed development have been assessed as part of a Groundwater Risk Assessment (GRA) presented in Appendix 11.4. This included developing a conceptual hydrogeological model of the area that formed the basis of a risk assessment of the potential impacts of the construction and operation of the Scheme on groundwater in the Chalk, superficial deposit aquifers and on associated surface waters.

11.3.7 During construction abstraction of groundwater may be used as a water supply. This abstraction would be dealt with pursuant to the protective provisions for the Environment Agency within the draft DCO.

11.3.8 All sources of flood risk to and from the Scheme, including rapid snow melt, have been assessed as part of a FRA presented in Appendix 11.5. This assessment includes hydraulic modelling of fluvial and pluvial flood risk and draws from the GRA to inform the assessment of groundwater flood risk.

Scoping

11.3.9 The approach to scoping involved discussion with the Environment Agency and Wiltshire Council regarding road drainage and all water-related topics. This was supplemented by comments made in the responses to the Scoping Report consultation undertaken by the Inspectorate. Table 11.2 includes the points raised in the Inspectorate's Scoping Opinion regarding road drainage and the water environment. 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 stakeholders, an explanation is provided. The Scoping Opinion as received is provided in Appendix 4.1

Table 11.2: Scoping Opinion and response

Scoping Opinion	Where addressed within the ES
The Inspectorate	
Study Area The Scoping Report sets out a 1km study area proposed for the assessment which is to be extended to 5km for the groundwater assessment. There is also reference to a 2km zone of influence for consideration as part of the biodiversity assessment (paragraph 6.4.5 of the Scoping Report). It is important that there is consistency across these matters when presented in the ES and any study area should be justified in the ES. These study areas are referred to as being relative to the preferred route alignment, and for clarity, the Inspectorate considers that the study areas should be defined relative to the entirety of the DCO boundary. The study areas used for the assessment should be specifically agreed with the EA, the lead local flood authority and if possible based on recognised guidance.	The study area is described in Section 11.5 of the ES. The approach taken has been discussed with the Environment Agency and Wiltshire Council who have endorsed the approach to defining the extended study area. A summary of consultation and engagement with Environment Agency is given in Section 1.6 of the ES, with a more detailed account provided in the Consultation Report.
Identified receptors The controlled waters assessment should be extended to consider other features such as wells, springs and boreholes that may not be recorded (i.e. do not require a licence) but may be significantly affected by the Proposed Development.	The groundwater baseline was informed by a comprehensive survey of wells, springs and boreholes, as described in section 11.6 of the ES.
Sustainable Drainage System (SuDS) The ES should include sufficient detail as to the drainage design (and how it is to be secured in the DCO) so as to understand its role as mitigation for potential effects on water resources. The ES should include details of the drainage strategy and explain any other options considered along with the reasons as to why infiltration is the preferred method.	The Drainage Strategy for the Scheme is set out in Appendix 11.3 Drainage Strategy.
Potential Impacts and Mitigation The assessment should specifically address the impact of the development on potential for groundwater flooding given the construction of the bored tunnel and its potential to affect groundwater movements and levels.	The potential for groundwater flooding as a result of construction of the bored tunnel is addressed section 11.6 of the ES and covered in further detail in Appendix 11.4, Groundwater Risk Assessment.
Methodology The Scoping Report explains that sensitive receptors within the study area will be identified. However, it does not set out how the sensitive receptors will be determined. The ES should set out the process of defining receptors and how sensitivity is determined for each against established criteria	The assessment methodology is set out in Sections 11.3 and 11.9 of the ES.

Scoping Opinion	Where addressed within the ES
Methodology The Scoping Report notes that the methodology to be followed is 'unpublished', as such the Inspectorate is unable to comment if the methodology set out in the Scoping Report reflects that of DMRB. The methodology used in the ES should be explained in detail.	The assessment methodology is set out in Section 11.3 of the ES and Appendix 11.1 describes the methodologies that have been amended from those in the published DMRB.
Flood Risk and WFD As the Flood Risk and WFD Impact Assessment are to be standalone documents, the Applicant should ensure clear and consistent cross-referencing to ensure the aspect chapter provides a robust assessment of the water environment. The FRA should give specific consideration to the potential for flooding to and from the bored tunnel section as a result of the construction and operation of the Proposed Development. The same applies to the detailed controlled water risk assessment modelling being undertaken.	The ES, FRA and WFD assessments were progressed in parallel and make reference to one another where required. The potential for flooding to and from the bored tunnel is addressed in Appendix 11.5, FRA.
Scoping Opinion – Other consultees	
Wiltshire Council	
Highways drainage Concern about the proposed highways drainage infiltration method due to the high groundwater levels	Drainage strategy (Appendix 11.3) GRA (Appendix 11.4)
Surface water flooding and drainage Concern about the proposed highways drainage and surface water disposal infiltration method due to the area being susceptible to surface water run-off and flooding	Drainage strategy (Appendix 11.3) FRA (Appendix 11.5)
Natural England	
River Avon The road has the potential to affect the River Avon via changes to the hydrological regime. The EIA should consider this, and gather such data as is needed.	WFD Impact Assessment (Appendix 11.2) GRA (Appendix 11.4)
Environment Agency	
Flood Risk Assessment Confirms that a Flood Risk Assessment will be submitted as a standalone document submitted with the Development Consent Order (DCO) application. Further on in the Scoping Report some detail is provided to explain how flood risk will be assessed. Furthermore the report confirms all sources of flood risk to and from the proposed development will be assessed. To date we have not seen a draft of the Flood Risk Assessment hence we are not in position, at present, to comment any further on the flood risk implications, if any, of the proposed development.	FRA (Appendix 11.5)

Scoping Opinion	Where addressed within the ES
Groundwater abstractions We welcome the “very high” importance assigned to groundwater and surface water receptors in this sensitive area and the proposal to undertake Detailed Assessment of the impacts on quality and quantity both during the construction and operational phases of the scheme. Groundwater abstractions without published Source Protection Zones should be identified through a thorough water interest survey and given the same level of consideration and assessment as those with published zones.	Sections 11.6.53 - 11.6.58 GRA (Appendix 11.4)
Groundwater and surface water zone of influence We note that the assessment of surface water impacts is proposed to extend to 1km from the preferred route alignment, but the groundwater assessment will extend to 5km. Due to the interaction between groundwater and surface water in the area, there may be impacts on surface water features beyond 1km and these should be considered as part of an integrated water environment assessment. Impacts on groundwater may also extend beyond 5km, so the zone of consideration should be determined through calculation of the radius of influence of the proposed activities and based on site specific hydrogeological data. Where necessary further water interest surveys may need to be undertaken in any locations, identified as being impacted by the proposals. In Section 6.9.2 it states that the scope of the assessment is “features of the water environment within 1km of the preferred route alignment”. Please can it be confirmed how this relates to the 2km limit for the zone of influence cited in paragraph 6.4.5.	WFD Impact Assessment (Appendix 11.2) GRA (Appendix 11.4)
Enhancement strategies for improving WFD Enhancement strategies for improving WFD status should be promoted wherever possible e.g. by reducing existing road runoff to rivers. Hence an assessment of current road runoff impacts to the rivers from road and field drainage should be included for assessment where practically possible.	Water Quality assessment (Appendix 11.1) Drainage Strategy (Appendix 11.3)
Groundwater flooding The proposals should also consider the impact of the development on groundwater flooding. The proposals have the potential to impede groundwater movement and so raising water levels locally and diverting more or less groundwater to certain parts of the catchment. The impact of this on water resources and flooding should be considered and where necessary mitigation put forward	Sections 11.6.67 – 11.6.71 GRA (Appendix 11.4)

Scoping Opinion	Where addressed within the ES
Operational mitigation There is mention of a potential need for relocating existing abstractions and discharges. This may lead to the need for Environment Permit or Abstraction Licence reviews because the environmental risk assessment and granting of a permit or abstraction licence would be based on the existing location. The Environment Agency would need to be consulted on these specific proposals.	Section 11.3.5 GRA (Appendix 11.4)
Conceptual and numerical models The conceptual model can be informed by the Wessex Basin Groundwater Model. The numerical model (and other models where appropriate) should be used to quantify potential impacts of the proposals on surface and groundwater quality quantity and flooding.	Section 11.4 GRA (Appendix 11.4)
Further aquifer site investigations Further site investigations may be required to confirm or revise the aquifer parameters included in the Wessex Basin Model and used in the Hydrogeological Quantitative Risk Assessment.	GRA (Appendix 11.4)
De-watering De-watering should consider the impact of passive and active de-watering (pumped and gravity drainage) on water quality. The zone of influence used for considering de-watering and contaminant investigation areas should be informed by future modelling.	GRA (Appendix 11.4) refers to dewatering which covers both active and passive temporary dewatering. There is no permanent dewatering. Dewatering impacts will also be addressed in the OEMP Groundwater Management Strategy.
De-watering De-watering should consider the impact of passive and active de-watering (pumped and gravity drainage) on water quality. It is agreed that the zone of influence used for considering de-watering and contaminant investigation areas should be informed by future modelling. Activities from de-watering, etc. may also impact on the quantity of surface and groundwaters. This could be detrimental during high and low flows and should be considered. De-watered water may also be discharged to groundwater as well as surface waters	GRA (Appendix 11.4) refers to dewatering which covers both active and passive temporary dewatering. There is no permanent dewatering. Dewatering impacts will also be addressed in the OEMP Groundwater Management Strategy.
Groundwater Risk Assessment Groundwater Risk Assessment should consider the risk of the proposals (construction and operation) on water interests in and around A303.	GRA (Appendix 11.4)
Hampshire Avon WFD The impact of construction and operation of the site on water quality (including mobilisation of phosphorus and leaching potential), should be considered. The results of investigations should also be shared with the EA and partners who are carrying out investigations into this area.	Section 11.6.61 – 11.6.63

Scoping Opinion	Where addressed within the ES
Land drainage, alteration of recharge and flow pathways The introduction of land drainage, alteration of recharge and flow pathways in surface and groundwaters, and road drainage discharges, in particular during accidents, may impact on water quantity to the River Avon and River Till and should be considered and mitigated against.	Section 11.6 Water Quality Assessment (Appendix 11.1) GRA (Appendix 11.4)
Further site investigations Where required further site investigations should be undertaken to assess the impact of the construction and operation of the tunnel on hydrogeology in the area. This is likely to include undertaking pumping tests to confirm aquifer hydraulic conductivity and storativity.	Section 11.10 GRA (Appendix 11.4)
Hydrogeological Risk Assessment The scope of the Hydrogeological Risk Assessment should be agreed with the Environment Agency before it takes place. The primary aim should be to determine the impact of the proposals on surface and groundwater quality, quantity and receptors. Wells, springs and boreholes The EIA also needs to consider other wells, springs and boreholes that may not be recorded. Water Interest Surveys should have been undertaken to identify such sources that do not require a licence and may exist.	GRA (Appendix 11.4)

Consultation

11.3.10 There has been regular and extensive liaison with the Environment Agency and with Wiltshire Council's Principal Drainage Engineer to discuss the available baseline data, to develop the modelling and impact assessment methodologies, including the climate change allowances to be used, and the assessments' outcomes for water quality, WFD, road drainage, groundwater and flood risk. This liaison took place within every month from July 2017 to September 2018 and involved meetings, teleconferences and email correspondence on single or multiple water and drainage topics. Engagement with Wessex Water was also undertaken to discuss available baseline data and impact assessment methodologies.

11.3.11 Highways England attended two meetings of the Wiltshire South Operational Flood Group in 2017 and 2018. The group comprises representatives of parish or town councils, community flood wardens, Wiltshire Council, the Environment Agency, Wessex Water and Dorset and Wiltshire Fire and Rescue Service. The group was briefed on the Scheme and the assessment of flood risk. Community records of historic flood events were provided to Highways England via Wiltshire Council's Principal Drainage Engineer as part of the exercise to collate baseline data.

11.3.12 Through this engagement the Environment Agency and Wiltshire Council have:

a) noted the extensive efforts Highways England have undertaken to collate available baseline data for water quality, WFD, road drainage, groundwater and flood risk which were then used to inform the assessment of impacts;

b) agreed to the methodology for the fluvial flood risk hydraulic modelling and WFD Compliance Assessment (Environment Agency), pluvial flood risk hydraulic modelling (Wiltshire Council) and agreed in principle to the approach to be adopted for the preparation of the FRA;

c) discussed the methodologies used for the groundwater hydraulic modelling (including groundwater flood risk) and the groundwater impact assessment;

d) discussed the proposed outline design of the temporary haul road and bridge crossing in the Till valley and no in-principle objections were raised. Agreement was reached with the Environment Agency that the outline design could progress to the provision of full design details pursuant to the Environment Agency's protective provisions in the draft DCO.

11.3.13 Environment Agency and Natural England advice on potential environmental enhancements was taken into consideration. This has informed the decisions on the location and design of road drainage areas to provide biodiversity enhancements.

11.3.14 There have been archaeological/hydrogeological discussions regarding the archaeological site at Blick Mead with Historic England and other members of the Heritage Monitoring Advisory Group (HMAG), including Wiltshire Council, English Heritage and National Trust. The discussions culminated in agreement that a water environment assessment (a ‘tiered’ assessment) should be undertaken for the site (provided at Appendix 11.4 Annex 3) and that groundwater/surface water surveys should continue at Blick Mead. Further investigation and monitoring will be undertaken and is the subject of ongoing discussion with Historic England, the land owner and other interested stakeholders.

11.4 Assessment assumptions and limitations

11.4.1 The quality of water environment receptors has been defined using published data sources, with some groundwater and spring sampling undertaken only. The availability of contemporary data with which to define the importance (sensitivity) of these attributes is considered robust and therefore this approach is considered acceptable.

11.4.2 With regard to groundwater level data coverage: all but one of the groundwater monitoring boreholes installed in 2001 (R158) have been lost. Additional groundwater level monitoring boreholes were installed in 2017 with water level data collected and a telemetry system installed. Long term data available from

Environment Agency monitoring boreholes has been used to extrapolate groundwater levels where only short term data is present in the vicinity of the Scheme boundary.

11.4.3 The Wessex Basin groundwater model was developed on behalf of the Environment Agency and Wessex Water by the consultants Amec (now Wood). Mott MacDonald provided peer review as part of the stakeholder group. The use of the model for this assessment is considered to be an appropriate use of a groundwater model, and modifications have been made to the model in consultation with the Environment Agency and are considered to be appropriate to the local data available.

11.4.4 With regard to model resolution: It is assumed that the Environment Agency Product 4 fluvial and pluvial data was derived from a coarse JFlow model with a 20m grid in 2D. This source of information is outdated and has been replaced by a more refined ESTRYTUFLOW (1D-2D) fluvial hydraulic model to inform this assessment, with a resolution of a 5m grid. A TUFLOW pluvial model has also been prepared with an improved resolution of a 2m grid to assess the effects of the Scheme on surface water. The methodology has been discussed and agreed with the Environment Agency and Wiltshire Council.

11.5 Study area

11.5.1 The spatial scope of the assessment includes, as a minimum, features of the water environment within 1km of the Scheme boundary. The two main surface water bodies in the study area are the River Avon and the River Till.

11.5.2 Following receipt of the Scoping Opinion, for the groundwater and WFD assessments the study area has been extended to encompass WFD surface water and groundwater bodies and groundwater Source Protection Zones (SPZ) and therefore in places extends beyond 5km of the Scheme boundary (Figure 11.1). This has been discussed with the Environment Agency and Wiltshire Council who have endorsed the approach to defining the extended study area.

11.5.3 The study area includes the surface water body catchments of the River Till and River Avon (upstream and downstream of the Nine Mile River) and part of the Chalk groundwater body (Upper Hampshire Avon). This encompasses the areas to be used for construction and the potential zone of influence caused by any dewatering required for construction and operational purposes.

11.6 Baseline conditions

11.6.1 A number of activities were undertaken to gather baseline information, including identification of the appropriate study area in respect of the Scheme and consideration of issues raised during consultations. A desk study was undertaken (including requesting information from third parties) and a gap analysis of data to identify further data gathering requirements, for example groundwater level and quality data and pumping tests.

11.6.2 The desk-based assessment for the water environment included obtaining and reviewing all available information sources. These sources included, but are not limited to: Environment Agency, Wiltshire Council and Wessex Water datasets in relation to water quality, pollution incidents, rainfall, groundwater, and flood risk; Ordnance Survey (OS) mapping; topographic data; British Geological Survey (BGS) Mapping; MAGIC Interactive Mapping; and information collated from the previous stages of site investigation undertaken in the area.

11.6.3 Site walkovers were undertaken where possible to complete a visual assessment of the study area to develop an understanding of the hydraulic interactions and hydrology of the water environment. River Till and River Avon channel cross-section surveys and photogrammetry surveys were undertaken in November 2017-April 2018 for the purpose of setting up hydraulic models of the watercourses. A water features survey was conducted between November 2017 and April 2018 to determine groundwater receptors and groundwater level and quality monitoring has been undertaken from boreholes installed in 2017 (the details of these surveys are presented in the GRA - Appendix 11.4). A fluvial audit of the River Till was completed in December 2017 to identify the potential impacts of a new crossing on the geomorphology of the river (the details of this survey are presented in the WFD Impact Assessment – Appendix 11.2).

Surface water and road drainage

11.6.4 The study area (Figure 11.1) is characterised by rural land use with a number of small settlements located within or adjacent to it. The ground levels vary from 54m to 205m Above Ordnance Datum (AOD), which reflects the existence of several valleys within the area. The study area receives an annual average rainfall total of between 748mm (Boscombe Down) and 770mm (Larkhill) and its hydrology is dominated by groundwater given the nature of the Chalk bedrock, which facilitates infiltration of incident rainfall.

11.6.5 The study area lies within the South West River Basin District and Avon Hampshire management catchment, as set out within the River Basin Management Plan (RBMP) (Ref 11.2).

The River Avon

11.6.6 Based on the Environment Agency Water Abstraction Licences map (Ref 11.3), there are six surface water abstraction points from the River Avon within the study area (Table 11.3 and Figure 11.2).

Table 11.3: Surface water abstraction points along the River Avon within the study area

Location	Approximate distance from Scheme
Haxton	12km upstream
Haxton	12.5km upstream
Haxton	12.6km upstream
West Amesbury	0.75km downstream

Location	Approximate distance from Scheme
Lake	2.6km downstream
Lower Woodford	7.1km downstream

11.6.7 The River Avon is a classified WFD surface water body. It is also a designated SAC for water dependent populations of Desmoulin's whorl snail (*Vertigo moulinsiana*), sea lamprey (*Petromyzon marinus*), brook lamprey (*Lampetra planeri*), Atlantic salmon (*Salmo salar*) and bullhead (*Cottus gobio*). Further information on the SAC designation is presented in Chapter 8 Biodiversity.

11.6.8 The study area lies within the Hampshire Avon (Upper) upstream of the Nine Mile River confluence WFD waterbody catchment (GB108043022351) and is linked to protected areas under the Habitats and Species Directive (River Avon SAC) and Nitrates Directive (PA 151). It has an overall status of 'Poor' with an objective to reach 'Good' status by 2027 (Table 11.4).

Table 11.4: Classification elements of less than Good status for the Hampshire Avon (Upper) upstream of the Nine Mile River confluence

Classification Element	Current Status (2015)	Reasons for Not Achieving Good Status (Activity and Certainty)	Objective
Fish	Poor	Livestock – Probable	Good by 2021
Macrophytes and Phytobenthos	Poor	Sewage discharge (continuous) - Confirmed	High by 2027
		Natural mineralisation - Confirmed	
Phosphate	Moderate	Sewage discharge (continuous) - Confirmed	Good by 2027
		Natural mineralisation - Confirmed	

11.6.9 The study area also lies within the Hampshire Avon (Upper) downstream of the Nine Mile River confluence WFD waterbody catchment (GB108043022352) and is linked to protected areas under the Habitats and Species Directive (River Avon) and Nitrates Directive (PA 151). It has an overall status of 'Moderate' and an objective to reach 'Good' status by 2021 (Table 11.5).

Table 11.5: Classification elements of less than Good status for the Hampshire Avon (Upper) downstream of the Nine Mile River confluence

Classification Element	Current Status (2015)	Reasons for Not Achieving Good Status (Activity and Certainty)	Objective
Phosphate	Moderate	Sewage discharge (continuous) - Confirmed	Good by 2021
		Mixed agricultural - Confirmed	
		Natural mineralisation - Confirmed	

11.6.10 Based on the Environment Agency Permits Register (Ref 11.4) there are a number of existing discharge permits allowing the discharge of potentially polluting substances into the River Avon within the study area (Table 11.6 and Figure 11.2).

Table 11.6: Existing permitted discharges to the River Avon within the study area

Location	Effluent type	Approximate distance from Scheme
Ratfyn	Sewage – water company	0.8km upstream
Amesbury	Sewage – water company	2.1km downstream
Amesbury	Sewage – water company	2.1km downstream
West Amesbury	Sewage – not water company	4.5km downstream
West Amesbury	Sewage – not water company	4.6km downstream
Wilsford	Sewage – not water company	7.1km downstream
Lake	Sewage – not water company	8km downstream
Lake	Sewage – not water company	8.1km downstream
Great Durnford	Trade	9km downstream
Great Durnford	Sewage – not water company	9.3km downstream
Upper Woodford	Sewage – not water company	11.1km downstream
Middle Woodford	Sewage – not water company	13.4km downstream

11.6.11 According to the Environment Agency Environmental Pollution Incidents data published in January 2018, there were five recorded incidents within the study area for the River Avon, as shown on Figure 11.2. Three of these incidents were classed as significant in respect of the water environment with the most recent incident occurring in August 2014.

11.6.12 The River Avon is designated by the Environment Agency as a Main River. There are also a number of small channels, ponds and ditches located within its floodplain. These are classed as Ordinary Watercourses by the Environment Agency and are not classified under the WFD. However these watercourses are hydrologically connected to the River Avon and will therefore contribute to its water quality. This includes the Amesbury Abbey Pond and Blick Mead drain located in the Amesbury Abbey estate, as well as a seasonal pond within the Blick Mead archaeological site that can occur in winter.

The River Till

11.6.13 The River Till is designated by the Environment Agency as a Main River and in its upper reaches north of Berwick St James it flows as a winterbourne on an intermittent basis. A small number of channels, ditches and ponds are located to the north and south of Winterbourne Stoke throughout the floodplain. These watercourses are hydrologically connected to the River Till and will therefore

contribute to the water quality in the river. The River Till discharges into the River Wylye, south of the A36 at Serrington, approximately 5.8km downstream of the Scheme.

11.6.14 Based on the Environment Agency Water Abstraction Licences map, there are no surface water abstraction points from the River Till within the study area.

11.6.15 The study area lies within the Till, Hampshire Avon WFD waterbody catchment (GB108043022570) which has an overall status of 'Good' and is linked to protected areas under the Habitats and Species Directive (River Avon SAC) and Nitrates Directive (PA 151). Its designation as a SAC represents the site as an example of a winterbourne Chalk stream containing "floating vegetation of water crowfoot *Ranunculus* of plain and sub-mountainous rivers". Further information on these species and the designations is presented in Chapter 8 Biodiversity.

11.6.16 Based on the Environment Agency Permits Register there are a number of existing permits allowing the discharge of potentially polluting substances into the River Till within the study area (Table 11.7 and Figure 11.2)

Table 11.7: Existing permitted discharges to the River Till within the study area

Location	Effluent type	Approximate distance from Scheme
Orcheston	Sewage – not water company	6.2km upstream
South of Shrewton	Sewage – water company	2.1km upstream
Winterbourne Stoke	Sewage – not water company	0.5km downstream
Winterbourne Stoke	Sewage – not water company	0.5km downstream
Winterbourne Stoke	Sewage – not water company	0.6km downstream
Winterbourne Stoke	Sewage – not water company	0.7km downstream
Winterbourne Stoke	Sewage – not water company	1.2km downstream
Winterbourne Stoke	Sewage – not water company	1.3km downstream
Berwick St James	Sewage – not water company	2.7km downstream
Berwick St James	Sewage – water company	3.5km downstream

11.6.17 According to the Environment Agency Environmental Pollution Incidents data published in January 2018 there was one recorded incident within the catchment for the River Till occurring in October 2013, but it was classed as having no impact in respect of the water environment.

11.6.18 Based on the analysis of historic maps, the channel of the River Till appears to be stable but has been subject to man-made interventions for land drainage related to the relic water-meadow. These historical changes may have altered flow dynamics within the river leading to increased areas of both erosion and sedimentation in the sections upstream and downstream of the Scheme crossing point which are evident in the present day river.

Lakes, ponds and other surface water features

11.6.19 There are a number of surface water features within the study area that are fed entirely by groundwater. These include: a seasonal spring at Springbottom Farm (present at peak groundwater levels only), a seasonal groundwater-fed lake near the village of Lake, just to the west of the River Avon; a spring system in West Amesbury and Gallows Hill; and Amesbury Abbey Springs (previously referred to as Blick Mead spring), in the grounds of Amesbury Abbey and adjacent to the Blick Mead archaeological site (further described in Chapter 6 Cultural Heritage). These features are shown on Figure 11.3, and discussed further in the Groundwater Risk Assessment (GRA) in Appendix 11.4.

11.6.20 The water quality of these smaller watercourses, ditches and ponds or lakes located in the study area is not assessed by the Environment Agency under the WFD and no dataset is available to define their baseline quality. The value of their water quality attributes has therefore been inferred based on their physical characteristics and surrounding land use.

Contaminated land

11.6.21 There are several sites that could contain contaminants within the soils, associated with historical and current land uses, which could affect baseline water quality conditions within the study area. The existence of contaminants within the soils could become mobilised by construction activities which could lead to an adverse effect on the water quality of surface water and groundwater bodies. Further details on land contamination are provided in Chapter 10 Geology and Soils and the GRA in Appendix 11.4.

Highway drainage

11.6.22 At the western extent of the Scheme the existing A303 carriageway is drained by gullies that discharge directly into roadside ditches which infiltrate the runoff to ground. Filter drains are also used to convey and discharge runoff to the ditches. At Winterbourne Stoke, the highway runoff outfalls directly to the River Till.

11.6.23 The existing A303 between Winterbourne Stoke and Countess Roundabout is drained via gullies, grip outlets or combined kerb drains. These discharge to either a filter drain or directly into the roadside ditches. The ditches attenuate the runoff before discharging to ground via infiltration.

11.6.24 At Countess Roundabout the carriageway is drained via gully and combined kerb drain systems. To the west of the roundabout the existing eastbound carriageway gullies outfall northwards to a ditch located at the base of the earthworks. The ditches in this locality outfall into a culvert which passes under the existing A303 and outfalls to the River Avon on the south side of the highway. The runoff from the westbound carriageway is also collected in ditches and conveyed to the point of confluence with the culvert, before discharging freely to the River Avon. To the east of Countess Roundabout the highway runoff is discharged via gullies to either a ditch or carrier pipe network. The majority of the eastbound carriageway drains in an easterly direction,

discharging to the Avon at a point north of the River Avon bridge. A small length of the eastbound carriageway drains in a westerly direction before discharging into a culvert which passes beneath the existing A303 and ultimately to the River Avon to the south. The runoff from the westbound carriageway also discharges to ditches at the base of the embankment to the south which outfall to the River Avon at various locations.

11.6.25 Drainage of surface water runoff does not meet DMRB current standards on any part of the existing road from Yarnbury Castle to east of the River Avon Bridge. Runoff discharges via infiltration to the ground or via conveyance into watercourses and SAC designated Rivers Till and Avon without any modern standards of treatment to mitigate pollution.

11.6.26 There are no recorded incidents on the A303 between Winterbourne Stoke and Amesbury in Highways England's spills register.

Groundwater

Regional geology

11.6.27 The study area is underlain by the White Chalk, including principally the Seaford Chalk and a north east south west trending outcrop of Newhaven Chalk present in the area between the Avenue and Normanton Down, and an outcrop on Coneybury Hill. The Lewes Nodular Chalk beneath the Seaford Chalk outcrops at Berwick St James in the Till valley, and from Upper to Lower Woodford in the Avon valley (Figure 11.3).

11.6.28 The Chalk on the western side of the Stonehenge Bottom valley has been found to contain Phosphatic Chalk, comprising a sand and gravel peletal Chalk.

11.6.29 Superficial deposits are present in the dry valleys in the area and in the river valleys. The dry valleys contain head deposits, comprising clay, silt, sand and gravel, overlying the Chalk. The river valleys of the Avon and Till contain alluvial and terrace gravel deposits, as well as head deposits of gravel. Additional superficial Head deposits of clay with flints are located on a number of hill tops.

11.6.30 The geology of the study area is described and assessed in detail in Chapter 10 Geology and Soils, and further detail is given in the GRA in Appendix 11.4.

Regional hydrogeology

11.6.31 The White Chalk bedrock in the region is classified by the Environment Agency as a Principal aquifer, and is within the WFD Upper Hampshire Avon groundwater body (GB40801G806900).

11.6.32 The details for the WFD waterbody, as available at the time of reporting, are shown in Table 11.8. As a Principal aquifer the Chalk provides water supply on a strategic scale and river base flow, and the aquifer is of regional importance.

Table 11.8: WFD groundwater body summary

Water body name	Water body ID	Current Chemical Status (2016)	Objective	Current Quantitative Status (2016)	Objective
Upper Hampshire Avon	GB40801G806900	Poor[1]	Good by 2027	Poor	Poor by 2015[2]

11.6.33 The Chalk is a dual porosity medium with groundwater flow principally through fractures and fissures. The majority of aquifer storage is derived from secondary porosity within these fractures. A strong topographical control on aquifer transmissivity is evident with high transmissivity values occurring within valleys decreasing towards the interfluves. Further information is provided within the GRA in Appendix 11.4.

11.6.34 The superficial deposits present in the study area are classified by the Environment Agency as Secondary aquifers:

a) The Secondary A aquifers are associated with the alluvial and terrace gravel deposits, and gravel head deposits, which provide groundwater that flows to the River Avon and River Till. These are permeable layers with a moderate to high primary permeability and which are capable of supporting water supplies at a local rather than strategic scale, and in some cases form an important source of baseflow to rivers.

b) The Secondary B aquifers are associated with sand and clay deposits located on hill tops. These are predominantly lower permeability layers that may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These aquifers are not crossed by the Scheme.

c) The Secondary (undifferentiated) aquifers are associated with the head deposits (comprising clay, silt, sand and gravel) present across the study area. These aquifers are defined where it has not been possible to provide an A or B category.

Hydrogeology - groundwater levels and flows

11.6.35 Groundwater level monitoring data from ground investigation boreholes installed in 2001 near the proposed tunnel alignment covered the 2001-2006 period. All but one of these investigation boreholes (R158) has since been lost. Fourteen additional groundwater level monitoring boreholes were installed in 2017, with the data collected presented in the GRA (Appendix 11.4). A telemetry

1 This is through the dependent surface water body and general chemical tests.
2 The objective of Poor status by 2015 was met in that year, no current improvement from current status has been identified as a future objective, as the Environment Agency has deemed this disproportionately expensive.

monitoring system has been installed to provide ongoing data collection. Additional long term groundwater level data in the study area is available from ten current Environment Agency monitoring boreholes. This long term data, and the Environment Agency Wessex Basin groundwater model that it informs, has been used to extrapolate groundwater levels where only short term data is present in the Scheme area. The location of the groundwater monitoring boreholes is presented on Figure 11.3.

11.6.36 Monitoring data shows that groundwater levels in the Chalk aquifer between the river valleys (in the interfluve areas) respond rapidly to recharge events at the surface due to a low aquifer storage capacity, and large fluctuations in groundwater level can occur over short periods of time. Annual fluctuations shown in the Environment Agency borehole at Berwick Down are between approximately 6m and 25m, with rapid rises in excess of 10m occurring over approximately one month.

11.6.37 The seasonal fluctuations in the groundwater level tend to be less in the dry valleys than below topographic divides as the storage capacity is usually greater beneath dry valley systems, than in the interfluve areas.

11.6.38 Groundwater is known to rise to the surface in otherwise dry valleys during periods of high rainfall, including in Stonehenge Bottom (80m AOD near piezometer P2 shown on Figure 11.3) and the River Till north of Berwick St James.

11.6.39 Groundwater elevation contours produced by the Environment Agency (Ref 11.5) for the area indicate that regionally groundwater in the Chalk aquifer flows in a southerly direction, with flow converging towards the River Till in the west of the study area and towards the River Avon in the east of the study area, creating a groundwater divide within the study area. The groundwater discharges naturally as baseflow to the Rivers Avon and Till. The discharge to the River Avon is perennial whereas the River Till is a winterbourne (dry through periods of low groundwater levels) north of Berwick St James. Groundwater level contours are given in Appendix 11.4 Figure 4.8.

11.6.40 At low groundwater levels, the Environment Agency groundwater level contours indicate that the upper River Avon north east of Larkhill may lose flow to the Chalk aquifer with groundwater flow occurring in a south westerly direction towards the Stonehenge Bottom dry valley catchment.

11.6.41 At low groundwater levels, the groundwater level contours indicate that the River Till loses flow to the aquifer in its central reaches flowing over the higher transmissivity Chalk units in the syncline, with groundwater flow across catchment into the Stonehenge Bottom dry valley catchment.

11.6.42 In the southern part of the study area groundwater flow in the Stonehenge Bottom valley flows in a south easterly direction to discharge into the River Avon at Lake. The River Avon accretes flow significantly below Amesbury reflecting the discharge of the Stonehenge Bottom catchment.

11.6.43 Localised ephemeral flow occurs within the dry valleys in the Chalk landscape, where preferential pathways are formed by more permeable zones during periods of high groundwater level. The dry valleys are corridors where the majority of the flow occurs beneath the surface and occasionally partially above surface when groundwater levels are particularly high. This is the case in the Stonehenge Bottom area.

11.6.44 There are also north to south trending dry valleys to the east of Coneybury Hill and above the existing A303 to the north of the Blick Mead area. There is no evidence that there is flow in these dry valleys. The geological map shown in Figure 11.3 indicates that these dry valleys contain valley infill material of head deposits.

Aquifer properties

11.6.45 The properties of the aquifer define the capacity of the aquifer to release water and the ability of groundwater flow to be transmitted with ease.

11.6.46 Pumping tests were carried out close to the route alignment in 2002 (winter) and 2004 (summer), at two locations close to Stonehenge Bottom (W148 in the dry valley, W137 in the interfluve area) (Refs 11.6 and 11.7). Transmissivities of 1,430 - 2,650m^2/d for the dry valley, and 400 – 850m^2/d in the interfluve are quoted, with the lower values reported in the summer. The results of the winter pumping tests and water levels observed in December 2002 and January 2003 were used to estimate groundwater throughput in Stonehenge Bottom (Ref 11.8).

11.6.47 Geological information has been reviewed in order to evaluate whether preferential flow pathways (area of increased groundwater flow) exist in the Chalk strata, this is described in detail in the GRA (Appendix 11.4). In the Stonehenge Bottom area, pumped flow velocity tests in the pumping test boreholes W137 and W148 recorded a significant increase in flow between 69 and 73m AOD. The most marked change is in Stonehenge Bottom, with a more gradual increase on the interfluve test. This horizon correlates with the zone of water table fluctuation and is within the average low and high water levels. This indicates that there may be preferential flow in this zone reflecting a zone of fracturing in the dry valley.

11.6.48 These pumping tests were conducted in structured Chalk. There is no strong evidence within the geological information reviewed that the phosphatic chalk could form a preferential flow pathway. A pumping test specific to the phosphatic chalk was undertaken in July 2018. This will provide additional information for the detailed design stage.

11.6.49 Permeability testing undertaken in borehole RX502A during the 2017 site investigations in the Coneybury Hill area to the northeast of Spring Bottom Farm, showed slightly lower hydraulic conductivities than elsewhere, indicating this interfluve could be limiting flow from the upper reaches of Stonehenge Bottom eastwards towards the River Avon.

Springs

11.6.50 In general, groundwater baseflow enters the rivers as seepages rather than at discrete springs. Springs, which have been identified and visited as part of the 2017-2018 water features survey, include:

a) A seasonal spring at Spring Bottom Farm in Stonehenge Bottom valley (understood to be present at peak high seasonal Chalk groundwater levels only).

b) A seasonal groundwater-fed lake near the village of Lake, just to the west of the River Avon.

c) A spring system at West Amesbury and Gallows Hill.

d) A seasonal spring at Durrington.

e) Amesbury Abbey springs (referred to as Blick Mead Spring in the PEI Report) in the grounds of Amesbury Abbey, and adjacent to the Blick Mead archaeological site.

11.6.51 Further information on these spring features is presented in the GRA in Appendix 11.4, including the results of the water features survey, and previous investigations carried out.

11.6.52 The Blick Mead Archaeological site (a non-designated Historic Environment Record) is located east of the Vespasian's Camp Iron Age Hillfort in the grounds of the Amesbury Abbey estate (further described in Chapter 6 Cultural Heritage). Archaeological excavations carried out since 2005 at the site have located Mesolithic deposits in association with what is reported as a springhead depression. Further information on the water environment, and the monitoring undertaken at the site, is presented in the tiered assessment undertaken in line with guidance produced by Historic England (Ref 11.9) in Annex C of the GRA (Appendix 11.4).

Abstractions

11.6.53 SPZs are areas designated by the Environment Agency in order to protect significant potable water groundwater abstractions. The zones identify areas which may be at risk of pollution resulting in contamination of the groundwater source. They are classified into three zones depending on travel time of pollutants and therefore potential risk to the source: the inner zone (or zone 1), the outer zone (or zone 2) and the total catchment (or zone 3). The zones have been determined to represent respectively a 50 day travel time, a 400 day travel time, and the whole groundwater catchment for public water supply and other sensitive groundwater sources.

11.6.54 There are five published SPZs for public drinking water supply abstractions within 5km of the scheme in the study area. The SPZs are shown in Figure 11.4, and they are discussed in further detail in the GRA in Appendix 11.4. The

construction of a new water treatment works, for the Dean's Farm water treatment works, located at Middle Barn Farm, Salisbury, is proposed and may soon be under construction. This water treatment works is located at a Wessex Water public water supply site and constitutes a change of use from agricultural to water treatment, designed to provide a more efficient use of the existing groundwater abstraction licences held.

11.6.55 Twenty eight active Environment Agency licensed groundwater abstractions are located within the study area and the locations provided are presented on Figure 11.4. Eight are licensed for drinking water supply, one is licensed for the production of energy, two are licensed for industrial, commercial and public services, fourteen are licensed for agricultural purposes and three are licensed for agriculture and drinking water supply. The locations of the abstractions provided by the Environment Agency are shown in Figure 11.4, and they are discussed in further detail in the GRA in Appendix 11.4. Where not covered by a published SPZ, each abstraction is defined a nominal SPZ1 of 50m, and an SPZ2 of 250m by the Environment Agency.

11.6.56 Through the water features survey undertaken in 2018 (the results of which are provided in the GRA in Appendix 11.4) an additional expired licence has been identified at Manor Farm in Winterbourne Stoke. This licence, which covers four boreholes for agricultural (general and domestic) purposes, lapsed in March 2017 and was reapplied for in February 2018. It was included in the water features survey in case it was re-licensed, which The Applicant understands has now occurred.

11.6.57 The Wiltshire Council register of Private Water Supplies for potable use listed 21 private groundwater supplies within the wider search area, twelve of which were licensed by the Environment Agency, mainly for agricultural purposes. A water features survey (provided in the GRA in Appendix 11.4) has been undertaken to confirm this information and gain more information on private water supplies. Through the water feature survey it has become apparent that some of the coordinates provided by Wiltshire Council are likely to be the tap sampling points rather than locations of the boreholes/wells.

11.6.58 Six private water supplies, in addition to those licensed by the Environment Agency, were identified within the study area through the 2018 water features survey. The locations of these are provided on Figure 11.4, with further detail provided in the GRA in Appendix 11.4.

Groundwater chemistry

11.6.59 The Chalk groundwater quality (informed by data from water quality samples taken in the study area historically and in 2018 and from nearby Environment Agency boreholes (Refs 11.6, 11.10, and 11.11)) is of a calcium bicarbonate type, with chemistry generally consistent with the BGS baseline data (Ref 11.12). Only nitrate and turbidity concentrations have exceeded the DWS in groundwater samples collected and analysed in 2018. The groundwater quality

is discussed further in the GRA (Appendix 11.4). There is little variation in the quality of the Chalk aquifer across the study area.

11.6.60 Natural sources are postulated for elevated sulphate, dissolved phosphate and arsenic concentrations compared to the BGS baseline (Ref 11.12), with elevated nitrate and ammoniacal nitrogen likely to be related to the general agricultural land use in the study area. Elevated concentrations of chloride and sodium encountered in historic data could be attributed to road salt.

11.6.61 Elevated dissolved phosphorus is a key reason for the surface water bodies of the River Avon and River Till failing to achieve “good status” classification under the WFD. Dissolved phosphorus concentrations measured in groundwater in 2018 were at or below 11µg/l in all locations, compared to the WFD 'good' class limit of 43ug/l. There were no apparent anthropogenic sources of dissolved phosphorus, but it should be noted that the sites closest to the phosphatic chalks did not show notably different concentrations to other sites. Leachate tests on phosphatic chalk samples (discussed further in Chapter 10 Geology and Soils) all reported concentrations of orthophosphate below the detection limit, and it is therefore unlikely that the phosphatic chalk will yield large concentrations of dissolved phosphorus.

11.6.62 The dominant calcium carbonate chemistry of the chalk is likely to generate a precipitated form of phosphorus rather than a soluble form. The general low concentration of orthophosphate measured in the groundwater is in contrast to higher concentrations measured in the River Avon. This suggests that the origin of the natural phosphorus in the surface water is more significant from the Upper Greensand rather than the Chalk.

11.6.63 From the available information there is no evidence of significant groundwater contamination from potentially contaminated land identified in the study area. However, no data has been collected in the vicinity of the Countess Roundabout where more potential sources are located.

Flood risk

Surface water flood risk

11.6.64 This type of flooding occurs when receptors are affected by direct rainfall flowing overland. The Environment Agency surface water flood risk map (Appendix 11.5) shows the main overland pluvial flow paths (following saturation) that flow south within the dry valleys, such as Stonehenge Bottom, past the existing A303 between Longbarrow Roundabout and Amesbury. The Environment Agency surface water flooding is classified into four flood risk categories: Very Low (Annual Exceedance Probability (AEP) of less than 0.1%), Low (AEP between 0.1% and 1%), Medium (AEP of between 1% and 3.3%) and High (AEP of greater than 3.3%). The majority of the surface water flood risk in the study area is categorised as Low. There are also relatively small areas at Medium or High flood risk. These are typically in valley bottoms such

as Stonehenge Bottom, the Till and Avon river valleys and where surface water flow paths are impeded by artificial structures such as road embankments.

11.6.65 To assess the impacts of surface water flow paths within areas where wide-scale topographical changes are proposed, these have been assessed within a site specific pluvial hydraulic model. This has therefore been undertaken at Parsonage Down area where permanent landscape changes are proposed, in agreement with Wiltshire Council and the Environment Agency. For all other areas within the scheme boundary the Environment Agency surface water flood maps have been taken as the baseline representation.

11.6.66 The baseline site specific pluvial model for the Parsonage Down area has concluded that the outline flood extents are very comparable to the EA surface water flood maps, showing a slightly larger flood extents for the 1% AEP event. Further information and depiction of the site specific pluvial model build and associated baseline results can be viewed in Appendix 11.5.

Groundwater flood risk

11.6.67 This type of flooding occurs when receptors are affected by water emerging from the ground rather than by direct rainfall. The River Avon and River Till are Chalk rivers fed both by groundwater and also from overland sources during periods of heavy or prolonged rainfall (Ref 11.13). There are four groundwater flooding mechanisms that are interpreted to exist in the study area:

a) Water table elevation in the chalk aquifer rising to above the ground surface. This is where elevated groundwater levels results in the water table rising above the ground surface, via springs and seepages: such that the flooded area is a representation of the groundwater table.

b) Water table in the Chalk aquifer induced groundwater floods. This is where the water table rises in the Chalk aquifer in the catchments of the River Avon and its tributaries, resulting in the flowing of ephemeral springs and streams and greater river flows downstream.

c) Along the River Avon valley, high river flows will lead to increased groundwater levels in superficial deposits, which could then lead to groundwater emergence elsewhere in the valley.

d) Groundwater emergence from a high water table in superficial deposits after excess direct rainfall recharge.

11.6.68 High groundwater levels can also have secondary impacts on other types of flooding, for example, through reducing floodwater storage in the chalk, resulting in a higher risk of pluvial and fluvial flooding. In addition, raised groundwater levels can impede flood flows in storm sewers.

11.6.69 There is a notable history of groundwater flooding within the study area. Further details are provided in the Historic Flooding Events section below, the GRA (Appendix 11.4) and in the FRA (Appendix 11.5).

11.6.70 The Environment Agency has a groundwater flood warning system in place in the study area. There is also a flood alert system that includes the communities of Orcheston, Shrewton, Tilshead, Winterbourne Stoke and Woodford. Alerts are issued when groundwater levels are high enough that they may start affecting roads and ponding is seen in fields. Prior to the publication of this ES the last alert was issued on the 10th April 2018.

11.6.71 The flood warning system is more specific than the alert system and is used to alert vulnerable communities to the onset of groundwater flooding, in some cases a week in advance. The flood warning is issued when there is a potential for properties to be flooded, which allows residents to prepare for groundwater flooding, by turning on pumps and activating resilience measures.

Fluvial flood risk

11.6.72 This type of flooding occurs when water in streams and rivers exceed the channel's capacity and overflow beyond the channel's banks. For the River Till and River Avon, the Environment Agency's 'Flooding from Rivers' online mapping (Ref 11.14) classifies some parts of the study area as Flood Zone 2 or 3, indicating that there are areas at medium or high probability of flooding. Areas in Flood Zone 1 are shown to be at less than 0.1% AEP. Areas in Flood Zone 2 have an indicative AEP of flooding between 0.1% and 1%, and those in Flood Zone 3 an AEP greater than 1%. The presence of Flood Zone 3 requires that flood risk is assigned high importance. These areas are generally located at valley saddles and along Main River and tributary corridors. Within the Scheme, the River Till viaduct does not intersect the Flood Zone 3 boundary to the north of Winterbourne Stoke.

11.6.73 The Environment Agency Product 4 information consists of a series of maps displaying fluvial flood risk in different scenarios (Appendix 11.5). The River Avon 'water depth without flood defences' map shows that the floodwater depth is approximately 2.0m where the existing A303 crosses the River Avon in both the 1% AEP and 0.1% AEP scenarios.

11.6.74 According to the River Till 'water depth without flood defences' map there is an estimated floodwater depth of up to 0.5m within the floodplain for both the 1% AEP and 0.1% AEP.

11.6.75 Hydraulic modelling of the River Till has been undertaken to review and update the available flood zone baseline mapping from the Environment Agency. The site specific baseline hydraulic modelling results show good agreement with the Environment Agency's flood map (Appendix 11.5). There are small differences in flood extent in some locations. For example, in the northern area of Shrewton, the extent of the 1% AEP flood event is extended to encompass the area to the east of Elston Lane, between the Shrewton Farm access via restricted byway and Hinde's Meadow / The Hollow. Similarly, in Winterbourne Stoke the extent of the 1% AEP flood event is expanded; the area of change is centred on the Brook Close area to the south of the A303.

11.6.76 Hydraulic modelling of the River Avon has also been undertaken to review and update the available flood zone baseline mapping from the Environment Agency. The site specific baseline hydraulic modelling shows a moderate decrease in fluvial flood extents in comparison to the equivalent Flood Zone 3 event (1% AEP). From a review of gauged data, the site specific hydraulic model more closely correlates with historical events than the broad scale modelling previously employed for the original Environment Agency flood maps.

Other sources of flood risk

11.6.77 Rapid snow melt run-off over still frozen ground is another source of flood risk in the study area. When these circumstances occur, the impermeable nature of the frozen ground results in the meltwater flowing overland or discharging into the River Avon and River Till catchments.

Historic flooding events

11.6.78 From the available information there have been a number of minor and major historic flood events in the study area. Groundwater flooding and rapid snow melt run-off over frozen ground are the two primary causes. Examples of major historic flood events are outlined below.

11.6.79 On the 16th January 1841, snow melt and rainfall on frozen ground caused extensive flooding along the River Till and River Avon (Ref 11.15). The communities affected by this included Tilshead, Berwick St James, Winterbourne Stoke, Orcheston, Shrewton and Salisbury. Records of the 1841 event suggest the snow melt and rainfall combined with high groundwater levels to exacerbate the flood severity (Ref 11.16).

11.6.80 A combination of snow melt, fluvial and groundwater flooding also occurred in January 1915 (Ref 11.17) on the River Till, affecting the village of Elston near Shrewton. It also created flooding on the River Avon including in Salisbury.

11.6.81 A flood event recorded in September 2008 was caused by surface water flooding, and possibly also groundwater flooding, with a number of properties in Durrington affected (Ref 11.17).

11.6.82 Data provided from the Environment Agency for the river level gauge at Amesbury shows that the highest water level since recording began was on January 3rd 2003 at 68.05m AOD. Since this time, the most recent highest level recorded at this gauge is 68.02m AOD on January 5th 2014. The Environment Agency have stated that flooding is possible where the Amesbury gauge records a water level above 67.72m AOD, which would suggest that flooding occurred in Amesbury on the two dates stated above. However, with regards to 2014, there are no records of Amesbury flooding. For the 2003 event, records indicate that the flooding did occur and was possibly related to highway drainage being unable to discharge to the Avon (Ref 11.16). Flooding was also recorded in Amesbury in 1999 according to historic records, reportedly as a result of surface water flooding involving a blocked ditch (Ref 11.16).

11.6.83 Severe flooding between December 2013 and March 2014 resulted in over 500 properties across Wiltshire being flooded and a number of roads having to be closed to traffic, including the A360 which was affected due to groundwater flooding for a number of weeks, requiring temporary management measures to be introduced. In Tilshead, 11 properties were flooded during the 2013 - 14 event. Extreme rainfall events in combination with high groundwater levels during the winter of 2013 – 2014, meant that the flows in the River Till exceeded culvert capacities and the surface water sewer system, causing public highway and property flooding.

11.6.84 A map of properties flooded between December 2013 and March 2014 from the Wiltshire Local Flood Risk Management Strategy shows that Tilshead, Orcheston, Shrewton, Winterbourne Stoke and Lake were flooded. This report states that surface water and groundwater were the primary causes of flooding in 2013 – 2014, which is in line with records of prolonged periods of wet weather through that winter.

11.6.85 Amesbury, Durrington and Bulford experienced extensive flooding in fields on the 10th February 2014. The flooding was caused by heavy rainfall resulting in groundwater and river levels increasing and overflowing (Ref 11.18). Records also suggest Woodford parish (comprising Lower and Upper Woodford) was also flooded as a result of high river levels (Ref 11.18).

11.6.86 Reports from the Amesbury Flood Action Group documented that the cause of surface water flooding in Amesbury in July 2015 and June 2016 may have been a result of highway drains becoming blocked or their capacity overwhelmed (Ref 11.19). Church Street and Salisbury Road were badly affected and up to 0.6m of internal flooding was recorded in properties.

11.6.87 Highways England's Drainage Data Management System (HADDMS) contains information on seventeen events where flooding affected the current A303 between Winterbourne Stoke and Amesbury. These occurred in 2006, 2007, 2010, 2013, 2014 and 2015. Of these, 15 were rated between 0 – 4 out of 10 and two rated as 5 out of 10. The severities of these events were rated by Highways England using the following factors: impact on traffic, duration of impact, road classification and annual average daily traffic for one carriageway. Information on the sources of these flood events are not noted in HADDMS.

Assessment of importance

11.6.88 Table 11.9 summarises the assessment of the importance of the water environment attributes within the study area, including the indicator of quality supporting the rating, which is in line with DMRB guidance.

Table 11.9: Water environment receptors, attributes and importance

Receptor	Attribute	Importance	Quality
Hampshire Avon (Upper) downstream of Nine Mile River confluence	Water supply/quality	Very High	WFD waterbody with 'Moderate' status Designated SAC/SSSI
	Dilution and removal of waste products	High	Twelve existing permitted discharges
	Recreation	High	Locally important for recreation (fishing in particular)
	Conveyance of flow (river channel, floodplain and overland pathways)	Very High	Main River Presence of fluvial Flood Zone 3 Overland surface water pathways
	Biodiversity	Very High	Designated SAC/SSSI
Till (Hampshire Avon)	Water quality	Very High	WFD waterbody with 'Good' status Designated SAC/SSSI
	Dilution and removal of waste products	High	Ten existing permitted discharges
	Recreation	Medium	Winterbourne and therefore doesn't contain water along the full channel length all year round
	Conveyance of flow (river channel, floodplain and overland pathways)	Very High	Main River Presence of fluvial Flood Zone 3 Overland surface water pathways
	Biodiversity	Very High	Good WFD Ecological status Designated SAC/SSSI
Upper Hampshire Avon Groundwater waterbody	Water supply/quality	Very High	Principal chalk aquifer and WFD waterbody Abstractions with Published Source Protection Zones
	Vulnerability	Very High	Principal chalk aquifer of high vulnerability
	Conveyance of flow	Very High	Two watercourses fed by baseflow
	Biodiversity	Very High	Water dependent designated sites which are fed by baseflow

Receptor	Attribute	Importance	Quality
Lakes and ponds	Water supply/quality	Medium	Not a WFD waterbody Not used for water supply
	Dilution and removal of waste products	Low	No permitted discharges
	Recreation	Low	Not publicly accessible
	Biodiversity	Medium	Not a WFD waterbody Not designated

Future baseline

Construction Year Baseline (2021)

11.6.89 A new development planned at Archers Gate Amesbury is within the River Avon catchment area to the south of Amesbury. This will become part of the construction year baseline. The development will introduce new urban areas and therefore a potential additional source of diffuse urban pollution into the River Avon catchment unless appropriate SuDS measures or other treatment is introduced to ensure that long term water quality impacts do not occur.

11.6.90 No changes to the groundwater body WFD status are expected for the construction year baseline at 2021.

11.6.91 Private abstraction licences may alter for the construction year baseline, but no applications are currently known. Private water supplies may alter and the contractor will need to confirm any new supplies through the requirements of the Outline Environmental Management Plan (OEMP).

11.6.92 The construction of the Tilshead Reservoir, a 95,000m^3 storage area that attenuates flow from excess groundwater emerging from springs and overland runoff to the north of Tilshead will modify the current baseline. Designed as a flood alleviation scheme to reduce flood risk to properties in the villages of Tilshead and Orcheston and the A360 highway, this would reduce existing flood risk in these areas prior to the implementation of the Scheme.

Opening Year Baseline (2026)

11.6.93 No changes to the groundwater body WFD status are expected for the opening year baseline at 2026, although the Environment Agency has an objective to have good groundwater quality status by 2027.

11.6.94 Private abstraction licences may alter for the operational year baseline. Private water supplies may alter, but the scheme should not have any impact on any changes to groundwater receptors for the operational year baseline.

11.6.95 No other changes to the 2026 baseline are currently foreseen.

11.7 Potential impacts

11.7.1 Mitigation measures being incorporated in the design and construction of the Scheme are set out in Section 11.8. Prior to implementation of the mitigation and following a review of the Scheme design and associated construction activities, the Scheme has the potential to affect road drainage and the water environment negatively, both during construction and once in operation, in the following ways.

Construction

11.7.2 The potential temporary impacts arising from the construction of the Scheme include:

a) risks to the water environment due to:

i. excavation, and the subsequent deposition of soils, sediment, or other construction materials causing pollution;

ii. management, storage, treatment and disposal of water from the excavated material;

iii. spillage of fuels or other contaminating liquids causing pollution;

iv. temporary physical modifications interrupting the natural passage of surface and sub-surface flow; and

v. mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff.

b) risks to groundwater associated with cuttings/foundations and/or tunnel construction including:

i. contamination risk to the underlying Chalk aquifer;

ii. temporary dewatering, if required, for diverting water away from groundwater-dependent receptors, or bypassing part of the system, leading to reduced groundwater level and flow; and

iii. release or leaching of substances (e.g. cement or grout) used in the tunnelling process, which may negatively impact groundwater quality.

c) impacts on existing abstractions and springs from dewatering activities (e.g. tunnel construction) and/or groundwater abstraction (e.g. construction compound water supply), if required, which could cause drawdown of the local water table.

d) an increase in flood risk arising from activities such as:

i. construction work temporarily impacting on the function of the floodplain and existing processes;

ii. temporary and/or permanent deposition of excavated material impacting on existing flood flow paths or flood storage areas; and

iii. during the construction process, construction access and compound facilities within the floodplain could result in an increase in flood risk elsewhere.

e) impacts on water dependent designated sites (namely the River Avon SAC including the Rivers Avon and Till) from, for example, discharge of abstracted water during construction resulting in excess summer flows and/or increased silt loading that could impact the ecological features of the system.

11.7.3 The potential permanent impacts arising from the construction of the Scheme include:

a) physical and hydromorphological impacts from watercourse crossings and other hydraulically linked surface water features, with potential for direct effects on the biological, chemical and physical WFD parameters for surface waters and hydraulically connected groundwater bodies;

b) the presence of underground structures that could cause interference to groundwater flow in close proximity to the internationally designated groundwater-fed Rivers Avon and Till that could affect habitats and/or species;

c) those impacts caused by lengths of the tunnel below the groundwater level in the Chalk interfering with groundwater flow. This could lead to a rise in groundwater levels on the northern, upstream side, which could cause additional groundwater flooding, and a reduction of groundwater levels on the southern, downstream side. There are a number of springs in the area down hydraulic gradient of the tunnel including the spring system around Amesbury Abbey, which could be affected;

d) any increase in discharges to ground that may have implications for groundwater quality; and,

e) construction of proposed bridge piers in the River Till floodplain, other structures, cuttings, embankments and other landscaping features or material deposited, within the floodplain or intersecting key overland flow paths (within both River Till and River Avon catchments) that could alter flood flows and increase flood risk.

Operation

11.7.4 The potential impacts on the water environment during the operational phase are:

a) impacts on surface water and groundwater arising from pollutants, e.g. oils from fuel combustion/accidental spillages and salts or herbicides from road maintenance.

11.8 Design, mitigation and enhancement measures

11.8.1 Influencing the Scheme's design has been a key consideration to maximise the opportunities for delivering mitigation of impacts by avoidance and reduction.

11.8.2 Mitigation of potentially significant adverse environmental effects has been an iterative part of the Scheme's development following the hierarchy outlined in Chapter 4: Avoidance; Reduction; Compensation/Remediation and Enhancement.

Construction

11.8.3 Opportunities realised to provide embedded mitigation during the construction phase are firstly those delivered through the design of the Scheme and secondly via construction methods:

a) selecting a location for the crossing of the River Till that requires the minimum length to span it, minimising any impacts on surface water and groundwater flows and quality, hydromorphology and flood risk;

b) the River Till viaduct is proposed to be a five span structure with the location and orientation of the piers and foundations placed as far from the River Till as practically possible and to minimise obstruction of water flows over the floodplain;

c) design for the cutting to the western tunnel portal within the Scheme to be a retained cut for two thirds of its depth, to allow for the inclusion of structures that would reduce the ingress of groundwater that could occur when groundwater levels are high;

d) the strategy for managing surface water runoff from the road, as described in Appendix 11.3, is based on good practice embodied in the DMRB and includes provision to mitigate pollution to notably higher standards than at present. This would minimise any impacts upon the quality of surface water and groundwater and would reduce the current impacts caused by drainage gullies and roadside ditches discharging directly to the River Till and River Avon or infiltrating the runoff to ground without treatment. The design has located the discharges of the proposed drainage system outside any published or nominal SPZ for licensed groundwater abstractions as required by the Environment Agency;

e) the road is designed to minimise the risk of it flooding by incorporating current design standards and future climate change allowances to improve its resilience;

f) the road and the drainage strategy are designed to minimise the risk of causing flooding elsewhere through the use of attenuation features to detain runoff from all events expected to occur with 1% annual probability or more frequently;

g) selecting a route that avoids any new crossing of the River Avon;

h) works undertaken with regard to Government planning practice, water-land management guidance matters, the principles of the non-statutory technical standards for SuDS (Ref 11.20) and the DMRB;

i) application of tunnel construction techniques (such as the use of Tunnel Boring Machines) that limit the requirement for dewatering during construction. This minimises any changes to groundwater levels and flows in the Chalk aquifer that could otherwise adversely alter the hydrological regime of the rivers, springs and other surface water features dependent on groundwater discharge.

11.8.4 Other opportunities realised to provide embedded mitigation during the construction phase via the OEMP for the Scheme, which includes:

a) bunding for areas that may generate contaminated water;

b) minimising the extent of groundwater dewatering and groundwater abstraction where practically possible by the construction techniques;

c) water, such as from excavated material and construction compounds, discharged to self-contained units with appropriate treatment facilities;

d) no direct discharges to groundwater;

e) tests would be undertaken to ensure contaminated material is identified, isolated and reworked or removed to appropriate landfill or treatment to avoid any leachate problems;

f) floodplain working would be minimised as far as reasonably practicable; and

g) temporary land-take includes adequate areas of land set aside for robust control measures, for example sustainable drainage control.

11.8.5 The groundwater-related monitoring is detailed in the groundwater strategy within the GRA (Appendix 11.4) and would be delivered as part of the OEMP.

Operation

11.8.6 The contractor would identify pollution risks (for example in the drainage system) and works will be undertaken in accordance with the wastewater strategy set out in the OEMP.

11.8.7 Effects that remain after mitigation are referred to as residual effects. The assessment of the significance of the residual effects after mitigation is outlined below in the assessment of effects section.

11.8.8 Opportunities realised to provide enhancement opportunities are:

a) the potential for the Environment Agency and Wiltshire Council to adopt some of the groundwater monitoring boreholes as part of their groundwater flood warning system after the agreed period of post-construction monitoring;

b) the use of Highways England's fluvial, pluvial and groundwater hydraulic models to enhance the understanding of river, surface water and groundwater flood risk likelihood and consequences and communication via Environment Agency flood mapping.

11.9 Assessment of effects

11.9.1 To assess the effects of the Scheme on the water environment a number of assessments were undertaken in accordance with the procedures as previously outlined in the DMRB.

11.9.2 Table 11.10 outlines the summary of likely significant effects. These tables take into consideration the agreed mitigation measures outlined above in section 11.8.

11.9.3 In summary, for all water related aspects except one significant beneficial effect, the magnitude of impacts from the Scheme have been assessed as negligible and thus have no reported likely residual significant effects on the identified water environment receptors/attributes. This includes temporary and permanent construction phases and the operational phase. Further information on the non-significant effects is reported in Appendix 11.6.

Table 11.10: Summary of significant effects

Potential Impact	Receptor	Attribute	Quality	Receptor Importance	Design and Mitigation Measures	Magnitude	Residual effect
Construction							
There are no significant adverse construction effects							
Operation							
Increased pollution from road runoff Increased sediment transport	River Avon	Water quality	WFD classification 'Moderate' Designated SSSI/SAC	Very High	Control surface water runoff as close as possible to its source through the use of sustainable highways drainage techniques to manage road runoff as identified in Appendix 11.3.	Minor Beneficial	Moderate Beneficial

Surface water and road drainage

11.9.4 For water quality, the assessments of effects included spillages and routine road runoff on both surface water quality and groundwater quality. For water quality in the River Avon there is a Moderately Beneficial residual effect as a result of improved prevention and treatment of pollution from road runoff and sediment transport. This assessment is based on the soluble pollutant (Copper) becoming a Pass from the existing baseline which is a Fail condition.

11.9.5 All other water quality effects were found to be non-significant for the temporary and permanent construction phases and the operational phase. The main reasons for these conclusions are that potential impacts from the Scheme would be avoided through the design measures set out above, such as selection of a viaduct design for the new River Till crossing to avoid any alterations to the existing river channel. Where any impacts could not be avoided appropriate mitigation measures have been incorporated into the design and construction techniques to reduce their effects, such as the use of SuDS to provide suitable control and treatment of road runoff and best practice construction techniques identified in the OEMP. Further details are summarised in Appendix 11.6 and the rationale for reaching those conclusions is presented in Appendices 11.1, 11.2 and 11.3.

Groundwater

11.9.6 For groundwater, the assessments included the effects of construction of the tunnel on groundwater flows and levels and on the archaeological site at Blick Mead. The effects on water levels and flows from construction works at Countess Junction and the River Till viaduct were also considered.

11.9.7 All groundwater effects were found to be non-significant for the temporary and permanent construction phases and the operational phase. These are summarised in Appendix 11.6 and the rationale for reaching those conclusions is presented in Appendix 11.4. The main reasons for these conclusions are:

a) potential impacts from the Scheme being avoided through design considerations, such as the selection of a viaduct design and orientation of its piers for the new River Till crossing and the foundation design for the Countess Junction flyover, which would not cause any continuous impediment to shallow groundwater flow.

b) application of tunnel construction techniques that limit the requirement for dewatering during construction. Groundwater modelling predicts resulting groundwater level changes as being minimal in the tunnel's vicinity and these do not extend to the rivers Till and Avon. The groundwater modelling also predicts the tunnel construction techniques would cause negligible changes to Chalk groundwater levels in the Blick Mead area. Archaeological remains are located in alluvial deposits, the groundwater in which is sourced from local recharge and interaction with the River Avon.

c) Road runoff outfall locations would not change and runoff catchment area would increase slightly, which is not predicted to decrease the potential contribution of runoff to alluvial groundwater levels supporting the Blick Mead archaeological site.

Flood risk

11.9.8 For flood risk, the assessments of effects included risk to receptors from the rivers Till and Avon, surface water and groundwater flooding. All flood risk effects, including those that could result from climate change, were found to be non-significant for the temporary and permanent construction phases and the operational phase.

11.9.9 The main reasons for these conclusions are that potential impacts from the Scheme would be avoided through design considerations, including the selection of a viaduct design for the new River Till crossing to avoid significant impediment of flood flows and levels and drainage at appropriate locations to manage overland flows. These effects are summarised in Appendix 11.6 and the rationale for reaching those conclusions is presented in Appendix 11.5.

Future baseline (2021)

11.9.10 No differences in the Scheme water effects have been identified for the construction phase in relation to the future baseline in 2021.

Future baseline (2026)

11.9.11 No differences in the Scheme water effects have been identified for the operational phase in relation to the future baseline in 2026.

11.10 Monitoring

Monitoring of significant effects

11.10.1 As no likely significant adverse effects are identified for the water environment or for flood risk no monitoring of significant effects is proposed.

11.10.2 The OEMP sets out monitoring to be undertaken during the construction stage to ensure that the mitigation measures embedded in the scheme design are appropriately implemented.

References

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Ref 11.2: Environment Agency South West River Basin District River Basin Management Plan (February 2016)

Ref 11.3: Environment Agency Water Abstraction Licences (2018)

Ref 11.4: Environment Agency Public Register: Environmental Permitting Regulations – Discharges to water and groundwater (2018) https://environment.data.gov.uk/public-register/view/search-water-discharge-consents

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Ref 11.6: WJ Groundwater, 2003. A303 Stonehenge Improvements: Pumping Test Interpretative Report.

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Ref 11.8: Balfour Beatty-Costain Halcrow Gifford, 2006. A303 Stonehenge Improvement, Preliminary Geotechnical report

Ref 11.9: Historic England, 2016. Preserving Archaeological Remains, Appendix 3 – Water Environment Assessment Techniques

Ref 11.10: Structural Soils, July 2017. A303 Amesbury to Berwick Down. Factual Report on Ground Investigations

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Ref 11.14: The Environment Agency 'Flooding from Rivers' map: Https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=410063&northing=142800&address=10090860639&map= RiversOrSea. Last Accessed: 18/09/2017

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Ref 11.19: Spire FM: https://www.spirefm.co.uk/news/local-news/2039215/amesbury-takes-action-on-its-own-flooding-issues/. Last Accessed: 07/11/2017

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