A66 Northern Trans-Pennine Project
TR010062

3.2 Environmental Statement Chapter 14 Road Drainage and the Water Environment

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3.2 ENVIRONMENTAL STATEMENT CHAPTER 14 ROAD DRAINAGE AND THE WATER ENVIRONMENT

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14 Road Drainage and the Water Environment

14.1 Introduction

14.1.1 This chapter assesses the likely significant road drainage and water environment impacts of the construction and operation of the Project, following the methodology set out in the Design Manual for Roads and Bridges (*DMRB*) *LA 104 Environmental assessment and monitoring* (*DMRB LA 104*) (Highways England, 2020a)[1] and *DMRB LA 113 Road drainage and the water environment* (*DMRB LA 113*) (Highways England, 2020b)[2] and other relevant guidance. It details the assessment methodology, summarises the legislation and policy framework related to road drainage and the water environment and describes the existing environment in the area surrounding the Project. It then considers the design, mitigation and residual effects of the Project, including taking account of relevant characteristics of the future baseline environment. Any key assumptions and limitations applicable to the assessment are also identified.

14.1.2 For the purposes of this chapter, the water environment is considered to comprise:

- Surface water features within the study area.
- Groundwater contained within aquifer units that underlie the study area.
- Other water bodies or water dependent features, such as ground water dependant terrestrial ecosystem's (GWDTE's) that may potentially be affected.
- The aspects of potable water supply that directly depend on water resources (e.g. private wells).

14.1.3 The assessment considers the potential effects on the quality and quantity of surface and groundwaters, geomorphology and flood risk that may result from construction activities, the operational road drainage, and accidental spillages.

14.1.4 The road drainage and water environment effects predicted to be significant are identified in Section 14.10: Assessment of likely significant effects. Effects identified in the course of the assessment but not predicted to be significant are presented in ES Appendix 14.11: Non-Significant Effects (Application Document 3.4).

14.1.5 This chapter is supported by a number of figures (Application Document 3.3) and Technical Appendices (Application Document 3.4) as listed on the contents page.

14.1.6 Associated effects on ecology (including aquatic ecology) are considered in ES: Chapter 6: Biodiversity (Application Document 3.2), although ecological proxy indicators of water quality are considered in Section 14.10: Assessment of likely significant effect. Effects on ground

[1] Highways England (2020a) Design Manual for Roads and Bridges LA 104 Environmental assessment and monitoring]
[2] Highways England (2020b) Design Manual for Roads and Bridges LA 113 Road Drainage and the Water Environment]

conditions and water quality arising from existing land contamination are considered in Chapter 9: Geology and soils (Application Document 3.2).

14.1.7 This EIA has been undertaken by competent experts with the relevant and appropriate experience in their respective topics. The lead author of this chapter has:

- BSc Geography (hons), MSc Catchment Dynamics and Management, PhD Geomorphology and Remote Sensing
- MCIWEM, C.WEM, CSci, CEnv, FRGS, CGeog (Geomorph)
- 17 years of experience in professional practice

14.2 Key assessment parameters

14.2.1 The following key assessment parameters have been used in order to enable flexibility in the assessment and to ensure that a reasonable worst case has been assessed.

Table 14-1: Key Assessment Parameters

Key Assessment Parameters
• The assessment has been conducted for all identified water environment receptors within the Order Limits and study area as detailed in Section 14.6: Study Area. • The assessment of construction impacts upon water environment receptors has been undertaken based upon the construction and ground investigation information available at the time of writing. Key assumptions are included within are presented in Section 14.5: Assumptions and limitations and within the relevant appendices (Application Document 3.4). • Conservative inputs have been derived from available field or desk study data and published research literature relevant to the study area. • All assessments have been conducted using the indicative design. • The assessment has been conducted using the worst-case Limits of Deviation (LoD). Therefore, changes to the design within the LoD are not anticipated to give rise to any significant new or worse water environment effects from those already reported in the chapter and the supporting appendices and is detailed in Section 14.5: Assumptions and limitations.

14.3 Legislation and policy framework

Legislation

14.3.1 The following key legislation is applicable to the assessment:

- *The Environment Act 2021:* The act *relates to* the Secretary of State's ability to manage water resources and wastewater infrastructure. It *gives* powers to the Secretary of State to specify what chemicals should be taken into account in assessing water quality and further controls over licenced abstractions.
- *Environmental Permitting (England and Wales) (Amendment) (EU Exit) Regulations 2019:* Ensures that The Environmental Permitting (England and Wales) Regulations 2016 for England and Wales continues to function in accordance with the European Union (Withdrawal) Act 2018.

- *Environment (Amendment etc.) (EU Exit) Regulations 2019*: Part 2 amends the following primary legislation of relevance to the water environment:
  - *The Environmental Protection Act 1990*
  - *The Environment Act 1995*
- *Environmental Protection Act 1990*: Makes provision to control pollution arising from industrial and other processes for waste management.
- *Environment Act 1995:* Sets standards for environmental management, such as requiring national strategies for air quality and waste. It also deals with the establishment of the Environment Agency.
- *Environmental Permitting (England and Wales) Regulations 2016*: The amendments extended the requirement for an environmental permit to flood risk activities, in addition to polluting activities included under the previous regulations. The permitting requirements for flood risk activities allow the Environment Agency (as regulator for England) to concentrate on higher risk activities.
- *Water Resources Act 1991*: Establishes the Environment Agency's powers and duties for the protection of water resources, flood defence, fisheries, recreation, conservation and navigation.
- *Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (WFD)*: Aims to provide an integrated framework for the protection and restoration of the water environment through the delivery of actions set out in 11 River Basin Management Plans (RBMPs).
- *Land Drainage Act 1991*: Provides functions to drainage boards and local authorities to manage watercourses and provide consenting powers for proposed works to watercourses associated with development.
- *Water Act 2014*: Amends the *Water Resources Act 1991* and *the Water Industry Act 1991* to make provision with respect to compensation under section 61 of the *Water Resources Act 1991*.
- *Water Resources (Abstraction and Impounding) Regulations 2006*: Contains provisions relating to the licensing of abstraction and impounding of water in England and Wales in the light of amendments made by the *Water Act 2003* to the *Water Resources Act 1991*. The 2006 regulations have been updated by the *Water Abstraction and Impounding (Exemptions) Regulations 2017*.
- *Water Abstraction and Impounding (Exemptions) Regulations 2017*: Contains circumstances where water abstractions and impounding works are exempt from licensing requirements.
- *Flood Risk Regulations 2009*: The regulations designate Local Lead Flood Authorities (LLFA) and impose duties on the Environment Agency and LLFAs to prepare a number of documents including:
  - preliminary flood risk assessments
  - flood risk and flood hazard maps
  - flood risk management plans

- *Water Supply (Water Quality) Regulations 2018*: Provides the framework for drinking water quality in England in respect of public supplies provided by water companies and licensed water suppliers.
- *Flood and Water Management Act 2010*: Gives the Environment Agency a strategic overview of the management of flood and coastal erosion risk in England. In accordance with the Government's Response to the Pitt Review, it also gives upper tier local authorities in England responsibility for preparing and putting in place strategies for managing flood risk from groundwater, surface water and ordinary watercourses in their areas.
- *Environmental Damage (Prevention and Remediation) (England) Regulations 2015***:** These regulations are based on the 'polluter pays' principle and impose obligations on operators of economic activities requiring them to prevent, limit or remediate environmental damage. They apply to damage to protected species, natural habitats, sites of Special Scientific Interest (SSSI), water and land and implement directive 2004/35/EC, on environmental liability.
- *Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*: The WFD Directions present the updated environmental standards to be used in the second cycle of the WFD (2000/60/EC) river basin management planning process in England and Wales.
- *Groundwater (Water Framework Directive) (England) Direction 2016*: The direction sets out instructions to the Environment Agency on obligations to protect groundwater, including requirements to monitor and set thresholds for pollutants, add new pollutants to the monitoring list and change the information reported to the European Commission.
- *Conservation of Habitats and Species Regulations 2017 (the 'Habitat Regulations 2017')*: Ensures the conservation of a range of rare or threatened species.

National level policy

National Policy Statement for National Networks

14.3.2 The primary basis for the Secretary of State deciding whether or not to grant a Development Consent Order (DCO) for the Project is the *National Policy Statement for National Networks (NPSNN)* (Department for Transport, 2014)[3].

Table 14-2: Relevant NPSNN policies identifies the *NPSNN* policies relevant to this assessment and a reference to where information is provided to address each policy.

[3] Department for Transport (2014) National Policy Statement for National Networks

Table 14-2: Relevant NPSNN policies

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
4.40 to 4.47	*NPSNN* sets out the need to take effects of climate change adaption into account, and the impacts of climate change when planning location, design, build and operation should be considered. An environment statement should set out how the scheme will take account of the projected impacts of climate change.	Climate adaption is covered in detail in Chapter 7: Climate (ES Application Document 3.2). It is also considered in the Baseline conditions - Future baseline and Potential impacts of this Chapter. Climate change factors have been included in the Project's Flood Risk Assessment (FRA).	Chapter 7: Climate (Application Document 3.2) Section 14.7: Baseline conditions and Section 14.8: Potential impacts ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)
4.52 to 4.55	*NPSNN* sets out the need for pollution control and other environmental protection regimes, including consenting and licensing regimes. Pollution control involves the prevention of pollution using measures to stop or limit the releases of substances from different sources to the environment to the lowest practicable level. It also ensures that water quality meets standards that guard against the impacts to the receiving environment or human health. It requires that the scheme takes into account the full account of environmental impacts, which may require close cooperation with the Environment Agency and other bodies, to ensure that in the case of pollution events they are satisfied that potential releases can be adequately regulated under the relevant pollution control framework. It also requires that cumulative effects of pollution, including that from existing sources and the scheme are considered.	These are outlined in Essential mitigation and enhancement measures and the Assessment of likely significant effects sections of this Chapter. An Environmental Management Plan (EMP) is included as part of the DCO submission. Cumulative effects are assessed in Chapter 15: Cumulative Effects (ES Application Document 3.2).	Section 14.9: Essential mitigation and enhancement measures Section 14.10: Assessment of likely significant effects EMP (Application Document 2.7) Chapter 15: Cumulative Effects (Application Document 3.2)

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
5.90 to 5.115	*NPSNN* sets out how flood risk impacts should be considered, including that flood risk will not be increased elsewhere and is only appropriate in areas at risk of flooding where it can be demonstrated that: • The most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location. • Development is appropriately flood resilient and resistant, including safe access and escape routes where required. • Any residual risk can be safely managed, including by emergency planning. • Priority is given to the use of sustainable drainage systems (SuDS). The Flood Risk Assessment should: • Consider the risk of all forms of flooding arising from the scheme (including in adjacent parts of the United Kingdom), in addition to the risk of flooding to the scheme and demonstrate how these risks will be managed and mitigated (where relevant), so that the development remains safe throughout its lifetime. • Consider the impacts of climate change, clearly stating the development lifetime over which the assessment has been made. • Consider the vulnerability of those using the infrastructure, including arrangements for safe access and egress. • Include a residual risk assessment after mitigation measures have considered and demonstrate that they are acceptable for the scheme.	Baseline flood risk is outlined in the Baseline Conditions section of this Chapter. Flooding impacts are considered in Potential impacts and Assessment of likely significant effects section of this Chapter. An FRA has been used to assess the flood risk impact to and from the Project.	Section 14.7: Baseline conditions and Section 14.8: Potential impacts Section 14.10: Assessment of likely significant effects ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
	• Consider if there is a need to remain operational during a worst-case flood event over the schemes' lifetime. Provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test, as appropriate.		
5.219 to 5.231	*NPSNN* considers the assessment of impacts to water quality and resources. The proposal has considered the relevant River Basin Management Plans and the requirements of the WFD. An environmental statement should describe: • The existing quality of waters affected by the scheme. • Existing water resources affected by the scheme and the impacts of the scheme on water resources. • Existing physical characteristics of the water environment (including quantity and dynamics of flow) affected by the scheme and any impact of physical modifications to these characteristics. • Impacts of the scheme on waterbodies or protected under the WFD and source protection zones (SPZs) around potable groundwater abstractions. • Cumulative effects.	Existing quality of waters and assessment of impact on these is included in this chapter. Existing physical characteristics of the water environment are included in the WFD compliance assessment, Hydromorphology assessment, and the Hydrogeological impact assessment Impacts of WFD waterbodies is considered in the WFD compliance assessment and impacts on SPZs are considered in the Hydrogeological impact assessment Cumulative effects are assessed in a standalone chapter.	Section 14.7 Baseline conditions Section 14.8 Potential impact Section 14.10 Assessment of likely significant effects. ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4) ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4) ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) ES Chapter 15: Cumulative Effects (Application Document 3.2)

National Planning Policy Framework

14.3.3 The *National Planning Policy Framework (NPPF)* (Ministry of Housing, Communities and Local Government, 2021)[4] provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans. Section 14, titled "Meeting the challenge of climate change, flooding and coastal change" relates to flooding. The policy states that development should be directed away from areas at highest risk of flooding (both existing and predicted). However, where development is necessary in such areas, the development must be safe, for the lifetime of the development, without increasing flood risk elsewhere.

Planning Practice Guidance

14.3.4 *Planning Practice Guidance* (Ministry of Housing, Communities and Local Government, 2018)[5] details how to take account of and address the risks associated with flooding within the planning process. It also details how planning can ensure water quality.

Regional and local level policy

14.3.5 Other regional and local level policies have been considered as part of the Road Drainage and the Water Environment assessment where these have informed the identification of receptors and resources and their sensitivity; the assessment methodology; the potential for likely significant environmental effects; and required mitigation. These policies at a regional level include:

- Cycle 2 RBMPs 2015-2021 (Environment Agency, 2016)[6]: Within the study area there are three RBMPs of relevance; Solway Tweed, Northumbria, and Humber. These plans provide a framework for protecting and enhancing the benefits provided by the water environment. They also inform decisions on land use planning. Draft Cycle 3 RBMPs were in consultation until the end of April 2022.
- Flood Risk Management Plans (FRMPs) 2015-2021: The FRMPs set out how organisations, stakeholders and communities will work together to manage flood risk.

Cumbria local policy, strategy, and evidence

14.3.6 Local policy, strategy and evidence documents for Cumbria used to inform this chapter include:

- Cumbria County Council - Local Flood Risk Management Strategy Public Summary (Cumbria County Council, 2015)[7]

[4] Ministry of Housing, Communities and Local Government (2021) The National Planning Policy Framework
[5] Ministry of Housing, Communities and Local Government (2018) Planning practice guidance
[6] Environment Agency (2016) Cycle 2 River Basin Management Plans
[7] Cumbria County Council (2015) Local Flood Risk Management Strategy

- Cumbria County Council – Flood Risk Regulations 2009 - Preliminary Flood Risk Assessment, Cumbria Area Preliminary Appraisal Report (Cumbria County Council, 2011)[8]
- Cumbria County Council - Cumbria Minerals and Waste Local Plan Strategic Flood Risk Assessment (Cumbria County Council, 2018)[9]
- Cumbria County Council - Cumbria Development Design Guide, (Cumbria County Council, 2017)[10]
- Eden District Council - Eden Local Plan 2014 to 2032 (Eden District Council, 2014)[11]
- Eden District Council - Strategic Flood Risk Assessment, (Eden District Council, 2020)[12]
- Solway Tweed River Basin District Flood Risk Management Plan 2015- 2021 (Environment Agency, 2016)[13]
- Soloway Tweed (English Catchments) River Basin District Draft Flood Risk Management Plan 2021 to 2027 (Environment Agency 2021)[14]
- Eden District Council - Core Strategy Development Plan Document (Eden District Council, 2010)[15]

County Durham policy, strategy, and evidence

14.3.7 Local policy, strategy and evidence documents for County Durham used to inform this chapter include:

- Durham County Council - Local Flood Risk Management Strategy 2016-2020 (Durham County Council, 2017)[16]
- Durham County Council - Sustainable Drainage Systems (SuDS) Adoption Guide (Durham County Council, 2016)[17]
- Durham County Council - Preliminary Flood Risk Assessment, (Durham County Council, 2016)[18]
- River Tees Catchment Flood Management Plan (CFMP) (Environment Agency, 2009)[19]

North Yorkshire policy, strategy, and evidence

14.3.8 Local policy, strategy and evidence documents for North Yorkshire used to inform this chapter include:

[8] Cumbria County Council (2011) Flood Risk Regulations 2009 – Preliminary Flood Risk Assessment: Cumbria Area Preliminary Appraisal Report
[9] Cumbria County Council (2018) Cumbria Minerals and Waste Local Plan Strategic Flood Risk Assessment
[10] Cumbria County Council (2017) Cumbria Development Design Guide
[11] Eden District Council (2014) Eden Local Plan 2014 to 2032
[12] Eden District Council (2020) Eden Level 1 Strategic Flood Risk Assessment.
[13] Environment Agency (2016) Solway Tweed River Basin District Flood Risk Management Plan 2015- 2021.]
[14] Environment Agency (2021b) Soloway Tweed (English Catchments) River Basin District Draft Flood Risk Management Plan 2021 to 2027. DRAFT for consultation
[15] Eden District Council (2010) Core Strategy Development Plan Document Joint Core Strategy
[16] Durham County Council (2017) Local Flood Risk Management Strategy 2016-2020
[17] Durham County Council (2017) Sustainable Drainage Systems (SuDS) Adoption Guide 2016
[18] Durham County Council (2016) Preliminary Flood Risk Assessment
[19] Environment Agency (2009) Tees Catchment Flood Management Plan

- North Yorkshire County Council - SuDS Design Guidance (North Yorkshire County Council, 2018)[20]
- North Yorkshire County Council, City of York Council, and the North York Moors National Park Authority - Strategic Flood Risk Assessment (Level 1), 2016[21]
- North Yorkshire County Council Preliminary Flood Risk Assessment, (North Yorkshire County Council, 2011)[22]
- North Yorkshire County Council - Preliminary Flood Risk Assessment (addendum), (North Yorkshire County Council, 2017)[23]
- The Richmondshire Local Plan (2012 – 2028) (Richmondshire District Council, 2014)[24]
- Wear CFMP (Environment Agency, 2009)[25]
- North West Yorkshire Level 1 Strategic Flood Risk Assessment Update, (JBA, 2010)[26]
- North Pennines Area of Outstanding Natural Beauty (AONB) Management Plan 2019-24 (North Pennines AONB Partners, 2018)[27]

Other relevant policy and guidance

14.3.9 Due reference has been made to the UK Government guidance for preventing pollution[28], working on or near water[29], and for managing water on land[30].

14.3.10 Construction Industry Research and Information Association (CIRIA) guidance used for the assessment includes:

- Control of Water Pollution from Construction Sites – Guide to Good Practice (SP156).
- Control of Water Pollution from Construction Sites – Guidance for Consultants and Contractors (C532).
- Control of Water Pollution from Linear Construction Projects – Technical Guidance (C648).
- Control of Water Pollution from Linear Construction Projects – Site guide (C649).
- Environmental good practice on site (C692).
- Groundwater control: design and practice (second edition) (C750).
- The SuDS Manual (C753).
- Guidance on the construction of SuDS (C768).

[20] North Yorkshire County Council (2018) SuDS Design Guidance 2018 Update
[21] North Yorkshire County Council, City of York Council and the North York Moors National Park Authority (2017) Strategic Flood Risk Assessment (Level 1)
[22] North Yorkshire County Council (2011) Preliminary Flood Risk Assessment
[23] North Yorkshire County Council (2017) Preliminary Flood Risk Assessment (addendum)
[24] Richmondshire District Council (2014) Richmondshire Local Plan 2012-2028: Core Strategy
[25] Environment Agency (2009) Wear Catchment Flood Management Plan
[26] JBA Consulting (2010) North West Yorkshire Level 1 Strategic Flood Risk Assessment Update
[27] North Pennines AONB Partners (2018) North Pennines Area of Outstanding Natural Beauty Management Plan 2019-24
[28] Environment Agency (2021e). Pollution prevention for businesses.
[29] Environment Agency (2021c). Check if you need permission to do work on a river, flood defence or sea defence
[30] Environment Agency (2015). Manage water on land: guidance for land managers

14.3.11 The design of any new, realigned, or improved channels is to be undertaken in accordance with the Manual of River Restoration Techniques (River Restoration Centre 2019)[31]. This is secured in the Project Design Principles (Application Document 5.11) which is certified as part of the DCO.

14.4 Assessment methodology

14.4.1 The methodology for the Road Drainage and the Water Environment assessment follows the guidance set out within *DMRB LA 113* and *DMRB LA 104*.

14.4.2 The assessment will follow the requirements of *DMRB LA 113* and *DMRB LA 104*. These provide a methodology and criteria for assessing the impact of a proposed road scheme on the water environment.

14.4.3 The methodology for assessing effects uses the following steps:

- Definition of a study area (as defined in Section 14.6: Study area)
- Identification of potential receptors within the study area to form baseline conditions, based on the features outlined in Table 14-3: Attributes and indicators of quality for water features, as per Table 3.69 of *DMRB LA 113*
- Assessment of importance or value (hereafter referred to as value) and sensitivity of each of these receptors, shown in Table 14-4: Estimating the value of water environment attributes, as per Table 3.70 of *DMRB LA 113*. Values of each receptor are presented in ES Appendix 14.10: Assessment of Value (Application Document 3.4)
- Assessment of the potential magnitude of any construction or operation impact on the receptor, shown in Table 14-5: Estimating the magnitude of an impact on an attribute, as per Table 3.71 of *DMRB LA 113*
- Assessment of the overall significance of any effects on receptors due to impacts, shown in Table 14-6: Significance matrix, as per Table 3.8.1 of *DMRB LA 104*. The significance of effect is determined by a combination of the identified value/sensitivity of the receptor with the estimated magnitude of the impact, considering embedded and essential mitigation. For the purpose of this assessment, significance of moderate and above will be defined as likely significant effects.

14.4.4 Appendix B of *DMRB LA 113* outlines specific criteria for establishing importance (value) in Table B.1 and risk (significance of effect) of groundwater dependent terrestrial ecosystems (GWDTEs) in Table B.3, which varies from the criteria used for the other assessments.

14.4.5 In accordance with *DMRB LA 113* a ‘simple assessment’ has been conducted for the following, details of the approach for each is presented in the relevant appendix (all contained within Application Document 3.4):

[31] River Restoration Centre (2021) Manual of River Restoration Techniques. Update 3 2021. River Restoration Centre: Cranfield, UK

- Routine runoff and surface water quality, ES Appendix 14.1: WFD Compliance Assessment and ES Appendix 14.3: Water Quality Assessment (Application Document 3.4)
- Hydromorphology assessment, ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4)
- Spillage and water quality, ES Appendix 14.5: Spillage Risk Assessment and Appendix 14.3: Water Quality Assessment
- Groundwater level and flow, ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4)
- Groundwater quality and routine runoff, ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4)
- Groundwater-dependent terrestrial ecosystems (GWDTEs), ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment (Application Document 3.4).

14.4.6 A 'simple assessment' involves "the collection and assessment of data and information that is readily available to reach an understanding of the likely environmental effects of a project". Following a 'simple assessment', where a detailed assessment was considered necessary in accordance with *DMRB LA 113*, it was undertaken as per the methodology detailed in Table 3.2 of *DMRB LA 113*. Due to the conservative nature of the assessments, the mitigation outlined is based on a worst case scenario and as such it may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this chapter) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this chapter This has been included in the outlined assessment mitigation and is secured by the EMP (Application Document 2.7).

14.4.7 Specific methods of assessment required by *DMRB LA 113* in relation to particular construction and operational impacts are described in more detail for construction and operation impacts in the following sections.

14.4.8 The Preliminary Sources Study report (PSSR) (Highways England, 2019[32]) states that dissolution in the gypsum and limestone bedrock present in scheme areas can develop dissolution features. These features, such as caves, voids, dolines, stream sinks and risings, are referred to as karst and are significant geotechnical subsidence hazards. Due to these underlying ground conditions across the Project's study area, ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4) has been prepared.

14.4.9 Due to the connectivity to the River Eden Special Area of Conservation (SAC) and functionally connected habitats, it was considered that, for the Penrith to Temple Sowerby and Appleby to Brough schemes,

[32] Highways England (2019) HE565627-ARC-HGT-A66-RP-CE-2005. A66 Northern Trans-Pennine Project. Preliminary Sources Study Report.

detailed geomorphological modelling and assessment was appropriate. This has been completed and is presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4).

Identification of receptors

14.4.10 To identify water receptors within the study area, a desk-based review of potential receptors within the study area (defined in Section 14.6: Study area) and site walkovers and investigations (detailed in Section 14.7: Baseline conditions) were completed. The identification was based on the features outlined in Table 14-3: Attributes and indicators of quality for water features, which is taken from Table 3.69 of *DMRB LA 113*.

Table 14-3: Attributes and indicators of quality for water features

Feature	Attribute	Indicator of quality	Possible measure
Watercourse	Water supply/ quality	Amount used for water supply (potable) Amount used for water supply (industrial/ agricultural) Chemical water quality	Location and number of abstraction points Volume abstracted daily WFD chemical status
	Dilution and removal of waste products	Presence of surface water discharges Effluent discharges	Daily volume of discharge (treated/untreated)
	Recreation	Access to river Use of river for recreation	Length of river used for recreation (fishing, water sports) Number of clubs
	Value to economy	Value of use of river	Length of river used for recreation commercially Number of people employed Length of riverbank developed Length of river fished commercially
	Conveyance of flow	Presence of watercourses	Number and size of watercourses, natural, artificial or heavily modified water body Number of watercourses artificially managed to control flow/levels
	Biodiversity	Biological water quality	Fisheries quality
		Fisheries quality	Fish status, as defined in the WFD
Floodplain	Conveyance of flow	Presence of floodplain Flood flows	Developed area within extent of floodplain affected, as determined from hydraulic modelling Flood risk Mean annual flood
Groundwater	Water supply/ quality	Amount used for water supply	WFD groundwater quantitative and chemical status

Feature	Attribute	Indicator of quality	Possible measure
		Amount used for water supply (industrial/agricultural)	Catchment abstraction management Strategy (CAMS) status Location and number of abstraction points Volume abstracted daily and use (potable most important) Location and grade of Source Protection Zone (SPZ)
	Soakaway	Presence of soakaways or other discharges to the ground	Location, type and number of discharge points. Daily volume discharged
	Vulnerability	Groundwater vulnerability	Classification of aquifer vulnerability
	Economic value	Extent of use for abstractions	Number of people employed, cost of alternatives
	Conveyance of flow	Presence of groundwater supported watercourses Potential for groundwater flooding Groundwater interception by road structures or drainage	Changes to groundwater recharge, levels or flows Number and size of watercourses fed by baseflow
	Biodiversity	Presence of GWDTE	Changes to groundwater recharge, levels or flows. Status or classification of wetland including GWDTE under WFD
Lakes, ponds and reservoirs	Recreation	Access Use for recreation	Area used for recreation (fishing, water sports) Number of clubs
	Water supply/quality	Amount used for water supply (potable) Amount used for water supply (industrial/agricultural) Chemical water quality	Volume abstracted daily WFD chemical status
	Dilution and removal of waste products	Presence of surface water discharges Effluent discharges	Daily volume of discharge (treated/untreated)
	Value to economy	Extent of employment	Number of people employed
	Biodiversity	Biological water quality	WFD ecological status
		Fisheries quality	Fish status, as defined in the 2000/60/EC

Feature	Attribute	Indicator of quality	Possible measure
		Populations of birds	Assemblages or number of species of UK biodiversity Action plan or birds of conservation concern

Assessment of value

14.4.11 The value of each water environment feature within the study area (defined in Section 14.6 Study area) was determined according to the DMRB criteria set out in Table 3.70 of *DMRB LA 113*, and as shown in Table 14-4: Estimating the value of water environment attributes.

Table 14-4: Estimating the value of water environment attributes

Value	Criteria	Attribute	
Very High	Nationally significant attribute of high importance	Surface water	Watercourse having a WFD classification shown in a River Basin Management Plan (RBMP) and Q95 (flow exceeded 95% of the time) ≥1.0 m3/s Site protected/designated under UK legislation (Special Area of Conservation (SAC), Special Protection Area (SPA), Site of Special Scientific Interest (SSSI), Ramsar site, salmonid water) /Species protected by EC legislation Ecology and Nature Conservation
		Groundwater	Principal aquifer providing a regionally important resource and/or supporting a site protected under UK legislation Ecology and Nature Conservation Groundwater locally supports GWDTE Source Protection Zone I (inner zone)
		Flood risk	Essential infrastructure or highly vulnerable development
High	Locally significant attribute of high importance	Surface water	Watercourse having a WFD classification shown in a RBMP and Q95 <1.0m3/s Species protected under EC or UK legislation Ecology and Nature Conservation
		Groundwater	Principal aquifer providing locally important resource or supporting a river ecosystem Groundwater supports a GWDTE Licensed abstraction Source Protection Zone II (outer zone)
		Flood risk	More vulnerable development
Medium	Of moderate quality and rarity	Surface water	Watercourses not having a WFD classification shown in a RBMP and Q95 >0.001m3/s
		Groundwater	Aquifer providing water for agricultural or industrial use with limited connection to surface water Source Protection Zone III (total catchment)
		Flood risk	Less vulnerable development
Low	Lower quality	Surface water	Watercourses not having a WFD classification shown in a RBMP and Q95 ≤0.001m3/s

Value	Criteria	Attribute	
		Groundwater	Unproductive strata
		Flood risk	Water compatible development

Magnitude of impact

14.4.12 The approach used to assess magnitude of impacts on water environment features considers the change to the receptor. This considers the severity of impact of the scheme, together with the vulnerability of the receptor to change.

14.4.13 Table 14-5: Estimating the magnitude of an impact on an attribute summarises the potential magnitude of any construction or operation impact on the receptor, as per Table 3.71 of *DMRB LA 113*.

Table 14-5: Estimating the magnitude of an impact on an attribute

Magnitude	Criteria		Attribute
Major adverse	Results in loss of attribute and/or quality and integrity of the attribute	Surface water	Failure of both acute-soluble and chronic-sediment related pollutants in Highways England's Water Risk Assessment Tool (HEWRAT) and compliance failure with Environmental Quality Standards (EQS) values Calculated risk of pollution from a spillage ≥2% annually (spillage assessment) Loss or extensive change to a fishery Loss of regionally important public water supply Loss or extensive change to a designated nature conservation site Reduction in water body WFD classification
		Groundwater	Loss of, or extensive change to, an aquifer Loss of regionally important water supply Potential high risk of pollution to groundwater from routine runoff – risk score >250 (Groundwater quality and runoff assessment) Calculated risk of pollution from spillages ≥2% annually (spillage assessment) Loss of, or extensive change to GWDTE or baseflow contribution to protected surface water bodies Reduction in water body WFD classification Loss or significant damage to major structures through subsidence or similar effects
		Flood risk	Increase in peak flood level (>100mm)
Moderate adverse	Results in effect on integrity of	Surface water	Failure of both acute-soluble and chronic-sediment related pollutants in HEWRAT but compliance with EQS values

Magnitude	Criteria		Attribute
	attribute, or loss of part of attribute		Calculated risk of pollution from spillages ≥1% annually and <2 % annually Partial loss in productivity of a fishery Degradation of regionally important public water supply or loss of major commercial/industrial/agricultural supplies Contribution to reduction in water body WFD classification
		Groundwater	Partial loss or change to an aquifer Degradation of regionally important public water supply or loss of significant commercial/industrial/agricultural supplies Potential medium risk of pollution to groundwater from routine runoff – risk score 150-250 Calculated risk of pollution from spillages ≥1% annually and <2 % annually Partial loss of the integrity of GWDTE Contribution to reduction in water body WFD classification Damage to major structures through subsidence or similar effects or loss of minor structures
		Flood risk	Increase in peak flood level (>50mm)
Minor adverse	Results in some measurable change in attributes, quality or vulnerability	Surface water	Failure of either acute soluble or chronic sediment related pollutants in HEWRAT Calculated risk of pollution from spillages ≥0.5% annually and < 1% annually Minor effects on water supplies
		Groundwater	Potential low risk of pollution to groundwater from routine runoff – risk score <150 Calculated risk of pollution from spillages ≥0.5% annually and <1%annually Minor effects on an aquifer, GWDTEs, abstractions and structures
		Flood risk	Increase in peak flood level (>10mm)
Negligible	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity	The proposed project is unlikely to affect the integrity of the water environment.	
		Surface water	No risk identified by HEWRAT (pass both acute-soluble and chronic-sediment related pollutants) Risk of pollution from spillages <0.5%
		Groundwater	No measurable impact upon an aquifer and/or groundwater receptors and risk of pollution from spillages <0.5%
		Flood risk	Negligible change to peak flood level (≤ +/- 10mm)

Magnitude	Criteria		Attribute
Minor beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring	Surface water	HEWRAT assessment of either acute soluble or chronic-sediment related pollutants becomes pass from an existing site where the baseline was of 'fail' condition Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is <1% annually)
		Groundwater	Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually) Reduction of groundwater hazards to existing structures Reductions in waterlogging and groundwater flooding
		Flood risk	Creation of flood storage and decrease in peak flood level (>10mm)
Moderate beneficial	Results in moderate improvement of attribute quality	Surface water	HEWRAT assessment of both acute-soluble and chronic-sediment related pollutants becomes pass from an existing site where the baseline was of 'fail' condition Calculated reduction in existing spillage by 50% or more (when existing spillage risk >1% annually) Contribution to improvement in water body WFD classification
		Groundwater	Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually) Contribution to improvement in water body WFD classification Improvement in water body CAMS (or equivalent) classification Support to significant improvements in damaged GWDTE
		Flood risk	Creation of flood storage and decrease in peak flood level1 (>50mm)
Major beneficial	Results in major improvement of attribute quality	Surface water	Removal of existing polluting discharge or removing the likelihood of polluting discharges occurring to a watercourse. Improvement in water body WFD classification
		Groundwater	Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring Recharge of an aquifer. Improvement in water body WFD classification
		Flood risk	Creation of flood storage and decrease in peak flood level (>100mm)

Magnitude	Criteria	Attribute
No change		No loss or alteration of characteristics, features or elements; no observable impact in either direction

Significance of effect

14.4.14 By combining the magnitude of impact (or change) and the value of each water environment feature (sensitivity), an assessment has been made of the significance of effect. The possibility and extent of successful mitigation is then considered, and the residual effect reported. The resultant effects may be either negative (adverse), positive (beneficial) or neutral, depending on the nature of the impact.

14.4.15 In accordance with Table 3.8.1 of *DMRB LA 104*, the significance of effect upon the receptor is assessed using the matrix in Table 14-6: Significance matrix. Effects are defined on a nine-point scale (very large beneficial, large beneficial, moderate beneficial, slight beneficial, neutral, slight adverse, moderate adverse, large adverse or very large adverse).

14.4.16 Where the matrix suggests more than one likely outcome, for instance slight or moderate, professional judgement has been used in conjunction with Table 14-5: Estimating the magnitude of an impact on an attribute to arrive at a robust conclusion.

Table 14-6: Significance matrix

		Magnitude of impact (degree of change)				
		No change	Negligible	Minor	Moderate	Major
Environmental value (sensitivity)	Very high	Neutral	Slight	Moderate or large	Large or very large	Very large
	High	Neutral	Slight	Slight or moderate	Moderate or large	Large or very large
	Medium	Neutral	Neutral or slight	Slight	Moderate	Moderate or large
	Low	Neutral	Neutral or slight	Neutral or slight	Slight	Slight or moderate
	Negligible	Neutral	Neutral	Neutral or slight	Neutral or slight	Slight

14.4.17 For the purpose of this assessment, significance of moderate and above will be defined as likely significant effects.

14.4.18 All assessments follow a source – pathway – receptor approach, under which, for there to be a risk of impact to surface water or groundwater, a source, pathway and receptor all have to be present to create a pollutant linkage or create a linkage based on natural processes. In the context of this chapter, pollutant sources are those associated with the construction and operation of the scheme, and the receptors are the receiving water environment, including surface water, groundwater and springs.

Construction impact

14.4.19 *DMRB LA 113* recommends that an assessment of construction impacts should use the advice given in CIRIA Report C648 Control of Water Pollution from Linear Construction Projects (CIRIA, 2006)[33] on potential impacts arising during the construction phase and the assessment and mitigation of these risks.

14.4.20 The potential impacts of construction on surface water, sediment runoff, water quality, flood risk and groundwater quality or level have been assessed based on the proposed construction methods outlined in ES Chapter 2: The Project (Application Document 3.2). Where construction methods have not been available, standard construction practices that follow CIRIA guidance (as outlined in 14.3.10) have been assumed. Cumulative impacts as a result of anticipated construction phasing have also been assessed within Chapter 15: Cumulative Effected (Application Document 3.2).

14.4.21 Outline measures to reduce construction impacts are included in the Environmental Management Plan (EMP) (Application Document 2.7). Measures included within the EMP will be secured by the DCO through the imposition of a requirement and these measures are therefore relied on for the purposes of this assessment. These measures are also reported in the Register of Environmental Actions and Commitments (REAC) within the EMP (Application Document 2.7)

14.4.22 The potential impacts of construction on hydrogeology have been evaluated as part of ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4), by consideration of the proposed construction activities in the context of a baseline conceptual model of the hydrogeological regime. The methodology for groundwater assessment incorporates guidance for Dewatering Abstractions SC040020 SR1 (Environment Agency, 2007)34 and SR2 (Environment Agency, 2007)35.

Operational impact

WFD compliance assessment

14.4.23 A WFD compliance assessment for the scheme has been conducted and is provided in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4), with reference to the *Advice Note 18* The Water Framework Directive (The Planning Inspectorate, 2017)[36].

14.4.24 The WFD quality and quantity elements identified through scoping as being at potential risk of impact from the scheme have been assessed in the WFD compliance assessment.

14.4.25 The WFD assessment identifies how the scheme has the potential to affect each of the water bodies' quality/quantity elements and if this

[33] CIRIA (2006) Control of Water Pollution from Linear Construction Projects (C648)
[34] Environment Agency (2007). Hydrogeological impact appraisal for dewatering abstractions.
[35] Environment Agency (2007). Hydrogeological impact appraisal for groundwater abstractions.]
[36] The Planning Inspectorate (2017). Advice Note 18: The Water Framework Directive.]

results in non-compliance with the WFD. The results of the other assessments in this chapter are used to inform the WFD assessment, where considered applicable.

14.4.26 For water bodies that have the potential to be impacted by the Project, the effect of the Project on any mitigation measures identified within the relevant RBMP has been assessed.

Flood risk assessment

14.4.27 An FRA has been conducted and is provided in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4).

14.4.28 This includes the details of the methodology used to assess the risk of flooding from pluvial and fluvial sources as a result of the Project. This follows an approach agreed with the Lead Local Flood Authorities (LLFAs) within the study area and the Environment Agency (as Lead Authority for Main Rivers).

14.4.29 The FRA includes a quantitative assessment of pluvial and fluvial flood risk for the Project, including hydrological and hydraulic modelling. It uses the latest available climate change data to apply the central, higher central, and upper end peak rainfall allowances for the 2080s epoch for all schemes. The upper end allowances for the catchment management areas within the study area are taken from Climate Change Allowances: Peak River Flow in England (Environment Agency, 2021)[37], are:

- Eden and Esk: 94% uplift
- Tees: 61% uplift
- Swale, Ure, Nidd and Ouse Upper: 53% uplift.

14.4.30 The susceptibility of flooding from groundwater sources is detailed in this chapter and is to be reviewed on receipt of additional groundwater monitoring, taking into consideration potential climate change impacts.

Routine runoff and surface water quality assessment

14.4.31 A simple assessment of the potential impacts of routine runoff on surface water quality has been undertaken using the Highways England Water Risk Assessment Tool (HEWRAT) to determine whether the risk is acceptable. This is provided in ES Appendix 14.3: Water Quality Assessment (Application Document 3.4).

14.4.32 The assessment has been conducted at the locations of existing and proposed highway drainage system outfall locations.

14.4.33 Proposed highway drainage modelling includes:

- MicroDrainage modelling – to understand surface water flow paths, provide a measure of pipe size and attenuation.
- Estimation of the rainfall return period events with allowance for climate change.

14.4.34 This information has been used to design suitable drainage systems and mitigation measures, including the design of channel diversions.

[37] Environment Agency (2021a) Climate Change Allowances: Peak River Flow in England.]

Accidental spillage assessment

14.4.35 An accidental spillage assessment has been undertaken using Appendix D Spillage assessment from DMRB LA 113 and is provided in ES Appendix 14.5: Spillage Risk Assessment (Application Document 3.4). Using the spillage assessment method, for the risk of a serious pollution incident to be acceptable the calculated annual probability of such an incident shall not be greater than 1%. Where spillage has the potential to affect an SAC, SSSI, SPZ, protected area, drinking water supply or commercial activity abstracting from the watercourse, for the risk of a serious pollution incident to be acceptable the calculated annual probability shall not be greater than 0.5%.

Groundwater quality and routine runoff assessment

14.4.36 A simple assessment of groundwater quality and routine runoff has been undertaken (ES Appendix 14.3: Water Quality Assessment (Application Document 3.4)). This uses *Appendix C: Groundwater quality and run off* of *DMRB LA 113*, which provides a methodology to determine the risk of impact on groundwater quality from routine runoff. For there to be a risk of impact to groundwater quality, a source, pathway and receptor all have to be present to create a pollutant linkage or create a linkage based on natural processes.

Hydromorphological assessment

14.4.37 A simple hydromorphological assessment has been undertaken to determine the potential impacts upon hydromorphology (see ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4)).

14.4.38 The appropriate methods of assessment to measure hydromorphological change have been determined by a competent expert on a site-specific basis. *Appendix E: Hydromorphological assessment* of *DMRB LA 113* has been followed.

14.4.39 A qualitative assessment of possible impacts on the hydromorphology of watercourses has been undertaken based on a suitably qualified geomorphologist's understanding of the potential for impacts on the flow dynamics and sediment transport processes, and the subsequent effects that this might have on the ecological potential of a waterbody.

14.4.40 The assessment has been made using professional judgement and experience of working within similar watercourses and is focussed on locations where the Project physically interacts with watercourses (for example culverts or realignments) or where sediment loading from the drainage system may occur.

14.4.41 Associated effects on ecology (including aquatic ecology) are considered in Chapter 6: Biodiversity (Application Document 3.2).

Detailed geomorphological modelling

14.4.42 Detailed geomorphological modelling of watercourses in the Temple Sowerby to Appleby and Appleby to Brough schemes and their associated floodplains was also conducted to inform ES Appendix 14.1:

WFD Compliance Assessment (Application Document 3.4) and DCO Application Documents Number 3.5: Habitats Regulations Assessment Stage 1: Likely Significant Effects (HRA LSE) and 3.6: Habitats Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (HRA SIAA). This is due to both schemes directly interacting with the River Eden SAC or functionally linked habitat associated with the receptor. The results from this modelling are presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4).

14.4.43 Associated effects on ecology (including aquatic ecology) are considered in ES Chapter 6: Biodiversity (Application Document 3.2).

Groundwater

14.4.44 An assessment has been undertaken following the procedures set out in *Appendix A Groundwater levels and flow* of *DMRB LA 113*. This follows a stepped approach.

- Step 1 – Establish regional groundwater body status
- Step 2 – Develop a conceptual model for the surrounding area
- Step 3 – Based on the conceptual model, identify all potential features which are susceptible to groundwater level and flow impacts.

14.4.45 The assessment of potential effects resulting from the Project construction and operation considers the interaction of the baseline conditions presented in ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4).

14.4.46 The Hydrogeological Impact Assessment has been prepared to evaluate the quantitative impacts of the scheme on selected groundwater receptors before and after mitigation. It was conducted in accordance with *DMRB LA 113* and guidance for dewatering abstractions *SC040020/SR1* and groundwater abstractions *SC040020/SR2*.

14.4.47 The source-pathway-receptor model has been applied to water resources and water features that are sensitive to groundwater levels and flow. In this context sources include abstraction and recharge points, which may be for dewatering or drainage purposes, that are artificially altering groundwater level and flows. The pathway is the hydraulic connection between the water resource that is being changed and features up or down gradient, so this could include the aquifer that connects the two. The receptors are groundwater bodies and groundwater-dependent features.

Groundwater-dependent terrestrial ecosystem (GWDTE) assessment

14.4.48 A simple assessment has been undertaken following the procedures set out in *Appendix B Groundwater-dependent terrestrial ecosystems* of *DMRB LA 113*, which follows a stepped, risk-based approach which depends upon establishing linkages between potential impacts from the scheme on the hydrological and hydrogeological regime and the GWDTEs. This is presented in ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment (Application Document 3.4).

14.4.49 The conceptual hydrogeological model provides an overview of the interactions between groundwater and surface water and identifies potential linkages between potential impacts from the scheme (during construction or operation) and GWDTEs. Groundwater flow paths, groundwater levels and the proximity of GWDTEs have been taken into account in the conceptual hydrogeological model, included in ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4).

Karst risk assessment

14.4.50 An assessment of potential karst risk to the Project has been undertaken and is presented in ES Appendix 14.8: Karst Risk Assessment Desk Study (Application Document 3.4).

14.4.51 The assessment provides a review of existing public databases, documents and publications of karst occurrence across the Project, and subsequently uses LIDAR ground elevation data to screen where surface karst features may be present. This data, in conjunction with the distribution of rock types, are used to assesses the potential for karst risk to the Project.

In-Combination Climate Change Impact (ICCI) assessment

14.4.52 An in-combination climate change assessment (ICCI) (Section 14.10.125) has been conducted to assess likely changes to the significance of effects when considering the combined impact of the Project in a future changed climate on road drainage and the water environment receptors in the surrounding environment. The assessment considers whether climate change could impact the likelihood and magnitude of the effects of the Project on the road drainage and the water environment receptors, or affect the susceptibility, vulnerability, value or importance of the receptors themselves. The assessment has been based on the latest UK Climate Change Projections (UKCP18) and considers a range of climatic hazards including rising temperatures, higher and lower rainfall, and the increased frequency and magnitude of extreme events such as heat waves and flooding.

Scoping

14.4.53 Table 14-7: Summary of scoping opinion and response sets out the key points from PINS Scoping Opinion relevant to this assessment. The full Scoping Opinion is provided in ES Appendix 4.2: Scoping Opinion (Application Document 3.4). Where relevant, reference to the relevant section of the assessment is provided.

Table 14-7: Summary of scoping opinion and response

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
The Planning Inspectorate	Flood risk and floodplain impacts for M6 Junction 40 to Kemplay Bank should be assessed due to proximity of 'high' pluvial flood risk.	Pluvial and fluvial flood risk has been assessed within the ES chapter for M6 Junction 40 to Kemplay Bank scheme.	Section 14.10 reports Assessment of Likely Significant Effects.

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
		Pluvial and fluvial flood risk modelling has been completed, accounting for climate change uplift values. Climate change uplift values have also been allowed for in the drainage design.	ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4) Assessment fully assesses flood risk to and from the Project.
The Planning Inspectorate	Fluvial and pluvial flood risk and floodplain impacts for A1(M) Junction 53 Scotch Corner section (construction and operation) can be scoped out of the ES chapter.	Accepted and scoped out.	Not applicable
The Planning Inspectorate	The study area should be justified in the ES based on the extent of potential impacts on receptors that are hydrologically linked to the Project.	The rationale behind the study area is explained within Section 14.6: Study area.	Section 14.6: Study area
The Planning Inspectorate	The ES should assess impacts on ponds within the study area where significant effects are likely to occur or justify their omission from the assessment.	Ponds have been incorporated into the baseline and assessment undertaken where likely significant effects may occur.	Section 14.7 Baseline conditions
The Planning Inspectorate	The ES should identify all pathways and receptors and locate them in the context of the Project and surrounding hydrological environment.	Figures include pluvial and fluvial flooding, all identified receptors, and the proposed alignment and DCO boundary accompany the ES chapter.	Section 14.7 Baseline conditions and associated figures in Application Document 3.3
The Planning Inspectorate	The Scoping Report identifies that the Highways Agency Drainage Data Management System (HADDMS) information is incomplete and expresses that effort will be made to identify existing assets that are not captured in this system in the EIA. The ES should explain how this information has been substituted/collected or otherwise acknowledged as a limitation in the assessment, and any	Existing baseline drainage information has been collected in addition to the existing HADDMS database information.	ES Appendix 14.3: Water Quality Assessment (Application Document 3.4)

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
	additional assumptions made and implications to the conclusions around likely significant effects.		
The Planning Inspectorate	For high importance surface water receptors, reference is made to the WFD classification and designation status but there is no reference to protected species therefore it is unclear whether these criteria have been considered in assigning importance.	Tributaries to the River Eden SAC that have the designating features have been considered to be functionally linked habitat and so the ability for receptors to support protected species has been taken into account in the assessment. Further details on species are presented in Chapter 6: Biodiversity (Application Document 3.2).	ES Appendix 14.10: Assessment of Value (Application Document 3.4) ES Chapter 6: Biodiversity (Application Document 3.2).
The Planning Inspectorate	Flood impacts during construction: Whilst changes to local land drainage structures and patterns are identified as a potential impact pathway, for clarity this should specifically include changes and possible increase in flood velocity and flood depths due to structures/topographical alterations such as construction compounds and earthworks (and the durations for which these will be in place).	Impacts from flooding during construction are considered in the Flood Risk Assessment and summarised in this chapter.	ES Appendix 14.3: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)
The Planning Inspectorate	The Project description of the ES should include a description of proposed flood mitigation measures and assess any likely significant effects associated with construction and operation of these features as part of the relevant aspect assessments, which may be beyond purely the Road Drainage and the Water Environment chapter.	This is reported in ES Appendix 14.3: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4) and summarised in ES Chapter 2: The Project (Application Document 3.2).	ES Appendix 14.3: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4) ES Chapter 2: The Project (Application Document 3.2)
The Planning Inspectorate	The Environment Agency's consultation response states that no viable or affordable option for	This response has been accepted. The flood alleviation scheme at	Not applicable

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
	Eamont Bridge flood alleviation has been identified. The ES should represent the current status of other developments.	Eamont Bridge has not been included in the chapter and has not been included in the assessment of cumulative effects.	

Consultation

14.4.54 The relevant stakeholders have been consulted to gather baseline data and inform the assessment, including the Environment Agency and LLFAs. An overview of the consultees and the reasons for consultation with them (specific to this chapter) are described in the following sections and Table 14-8: Summary of Consultation. This consultation is additional to the scoping opinion provided by PINS. The full record of consultation is recorded in ES Appendix 1.1: Evidence Plan (Application Document 3.4) and the Statement of Commonality and Statements of Common Ground (Application Document 4.5).

14.4.55 The Environment Agency and Natural England have been consulted on the detailed geomorphology modelling methodology and hydromorphology assessment methodology, and their comments incorporated into the approach. Additionally, they have been consulted on the key effects of the scheme and mitigation.

14.4.56 The Environment Agency will be consulted on future risk assessments for activities that may impede groundwater flow and quality, via the construction of impermeable barriers, and activities such as piling, ground improvement works and foundations, as per their request. This is secured via the EMP (Application Document 2.7).

14.4.57 The Environment Agency and LLFAs have been consulted on the assessment methodology, including climate change allowances, for the flood risk assessment.

14.4.58 Richmondshire District Council, Durham County Council, Cumbria County Council, Eden District Council, and North Yorkshire County Council were consulted to obtain baseline data including local and unlicensed abstractions.

14.4.59 Cumbria County Council has been consulted in their capacity as the LLFA with regards to the assessment of flood risk, crossing of ordinary watercourses and road drainage.

14.4.60 All host authorities have been included in a series of Technical Working Groups that have provided monthly updates on the progress of the design and assessment. Details of these meetings can be found in the recorded minutes within ES Appendix 1.1: Evidence Plan (Application Document 3.4).

Table 14-8: Summary of Consultation

Consultee/ respondent	Comment	Applicant response	Where addressed?
Cumbria County Council	Requested that pluvial flood modelling is carried out alongside fluvial flood modelling using future climate change uplift values.	Pluvial flood modelling for highways catchments has been undertaken and incorporated into the drainage design using the latest available published values at the time of publication.	Details can be found in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)
Environment Agency	Highlighted that there are a number of small watercourses that are culverted across the scheme, and enquired if there is potential to enhance these.	De-culverting and daylighting was considered as a part of BNG and WFD mitigation and enhancement.	Details can be found in the DCO Application Document 3.5: Habitats Regulations Assessment Stage 1: Likely Significant Effects (HRA LSE) and 3.6: Habitats Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (HRA SIAA)
Environment Agency	Highlighted the presence of groundwater source protection zones across the scheme, and requested they be incorporated into the assessment.	Groundwater source protection zones have been considered as potential receptors and scoped into the assessment as detailed in the Hydrogeological Impact Assessment.	ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) Section 14.7 Baseline conditions ES Appendix 14.10: Assessment of Value (Application Document 3.4)
Environment Agency and Cumbria County Council	Questioned if the team were aware of recently published climate change allowances and how they will be	The most recently published climate change uplifts have been used for flood modelling.	Details can be found in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)

Consultee/ respondent	Comment	Applicant response	Where addressed?
	incorporated into the design and the flood modelling.		
Natural England	Raised concerns regarding the scheme design at Trout Beck and that Eden Rivers Trust has revealed a proposal to reinstate a more naturalised channel for Trout Beck.	The crossing of Trout Beck has been high on the agenda throughout the design and assessment of the scheme. Detailed modelling has been carried out at the crossing point. The design of the crossing will cause minimal impact to the Eden Rivers Trust proposal and consultation has occurred throughout the design process.	Section 14.9: Essential mitigation and enhancement Additional details can be found in the DCO Application Documents 3.5: Habitats Regulations Assessment Stage 1: Likely Significant Effects (HRA LSE) and 3.6: Habitats Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (HRA SIAA)
Natural England	Raised concerns regarding the potential for gypsum caves creating and risk of subsidence under the proposed route.	The presence of gypsum has been assessed thoroughly, with collaboration between the RDWE team and Geotechnics team. A desk study of karst risk along the route was undertaken, with potential mitigation measures identified for areas where karst/ dissolution features may be encountered. Development of a voids protocol and a settlement monitoring plan is secured within the EMP (Application Document 2.7).	Details of karst risk, identified features and potential mitigation measures can be found in ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4) Mitigation is secured via the REAC table within the EMP (Application Document 2.7)

14.5 Assumptions and limitations

14.5.1 Assessment of the road drainage and the water environment aspects of the scheme has been undertaken in accordance with *DMRB LA 113*, and supplementary methods as explained in Section 14.4 Assessment methodology for potential impacts not covered in *DMRB LA 113*.

14.5.2 For the assessment of construction impacts, where construction methods and sequencing are not available, current standard

construction practices are based on the Environment Agency's Pollution Prevention Guidelines (PPGs) (withdrawn in 2015), subsequent guidance on GOV.UK, the relevant CIRIA publications and best practice measures outlined in the Guidelines for Pollution Prevention (GPPs).

14.5.3 The baseline conditions have been derived from both desk-based and field studies, and data updated based upon latest findings from direct observations and sampling. This has included information obtained from walkover surveys, flood risk surveys, hydromorphology surveys, intrusive ground investigations and groundwater monitoring.

14.5.4 It is acknowledged that uncertainty is inherent to the assessment of interaction between surface water and groundwater. However, the collected data have enhanced the understanding of current and future conditions and are reported in the ES.

14.5.5 This chapter includes the information reasonably required to assess likely significant environmental effects. The assessments represent a ‘reasonable worst-case’ and are based on conservative inputs derived from available field or desk study data and published research literature relevant to the study area.

14.5.6 The findings presented in this chapter are based upon the data available at the time of writing including data collected to early March 2022 for groundwater, springs and surface water. Any data collected following these dates would be used to refine the conceptual models to support the detailed design phase and would form part of the ongoing dialogue with the Environment Agency, Natural England and LLFAs.

14.5.7 Information on WFD datasets including Extended Water Body Summary Reports, latest water body measures/actions data and any supporting WFD Investigation Reports to provide more details regarding the identified waterbodies was requested from the Environment Agency. This was used to inform ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

14.5.8 For the assessment of construction impacts, where construction methods and sequencing were not available, current standard construction practices are assumed.

14.5.9 Further topic-specific limitations and assumptions associated with the Project are discussed in the following sections and the appendices, where relevant.

Mitigation

14.5.10 As set out in this Section, 14.5, the assessment reported in this chapter is based on a precautionary worst case scenario. As such, the mitigation identified in this chapter as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the ‘maximum’ extent of mitigation required (as identified in this chapter) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to

establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this chapter. The fundamental point is that the mitigation identified in this chapter is secured by the EMP, where required to achieve the outcome reported in this chapter.

14.5.11 All mitigation measures discussed in this chapter are secured within the EMP (Application Document 2.7) and the Project Design Principles (Application Document 5.11) and as such are secured through the DCO.
Surface water

14.5.12 All named watercourses within the 1km study area have been assessed. Unnamed watercourses have been assigned a project specific name in order to maintain consistency across design and assessments. The standard naming convention was applied to all unnamed watercourses within 250m of the Order Limits, and then expanded when needed. Watercourses referred to in this chapter are shown on Figure 14.1: Surface Water Features (Application Document 3.3) and this should be referred to in conjunction with the chapter.

14.5.13 Available hydraulic models for watercourses within the study area have been provided by the Environment Agency. The hydraulic model of the Hayber Beck and Moor Beck, located to the north of Warcop, includes several tributaries of the River Eden and has been used inform the design and this assessment.

14.5.14 No unlicenced abstraction data from surface water sources was available at the time of writing. To form a conservative assessment, it has been assumed that every property in areas where drawdown of groundwater levels is anticipated has the potential to include a groundwater-fed private water supply. Additional surveying is to be undertaken at detailed design to allow refinement of the mitigation proposed in the assessment as per Paragraph 14.5.10.

14.5.15 Any third-party information, including the readily available data sources and input from external consultations has been assumed to be accurate at the time of writing.

Groundwater

14.5.16 Full numerical modelling of the groundwater system is beyond the scope of this assessment, due to the complexities of the hydrogeological regime in the study area, which cannot be defined in a three-dimensional numerical model sufficiently enough to accurately represent the processes occurring and how they may be affected by the scheme. Therefore, analytical and two-dimensional conceptual models have been developed for key assessment areas, which are tailored for structural and geotechnical design assessments, following the standard set out *in Appendix A Groundwater levels and flow* of *DMRB LA 113*.

14.5.17 Baseline groundwater level monitoring was undertaken as part of the first phase of ground investigation in the spring and summer months (March to August) of 2021. Two follow up visits were undertaken in February 2022. Data on the seasonal variation is limited at this stage.

For conceptual models applied within the assessment, conservative groundwater levels have been assumed to address limitations in the groundwater level monitoring. The piezometric level has been assumed to be at ground level in superficial deposits, with engineering judgement of a reasonable worst-case groundwater level assumed for bedrock. Additional hydrogeological data obtained from the planned summer 2022 ground investigations and monitoring will be considered at detailed design to refine the conceptual models.

14.5.18 Information on unlicensed abstractions has been provided by Durham County Council. At the time of publishing, information was outstanding from the remaining councils within the Project study area. Some information was provided by individual landowners through Statutory Consultation feedback. In order to determine risk to small private water wells the conceptual model developed for each scheme has been used to determine the groundwater regime. On the basis of each conceptual model, those areas hydraulically down gradient of the road have been considered at risk from potential construction water quality impacts. Those areas where drawdown of groundwater levels is anticipated have been identified as areas where there is risk of groundwater lowering. It has been assumed that every property in these areas has the potential to include a groundwater-fed private water supply. As additional groundwater monitoring enables identification of areas at risk of impact, additional surveying is to be undertaken at detailed design to allow refinement of this assumption.

14.5.19 The *DMRB LA 113* Appendix C Groundwater quality and run off assessments has been undertaken and is presented in ES Appendix 14.3: Water Quality Assessment (Application Document 3.4).

14.5.1 The details of any temporary abstractions required during the construction process for temporary works (e.g. borrow pits) will be confirmed during detailed design. The impacts of these temporary abstractions will be assessed within the regulatory framework for abstractions (Environment Agency abstraction licenses) and discharges (Environment Agency environmental permits), ensuring that the works do not have an unacceptable impact on receiving receptors.

Existing road drainage and outfalls

14.5.2 Highways England's Drainage Data Management System (HADDMS) (Highways England, 2021) information has been used to inform baseline drainage information relating to existing assets. Information within HADDMS is known to be incomplete across the schemes. To complete the HEWRAT assessments for the baseline scenario, a combination of data from HADDMS and observations from site surveys were used to inform on the existing drainage network and outfall locations. This is considered to be representative of the current conditions.

14.5.3 For the HEWRAT model, flow data is required. Catchment descriptors were obtained from the Flood Estimation Handbook (FEH) Web Service and Q95 (flow in cubic metres per second which equals or exceeds 95% of the flow record) subsequently derived using the FEH Low Flows tool,

the standard method for estimating Q95 in the absence of monitoring data. The estimated values have been confirmed through direct observation via site walkover and spot flow measurement.

14.5.4 The water hardness parameter for HEWRAT was obtained from the Drinking Water Inspectorate Map for England and Wales which shows the rate of water hardness. This data was considered to be appropriate to use in the absence of chemical data for each watercourse when the HEWRAT analysis was undertaken. This assumption has been validated by baseline water quality monitoring. It is assumed that local potable water would have a similar hardness characteristic as the local surface water and the three water hardness levels used by the HEWRAT model are based on broad ranges.

Limits of deviation (LoD)

14.5.5 The assessment has been conducted using the worst case LoD outlined within Chapter 2: The Project (Application Document 3.2).

14.5.6 The vertical and lateral LoD for the scheme have been reviewed with respect to identified surface water and groundwater sensitive receptors, particularly considering potential impacts on conclusions of the hydrogeological impact assessment and potential impacts as a result of an extended footprint of the Project. The vertical and lateral LoD are not considered to significantly affect the conclusions of the assessments.

14.6 Study area

14.6.1 The study area includes surface water and groundwater features within a 1km radius of the Order Limits and is based on the 'source-pathway-receptor' pollutant linkage principle. The study area was outlined in the scoping report and numerous conversations within Technical Working Group meetings and agreed with stakeholders. The 1km study area for each scheme is shown on all road drainage and water environment figures in ES Volume 2 (Application Document 3.3).

14.6.2 Extension of the study area beyond the 1km buffer was necessary to capture potential impacts to karst features, for which the study area was 2km.

14.6.3 For surface waters, the study area includes the geographical extent of the full scope of the works for each scheme and all surface water features, including main rivers and their tributaries, ordinary watercourses, surface water abstractions and flood zones within 1km of the Order Limits, where features have hydrological connectivity to the Project.

14.6.4 For flood risk, the study area includes all watercourses crossed by the scheme, or watercourses receiving run-off from the Project via its drainage design.

14.6.5 For groundwater, the study area includes the geographical extent of the full scope of the works for each scheme of works and all groundwater features which include underlying aquifers, SPZs, springs, groundwater abstractions and GWDTEs within 1km of the Order Limits.

14.6.6 The study area across the full extent of the Project is referenced to as the 'routewide study area' and where specific schemes are being referred to it will be stated as the scheme name study area.

14.7 Baseline conditions

Baseline methodology

14.7.1 The baseline describes the existing condition of surface waters, groundwater and flood risk within the study area. The value of each water feature identified has been determined based on the attributes and indicators of quality listed in Table 3.69 of *DMRB LA 113* and is detailed in ES Appendix 14.10: Assessment of Value (Application Document 3.4).

14.7.2 The following data sources were used to compile the baseline conditions:

- Observations from site walkover surveys
- Environment Agency Catchment Data Explorer (Environment Agency, 2019a)[38]
- River Basin Management Plans
- Existing highway drainage plans
- National River Flow Archive (Centre for Ecology and Hydrology, 2019)[39]
- Natural England, Multi-Agency Geographic Information for the Countryside (MAGIC) (Department for Environment, Food and Rural Affairs, 2019)[40]
- Ordnance Survey (OS) mapping (including topography)
- British Geological Survey (BGS) mapping (British Geological Survey, 2019)[41]
- Environment Agency Pluvial flood risk mapping (Gov.uk, 2019a)[42]
- Environment Agency Fluvial flood risk mapping (Gov.uk, 2019b)[43]
- Environment Agency Historic Flood Map (Gov.uk, 2021)[44]
- Environment Agency Water Quality Archive (Environment Agency, 2019b)[45]
- Highways England's Drainage Data Management System (HADDMS) (Highways England, 2021)[46]

14.7.3 Further to the list above, the following also provide baseline information as part of the suite of appendices supporting this ES chapter (all to be found within Application Document 3.4):

[38] Environment Agency (2019a) Catchment Data Explorer
[39] Centre for Ecology and Hydrology (2019) National River Flow Archive.]
[40] Department for Environment, Food and Rural Affairs (2019). MAGIC, Interactive mapping at your fingertips
[41] British Geological Survey (2019) Geology of Britain viewer.
[42] GOV.uk (2019a) Flood map for planning.
[43] GOV.uk (2019b) Flood map for planning.]
[44] GOV.uk (2021) Historic Flood Map data download.]
[45] Environment Agency (2019b) Water Quality Archive.]
[46] Highways England (2021) Highways England's Drainage Data Management System.]

- ES Appendix 14.1: Water Framework Directive Compliance Assessment
- ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy
- ES Appendix 14.4: Hydromorphology Assessment
- ES Appendix 14.6: Hydrogeological Impact Assessment
- ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment
- ES Appendix 14.8: Desk Study Karst Risk Assessment
- ES Appendix 14.9: Detailed Geomorphological Modelling.

Water feature surveys

14.7.4 Surveys of water features within the study area of each scheme were undertaken between 19 October 2020 and 22 October 2020, 14 June 2021 to 18 June 2021, and 4 February 2022 and 5 February 2022. The visits focused on supplementing the knowledge gained from desk-based sources for surface water, groundwater and flood risk receptors to gain a good overall understanding of the hydrological and hydrogeological regime within the Project's study area.

14.7.5 This included surveys to collect data from springs and licensed abstraction points. In-situ assessments of flow rate, electrical conductivity, pH and temperature were undertaken, where feasible. Additionally, observations of the design of wells, their pump-rate, usage, abstraction volume and groundwater level were recorded where possible.

14.7.6 The weather conditions for the visits varied and different conditions in the water environment were evident. Summer visits showed springs generally producing low volumes of water and low flows within watercourses, and spring, autumn and winter visits showed springs producing higher volumes of water and watercourses having higher levels and flows.

Hydromorphology surveys

14.7.7 Hydromorphological walkovers were carried out at each proposed crossing between 25 October 2021 and 5 November 2021. The purpose of the site visit was to understand site conditions in the area of interest, which is essential to understanding sediment and flow dynamics and to determine any potential impacts.

Geomorphology surveys

14.7.8 Geomorphological surveys were undertaken between 5 May 2021 and 7 May 2021 to gain a comprehensive understanding of morphological processing occurring within Temple Sowerby to Appleby and Appleby to Brough schemes. These two schemes were scoped into detailed geomorphological assessment due to their connections to the River Eden SAC.

14.7.9 A geomorphological survey of Trout Beck within the study area was undertaken by suitability qualified geomorphologists for the Temple

Sowerby to Appleby scheme. At Appleby to Brough, a geomorphological survey of the watercourses in the vicinity of Warcop was undertaken, focusing on Hayber Beck, Moor Beck, Moor Beck (Offtake), Eastfield Sike, and Crooks Beck.

14.7.10 Morphological features of the watercourses, the riparian strip and the associated floodplain were recorded, to provide a detailed understanding of the functioning of the river system and how this influences the geomorphology of the river, banks and floodplain.

Hydraulic modelling

14.7.11 Hydraulic modelling was undertaken across the Project to inform the FRA (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application 3.4). Floodplain cross sections and in channel surveys were completed between November 2020 and June 2021 to establish the baseline conditions to be modelled.

Existing drainage feature surveys

14.7.12 Additionally, a series of surveys across the routewide study area in September 2021 were undertaken to identify and inform an understanding of the existing drainage features and network and to meet local landowners to discuss existing drainage and flooding issues. This has been used to supplement the HADDMS data available.

Ground investigations

14.7.13 Details on the ground investigation can be found in Chapter 9: Geology and soils (Application Document 3.2). The investigation was tailored to provide geotechnical information to address the principal geotechnical risks identified at previous stages and provide sufficient detail to inform general Project-wide ground conditions in terms of geological profiles, groundwater regime, depth to bedrock, potential contaminants, and suitability of excavated material for re-use.

14.7.14 The purpose of the investigation was to ascertain:

- The geological sequence
- Groundwater levels across the development area
- Permeability of the underlying soil horizons and bedrock strata at the proposed location of attenuation ponds
- Undertake in situ geotechnical testing
- Obtain soil and rock samples to permit geotechnical and geo-environmental laboratory testing.

Routewide

Designated sites

14.7.15 The following statutory designated sites have been identified within the routewide study area and can be found on Figure 6.1: Statutory and Non-Statutory Designated Sites (Application Document 3.3):

- River Eden SAC (Natural England, 2019a)[47]
- The North Pennine Moors SAC (Joint Nature Conservation Committee, 2021)[48]
- The North Pennine Moors SPA (Natural England, 1997)[49]
- River Eden and Tributaries SSSI (Natural England, 1997b)[50]
- Temple Sowerby Moss SSSI (Natural England, 1985)[51]
- Bowes Moor SSSI (Natural England)[52]
- Kilmond Scar SSSI (Natural England)[53]

14.7.16 Further non-designated sites that have been identified within the GWDTE assessment are presented on ES Figure 14.12: Potential Ground Water Dependant Terrestrial Ecosystems (GWDTE) (Application Document 3.3) and are detailed further in ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment (Application Document 3.4).

14.7.17 Proximity to designated and non-designated sites is provided and further details of the designated features relating to respective designated sites are provided within ES Appendix 6.2: Designated Sites (Application Document 3.4).

Surface water

14.7.18 The Project crosses between three river basin management catchments, the Eden and Esk to the west of the Pennines and the Tees and Swale Ure Nidd and Ouse Upper to the east, as displayed on ES Figure 14.3: WFD Surface Water Bodies (Application Document 3.3).

14.7.19 In addition to the watercourses described in the following sections, a number of smaller field drains and ditches are present across the study areas, which drain into the identified watercourses. All watercourses are displayed on Figure 14.1: Surface Water Features (Application Document 3.3).

Surface water abstractions

14.7.20 Environment Agency data on surface water abstractions was used to identify any features of this nature within the routewide study area. Details on the abstractions presented in this dataset are presented in the relevant scheme baselines. It is noted that there may be potential for further unlicensed abstractions that are not recorded in this dataset. Additional surveying is to be undertaken at detailed design to allow refinement of the mitigation proposed in the assessment, as detailed in Paragraph 14.8.76, due to conservative assessments as explained in Paragraph 14.5.10.

[47] Natural England (2019) River Eden Special Area of Conservation (SAC) Site Code: UK0012643
[48] Joint Nature Conservation Committee (2021) North Pennine Moors.]
[49] Natural England (2019) North Pennine Moors Special Protection Area (SPA) Site code: UK9006272
[50] Natural England (1997) River Eden and Tributaries SSSI.]
[51] Natural England (1985). Temple Sowerby Moss SSSI.]
[52] Natural England (undated) Designated Sites: Bowes Moor.]
[53] Natural England (undated) Designated Sites: Kilmond Scar.]

Ponds

14.7.21 19 ponds were identified across the routewide study area, these range from large ecologically valuable ponds to small field ponds and a manmade water holding pond. The majority of the ponds are not hydrologically connected to their neighbouring watercourses. Two of the ponds within the Appleby to Brough study area are connected to watercourses. None of the recorded ponds are within the Order Limits. Further details on their ecological value are provided in ES Chapter 6: Biodiversity (Application Document 3.2) and they are presented on ES Figure 6.3: Phase 1 Habitat and Terrestrial Invertebrate Survey (Application Document 3.3).

14.7.22 One pond within the Temple Sowerby to Appleby study area is used for an industrial abstraction source, details are presented within the Temple Sowerby to Appleby baseline conditions section.

Drinking Water Protected Areas (DWPA)

14.7.23 DWPA are designated under the WFD and are where raw water is abstracted from rivers and reservoirs, the designation serves to target action to address pollution so that extra treatment of raw water can be avoided. There are two DWPA across the study area, in the west the Lowther (Lower) catchment and in the east, the Tees from River Greta to River Skerne catchment. Further details and assessment are detailed in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Groundwater

14.7.24 The hydrogeology in the routewide study area comprises of superficial deposits that overlie bedrock. Full details of geological stratigraphy in the study area are presented in ES Chapter 9 Geology and Soils (Application Document 3.2).

14.7.25 Regional aspects of the hydrogeology that underlie the schemes, including the aquifer units and WFD groundwater bodies, are described here as routewide. Those site-specific features, such as groundwater surface water interactions (surface water baseflow contribution, springs, sinks and GWDTE) as well as licensed abstractions, are described below for each individual scheme. For small private abstractions (less than $20m^3/d$), it is assumed routewide that each property may have an existing supply. Those properties potentially at risk from construction (hydraulically downgradient of the schemes or 200m upgradient) have been identified and risk assessed on a scheme-by-scheme basis. Groundwater features are displayed on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

Superficial aquifers

14.7.26 Till is designated as a Secondary undifferentiated aquifer; defined as an aquifer where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type and having only a minor value. The stratigraphy of the Till superficial deposits may be complex, with interdigitations of sand, gravel, silt and

clay which may each develop their own piezometric level, resulting in perched water tables.

14.7.27 Alluvium and River Terrace deposits are present route-wide, associated with main surface water features. These deposits both comprise a mixture of sand, silt and clay. Glaciofluvial deposits, comprising sand and gravel, are present in discrete areas along the route, but primarily in the west. Alluvium, River Terrace Deposits and Glaciofluvial deposits are all designated as Secondary A aquifers; defined as aquifers comprising permeable layers that can support local water supplies, and may form important source of base flow to rivers.

14.7.28 Groundwater flow through the superficial deposit aquifers is dominated by intergranular flow. The variable nature of the material may allow for perching of groundwater within coarse grained zones above the local groundwater table. The superficial deposits are unconfined. However, clays may cause some local confinement of water bearing, coarse grained lenses.

14.7.29 Locally the superficial deposits may confine the underlying bedrock aquifer and reduce the quantity of recharge that may occur.

14.7.30 Aquifers are displayed on ES Figure 14.7: Aquifer Designations (Application Document 3.3).

Bedrock aquifers

14.7.31 The bedrock geology comprises of Carboniferous age sandstones, siltstones, mudstones, limestones and some coals west of Penrith and from Brough to the A1 at Scotch Corner. The main western section from Penrith to Brough comprises of Permian aged sandstones and shales.

14.7.32 The Carboniferous strata comprises of the Stainmore Formation (mudstone, siltstone and sandstone), the Great Limestone Member (limestone member of the Alston Formation), the Alston Formation (limestone, sandstone, siltstone and mudstone) and Four Fathom Limestone Member (limestone member of the Alston Formation). These carboniferous strata are designated by the Environment Agency as being Secondary A aquifers. Locally, the limestone members include karst landforms and can include dissolution enhanced groundwater pathways, including fracture flow, conduits and caves.

14.7.33 Groundwater flow through the limestones is dominated by secondary (fracture) porosity pathways and tertiary (karstic) porosity features, so the aquifer may locally have a high permeability but overall have low storage capacity. Fracture flow through rock defects like joints and bedding planes is expected to be the main way groundwater will flow within sandstone units. Compared to the limestone, sandstone is likely to have a lower hydraulic conductivity, but greater storage capacity.

14.7.34 Limestones which are thicker and more fractured (Great Limestone Member) are expected to have higher hydraulic conductivity in comparison to thinner and less fractured units (Four Fathom Limestone Member). The density and size of fractures often decreases rapidly the

deeper into the aquifer, these effects can be observed at depths of 50m to 80m and deeper.

14.7.35 Borehole yields are highly variable, within Carboniferous Limestones in the Northern Pennines a general range from 240m^3/d to 1,920m^3/d has been observed. There are also cases of dry boreholes with no yield. It is expected the hydraulic conductivity of the aquifer in the study area is also highly variable.

14.7.36 The Permian strata comprises of the Penrith Sandstone Formation and the Eden Shales Formation. The Penrith Sandstone Formation is designated as a Principal aquifer, whilst the Eden Shale Formation is designated as Secondary B aquifer. Parts of the Eden Shale Formation have gypsum and anhydrite beds, which are designated as unproductive although they can be susceptible to dissolution.

14.7.37 The Penrith Sandstone Formation is highly permeable with high intergranular flow occurring except in areas where significant silica cementation has occurred. Silicified layers occur within the Penrith Sandstone Formation throughout the study area. These areas of silification planes are in the form of join infillings or bedding-parallel horizons; these may act as barriers to flow. The Penrith Sandstone aquifer is regionally significant and is widely used for to support abstraction for industry, public supply and small farms. Large quantities of groundwater for public supply are obtained from the aquifer.

14.7.38 The Penrith Sandstone Formation exhibits a dual permeability comprising of intergranular matrix flow as well as fracture flow. Allen et al 1997 presents hydraulic conductivity of the Penrith Sandstone in the range from 3x10^{-4}m/s to 4x10^{-10}m/s, based on a compilation of laboratory testing of intergranular permeability and in situ pumping and packer tests. Allen refers to the importance of both grain size and cementation in relation to the variation in intergranular permeability. Established large diameter boreholes within the Penrith Sandstone in the Vale of Eden typically yield up to 3,000m^3/d.

14.7.39 Aquifers are displayed on ES Figure 14.7: Aquifer Designations (Application Document 3.3).

Groundwater WFD catchments

14.7.40 The superficial deposit aquifers are not specifically designated as WFD groundwater bodies. However, it is anticipated they are hydraulically connected to the relevant underlying designated bedrock aquifer WFD groundwater bodies, and as such they are inherently included with the underlying bedrock groundwater bodies.

14.7.41 The routewide study area is located within the Solway Tweed River Basin District, the Northumbria River Basin District and the Humber River Basin District, as displayed on ES Figure 14.4: WFD Groundwater Bodies (Application Document 3.3).

14.7.42 The Solway Tweed River Basin District includes two WFD groundwater bodies within the study area: the Eden and Esk Lower Palaeozoic and Carboniferous Aquifer and the Eden Valley and Carlisle Permo-Triassic

sandstone Aquifers. The boundary between the WFD groundwater bodies runs in a north-west to south-east direction between the M6 and the A6, generally following the geological divide between the Permo-Triassic bedrock to the east and the Carboniferous bedrock to the west. These Groundwater bodies have 'Good' quantitative status but 'Poor' current chemical status. The 'current overall status (2019)' of these groundwater bodies is 'Poor'.

14.7.43 The Northumbria River Basin District includes one WFD groundwater body: the Tees Carb Limestone and Millstone Grit. The current overall status (2019) for the Tees Carb Limestone and Millstone Grit is 'poor', due to achieving 'good' Quantitative but 'poor' Chemical WFD status.

14.7.44 The Humber River Basin District includes one WFD groundwater body: the SUNO Millstone Grit and Carboniferous Limestone. The current overall status (2019) for the SUNO Millstone Grit and Carboniferous Limestone is 'poor', due to achieving 'good' Quantitative but 'poor' Chemical WFD status.

Groundwater levels

14.7.45 Groundwater monitoring was undertaken as part of the first phase of ground investigation, with monitoring data available for selected dates between March 2021 and March 2022. Results of the groundwater monitoring are summarised in ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) and locations are shown on ES Figure 14.10: Groundwater Monitoring Locations (Application Document 3.3).

14.7.46 Groundwater flow will generally drain towards the main rivers, which will receive groundwater contribution as baseflow. Groundwater levels will fluctuate seasonally, generally being highest between January and March and lowest between June and September. Conservative assumptions have been made based on existing data, and further groundwater monitoring at detailed design will confirm the seasonal variation in groundwater levels along the route.

14.7.47 Groundwater contained in alluvium and river terrace deposits are assumed to be hydraulically connected with associated watercourses and the underlying bedrock geology. This is particularly the case with the Penrith Sandstone Formation, which is assumed to have complete continuity between bedrock, superficial deposits and the main rivers (e.g. River Eden).

Groundwater abstractions

14.7.48 The majority of the scheme study areas are not located within designated groundwater source protection zones (SPZ). The western schemes (M6 J40 to Kemplay Bank and Penrith to Temple Sowerby) are located in an SPZ (Zone III) associated with public water supply boreholes to the north of Penrith (outside the study area). Two SPZs (Zone I) were identified in the Stephen Bank to Carkin Moor study area associated with two licensed abstractions.

14.7.49 Licensed abstractions within the study area of the route have been provided by the Environment Agency and considered within ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) and are displayed on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

14.7.50 Durham County Council provided records for private abstractions in their region within the designated study area. All DCC abstractions were considered to not be hydraulically connected with the scheme, due to their distance from the scheme or their locations relative to the scheme (opposite sides of main rivers).

14.7.51 During statutory consultation, an additional private water supply was identified in the Kirby Thore area, which has been considered within ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4).

14.7.52 There are likely to be a number of small private domestic and agricultural groundwater fed abstractions within the routewide study area, not identified in the works to date. These wells are assumed to abstract less than 20m^3/d and as such be under the daily abstraction rate by which a licence is required. It is assumed that each property within the study area has the potential to include a small private groundwater supply.

Catchment abstraction management strategy (CAMS)

14.7.53 The routewide study area crosses over the three following CAMS areas as designated by the Environment Agency, these are displayed on Figure 14.5: Catchment Abstraction Management Strategy Areas (Application Document 3.3):

- Eden and Esk
- Tees
- Swale, Ure, Nidd & Upper Ouse

14.7.54 The Eden and Esk CAMS area covers the River Eden and its tributaries which rises in the eastern and northern Lake District fells and north-western Pennines and flow north-west to the Solway First.

14.7.55 In the location of the A66 within the Eden and Esk CAMS area, the groundwater unit balance shows groundwater available for licensing.

14.7.56 The Tees CAMS area covers an area of approximately 1092km², including the catchments of the River Tees and its associated tributaries.

14.7.57 In the location of the A66 within the Tees CAMS area, the groundwater unit balance shows groundwater available for licensing.

14.7.58 The Swale, Ure, Nidd and Upper Ouse CAMS encompasses an area of circa 3509 km² of North Yorkshire, defined by the natural boundaries and catchment watersheds of the four noted rivers. The groundwater resource availability in this CAMS area is not designated.

Hydrogeological conceptual model

14.7.59 Local hydrogeological conditions along the Project are shown on a series of conceptual models (refer to ES Figure 14.12 Groundwater Conceptual Models, Application Document 3.3) and detailed descriptions are presented in ES Appendix 14.6 Hydrogeological Impact Assessment (Application Document 3.4)).

Flood risk

Fluvial flooding

14.7.60 Sections within the routewide study area are indicated on Environment Agency mapping to be at risk of fluvial flooding (from rivers or the sea), presented on ES Figure 14.2: Existing Flood Risk (Application Document 3.3). Due to the difference in elevation between the study area and the coast, flood risk in the study area is not considered to be associated with coastal sources.

14.7.61 Baseline fluvial hydraulic modelling has been completed for all schemes, apart from the schemes that were scoped out (M6 Junction 40 to Kemplay Bank, due to no changes to existing crossings, and A1(M) Junction 53 Scotch Corner) due to no significant watercourses present within the study area. This was agreed by the Environment Agency and PINS the during consultation on the Scoping Report (ES Appendix 4.1 (Application Document 3.4)).

Pluvial flooding

14.7.62 Sections within the routewide study area are indicated on Environment Agency mapping to be at risk of pluvial flooding (from rainfall and surface water sources), presented on ES Figure 14.2: Existing Flood Risk (Application Document 3.3). The mapping does not distinguish between areas at risk of flooding purely from surface water runoff (specifically during heavy rainfall events) and areas at risk from small watercourses that are too small to be included on fluvial flood risk mapping.

Groundwater flooding

14.7.63 The BGS Groundwater Flooding map (see ES Figure 14.8: Groundwater Flooding Susceptibility, Application Document 3.3) indicates there is the potential for clearwater flooding and flooding from superficial deposits within the routewide study area. Clearwater groundwater flooding refers to groundwater levels rising in an unconfined bedrock aquifer in response to recharge higher in the catchment.

14.7.64 Ongoing groundwater monitoring would be reviewed to ascertain the risk of groundwater flooding in the scheme areas and suitable control measures identified and included during the detailed design stage.

Drainage

Existing road drainage

14.7.65 As detailed in paragraph 14.7.12, efforts were made to determine the location and condition of existing road drainage assets within the

routewide study area. This has been used to supplement the HADDMS data available, which is known to be incomplete.

Existing land drainage

14.7.66 Land drainage plays an important role in preventing localised flooding and feeding local surface water features. Any cuttings, embankments or structures may intercept localised land drainage which will need to be appropriately maintained, reinstated or compensated. Drainage surveys, as detailed in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4), have identified existing land drainage which has been used as the assessment baseline. The EMP (Application Document 2.7) requires further surveys to be undertaken to establish which features need to reinstated or compensated and understand the extent that mitigation measures will be required. Mitigation measures identified as being required will be implemented and this will be established pre-construction and as part of detailed design.

Accidental spillage

14.7.67 Incidents occurring on roads can cause spills of fuels and other potentially polluting substances. These spills can enter the road drainage system and consequently enter surface waters that receive highways drainage. There is also a risk of spills entering groundwater from natural infiltration.

14.7.68 Personal Injury Collision data on the A66 for each scheme has been collected for a seven-year period from 2012 to 2018 inclusive. The data indicates that the Fatally Weighted Injury per billion vehicle miles annual average is substantially higher than the national average for A-roads. As a result of collisions, there is potential for fuel spills and other spills of potentially polluting substances. The risk of accidental spillages has been assessed and is presented in ES Appendix 14.5: Spillage Risk Assessment (Application Document 3.4).

M6 Junction 40 to Kemplay Bank

Designated sites

14.7.69 The River Eamont and River Lowther, both tributaries of the River Eden, are located within the study area, south of the existing A66. They are designated as part of the River Eden SAC and River Eden and Tributaries SSSI, as presented on ES Figure 14.1: Surface Water Features (Application Document 3.3).

14.7.70 River Habitat Survey (RHS) and River Corridor Survey (RCS) have confirmed that Thacka Beck supports habitats and species included in the River Eden SAC designation. Further details of the designated features relating to the River Eden SAC are provided within ES Chapter 6: Biodiversity (Application Document 3.2).

Surface water

14.7.71 A number of watercourses flow through the study area. All eventually flow into the River Eamont to the south-west of the existing A66.

14.7.72 Most of the watercourses in the study area drain from agricultural lands north and west of Penrith and flow through urban landscapes with modification such as culverts in place. Exceptions are the River Eamont, that drains from Ullswater situated south-west of the study area, and the River Lowther which drains from the south-west of Shap, outside of the study area.

14.7.73 Table 14-9: Surface water receptors within M6 Junction 40 to Kemplay Bank study area gives a brief description and the classification of the surface water receptors within the study area (from west to east) which are also displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3). The standard naming convention is used for unnamed watercourses, as outlined in Paragraph 14.5.10.

Table 14-9: Surface water receptors within M6 Junction 40 to Kemplay Bank study area

Receptor	Description	Watercourse classification
Carlsike Beck	Flows south into the River Eamont, crossed by the existing A66/A592 roundabout, in the west of the study area.	Ordinary watercourse
Myers Beck	Flows east into Dog Beck, crossed by the existing M6, and then culverted under the railway and housing within Penrith, in the north-west of the study area.	Ordinary watercourse
Dog Beck	Flows east into Thacka Beck, culverted through Penrith beneath Victoria Road, in the north of the study area.	Main River
Thacka Beck	Flows south into the River Eamont, through Penrith and is crossed by the existing A66 and then culverted beneath Carlton Hall, in the centre of the study area	Main River
Unnamed Tributary of River Eamont 3.2	Flows east into the River Eamont, straightened channel through Frenchfield sports centre, in the east of the study area	Main River
River Eamont	Flows east, crossed by the existing M6, and flows parallel, to the south of the existing A66. Joins the River Lowther to the east of the study area, then joins the River Eden approximately 7km further downstream.	Main River
River Lowther	Flows east, located parallel, to the south of the River Eamont. Joins the River Eamont at Brougham Castle 250m upstream of the existing A66 crossing.	Main River

14.7.74 In addition to the watercourses described in Table 14-9: Surface water receptors within M6 Junction 40 to Kemplay Bank study area, a number

of smaller field drains are present across the study area, which drain into these watercourses.

Surface water WFD catchments

14.7.75 River Eamont Upper (GB102076071020) WFD surface waterbody catchment underlies the majority of the study area. This waterbody is associated with a ‘Good’ Ecological and ‘Fail’ Chemical WFD status in 2019. The Environment Agency do not give a Reason for Not Achieving Good (RNAG) for this catchment.

14.7.76 The Lowther (Lower) (GB102076071010) WFD catchment, to the south of the study area is associated with a ‘Moderate’ ecological and ‘Fail’ chemical WFD status in 2019. The river is classified as ‘Heavily Modified’ which impacts on its ability to achieve ‘Good’ status, with physical modification for flood protection recorded as reason for not achieving 'Good’ status.

14.7.77 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3) and detailed further in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Surface water quality

14.7.78 There are two relevant Environment Agency water quality sampling points shown on the Environment Agency's online Water Quality Archive as within the study area, outlined in Table 14-10: Environment Agency water quality monitoring points within the M6 Junction 40 to Kemplay Bank study area, presented on ES Figure 14.1: Surface Water Features (Application Document 3.3). The sampling points give an existing water quality baseline for the study area and a summary of this is provided Table 14-11: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the M6 Junction 40 to Kemplay Bank study area.

Table 14-10: Environment Agency water quality monitoring points within the M6 Junction 40 to Kemplay Bank study area

Sampling Point ID	Site Name	Coordinates
NW-88006261	River Lower at Lowther Bridge	NY 52460 28196
NW-88006246	River Eamont at Eamont Bridge	NY 52228 28749

Table 14-11: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the M6 Junction 40 to Kemplay Bank study area

Site Name	pH			Temperature (°C)			Dissolved Oxygen (mg/l)			Electrical Conductivity (µs/cm)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
River Lowther at Lowther Bridge	8.2	8.9	7.3	10.1	17.0	2.2	12.0	15.0	9.6	188.4	288.0	91.0
River Eamont at Eamont Bridge	8.1	8.8	7.6	9.6	18.8	3.6	11.8	14.3	9.3	114.9	185.0	79.0

Hydromorphology

14.7.79 Hydromorphology surveys were completed for selected watercourses to understand the existing catchment flow and sediment dynamics and are summarised in Table 14-12: Hydromorphological survey results for M6 Junction 40 to Kemplay Bank. Full details are within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). Water Crossing Points (WCP) are displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3).

Table 14-12: Hydromorphological survey results for M6 Junction 40 to Kemplay Bank

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP1 Thacka Beck	Upstream: energetic flow creating rapids to riffles Downstream: Shallow gradient reduced flow, creating runs	Upstream: cobbles to gravels Downstream: gravels to sands Classified as a sediment transfer reach	Upstream: thin buffer strip on left bank. Right bank bare, susceptible to erosion Downstream: lack of tree cover and fencing installed to stop poaching	Upstream: historically straightened channel is disconnected from the floodplain Downstream: incised trapezoidal channel geometry disconnects the channel from the floodplain

Groundwater

14.7.80 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the routewide baseline section. Those site-specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the following sections.

Groundwater-surface water interactions

14.7.81 No springs and seepages are mapped within the study area. Springs and seepages are likely to be present particularly in the banks and below the river level of the River Eamont and River Lowther.

14.7.82 The River Eamont and River Lowther will receive groundwater baseflow from the bedrock formations and superficial deposits.

14.7.83 There are areas of habitat with the potential to support low and moderate dependency GWDTEs within the study area.

Groundwater abstractions

14.7.84 The eastern end of the study area lies within an SPZ Zone III associated with public water abstractions to the north and the north-west of the scheme (outside the study area).

14.7.85 There are two licensed wells in the scheme study area, presented on ES Figure 14.6 Hydrogeological Study Areas and Features (Application Document 3.3), these are:

- Abstraction well 2776004056/R01 at Penrith Industrial Estate - Permo-Triassic Sandstone
- Abstraction well 277600644 at Penrith and District Farmers Auction Mart - Permo-Triassic Sandstone

14.7.86 There are potentially a number of smaller private domestic, commercial and agricultural unlicensed supplies within the scheme study area, which are assumed to abstract less than 20 m^3/d. It is assumed that each property within the study area has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.7.87 The majority of the study area is not at risk of fluvial flooding during events up to and including the 0.1% annual chance, and consequently are mapped as Flood Zone 1[54]. Environment Agency mapping shows sections of the study area are within Fluvial Flood Zone 2[55] and Flood Zone 3[56], which are associated with:

- Dog Beck and Myers Beck to the north-west of the study area, within the Penrith Industrial Estate
- Thacka Beck to the north-east of the study area.
- Unnamed Tributary of River Eamont 3.2 within the Frenchfield sports fields in the east of the study area
- The River Eamont in the south of the study area from Red Hills to Eamont Bridge.

14.7.88 Baseline fluvial modelling undertaken for the scheme has highlighted increased flood risk at Eamont Bridge, and a slightly reduced extent associated with Dog Beck when compared against the Environment Agency flood mapping.

14.7.89 Full details of the modelling results are published in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4) and presented on ES Figure 14.2: Existing Flood Risk (Application Document 3.3).

Pluvial flooding

14.7.90 There are areas of 'High'[57] pluvial water flood risk associated with Dog Beck, Myers Beck and Thacka Beck within Penrith, in the north-east of the study area located within industrial estates, along residential roads,

[54] Areas deemed to be in flood zone 1 have been shown to less than 0.1% chance of flooding from rivers in any year (less than 1 in 1000 chance)
[55] Areas deemed to be in flood zone 2 have been shown to have between 0.1% – 1% chance of flooding from rivers in any year (between 1 in 1000 and 1 in 100 chance)
[56] Areas within flood zone 3 have been shown to be at a 1% (1 in 100 chance) or greater probability of flooding from rivers
[57] High risk equates to a chance of flooding of greater than 3.3% each year.

the A6 road through the town centre, the existing A66, adjacent parkland to Thacka Beck and a small area of the A686.

14.7.91 In the north of the study area, adjacent to the existing A66, Wetheriggs Country Park has areas of 'High' pluvial water flood risk and this also impacts on Clifford Road. Parkland in the east of the study area. Frenchfield has areas of 'High' flood risk that continue north towards the existing A686 and Charleton residential areas.

14.7.92 Small sections of 'High' pluvial flood risk are displayed adjacent to the River Eamont at Skirsgill and Eamont Park. This is likely to be a result of localised depressions in the topography and may be influenced by the watercourse. Areas of 'High' pluvial flood risk within the Brougham area in the south of the study area impact agricultural and recreational land uses.

Historic flooding

14.7.93 Environment Agency data show historic flooding events associated with Thacka Beck within Penrith in 2002 and 2005. Historic flooding associated with the River Eamont has also occurred south of the existing A66 around the area of Skirsgill in 1995, 1997, 2005 and 2015. A further area of flooding occurred in 2005 associated with the River Eamont and River Lowther in the east of the study area, around Brougham.

Consented discharges

14.7.94 Seven active consented discharges have been identified from Environment Agency data within the study area. As shown in Table 14-13: Consented discharge licences within the M6 Junction 40 to Kemplay Bank study area, these include discharges associated with storm tanks, combined sewage overflows (CSO) and a pumping station. Presented on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

Table 14-13: Consented discharge licences within the M6 Junction 40 to Kemplay Bank study area

Site name	Receiving watercourse	Description
Brougham Pumping Station	Tributary to River Eamont	Pumping Station on Sewerage Network (water company)
Carleton Hall Templebank CSO	Culvert of River Eamont	Storm Tank/CSO on Sewerage Network (water company)
Castle Hill Drive	Dog Beck	Storm Tank/CSO on Sewerage Network (water company)
Moor House	Yanwath Beck	WwTW (sewage discharges – not water company)
Penrith Grammar School	Dog Beck	Storm Tank/CSO on Sewerage Network (water company)
Penrith Outfall CSO	River Eamont	Storm Tank/CSO on Sewerage Network (water company)

Site name	Receiving watercourse	Description
Yanwath School	Tributary to River Eamont	Education (sewage & trade combined)

Penrith to Temple Sowerby

Designated sites

14.7.95 The River Eamont and the Light Water, both tributaries to the River Eden, are located within the study area, with the existing A66 crossing the River Eamont at Brougham Castle and the Light Water 900m west of this. The River Eamont is designated as part of the River Eden SAC and River Eden and Tributaries SSSI.

14.7.96 River Habitat Survey (RHS) and River Corridor Survey (RCS) have confirmed that the Light Water supports habitats and species included in the River Eden SAC designation. Further details of the designated features relating to the River Eden SAC are provided within ES Chapter 6: Biodiversity (Application Document 3.2).

Surface water

14.7.97 Watercourses within the study area drain into the River Eden via a number of tributaries. Minor watercourses which are tributaries of these named rivers and the River Eden have also been included in the assessment and grouped where required.

14.7.98 All watercourses within the study area flow through agricultural, rural landscapes. The River Eamont drains from Ullswater situated south-west of the study area, and the River Lowther which drains from the south-west of Shap, outside of the study area.

14.7.99 Table 14-14: Surface water receptors within the Penrith to Temple Sowerby study area gives a brief description and the classification of the surface water receptors within the study area (from west to east) which are also displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3). The standard naming convention is used for unnamed watercourses, as outlined in Paragraph 14.5.10.

Table 14-14: Surface water receptors within the Penrith to Temple Sowerby study area

Receptor	Description	Watercourse classification
River Eamont	Flows east, joined by the River Lowther and crossed by the existing M6 in the west of the study area, flows north-east and joins the River Eden 2.3km directly north of the existing A66.	Main River
River Lowther	Flows east, located parallel, to the south of the River Eamont. Joins the River Eamont at Brougham Castle 250m upstream of the existing A66 crossing, in the west of the study area.	Main River
Unnamed Tributary of	Flows east into the River Eamont, straightened channel through Frenchfield sports centre, in the west of the study area	Main River

Receptor	Description	Watercourse classification
River Eamont 3.2		
Unnamed Tributary of Light Water 3.1	Flows north into the Light Water in the west of the study area, crossed by the existing A66.	Ordinary watercourse
Light Water	Flows north into the Eamont, crossed by the existing A66, and joins the River Eamont 780m downstream of the crossing point, in the western extent of the study area.	Ordinary watercourse
Unnamed Tributary of River Eamont 3.3	Flows north into the River Eamont, in close proximity to Whinfell Park, crossed by the existing A66 and joins the River Eamont 350m downstream.	Ordinary watercourse
Unnamed Tributary of River Eamont 3.4	Small roadside drain that flows west into Unnamed Tributary of River Eamont 3.3, in the central west of the study area.	Ordinary watercourse
Unnamed Tributary of River Eamont 3.5	Flows north into the River Eamont, crossed by the existing A66 in line with the meander in the River Eamont in the centre of the study area.	Ordinary watercourse
Swine Gill	Flows north into the River Eden, crossed by the existing A66, to the west of Whinfell. Joins the River Eden 1.67km downstream of the crossing point.	Ordinary watercourse
Unnamed tributary of River Eden 4.5	Flows north into the River Eden, at existing A66 and B6412 junction in the east of the study area.	Ordinary watercourse
River Eden	Flows north-west in the far east of the study area.	Main River
Unnamed Tributary of River Eamont 3.7	Small watercourse that flows west, redirected via field drains before discharging into the River Eamont. Situated north of the existing A66.	Ordinary watercourse

14.7.100 In addition to the watercourses described in Table 14-14: Surface water receptors within the Penrith to Temple Sowerby study area, a number of smaller field drains are present across the study area, which drain into these watercourses.

Surface water WFD catchments

14.7.101 Eamont (Lower) (GB102076070990) WFD surface waterbody catchment underlies the majority of the study area. This waterbody is associated with ‘Good’ Ecological and ‘Fail’ Chemical status’ in 2019. The Environment Agency do not give a RNAG for this catchment.

14.7.102 The Lowther (Lower) (GB102076071010) WFD catchment, situated in the south-west of the study area, is associated with ‘Moderate’ Ecological and ‘Fail’ Chemical status’ in 2019. The watercourse is classified as ‘Heavily Modified’ which impacts on its ability to achieve

'Good' status. The Environment Agency do not give a RNAG for this catchment.

14.7.103 Eden Lyvennet to Eamont (GB102076070980) WFD catchment, in the east of the study area, is associated with 'Moderate' Ecological and 'Fail' Chemical status in 2019. Sediment from unknown sources recorded as reason for not achieving 'Good' status.

14.7.104 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3) and further detailed within ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Surface water quality

There are two relevant Environment Agency Water Quality sampling point**s** shown on the EA's online Water Quality Archive as within the study area, outlined in Table 14-15: Environment Agency water quality monitoring points within the Penrith to Temple Sowerby study area, presented on ES Figure 14.1: Surface Water Features (Application Document 3.3). The sampling points give an existing water quality baseline for the study area, and a summary is provided in Table 14-16: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Penrith to Temple Sowerby study area.

Table 14-15: Environment Agency water quality monitoring points within the Penrith to Temple Sowerby study area

Sampling Point ID	Site Name	Coordinates
NW-88006220	River Eden at Temple Sowerby	NY 60394 28201

Table 14-16: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Penrith to Temple Sowerby study area

Site Name	pH			Temperature (°C)			Dissolved Oxygen (mg/l)			Electrical Conductivity (µs/cm)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Eden at Temple Sowerby	8.2	8.7	7.5	9.6	20.2	2.6	11.6	14.3	8.5	375.4	479.0	169.0

Hydromorphology

14.7.105 Hydromorphology surveys were completed for selected watercourses to understand the existing catchment flow and sediment dynamics and are summarised in Table 14-17: Hydromorphological survey results for Penrith to Temple Sowerby. Full details are within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). WCP are displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3).

Table 14-17: Hydromorphological survey results for Penrith to Temple Sowerby

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP2, Unnamed Tributary of Light Water 3.1	Upstream: diverse range from riffles to runs with sinuous planform Downstream: Glide flows due to reduction in flow energy	Upstream: cobbles to gravels and sands Downstream: silts and sands	Upstream: well vegetated on both banks Downstream: dense overgrown riverbanks and riverbed vegetation	Upstream: incised channel is disconnected from the floodplain Downstream: riverbed scour from culvert, lowered riverbed level leading to disconnection
WCP3 and WCP78, Light Water	Upstream: good sinuosity with runs to riffles then transitions to historically straightened with riffles Downstream: high flow velocities resulting in riffles to runs	Cobbles to gravels with moderate flow energy. Classified as a sediment transfer reach	Upstream: poor coverage with significant poaching of banks Downstream: trees on both banks with areas of rushes	Upstream: good connectivity within woodland. Within agricultural land, heavily incised disconnected from the floodplain Downstream: historically incised with poor connectivity.
WCP3.3, Unnamed Tributary of Eamont 3.3	Upstream: shallow channel gradient, overgrown, results in low flow energy Downstream: Scour pool at culvert, with steep gradient creating continuous riffles	Upstream: sands to silts Downstream: cobbles to gravels	Upstream: overgrown, long grasses. Lack of trees Downstream: deteriorated cover leading to erosion, undercutting and slumping	Upstream: reasonable connectivity Downstream: degraded, straightened incised channel. Disconnected with floodplain.
WCP3.4, Unnamed Tributary of Eamont 3.4	Moderate flow energy, dominated by runs	Silts to sands	Upstream: devoid of vegetation with cattle poaching Downstream: thin strip of tree cover and a fence excludes poaching	Generally poor, natural incision leading to low riverbed levels.

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP6, Unnamed Tributary of Eamont 3.5	Upstream: low flow, gliding flows Upstream: steam within a confined gully	Gravels and cobbles to fine material such as silts	Upstream: Lack of trees, dense overgrown vegetation on banks Downstream: thicket of woodland improves condition	Upstream: Low flow section is well connected Downstream: no access to the floodplain
WCP7, Swine Gill	Upstream: low flow energy creating glides, water pools at culvert Downstream: Sinuosity and flow increase, riffles to glides	Upstream: silts to sands Downstream: Gravels to cobbles	Upstream: dense vegetation, lack of tree cover Downstream: Tree cover improved with good bank integrity	Upstream: good connectivity with inundated woodland Downstream: remails well connected

Groundwater

14.7.106 Regional aspects of the hydrogeology that underlie the schemes, including the aquifer units and WFD groundwater bodies, are described in the routewide baseline section. Those site-specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the following sections.

Groundwater-surface water interactions

14.7.107 Review of available data, including aerial photography and mapping, identified one potential spring (S29) in the study area. Surveying subsequently confirmed that this is mostly likely to be land drainage related.

14.7.108 Springs and seepages are likely to be present in the area; particularly in the banks of the rivers and below the river level of the River Eamont. The River Eamont and its various tributaries are likely to receive groundwater baseflow from the superficial deposits and bedrock formations, as well as surface water runoff.

14.7.109 There are areas of habitat with the potential to support low dependency GWDTEs within the study area.

Groundwater abstractions

14.7.110 The western end of the study area lies within an SPZ III associated with abstractions to the north and the north-west of the scheme (outside the study area).

14.7.111 There are no licensed wells in the scheme study area.

14.7.112 There are potentially a number of smaller private domestic, commercial and agricultural unlicensed supplies within the scheme study area, which are assumed to abstract less than 20 m^3/d. It is assumed that each property within the study area has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.7.113 The western section of the study area contains an area within Fluvial Flood Zones 2 and 3, associated with the River Eamont and River Lowther and their floodplains which occurs on both sides of the existing A66.

14.7.114 In the east centre of the study area adjacent to Barrackbank Wood and Whinfell Holme there is a floodplain, north of the existing A66, designated as Fluvial Flood Zone 3. This floodplain is associated with the River Eamont.

14.7.115 Baseline fluvial modelling undertaken for the scheme has highlighted increased extent of Flood Zone 3 to the south, adjacent to the existing A66, in the central section of the study area when compared to the EA flood map. This is assumed to be associated with existing culverts at Light Water and Unnamed Tributary of River Eamont 3.3. A further additional area of flood risk is identified both north and south of the existing A66 at the culvert of Unnamed Tributary of River Eamont 3.5.

14.7.116 Full details of the modelling results are published in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage (Application Document 3.4) and presented on ES Figure 14.2: Existing Flood Risk (Application Document 3.3).

Pluvial flooding

14.7.117 There are areas of 'Medium'[58] pluvial water flood risk displayed adjacent to the River Eamont along the existing A66 and Moor Lane.

14.7.118 There are areas of 'Low'[59] pluvial water flood risk displayed adjacent to the Light Water at Light Water Bridge on along the existing A66 and the land adjacent to the south, likely to be a result of localised depressions in the topography. Similarly, there are areas of 'Low' pluvial water flood risk influenced by the Unnamed Tributary of River Eamont 3.3 on the existing A66.

Historic flooding

14.7.119 Environment Agency data shows historic flooding events associated with the River Eamont in 2005, 2009 and 2015. Historic flooding associated with the study area is indicated on Environment Agency mapping to be at risk of fluvial flooding (from rivers or the sea).

[58] Medium risk equates to a chance of flooding of between 1% and 3.3% each year
[59] Low risk equates to a chance of flooding of between 0.1% and 1% each year

14.7.120 The consultation response received from Cumbria Council LLFA stated that “Flooding has been experienced in the vicinity of the Karma Llama Kafé due to a watercourse culvert underneath the A66”.

Consented discharges

14.7.121 Nine active consented discharges have been identified from Environment Agency data as being within the study area for this scheme. As shown in Table 14-18: Consented discharge licences within the Penrith to Temple Sowerby study area, these include discharges associated with sewage treatment works, pumping stations, quarrying and hospitality. Presented on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

Table 14-18: Consented discharge licences within the Penrith to Temple Sowerby study area

Site name	Receiving watercourse	Description
1 - 4 Swinegill Cottages	Swine Gill	Domestic property (multiple) (including farmhouses)
Brougham Pumping Station	Tributary of River Eden	Storm Tank/CSO on Sewerage Network (water company)
Carleton.Hall Templebank CSO	Culvert of Eamont River	Storm Tank/CSO on Sewerage Network (water company)
Fremington	Tributary of River Eamont	WwTW (not water company) (not STP at a private premises)
Penrith outfall CSO	River Eamont	Storm Tank/CSO on Sewerage Network (water company)
Penrith Wastewater Treatment Works (WwTW)	River Eamont	WwTW/Sewage Treatment Works (water company)
Sceugh Farm	Tributary of River Eamont	WwTW (non-water company) (not STP at a private premises)
Winderwath	River Eden	WwTW (non-water company) (not STP at a private premises)
Winderwath Cottages	River Eden	Domestic property (multiple) (including farmhouses)

Temple Sowerby to Appleby

Designated sites

14.7.122 The River Eden and Trout Beck, a tributary to the River Eden, are located within the study areas. Both watercourses are designated as part of the River Eden SAC and River Eden and Tributaries SSSI.

14.7.123 River Habitat Survey (RHS) and River Corridor Survey (RCS) have confirmed that Trout Beck supports habitats and species included in the River Eden SAC designation. Further details of the designated features relating to the River Eden SAC are provided within ES Chapter 6: Biodiversity (Application Document 3.2).

14.7.124 Located to the east of Temple Sowerby and 350m north of the existing A66, within the study area, is the Temple Sowerby Moss SSSI. This site is within a slight depression in the glacial drift over an area of Penrith Sandstone and is notable for the development of its fen communities.

Surface water

14.7.125 Watercourses within the study areas drain into the River Eden via a number of tributaries.

14.7.126 The watercourses in the north and west of the study areas drain from the fells to the north, including Knock Pike and Dufton Pike, and flow through agricultural fields and small villages, including Long Marton. In the south of the study areas the watercourses flow north from the Howgill Fells through largely agricultural land.

14.7.127 Table 14-19: Surface water receptors within the Temple Sowerby to Appleby study areas gives a brief description and the classification of the surface water receptors within the study area (from west to east) which are also displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3). The standard naming convention is used for unnamed watercourses, as outlined in Paragraph 14.5.10.

Table 14-19: Surface water receptors within the Temple Sowerby to Appleby study areas

Receptor	Description	Watercourse classification
Birk Sike	Flows west into the River Eden via the Crowdundle Beck, parallel to the north of the existing A66 in the north of the study areas. Joins the River Eden to the west of the study areas.	Main River
River Eden	Flows northwest, parallel to the south of the existing A66. Joined by several tributaries to the south of the study area and joins River Lyvennet in the south-east of the study areas.	Main River
River Lyvennet	Flows north, joins the River Eden 520m to the south of the existing A66.	Main River
Coat Sike	Flows north, joins the River Eden 1.2kmm to the south of the existing A66, in the south-west of the study area.	Main River
Unnamed Tributary of Birk Sike 4.2	Situated north-west of Kirkby Thore, flows north-east through agricultural land into Birke Sike.	Ordinary watercourse
Unnamed Tributary of Birk Sike 4.3	Situated north-east of Kirkby Thore, flows northwest through agricultural land into Birk Sike, adjacent to British Gypsum factory.	Ordinary watercourse
Unnamed Tributary of Trout Beck 4.1	Situated 440m south of existing A66, flows south-west into the River Eden in west of study areas.	Ordinary watercourse
Trout Beck	Flows north-west into the River Eden, from Long Marton, crossed by the existing A66 to the south of Kirby Thore.	Main River

Receptor	Description	Watercourse classification
Unnamed Tributary of Keld Sike 4.1	Partially subterranean artificially straightened field drainage channel situated 200m north of Sleastonhow Lane, to the east of Kirkby Thore. Flows south-east into Keld Sike.	Ordinary watercourse (field drain)
Keld Sike (1)	Flows south into Trout Beck where it becomes a straightened channel to the west of Long Marton.	Ordinary watercourse
Unnamed Tributary of Trout Beck 4.2	Flows north from Crackenthorpe, parallel to the existing A66. Data received from the Environment Agency indicates a culvert linking this watercourse to the watercourse along the field boundary to the south of Powis House, flowing via another culvert into Trout Beck.	Ordinary watercourse
Unnamed Tributary of Trout Beck 4.3	Flows north into Trout Beck, located within the area of low ground adjacent to the Roman Road and flows along Castrigg Lane and past Broad Lea House.	Ordinary watercourse
Unnamed Tributary of Trout Beck 4.6	Flows west with areas of artificially straightened channel and into Trout Beck 100m north of the existing A66.	Ordinary watercourse (field drain)
Keld Sike (2)	Flows from Castrigg Lane at the railway line north past Broom House Farm and joining Trout Beck 200m to the south of Long Marton, parallel to the north of the Roman Road.	Ordinary watercourse
Unnamed Tributary of River Eden 4.2	Situated north-east of Colby Laithes, flows south from existing A66 and into the River Eden	Ordinary watercourse
Unnamed Tributary of River Eden 4.3	Situated north-west of Appleby, flows south from existing A66 for 60m into the River Eden.	Ordinary watercourse
Unnamed Tributary of Birk Sike 4.1	A stretch of open field drain for approximately 150m before it is culverted again.	Ordinary watercourse (field drain)
Unnamed Tributary of River Eden 4.0	Flows south, in the south of the study area, into the River Eden just south of Skygarth Farm, culverted under the dismantled railway.	Ordinary watercourse
Colby Beck	Flows north, adjacent to Colby, through some areas of forest before joining the River Eden in the south-east of the study area.	Main River
Palmer Gill	Flows north with some artificially straightened sections, into the River Eden, in the south of the study area.	Ordinary watercourse
Sweetmilk Sike	Flows north into the River Eden, in the south of the study area, flows under Sweetmilk Bridge by New Bewley Castle.	Ordinary watercourse
Teas Sike	Flow north before splitting to feed Sweetwilk Sike, in the south of the study area.	Ordinary watercourse
Unnamed Tributary of River Eden 4.1	Flows north into the River Eden at Limekiln Hill after an artificially straightened stretch, in the central east of the study area.	Ordinary watercourse

Receptor	Description	Watercourse classification
Unnamed Tributary of Birk Sike 1.1	Flows south and into Trout Beck, culverted under the railway line and flows into Birk Sike, in the north-west of the study area.	Ordinary watercourse

14.7.128 In addition to the watercourses described in Table 14-19: Surface water receptors within the Temple Sowerby to Appleby study areas, a number of smaller field drains are present across the study area, which drain into these watercourses.

Surface water WFD catchments

14.7.129 The Eden - Scandal Beck to Lyvennet (GB102076070880), Crowdundle Beck – Lower (GB102076070950) and Trout Beck (GB102076070930) are all associated with ‘Good’ Ecological and ‘Fail’ Chemical WFD status, in 2019. The Environment Agency do not give a RNAG for The Eden - Scandal Beck to Lyvennet (GB102076070880), or Crowdundle Beck – Lower (GB102076070950). Pollution from agricultural land management is recorded as reason for not achieving 'Good’ status for Trout Beck. At the existing A66 and Trout Beck crossing, the channel has historically been realigned and meanders have been removed in the past century, thus reducing the wet channel length significantly.

14.7.130 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3) and further detailed within ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Surface water quality

14.7.131 There are six relevant Environment Agency water quality sampling points shown on the EA’s online Water Quality Archive as within the study area, outlined in Table 14-20: Environment Agency water quality monitoring points within the Temple Sowerby to Appleby study area, presented on ES Figure 14.1 Surface Water Features (Application Document 3.3). The sampling points give an existing water quality baseline for the study area, and a summary is provided in Table 14-21: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Temple Sowerby to Appleby study area.

Table 14-20: Environment Agency water quality monitoring points within the Temple Sowerby to Appleby study area

Sampling Point ID	Site Name	Coordinates
NW-88019870	Crowdundle Beck 50 M U/S Birk Sike	NY 60850 28150
NW-88006197	Trout Beck at Kirkby Thore	NY 63530 25256
NW-88006186	River Eden at Bolton	NY 64194 23496
NW-88006190	Hoff (Ashby) Beck at Colby Hall	NY 64194 23496

Sampling Point ID	Site Name	Coordinates
NW-88010151	River Eden at Colby Laithe	NY 67166 21591
NW-88006180	River Eden at Appleby	NY 68431 20463

Table 14-21: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Temple Sowerby to Appleby study area

Site Name	pH			Temperature (°C)			Dissolved Oxygen (mg/l)			Electrical Conductivity (µs/cm)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Crowdundle Beck 50 M U/S Birk Sike	8.1	8.5	7.6	9.0	16.9	2.3	11.7	14.6	9.8	227.1	1183.0	93.0
Trout Beck at Kirkby Thore	8.1	8.8	7.7	8.9	14.2	3.4	12.0	14.6	9.7	433.6	826.0	79.0
River Eden at Bolton	8.3	8.8	8.0	10.2	20.6	2.7	11.5	13.4	9.4	391.1	455.0	307.0
Hoff (Ashby) Beck at Colby Hall	8.3	8.7	7.8	10.1	21.5	4.5	12.1	14.4	8.4	434.6	550.0	225.0
River Eden at Colby Laithe	8.2	8.7	7.9	9.7	16.7	4.4	11.8	14.0	9.6	341.9	461.0	177.0
River Eden at Appleby	8.2	9.0	7.7	9.4	16.7	1.6	11.5	14.2	9.5	324.8	451.0	165.0

Surface water abstractions

14.7.132 One surface water abstraction was identified within the study area. This Industrial surface water abstraction (Licence number: 2776003009) is the commercial use of the Kirby Thore Reservoir, situated adjacent to British Gypsum in the north of the study area.

Hydromorphology

14.7.133 Hydromorphology surveys were completed for selected watercourses to understand the existing catchment flow and sediment dynamics and are summarised in Table 14-22: Hydromorphological survey results for Temple Sowerby to Appleby. Full details are within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). WCP are displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3).

Table 14-22: Hydromorphological survey results for Temple Sowerby to Appleby

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP 38, WCP41, WCP10, Unnamed Tributary of Trout Beck 4.6	Shallow gradient with low flow results in glides and runs. Overgrown bed. Likely a partial blockage in the culvert impounding flow upstream.	Upstream: Fine silty material Downstream: sands to gravels	Generally poor, sporadic tree cover with cattle poaching widespread	Areas of open channel, floodplain connectivity is moderate
WCP42, Unnamed Tributary of Trout Beck 4.5	Low flow velocities, glides to runs	Silts and sands to gravels	Overgrown riparian strip of long grasses and rushes. Lack of tree cover	Generally poor, artificially straightened and incised
WCP37, Trout Beck	Upstream: Alternating riffle, pool, and run sequences. Sinuosity in the channel Downstream: channel planform sinuosity decreases due to artificial straightening. Plane bed glide and runs	Sands to gravels and cobbles	Upstream: good corridor of trees on both banks, some wet woodland Downstream: deteriorated cover leading to erosion, bank toe undercutting and slumping	Due to artificial straightening, bed is incised and cut down. Disconnected from floodplain

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP44, Unnamed Tributary of Trout Beck 4.3	Upstream: runs to glides, heavily choked with vegetation Downstream: low flow with no discernible flow biotopes	Upstream: Silts to sands Downstream: Homogeneous bed of fine material	Upstream: Overgrown riparian strip of long grasses. Lack of tree cover Downstream: lack of vegetation, significant cattle poaching	Upstream: moderate connectivity Downstream: Degraded, incised bed with trapezoidal channel shape

Groundwater

14.7.134 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the routewide baseline section. Those site-specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the following sections.

14.7.135 The River Eden, Birk Sike and Trout Beck will receive groundwater baseflow from the bedrock formations and superficial deposits.

Groundwater-surface water interactions

14.7.136 A number of potential groundwater-surface water interactions were mapped within the study area (S24, S26, S27 and S28), presented on Figure 14.6 Hydrogeological Study Areas and Features (Application Document 3.3). Surveying confirmed that Spring S24 comprised a bedrock fed spring which feeds into Unnamed tributary of Trout Beck 4.3, whilst Spring S26 comprised boggy ground with iron oxide indicative of groundwater seepage (although no flowing water was observed). No land access was possible to confirm the S27 and S28 groundwater-surface water interactions.

14.7.137 Springs and seepages are likely to be present; particularly in the banks of the rivers and below the river level of the River Eden and Trout Beck. The River Eden and its various tributaries are likely to receive groundwater baseflow from the superficial deposits and bedrock formations, as well as surface water runoff.

14.7.138 There are areas of habitat with the potential to support low dependency GWDTEs within the study area.

Groundwater abstractions

14.7.139 There are five licensed abstractions in the scheme study area, presented on ES Figure 14.6 Hydrogeological Study Areas and Features (Application Document 3.3), these are:

- Agricultural abstraction well (Licence number: 2776003013) at Spittals Farm - Permo-triassic Sandstone

- Agricultural abstraction well (Licence number: 2776003012/R01) in Kirkby Thore - Permo-Triassic Sandstone
- Two Industrial abstraction wells (Licence number: 2776003011) in Kirkby Thore - Permo-Triassic Sandstone
- One agricultural abstraction well (License number: 2776001134/R01) west of Appleby-in-Westmorland.

14.7.140 During consultation, an additional unlicensed private abstraction was identified in the study area utilised for residential and commercial water supply, located south-west of Sleastonhow Farm.

14.7.141 There are potentially a number of additional private domestic, commercial and agricultural unlicensed supplies within the scheme study area, which are assumed to abstract less than 20 m^3/d. It is assumed that each property has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.7.142 Areas of Fluvial Flood Zone 2 and 3 shown within Environment Agency mapping include areas associated with:

- Birk Sike and its floodplain in the western section of the study areas
- Trout Beck and its floodplain, to the north-west of the existing A66 between Kirby Thore and Long Marton
- The River Eden and its floodplain, parallel and to the south-west of the existing A66. Within the eastern section of the study areas the extent of Fluvial Flood Zone 3 associated with the River Eden are separated from the existing A66 by a steep embankment.

14.7.143 Baseline fluvial modelling undertaken for the scheme has highlighted increased flood risk extent around Trout Beck when in comparison with the Environment Agency mapping. An additional area of flood risk has been identified associated with Unnamed Tributary of Trout Beck 4.5 and Unnamed Tributary of Trout Beck 4.6, both north and south of the existing A66.

14.7.144 Full details of the modelling results are published in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4).

Pluvial flooding

14.7.145 There are areas of ‘High’ pluvial water flood risk influenced by tributaries of Trout Beck within Kirkby Thore along a number of residential roads as well as at the junction of Piper Lane and the existing A66. North-west of Crackenthorpe there are areas of ‘High’ and ‘Medium’ pluvial flood risk in the vicinity of Meadow Ing Farm and Powis Cottages associated with depressions in the topography. There are also areas of ‘High’ pluvial flood risk associated with the River Eden along several residential roads within Appleby, including Drawbriggs Lane and the B6542.

14.7.146 There are areas of pluvial flood risk adjacent to and within the wider floodplain of both Trout Beck and the River Eden. These are likely to

indicate historic flow paths for the respective channels, particularly downstream of the historically realigned section of Trout Beck (to the west of Powis House), where there are areas of 'High' pluvial flood risk parallel to the north of the existing channel.

Historic flooding

14.7.147 Environment Agency data show historic flooding events associated with Trout Beck within Kirkby Thore in 2004, 2005 and 2015. Historic flooding associated with the River Eden has also occurred in Bolton in 2005, 2009 and 2015 and on seven occasions within Appleby between 1990 and 2015.

14.7.148 Consultation responses highlight that the flooding has occurred at Kirkby Thore from Trout Beck and the River Eden both independently and in combination.

14.7.149 HADDMS highlights two flooding hotspots within the study area, both of which are classified as 'Risk Addressed'. One is located at the junction of A66 and Piper Lane, to the west of Kirby Thore, and the other is located east of Crackenthorpe the Oakdene junction with A66.

Consented discharges

14.7.150 Seventeen active consented discharges have been identified in Environment Agency data as within the study area for this scheme. As shown in Table 14-23: Consented discharge licences within the Temple Sowerby to Appleby study area, these include discharges associated with sewage treatment works, pumping stations, quarrying and hospitality, presented on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

Table 14-23: Consented discharge licences within the Temple Sowerby to Appleby study area

Site name	Receiving watercourse	Description
Appleby CSO	River Eden	Storm Tank/CSO on Sewerage Network (water company)
Appleby WwTW	River Eden	WwTW/Sewage Treatment Works (water company)
Bolton Mill Caravan Park	Groundwater via soakaway	Holiday Accom/Camp Site/Caravan Site/Hotel/Hostel
Bolton Penrith WWTW	River Eden	WwTW/Sewage Treatment Works (water company)
Butts Car Park	River Eden	Storm Tank/CSO on Sewerage Network (water company)
Chapel Street (Temple Sowerby) CSO	Birk Sike	Pumping Station on Sewerage Network (water company)
Hall Farm House	Tributary to the River Eden	WwTW (not water company) (not STP at a private premises)
Hole St/Chapel St SSO	River Eden	Storm Tank/CSO on Sewerage Network (water company)

Site name	Receiving watercourse	Description
Kirkby Thore PS	Trout Beck	Pumping Station on Sewerage Network (water company)
Kirkby Thore STW	River Eden	WwTW/Sewage Treatment Works (water company)
Long Marton East STW	Trout Beck	WwTW/Sewage Treatment Works (water company)
Long Marton West STW	Trout Beck	WwTW/Sewage Treatment Works (water company)
Roman Road Campsite	Groundwater	Holiday Accom/Camp Site/Caravan Site/Hotel/Hostel
Stamphill Mine (1)	Keld Sike	Mineral/Gravel Extraction/Quarrying
Stamphill Mine (2)	Keld Sike	Mining of Coal + Lignite
Temple Sowerby STW	Birk Sike	WwTW/Sewage Treatment Works (water company)
The Stackyard	Groundwater	Food + Beverage Services/Cafe/Restaurant/Pub

Appleby to Brough

Designated sites

14.7.151 The River Eden and a number of tributaries of the River Eden, are located within the study area. The River Eden is designated as part of the River Eden SAC. River Habitat Survey (RHS) and River Corridor Survey (RCS) have confirmed that some of these tributaries support habitats and species included in the River Eden SAC designation.

14.7.152 The following watercourses are considered to be Functionally Linked to the River Eden SAC:

- Mire Sike
- Unnamed Tributary of Mire Sike 6.12
- Cringle Beck
- Crooks Beck
- Hayber Beck
- Moor Beck
- Eastfield Sike
- Lowgill Beck
- Woodend Sike
- Yosgill Sike.

14.7.153 Further details of the designated features relating to the River Eden SAC are provided within ES Chapter 6: Biodiversity (Application Document 3.2).

14.7.154 The scheme is located on the southern boundary of the North Pennines AONB, with the following designations relating to the water environment within the eastern extent of the study area:

- The North Pennine Moors SPA
- The North Pennine Moors SAC.

Surface water

14.7.155 A number of watercourses flow through the study area. All eventually flow into the River Eden.

14.7.156 All watercourses in the study area, with the exception of the River Eden, drain from fells to the north of the study area and flow through predominately agricultural land and some small settlements, including Warcop and Sandford.

14.7.157 Table 14-24: Surface water receptors within Appleby to Brough study area gives a brief description and the classification of the surface water receptors within the study area (from west to east) which are also displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3). The standard naming convention is used for unnamed watercourses, as outlined in Paragraph 14.5.10.

Table 14-24: Surface water receptors within Appleby to Brough study area

Receptor	Description	Watercourse classification
Hilton Beck	Flows south in the north-west of the study area. Discharges into the Coupland Beck.	Ordinary watercourse
George Gill	Flows west into Coupland Beck, to the south of Brackenber, in the north-west of the study area.	Ordinary watercourse
Coupland Beck	Flows south into the River Eden, to the south of Coupland in the north-west of the study area and drains George Gill and Hilton Beck.	Main River
Lycum Beck	Flows south into the George Gill, in the west of the study area.	Ordinary watercourse
River Eden	Flows northwest, south of the existing A66, Warcop and Sandford in the north-west of the study area.	Main River
Greenber Sike	Flows north in the south-west of the study area, flowing into the River Eden east of Little Ormside.	Ordinary watercourse
Helm Beck	Flows north in the south-west of the study area, passing between Great Ormside and Little Ormside and into the River Eden.	Main River
Unnamed Tributary of Mire Sike 6.1	Drain flows east from Middle Bank End, before flowing south and into Mire Sike to the south of Far Bank End.	Ordinary watercourse
Unnamed Tributary of Mire Sike 6.5	Drainage that flows through Far Bank End farm and discharges into Unnamed Tributary of Mire Sike 6.1	Ordinary watercourse (field drain)
Unnamed Tributary of Mire Sike 6.4	Flows west parallel to the existing A66 before joining Unnamed Tributary of Mire Sike 6.1 to the north of Far Bank End.	Ordinary watercourse

Receptor	Description	Watercourse classification
Unnamed Tributary of Mire Sike 6.8	Flows south through Sandford Mire, three small drains discharge into it as it flows through the mire before discharging into Mire Sike.	Ordinary watercourse
Unnamed Tributary of Mire Sike 6.6	Field drain that flows east from New Hall farm in the south of the study area and discharges into Unnamed Tributary of Mire Sike 6.8.	Ordinary watercourse (field drain)
Unnamed Tributary of Mire Sike 6.12	Flows south and crosses existing A66 to the west of Dike Nook, in the north-west of the study area. Watercourse flows into Mire Sike.	Ordinary watercourse
Unnamed Tributary of Mire Sike 6.13	Flows west through an area of fen and joins Unnamed Tributary of Mire Sike 6.12 in a depression north of the existing A66.	Ordinary watercourse
Mire Sike	Crossed by the existing A66 to the south of Wheat Sheaf Farm in the centre of the study area. Watercourse flows north-west into the River Eden at the confluence to the west of Far Bank End.	Main River
Unnamed Tributary of Cringle Beck 6.1	Flows south from Moor House and Hilton Road, passing adjacent east to Wheat Sheaf Farm, culverted under Eden Valley Railway before discharging into Cringle Beck.	Ordinary watercourse
Cringle Beck	Flows south then west into Mire Sike, crossing the existing A66 adjacent to the east of Wheat Sheaf Farm in the centre of the study area. It is also culverted under the Eden Valley Railway.	Ordinary watercourse
Unnamed Tributary of Cringle Beck 6.3	Flows south and west culverted under the Eden Valley Railway.	Ordinary watercourse
Hayber Beck	Crossed by the existing A66 and flows south through the centre of the study area, where a weir splits the channel, and Moor Beck continues to the east while Moor Beck (Offtake) continues into the Warcop Training Camp.	Main River
Moor Beck	Flows south-east from Hayber Beck, across open fields with an artificially straightened section and into Crooks Beck, in the centre of the study area.	Main River
Moor Beck (Offtake)	Flows south from Hayber beck after the split in channel. Artificial channel that supplies the fire ponds within the Warcop Training Camp before being culverted into Crooks Beck.	Main River
Eastfield Sike	Crossed by the existing A66 and flows south-west through the centre of the study area. Meets Moor Beck at a confluence and becomes Crooks Beck, to the east of Warcop.	Ordinary watercourse

Receptor	Description	Watercourse classification
Crooks Beck	Flows west though Warcop into the River Eden in the centre of the study area. Watercourse drains Hayber Beck, Eastfield Sike and Lowgill Beck.	Main River
Lowgill Beck	Flows under the existing A66 in the east of the study area. Flows west and drains into Crooks Beck.	Main River
Unnamed Tributary of Lowgill Beck 6.1	Unnamed watercourse flows from Bale Hill to under the existing A66 into Lowgill Beck, towards the east of the study area.	Ordinary watercourse
Woodend Sike	Located in the east of the study area, the watercourse flows south before the confluence with Yosgill Sike (to the north of the existing A66) and becoming Lowgill Beck.	Ordinary watercourse
Yosgill Sike	Located in the east of the study area, the watercourse flows south before the confluence with Woodend Sike (to the north of the existing A66) and becoming Lowgill Beck.	Ordinary watercourse
Unnamed Tributary of Lowgill Beck 6.7	Located in the east of the study area, the watercourse flows south, crossed by the existing A66 before becoming feeding into Unnamed Tributary of Lowgill Beck 6.3.	Ordinary watercourse
Unnamed Tributary of Lowgill Beck 6.3	Located in the south-east of the study area, the watercourse flows west and joins the Lowgill Beck just south of Broom Rigg.	Ordinary watercourse
Swindale Beck	Located in the east of the study area, the watercourse flows south crossed by the existing A66. Joins the River Eden approximately 2.8km downstream.	Main River
Augill Beck	Located in the east of the study area, the watercourse flows south crossed by the existing A66. Discharges into the Swindale Beck south-west of Brough Primary School.	Ordinary watercourse
Unnamed Tributary of Mire Sike 6.9	Flows south-east, artificially straightened through fields, and then flows into Unnamed Tributary of Mire Sike 6.12, 150m north of the existing A66.	Ordinary watercourse (field drain)
Unnamed Tributary of Mire Sike 6.10	Located in south central areas of the study area. Flows west culverted in sections through Sandford Mire, parallel to the railway line, and joins Unnamed Tributary of Mire Sike 6.8	Main River
Unnamed Tributary of Lowgill Beck 6.6	Flows north, in the south-east of the study area, and into Lowgill Beck.	Ordinary watercourse

Receptor	Description	Watercourse classification
Unnamed Tributary of Lowgill Beck 6.5	Flows south from and Brough Hill and joins Unnamed Tributary of Lowgill Beck 6.1 upstream of the crossing of the existing A66.	Ordinary watercourse
Unnamed Tributary of Augill Beck 1.1	Flows south crossed by the existing A66, in the east of the study area, between Swindale Beck and Augill beck before joining Augill Beck downstream of a crossing with the A685.	Ordinary watercourse
Unnamed Tributary of Yosgill Sike 1.1	Flows west from Helbeck, in the north-east of the study area, and joins Yosgill Sike	Ordinary watercourse
Unnamed Tributary of Mire Sike 6.15	Flows west in the central area of the study area, through agricultural fields and into the Mire Sike.	Ordinary watercourse
Unnamed Tributary of Lowgill Beck 6.8	Flows north-west, in the south-west of the study area, and into Lowgill Beck upstream of its crossing with the B6259.	Main River

14.7.158 In addition to the watercourses described in Table 14-24: Surface water receptors within Appleby to Brough study area, a number of smaller field drains are present across the study area, which drain into these watercourses.

Surface water WFD catchments

14.7.159 The following surface water WFD catchments are located within the study area:

- Hilton Beck (ID: GB102076070770)
- Eden - Scandal Beck to Lyvennet (ID: GB102076070880)
- Low Gill (Crooks Beck) (ID: GB102076070750).

14.7.160 Hilton Beck is associated with ‘Good’ ecological and ‘Fail’ chemical WFD status in 2019. Diffuse pollution of heavy metals from mining activity is recorded as reason for not achieving 'Good’ status.

14.7.161 The Eden - Scandal Beck to Lyvennet is associated with ‘Good’ ecological and ‘Fail’ chemical WFD status’ in 2019. The Environment Agency do not give a RNAG for this catchment.

14.7.162 Low Gill (Crooks Beck) is associated with ‘Poor’ ecological and ‘Fail’ chemical WFD status in 2019. The Environment Agency lists diffuse pollution from poor nutrient management from agriculture (livestock) and impacts of sediment from agriculture and rural land management on fish as reasons for not achieving 'Good’ status for Low Gill (Crooks Beck).

14.7.163 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3) and further detailed within ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Surface water quality

14.7.164 There are five relevant Environment Agency water quality sampling points shown on the EA's online Water Quality Archive as within the study area, outlined in Table 14-25: Environment Agency water quality monitoring points within the Appleby to Brough study area, presented on ES Figure 14.1 Surface Water Features (Application Document 3.3). The sampling points give an existing water quality baseline for the study area, and a summary is provided in Table 14-26: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Appleby to Brough study area.

Table 14-25: Environment Agency water quality monitoring points within the Appleby to Brough study area

Sampling Point ID	Site Name	Coordinates
NW-88006185	Hilton Beck At Roman Road Coupland	NY 71049 18885
NW-88022231	Crooks Beck D/S Lowgill Beck	NY 74705 15418
NW-88006173	River Eden at Warcop	NY 74291 15086
NW-88023117	Augill Beck at Yarford Bridge	NY 79547 14029
NW-88022536	Swindale Beck near Swinside cottages	NY 79800 14700

Table 14-26: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Appleby to Brough study area

Site Name	pH			Temperature (°C)			Dissolved Oxygen (mg/l)			Electrical Conductivity (µs/cm)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Hilton Beck at Roman Road Coupland	8.4	9.0	7.8	10.0	19.0	3.7	11.5	13.6	7.6	212.6	263.0	119.0
Crooks Beck D/S Lowgill Beck	8.0	8.2	7.7	8.8	17.1	4.7	12.1	13.6	10.4	389.1	623.0	187.0
Augill Beck at Yarford Bridge	8.3	8.7	7.8	9.8	16.7	3.9	12.3	15.6	9.9	483.9	821.0	206.0
Swindale Beck near Swinside cottages	8.2	8.5	7.6	8.1	12.8	4.3	12.2	13.3	10.4	229.0	380.0	107.0

Hydromorphology

14.7.165 Hydromorphology surveys were completed for selected watercourses to understand the existing catchment flow and sediment dynamics and are summarised in Table 14-27: Hydromorphological survey results for Appleby to Brough. Full details are within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). WCP are displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3).

Table 14-27: Hydromorphological survey results for Appleby to Brough

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP11, Unnamed Tributary of Mire Sike 6.12	Upstream: riffle Downstream: glide to riffles	Upstream: cobbles and gravels Downstream: sands to silts and then transitions back to cobbles and gravels	Moderate, narrow strips of woodland, some overgrowing and bed vegetation in middle reach	Disconnected due to incised channel.
WCP11, Mire Sike	Upstream: alternating riffle and glide biotopes Downstream: continuous riffle feature, sinuosity reduces.	Upstream: cobbles and gravels to gravels and sands depending on the biotope Downstream: coarse bed material, absence of fine sediment	Upstream: poor cover with sheep poaching Downstream: improved cover, woodland area	Upstream: incised modified channel, poor connectivity Downstream: more natural geometry, moderate connectivity
WCP12, Unnamed Tributary of Mire Sike 6.1	Overgrown with low flow, no distinguishable flow biotopes	Sands to silts	Upstream: overgrown long grasses, lack of tree cover Downstream: deteriorated cover leading to poaching and degraded banks	Upstream: moderate with evidence of spill over Downstream: due to artificial straightening, bed is incised and cut down. Disconnected from floodplain

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP13, Cringle Beck	Upstream: high energy, riffles Downstream: sinuous and active, riffles and runs. Some glides in lower reaches	Upstream: coarse cobbles and gravels Downstream: cobbles and gravels at riffles to sands and silts at glides	Upstream: poor, some isolated thickets of trees and rushes. Livestock poaching occurs Downstream: buffer strip on left bank providing structural integrity, right bank suffers erosion	Moderate connectivity
WCP50, Moor Beck (Offtake)	Overgrown and low flow, predominately glides	Gravels to very fine material	Upstream: none, bank instability and poaching Downstream: tree cover on both banks, areas of wet woodland	Little bed incision and so connectivity is reasonable
WCP15, WCP51, WCP52 Hayber Beck, Moor Beck	Upstream: high energy, long riffles and rapids Downstream: alternating riffle and glides sequences	Upstream: boulders to coarse cobbles Downstream: cobbles and gravels at riffle features to gravels and sands at glide biotopes	Upstream: forest on both banks providing structural integrity Downstream: lack of trees with poaching evident	Upstream: naturally confined in a narrow steep sided channel Downstream: Realignment and straightening of the channel, disconnected from floodplain
WCP17, Eastfield Sike	Upstream: high energy biotopes such as riffles Downstream: alternating riffle and run sequences into riffle and glide sequences	Upstream: coarse cobbles to gravels. Considered a sediment transport reach Downstream: gravels to sands	Generally poor, lack of riparian tree cover. Some livestock poaching	Upstream: steep upland nature makes for naturally poor connectivity Downstream: Realignment and straightening of the channel, disconnected from floodplain
WCP55 WCP58 Lowgill Beck	Upstream: diverse and	Cobbles to gravels in high flow biotopes.	Upstream: woodland, trees and hedgerows	Generally poor, some improvement

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
	sinuous, riffles and pools Downstream: riffles to runs and glides	Sands and siles where flow velocity reduces	Downstream: Lack of tree cover with livestock poaching	within woodland areas
WCP18, Unnamed Tributary of Lowgill Beck 6.1	Upstream: overgrown with low energy flow biotopes Downstream: gliding flows with limited riffles	Upstream: sands to silts Downstream: silts and sands to gravels	Upstream: overgrown riverbanks, occasional tree Downstream: thin buffer strip of woodland on both banks	Upstream: artificially straightened and become incised. Disconnected from floodplain Downstream: Bed incision, disconnected from floodplain
WCP59, WCP19, Woodend Sike	Upstream: high low energy, riffles and runs Downstream: continuous riffle/plane-bed feature at culvert	Coarse cobbles and gravels. Sediment transport reach	Upstream: woodland on both banks Downstream: lack of tree cover, poaching evident	Generally poor, realigned and straightened historically. Bed incision leaving it disconnected from floodplain
WCP60, Yosgill Sike	Upstream: riffles and rapids Downstream: riffle and run sequences	Coarse cobbles and gravels. Sediment transport reach	Generally poor, lack of trees with poaching evident	Naturally incised bed due to active channel, disconnected from the floodplain
WCP62, WCP63, Unnamed Tributary of Lowgill Beck 6.7	Upstream: low flow volume, overgrown channel Downstream: glides and runs	Sands to silts, overgrown bed	Upstream: buffer zone on each bank, good tree cover Downstream: no riparian cover, livestock poaching	Upstream: reasonably well connected to woodland but disconnected where channel is incised with trapezoidal geometry Downstream: channel gradient reduces, better connected to floodplain

Groundwater

14.7.166 Regional aspects of the hydrogeology that underly the study area, including the aquifer units and WFD groundwater bodies, are described in routewide baseline conditions section. Those site-specific features, such as groundwater surface water interactions (springs and sinks) and abstractions, are described below for the study area.

Groundwater-surface water interactions

14.7.167 Two potential groundwater-surface water interactions were identified within the study area; S23 and S50 (shown on ES Figure 14.6: Hydrogeological Study Areas and Features, Application Document 3.3). Surveys identified that Spring S50 was most likely to be a drainage feature, whilst S23 comprised boggy ground indicative of seepage (although no visible groundwater flow was evident).

14.7.168 The study area crosses the Pennine fault, which separates the Penrith Sandstone Formation and the Stainmore Formation. Spring S23 is in a steep sided valley that lies in the north-east of the study area. The groundwater flow that feeds this study area is likely to be from limestones of the Alston Formation.

14.7.169 During consultation additional potential groundwater-surface water interactions were noted by stakeholders within the study area:

- Potential springs/seepages that feed the fen habitat north-east of Sandford Junction (Dyke Nook Fen).
- Flitholme ‘Spring’ - north-east of Flitholme
- Wildboar Hill ‘springs’ - north-east of Wildboar Hill.

14.7.170 Additional springs and seepages are likely to be present; particularly in the banks of the rivers and below the river level of the River Eden and associated tributaries. The River Eden and its various tributaries are likely to receive groundwater baseflow from the superficial deposits and bedrock formations, as well as surface water runoff.

14.7.171 There are areas of habitat with the potential to support low and moderate dependency GWDTEs within the study area.

Groundwater abstractions

14.7.172 There are no designated groundwater SPZs within the study area.

14.7.173 There are two licensed groundwater abstractions within the study area, presented on ES Figure 14.6 Hydrogeological Study Areas and Features (Application Document 3.3):

- Eastfield Farm (Licence Number: NW/076/0001/009) – Permo-Triassic Sandstone
- Borehole at West View Brough, Kirkby Stephen (Licence number: 2776001135/R01) – Permo-Triassic Sandstone.

14.7.174 There are potentially a number of smaller private domestic, commercial and agricultural unlicensed supplies within the scheme study area, which are assumed to abstract less than 20 m^3/d. It is assumed that each property has the potential to include a small private groundwater supply.

14.7.175 There are areas of habitat with the potential to support low and moderate dependency GWDTEs within the study area

Flood risk

Fluvial flooding

14.7.176 Areas of Fluvial Flood Zone 2 and 3 shown within Environment Agency mapping, presented on ES Figure 14.2: Existing Flood Risk (Application Document 3.3), include areas associated with:

- Coupland Beck and its floodplain in the north-west of the study area
- River Eden and Mire Sike between Warcop and Ormside
- Hayber Beck, the confluence and floodplain of Hayber Beck, Moor Beck and Eastfield Sike in the centre of the study area
- Cringle Beck and Unnamed Tributary of Cringle Beck 6.1, north-west of Warcop
- The wide floodplain of Crooks Beck and the lower reaches of Lowgill Beck within Warcop
- Lowgill Beck at Flitholme and Flitholme Bridge
- Lowgill Beck where it is crossed by the existing A66 which extends to Woodend Sike, upstream of its confluence with Yosgill Sike
- Swindale Beck and Augill beck, through Brough in the east of the study area.

14.7.177 Baseline fluvial modelling undertaken for the scheme has highlighted increased flood risk extent associated with Cringle Beck both north and south of the existing A66, and the Lowgill Beck when compared against the Environment Agency flood mapping. Additionally, the Project modelling has refined the flood risk associated with the confluence and floodplain of Hayber Beck, Moor Beck and Eastfield Sike in the centre of the study area. This confirms the anecdotal evidence from consultees that floodwater is stored by the railway line.

14.7.178 Full details of the modelling results are published in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4).

Pluvial flooding

14.7.179 In the northern sections of the study area there are areas of ‘High’ and ‘Medium’ pluvial water flood risk associated with Coupland Beck and its tributaries upstream and adjacent to the existing A66.

14.7.180 Downstream of the existing A66 there are areas of ‘High’ and ‘Medium’ pluvial water flood risk associated with small areas of wetland and field drains to the north and east of both Far Bank End and Middle Bank End. Additionally, to the south of the railway line, are areas of ‘Medium’ pluvial water flood risk associated with Sandford Mire and Mire Sike.

14.7.181 In the central sections of the study area there are areas of ‘High’ and ‘Medium’ pluvial water flood risk adjacent to Cringle Beck and an extensive area to the east of Cringle Beck’s confluence with Mire Sike. This is considered to be a result of a number of small tributaries and the railway line. There are also large areas to the north, east and south of

Warcop, associated with depressions in the land around existing A66 watercourse crossings and the large valley bottom immediately upstream and downstream of the railway embankment, to the north-west and east of Warcop. To the east of Warcop, there are areas of 'High' and 'Medium' pluvial water flood risk around Eastfield Sike and upstream of the existing A66 crossing at Toddygill Bridge.

14.7.182 In the eastern sections of the study area, there are areas of 'High' and 'Medium' pluvial water flood risk along the extent of Lowgill Beck, with a large area to the north of Flitholme, and areas adjacent to large reaches of Woodend Sike and Yosgill Sike and their confluence north of the existing A66 crossing.

14.7.183 Throughout the study area there are areas of 'High' and 'Medium' pluvial water flood risk associated with the River Eden and its floodplain, including some areas around minor unnamed tributaries.

14.7.184 The east of the study area has areas of 'High' and 'Medium' pluvial water flood risk associated with the Swindale Beck and Augill Beck, affecting sections of the existing A66 junction.

Historic flooding

14.7.185 Environment Agency data, including a flood incident investigation report published in 2016[60], show historic flooding events associated with the following events in the study area:

- Coupland Beck at Coupland in 2000, 2002, 2005 and 2015
- The River Eden at Ormside in 2005 and 2015 and Sandford in 2015
- Moor Beck at Warcop in 2015
- Swindale Beck within Brough town centre
- River Eden at Warcop in 2009

14.7.186 The flood incident investigation report[60] highlights that Warcop has reportedly experienced minor flood events approximately six times since 1968, most recently in 2015 as the document reports, and before that in 2009 where the River Eden flooded the southern side of the village.

Consented discharges

14.7.187 Seven consented discharges have been identified in Environment Agency data within the study area. As shown in Table 14-28: Consented discharge licences within the Appleby to Brough study area, these include discharges associated with sewage treatment works, pumping stations and hospitality. Presented on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

Table 14-28: Consented discharge licences within the Appleby to Brough study area

Site name	Receiving watercourse	Description
Brough WWTW	Swindale Beck	WwTW/Sewage Treatment Works (water company) Final Effluent

[60] Environment Agency, Cumbria County Council (2016) Flood Incident Investigation Report: Warcop, Flood Event 5th December 2015. Available online. [Accessed February 2022]

Site name	Receiving watercourse	Description
Coupland Hall	Coupland Hall	WwTW (not water co) (not STP at a private premises)
Crooks Beck Syphon CSO	Crooks Beck	Storm tank/CSO on sewerage network (water company – UU)
Hayber Gill Centre	Hayber Beck	Sport, recreation/Golf/Gym/Theme Pk/Spa
Sandford Village WWTW	River Eden	WwTW/Sewage Treatment Works (water company)
Warcop Camp STW	River Eden	WwTW/Sewage Treatment Works (water company – UU)
Warcop Village PS	Crooks Beck	Pumping station on sewerage network (water company – UU)

Bowes Bypass

Designated sites

14.7.188 The scheme is located on the southern boundary of the North Pennines AONB, with the following designations relating to the water environment falling into the eastern extent of the study area:

- The North Pennine Moors SPA
- The North Pennine Moors SAC
- Bowes Moor SSSI
- Kilmond Scar SSSI.

14.7.189 Further details of designated sites within the study area are provided within ES Chapter 6: Biodiversity (Application Document 3.2).

Surface water

14.7.190 The majority of watercourses within the study area drain into the River Greta via a number of tributaries that converge at a low point to the north-east of the A66 and A67 junction.

14.7.191 Table 14-29: Surface water receptors within the Bowes Bypass study area gives a brief description and the classification of the surface water receptors within the study area (from west to east) which are also displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3). The standard naming convention is used for unnamed watercourses, as outlined in Paragraph 14.5.10.

Table 14-29: Surface water receptors within the Bowes Bypass study area

Receptor	Description	Watercourse classification
Bessy Sike	Flows east and then north in the north-west of the study area.	Ordinary watercourse
Unnamed Tributary of River Greta 7.7	Flows south into the River Greta in the west of the study area.	Ordinary watercourse
Unnamed Tributary of River Greta 7.1	Flows south from the existing A66 into the River Greta, south-west of Ivy Hall Farm.	Ordinary watercourse

Receptor	Description	Watercourse classification
Unnamed Tributary of River Greta 7.3	Flows south, crossed by Clint Lane in the north of the study area. Converges multiple field drains into one culvert which flows under the existing A66 and emerges to the south of the existing A66 at Stone Bridge Farm. Watercourse then flows south into the River Greta.	Ordinary watercourse
Chert Gill	Flows north into the River Greta in the south of the study area, culverted under Long Close Lane.	Ordinary watercourse
How Low Gill	Flows north into the River Greta in the south of the study area, culverted at Whorlands.	Ordinary watercourse
Unnamed Tributary of River Greta 7.5	Flows south from Stone Bridge Farm, in the centre of the study area, and is artificially straightened as it flows into the River Greta.	Ordinary watercourse
Unnamed Tributary of River Greta 7.6	Flows east, south of the existing A66, and towards Thackholm with some sections of artificial straightening. Joins the River Greta in the far south-east of the study area, south of Low Broats.	Ordinary watercourse
River Greta	Flows east, parallel to the south of the existing A66 and Bowes. Flows into the River Tees 9.5km downstream of the study area.	Main River
Unnamed Tributary of River Greta 7.2	Flows west, south of the existing A66, in the west of the study area. Flows into the River Greta.	Ordinary watercourse
Thorsgill Beck	Flows east in the north-west of the study area, discharges into the River Tees approximately 5km downstream of the study area.	Ordinary watercourse
Huggill Sike	Flows north, over Huggill Force and into the River Greta, in the south-west of the study area.	Ordinary watercourse
Tom Gill	Flows north and into the River Greta at Tom Gill Plantation, in the south and central area of the study area.	Ordinary watercourse
Unnamed Tributary of River Greta 7.4	Flows east, north of and paralleled to the existing A66 in the central portion of the study area. It is then culverted under the existing A66 and joins the Unnamed Tributary of River Greta 7.5	Ordinary watercourse

14.7.192 In addition to the watercourses described in Table 14-29: Surface water receptors within the Bowes Bypass study area, a number of smaller field drains are present across the study area, which drain into these watercourses.

Surface water WFD catchments

14.7.193 The majority of the study area is within the Greta from Sleightholme Beck to Eller Beck (GB103025072140) WFD catchment. This waterbody

is associated with ‘Moderate’ ecological and ‘Fail’ chemical WFD status in 2019. Barriers of both natural and physical modification origins are recorded as reasons for not achieving 'Good’ status.

14.7.194 In the northern extent of the study area, Deepdale Beck from Source to River Tees (GB103025072170) and Tees from Percy Beck to River Greta (GB103025072512) both are associated with ‘Good’ ecological and ‘Fail’ chemical WFD status in 2019. The Environment Agency do not give a RNAG for either catchment.

14.7.195 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3) and detailed further in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Surface water quality

14.7.196 There is one relevant Environment Agency water quality sampling point shown on the Environment Agency’s online Water Quality Archive as within the study area, outlined in Table 14-30: Environment Agency water quality monitoring points within the Bowes Bypass study area, presented on ES Figure 14.1: Surface Water Features (Application Document 3.3). The sampling point gives an existing water quality baseline for the study area, and a summary is provided in Table 14-31: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Bowes Bypass study area.

Table 14-30: Environment Agency water quality monitoring points within the Bowes Bypass study area

Sampling Point ID	Site Name	Coordinates
NE-45100082	Greta At Gilmonby Br (U/S Bowes Stw)	NY 99560 13220

Table 14-31: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Bowes Bypass study area

Site Name	pH			Temperature (°C)			Dissolved Oxygen (mg/l)			Electrical Conductivity (µs/cm)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Greta At Gilmonby Br (U/S Bowes Stw)	8.0	8.9	6.8	8.0	15.3	1.9	11.8	14.0	7.9	160.6	329.0	54.0

Hydromorphology

14.7.197 Hydromorphology surveys were completed for selected watercourses to understand the existing catchment flow and sediment dynamics and are summarised in Table 14-32: Hydromorphological survey results for Bowes Bypass. Full details are within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). WCP are displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3).

Table 14-32: Hydromorphological survey results for Bowes Bypass

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP20, Unnamed Tributary of River Greta 7.3	Upstream: low flow velocity, ponded Downstream: overgrown channel, gliding flows	Silts and sands	Low lying grasses with sparce tree cover	Generally well connected
WCP21, Unnamed Tributary of River Greta 7.4, Unnamed Tributary of River Greta 7.5	Upstream: little flow and overgrown Downstream: gliding flows, overgrown	Fine sediments with some small gravels	Overgrown riparian strip of long grasses, sporadic thickets of trees	Generally moderate

Groundwater

14.7.198 Regional aspects of the hydrogeology that underlie the schemes, including the aquifer units and WFD groundwater bodies, are described in the routewide baseline section. Those site-specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the following sections.

Groundwater-surface water interactions

14.7.199 All of the limestone formations within the study area have the potential to form karstic features, such as enclosed depressions, caves and springs. The Great Limestone Member includes a number of significant karst features in the area, including caves. The other limestone units have the potential for dissolution but those karst features in the area are generally small scale.

14.7.200 Bowes includes two known caves (K2 and K4) within the study area, and six karst landforms. Further details on these features are presented in ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4).

14.7.201 Twenty groundwater-surface water interactions were initially mapped within the area, which are discussed in ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4).

14.7.202 During consultation, an additional three springs were also identified at the western end of the scheme, at the west end of The Street, Bowes, in the fields to the north of the existing A66 (hereby referred to as Western Bowes Springs).

14.7.203 Additional springs and seepages are likely to be present; particularly in the banks of tributaries and rivers and below the river level of the River

Greta. The River Greta will receive groundwater baseflow from the superficial deposits and bedrock formations.

14.7.204 There are areas of habitat with the potential to support low and moderate dependency GWDTEs within the study area.

Groundwater abstractions

14.7.205 There are no designated groundwater SPZs within the scheme study area.

14.7.206 There are no Environment Agency licensed abstractions within the study area.

14.7.207 Unlicensed abstractions data from Durham County Council identified a number of unlicensed abstractions across the region, including two abstractions to the south of the scheme; labelled as springs and assumed to be surface water abstractions. Due to their locations south of the River Greta (with the A66 north of the river), these springs have been determined to not be in hydraulic continuity with the scheme and have been scoped out of further assessment. ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) provides further details.

14.7.208 There are potentially a number of smaller private domestic, commercial and agricultural unlicensed supplies within the scheme study are, which are assumed to abstract less than 20 m^3/d. It is assumed that each property has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.7.209 There is an area of Fluvial Flood Zone 2 and 3 associated with the River Greta, along the southern extent of the study area. This is relatively confined to the extents of the watercourse due to the surrounding topography. Bowes itself, the existing road and northern tributaries to the River Greta are within Fluvial Flood Zone 1, and therefore have low potential of flooding from rivers.

14.7.210 Baseline fluvial modelling undertaken for the scheme has highlighted flood risk associated with Unnamed Tributary of River Greta 7.3, both north and south of the existing A66 alignment, and eastern Bowes along The Street. An additional area of flood risk adjacent to the north of the existing A66 in the east of the study area is associated with Unnamed Tributary of River Greta 7.4.

14.7.211 The floodplain to the south of the existing A66, associated with Unnamed Tributary of River Greta 7.6 and Unnamed Tributary of River Greta 7.5 shows fluvial flood risk, that is contained within this depression in the landscape.

14.7.212 Full details of the modelling results are published in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4).

Pluvial flooding

14.7.213 There are areas of 'High' pluvial flood risk associated with tributaries of the River Greta along a number of roads within the study area including at the A66 and A67 junction and along sections of The Street, to the west of Bowes. Pluvial flood risk is mostly confined to roads, field drains and within close proximity to existing watercourses, with the majority of the properties within Bowes located within areas of 'Low' risk.

Historic flooding

14.7.214 No historic flood outlines within the study area are shown within Environment Agency data.

14.7.215 HADDMS highlights five flooding hotspots within the study area, one classified as high priory (category B status), south of Clint Quarry and three as moderate priority (category C status) located west of Mount Pleasant Farm, A67 Slip Road, and A66 junction with Low Road. The final low priority (category D) hotspot located south of Hulands Quarry.

Consented discharges

14.7.216 Two consented discharges have been identified in Environment Agency data within the study area for this scheme. As shown in Table 14-33: Consented discharge licences within the Bowes Bypass study area, this includes one discharge linked to a sewage treatment works and one to a quarry. Presented on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

Table 14-33: Consented discharge licences within the Bowes Bypass study area

Site name	Receiving watercourse	Description
Bowes Sewage Treatment Works	River Greta	WwTW/Sewage Treatment Works (water company)
Hulands Quarry	Thorsgill Beck	Mineral/Gravel Extraction/Quarrying

Cross Lanes to Rokeby

Designated sites

14.7.217 There are no designated sites associated with the water environment within the study area for this scheme.

Surface water

14.7.218 Watercourses within the study area drain into the River Tees via a number of tributaries.

14.7.219 Table 14-34: Surface water receptors within the Cross Lanes to Rokeby study area gives a brief description and the classification of the surface water receptors within the study area (from west to east) which are also displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3). The standard naming convention is used for unnamed watercourses, as outlined in Paragraph 14.5.10.

Table 14-34: Surface water receptors within the Cross Lanes to Rokeby study area

Receptor	Description	Watercourse classification
Thorsgill Beck	Flows east in the north-west of the study area, discharging into the River Tees.	Ordinary watercourse
Punder Gill	Flows east parallel to the south of the existing A66, crossed by the Moorhouse Lane in the west of the study area, flowing into Tutta Beck.	Ordinary watercourse
Unnamed Tributary of Punder Gill 8.1	Flows east into Punder Gill, crossing the existing A66 in the west of the study area.	Ordinary watercourse
Unnamed Tributary of Tutta Beck 8.1	Flows north into Tutta Beck, parallel to Moorhouse Lane in the west of the study area.	Ordinary watercourse
Tutta Beck	Flows east, parallel to the south of the existing A66. Crossed by the existing A66 and joins the River Greta in the east of the study area.	Ordinary watercourse
New Cut	Flows south in the south-west of the study area, discharges into the River Greta.	Ordinary watercourse
Unnamed Tributary of Tutta Beck 8.2	Flows north along agricultural field boundaries into Tutta Beck, to the west of Birk House, in the east of the study area.	Ordinary watercourse
Unnamed Tributary of Tutta Beck 8.3	Flows north into Tutta Beck, to the east of Birk House in the west of the study area.	Ordinary watercourse
Partridge Gill	Flows east in the south of the study area, flows into the Wellfield Strand at Jack Wood.	Ordinary watercourse
Wellfield Strand	Flows north in the south of the study area, flows into the Tutta Beck near Ewbank farm.	Ordinary watercourse
Manyfold Beck	Flows east into the River Tees, parallel to the north of the existing A66, joins the River Tees on the east of the study area, downstream of the Abbey Road bridge crossing.	Ordinary watercourse
Unnamed Tributary of Manyfold Beck 8.3	Flows east into Manyfold Beck from Princess Charlotte Wood, culverted beneath B6277.	Ordinary watercourse
Unnamed Tributary of Manyfold Beck 8.1	Flows east into Manyfold Beck from Smithy Cottage, culverted beneath B6277.	Ordinary watercourse
River Greta	Flows north into the River Tees, crossed by the existing A66 (to the north of Greta Bridge) and joins the River Tees 1.1km downstream, in the east of the study area.	Main River
River Tees	Flows east from Barnard Castle to the north of the existing A66, joined by the River Greta to the north-east of the study area.	Main River
Unnamed Tributary of Mannyfold Beck 8.4	Located in the north-east of the study area. Flows north, straightened, and joins the Manyfold Beck, slightly upstream of its meeting with the River Tees.	Ordinary watercourse (field drain)
Unnamed Tributary of River Tees 1.1	Flows east and then north, along predominantly artificially straightened channels, in the north central	Ordinary watercourse

Receptor	Description	Watercourse classification
	portion of the study area. Discharges directly into the River Tees at Abbey Mill House.	

14.7.220 In addition to the watercourses described in Table 14-34: Surface water receptors within the Cross Lanes to Rokeby study area, a number of smaller field drains are present across the study area, which drain into these watercourses.

Surface water WFD catchments

14.7.221 The Greta from Gill Beck to River Tees (GB103025072130) and the Tees from Percy Beck to River Greta (GB103025072512) both are associated with 'Good' Ecological and 'Fail' Chemical status in 2019. The Environment Agency do not give a RNAG for either catchment.

14.7.222 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3) and detailed further in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Surface water quality

14.7.223 There are two relevant Environment Agency water quality sampling points shown on the Environment Agency's online Water Quality Archive as within the study area, outlined in Table 14-35: Environment Agency water quality monitoring points within the Cross Lanes to Rokeby study area, presented on ES Figure 14.1: Surface Water Features (Application Document 3.3). The sampling points give an existing water quality baseline for the study area, and a summary is provided Table 14-36: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Cross Lanes to Rokeby study area.

Table 14-35: Environment Agency water quality monitoring points within the Cross Lanes to Rokeby study area

Sampling Point ID	Site Name	Coordinates
NE-45100075	Tees at Egglestone Abbey	NZ 07229 14701
NE-45100074	Greta at Greta Bridge	NZ 08600 13155

Table 14-36: Summary of water quality data recorded between 2015 and 2020, measured at sampling points within the Cross Lanes to Rokeby study area

Site Name	pH			Temperature (°C)			Dissolved Oxygen (mg/l)			Electrical Conductivity (µs/cm)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Tees at Egglestone Abbey	7.9	8.5	7.3	8.5	19.7	2.0	11.7	14.3	8.4	195.8	727.0	42.0
Greta at Greta Bridge	8.2	8.9	7.5	8.0	16.7	1.5	11.7	14.7	7.6	255.4	1671.0	90.0

Hydromorphology

14.7.224 Hydromorphology surveys were completed for selected watercourses to understand the existing catchment flow and sediment dynamics and are summarised in Table 14-37: Hydromorphological survey results for Bowes Bypass. Full details are within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). WCP are displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3).

Table 14-37: Hydromorphological survey results for Bowes Bypass

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP67, WCP68, Punder Gill	Riffle and pool biotopes to glide flows as velocity slows	Gravels and cobbles	Significant riparian tree cover on both banks, with long grasses and rushes	Upstream: incision and bank erosion, poor connection Downstream: good connection with evidence of out of channel wetting
WCP25, Unnamed Tributary of Tutta Beck 8.2	Very low velocity	Fine material	Overgrown grasses and rushes, some tree cover on right bank	Modified into an agricultural drain, no connection to floodplain
Unnamed Tributary of Punder Gill 8.1	Gliding flows, overgrown channel	Small gravels to very fine sediment	Long grasses and rushes	Moderate connection, some evidence of out of channel wetting
Unnamed Tributary of Tutta Beck	No flow observed	Fine material, bed overgrown	Overgrown with terrestrial vegetation, some lengths of hedgerow	Modified into drain, not connected to the floodplain
Unnamed Tributary of Tutta Beck 8.1	No flow observed	Fine material, bed overgrown	Overgrown with terrestrial vegetation, some tree cover	Modified into drain, not connected to the floodplain

Groundwater

14.7.225 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the routewide baseline section. Those site-specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the following sections.

Groundwater-surface water interactions

14.7.226 All of the limestone formations within the study area have the potential to form karstic features, such as enclosed depressions, caves and springs.

14.7.227 No enclosed depressions or caves were identified within 1km of the study area. Further details on these features are presented in ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4).

14.7.228 Two potential groundwater-surface water interactions were mapped within the study area, presented on ES Figure 14.6 Hydrogeological Study Areas and Features (Application Document 3.3); S18 and S21.

14.7.229 Spring S18 is located south-west of Greta Bridge on the south side of Graham's Gill (with the A66 to the north); upgradient and several hundred metres from the scheme. As such, it is considered that the potential groundwater-surface water interaction is unlikely to be impacted.

14.7.230 Spring S21 is located north-west of the western end of the scheme in an area of limited to no superficial cover with the Great Limestone Member underlying. A pond is located at a topographical low within a field, which drains to an adjacent ditch. Surveying indicates the possibility that the pond may be groundwater fed.

14.7.231 Springs and seepages are likely to be present; particularly in the banks of the rivers and below the river level of the River Tees, Tutta Beck and River Greta. The River Tees, River Greta and Tutta Beck will receive groundwater baseflow from the superficial deposits and bedrock formations.

Abstractions

14.7.232 There are no designated groundwater SPZs within the scheme study area.

14.7.233 There are no Environment Agency licensed abstractions or unlicensed abstractions (provided by Durham County Council) recorded within the scheme study area.

14.7.234 There are potentially a number of smaller private domestic, commercial and agricultural unlicensed supplies within the scheme study are, which are assumed to abstract less than 20 m^3/d. It is assumed that each property has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.7.235 Areas of Fluvial Flood Zone 2 and 3 shown within Environment Agency mapping include areas associated with Thorsgill Beck and its floodplain in the north-west section of the study area and with Tutta Beck parallel, along the south of the study area. Additional areas associated with River Greta are also observed but are limited to the river channel.

14.7.236 Baseline fluvial modelling undertaken for the scheme has revealed additional flood risk areas in the west of the study area, south of the existing A66. This flood risk is associated with Tutta Beck and Plunder Gill.

14.7.237 Full details of the modelling results are published in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4).

Pluvial flooding

14.7.238 Areas of 'high' pluvial water flood risk include:

- In the south-east of the study area associated with natural localised depressions and influenced by the Tutta Beck and River Greta
- In the north of the study area, associated with the Manyfold Beck and minor field drains to the north of the existing A66
- In the west of the study area in pockets of localised depressions in the fields adjacent to the existing A66.

Historic flooding

14.7.239 Environment Agency data shows a small area of historic flooding in the east of the study area at Greta Bridge Bank associated with the River Greta.

14.7.240 HADDMS highlights one flooding hotspots within the study area, classified as high priory (category B status) located at the junction of A66 and Norbeck Bank.

Consented discharges

14.7.241 Seven consented discharges have been identified in Environment Agency data within the study area for this scheme. As shown in Table 14-38: Consented discharge licences within the Cross Lanes to Rokeby study area, these include discharges associated with domestic properties, hospitality and wastewater treatment works. Presented on ES Figure 14.6: Hydrogeological Study Areas and Features (Application Document 3.3).

Table 14-38: Consented discharge licences within the Cross Lanes to Rokeby study area

Site name	Receiving watercourse	Description
Boldron STW	Tributary of Manifold Beck	Waste Collection/Treatment/Disposal/Materials Recovery
Castle Farmhouse Egglestone Abbey	Thorsgill Beck	Domestic property (single) (incl farmhouse)
Cross Lanes Organic Farm	Tutta Beck	Food+Beverage Services/Cafe/Restaurant/Pub
Greta Bridge Farm	River Greta	WwTW (not water co) (not STP at a private premises)

Site name	Receiving watercourse	Description
Sewage treatment plant serving the Morritt Arms Hotel	Tutta Beck	Food+Beverage Services/Cafe/Restaurant/Pub
The Square	River Greta	WwTW (not water co) (not STP at a private premises)
Thorpe Farm	Groundwater via Soakaway	Holiday Accom/Camp Site/Caravan Site/Hotel/Hostel

Stephen Bank to Carkin Moor

Designated sites

14.7.242 There are no designated sites associated with the water environment within the study area for this scheme.

Surface water

14.7.243 Watercourses within the study area drain into the River Swale via a number of tributaries.

14.7.244 Table 14-39: Surface water receptors within Stephen Bank to Carkin Moor study area gives a brief description and the classification of the surface water receptors within the study area (from west to east) which are also displayed on ES Figure 14.1: Surface Water Features (Application Document 3.3). The standard naming convention is used for unnamed watercourses, as outlined in Paragraph 14.5.10.

Table 14-39: Surface water receptors within Stephen Bank to Carkin Moor study area

Receptor	Description	Watercourse classification
Browson Beck	Flows south from Cottonmill Beck into Stalwath Beck, within the River Swale catchment. Located to the east of Newsham, within the south-west of the study area.	Ordinary watercourse
Sprent Beck	Flows north and joins Cottonmill Beck at same confluence point as Sker Burn, in the south-west of the study area.	Ordinary watercourse
Sker Burn	Flows north in the south-west of the study area and into Cottonmill Beck east of Newsham.	Ordinary watercourse
Cottonmill Beck	Flows east into Browson Beck, within the River Swale catchment. Located to the east of Newsham, within the south-west of the study area.	Ordinary watercourse
Dyson Beck	Flows north into Smallways Beck, within the Aldbrough Beck catchment. Located on the west of the study area.	Ordinary watercourse
Hartforth Beck	Flows south from Grange Farm, discharges into Holme Beck at culvert of Comfort Lane.	Ordinary watercourse
Holme Beck	Flows south-west, parallel approximately 1km to the south of the existing A66, within the River Swale catchment. Located in the south-east of the study area.	Ordinary watercourse

Receptor	Description	Watercourse classification
Mains Gill	Flows south to Holme Beck along the west of Mainsgill Farm. Located in the east of the study area. Crossed by existing A66.	Ordinary watercourse
Smallways Beck	Flows north into Hutton Beck, within the Aldbrough Beck catchment. Crossed by the existing A66 to the west of Smallways, on the west of the study area.	Ordinary watercourse
Stalwath Beck	Flows east culverted under Dick Scot Lane and discharges into Dalton Beck south of the existing A66.	Ordinary watercourse
Dalton Beck	Flows east, in the south of the study area. Joins Holme Beck at Ravensworth.	Ordinary watercourse
Unnamed Tributary of Cottonmill Beck 9.3	Flows south from existing A66 through Black Plantation and into Cottonmill Beck.	Ordinary watercourse
Unnamed Tributary of Dalton Beck 9.1	Flows east parallel to the existing A66 and into Unnamed Tributary of Dalton Beck 9.2.	Ordinary watercourse
Unnamed Tributary of Hartforth Beck 1.1	Flows south-east, past Hartford Grange, in the south-east of the study area, and into the Hartforth Beck.	Ordinary watercourse
Unnamed Tributary of Holme Beck 9.8	Flows south to Holme Beck. Crossed by the existing A66 at the upper reach of the watercourse and follows field boundaries to the point it joins Hartforth Beck, to the west of Hartforth. Located on the east of the study area.	Ordinary watercourse (field drain)
Unnamed Tributary of Holme Beck 9.2	Flows south to Holme Beck via Hartforth Beck, crossed by the existing A66 at the upper reach of the watercourse and follows field boundaries to the point it joins Hartforth Beck, to the west of Hartforth. Located on the east of the study area.	Ordinary watercourse (field drain)
Unnamed Tributary of Holme Beck 9.3	Flows south into Holme Beck, crossed by the existing A66 slightly east of Collier Lane and culverted under Waitlands Lane, joins Holme Beck to the north of New Lane. In the centre of the study area.	Ordinary watercourse
Unnamed Tributary of Holme Beck 9.4	Flows south into Holme Beck, crossed by the existing A66 between Collier Lane and Moor Lane, joins Holme Beck to the north of Ravensworth. In the centre of the study area.	Ordinary watercourse
Unnamed Tributary of Holme Beck 9.6	Flows south, crossed by existing A66 and into Unnamed Tributary of Holme Beck 9.3.	Ordinary watercourse
Unnamed Tributary of Holme Beck 9.1	Flows south-west to Holme Beck, upper reach of the watercourse within Street Plantation and crossed by the existing A66. Follows field boundaries to Holme Beck, located on the east of the study area.	Ordinary watercourse
Unnamed Tributary of Hutton Beck 1.1	Flows north, predominantly artificially straightened, in the north of the study area and into Hutton Beck.	Ordinary watercourse (field drain)
Unnamed Tributary of Mains Gill 9.1	Flows south through Middle Plantation in the north of the study area and discharges into Mains Gill east of Moor Lane.	Ordinary watercourse

Receptor	Description	Watercourse classification
Unnamed Tributary of Mains Gill 9.3	Two field drainage features flow south into Mains Gill, join to the east of Moor Lane. Located on the west of the study area.	Ordinary watercourse (field drain)
Unnamed Tributary of Smallways Beck 9.1	Flows north, culverted by existing A66 and Lanehead Lane, and discharges into Smallways Beck south-east of Holm Hills.	Ordinary watercourse
Unnamed Tributary of Smallways Beck 9.4	Flows west and into Unnamed Tributary of Smallways Beck 9.1 in the west of the study area.	Ordinary watercourse

14.7.245 In addition to the watercourses described in Table 14-39: Surface water receptors within Stephen Bank to Carkin Moor study area, a number of smaller field drains are present across the study area, which drain into these watercourses.

Surface water WFD catchments

14.7.246 Skeeby/Holme/Dalton Bk from Source to River Swale (GB104027069180) is associated with ‘Moderate’ Ecological and ‘Fail’ Chemical status in 2019. The status for the supporting element hydromorphology is ‘Good’ and the physio-chemical quality elements have a status of ‘Good’. Pollution from agricultural land management and physical modification are recorded as reasons for not achieving 'Good’ status.

14.7.247 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3) and detailed further in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

Surface water quality

14.7.248 There are no Environment Agency water quality sampling points with the study area.

Hydromorphology

14.7.249 Hydromorphology surveys were completed for selected watercourses to understand the existing catchment flow and sediment dynamics and are summarised in Table 14-40: Hydromorphological survey results for Bowes Bypass. Full details are within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4).

Table 14-40: Hydromorphological survey results for Bowes Bypass

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP74, WCP26, Unnamed Tributary of Cottonmill Beck 9.3	No flow observed	Fine material	Channel overgrown, riparian trees and hedgerows along banks	No evidence of connectivity, roadside drain

Watercourse	Flow Biotypes	Bed Substrate	Riparian Composition	Floodplain Connectivity
WCP27, WCP75, Unnamed Tributary of Browson Beck 9.1	No flow observed	Fine material	Channel overgrown, riparian trees along banks	No evidence of floodplain connectivity
WCP28, Unnamed Tributary of Holme Beck 9.6	Low flow, still pooled water	Fine material	Woodland and hedgerows along banks. Channel vegetated	No evidence of connectivity, roadside drain
WCP76, Unnamed Tributary of Holme Beck 9.5	Pooled sections, low flow	Upstream: fine materials Downstream: gravels and cobbles	Upstream: poor coverage with livestock poaching Downstream: Thickets of riparian tree cover, vegetation within channel bed	Trapezoidal channel, incised. Disconnected from the floodplain
WCP31,Unnamed Tributary of Mains Gill 9.1 WCP30, Mains Gill	Upstream: low flow with gliding flows Downstream: alternating riffle and pool biotopes	Upstream: gravels and fine sediment Downstream: gravels, cobles and boulders	Large areas of woodland, interspersed with sections of long grasses	Some over deepening of the channel has led to disconnection but in general good connection
WCP32, WCP77, Unnamed Tributary of Holme Beck 9.8	Low flow with no distinguishable flow biotopes	Fine sediments	Channel is vegetated with long grass, areas of riparian tree cover	Lack of connection to floodplain due to trapezoidal shape
WCP33, Unnamed Tributary of Holme Beck 9.2 WCP34, Unnamed Tributary of Holme Beck 9.7	Very low flow velocity	Fine sediments with some gravels	Channel bed colonised by grasses, hedgerows line banks	Incised trapezoidal shape, no connection to floodplain

Groundwater

14.7.250 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the routewide baseline section. Those site-specific features, such as

groundwater surface water interactions (springs and sinks) and abstractions are described in the following sections.

Groundwater-surface water interactions

14.7.251 All of the limestone formations within the study area have the potential to form karstic features, such as enclosed depressions, caves and springs. The Great Limestone Member includes a number of significant karst features in the area, including caves. The other limestone units have the potential for dissolution but those karst features in the area are generally small in scale. Further details on these features are presented in ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4).

14.7.252 There is one potential groundwater-surface water interaction in this scheme study area, presented on ES Figure 14.6 Hydrogeological Study Areas and Features (Application Document 3.3); Spring S1. Spring S1 is a suspected groundwater-surface water interaction comprising an ornamental pond fed by a pipe at the base of a brick wall on sloping ground. The area is overgrown, but water quality parameters indicate that the pond is likely to be groundwater fed.

14.7.253 Additional springs and seepages are likely to be present; particularly in the banks of watercourses and below the river level of the courses. The watercourses will receive groundwater baseflow from the superficial deposits and bedrock formations.

14.7.254 There are areas of habitat with the potential to support low and moderate dependency GWDTEs within the study area.

Abstractions

14.7.255 There are two designated groundwater SPZs within the study area. These SPZs are associated with Environment Agency licensed abstractions.

14.7.256 The Environment Agency licensed abstractions within the study area, presented on ES Figure 14.6 Hydrogeological Study Areas and Features (Application Document 3.3), comprise:

- Pond Dale abstraction well (license number: 2/27/23/661/R01)
- Blackhill Farm abstraction well (no licence number).

14.7.257 There are potentially a number of smaller private domestic, commercial and agricultural unlicensed supplies within the scheme study are, which are assumed to abstract less than 20 m^3/d. It is assumed that each property has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.7.258 The western section of the study area contains an area within Fluvial Flood Zones 2 and 3, associated with the Cottonmill Beck and Browson Beck and the*ir* combined floodplain, as shown on the Environment Agency flood map.

14.7.259 Baseline fluvial modelling undertaken for the scheme has highlighted small areas of flood risk along the existing A66 corridor in the central and east of the study area, associated with tributaries of the Holme Beck and Mains Gill.

14.7.260 Full details of the modelling results are published in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4).

Pluvial flooding

14.7.261 In the centre of the study there are areas of 'High' pluvial water flood risk displayed adjacent to the tributaries of Holme Beck located south of, and crossing under, the existing A66.

14.7.262 In the east of the study area there are areas of 'High' pluvial water flood risk associated with depressions in the topography and influenced by the Unnamed Tributary of Mains Gill 9.3 and Mainsgill that cross underneath the existing A66.

14.7.263 In the east of the study area there are areas of 'High' pluvial water flood risk adjacent to the existing A66, likely influenced by field drains.

Historic flooding

14.7.264 Environment Agency data shows no historic flooding events within the study area.

14.7.265 HADDMS highlights six flooding hotspots within the study area, one classified as very high priory (category A status) located east of the A66 junction with Waitlands Lane, two as high priory (category B status) at New Lane junction and Forcet Lane junction with A66, two as moderate priority (category C) at New Road and Forcet Lane junction with A66 and one low priority hotspot (category D) located at Browson Bank.

Consented discharges

14.7.266 Six consented discharges have been identified in Environment Agency data as within the study area for this scheme. As shown in Table 14-41: Consented discharge licences within the Stephen Bank to Carkin Moor study area, these include wastewater treatment works.

Table 14-41: Consented discharge licences within the Stephen Bank to Carkin Moor study area

Site name	Receiving watercourse	Description
A66 Motel	Infiltration to land	WwTW (not water co) (not STP at a private premises)
Foxwell Farm	Ravensworth	WwTW (not water co) (not STP at a private premises)
Monks Rest Farm	Tributary of Mains Gill	WwTW (not water co) (not STP at a private premises)
Newsham (Richmond) STW	Burdeys Gill	WwTW/Sewage Treatment Works (water company)
Ravensworth WPC Works	Holme Beck	WwTW/Sewage Treatment Works (water company)

Site name	Receiving watercourse	Description
Ravensworth SPS	Holme Beck	Pumping Station on Sewerage Network (water company)

A1(M) Junction 53 Scotch Corner

Designated sites

14.7.267 There are no designated sites associated with the water environment within the study area for this scheme.

Surface water

14.7.268 The study area surrounds the Scotch Corner junction, west of Middleton Tyas. This area is characterised by a number of major roads and their associated infrastructure and agricultural land.

14.7.269 There are no main watercourses within the study area. The ordinary watercourses in the study area drain south towards the River Swale. Ludburn Beck flows south in the east of the study area towards Moulton, crossed by existing Middleton Tyas Lane and is culverted for the majority of its length.

14.7.270 In addition to the Ludburn Beck, a number of smaller field drains are present across the study area.

Surface water WFD catchments

14.7.271 The Scorton Beck from Source to River Swale (GB104027069160) is associated with ‘Poor’ Ecological status and ‘Fail’ Chemical status in 2019. Pollution from the water industry and agricultural land management are recorded as reasons for not achieving 'Good’ status.

14.7.272 WFD surface waterbodies are presented in ES Figure 14.3: WFD Surface Waterbodies (Application Document 3.3).

Surface water quality

14.7.273 There are no Environment Agency water quality sampling points with the study area.

Groundwater

14.7.274 Regional aspects of the hydrogeology that underly the study area, including the aquifer units and WFD groundwater bodies, are described in the routewide baseline section. Those site-specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described below.

Groundwater-Surface water interactions

14.7.275 There are no recorded springs or sinks in the study area.

14.7.276 No groundwater-surface water interactions are mapped within the area. Springs and seepages are likely to be present; particularly in the banks

of watercourses. Watercourses in the area will receive groundwater baseflow from the superficial deposits and bedrock formations.

Abstractions

14.7.277 There are no designated groundwater SPZs within the study area.

14.7.278 There is one Environment Agency licensed abstraction within the study area:

- Abstraction well (licence reference 2/27/23/702/R01) in Middleton Tyas

14.7.279 There are potentially a number of smaller private domestic, commercial and agricultural unlicensed supplies within the scheme study are, which are assumed to abstract less than 20 m^3/d. It is assumed that each property has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.7.280 The study area is located within Fluvial Flood Zone 1 and is therefore of low flood risk from fluvial sources.

Pluvial flooding

14.7.281 Areas in the west and north of the study area have ‘Low’ with small areas of ‘Medium’ pluvial water flood risk, associated with minor field drains and holding ponds.

14.7.282 Areas of ‘High’ pluvial water flood risk are concentrated in the south and south-west of the study area, associated with depressions in the topography and the Ludburn Beck.

Historic flooding

14.7.283 Environment Agency data shows no historic flooding events within the study area.

14.7.284 HADDMS highlights one flooding hotspot within the study area, classified as moderate priory (category C status) located at the A1(M) junction.

Consented discharges

14.7.285 There are no consented discharges within the study area recorded in the Environment Agency data.

Assessment of Value

14.7.286 Assessment of value of water environment receptors within the study area, as per the methodology described in Section 14.4 Assessment Methodology are reported in detail within ES Appendix 14.10: Assessment of Value (Application Document 3.4).

Future baseline

14.7.287 As set out in ES Chapter 4: Environmental Assessment Methodology (Application Document 3.2), the 'Do-Minimum' and ‘Do-Something’

scenarios have been set out, with the 'Do-Minimum' scenario representing the future baseline without the Project (i.e. the existing road, only subject to ongoing maintenance). The future baseline considers any likely change in conditions that will occur in the absence of the Project - for this chapter that is mainly climate change impacts.

14.7.288 There are two future baseline years that the Project considers:

- Opening year - when the scheme is operational (i.e. open to traffic) is 2029
- Design year/future year - a future year scenario 15 years after the opening year when mitigation measures are likely to have achieved their desired outcome, (i.e. future/design year) is 2044.

14.7.289 Consultation with the Eden Rivers Trust has revealed a proposal to create a more naturalised channel for Trout Beck, closer to its original path through the floodplain. This has been incorporated into the design and considered as being in the future baseline.

14.7.290 There is potential for water quality to improve and baseline WFD status to improve as the RBMPs are implemented, as these aim to achieve 'good' status by 2027 for WFD waterbodies. This is considered to be within the future baseline.

14.7.291 Potential changes to road drainage and water environment receptors in the future will not be noticeable i.e. accidental spillage is unlikely to change and the receptor groups are unlikely to be different to those identified in Section 14.7 Baseline Conditions.

14.7.292 The in-combination climate change assessment has used a future climate baseline that is based on representative concentration pathway 8.5 (RCP 8.5) of the UK Climate Change 2018 Projections (UKCP18). They indicate that the study area may undergo climatic changes including higher temperatures, increase in heat waves, reduced precipitation in summer and increased precipitation in winter. Surface water flows are likely to become more variable, with more frequent extremes and an increase in flooding. This future climate baseline is presented in ES Chapter 7: Climate (Application Document 3.2).

14.7.293 ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4) accounts for the UKCP18 projections within the highways drainage design and the assessment. At the time of writing, the latest published climate change data was used to apply the central, higher central, and upper end peak rainfall allowances for the 2080 epoch for all schemes.

14.8 Potential impacts

14.8.1 Based on the Project design and associated construction activities, the Project has the potential to impact upon the receiving water environment during both construction and operation.

14.8.2 The design of the Project, including any embedded mitigation measures that have been incorporated, are described in ES Chapter 2: The Project (Application Document 3.2). Any key aspects of the design and

embedded mitigation are also referenced in this section where they are directly applicable to this assessment.

14.8.3 Potential impacts of the Project are described in this section prior to the implementation of the essential mitigation described in Section 14.9 Essential mitigation and enhancement measures. The residual effects of the Project, taking into account this essential mitigation, are then described in Section 14.10 Assessment of likely significant effects.

14.8.4 Embedded mitigation measures for road drainage and the water environment include structures within the watercourse designed in accordance with CD 529 (Design of outfall and culvert details) and CIRIA C786 Culvert, Screen and Operation Manual guidance. In addition, embedded mitigation such as the incorporation of climate change allowances in the drainage design have been informed by flood modelling. This is detailed in the EMP (Application Document 2.7).

14.8.5 Opportunities have been explored through the optioneering process, to avoid identified water environment constraints. The optioneering process is detailed in ES Chapter 3: Assessment of Alternatives (Application Document 3.2), which has identified offline routes to minimise impacts on the floodplain (minimise crossing distance, minimise land take within floodplain, increasing distance from sensitive receptors) and hydromorphology.

Construction

Design and embedded mitigation

14.8.6 As set out in Section 14.5, the assessment reported in this chapter is based on a precautionary worst case scenario. As such, the mitigation identified in this chapter as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this chapter) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this chapter. The fundamental point is that the mitigation identified in this chapter is secured by the EMP (Application Document 2.7) and the Project Design Principles (PDP) (Application Document 5.11) which is provided as part of the DCO submission. The EMP and DPD will be secured by a legal requirement in the DCO.

14.8.7 The EMP includes measures that are considered standard good practice to be implemented by the construction contractor to reduce the likelihood of impacts, or their magnitude if they were to occur (including, for example, pollution prevention measures set out on GOV.UK and in the Construction Industry Research and Information Association's Guidance for Pollution Prevention). The EMP also includes the Ground and Surface Water Management Plan (Annex B7 of the EMP).

Monitoring requirements are outlined in Section 14.11: Monitoring, and detailed requirements will be derived during the detailed design phase.

14.8.8 Examples of standard practice mitigation measures that are included in the EMP include the provision of spill kits, restricting site traffic to dedicated haul roads and ensuring hard-standing areas are regularly swept and maintained.

14.8.9 Effective delivery of the measures outlined in the EMP would be monitored during the construction phase.

Surface Water Management

14.8.10 Scheme specific measures to manage surface water include surface water management systems that utilise measures such as temporary silt fencing, cut off ditches, settlement ponds and bunds. These will be set up early in the construction period to capture all runoff and prevent ingress of sediments and contaminants into existing drainage ditches where necessary. This would be managed through implementation of the EMP in accordance with CIRIA guidelines and the Environment Agency's approach to groundwater protection (Environment Agency, 2017a)[61] and groundwater protection guidelines (Environment Agency, 2017b)[62].

14.8.11 Areas of exposed sediment deemed at risk of erosion during heavy rainfall or flood inundation will be protected using either temporary measures (e.g. sheeting) or semi-permanent measures (for example coir matting) until vegetation is able to establish on these surfaces. Further measures on the storage and management of soils are included in ES Chapter 9: Geology and soils (Application Document 3.2) and the Soil Management Plan (Annex B9 of the EMP, Application Document 2.7).

14.8.12 Works within areas of floodplain, as defined by Environment Agency and the Projects flood modelling, will utilise the Environmental Agency 5-day flood risk forecast and the Environment Agency Floodline Warnings Direct to be proactive in the management of risks associated with working in the floodplain.

14.8.13 Impacts of surface water temporary abstractions will be assessed within the regulatory framework for abstractions (Environment Agency abstraction licenses) and discharges (Environment Agency environmental permits), ensuring that the works do not have an unacceptable impact on receiving receptors. Abstractions from the River Eden SAC and functionally linked habitats will not be taken direct from surface waters, to avoid impact on designated features and the species supported by the River Eden SAC. Details are presented within the HRA LSE and SIAA (Application Document 3.4).

14.8.14 Water with a higher risk of contamination which requires discharge, including groundwater pumped out of pilings during concrete pouring, will be contained and treated using appropriate measures such as coagulation of sediments, dewatering and pH neutralisation prior to

[61] Environment Agency (2017a) Protect groundwater and prevent groundwater pollution
[62] Environment Agency (2017b) Groundwater protection technical guidance

discharge. Such discharges will be regulated via environment permits issued by the Environment Agency.

14.8.15 A water quality monitoring programme prior to and during construction works will be established. Further details on this are provided in Section 14.11: Monitoring and Annex B7 of the EMP (Application Document 2.7).

Watercourse crossings and realignments

14.8.16 Where culverts are to be constructed or in channel works are proposed then construction activities will be appropriately timed and staggered to reduce impacts on surface and groundwater flows that are temporarily diverted upstream of the works area. Timing of works to avoid sensitive seasons such as fish spawning will also be implemented and is detailed in ES Chapter 6: Biodiversity (Application Document 3.2).

14.8.17 Construction of temporary crossings and other temporary infrastructure such as haul roads and set down areas will be designed with due consideration, in the use of materials and techniques, to the sensitivity of the location, such as proximity to the River Eden SAC and functionally linked habitats. Temporary infrastructure will avoid the introduction of foreign sediments into the floodplain or watercourses by using modular metal folding roads/grids rather than imported materials, so to not impact the geomorphology of the sensitive area.

Management of dewatering activities

14.8.18 Local groundwater catchment and flow regimes that may be affected by dewatering design will be included within the design and planning at detailed design stage, with abstracted water discharged to the same groundwater catchment and down gradient of the dewatered element, where feasible.

14.8.19 Discharge from dewatering activities such as earthworks, works within a floodplain or within eight metres of a watercourse will have a tailored risk assessment, alongside appropriate consents, and licences from the Environment Agency. Dewatering abstractions may also require transfer licenses from the Environment Agency. These will be informed by site specific hydrogeological assessments completed at detailed design as further site-specific information is received. Further mitigation in relation to the safeguarding of aquatic ecology during dewatering activities is outlined in ES Chapter 6: Biodiversity (Application Document 3.2).

14.8.20 Grouting may be required to treat voids encountered during earthworks. Furthermore, cutting and slope stabilisation works may involve the use of soil nails, rock anchors and/or rock bolts, all of which involve the use of typically steel reinforcing elements drilled and grouted into the slopes or cutting faces. Grout is usually injected under pressure through the centre of hollow threaded steel reinforcement bars in order to completely fill the annulus between the bar and the surrounding ground. It is not readily possible to prevent grout from entering fissures or voids should they be present within the rock mass being stabilised.

14.8.21 However, appropriate grouting methodologies will be adopted to reduce any risks to the water environment, where appropriate. This will include limitation of grout volumes, use of high viscosity grout, monitoring for pH spikes in monitoring standpipes/surface flows. The use of polymer grouts is proposed in the event that such control measures are not practical to control risks associated with conventional cementitious grout. The results of intrusive and geophysical investigations, and tracer tests where available, will be used when developing design solutions which may require the use of grout.

Underground structures

14.8.22 A site-specific foundation works risk assessment (FWRA) for the construction of underground structures and ground improvement works will be conducted. This will be shared with the Environment Agency for consultation and agreement prior to construction. This is also required with respect to land contamination risk management and is detailed further in ES Chapter 9: Geology and soils (Application Document 3.2).

14.8.23 Design of underground structures will require drainage provisions to relieve hydrostatic pressure. These will allow for groundwater flow around the structure.

14.8.24 Abstraction points will be pre-approved and a permit system put in place for extraction. Attenuation ponds will be constructed and set up to facilitate extraction of water for use in damping down (dust suppression) during construction.

Potential impacts before essential mitigation and enhancement

14.8.25 During construction, significant potential impacts to surface water and groundwater features and flood risk receptors could arise from:

- Increased pollution entering the watercourses or aquifers, from mobilised suspended solids and spillage of fuels or other harmful substances that may migrate to surface water and groundwater receptors impacting water quality
- Impacts to the hydromorphological and ecological quality of watercourses associated with works within or in close proximity to watercourses, including physical change to the watercourses and longer-term changes associated with sediment deposition
- Changes to impermeable areas and flow rates impacting flood risk
- Impacts to local land drainage structures, which may alter existing drainage patterns within catchments and provide potential pathways for pollution
- Impacts to groundwater levels, flows and quality arising from construction activities, primarily dewatering; earthworks and intrusive investigation works creating new flow paths for groundwater.

14.8.26 Further details of construction potential impacts are provided in the following sections.

Surface water

Surface water quantity

14.8.27 The introduction construction water management drainage may divert water between surface water catchments. This potential interruption and diversion of flow may lead to a reduction or loss of water supply to abstractions, springs and watercourses and potential loss of habitat (which may be permanent). The transfer of water from one catchment to another potentially affects resource availability further down-gradient in the confined aquifers.

14.8.28 Embankments and earth bunds could create a barrier for springs that feed into the surface watercourses, and redirection of flows to a different catchment could reduce catchment areas and change the flow regime within receiving surface waters. This may also have consequential effects on aquatic ecology.

14.8.29 The construction of cuttings and treatment of any voids (e.g., large fissures or conduits) encountered may result in blockage of flow paths within the rock mass. This could impact upon water resource availability for springs and baseflow.

14.8.30 Construction works may require abstractions from surface water features to provide a source of water for processes such as dampening down/dust suppression. The abstraction of water from watercourses has the potential to impact on the quantity of water of the receptor, impacting on the hydromorphology processes and biodiversity. Any abstractions from watercourses would be subject to the securing the appropriate licences prior to abstraction.

Surface water quality

14.8.31 Working in, on or adjacent to watercourses and their floodplains may affect surface water quality through the accidental discharge of fine sediments or chemicals, including hydrocarbons. There may also be impacts to channel form through plant movements and operations.

14.8.32 Where works require groundwater control measures, such as local groundwater level reduction or removal of the water from the excavation (dewatering), the discharge of removed groundwater into surface watercourses may affect the quality of the receiving watercourses, primarily through sediment release but also if the removed groundwater is contaminated.

14.8.33 Stockpiling of construction materials and excavated spoil may contaminate or pollute surface waters if they are not stored correctly. These contaminants and pollutants may include fuels, oils, chemicals and concrete. Removal of topsoil or hardstanding and exposure of underlying soils to increased rainwater infiltration may result in pollutants leaching into the underlying aquifer.

14.8.34 Drainage for construction works may also distribute contaminants and pollutants to surface water receptors or their catchments, or create an accumulation of these substances where soakaway basins are used.

Hydromorphology and geomorphology

14.8.35 The culverting and realignment of watercourses may result in the permanent loss of hydromorphological features and ecological value. The construction works may also result in the loss of geomorphological features and habitat niches within the affected channel and potentially downstream.

14.8.36 Such physical/morphological changes to watercourses can be associated with changes in sediment deposition and erosion (river processes) and are likely to have localised impacts on the watercourse. There is potential for culverting and realignments to change the geomorphological features of a watercourse that could impact downstream river processes such as the qualifying features of the River Eden SAC.

14.8.37 Additionally, the introduction of haul roads and set down areas into the floodplain have the potential to introduce foreign materials to the system, and to create a barrier in the floodplain that disrupts flow pathways in the event of a flood. This may result in an adverse impact on the geomorphology of the River Eden SAC and functionally linked habitats.

Groundwater

Groundwater levels and flows

14.8.38 Construction works may locally reduce the rate of recharge to aquifers where the runoff is managed and then discharged. This has the potential to reduce flow of springs, watercourses and groundwater abstractions.

14.8.39 ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) identifies that numerous cuttings along the route have the potential to intersect groundwater levels; primarily within the superficial deposits. On this basis, the requirement for temporary groundwater control measures to enable construction will need to be considered for each cutting.

14.8.40 Where works would require groundwater control measures e.g., local groundwater level reduction or removal of the water from the excavation (dewatering), this could locally reduce groundwater levels and divert flow. This risk would depend on the time of year as flows and levels would vary in an aquifer of this nature. This water may also be connected to spring systems which feed into local watercourse baseflows and agricultural irrigation. The impact of temporary dewatering on groundwater resources would be local to the excavations and last for the duration of the works only.

14.8.41 The majority of cuttings are located within the superficial deposits and are significantly shallower than abstraction levels. As such, temporary dewatering impacts on the majority of licensed abstractions are generally considered to be negligible along the scheme.

14.8.42 The radius of influence of cuttings in the M6 Junction 40 to Kemplay Bank Roundabout area will extend into the SPZ III; however, these

cuttings are located within glacial deposits and not the Penrith Sandstone.

14.8.43 A number of abstractions are likely to be directly impacted by the construction works, including the two British Gypsum wells in the Kirby Thore Bypass area, and Flitholme Spring in the Appleby to Brough area. These receptors will need a suitable alternative supply to be provided, in consultation with the stakeholders.

14.8.44 Construction activities may lead to a reduction or cessation of spring flow and baseflow supplying watercourses along the route. The impacts on mapped springs along the route have generally been considered to be negligible following assessment, however, groundwater-surface water interactions are anticipated to be prolific across the scheme and locally irrigate agricultural fields and feed drains/ditches/troughs.

14.8.45 Where impacts are potentially more significant (e.g., where springs may feed GWDTE), further detailed survey and assessment would be undertaken during detailed design. If detailed assessment still shows that there are risks that could impact local receptors then additional mitigation will be implemented. This mitigation will comprise lining of cuttings to prevent groundwater ingress with an appropriate drainage blanket beneath/surrounding to promote groundwater flow and prevent mounding. Alternatively, specific scheme components (such as underpasses) will be redesigned within the LoDs to avoid sensitive areas.

14.8.46 The Project comprises structures such as overbridges and underbridges, which will require appropriate foundation design which may include piled foundations. Such below ground structures may act as barriers to shallow groundwater flow and they may provide more vertical downward pathways for perched/shallow groundwater flow into the deeper aquifer. Contamination migration as a result of the scheme is considered in ES Chapter 9: Geology and soils (Application Document 3.2).

14.8.47 Underground structures may cause local changes to groundwater flow and mounding of groundwater on the up-gradient side of the structure (raised groundwater levels on the up-gradient side with potentially reduced groundwater levels on the down-gradient side) causing creation or reactivation of springs or even induce groundwater flooding. This could have an impact on springs, watercourses, groundwater-dependent habitats and abstractions, where flow could be reduced or temporarily ceased. Considering the structures as part of the scheme and the extent of the below ground foundation works associated with these structures, these impacts are likely to be localised. Drainage can be incorporated to enable groundwater flow around impermeable structures where flow impacts could have a significant local effect.

Groundwater quality

14.8.48 Where works would require groundwater control measures e.g., local groundwater level reduction or removal of the water from the excavation (dewatering), this could locally reduce groundwater levels and divert

flow, allowing migration of any contamination. Risk assessment for contaminant mobilisation, and detailed planning of mitigation to prevent it occurring, is to be undertaken in areas where contamination is identified (e.g., during further ground investigation or construction).

14.8.49 Discharge of removed groundwater into surface watercourses may affect the quality of the receiving watercourses, primarily through sediment release but also if the removed groundwater is contaminated.

14.8.50 Ground investigation boreholes may create pathways to sensitive aquifers through relatively low permeability formations. New flow pathways for pollution may also be created, allowing polluted waters to enter water bodies not previously impacted by pollution. There may be localised effects upon water quality within the aquifers.

14.8.51 Drainage for construction works may also distribute contaminants and pollutants to other parts of the aquifer and create an accumulation of these substances where soakaway basins are used. This has the potential to impact the water quality of surface waters, aquifers, springs, abstractions and groundwater-dependent habitats indirectly via site runoff or directly where works are close to and within a waterbody. Pollution prevention measures are to be implemented to minimise the risk of pollution entering water bodies.

GWDTE

14.8.52 The Project has the potential to alter existing hydrogeological conditions which may impact on habitats with the potential to support GWDTEs during construction.

14.8.53 Impacts upon ecological habitats by the Project is considered in detail in ES Chapter 6: Biodiversity (Application Document 3.2).

Accidental spillage

14.8.54 Stockpiling of construction materials and excavated spoil may contaminate or pollute water environment receptors if they are not stored correctly. These contaminants and pollutants may include fuels, oils, chemicals, and concrete. This has the potential to impact the water quality of surface waters, aquifers, springs, abstractions, and groundwater-dependent habitats indirectly via site runoff or directly where works are close to and within a water body.

14.8.55 Introduction of wet concrete and grout into potential fissures has the potential to impact upon groundwater quality due to its inherently high pH and the potential to migrate. This would impact upon the water quality of the aquifer, springs, watercourse base flows and groundwater-dependent habitats. Local abstractions may also be impacted, dependent on their proximity.

14.8.56 Removal of topsoil or hardstanding and exposure of underlying soils to increased rainwater infiltration may result in pollutants leaching into the underlying aquifer.

14.8.57 Drainage for construction works may also distribute contaminants and pollutants to other parts of the aquifer and create an accumulation of these substances where soakaway basins are used.

Flood risk

Pluvial and fluvial flood risk

14.8.58 Flood risk may be affected during the construction phase as a result of construction works and temporary storage areas within a floodplain that may temporarily affect the floodplain function, resulting in an increase in flood risk at that location or elsewhere.

14.8.59 Any construction works on areas that drain to watercourses have the potential to increase the rate and volume of runoff and increase the risk of blockages in watercourses that could lead to flow being impeded, and a potential rise in flood risk. Changes to ground levels, temporary increases in impermeable area and vegetation clearance works may also increase the risk of surface water flooding. Finally, excavations can potentially damage existing sewers leading to flooding.

14.8.60 Land drainage plays an important role in preventing localised flooding, irrigating fields and feeding local surface water features. Any impacted land drainage features would be appropriately maintained, reinstated, or compensated.

Groundwater flood risk

14.8.61 The BGS Groundwater Flooding map indicates there is the potential for clearwater flooding and flooding from superficial deposits within the routewide study area. In these areas, any excavations would be at an increased risk of groundwater flooding and any discharges to ground could exacerbate groundwater flooding.

Construction Decommissioning

14.8.62 Consideration has been given to the decommissioning of the construction phase, particularly how site compounds and any dedicated haul routes will be decommissioned to avoid unwanted environmental impacts. The EMP (Application Document 2.7) sets out measures that would be implemented upon decommissioning of the construction phase to and during transition of the Project from construction to operation. This may include construction drainage and settlement ponds that require to be infilled and removed once the operational drainage systems are in place.

Operation

Design and embedded mitigation

14.8.63 As set out in Section 14.5, the assessment reported in this chapter is based on a precautionary worst case scenario. As such, the mitigation identified in this chapter as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same

outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this chapter) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this chapter. The fundamental point is that the mitigation identified in this chapter is secured by the EMP (Application Document 2.7) and the Project Design Principles (DPD) (Application Document 5.11) which is provided as part of the DCO submission. The EMP and DPD will be secured by a legal requirement in the DCO.

14.8.64 As described in ES Chapter 2: The Project (Application Document 3.2), the crossing of Trout Beck for the Temple Sowerby to Appleby scheme and a number of watercourse crossings, including Hayber Beck, Moor Beck and Eastfield Sike, for the Appleby to Brough scheme, have the potential to affect qualifying features of the River Eden SAC designation.

14.8.65 Through consultation with the Environment Agency and Natural England, the following design principles (outlined in Application Document 5.11) have been incorporated for the relevant crossings so that the scheme designs will not prevent the SAC achieving its target of restoring natural hydrological processes:

- Locations and orientation of piers within the floodplain to be placed in order to minimise disturbance to flood flows, sediment transport and biodiversity. This will require an iterative design process to be informed by flood risk and geomorphological modelling (secured in the EMP (Application Document 2.7)). The EMP requires flood risk and geomorphological modelling to be undertaken as part of the detailed design process and the outcomes of that will inform the location and orientation of the piers to achieve the necessary outcomes.
- Specialist geomorphologist input throughout the detailed design of the Project to inform the pier design including shape, alignment relative to the watercourse flow and foundation depth. This will minimise the risk of an interruption of the hydraulic processes should the piers become mid-channel structures following lateral migration of the watercourse
- Permanent outfall structures from road drainage into Trout Beck will be set back from the watercourse banks and an open channel used to connect the outfalls to the watercourse. This will allow lateral migration of the river channel and limit damage to outfalls.

14.8.66 In addition to the specific design and embedded mitigation detailed in this section, the Project commits to the design principles outlined in Project Design Principles (Application Document 5.11).

Watercourse crossings and realignments

14.8.67 New or extended crossings may require a change to the watercourse channel plan to align the existing watercourse through the proposed crossing. Realignments due to watercourse crossings are proposed for Unnamed Tributary of the Lowgill Beck 6.1, Punder Gill, Yosgill Sike and Woodend Sike. The design of the watercourse realignments have been

assessed by experienced hydromorphologists. Further input at detailed design by experienced hydromorphologists and ecologists will be sought and is secured in the EMP (Application Document 2.7). The EMP input from experienced hydromorphologists and ecologists to be undertaken as part of the detailed design process and the outcomes of that will inform the design of watercourse crossings and alignments to achieve the necessary outcomes. This will include the following in-channel enhancements (as appropriate to the hydromorphological regime of the watercourse at the site location), which will be designed in consultation with the Environment Agency and with input from a suitable qualified Fluvial Geomorphologist and Aquatic Ecologist:

- re-meandering of watercourses (within Order Limits)
- provision of in-channel fluvial geomorphological features such as berms and bars to promote flow sinuosity and width/depth variation and provide marginal habitat
- improvement of morphological flow types such as pools, riffles and runs, to provide aquatic habitat diversity
- provision of defined low-flow channels to sustain appropriate flow depths and velocities and improve potential for fish passage
- provision of varied channel bank profiles to improve morphological diversity, included areas of shallow-graded channel banks to allow for marginal vegetation growth.

14.8.68 Proposed realignments will incorporate a 10m wide buffer strip on both sides of the new channel in order to allow for, where practicable, the implementation of marginal and riparian habitat improvements.

14.8.69 Watercourse crossings associated with the River Eden SAC and functionally linked habitats have been designed so that no realignments are required and to ensure that impacts on the SAC and to supporting hydromorphological and geomorphological processes are avoided.

14.8.70 Potential adverse effects upon hydromorphology from new culverts and outfalls would be suitably mitigated by following the guidance in *DMRB CD 529 Design of outfall and culvert details* during detailed design.

Drainage design

14.8.71 The carriageway drainage consists of multi-stage treatment measures to collect, store, convey and treat routine runoff. These include will measures such as grassed swales (dry), catch-pits and detention basins to remove and retain soluble and suspended pollutants to ensure discharges to groundwater or watercourses are to acceptable levels.

14.8.72 The drainage design will also incorporate measures to control and contain spillages, where required. Any spillages on the scheme following road accidents would be routinely managed by National Highways, which is responsible for the maintenance of trunk road assets.

14.8.73 Discharges from the proposed drainage system, including any treatment requirements, will be compliant with relevant standards (*DMRB LA 113*,

CG 501[63] and *CG 532*[64] and have been assessed using HEWRAT). Further water quality improvement measures will be added if the detailed assessment undertaken at detailed design identifies the need. Further treatment may include, for example, vegetated ditches, vortex grit separators and swales.

14.8.74 Flow volume, discharge rate and quality control measures are incorporated into the scheme design, flow volumes have been set for each scheme based on CIRIA guidance and agreed with the relevant county councils where required. The drainage design includes a 20% climate uplift, details of this and the drainage discharge rates for each scheme can be found within ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4). Detailed design will ensure that scour protection, including headwalls, is implemented where necessary. The design will aim to minimised the footprint of the drainage outfall within the channel to be a suitably sized compared to the size of the channel, informed by a fluvial geomorphologist (secured in the EMP (Application Document 2.7)).

14.8.75 Where schemes have sections in cutting, the drainage system for each scheme, including attenuation basins, will be appropriately sized to allow for potential groundwater ingress within the cuttings. Cutting, embankment or structure drainage will maintain flow directions and existing catchment areas wherever possible.

14.8.76 In locations where the geology is susceptible to dissolution (e.g., gypsum and limestone), the drainage system will be appropriately designed to prevent infiltration (e.g. lined drainage).

14.8.77 These measures are also outlined and secured in the EMP (Application Document 2.7).

Drainage basin design

14.8.78 The drainage design includes measures to capture, attenuate, and treat routine runoff from the highway to ensure that there is no increase in runoff rates as a result of the proposals and that the appropriate pollution controls are in place. The proposed drainage design is detailed within ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4), where potential flood impacts are assessed. Potential impacts on water quality are outlined and assessed within ES Appendix 14.3: Water Quality Assessment (Application Document 3.4).

14.8.79 The proposed drainage basin design has been designed considering the context of the underlying geology, such as the presence of karst features. Detailed assessment of risks posed by routine runoff to groundwater quality would be completed at detailed design when infiltration rates through the ground and ground conditions specific to the basin locations would be obtained. Further assessment of risks to

[63] Highways England (2020a) Design Manual for Roads and Bridges: CG 501 - Design of highway drainage systems. Revision 2
[64] Highways England (2020b) Design Manual for Roads and Bridges: CG 532 - Vegetated drainage systems for highway runoff. Revision 0

surface water receiving bodies may also be needed at detailed design stage, depending on the progression of the design.

14.8.80 The specific mitigation measures required in the design of drainage systems and basins to mitigate potential impacts to groundwater bodies will be refined at detailed design. These will include measures to separate carriageway drainage systems from groundwater, the lining of basins, and limitations on the disposal of surface water though infiltration. This is particularly pertinent in areas where dissolution is a risk. These measures are secured in the EMP (Application Document 2.7).

14.8.81 The assessment will be specific to a locale of the point of discharge, which is not relevant to the wider groundwater body due to dilution effects.

Abstractions

14.8.82 Where a licensed abstraction well or unlicensed supply has the potential to be impacted, a protection plan will be developed for that well/source. If protection is not possible, a new network connection, alternative water supply or replacement well (designed to current guidance) will be provided.

Overland flow compensation

14.8.83 To ensure that there is minimal flood risk to the Project from fluvial and pluvial flooding, it is necessary at Penrith to Temple Sowerby to mitigate an area that, within the 1-in-100 year plus 94% climate change event uplift value, is modelled to be impacted by flooding. The reprofiling of the farmland at Light Water Cottages between the Unnamed Tributary of River Eamont 3.3 and the Light Water is proposed to maintain the existing conveyance route, for the 1-in-100 year plus 94% climate change event uplift value, whilst ensuring that the overland flow does not inundate the carriageway or exacerbate flood risk further downstream. Details are provided in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4), which is secured via the EMP (Application Document 2.7).

Flood compensatory storage

14.8.84 Temple Sowerby to Appleby and Appleby to Brough schemes have proposed design elements within the floodplain, which is categorised as Flood Zone 2 and Flood Zone 3. To mitigate any loss of floodplain and ensure that there is no increase in flood risk downstream of the Project, areas of flood compensation storage have been embedded in the design, and operational flood models for 100-year event plus climate change have confirmed that they fully offset any loss and do not result in increased flood risk downstream of the Project. Details of the proposed compensatory storage areas are outlined in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4).

14.8.85 Flood compensation storage design mitigation is secured within the EMP (Application Document 2.7). The infrastructure will be designed

and implemented so that it does not alter the flood mechanism or reduce the connectivity of the affected watercourse and its floodplain. This will also include measures so any fish located within the flood storage area can return to the channel as the floodwater recedes by appropriately grading the flood storage area, which will be undertaken at detailed design stage with input from a suitably qualified Fluvial Geomorphologist and Aquatic Ecologist. Where flow control structures are required, these will be carefully designed to ensure flows under normal conditions are not adversely affected and the structure does not adversely affect upstream-downstream continuity (i.e. fish passage). Design of any flow control structures will be undertaken at detailed design stage with input from a suitably qualified hydrologist, geomorphologist and ecologist.

Potential impacts

14.8.86 During operation, significant potential impacts to surface water features and groundwater features and flood risk could arise from:

- Polluted surface water runoff containing sediment, hydrocarbons and soluble pollutants, such as copper and zinc, which may migrate or be discharged to surface water features or groundwater resources via the proposed highway drainage system, including from spillages
- Permanent impact to the hydro-morphological and ecological quality of surface water features associated with watercourse crossings and realignments
- Permanent impacts to catchment hydrology and hydrogeology caused by the introduction of a barrier to natural overland flow (e.g., introduction of embankments and changes to natural catchment dynamics associated with the proposed highway drainage system)
- Permanent impacts to catchment hydrology and hydrogeology caused by impact to natural groundwater springs or groundwater flow associated with proposed road cuttings that could affect baseflow to watercourses and groundwater resources
- Increased dissolution of gypsum bedrock from road drainage in the Kirkby Thore area of the Temple Sowerby to Appleby section where gypsum is present, leading to potential ground instability
- Increased dissolution of limestone bedrock from road drainage in the eastern schemes where present, leading to potential ground instability
- Increased rates and volumes of surface water runoff due to an increase in impermeable area or changes to the existing drainage regime leading to a potential increase in flood risk
- Increased flood risk to the Project and to people and property elsewhere caused by crossing of watercourses thus affecting flood flow conveyance and the potential loss of floodplain storage volume
- Change in the rate of recharge of aquifers due to change in ground surface cover and introduction of new drainage systems
- Reduced dilution and/or dispersion of consented discharges to groundwater and treated sewage effluent due to reduced or redirected groundwater flow paths.

14.8.87 There is limited information regarding the existing road drainage arrangements and water treatment provision. The scheme may provide an opportunity to provide betterment.

14.8.88 Further details on potential operational impacts are provided in the following sections.

Surface water impacts

Surface water quantity

14.8.89 Alteration of ground elevations and changes in surface water flood flow pathways may result in the overloading of drainage systems and/or surface watercourses. This may impact on flood-sensitive receptors near to overloaded systems. Wherever possible, the design will maintain existing catchments.

14.8.90 An increase in impermeable areas or changes to the existing drainage regime could result in increased rates and volumes of surface water runoff and therefore a potential increase in flood risk. This could impact properties and aquatic environments near to pluvial flood zones.

14.8.91 The introduction of a barrier to natural overland flow paths such as introduction of embankments and changes to natural catchment dynamics associated with the proposed highway drainage system may have permanent impacts on catchment hydrology and hydrogeology. This may result in a reduction or loss of water supply to downstream receptors, including abstractions, rivers and wetland, and the potential loss of aquatic habitat (which may be permanent).

Surface water quality

14.8.92 Polluted surface water runoff containing silts and hydrocarbons that may migrate or be discharged to surface water features or groundwater resources via the proposed highway drainage system, including from spillages. This has the potential to result in long-term degradation of water quality, pollution of environmental receptors and the potential loss of aquatic habitat. Water quality is particularly sensitive for schemes located within the River Eden catchment, which contains a number of watercourses designated as part of the SAC and SSSI, as a number of qualifying species are dependent upon high water quality.

14.8.93 The pollution of surface watercourses may result in potential loss of aquatic habitat. This may, in turn, result in impacts on the amenity and economic value of surface water bodies. Surface water abstractions have the potential to be impacted if their water source is polluted, their catchment reduced and are no longer appropriate for the abstraction requirement.

14.8.94 The Project may provide an opportunity to provide betterment on the existing road drainage treatment within the Order Limits.

Hydromorphology and geomorphology

14.8.95 Culverts have the potential to affect watercourses by causing local shading, reducing river habitat connectivity and inducing hydromorphological change. There is potential for a permanent impact

to the hydromorphological and ecological quality of water features associated with confining the migration of watercourses and increasing the shading and interrupting processes of sediment transfer. Loss or alteration of the channel characteristics can also occur where realignment of the watercourse is required to facilitate the culverting works.

14.8.96 New outfall structures within a watercourse can alter local channel cross section and induce local bank or bed erosion, as well as reduce the available natural bank and riparian habitat area. This geomorphological impact is considered highest risk for Appleby to Brough where there are a number of offline crossings of tributaries to the River Eden, posing a risk to both the WFD status and the condition status of the River Eden SAC and SSSI.

14.8.97 An interruption of flow in the watercourse may result in a reduction or loss of water supply to downstream receptors, including abstractions, rivers and wetlands, and the potential loss of aquatic habitat (which may be permanent).

14.8.98 Where piers within the floodplain are proposed for watercourse crossings, there is a potential to create an obstacle to flow and sediment transport. This has the potential to impact the objectives of the River Eden SAC as a result of the Temple Sowerby to Appleby and Appleby to Brough schemes. Detailed assessment of the hydromorphological impacts on the River Eden SAC is provided within ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4), ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4), and the HRA LSE and SIAA (Application Document 3.4).

Groundwater

14.8.99 Proposed road cuttings may have permanent impacts on catchment hydrogeology. This may result in changes to the natural groundwater regime and modify the flow at springs, reduce yield from abstraction wells or reduce baseflow contribution to watercourses.

14.8.100 Structures such as piles, retaining walls and deep excavations have the potential to divert or impound groundwater flow, causing groundwater levels to rise on the upgradient side but lower on the down gradient side. Receiving water on the down gradient side may be impacted by a reduction in baseflow or alteration of the pathway to where the baseflow contribution occurs.

14.8.101 A change in the rate of recharge of aquifers due to change in ground surface cover and introduction of new drainage systems may also result in a reduction or loss of water supply to abstractions, springs, watercourses, and the potential loss of aquatic habitat (which may be permanent), and potential GWDTEs, which may be adversely impacted by changes in groundwater levels or quality.

Flood risk

Pluvial and fluvial flood risk

14.8.102 New watercourse crossings and development within the floodplain may affect flood flow conveyance, resulting in increased flood risk to the Project and to people and property elsewhere. A change in flood flow pathways may impact on properties and aquatic environments within, and associated with, flood zones.

14.8.103 As well as potential effects on operational flood risk, floodplain crossings have the potential to affect natural flood flows and geomorphological processes of the associated watercourses, which may lead to direct and indirect effects on the in-channel habitats.

14.8.104 An increase of impermeable surface caused by the Project may have an impact on the hydrology and dynamics of watercourse catchments. This has the potential to increase surface water runoff and the risk of pluvial flooding. The drainage design will mitigate this, discharging highways drainage at appropriate rates (as reported within ES Appendix 14.2: Flood Risk Assessment and Outline Drainage (Application Document 3.4)).

Groundwater flood risk

14.8.105 The BGS Groundwater Flooding map indicates there is the potential for clearwater flooding and flooding from superficial deposits within the routewide study area. Any excavations would be at an increased risk of groundwater flooding. Any discharges to ground could exacerbate groundwater flooding.

GWDTE

14.8.106 The Project could impact on the hydrological and hydrogeological regimes and consequently affect GWDTEs during operation. Areas of habitat with the potential to support GWDTEs within the cuttings ZoI have been identified at the following schemes:

- M6 Junction 40 to Kemplay Bank
- Penrith to Temple Sowerby
- Temple Sowerby to Appleby
- Appleby to Brough
- Bowes Bypass
- Stephen Bank to Carkin Moor

14.8.107 The impacts on GWDTEs are further detailed and assessed in ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment (Application Document 3.4).

Accidental spillage

14.8.108 Discharges via soakaways could lead to direct pollution of a strategically important aquifer underlying the scheme. Discharges directly to surface watercourses could lead to direct pollution of receiving watercourses.

In-combination impacts with climate change

14.8.109 Future climate conditions derived from the UK Climate Projections 2018 (UKCP18) indicate that the study area may undergo climatic changes including higher temperatures, increase in heat waves, reduced precipitation in summer and increased precipitation in winter. Surface water flows are likely to become more variable, with more frequent extremes.

14.8.110 Increasing long spells of hot weather and wildfires may result in soils developing water repellence, which may reduce or temporarily impede water infiltration, leading to preferential overland flow and increased surface runoff. This has the potential to impact on existing and future road drainage systems and filtration mitigation.

14.8.111 These conditions are likely to reduce the amount of recharge to groundwater. Abstractions, springs, groundwater-fed watercourses and areas of wetland are likely to be particularly sensitive to these impacts. Groundwater quality is also likely to be affected by a reduction in the flushing of aquifers, which may increase the residence time of groundwater within them. These impacts may compound effects when experienced in combination with other potential impacts of the Project, such as water table drawdown.

14.8.112 With increased precipitation and more extreme weather events, there is the potential for river flows to increase. This may have an increased effect on flood risk and the frequency of flood events or increase the area covered by a flood risk warning.

14.8.113 While the impacts of climate change are likely to affect the water environment, embedded mitigation in the Project design, such as climate change allowances in the drainage design and addition of flood compensation (as defined by flood modelling) will ensure that no significant effects arise as a result of the Project in combination with the effects of climate change.

14.8.114 The impact of the Project on climate change, and the resilience of the Project to the effects of climate change, are considered further in ES Chapter 7: Climate (Application Document 3.2).

14.9 Essential mitigation and enhancement measures

14.9.1 As set out in Section 14.5, the assessment reported in this chapter is based on a precautionary worst case scenario. As such, the mitigation identified in this chapter as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the ‘maximum’ extent of mitigation required (as identified in this chapter) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this chapter. The fundamental point

is that the mitigation identified in this chapter is secured by the EMP, where required to achieve the outcome reported in this chapter.

Construction

Essential mitigation

14.9.2 Essential mitigation to address likely significant effects includes:

- Any significant changes to proposed infrastructure that has the potential to interact with the floodplain will be subjected to detailed flood modelling that will identify the extent and type of mitigation required within the Order Limits to ensure no increase in flood risk to the Project or to third party land
- Changes to crossing points, including pier design or location, at detailed design will be designed and installed following consultation with appropriate hydromorphology and geomorphology experts, and with the Environment Agency and Natural England as appropriate
- Further surveys will be undertaken at detailed design to collect further data on springs and abstractions that are within areas of potential impact A plan to maintain, reinstate or compensate water supplies will be prepared, and implemented
- Where land drainage from agriculture is encountered during construction, actions will be taken to divert the flow to an appropriate location, such as the construction drainage network. Prior to completion of the Project, these field drains will be reinstated to the original locations, where practically possible, or diverted to an appropriate discharge location
- If the Environment Agency Floodline Warnings Direct service is issuing alerts, then temporary flood defences will be required for set-down areas associated with construction and will be agreed with the Environment Agency
- Development and implementation of voids protocols setting out procedures and measures allowing for treatment of voids that would reduce impact on groundwater flows
- Development and implementation of Settlement Monitoring Plan to identify and mitigate risk of subsidence

14.9.3 Further construction mitigation is included in the EMP, Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7) and secured by a requirement of the DCO.

Operation

Essential mitigation

14.9.4 Essential mitigation to address likely significant effects includes:

- Drainage design to incorporate feasible treatment. Where this is not possible to be implemented to groundwater, no infiltration will be permitted
- Detailed drainage design will retain the recharge of flows of all watercourses potentially affected

- Drainage will be appropriately sized to allow for potential groundwater ingress within cuttings, with drainage-maintained flow directions and existing catchment areas wherever possible
- Drainage will be appropriately designed to prevent infiltration (e.g., lined) in areas susceptible to dissolution
- Where a licensed abstraction or known unlicensed source of supply has the potential to be impacted, a protection plan will be developed for that well/source. If protection is not possible, an appropriate replacement of the water source will be provided (designed to current guidance and regulations).

14.9.5 Further operational mitigation is included in the EMP, Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7) and secured by a requirement of the DCO.

Hydromorphology

14.9.6 The following mitigation measures to ensure that there are no adverse impacts on watercourse hydromorphology will be implemented, with precise details to be confirmed in consultation with the Environment Agency during detailed design, as explained by paragraph14.5.10 (further details of this mitigation are outlined and secured in ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4)):

- Installing green bank protection measures, such as scour protection to mitigate against the potential to changes of the geometry of the channel
- Further hydraulic modelling for realigned sections of channel, with geomorphological input into the detailed design
- Naturalisation of culvert beds with appropriate riverbed substrate
- Riparian planting to introduce natural source of woody material to watercourses
- Measures to dissipate flow velocity at culvert outfalls, such as baffle structures inside the culvert or boulder pools

Geomorphology

Temple Sowerby to Appleby

14.9.7 Monitoring of the Trout Beck Viaduct crossing will be required by National Highways to assess the rate of scour to the piers. EMP details post construction monitoring to assess rate of scour. Should scour protection be required, National Highways will develop this in consultation with the Environment Agency.

14.9.8 At detailed design, further modelling of the crossing's piers will be undertaken in consultation with the Environment Agency to ensure no change to the reported potential effects on geomorphology as a result of updates to the design. Details of this mitigation are outlined in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4).

Appleby to Brough

14.9.9 The realignment of the channel, or the creation of a multi-threaded system/ increased sinuosity in this reach will help to slow the flow down and reduce flow velocities. This will also encourage the redirection of flow energy away from the embankment to reduce the risk of scour in the vicinity of the embankment in close proximity to the left bank of the Moor Beck, mitigating the increases to flow velocities and shear stresses in this location. This will ensure that the existing dynamics of flow within the Moor Beck are maintained. Improving the sinuosity of the channel as part of this proposed realignment would also provide additional benefits to the existing dynamics of flow.

14.9.10 The following mitigation measures to reduce flow velocities and redirect flow energy away from the embankment associated with the Warcop Junction will be implemented, with precise details to be confirmed following further modelling in consultation with the Environment Agency during detailed design:

- Realignment of the channel to increase sinuosity
- Green bank protection measures
- Increasing roughness of flood compensation structures to better store fine materials

14.9.11 Details of this mitigation are outlined in Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4).

14.9.12 As explained in paragraph 14.5.10, the assessment is based on conservative assumptions and the mitigation outlined within the EMP (Application Document 2.7) secures the ‘maximum’ extent of mitigation required (as identified in this chapter) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported.

14.9.13 Feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on geomorphology.

GWDTE

14.9.14 Where impacts to groundwater levels or flows may impact GWDTE, further ecological surveys will be completed to collect NVC data for this area and confirm any presence or likely absence of GWDTE. A localised detailed assessment of potential groundwater dependency and risk to the GWDTEs will then be completed, if necessary, with further ground

investigations data to give a more accurate representation of potential drawdown and associated impacts. If detailed assessment identifies that the risk of potential significant impacts remains, then additional mitigation will need to be implemented. This mitigation will comprise of lining of cuttings to prevent groundwater ingress with an appropriate drainage blanket beneath/surrounding which will enable continued groundwater flow to the GWDTE with limited mounding or drawdown.

14.9.15 At Dyke Nook Fen, if for any reason this mitigation is not feasible or detailed assessment demonstrates it may not be effective, the Order Limits and the Limits of Deviation for the design at this junction allow for the junction design to be adjusted to avoid the area completely (to be informed by detailed groundwater assessment of the area following further survey). Similarly, land has been included in the Order Limits to allow the adjacent drainage pond to be located and shaped in a suitable area so as to avoid any interactions with the hydrology of the fen.

14.9.16 This mitigation is secured in the Project Design Principles (Application Document 5.11) which is certified as part of the DCO and by way of the Limits of Deviation as set out in the DCO.

WFD compliance

14.9.17 Where the WFD assessment has identified a risk of deterioration in the status of water body quality elements, site-specific mitigation is required, described in detail in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4). At detailed design, the exact site-specific mitigation necessary will be determined and will include a selection of the following:

- Low flow channel creation to sustain appropriate flow depths and velocities
- Bank reprofiling to improve morphological diversity
- Removal of existing structures from the watercourses such as weirs or culverts
- Creation of wetland habitat and improving floodplain connectivity
- Riparian buffer strip planting

14.9.18 In addition to the above mitigation, a monitoring strategy will be developed in consultation with the Environment Agency to assess the effects of the Project and the effectiveness of mitigation to ensure compliance. This is secured through the EMP (Application Document 2.7).

Enhancement

14.9.19 The Project will comprise a road drainage scheme that will discharge carriageway runoff, ensuring it meets the quality standards required by *DMRB LA 113*. This is likely to provide a betterment on the existing road drainage system and improve the water quality of receiving waterbodies in comparison to existing outfalls.

14.9.20 During detailed design, a number of existing culverts may be removed to open up the channel and create open watercourses. This would re-naturalise areas of watercourses and field drains, resulting in positive

ecological benefits by improving connectivity of habitat for aquatic species and reducing shading effects. Roughening the bed of existing culverts and other features to improve fish passage and biodiversity value will also be explored.

14.9.21 The Eden Rivers Trust are leading a potential restoration project at Sleastonhow, which the Project has the potential to interface with. The design team are, and will continue to, work closely with the Rivers Trust, with the aim of ensuring the restoration project can successfully proceed alongside the Project. The detailed design of environmental mitigation in this area will be undertaken to integrate with the proposed restoration project where appropriate, with the aim of maximising the overall enhancement in this area.

14.10 Assessment of likely significant effects

14.10.1 This section identifies the likely road drainage and water environment effects of the Project that are predicted to be significant. Likely effects not predicted to be significant are presented in ES Appendix 14.11: Non-Significant Effects (Application Document 3.4).

14.10.2 Following a desktop review of baseline information, potential source and pathways to effects, and field surveys, it was considered that a number of identified receptors do not require further assessment due to a lack of hydrological connection or hydrological continuity to the Project. Of the 235 receptors identified within the routewide study area, 80 receptors do not require any further assessment. Details of the receptors not taken forward for further assessment can be found in ES Appendix 14.11: Assessment of Value (Application Document 3.4).

14.10.3 The assessment of effects considers the potential impacts to each receptor following the implementation of embedded and essential mitigation measures to determine the significance of the residual effects. The assessment of effects has been undertaken based on a reasonable worst-case scenario.

14.10.4 For effects on groundwater and groundwater-dependent features this scenario has been presented within ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4), where further details are provided.

14.10.5 The effects of the Project on WFD quality elements are discussed in greater detail in ES Appendix 14.1 WFD Compliance Assessment (Application Document 3.4).

Routewide

Construction

Surface water

Surface water quantity

14.10.6 The routewide study area crosses three surface water management catchments, the Eden and Esk to the west of the Pennines and the Tees to the east, and the eastern section of the Project crosses into Swale,

Ure, Nidd and Ouse Upper. Several springs emerge along the routewide study area, resulting in areas of interaction with cuttings and earthworks associated with the scheme.

14.10.7 Impacts include modifications to the hydrology of watercourses resulting from cutting or embankment drainage. This is due to local changes in groundwater flows or levels, potentially impacting the springs feeding the watercourses.

14.10.8 Given the potential changes in hydrology as a result of construction of the Project upon baseflows of watercourses from cuttings and embankment drainage, minimal changes to the flow regimes across the routewide study area are anticipated.

14.10.9 There is the potential for abstractions from surface water features, associated with the construction process. The impacts of these temporary abstractions will be assessed within the regulatory framework for abstractions (Environment Agency abstraction licenses) and discharges (Environment Agency environmental permits), ensuring that the works do not have an unacceptable impact on receiving receptors. Abstractions from the River Eden SAC and functionally linked habitats will not be taken direct from surface waters, to avoid impact on designated features and the species supported by the River Eden SAC. Details are presented within the HRA LSE and SIAA (Application Document 3.4). Receptor values range from low to high, and the impact is considered to be negligible after required licences are secured. Therefore, the effect would be neutral to slight adverse, and not significant.

14.10.10 The impacts of these temporary abstractions will be assessed within the regulatory framework for abstractions (Environment Agency abstraction licenses) and discharges (Environment Agency environmental permits), ensuring that the works do not have an unacceptable impact on receiving receptors.

14.10.11 Through detailed drainage design following detailed assessment of groundwater-surface water interaction and the adherence to Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7), any construction of cutting or embankment would retain the recharge of baseflows. Additionally, design of cutting or structure drainage will maintain flow directions and existing catchment areas wherever possible reducing the impact on surface water quantity. Following embedded and essential mitigation, the magnitude is considered to be negligible.

14.10.12 With the sensitivity of the receptors across the routewide study area ranging from 'Low' to 'Very High', and a magnitude of impact of negligible, the effect would be neutral to slight adverse and not significant.

Surface water quality

14.10.13 Following the implementation of mitigation listed in Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7), such as the magnitude of a pollution incident as a consequence of

the construction of the Project on the surface water receptors in the routewide study area is likely to be negligible.

14.10.14 With the sensitivity of the receptors across the routewide study area ranging from 'Low' to 'Very High', and a magnitude of impact of negligible, the effect would be neutral to slight adverse and not significant.

Hydromorphology

14.10.15 The construction of new and temporary crossings, both in the form of open span crossings and culverted channels, have the potential to impact upon hydromorphology during the construction period due to temporary dewatering and loss of channel. Following the implementation of mitigation listed in the Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7), and HRA LSE and SIAA (Application Documents 3.5 and 3.6), to maintain channel flow and uphold the conservation objectives of the River Eden SAC, the likely effect is considered to be localised and of negligible impact.

14.10.16 Temporary construction haul roads and set down areas have the potential to impact on local hydromorphology and wider geomorphological processes. This has the potential to impact on the River Eden SAC and functionally connected habitats. The Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7), and HRA LSE and SIAA (Application Documents 3.5 and 3.6), outlines mitigation to avoid the introduction of foreign materials to the floodplain and maintain flow paths in the event of a flood and this is secured within the EMP (Application Document 2.7). With this in place, the likely effect is considered to be localised and of negligible impact.

14.10.17 With the sensitivity of the receptors across the routewide study area ranging from 'Low' to 'Very High', and a magnitude of impact of negligible, the effect would be neutral to slight adverse and not significant.

Groundwater

Groundwater levels and flows

14.10.18 Groundwater receptors have been identified through ground investigation, site walkovers, monitoring and quality sampling, to enable the hydrogeology of the scheme areas to be understood prior to construction works. Available baseline hydrogeological conceptual models are presented in ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4).

14.10.19 The groundwater receptors that may be affected by temporary works include principal and secondary bedrock aquifers, and secondary superficial deposit aquifers, together with features dependent on these aquifers (such as springs and abstractions).

14.10.20 The assessment of potential impacts on groundwater levels and flows resulting from proposed works that intercept groundwater (e.g., cuttings, embankments and underground structures) is presented in detail in ES

Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4).

14.10.21 Through detailed drainage design (following detailed assessment of groundwater-surface water interaction) and adherence to the Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7), any cutting or embankment construction would retain the recharge of baseflow to surface water features and local groundwater-surface interactions (where feasible). If baseflow to features cannot be retained (e.g., springs dry up) then an appropriate and proportionate alternative will be implemented, such as provision of a mains supply. Additionally, design of cutting or structural drainage will maintain flow directions and existing catchment areas. Following embedded and essential mitigation, the magnitude of groundwater level and flow changes is considered to be negligible.

14.10.22 Where impacts to groundwater levels or flows may impact GWDTE, further detailed surveying and assessment is to be undertaken during detailed design. If detailed assessment identifies that the risk of potential significant impacts remains, then additional mitigation will need to be implemented. Mitigation determined through an update to the GWDTE assessment could comprise lining of cuttings to prevent groundwater ingress with an appropriate drainage blanket beneath/surrounding which will enable continued groundwater flow to the GWDTE with limited mounding or drawdown.

14.10.23 With the sensitivity of the receptors across the routewide study area ranging from 'Low' to 'Very High', and a magnitude of impact of negligible, the effect would be neutral to slight adverse and not significant.

14.10.24 The details of any temporary abstractions required during the construction process for temporary works (e.g., borrow pits) will be confirmed during detailed design. The impacts of these temporary abstractions will be assessed within the regulatory framework for abstractions (Environment Agency abstraction licenses) and discharges (Environment Agency environmental permits), ensuring that the works do not have an unacceptable impact on receiving receptors.

Groundwater quality

14.10.25 Groundwater receptors have been identified through ground investigation, site walkovers, monitoring and quality sampling, to enable the hydrogeology of the scheme areas to be understood prior to construction works. Available baseline hydrogeological conceptual models are presented in ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4).

14.10.26 The groundwater receptors that may be affected by temporary works include principal and secondary bedrock aquifers, and secondary superficial deposit aquifers, together with features dependent on these aquifers (such as springs and seepages).

14.10.27 Temporary works associated with the construction of cuttings, embankments and drainage basins have the potential to affect

groundwater quality although this is likely to be localised and temporary, with appropriate pollution prevention measures in place as outlined within the EMP (Application Document 2.7).

14.10.28 Temporary works associated with concrete foundations (e.g., piled foundations) may also impact groundwater quality. This is primarily of concern in aquifers where fissures of karst may be encountered, which can act as preferential pathways for the grout/cement to escape.

14.10.29 Following the implementation of mitigation listed in the Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7), the magnitude of a pollution incident as a consequence of the construction of the Project on the groundwater receptors in the routewide study area is considered likely to be negligible.

14.10.30 With the sensitivity of the receptors across the routewide study area ranging from 'Low' to 'Very High', and a magnitude of impact of negligible, the effect would be neutral to slight adverse, and therefore not significant.

GWDTEs

14.10.31 The assessment of effects on GWDTEs is detailed in ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment (Application Document 3.4). It has been based upon the outputs from ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) and ES Chapter 6: Biodiversity.

14.10.32 During construction there is potential for groundwater quality and quantity to be impacted, which would be considered an impact on potential GWDTEs within the cuttings ZoI. After mitigation outlined in the EMP (Application Document 2.7) and associated Ground and Surface Water Management Plan (Annex B7 of the EMP), the impact on groundwater quality and quantity to low, medium, and high importance GWDTE after mitigation is considered to be of negligible impact magnitude and therefore of negligible risk, which is not considered to be significant.

Flood risk

Fluvial flood risk

14.10.33 There are small, localised areas of fluvial flood risk identified on schemes: Penrith to Temple Sowerby; Bowes Bypass; Cross Lanes to Rokeby; Stephen Bank to Carkin Moor; A1(M) Junction 53 Scotch Corner. The Ground and Surface Water Management Plan (Annex B7 of the EMP, Application Document 2.7) explains how Environment Agency 5-day flood risk forecasts will be used and outlines the flood warning system that will be in place.

14.10.34 Following the implementation of mitigation outlined in the EMP (Application Document 2.7), the magnitude of impact posed by fluvial flooding to the Order Limits and to third party land as a result of the Project, for the schemes named above, from construction is considered to be no change. Therefore, the effect would be neutral and not significant.

14.10.35 The remaining schemes (M6 Junction 40 to Kemplay Bank, Temple Sowerby to Appleby, Appleby to Brough) have areas of fluvial flood risk Zone 2 and Zone 3 within or adjacent to the Order Limits, and the assessment of likely effects from fluvial flood risk Zone 2 and 3 has been assessed in the relevant scheme sections below.

14.10.36 Existing (baseline) fluvial flood risk across the Project is detailed on ES Figure 14.2: Existing Flood Risk (Application Document 3.3).

Pluvial flood risk

14.10.37 Surface water generated across the Order Limits would be managed by construction drainage (including suitably sized temporary settlement and drainage basins, drainage ditches and culverts). These would be installed early in the construction period as per the EMP (Application Document 2.7) which would manage surface flooding to ensure that flood risk does not increase as a result of the scheme. Where land drainage from agriculture is encountered during construction, actions will be taken to divert the flow to an appropriate location, such as the construction drainage network. Prior to completion of the Project, these field drains will be reinstated to the original locations, where practically possible, or to a suitable alternative discharge point determined by pre-construction surveys.

14.10.38 Following the implementation of mitigation and actions outlined in the EMP (application Document 2.7), the risk posed by pluvial flooding to the Order Limits and to third party land, for Penrith to Temple Sowerby; Bowes Bypass; Cross Lanes to Rokeby; Stephen Bank to Carkin Moor; A1(M) Junction 53 Scotch Corner, from construction is considered to be no change. With the Project considered very high value and third-party land high value, the effect is considered to be neutral and not significant.

14.10.39 Existing pluvial flood risk across the Project is detailed on ES Figure 14.2: Existing Flood Risk (Application Document 3.3).

Groundwater flood risk

14.10.40 The BGS Groundwater Flooding map indicates there is the potential for clearwater flooding and flooding from superficial deposits within the routewide study area. Any excavations would be at an increased risk of groundwater flooding, which would require appropriate control measures (e.g., construction dewatering).

14.10.41 Ongoing monitoring of groundwater levels will identify areas where groundwater flooding may be a particular risk during construction with suitable control measures, such as additional drainage, identified and included during the detailed design stage to reduce the impact to negligible. This would result in an effect that would be neutral to slight adverse, and not significant.

14.10.42 Groundwater flooding susceptibility across the Project is detailed on ES Figure 14.8: Groundwater Flooding Susceptibility (Application Document 3.3).

Operation

Surface water

Surface water quantity

14.10.43 The effects upon surface water quantity are principally related to new embankments, earth bund and cuttings, and the interactions with existing water features. Impacts include modifications to the hydrology of watercourses resulting from cutting or embankment drainage. This is due to local changes in groundwater flows or levels, potentially impacting the springs feeding the watercourses. Assessment of effects hasbeen discussed in paragraph 14.10.6 to 14.10.12. Receptor values range from low to high, and the impact is considered to be negligible after further assessment and licences. Therefore, the effect would be neutral to slight adverse, and not significant.

Surface water quality

14.10.44 The drainage design of the Project directs runoff from the mainline carriageway and realigned side roads to a combination of both new and existing outfalls that discharge to surface waters.

14.10.45 HEWRAT adopts a tiered approach to the method of assessment of the potential impacts on water quality, which is as follows:

- Step 1: Runoff quality. This predicts concentrations of pollutants in untreated and undiluted highway runoff prior to any treatment and dilution in a water body
- Step 2: In-river impacts. This predicts concentrations of pollutants after mixing within the receiving water body. At this stage, the ability of the receiving watercourse to disperse sediments is considered and, if sediment is predicted to accumulate, the potential extent of sediment coverage (i.e. the deposition index, DI) is also considered. Step 2 also incorporates two 'tiers' of assessment for sediment accumulation, based on different levels of input parameters. If one or more risks are defined as unacceptable at Tier 1, i.e. ‘fail’, then a more detailed Tier 2 assessment is undertaken, requiring values for further parameters relating to the physical dimensions of the receiving watercourse
- Step 3: In-river impacts with mitigation. Steps 1 and 2 assume that the road drainage system incorporates no mitigation measures to reduce the risk. Step 3 includes mitigation in the form of Sustainable Drainage Systems (SuDS), considering the risk reduction associated with any existing measures or any proposed new measures.

14.10.46 A cumulative assessment has been undertaken for outfalls within 1km of each other for soluble pollutants and within 100m for sediment. Outfalls only qualified if they were within the same catchment. With embedded mitigation incorporated, all outfalls achieved a 'Pass' for both Environmental Quality Standard (EQS) and run-off specific threshold (RST) soluble pollutants and sediment.

14.10.47 Further additional treatment is proposed in the form of a sediment forebay within all network drainage basins, as well as catchpits at every

outfall, to further remove sediment and pollutants. The forebay design would be developed at the detailed design stage. If any further mitigation is required to ensure appropriate treatment levels are met, this will be developed within the detailed drainage design. Details on the assessment are provided in ES Appendix 14.3: Water Quality Assessment (Application Document 3.4). Mitigation and design aspects to be developed at detailed design, as explained in paragraph 14.5.10, are outlined within ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4) which is secured through the EMP (Application Document 2.7).

14.10.48 Tier 2 HEWRAT sediment assessment, which accounts for riverbed width, bank slope, and Manning's values, has not been run at this stage. Tier 2 results provide more accurate outputs and negate the need for conservative estimates, which is anticipated to produce more favourable HEWRAT screening results. Additional HEWRAT screening will take place during detailed design and will include tier 2 sediment assessment.

14.10.49 The sensitivity of the receptors ranges from low to very high, and the magnitude of the impact of sediment and dissolved metals discharging into surface watercourse receptors is considered to be negligible. Therefore, the effect would be slight adverse and not significant.

14.10.50 Adverse effects upon designated areas, such as the River Eden SAC, and surface water abstraction points downstream of the discharge locations for the proposed drainage network are not anticipated due to the increased protection offered by the proposed pollution mitigation measures in the drainage design.

Hydromorphology

14.10.51 The potential impacts on the hydromorphology of identified surface water receptors due to watercourse crossings and realignments are assessed in detail within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). Mitigation that is secured through the EMP (Application Document 2.7) will be incorporated into the detailed design of the scheme, and so the magnitude of the impact is considered to be negligible for all schemes. With the sensitivity of the receptors ranging from low to very high, and the magnitude of the impact being negligible, the effect would be neutral to slight adverse and not significant.

Groundwater

14.10.52 The groundwater receptors that may be affected by the permanent works include principal and secondary bedrock aquifers, and secondary superficial deposit aquifers, together with features dependent on these aquifers (such as springs and seepages).

14.10.53 The effects upon groundwater quantity would be principally related to new structures (with associated foundations) and the road drainage in cuttings, which may impact groundwater levels or flows. The effects are generally the same during construction and operation of the scheme,

save for groundwater levels being be more susceptible to longer term seasonal and climatic variations in the operational phase.

14.10.54 Given that changes in groundwater levels and flows may impact upon identified groundwater dependent features, such as aquifers and springs, mitigation has been included within the design to reduce the overall impact on receptors to negligible. Water will be retained within the same catchments and suitable replacements for features such as springs which could be lost or significantly impacted as a result of the Project will be provided, as committed to in the EMP (Application Document 2.7).

14.10.55 The primary risks to groundwater quality during operation are from pollution incidents as a result of general traffic use and spillages. The drainage design, impacts and mitigation are discussed in further detail in the Surface water quality section and ES Appendix 14.3: Water Quality Assessment (Application Document 3.4). Accidental spillages which may result in an acute pollution incident are discussed in further detail in ES Appendix 14.5: Spillage Risk Assessment (Application Document 3.4).

14.10.56 With the sensitivity of the receptors across the routewide study area ranging from 'Low' to 'Very High', and a magnitude of impact of negligible, the effect would be neutral to slight adverse, and therefore not significant.

GWDTEs

14.10.57 The assessment of effects on GWDTEs is detailed in ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment (Application Document 3.4). It has been based upon the outputs from ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) and ES Chapter 6: Biodiversity.

14.10.58 The assessment considered the hydrological conceptual model and cuttings ZoI to establish where potential impacts to groundwater level and flow may occur. The assessment confirmed that no protected site within the Project study area that has the potential to support GWDTE is likely to be impacted, as they are all outside the ZoI.

14.10.59 The assessment concluded that there is a risk from the Project to habitats with the potential to support GWDTE. The risk ranges from ‘negligible risk’ to ‘significant risk’. For all schemes, with the exception of Appleby to Brough, the impact on groundwater quality and quantity to low, medium, and high importance GWDTEs after mitigation, outlined in the EMP (Application Document 3.4), is considered to be of negligible impact magnitude and therefore of negligible risk, which is not considered to be significant.

14.10.60 Details of the residual risk relating to GWDTEs within the Appleby to Brough scheme study area is included within the relevant scheme specific section below.

Accidental spillage

14.10.61 Assessment of accidental spillages of polluting substances from roads has been carried out using Appendix D as prescribed in *DMRB LA 113* using vehicle numbers for the design year (2044) AADT traffic flows, taken from the Project's traffic model and used in ES Appendix 14.5: Spillage Risk Assessment (Application Document 3.4).

14.10.62 On all roads, there is a risk that an accidental spillage or vehicle fire may lead to an acute pollution incident. *DMRB LA 113* states that the pollution risk on any road is linked to the risk of a heavy goods vehicle road traffic accident. Where a spillage does reach a surface watercourse the pollution effect can be severe but is usually of short duration.

14.10.63 The acceptable risk of a pollution incident, as stated in *DMRB LA 113*, is an annual probability of less than 1% (or a return period of 1 in 100 years), or less than 0.5% (or a return period of 1 in 200 years) for discharges into sensitive watercourses (SSSI, SCA, SPZ protected area, drinking water supply, commercial activity abstraction).

14.10.64 Using the assessment method prescribed in Appendix D of *DMRB LA 113*, the risk of spillages has been calculated for predicted future traffic conditions. The greatest risk of accidental spillage at any location is 0.066%, which is within the acceptable limit.

14.10.65 Based on the spillage assessment in ES Appendix 14.5: Spillage Risk Assessment (Application Document 3.4), with the sensitivity of the receptors across the routewide study area ranging from 'Low' to 'Very High', and a magnitude of impact the on surface or groundwater receptors considered to be negligible, the effect would therefore be slight adverse and therefore not significant.

Flood risk

14.10.66 The FRA (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)) assessed the risk of flooding to the Project and from the Project to third party land. As the Project results in an increase in impermeable area, potential disruption of surface flow routes and loss of floodplain, there is the potential to increase the risk of flooding from pluvial and fluvial sources. Mitigation in relation to flood risk is secured in the PDP (Application Document 5.11) and EMP (Application Document 2.7), including drainage design.

Fluvial flood risk

14.10.67 The risk to the Project from fluvial flooding is considered to be minimal, after analysis of the Environment Agency Flood Map for Planning and the Project flood modelling that has been completed. Therefore, for all schemes it is considered that the impact is no change. Given receptor sensitivity of very high for the Project, the effect is neutral and not significant.

14.10.68 For the parts of the Project located within Flood Zone 1, the FRA determines that no change of fluvial flood risk will be observed downstream and therefore there is not considered to be an adverse impact on downstream third party land as a result of the Project. For all

schemes, with the exception of Temple Sowerby to Appleby and Appleby to Brough (which have sections located within Flood Zone 2 and 3), it is therefore determined that the impact is no change. Given receptor sensitivity of very high for the Project, the effect is neutral and not significant.

14.10.69 Where the Project is to be constructed within Flood Zone 2 or Flood Zone 3 there is a potential impact of loss of flood water storage within the floodplain, with potential effect on downstream third-party land. In this instance, flood compensation areas have been embedded in the design and tested through operational flood modelling to ensure that the risk of flooding downstream of the Project is not increased. Further details and assessment can be found in the Temple Sowerby to Appleby and Appleby to Brough scheme specific sections below.

Pluvial flood risk

14.10.70 Small areas of pluvial flood risk have been identified across the Project. To mitigate against the potential impact to the Project, cut-off drainage has been provided where land outside of the highway corridor falls towards the highway. The cut-off drainage will intercept and convey surface water flows around the highway.

14.10.71 The Project will result in an increase of impermeable area. To mitigate the potential impact of increased flood risk downstream of the Project, sustainable highways drainage has been incorporated into the Project design, using 20% climate change uplift values included in Environment Agency guidance available at the time of the assessment65. Existing flow rates have been calculated, and proposed flow rates restricted to ensure that there is no increased flood risk created by the Project, where necessary additional storage has been provided within the new drainage system.

14.10.72 All pluvial flood risk effects, including those that could result from climate change, will not be increased beyond existing conditions. Given that the Project classified as very high value and third-party land of up to high value, and the impact is considered to be no change, the residual effect post mitigation is neutral and not significant.

Groundwater flood risk

14.10.73 The BGS Groundwater Flooding map indicates there is the potential for clearwater flooding and flooding from superficial deposits within the routewide study area.

14.10.74 Any cuttings would be at an increased risk of groundwater flooding, which would require appropriate drainage design to prevent flooding of the road.

14.10.75 Ongoing monitoring of groundwater levels will identify areas where groundwater flooding may be a particular risk during operation with suitable control measures identified and included during the detailed design stage to reduce the impacts to negligible. This would result in an effect that would be neutral to slight adverse, and not significant.

[65] Environment Agency (2021d). Flood risk assessments: climate change allowances

WFD compliance assessment

14.10.76 A WFD compliance assessment has been completed and is included as ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4). This provides a description of the relevant water bodies with the study area and how they could be impacted by the Project. This assessment is based on currently available design information for the Project, WFD baseline data and survey data (ES Appendix 6.18 Fish Habitat Assessment and MoRPh, ES Appendix 6.19 Fish, ES Appendix 6.20 Aquatic Macrophyte and River Corridor Survey, and ES Appendix 6.22 White Clawed Crayfish (all within Application Document 3.4))

14.10.77 It is concluded that the activities required for the construction and operation of the Project will not cause deterioration in the status of any WFD water bodies or prevent them from achieving either 'Good Ecological Status' or 'Good Ecological Potential' by 2021 or 2027, following the embedded mitigation and appropriate design and implementation of additional mitigation described in Section 6.4 of ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4) are implemented. The delivery of this mitigation is secured by its inclusion within the EMP (Application Document 2.7).

14.10.78 During detailed design, as information on the design is further developed, updates to the WFD compliance assessment will be required and reported to ensure that the reported outcomes are achieved. This and the mitigation required per waterbody are committed to through the EMP (Document Reference 2.7).

M6 Junction 40 to Kemplay Bank

Construction

Flood risk

Fluvial flood risk

14.10.79 The risk of fluvial flooding to or from the Order Limits is considered to be low due to the limited areas of construction that will be taking place within the flood risk areas. The areas of Flood Zone 2 and Flood Zone 3 present within the temporary land take are associated with the River Eamont, in the central and southern areas of the Order Limits.

14.10.80 Detailed mitigation to address flood risk during construction is contained within the EMP (Application Document 2.7) and includes measures such as adequate working platform levels based on flood modelling and historic records, temporary flood defences, and an early warning alarm system for flood events.

14.10.81 Following the implementation of mitigation outlined in the EMP (Application Document 2.7), the risk posed by fluvial flooding within the Order Limits, for the scheme named above, from construction is considered to be no change. The Project is considered a very high value receptor and so the effect is considered to be neutral and not significant.

Penrith to Temple Sowerby

Operation

Flood risk

Fluvial flood risk

14.10.82 The FRA (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)) assesses the risk of flooding to the scheme and from the scheme to third party land. The assessment of flood risk and associated modelling revealed that the scheme may be at risk from minor flooding associated with water backing up in the Unnamed Tributary of River Eamont 3.3 at Whinfell Park and flowing overland to the Light Water in the 1 in-100 year plus 94% climate change event.

14.10.83 To mitigate this impact, reprofiling of the farmland Light Water Cottages between the Unnamed Tributary of River Eamont 3.3 and the Light Water is proposed to maintain this conveyance route for the 1 in-100 year plus 94% climate change event. This will ensure that the overland flow does not inundate the carriageway or exacerbate flood risk further downstream. The reprofiling has been included in the hydraulic model, details are provided in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4), and is committed to within the EMP (Application Document 2.7).

14.10.84 Given that the Project is classed as very high value and surrounding third party land as high value, and the magnitude of impact is considered to be no change following mitigation, the residual effect is neutral and not significant.

Temple Sowerby to Appleby

Construction

Groundwater

Groundwater abstractions

14.10.85 The two industrial groundwater abstractions alongside Normal Lane are within the construction footprint and are likely to be directly impacted by the construction of the Kirkby Thore bypass. Without appropriate mitigation (e.g. borehole replacement outside the road footprint and revised licensing), the licensed abstraction would become redundant reducing water supply to the license holder (a significant impact to a high value receptor). With mitigation implemented as outlined above and within the EMP (Application Document 2.7), the risk posed to the receptors would be negligible, resulting in a slight adverse impact. To prevent potential contamination risks during construction works, the boreholes will be appropriately decommissioned to prevent a significant impact (pollution of the Principal Aquifer). With boreholes appropriately decommissioned, the risk posed to the receptor would be negligible, resulting in a slight adverse impact.

Flood risk

Fluvial flood risk

14.10.86 The risk posed by fluvial flooding within the Order Limits as a result of the Project is considered to be low due to the limited areas of construction that will be taking place within the flood risk areas. The areas of Flood Zone 2 and Flood Zone 3 present within the temporary land take are associated with the Trout Beck, in the central west of the Order Limits.

14.10.87 Detailed mitigation to address flood risk during construction is contained within the EMP (Application Document 2.7) and includes measures such as adequate working platform levels based on flood modelling and historic records, temporary flood defences, and an early warning alarm system for flood events.

14.10.88 Following the implementation of mitigation outlined in the EMP (Application Document 2.7), the risk posed by fluvial flooding within the Order Limits, for the scheme named above, from construction is considered to be no change. The Project is considered a very high value receptor and so the effect is considered to be neutral and not significant.

Operation

Surface water

Surface water abstractions

14.10.89 There is one surface water abstraction identified within the study area. This industrial surface water abstraction (Licence number: 2776003009) is the commercial use of the Kirby Thore Reservoir, situated adjacent to British Gypsum in the north of the study area. There is a proposed highways drainage outfall that will discharge into Unnamed Tributary of Birk Sike 4.3, this watercourse then flows through the abstraction pond.

14.10.90 Mitigation outlined in ES Appendix 14.3: Water Quality Assessment (Application Document 3.4) and committed to through the EMP (Application Document 2.7) will ensure that the water quality of this outfall will not lead to adverse effects on the receiving watercourse. The abstraction is for industrial use and therefore is not considered to be a sensitive receptor and has a value of medium. There will be no change to the abstraction, therefore the effect would be neutral and not significant.

Hydromorphology

14.10.91 The potential impacts on the hydromorphology of identified surface water receptors due to watercourse crossings and realignments are assessed in detail within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4) and committed to through the EMP (Application Document 2.7) and PDP (Application Document 5.11).

14.10.92 The proposed works do not include alteration of the riverbed or river banks, works within the channel, or alteration of the floodplain of Trout Beck. Therefore, no mitigation was considered to be required for the Trout Beck, which has been assigned very high value, the impact is

considered no change, and therefore the effect is neutral and not significant

14.10.93 A number of tributaries to Trout Beck were also assessed within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4). Following specific mitigation, including the placement of appropriate riverbed substrate within the impacted channels and to provide more natural outfall angles, it is considered that the impact would be negligible.

14.10.94 With the sensitivity of the tributaries to Trout Beck being low, and the magnitude of the impacts being negligible after mitigation, the significance of effect is neutral and not significant.

Geomorphology

14.10.95 The potential impacts to Trout Beck and the River Eden due to the proposed crossing and flood compensation for the Temple Sowerby to Appleby scheme have been assessed in detail within ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4).

14.10.96 The proposed works have the potential to create an obstacle to flow and sediment transport and so change the geomorphological characteristics of the watercourses.

14.10.97 Geomorphology modelling concluded that the proposed design is unlikely to generate significant morphological change within the Trout Beck channel and floodplain, with only localised impacts at the base of viaduct piers anticipated. Therefore, no downstream impacts will be experienced at the River Eden. Further details on scour protection will be incorporated at detailed design, updates during detailed design will model impacts as a result of any change in pier location or orientation as committed to in the EMP (Application Document 2.7) and PDP (Application Document 5.11).

14.10.98 Additionally, the proposed design is not likely to cause changes to the floodplain composition through erosion or deposition, with overland flow routes retained.

14.10.99 With the sensitivity of the receptors classed as very high, and the magnitude of the impacts being negligible, the significance of effect is considered slight adverse and not significant.

Flood risk

Fluvial flood risk

14.10.100 The FRA (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)) assesses the risk of flooding to the scheme and from the scheme to third party land. The proposed design of the Trout Beck crossing includes a viaduct with piers that are placed within the floodplain, therefore leading to a slight reduction in flood storage capacities at this location.

14.10.101 To mitigate for the loss of flood storage, flood compensation has been embedded into the proposed design, details are provided in ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy

(Application Document 3.4) which is secured through the EMP (Application Document 2.7) and has been informed by hydraulic modelling. This is expected to fully mitigate any adverse effect and land has been incorporated within the Order Limits to allow for further refinement at detailed design.

14.10.102 Given that the Project is classed as very high value and surrounding third party land as high value, and the magnitude of impact is considered to be no change following mitigation, the residual effect is neutral and not significant.

Appleby to Brough

Construction

14.10.103 Flitholme spring is located south of the scheme and north-east of Flitholme Farm. The 'spring' is utilised for supply of fields and buildings but lies within the construction footprint, so will likely be directly impacted (i.e. loss of supply) by the proposed roadworks that will connect the Flitholme local road to the underpass. To prevent a significant impact on the water supply, appropriate mitigation and/or compensation measures are to be implemented to ensure continued supply, in consultation with the stakeholder. With mitigation implemented as outlined above and within the EMP (Application Document 2.7), the risk posed to the receptors would be negligible, resulting in a slight adverse impact.

14.10.104 Springs in the area surrounding Wildboar Hill feed local ditches that are used by livestock. Cuttings in the area have the potential to reduce baseflow to springs, resulting in a reduction in spring flow rates or alteration of flow paths. Embankments in the area could act as a barrier to flow and alter flow paths. Due to uncertainty in the exact location of the springs, there is the potential for a significant impact without appropriate mitigation measures. Surveying of areas at risk prior to commencement of construction will assist in the identification of spring locations and enable a further assessment of risk to be undertaken. If required following further assessment, appropriate mitigation and/or compensation measures will need to be implemented to ensure continued supply (e.g. lining of cuttings or replacement mains supply etc), in consultation with the stakeholder. With mitigation implemented as outlined above and within the EMP (Application Document 2.7), the risk posed to the receptors would be negligible, resulting in a slight adverse impact.

Flood risk

Fluvial flood risk

14.10.105 The risk posed by fluvial flooding within the Order Limits as a result of the Project is considered to be low due to the limited areas of construction that will be taking place within the flood risk areas. The areas of Flood Zone 2 and Flood Zone 3 present within the temporary land take are associated with the Cringle Beck, Hayber Beck, Moor Beck, and Eastfield Sike, in the centre of the Order Limits.

14.10.106 Detailed mitigation to address flood risk during construction is contained within the EMP (Application Document 2.7). Flood risk will be mitigated by adequate working platform levels based on flood modelling and historic records and an early warning alarm system for flood events.

14.10.107 Following the implementation of mitigation outlined in the EMP (Application Document 2.7), the risk posed by fluvial flooding within the Order Limits, for the scheme named above, from construction is considered to be no change. The Project is considered a very high value receptor and so the effect is considered to be neutral and not significant.

Operation

Surface water

Hydromorphology

14.10.108 The potential impacts on the hydromorphology of identified surface water receptors due to watercourse crossings and realignments are assessed in detail within ES Appendix 14.4: Hydromorphology Assessment (Application Document 3.4).

14.10.109 With the exception of Unnamed Tributary of Lowgill Beck 6.1, Woodend Sike and Yosgill Sike there are no proposed modifications to the watercourse channel at Appleby to Brough, and therefore no impacts to the hydromorphology during in-channel flow events are anticipated as a result of the scheme. However, there is the potential to disrupt existing overland flow routes, and confine flows to a narrower floodplain which may result in increased scour and erosion.

14.10.110 At Unnamed Tributary of Lowgill Beck 6.1, Woodend Sike and Yosgill Sike where modifications to the channel are required, hydraulic modelling at detailed design will be undertaken to ensure that mitigation maintains natural geomorphological processes.

14.10.111 With the sensitivity of the receptors ranging from low to very high, and the magnitude of the impacts being negligible after mitigation, the significance of effect is considered to be neutral to slight adverse and not significant.

Geomorphology

14.10.112 The potential impacts to Moor Beck, Moor Beck (Offtake) and Eastfield Sike due to the proposed crossing structures and flood compensation at Temple Sowerby to Appleby have been assessed in detail within ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4).

14.10.113 The scheme has the potential to create an obstacle to flow and sediment transport and alter flow velocities, leading to a change in geomorphological processes and features. Geomorphology modelling concluded that the scheme design is unlikely to generate significant changes in the riverbed composition of floodplain composition. There is potential for increases in flow velocities on the right bank of the Moor Beck to increase scour of the floodplain, riverbank, and riverbed.

14.10.114 Mitigation including re-naturalisation of the channels and green scour protection will be further developed at detailed design, as outlined in the EMP (Application Document 2.7) and the PDP (Application Document 5.11).

14.10.115 With the sensitivity of the receptors classed as high, and the magnitude of the impact after mitigation considered to be negligible, the significance of effect the receptors is slight adverse and not significant.

GWDTEs

14.10.116 The assessment of effects on GWDTEs is detailed in ES Appendix 14.7: Groundwater Dependent Terrestrial Ecosystem Assessment (Application Document 3.4). It has been based upon the outputs from ES Appendix 14.6: Hydrogeological Impact Assessment (Application Document 3.4) and ES Chapter 6: Biodiversity.

14.10.117 The assessment concluded that there is a significant risk from the scheme to some habitats with the potential to support GWDTEs. This includes Dyke Nook Fen and Flitholme Fen which have both been categorised as highly important habitat with the potential to be highly dependent on groundwater, and therefore classified as a very high value receptor.

14.10.118 Dyke Nook Fen will be subject to further surveys to collect National Vegetation Classification (NVC) data and groundwater data to confirm any presence or likely absence of GWDTE and therefore determine the potential impact on this area of habitat. If required, lining of cuttings or adaptation of the design within the Order Limits and limits of deviation will be explored at detailed design, as outlined in the EMP (Application Document 2.7) and PDP (Application Document 5.11). The impact on groundwater quality and quantity to Dyke Nook Fen, a high dependency (very high value) receptor, after mitigation is considered to be negligible and therefore of negligible risk[66], which is not considered to be significant.

14.10.119 At detailed design, Flitholme Fen and Flitholme Woodland will be subject to further ecological surveys to collect NVC data for this area and confirm any presence or likely absence of GWDTE. Compensation for the loss of this habitat through creation of new habitat and commitment to a Landscape Environmental Management Plan that sets out long term management to maximise opportunities for biodiversity, is outlined in Chapter 6: Biodiversity (Application Document 3.2) and committed to through the EMP (Application Document 2.7).

14.10.120 Due to the nature of the design at this location, it is not currently possible to guarantee that impacts on Flitholme Fen and Flitholme Woodland can be avoided. The impact on these habitats, that are of high dependency (very high value), is considered to be major adverse

[66] Residual risk is applied as per Appendix B in DMRB LA 113, Negligible Risk is equivalent to a negligible effect and therefore not significant

impact magnitude and therefore of significant risk[67], which is considered to be significant.

Flood risk

Fluvial flood risk

14.10.121 The FRA (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)) assesses the risk of flooding to the scheme and from the scheme to third party land. The scheme is located within Flood Zone 3 and is considered to have the potential to reduce flood storage capacities at this location.

14.10.122 To mitigate for the loss of flood storage, flood compensation has been embedded into the proposed design and has been informed by hydraulic modelling. Compensatory storage areas have been provided close to the loss areas and are hydraulically connected to the floodplain. Additional storage is also proposed on both sides of Moor Beck. The flood modelling undertaken confirms that the storage results in no increase in flood risk downstream of the scheme to Warcop or to third party land.

14.10.123 Given that the Project is classed as very high value and surrounding third party land as high value, and the magnitude of impact is considered to be no change following mitigation, the residual effect is neutral and not significant.

Bowes Bypass

Construction

Groundwater

Groundwater abstractions/springs

14.10.124 Springs on the western end of the Bowes Bypass scheme (Western Bowes Springs) are used for local agricultural water supply. Cuttings in the area have the potential to reduce baseflow to springs, resulting in a reduction in spring flow rates or alteration of flow paths. Due to uncertainty in the exact location and nature of the springs, there is the potential for a significant impact without appropriate mitigation measures. Surveying of areas at risk in the area prior to commencement of construction will assist in the identification of spring locations and enable a further assessment of risk to be undertaken. If required following further assessment, appropriate mitigation and/or compensation measures (e.g. lining of cuttings or replacement mains supply etc) will need to be implemented to ensure continued supply, in consultation with the stakeholder. With mitigation implemented as outlined above and within the EMP (Application Document 2.7), the risk posed to the receptors would be negligible, resulting in a slight adverse impact.

[67] Residual risk is applied as per Appendix B in DMRB LA 113, Significant Risk is equivalent to a very large adverse effect and therefore significant

In-combination climate change effects

14.10.125 The in-combination climate change assessment has used a future climate baseline that is based on representative concentration pathway 8.5 (RCP 8.5) of the UK climate change 2018 projections (UKCP18). This future climate baseline is presented in Chapter 7: Climate (Application Document 3.2).

14.10.126 Table 14-42: ICCI assessment for construction likely effects details the in-combination climate change assessment for construction likely effects and Table 14-43: ICCI assessment for operation likely effects reports the assessment for operation likely effects. The expected changes in precipitation and temperatures, and extreme weather events are the climate hazards that are expected to increase the significance of effects for this chapter.

Construction

Table 14-42: ICCI assessment for construction likely effects

Effect impacted by climate change	Climate hazard(s)	Impact of climate hazard(s)	Impact on significance of the effect	Embedded mitigation or additional mitigation/enhancement
Fluvial and Pluvial flood risk	Increase in precipitation and more extreme weather events	Increased precipitation has the potential to increase watercourse volume and flow rates. This, in combination with saturated ground conditions or hydrophobic soils due to dry spells, gives an increased flood risk to construction works and compounds.	Higher volumes of water and increased frequency of flood risks will increase the likelihood and magnitude of flooding, making the significance of the effect greater.	The EMP details the surface and ground water management plan (Annex B7 of the EMP, Application Document 2.7) which will ensure that construction platforms are built at a suitable level based on flood modelling. Temporary flood defences and early warning alarm systems will also be applied where appropriate.

Operation

Table 14-43: ICCI assessment for operation likely effects

Effect impacted by climate change	Climate hazard(s)	Impact of climate hazard(s)	Impact on significance of the effect	Embedded mitigation or additional mitigation/enhancement
Fluvial and Pluvial flood risk	Increase in precipitation and more extreme weather events	Increased precipitation has the potential to increase watercourse volume and flow rates. This, in combination with saturated ground conditions or hydrophobic soils due to dry spells, gives an increased flood risk to areas within and outside the Order Limits.	Higher volumes of water and increased frequency of flood risks will increase the likelihood and magnitude of flooding, making the significance of the effect greater.	Embedded mitigation in the Project design, such as climate change allowances in the drainage design and addition of flood compensation (as defined by flood modelling).
Suspended solids in watercourses	Increase in dry spells	Increased temperatures and dry spells have the potential to cause increased erosion when heavy rains do arrive due to	Increased suspended solids within watercourses may impact on aquatic ecology, which are designating	Embedded mitigation in the Project drainage design has been included to capture suspended solids to ensure that discharge is of a satisfactory

Effect impacted by climate change	Climate hazard(s)	Impact of climate hazard(s)	Impact on significance of the effect	Embedded mitigation or additional mitigation/enhancement
		hydrophobic soils. Resulting in increased suspended sediment within watercourses that changes hydromorphological processes and can impact on aquatic ecology.	features of the River Eden SAC. The changes in hydromorphology potentially caused by the scheme will be of greater significance due to climate change increasing the magnitude of the effect.	quality. These systems have been designed using climate change scenario values.
Groundwater recharge	Number of hot days and heatwaves	Due to prolonged dry spells, the compacted ground will impact on infiltration rates with a consequence of reducing groundwater recharge rates. The increase in hot days has the potential to increase the water resource required and increase abstraction rates. Groundwater quality may also be impacted by the reduction in the flushing of aquifers, increasing the residence time of the groundwater they hold.	A change of groundwater recharge rates has the potential to impact on abstraction points, and on surface water – groundwater interaction. The significance of any project related drawdown will therefore be increased.	A cuttings assessment has been carried out to identify any areas of risk of excessive drawdown.

Summary of significant effects

14.10.127 No significant effects to the receiving water environment during the construction phase of the Project are anticipated following the assessment. Non-significant effects are detailed in ES Appendix 14.11: Non-Significant Effects (Application Document 3.4).

14.10.128 A summary of the significant effects to the receiving water environment during the operational phase of the Project are outlined in Table 14-: Summary of significant effects (operation). Non-significant effects are detailed in ES Appendix 14.11: Non-Significant Effects (Application Document 3.4).

Table 14-: Summary of significant effects (operation)

Receptor	Attribute	Receptor sensitivity	Potential impact before essential mitigation	Essential mitigation/ enhancement	Impact magnitude	Residual effect
Appleby to Brough						
GWDTEs: Flitholme Fen and Flitholme Woodland	Biodiversity	High	Loss or degradation of habitats with the potential to support GWDTEs.	At detailed design, further ecological surveys will be completed to collect NVC data for this area and confirm any presence or likely absence of GWDTE. Compensation for the loss of this habitat through creation of new habitat and commitment to a Landscape Environmental Management Plan that sets out long term management to maximise opportunities for biodiversity, is outlined in Chapter 6: Biodiversity (Application Document 3.2) and is secured in the EMP (Application Document 2.7).	Major adverse	Negligible[68]

[68] Residual risk is applied as per Appendix B in DMRB LA 113, this is equivalent to a very large adverse effect and therefore significant

14.11 Monitoring

14.11.1 *DMRB LA 104* sets out the requirements of monitoring, as detailed in Chapter 4: Environmental Assessment Methodology (Application Document 3.2).

Construction

14.11.2 Water environment monitoring should be conducted across the Project during the construction phase at appropriate locations to detect changes in the water environment from construction, and to determine locations for mitigation measures, as part of the management plans that are required by the EMP (Application Document 2.7). The duration of monitoring should be programmed to provide sufficient baseline data to allow comparison between the baseline and subsequent monitoring during the construction of the Project.

14.11.3 This may include the monitoring of the following groups of parameters (selected to capture construction risks) based upon WFD status and baseline pre-construction monitoring results:

- Hydrocarbons, suspended solids and heavy metals
- Physio-chemical parameters
- Visual inspections to be conducted by an Environmental Clerk of Works.

14.11.4 Locations, frequency and parameters to be monitored will developed in consultation with the Environment Agency prior to construction, particularly for watercourses associated with the River Eden SAC and associated functionally linked habitat.

14.11.5 Groundwater levels should continue to be collected pre-construction and during construction to ascertain a full seasonal baseline. Further hydrological surveys of areas that are potentially susceptible to groundwater level or flow impacts, where additional unmapped receptors are considered likely to be located, should be undertaken prior to construction and appropriate mitigation identified and installed.

14.11.6 Additional monitoring, as specified by regulatory authorities, will be undertaken in line with relevant obtained licenses, consents or permits.

WFD compliance

14.11.7 The WFD compliance assessment (ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4)) outlines that targeted WFD monitoring will be implemented on surface water bodies and watercourses that have the potential to be impacted. This is required prior to, during and following construction by National Highways, to assess the effects of the Project and the suitability and effectiveness of mitigation outlined in ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

14.11.8 This monitoring strategy will be developed in consultation with the Environment Agency and focused around the relevant Project components and quality elements affected. Monitoring outcomes will be

utilised to inform the development of any corrective measures and/or further mitigation if/where deemed necessary by the Environment Agency. This is secured in the EMP (Application Document 2.7) and will also be implemented in the operational phase of the project.

Operation

Hydromorphology

14.11.9 It is recommended that post construction surveys are undertaken of all new culverts to review the effectiveness of embedded mitigation and the function of channels. If there is any evidence of excessive erosion or sedimentation further actions will be implemented by National Highways to remedy the impact.

Geomorphology

14.11.10 As part of National Highways' maintenance, inspections of potential scour on the Trout Beck Viaduct crossing piers, and on the Moor Beck Viaduct crossing and Warcop Junction embankment will be conducted. Should any adverse changes be reported, appropriate mitigation plans to address this will be developed and implemented by National Highways. The Environment Agency and Natural England will be consulted on impacts to geomorphology.

Flood Risk

14.11.11 No likely significant adverse effects are identified for flood risk; therefore, no monitoring is required.

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