

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA2: Colwich to Yarlet

Water resources assessment (WR-002-002)

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Department
for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

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1 Introduction

1.1 Structure of the water resources and flood risk appendices

1.1.1 The water resources and flood risk appendices comprise both route-wide and community area specific documents. The route-wide appendices comprise:

- a Water Framework Directive (WFD) compliance assessment (Volume 5: Appendix WR-001-000); and
- a water resources operation and maintenance plan (Volume 5: Appendix WR-005-000).

1.1.2 For the Colwich to Yarlet (CA2) area, the area specific appendices comprise:

- a water resources assessment (i.e. this appendix); and
- a flood risk assessment (Volume 5: Appendix WR-003-002).

1.1.3 Hydraulic modelling reports, which describe the approach to assessing key flood risk issues identified within the community area, are included in Background Information and Data (BID)¹.

1.1.4 Maps (WR-01 and WR-02) referred to throughout this assessment are contained in the Volume 5, Water resources and flood risk Map Book.

1.2 Scope, assumptions and limitations

1.2.1 The scope, assumptions and limitations for the water resources assessment are set out in Volume 1 (Section 8), the Scope and Methodology Report (SMR)² and the SMR addendum³.

1.2.2 The Colwich to Yarlet area covers a 14.9km long section of the Proposed Scheme. The spatial scope of the assessment is based upon the identification of surface water and groundwater features within 1km of the centre line of the route of the Proposed Scheme. However, the spatial scope has been extended to include an area of land where works are proposed along Bishton Lane. For the purposes of this assessment this spatial scope is defined as the study area.

1.2.3 The assessment considers the construction and operational features of the Proposed Scheme within the study area. These are shown on Volume 2: Map Series CT-05 and Map Series CT-06. The route will be constructed on a series of cuttings and embankments and the Great Haywood viaduct.

1.2.4 This assessment covers the potential impacts of the Proposed Scheme on existing surface water and groundwater resources, including consideration of:

¹ HS2 Ltd (2017), *High Speed 2 (HS2) Phase 2a (West Midlands - Crewe), Background Information and Data, Hydraulic Modelling Reports. BID-WR-004*, www.gov.uk/hs2

² Volume 5: Appendix CT-001-001, Scope and Methodology Report

³ Volume 5: appendix CT-001-002, Scope and Methodology Report Addendum

- surface waters⁴;
- aquifers;
- abstractions (licensed and unlicensed) and consented discharges; and
- springs and other groundwater-surface water interactions with implications for water resources and/or groundwater dependent terrestrial ecosystems.

1.2.5 The route-wide WFD compliance assessment (Volume 5: Appendix WR-001-000) provides a comprehensive review of the potential impacts of the Proposed Scheme on designated WFD surface water and groundwater bodies. The WFD compliance assessment, which involved extensive walkover surveys, informed both the value attributed to relevant receptors, such as watercourses, and the assessment of impacts and effects used in this assessment.

1.2.6 The water resources assessment considers the pollution risks associated with routine discharges of runoff from new sections of highway proposed within the study area, during the operational phase of the Proposed Scheme. This assessment uses the Highways Agency Water Risk Assessment Tool (HAWRAT) as presented in Design Manual for Roads and Bridges⁵. An assessment is required if the Annual Average Daily Traffic flow value (AADT) exceeds 10,000 vehicles, and the heavy goods component of the AADT exceeds 500. A screening exercise identified three highway modifications in the Colwich to Yarlet area which required an assessment of highway pollution.

1.2.7 Pollution risks associated with trains using the Proposed Scheme during its operational phase are considered on a route-wide basis within Volume 3, Route-wide effects, Section 16, Water resources and flood risk.

1.3 Study area description and key features

1.3.1 The study area is predominantly rural, although there are a number of villages, hamlets and farmsteads located within close proximity to the Proposed Scheme. The most significant of these is Great Haywood, although Stafford Barracks and the outer urban extent of Stafford is located approximately 700m to the south-west of the Proposed Scheme.

1.3.2 Within the Colwich to Yarlet area the Proposed Scheme will be constructed in alternating sections of cuttings and embankments interspersed with a long viaduct required to span the floodplain of the River Trent. There are no tunnels or at grade sections.

1.3.3 The main environmental features of relevance to water resources include:

- the River Trent and its associated tributary watercourses;
- the Sherwood Sandstone Group Principal aquifer;

⁴ Ponds are not included in the water resources assessment, these are assessed as ecological features in Volume 2, Colwich to Yarlet area report, Section 8, Ecology and biodiversity

⁵ Design Manual for Roads and Bridges, *Road Drainage and the Water Environment*, Volume 11 Environmental Assessment, Section 3, Environmental Assessment Techniques, Part 10, HD45/09

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- the permeable superficial deposits Secondary A aquifers;
- the Mercia Mudstone Group Secondary B aquifer;
- Saline springs at the Lionlodge Covert Local Wildlife Site (LWS) and a potential spring feature at Lower Bridge Farm;
- three licensed private groundwater abstractions;
- four unlicensed groundwater abstractions; and
- Pasturefields Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC).

2 Stakeholder engagement

2.1.1.1 Discussions have been held with the following stakeholders to inform the water resources assessment:

- the Environment Agency;
- Stafford Borough Council (SBC), with regard to private unlicensed water abstractions;
- water companies to confirm details of public water abstractions (if and where present in the study area), and associated water resource management plans; and
- the owners of private licensed and unlicensed abstractions, where survey access has been available.

3 Baseline data

3.1 Surface water

- 3.1.1 The surface water features crossed by the Proposed Scheme within this study area, including their location, current overall WFD status and future overall status objectives, are tabulated in the Volume 2, Colwich to Yarlet area report, Section 15. The receptor values attributed to each individual water course, based on the methodologies set out in the SMR², as applied in the WFD compliance assessment (Volume 5, Appendix WR001-000), are also provided.
- 3.1.2 There are no licensed surface water abstractions in the study area. Records of unlicensed private water abstractions, which comprise those for quantities less than 20m³ per day, have been obtained from the local authorities. This data indicates that there are no registered private unlicensed surface water abstractions within the study area. As there is no obligation to register private water supplies, unregistered supplies may also be present. Private water supplies are assessed as high value receptors unless details obtained from the owner indicate otherwise.
- 3.1.3 There are 18 consented discharges to surface water within the study area, as shown in Table 1. These have been assessed as low value receptors.

Table 1: Consented discharges to surface water

Permit identifier (and map grid square)	Distance and direction from route	Discharge type	Receiving water body
T/05/36247/S (C6 ⁶)	1.1km south of the route (located 500m to the east of Bishton Lane)	Domestic property (single) (including farm house)	Unnamed tributary of River Trent
T/01/35920/S (H6 ⁷)	50m south of the route (located within the land required for construction of the Proposed Scheme)	Domestic property (single) (including farm house)	Tributary of River Trent
T/05/36420/S (H6 ⁷)	0.19km south of the route (located adjacent to the land required for construction of the Proposed Scheme)	Domestic property (single) (including farm house)	Unnamed tributary of River Trent
T/01/35547/O (H6 ⁷)	0.25km south of the route (located within the land required for construction of the Proposed Scheme)	Pumping station on unadopted sewerage network (not water company)	Tributary of River Trent

⁶ Map WR-01-102b. Discharges in the study area are listed from south to north.

⁷ Map WR-01-103. Discharges in the study area are listed from south to north.

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Permit identifier (and map grid square)	Distance and direction from route	Discharge type	Receiving water body
T/01/00104/O (H7 ⁷)	0.84km south of the route (located 320m south of the land required for construction of the Proposed Scheme)	Pumping station on sewerage network (water company)	River Trent
NPSWQD001024 (G4 ⁷)	0.91km north-east of the route (300m north-east of the land required for construction of the Proposed Scheme)	Domestic property (single) (including farm house)	Tributary of Pasturefields Brook
T/01/36221/R (G4 ⁷)	0.92km north of the route (330m north-east of the land required for construction of the Proposed Scheme)	Wastewater treatment works/sewage treatment works (water company)	Pasturefields Brook
T/01/36221/R (G4 ⁷)	0.92km north of the route (330m north-east of the land required for construction of the Proposed Scheme)	Wastewater treatment works/sewage treatment works (water company)	Pasturefields Brook
T/01/35480/S (F5 ⁷)	0.7km north-east of the route (located 275m west of the land required for construction of the Proposed Scheme)	Domestic property (multiple) (including farm houses)	Tributary of River Trent
T/01/36389/S (F5 ⁷)	0.64km north-east of the route (located 245m west of the land required for construction of the Proposed Scheme)	Domestic property (multiple) (including farm houses)	Un-named tributary of River Trent
T/01/10424/S (E5 ⁷)	0.68km north of the route (located 0.53km north of the land required for construction of the Proposed Scheme)	Wastewater treatment works (not water company)	Tributary of River Trent
T/01/36021/S (E5 ⁷)	0.78km north of the route (located 0.61km north of the land required for construction of the Proposed Scheme)	Domestic property (multiple) (including farm houses)	Tributary of River Trent
T/01/22658/S (E5 ⁷)	0.7km north of the route (located 0.54km north of the land required for construction of the Proposed Scheme)	Wastewater treatment works (not water company)	Tributary of River Trent
NPSWQD000673 (C6 ⁷)	Adjacent to Proposed Scheme (located within the land required for construction of the Proposed Scheme)	Domestic property (multiple) (including farm houses)	Tributary of Kingston Brook

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Permit identifier (and map grid square)	Distance and direction from route	Discharge type	Receiving water body
T/02/35214/S (A5 ⁷)	0.57km east of the route (located 50m north-west of the land required for construction of the Proposed Scheme)	Domestic property (multiple) (including farm houses)	Hopton Brook
T/02/35666/S (H1 ⁸)	0.26km north-east of the route (located adjacent to the land required for construction of the Proposed Scheme)	Domestic property (multiple) (including farm houses)	Tributary of River Trent
T/02/35628/S (H5 ⁸)	0.1km north-east of the route (located adjacent to the land required for construction of the Proposed Scheme)	Domestic property (single) (including farm house)	Tributary of River Trent
T/01/20449/S (E5 ⁸)	0.62km north-east of the route (located 260m north-east of the land required for construction of the Proposed Scheme)	Wastewater treatment works (not water company) (not STP at a private premises)	Tributary of River Trent

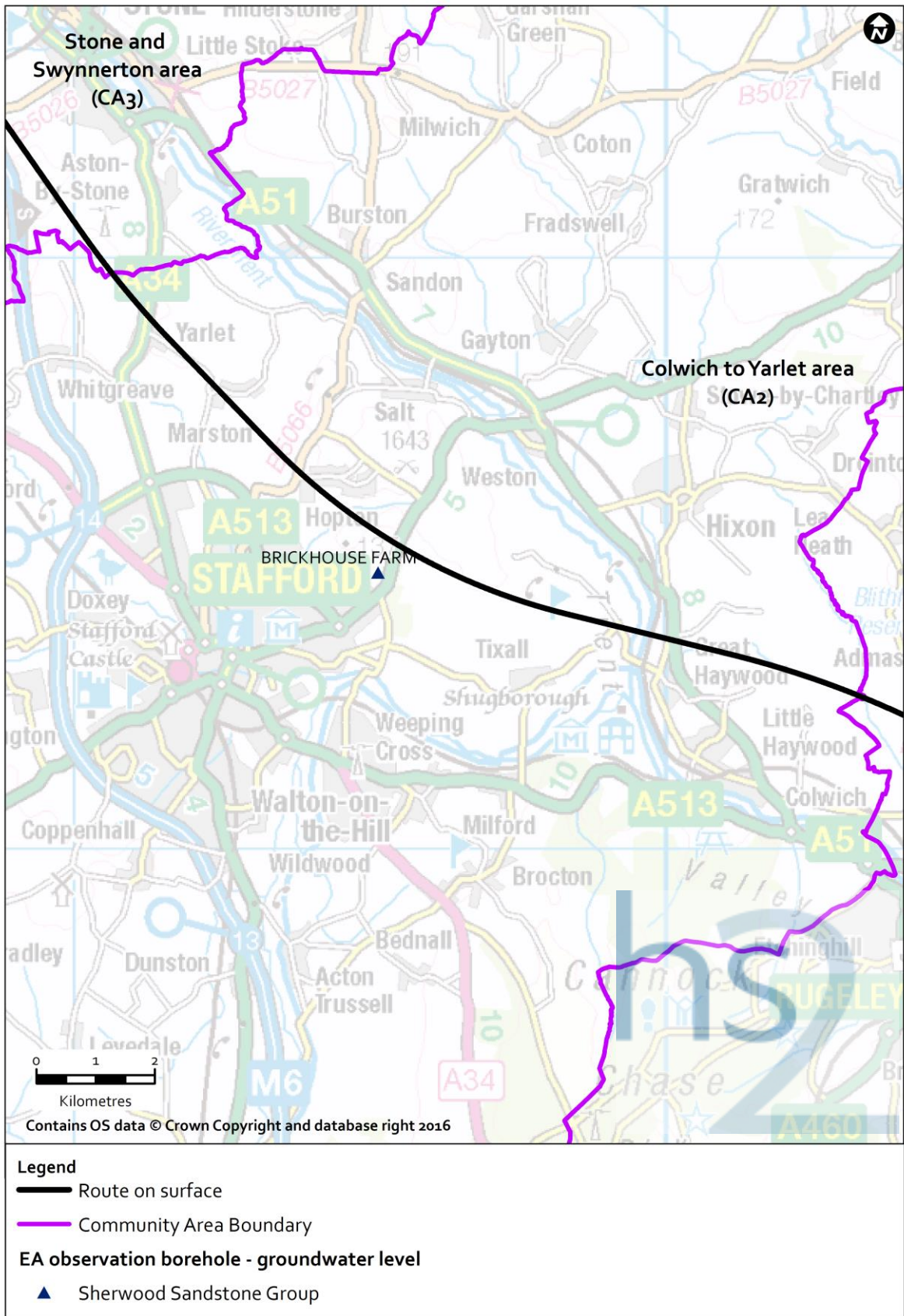
3.2 Groundwater

- 3.2.1 A summary of the geological units present in the study area is presented in the Land Quality section in ES Volume 2, Colwich to Yarlet area report, Section 10. The hydrogeological characteristics of the geological units are summarised in the Water resources and flood risk Volume 2, Colwich to Yarlet area report, Section 15. Further detail is provided in the following sections.
- 3.2.2 Map WR-02-202 (Volume 5: Water resources assessment and flood risk Map Book) shows the superficial and bedrock geology within the study area.
- 3.2.3 There are four superficial aquifers within the study area: Alluvium, River Terrace Deposits and Glaciofluvial Deposits, which are all classified as Secondary A aquifers by the Environment Agency, as well as Glacial Till, which is a Secondary (Undifferentiated) aquifer. Peat is also present and classified as Unproductive.
- 3.2.4 There are two main bedrock aquifers in the study area. The Sherwood Sandstone Group is classified as a Principal aquifer, and includes both the Helsby Formation and the Chester Formation, and the Mercia Mudstone Group, which includes the Stafford Halite Formation and is classified as a Secondary B aquifer. The exception is where the Sherwood Sandstone Group outcrops locally as mudstone within the Helsby Formation and is classified as a Secondary B aquifer in this area.

⁸ Map WR-01-104a. Discharges in the study area are listed from south to north.

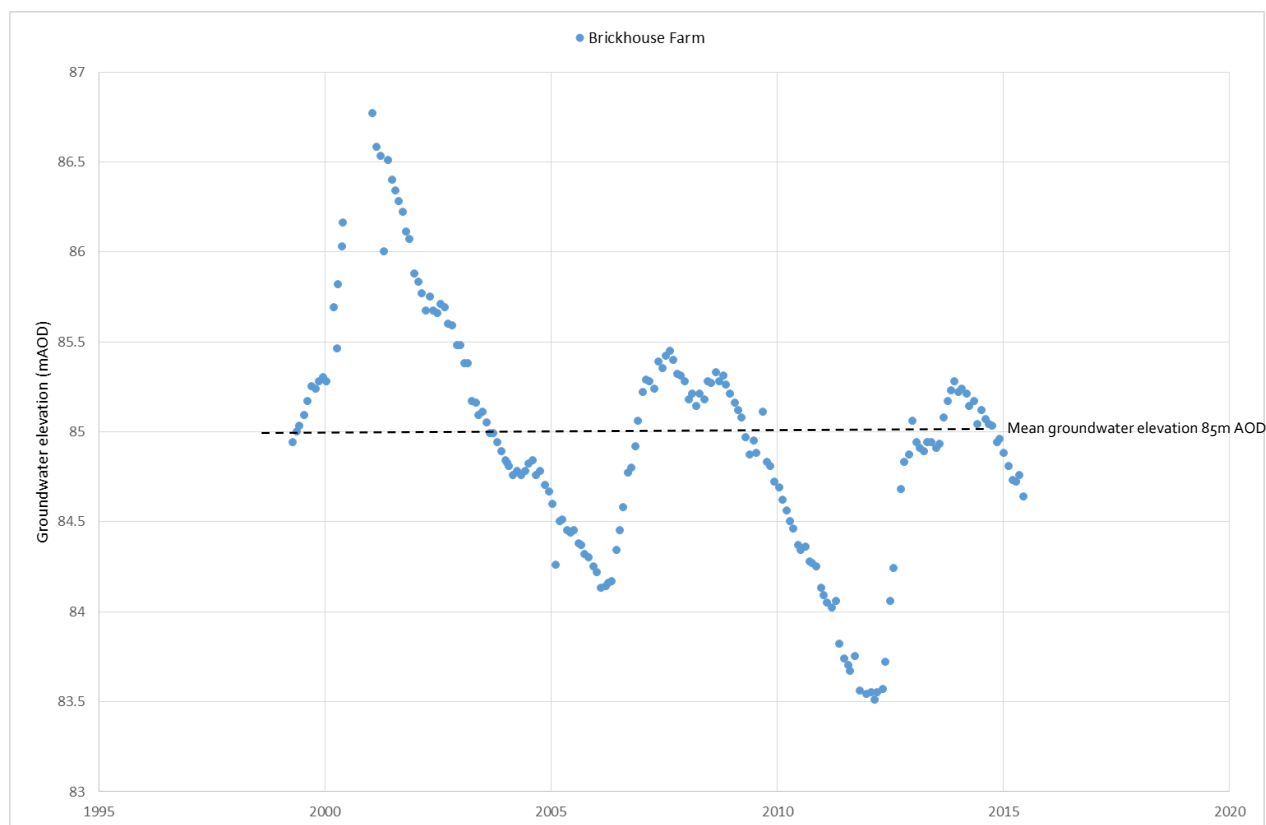
- 3.2.5 There is one Environment Agency observation borehole where groundwater levels are monitored in the Sherwood Sandstone Group within the study area at Brick House Farm, as shown in Figure 1. Figure 2 presents the time-series of available groundwater level monitoring data. There is one Environment Agency observation borehole at which groundwater quality in the Sherwood Sandstone Group is monitored, located immediately south of the Proposed Scheme at Ingestre Park Golf Club.

Figure 1: Location of Environment Agency groundwater level monitoring boreholes (Sherwood Sandstone Group)



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Figure 2: Groundwater level (Sherwood Sandstone Group) in metres above ordnance datum (mAOD) at Brick House Farm monitoring borehole



- 3.2.6 Groundwater level data from Brick House Farm indicate that the mean groundwater elevation at this location is 85m AOD (9.5 m below ground level (bgl)). Groundwater strikes recorded on borehole logs have also been referred to for the purpose of the assessment.
- 3.2.7 Groundwater in the superficial aquifers is expected to be shallow within the river valleys and at slightly greater depth on the valley sides. The direction of groundwater flow is likely to follow the general topography and the surface watercourses are likely to act as discharge points for converging groundwater flow in the area.
- 3.2.8 Some groundwater flow is expected in the Mercia Mudstone Group, though permeable horizons within this unit are expected to be laterally discontinuous and associated with thin siltstone and sandstone layers called skerries. There may also be a small element of fracture flow.
- 3.2.9 Table 2 summarises groundwater abstractions and their locations are shown on Map WR-02-202.
- 3.2.10 There are a number of private abstractions from groundwater (licensed and unlicensed) in the study area. These do not have mapped SPZs but, where they are

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used for potable water and some other purposes, they do have a nominal SPZ₁ of 50m⁹. These abstractions have all been assessed as high value receptors.

- 3.2.11 The private water supply information has been provided by the local authority, SBC. Where land access has been available, surveys have been undertaken to confirm abstraction details. Where the exact details of an abstraction are not known, a precautionary assessment has been undertaken.
- 3.2.12 There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day and not all of the unlicensed abstractions are registered with the local authority. These may also need to be protected.
- 3.2.13 There are no public water supply groundwater abstractions or associated SPZ within the study area.

Table 2: Summary of groundwater abstractions in Colwich to Yarlet area

Name, licence number (and map grid square) ¹⁰	Distance and direction from route	Abstraction source	Maximum annual abstraction quantity (m ³)	Maximum daily abstraction quantity (m ³)	Purpose	Number of boreholes
Private licensed water supplies						
Moreton Grange 03/28/05/0059/Ro 1 (I5)	95m south of the route of the Proposed Scheme (10m east of the land required for construction of the Proposed Scheme)	U24T Minor Aquifer - Upper Trent Area	16,920	48	General farming and domestic	1
Ingestre Park Golf Club 03/28/01/0201 (G6)	160m south of the route of the Proposed Scheme (50m east of the land required for construction of the Proposed Scheme)	F46 Hopton Unit (assumed to be the Sherwood Sandstone Group)*	4,546	73	Spray irrigation	1
Staffordshire County Showground MD/028/0004/00 1 (F6)	440m north-east of the route of the Proposed Scheme (160m north-east of the land required for construction of the Proposed Scheme)	F46 Hopton Unit (assumed to be the Sherwood Sandstone Group)*	17,500	370	Agriculture, industrial and commercial	1

⁹ Gov.uk (2017), *Protect groundwater and prevent groundwater pollution*. <https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution>

¹⁰ Map grid squares on Map WR-02-202 for SPZs, licence numbers (for licensed abstractions) and unique map identification (ID) numbers (for unlicensed groundwater abstractions). Abstraction features in the study area are generally listed from south to north.

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Name, licence number (and map grid square) ¹⁰	Distance and direction from route	Abstraction source	Maximum annual abstraction quantity (m ³)	Maximum daily abstraction quantity (m ³)	Purpose	Number of boreholes
Private unlicensed water supplies						
Upper Hanyards Farm Map ID: 2/GA/1 (F6)	The route of the Proposed Scheme passes over the abstraction (within the land required for construction of the Proposed Scheme)	Unknown (assumed to be the Sherwood Sandstone Group based on geological mapping) [#]	Unknown	<20	Domestic	1
Bishton Farm Map ID: 2/GA/2 (I5)	> 1km from the route (300m east of the land required for construction of the Proposed Scheme)	Unknown	Unknown	<20	Unknown	Unknown
Bishton Lane Farm Map ID: 2/GA/3 (I6)	> 1km from the route (immediately to the east of the land required for construction Of the Proposed Scheme)	Unknown	Unknown	<20	Unknown	Unknown
Bishton Hall Farm Map ID: 2/GA/4 (J6)	> 1km from the route (185m south of the land required for construction of the Proposed Scheme)	Unknown	Unknown	<20	Unknown	Unknown

^{*}Based on the information provided in the Staffordshire Trent Valley abstraction licensing strategy February 2013, Environment Agency, the Hopton Unit is assumed to be part of the Sherwood Sandstone Group.

[#]Currently supplying Upper Hanyards Farm, which is scheduled for demolition, and also Lower Hanyards Farm.

3.2.14 There are 10 consented discharges to groundwater in the study area and these have been assessed as low value receptors. These are summarised in Table 3.

Table 3 Discharge consents to groundwater

Permit identified (and map grid square) ¹¹	Distance and direction from route	Discharge type	Receiving water body
3/28/05/1690 (H4/I4)	740m north of the route of the Proposed Scheme. (570m north-east of the land required for construction of	Soakaway (domestic final/treated effluent)	Groundwater

¹¹ Map WR-02-202. Discharges in the study area are listed from south to north

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Permit identified (and map grid square) ¹¹	Distance and direction from route	Discharge type	Receiving water body
	the Proposed Scheme)		
3/28/05/2060 (H5)	350m of the route of the Proposed Scheme, (within the land required for construction)	Soakaway (domestic final/treated effluent)	Groundwater
T/04/36140/Sg (G6)	740m south of the route of the Proposed Scheme (420m south-west of the land required for the construction of the Proposed Scheme)	Soakaway (multiple domestic final/treated effluent)	Groundwater
EPryp3923gz (G5)	560m north of the route of the Proposed Scheme (415m north of the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Groundwater
T/02/36360/Sg (E6)	880m north-east of the route of the Proposed Scheme (500m north-east of the land required for the construction of the Proposed Scheme)	Soakaway (multiple domestic final/treated effluent)	Groundwater
WQ/72/123 (E6)	920m north-east of the route of the Proposed Scheme (500m north-east of the land required for the construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata
WQ/72/1004 (E6)	820m north-east of the route of the Proposed Scheme (530m east of the land required for the construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata
WQ/72/1006 (E5)	890 north-east of the route of the Proposed scheme (500m east of the land required for the construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata
WQ/72/213 (D6)	535m north-east of the route of the Proposed Scheme (185m east of the land required for the construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata
WQ/72/3725 (C6)	240m south-west of the route of the Proposed Scheme (immediately to the north of the land required for the construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata

3.3 Groundwater - surface water interaction

3.3.1 Table 4 summarises the potential groundwater water - surface water interactions within the study area.

3.3.2 Along with the main surface watercourses which could have connections with groundwater, springs and issues have been identified within the study area from Ordnance Survey (OS) maps. Where land access has been available, these have been surveyed to check if they are true expressions of groundwater (and therefore could contribute flows to surface water bodies), or if they are simply land drainage features. Where surveys have proved the latter, the features have been removed from the water resources assessment and they are not shown in the table below or on Map WR-02-202. In the absence of site surveys the features have been assumed to comprise springs, which are considered high value receptors.

Table 4 Groundwater - surface water interaction

Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Watercourses				
River Trent and tributaries	Crossed by the route	Alluvium and River Terrace Deposits	Approx. 72.8	The River Trent and tributaries are likely to be in hydraulic connection with the permeable superficial deposits where they cross them.
Trent and Mersey Canal	Crossed by the route	Alluvium and River Terrace Deposits	Approx. 72.8	The canal is likely to be lined.
Springs				
Potential spring to the west of Lount Farm (J5)	1,000m south of the route of the Proposed Scheme	Mercia Mudstone Group	92.4	Not surveyed. Assumed to be a high value receptor until this is verified by survey.
Spring, south-west of Moreton House (I5)	70m south of route of the Proposed Scheme (within the land required for construction).	Mercia Mudstone Group	114.6	Surveyed and confirmed to be a spring. During the survey it was noted that it may supply a man-made pond.
Spring, Moreton Brook potentially feeding marshland at Lount Farm LWS	170m north of the route of the Proposed Scheme	Mercia Mudstone Group	82.95	Surveyed and confirmed to be a spring. During survey it was noted that there was the possibility of groundwater feeding an area of

¹² Map WR-02-202. Watercourses cross several map grid squares and are labelled. Map grid squares are provided for the springs and potential spring locations within the study area. These features are listed from south to north.

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Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
(I4)				marshland.
Potential spring, north-east of Moreton Barn Farm (I4)	500m north of route of the Proposed Scheme	/Mercia Mudstone Group	89.5	Not surveyed. Assumed to be high value receptors until this is verified by surveys.
Potential spring, south-west of Gorie House (H4)	800m north of route of the Proposed Scheme	Glacial Till overlying Mercia Mudstone Group	92.67	
Potential spring, north of Tolldish Lane (H5)	610m north of route of the Proposed Scheme	Glacial Till overlying Mercia Mudstone Group	89.33	
Potential spring, east of Tixall Farm (G6)	480m south of route of the Proposed Scheme	River Terrace Deposits overlying Mercia Mudstone Group	74.03	
Potential spring, east of Tixall Farm (G6)	560m south of route of the Proposed Scheme	River Terrace Deposits overlying Mercia Mudstone Group	74.38	
Potential spring, Home Farm (G5)	700m north of route of the Proposed Scheme	At the edge of River Terrace Deposits overlying Mercia Mudstone Group	83.97	
Potential spring - Blackheath Covert (F7)	800m south of route of the Proposed Scheme	Helsby and Chester Sandstone Formation	100.05	
Potential spring, north of A518 Weston Road (F7)	950m south of route of the Proposed Scheme	Glacial Till overlying Chester Sandstone Formation	91.57	
Potential spring, north of Staffordshire County Showground (F5)	1000m north of route of the Proposed Scheme	Glacial Till overlying Helsby Sandstone Formation (Mudstone)	146.55	
Potential spring, north of Staffordshire County Showground (E6)	670m north of route of the Proposed Scheme	Helsby Sandstone Formation (Sandstone)	121.45	

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Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Potential spring, Hopton Pools Covert (E6)	640m north-east of route of the Proposed Scheme	Helsby Sandstone Formation (Sandstone)	116.5	
Potential spring, south-west of Lower Bridge Farm (E6)	200m south of route of the Proposed Scheme	Glaciofluvial Sheet Deposits overlying Mercia Mudstone Group	92.85	Not surveyed. Assumed to be a high value receptor until this is verified by survey. Other surveys undertaken in the vicinity of this 'issue' indicate that it is most likely to be a land drainage feature.
Potential spring, Ministry of Defence (MoD) Stafford (D7)	840m south of route of the Proposed Scheme	Glacial Till overlying Mercia Mudstone Group	84.95	Not surveyed. Assumed to be high value receptors until this is verified by surveys.
Potential spring, south of Marston Cottages (D6)	80m north-east of route of the Proposed Scheme (within the land required for construction)	Glacial Till overlying Mercia Mudstone Group	105.02	Not surveyed. Assumed to be a high value receptor until this is verified by survey. Appears to have been diverted.
Potential spring, north Marston Farm (D6)	140m south-west of route of the Proposed Scheme (within the land required for construction)	Mercia Mudstone Group	102.63	Not surveyed. Assumed to be a high value receptor until this is verified by survey.
Potential spring, south-west of Marston (C6)	475m south-west of route of the Proposed Scheme	Mercia Mudstone Group	99.57	
Potential spring, south-west of Marston (C7)	850m south-west of route of the Proposed Scheme	Mercia Mudstone Group	106.57	
Potential spring, Black Plantation (C5)	590m north-east of route of the Proposed Scheme	Glacial Till overlying Stafford Halite Formation	117.47	
Potential spring, west of Black Plantation (C5)	500m north-east of route of the Proposed Scheme	Glacial Till overlying Stafford Halite Formation	101.45	
Potential spring, east of Yarlet Hall Farm (C5)	700m north-east of the route of the Proposed Scheme	Glacial Till overlying Stafford Halite Formation	101.63	

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Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Potential spring, south of Top Farm (B6)	800m south-west of route of the Proposed Scheme	Glacial Till overlying Stafford Halite Formation	127.35	
Potential spring, north-west of Hundred Acres Farm (B6 /A6)	1000m south-west of route of the Proposed Scheme	Glacial Till overlying Stafford Halite Formation	109.93	

3.4 Water dependent habitats

3.4.1 Table 5 summarises the water dependent habitats within the study area.

3.4.2 Ecological impacts are assessed in Volume 2, Colwich to Yarlet area report, Section 8. Potential impacts to the hydrology and hydrogeology of these habitats are assessed in this appendix.

Table 5: Water dependent habitats

Name (and map grid square) ¹²	Distance from route	Designation	Comments
Pasturefields Site of Scientific Interest (SSSI) and Special Area of Conservation (SAC) (H5)	640m north of the land required for construction, 900m north of the route of the Proposed Scheme.	SSSI and SAC	Pasturefields is an inland saltmarsh. Further details are outlined in Section 8, Ecology and biodiversity.
Lionlodge Covert LWS (G5)	Crossed by the route of the Proposed Scheme	Local Wildlife Site. The saltmarsh is an Annex 1 priority habitat.	<p>Consists of a woodland and 1.5ha saltmarsh on the south side of the Lionlodge Covert.</p> <p>Historically the saltmarsh extended to the north of its current location, but land drainage has reduced the feature to its current size.</p> <p>It is thought that the source of the salt in the springs feeding the saltmarsh is from the dissolution of salts from the underlying bedrock.</p>

4 Site specific surface water assessments

4.1 Summary of assessment

- 4.1.1 Table 6 summarises the potential impacts and effects to surface water features, including watercourses and consented discharges within the study area.
- 4.1.2 The WFD compliance assessment (Volume 5: Appendix WR-001-000) provides a comprehensive review of the aspects of the Proposed Scheme that have potential to cause permanent impacts on water bodies, or which could constrain the future achievement of water body objectives. Temporary construction impacts, defined as those which would last less than three years, may not have implications for WFD compliance, but may nevertheless result in significant effects related to water resources. Such temporary effects have therefore been considered in this assessment, as shown in Table 6.
- 4.1.3 The draft Code of the Construction Practices (CoCP), referred to in Table 6, sets out the measures and standards of work that will be applied to the construction of the Proposed Scheme (see Volume 5: Appendix CT-003-000). These will provide effective management and control of such impacts during the construction period.
- 4.1.4 The WFD compliance assessment identifies a number of minor adverse impacts on water bodies within this study area. Because these minor adverse impacts are all associated with low value water bodies, no significant effects are anticipated. Adverse impacts on high and very high value water bodies identified in the WFD compliance assessment have been assessed as negligible as a result of the avoidance and mitigation measures incorporated into the design. These impacts and effects are not included in Table 7.
- 4.1.5 Table 7 includes all consented discharges to surface water within the area required for construction of the Proposed Scheme. It only includes those outside of this area where the potential for the Proposed Scheme to have an adverse impact on them has been identified.

Table 6: Summary of potential impacts to surface water receptors

Surface water feature/receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Watercourses									
River Trent and Trent and Mersey Canal at Great Haywood	Very high	- Realignments - Watercourse crossing/viaducts and bridges.	Potentially affected by pollution caused by the mobilisation of contaminants by runoff from the construction area. Typically these would include sediments, hydrocarbons related to fuel oils and high alkaline substances such as cement and concrete.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP	Magnitude of impact – Negligible Significance of effect – Negligible, not significant	None required	Magnitude of impact – Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Tributary of the River Trent at Tolldish Tributary of Kingston Brook at Hopton	Moderate	- Realignments - Watercourse crossings/Culverts/drop inlet culverts.	Potentially affected by pollution caused by the mobilisation of contaminants by runoff from the construction area. Typically these would include sediments, hydrocarbons related to fuel oils and high alkaline substances such as cement and concrete.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP	Magnitude of impact – Negligible Significance of effect – Negligible, not significant	None required	Magnitude of impact – Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Tributary of the Moreton Brook at Morton Grange Farm Tributary of the River Trent at Lionlodge covert Tributary of the Bentley Brook at Berryhill Tributary of the Kingston Brook at Mount Edge Tributary of the River Trent at Marston Lane Tributary of the River Trent at Yarlet Wood	Low	- Realignments - Watercourse crossings/Culverts/drop inlet culverts.	Potentially affected by pollution caused by the mobilisation of contaminants by runoff from the construction area. Typically these would include sediments, hydrocarbons related to fuel oils and high alkaline substances such as cement and concrete.	Magnitude of impact - Minor Significance of effect – Negligible, not significant	Implementation of measures described in the draft CoCP	Magnitude of impact – Negligible Significance of effect – Negligible, not significant	None required	Magnitude of impact – Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Discharges to surface water									
Discharge	Low	- Trent South embankment	Located within the land required for construction of the Proposed Scheme and within path of access road. The property will be demolished and the discharge	Magnitude of impact - Negligible	None required though the CoCP will be implemented throughout	Magnitude of impact – Negligible	None required	Magnitude of impact – Negligible	Construction (temporary and

Surface water feature/receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
T/01/35920/S (H6) ¹³			abandoned. Abandonment of discharge will not result in a measurable impact on flow into the watercourse which is a tributary of the River Trent.	Significance of effect - Negligible, not significant	construction	Significance of effect - Negligible, not significant		Significance of effect - Negligible, not significant	permanent)
Discharge T/01/35547/O (H6) ¹³	Low	- Trent South embankment	Discharge located within the land required for construction of the Proposed Scheme and may need to be safeguarded.	Magnitude of impact - Major Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP	Magnitude of impact – Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Discharge NPSWQD000673 (C6) ¹³	Low	- Hopton South cutting	Located within the land required for construction of the Proposed Scheme and within path of access road. Property will be demolished and discharge abandoned. Abandonment of discharge will not result in a measurable impact on flow into the watercourse which is a tributary of Kingston Brook.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required though the CoCP will be implemented throughout construction	Magnitude of impact - Negligible Significance of effect - Negligible, not significant.	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

¹³ As shown on Map WR-01-103

5 Site specific groundwater assessments

5.1 Summary of assessment

- 5.1.1 Table 7 summarises all the potential impacts to hydrogeology (aquifers), abstractions, discharges, groundwater-surface water interactions and groundwater dependent terrestrial ecosystems.
- 5.1.2 In Table 7 potential impacts on aquifers are grouped into those associated with above or at ground design elements and those associated with significant excavation or construction of permanent below ground features. Potential impacts on other groundwater receptors such as abstractions, discharges and springs are considered in the context of the relevant design elements with a focus on those elements which have the potential to cause an impact.
- 5.1.3 Table 7 includes all consented discharges to groundwater within the area required for construction of the Proposed Scheme. It only includes those outside of this area where the potential for the Proposed Scheme to have an adverse impact on them has been identified. Impacts on the springs and potential spring features identified in Table 4 are only included in Table 7, where the potential for adverse impacts has been identified.
- 5.1.4 The potential impacts of future ground investigations are considered negligible because of the measures outlined in the draft CoCP. As this assessment is applicable for all receptors it is not re-stated in Table 7.
- 5.1.5 Further detail of several elements of the assessment is presented in Section 5.2.

Table 7: Summary of potential groundwater impacts

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Hydrogeology (aquifers)									
Sherwood Sandstone Group - Helsby Sandstone Formation - Principal aquifer	High	Construction of above ground elements and shallow excavation (<1m) including: - Hopton embankment	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground and of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Sherwood Sandstone Group - Helsby Sandstone Formation - Principal aquifer	High	Construction involving deeper excavation (>1 m) including: - Utility diversions - Brancote South cutting - Brancote North cutting - Hopton South cutting	The temporary works have the potential to affect localised groundwater quality. Impacts on the groundwater levels due to the cutting dewatering will be negligible in the context of the aquifer. See Section 5.2 for further details on cuttings. Construction of Hopton South cutting is likely to intercept historical landfill at Staffordshire County Showground, however records show the landfill was inert, uncapped and unlined. Last input of waste 1989. Therefore, most mobile contaminants will most likely have been leached locally. Any waste encountered will be removed as part of the works. Groundwater within the Hopton South cutting is likely beneath the cutting base (see Section 5.2) therefore dewatering will not be required and there will be no increase in contaminant mobilisation due to the works. Temporary and permanent works are of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Moderate Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Sherwood Sandstone Group - Mudstone - Helsby Sandstone Formation - Secondary B aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Moreton North embankment - Trent South	Temporary works have the potential to affect localised groundwater quality. Temporary and permanent works are above ground, and of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect - Negligible, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
		embankment - Trent North embankment							
Sherwood Sandstone Group - Mudstone - Helsby Sandstone Formation - Secondary B aquifer	Moderate	Construction involving deeper excavation (>1 m) excavation including: - utility diversions	Temporary works have the potential to affect localised groundwater quality. Temporary and permanent works are of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect - Negligible, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Sherwood Sandstone Group - Chester Sandstone Formation - Principal aquifer	High	Construction involving deeper excavation (>1 m) including: - Hopton South cutting - Hopton North cutting - Hopton Retaining wall	Temporary works have the potential to affect localised groundwater quality. Impacts on groundwater levels due to the cutting dewatering will be negligible in the context of the aquifer. See Section 5.2 for further details on cuttings. Construction of Hopton South cutting is likely to intercept historical landfill at Staffordshire County Showground, however records show the landfill was inert, uncapped and unlined. Last input of waste 1989. Therefore, any mobile contaminants will have most likely have been leached locally. Any waste encountered will be removed as part of the works. Groundwater likely beneath the cutting base at Hopton South. Construction of the Hopton Retaining wall may affect localised groundwater flow. Temporary and permanent works are of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on recharge.	Magnitude of impact - Moderate Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required. ¹⁴	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Mercia Mudstone Group - Mudstone (Branscombe Mudstone Formation) - Secondary B aquifer	Moderate	Construction of above ground elements and shallow excavation(<1m)	Temporary works have the potential to affect localised groundwater quality. Temporary and permanent works are above ground and of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on	Magnitude of impact - Minor Significance of effect – Minor adverse, not	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible,	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not	Construction (temporary and permanent)

¹⁴ Groundwater control/drainage measures are outlined in Volume 2, Colwich to Yarlet area report, Section 15 and Volume 5, WFD compliance assessment, Appendix WR-001-000. These measures will be designed in detail, where required, following ground investigation and monitoring. They may include, for example, passive hydraulic bypasses at cuttings and other below ground structures or use of soakaways to promote local aquifer recharge

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
		including: At grade track - Moreton North embankment - Trent South embankment - Trent North embankment - Marston South embankment - Marston North embankment	groundwater flow or recharge.	significant		not significant		significant	
Mercia Mudstone Group - Mudstone (Branscombe Mudstone Formation) - Secondary B aquifer	Moderate	Construction involving deeper excavation (>1 m) including: - Utility diversions - Moreton cutting - Brancote South cutting - Hopton North cutting - Piling for Great Haywood viaduct - Moreton retaining wall	Temporary works have the potential to affect localised groundwater quality. Impacts on the groundwater level due to the cutting dewatering will be negligible in the context of the aquifer. See Section 5.2 for further details on cuttings. Construction of the Moreton Retaining wall may affect localised groundwater flow. Temporary and permanent works are of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater recharge.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required. ¹⁴	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Mercia Mudstone Group - Stafford Halite Member - Secondary B aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Marston North embankment	Temporary works have the potential to affect shallow groundwater quality, although this is likely to be very localised and temporary. Temporary and permanent works are above ground and of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Mercia Mudstone Group - Stafford Halite Member - Secondary B aquifer	Moderate	Construction involving deeper excavation (>1 m) including: - Utility diversions - Yarlet South cutting	Temporary works have the potential to affect localised groundwater quality. Impacts on the groundwater level due to the cutting dewatering will be negligible in the context of the aquifer. See Section 5.2 for further details on cuttings. Temporary and permanent works are of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Alluvium - Secondary A aquifer	Moderate	Construction of above ground elements and shallow excavation(<1m)	Temporary works have the potential to affect shallow groundwater quality although this is likely to be very localised and temporary. Temporary and permanent works are above ground and of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect – Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Alluvium - Secondary A aquifer	Moderate	Construction involving deeper excavation (>1 m) including: - Utility diversions - Piling for Great Haywood viaduct	Temporary works have the potential to affect localised groundwater quality and flow however this is likely to be temporary. Temporary and permanent works are of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater recharge. Potential alteration of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers within the much larger area of alluvium, the impact on groundwater flow pathways will be negligible.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
River Terrace Deposits - Secondary A aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Trent South embankment - Trent North embankment	Temporary works have the potential to affect shallow groundwater quality although this is likely to be very localised and temporary. Temporary and permanent works are above ground and of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
River Terrace Deposits - Secondary A aquifer	Moderate	Construction involving deeper excavation (>1 m) including: - Utility diversions - Piling for Great Haywood viaduct	Temporary works have the potential to affect shallow groundwater quality and flow although this is likely to be very localised and temporary. Temporary and permanent works are of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater recharge. Potential alteration of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers within the much larger area of River Terrace Deposits, the impact on groundwater flow pathways will be negligible.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Glacial Till - Secondary Undifferentiated aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Trent South embankment - Marston South embankment	Temporary works have the potential to affect shallow groundwater quality although this is likely to be very localised and temporary. Temporary and permanent works are above ground and of small areal extent compared to the aquifer as a whole therefore are likely to have a negligible impact on groundwater flow or recharge.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Glacial Till - Secondary Undifferentiated aquifer	Moderate	Construction involving deeper excavation (>1 m) including: - Utility diversions - Moreton cutting	Temporary works have the potential to affect groundwater quality but this is likely to be very localised and temporary. Impacts on the groundwater level due to the cutting dewatering will be negligible in the context of the aquifer. See Section 5.2 for further details on cuttings. Temporary and permanent works are of small areal extent compared to the aquifer so unlikely to affect recharge.	Magnitude of impact - Minor Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Abstractions									
Licensed abstraction Moreton Grange	High	- Moreton North embankment	Temporary works have the potential to affect groundwater quality.	Magnitude of impact - Moderate	Implementation of measures described in	Magnitude of impact - Negligible.	None required	Magnitude of impact - Negligible	Construction (temporary and

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
03/28/05/0059/R01 (I5 ¹⁵)		- Moreton cutting	Construction works will be within the default SPZ1 around the abstraction. British Geological Survey (BGS) borehole log at Moreton Grange indicates that the pump will be sufficiently below the cutting, so that groundwater flow to the abstraction will not be affected by the cutting. See Section 5.2 for further details on cuttings.	Significance of effect - Moderate adverse, significant	the draft CoCP. Further investigation and risk assessment by the contractor (as outlined in the draft CoCP). If required, mitigation proposals will be developed and discussed with the owner, with a view to an alternative supply being provided.	Significance of effect - Negligible, not significant		Significance of effect - Negligible, not significant	permanent)
Licensed abstraction Ingestre Park Golf Club 03/28/01/0201 (G6 ¹⁵)	High	- Brancote South cutting	Temporary works have the potential to affect groundwater quality. Abstraction most likely installed in the Sherwood Sandstone Group. Average cutting depth is 9.5m bgl. Maximum cutting depth is 13.3 mbgl in sandstone. Approximate depth to water based on BGS borehole log is 10m bgl. Groundwater flow to the abstraction will not be affected by the cutting. See Section 5.2 for further details on cuttings.	Magnitude of impact - Minor Significance of effect - Moderate, adverse, significant	Implementation of measures described in the draft CoCP. Further investigation and risk assessment by the contractor (as outlined in the draft CoCP). If required, mitigation proposals will be developed and discussed with the owner, with a view to an alternative supply being provided.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Licensed abstraction Staffordshire County Showground MD/028/0004/001 (F6 ¹⁵)	High	- Hopton embankment	Temporary and permanent works will be generally above ground, small in areal extent and at a distance (440m) so unlikely to affect groundwater quality or flow.	Magnitude of impact - Negligible Significance of effect - Negligible, significant	None required though the CoCP will be implemented throughout construction.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant.	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Unlicensed private water supply Upper Hanyards Farm 2/GA/1 (F6 ¹⁵)	High	- Brancote South cutting	The abstraction is likely to be decommissioned as part of the construction works. It currently supplies Upper Hanyards Farm which is scheduled for demolition, but also Lower Hanyards Farm. See Section 5.2 for further details on cuttings.	Magnitude of impact - Major Significance of effect - Major adverse, significant	Appropriate backfill and decommissioning of the borehole. Suitable alternative water source to be discussed with the landowner.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Unlicensed private water supply Bishton Lane Farm 2/GA/2 (I5 ¹⁵)	High	- Widening of Bishton Lane	As current 'tap' location is immediately adjacent to the land required for construction, temporary works have the potential to affect groundwater quality. Temporary works will be generally above ground and small in area extent so unlikely to affect groundwater flow.	Magnitude of impact - Moderate Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP. Site survey to determine the exact location of the abstraction. Further investigation and risk assessment by the contractor (as outlined in the draft CoCP). If required, mitigation proposals will be developed and discussed with the owner, with a view to an alternative supply being provided.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Monitor the abstraction during the works to ensure the flow and quality are not affected.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Unlicensed private water supply Bishton Farm 2/GA/3 (I5 ¹⁵)	High	- Widening of Bishton Lane	Only 'tap' location is currently known. Whilst this is 290m from the land required for construction, the actual abstraction may be closer. Therefore temporary works have the potential to affect groundwater quality. Temporary works will be generally above ground and small in area extent so unlikely to affect groundwater flow.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP. Site survey to determine the exact location of the abstraction. Further investigation and risk assessment by the contractor (as outlined in the draft CoCP). If required, mitigation proposals will be developed and discussed with the owner, with a view to an alternative supply being provided.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Monitor the abstraction during the works to ensure the flow and quality are not affected.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Unlicensed private water supply Near Bishton Hall Farm 2/GA/4 (J6 ¹⁵)	High	- Widening of Bishton Lane	Only 'tap' location is currently known. Whilst this is 190m from the land required for construction, the actual abstraction may be closer. Therefore temporary works have the potential to affect groundwater quality. Temporary works will be generally above ground and small in area extent so unlikely to affect groundwater flow.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP. Site survey to determine the exact location of the abstraction. Further investigation and risk assessment by the contractor (as outlined in the draft CoCP). If required, mitigation proposals will be developed and discussed with the owner, with a	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Monitor the abstraction during the works to ensure the flow and quality are not affected.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
					view to an alternative supply being provided.				

Discharges to groundwater

Discharge to soakaway 3/28/05/2060 (H5 ¹⁵)	Low	- Great Haywood viaduct	The discharge is within the land required for construction – in an area for creation of wetlands. There is therefore potential for this featured to be damaged or lost.	Magnitude of impact - Major Significance of effect - Minor adverse, not significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Major Significance of effect - Minor, not significant	Mitigation proposals will be developed and discussed with the consent holder, with a view to an alternative discharge point being provided if required.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
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Groundwater – surface water interaction

River Trent and its tributaries	Very High	- Great Haywood viaduct	Shallow groundwater flow in the superficial deposits may provide baseflow to the River Trent. Temporary works have the potential to affect the localised groundwater quality. Potential alterations of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers within the much larger area of aquifers, the impact on groundwater flow pathways will be negligible in context of baseflow to the River Trent.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Trent and Mersey Canal	High	- Great Haywood viaduct	Shallow groundwater flow in superficial deposits may provide baseflow to the Trent and Mersey Canal. However, connectivity is likely to be very limited due to lining of the canal.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required though the CoCP will be implemented throughout construction.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Spring, south-west of Moreton House (I5 ¹⁵)	High	- Moreton cutting	Spring is located within the land required for construction of the Proposed Scheme and in close proximity to the cutting. It may therefore be disrupted by the Propose Scheme. Spring may supply a pond. However, pond is also within the land required for construction and will be in-filled during the construction phase. The spring features will be intercepted by the land drainage systems to be constructed as part of the Proposed Scheme.	Magnitude of impact - Negligible Significance of effect - Negligible, significant	None required though the CoCP will be implemented throughout construction.	Magnitude of impact - Negligible Significance of effect - Negligible, significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
			See Section 5.2 for further details on cuttings.						
Spring, Moreton Brook (potentially feeding marshland at Lount Farm LWS) (I4 ³⁵)	High	- Moreton North embankment	Temporary works have the potential to affect localised groundwater quality. Temporary and permanent works are above ground so unlikely to affect groundwater flow. However, some of the Marshland (Lount Farm LWS) will be removed for the Proposed Scheme. This is considered further in the Ecology and biodiversity section of the Volume 5, Colwich to Yarlet area report.	Magnitude of impact - Minor Significance of effect - Moderate, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Potential spring, south-west of Lower Bridge Farm (E6 ³⁵)	High	- Hopton North cutting.	Temporary works may impact groundwater quality at the spring. The spring is within the land required for construction of the Proposed Scheme in an area of soft landscaping. It may be incorporated in the Sandon Road drop inlet culvert. Cutting may potentially result in reduction of groundwater catchment to the spring and therefore groundwater flow. See Section 5.2 for further details on cuttings.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control measures where required ³³	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Further survey of the spring to determine its value as a receptor. After which, further groundwater investigation may be required to determine appropriate mitigation measures.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Potential spring, south of Marston Cottages (D6 ³⁵)	High	- Marston South embankment	Located within the land required for the construction of the Proposed Scheme, therefore temporary works have the potential to affect groundwater quality. Temporary and permanent works are above ground and therefore unlikely to affect groundwater flow.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Potential spring, north of Marston Farm (D6 ³⁵)	High	- Marston South embankment	Located within the land required for the construction of the Proposed Scheme, therefore temporary works have the potential to affect groundwater quality. Temporary and permanent works are above ground and therefore unlikely to affect groundwater flow.	Magnitude of impact - Minor Significance of effect - Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Water dependent habitats									
Pasturefields SSSI and SAC	Very High	- Great Haywood viaduct - Trent North	Surface water drainage pathways, show that Pasturefields is up hydraulic gradient of the route of the Proposed Scheme.	Magnitude of impact - Negligible Significance of	None required though the CoCP will be implemented	Magnitude of impact - Negligible Significance of	None required	Magnitude of impact - Negligible Significance of effect -	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
(H5 ³⁵)		embankment	Saline groundwater source is upwelling from depth within the Mercia Mudstone Group whereas the design elements in this area are above ground embankment and shallow piles associated with the viaduct. Negligible impact.	effect - Negligible, not significant	throughout construction.	effect - Negligible, not significant		Negligible, not significant	
Lionlodge Covert LWS (Tixall Saltmarsh) (G5 ³⁵)	Tixall Saltmarsh was valued as moderate following a site visit due to the recent agricultural improvements made to the area meaning that the saltmarsh is currently assessed as being of county value. Further information is available in the Ecology and biodiversity section of the Volume 5, Colwich to Yarlet area report.	- Trent South embankment	The route of the Proposed Scheme goes directly over Lionlodge Covert. An area of saltmarsh will be permanently removed. Due to access constraints the full area of the saltmarsh and the location of the saltmarsh springs could not be determined.	Magnitude of impact - Major Significance of effect - Major adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control measures, including drainage design, where required, to deal with the potentially high water table and salinity of groundwater in this area.	Magnitude of impact - Major Significance of effect - Major adverse, significant	Historically the saltmarsh extended to the north of its current location, but installation of land drainage for land improvement has reduced the size of the saltmarsh to its current size. A detailed site investigation across the area of the current and historical saltmarsh is required to determine the full mitigation measures. Mitigation could include diversion of the current salt springs (as yet unsurveyed due to land access constraints) to the north of the route of Proposed Scheme to recreate the saltmarsh in a different location as compensation. This could also include altering the current land drainage to allow for the re-establishment of the saltmarsh at the new location.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

5.2 Detailed assessment

5.2.1 In support of the impact assessment presented in Table 7 further detail is provided in this Section to demonstrate the methodology and assumptions used in relation to specific design elements and locations along the Propose Scheme. Within the Colwich to Yarlet study area detailed assessments are presented demonstrating the likely impact to groundwater from several cuttings. There are no tunnels or borrow pits in this area.

Impact on groundwater from cuttings

5.2.2 The locations of cuttings are shown in the Volume 2: Map Series CT-05 and Map Series CT-06. The cuttings which intersect aquifers have been initially characterised to determine whether groundwater levels are likely to be above or below the base of the cutting. Where the groundwater elevation is not known or where the groundwater elevation has been found to be above the base of the cutting a further detailed assessment of the likely maximum zone of influence from dewatering of the cutting has been undertaken.

Initial characterisation of cuttings

Moreton cutting

Table 8: Summary of Moreton cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.75
Maximum depth (m bgl)	18.9
Strata intercepted	Glacial Till (Secondary Undifferentiated aquifer) Mercia Mudstone Group (Secondary B aquifer)
Lowest track level (mAOD)	96.0
Groundwater level(s) (mAOD)	Unknown but approximate depth to groundwater 3 m bgl based on resting groundwater level recorded on BGS log SK/02SW/13. Groundwater strike occurred at approximately 15m bgl. The elevation of the borehole is not noted on the log, however Lidar data shows the ground elevation in this area is approximately 95m AOD.
Principal receptors	Mercia Mudstone Group Moreton Grange licensed private water supply Spring south-west of Moreton House

5.2.3 There is limited groundwater elevation data available, however the approximate depth to groundwater based on the resting depth to groundwater recorded on the BGS borehole log for the abstraction at Moreton Grange is 3m bgl (or approximately

92m AOD) which is above the maximum depth of the cutting and therefore that groundwater flow within the Mercia Mudstone Group may be affected by the cutting. Further assessment is demonstrated in the following section (cuttings below rest groundwater level assessment). Application of the CoCP will ensure materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.

Brancote South cutting

Table 9: Summary of Brancote South cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.565 (total) o. 865 (Mercia Mudstone Group) o. 7 (Sherwood Sandstone Group)
Maximum depth (m bgl)	17 within the Mercia Mudstone Group 13.3 within the Sherwood Sandstone Group
Strata intercepted	Mercia Mudstone Group (Secondary B aquifer) Sherwood Sandstone Group (Principal aquifer)
Lowest track level (mAOD)	92.9
Groundwater level(s) (mAOD)	10 m bgl in Sherwood Sandstone Group outcrop, based on the resting depth to groundwater recorded on BGS borehole log SJ925E31 at Upper Hanyards Farm (1993). The elevation of the borehole is not noted on the log, however Lidar data shows the ground elevation in this area is approximately 107.5m AOD. No information in the Mercia Mudstone Group
Principal receptors	Groundwater in the Sherwood Sandstone Group aquifer Ingestre Park Golf Club licensed private water supply Upper Hanyards Farm unlicensed private water supply

5.2.4 Within the Sherwood Sandstone Group, where it outcrops, the recorded depth to groundwater is 10 mbgl or approximately 97.5m AOD. The maximum depth of the cutting in this section is 13.3m. There is no currently available information on groundwater elevations within the Mercia Mudstone Group. It has therefore been conservatively assumed that groundwater levels within the Mercia Mudstone Group are at ground level and therefore that groundwater flow within the Mercia Mudstone Group may be affected by the cutting. There may therefore be an effect to groundwater from dewatering of the cutting in both the Sherwood Sandstone Group and the Mercia Mudstone Group. Further assessment is demonstrated in the following section (cuttings below rest groundwater level assessment). Application of the CoCP will ensure materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.

Brancote North cutting

Table 10: Summary of Brancote North cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.540
Maximum depth (m bgl)	3
Strata intercepted	Sherwood Sandstone Group (Principal aquifer)
Lowest track level (mAOD)	118.7
Groundwater level(s) (mAOD)	10 mbgl in Sherwood Sandstone Group based on the resting depth to groundwater recorded on BGS log SJ925E31 at Upper Hanyards Farm (1993). The elevation of the borehole is not noted on the log, however Lidar data shows the ground elevation in this area is approximately 107.5m AOD.
Principal receptors	Groundwater in the Sherwood Sandstone Group aquifer.

5.2.5 The cutting would penetrate the Sherwood Sandstone Group aquifer to 3m depth, in an area where the maximum recorded groundwater levels are approximately 7m below the maximum cutting depth or at approximately 97.5m AOD. Groundwater flow will therefore not be disrupted. Application of the CoCP will ensure materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality. Therefore, no further assessment of this cutting has been undertaken.

Hopton South cutting

Table 11: Summary of Hopton South cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.475
Maximum depth (m bgl)	14.3
Strata intercepted	Sherwood Sandstone Group (Principal aquifer)
Lowest track level (mAOD)	103
Groundwater level(s) (mAOD)	86.75m AOD based on maximum recorded groundwater elevation at Brick House Farm monitoring well 1998-2015. 82.2m AOD based on the resting depth to groundwater recorded on BGS log SJ92NW/5 at Sandon Bank.

Cutting parameters	Parameter details
Principal receptors	Groundwater in the Sherwood Sandstone Group.

- 5.2.6 The cutting would penetrate the Sherwood Sandstone Group aquifer in an area where the recorded groundwater levels are approximately 16m below the maximum cutting depth. Groundwater flow will therefore not be disrupted. Application of the CoCP will ensure materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality. Therefore, no further assessment of this cutting has been undertaken.

Hopton North cutting

Table 12: Summary of Hopton North cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.605
Maximum depth (m bgl)	17
Strata intercepted	Sherwood Sandstone Group (Principal aquifer) Mercia Mudstone Group (Secondary B aquifer)
Lowest track level (mAOD)	97.2
Groundwater level(s) (mAOD)	No currently available information
Principal receptors	Groundwater in the Sherwood Sandstone Group

- 5.2.7 There is no currently available information on groundwater elevations or depth to groundwater in this area. It has therefore been conservatively assumed that groundwater levels are at ground level and therefore that groundwater flow may be affected by the cutting. Further assessment is demonstrated in the following section (cuttings below rest groundwater level assessment). Application of the CoCP will ensure materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.

Yarlet South cutting

Table 13: Summary of Yarlet South cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.250
Maximum depth (m bgl)	19.6
Strata intercepted	Stafford Halite (Secondary B aquifer)

Cutting parameters	Parameter details
Lowest track level (mAOD)	120.0
Groundwater level(s) (mAOD)	No currently available information
Principal receptors	Groundwater in the Stafford Halite

5.2.8 There is no currently available information on groundwater elevations or depth to groundwater in this area. It has therefore been conservatively assumed that groundwater levels within the Stafford Halite are at ground level and therefore that groundwater flow within the Stafford Halite may be affected by the cutting. Further assessment is demonstrated in the following section (cuttings below rest groundwater level assessment). Application of the CoCP will ensure materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.

Assessment of cuttings below groundwater level

5.2.9 Assessment of the likely maximum zone of influence from dewatering of the cuttings which may be below existing groundwater level (as set out above) has been made using Sichardt's formula.

5.2.10 The methodology follows the Environment Agency guidance¹⁶ and the methodology set out in CIRIA C750¹⁷, as summarised in the SMR Addendum³, Volume 5, Appendix CT-001-002.

5.2.11 Sichardt's formula is presented below:

$$L_o = C \times h \times \sqrt{k}$$

Where; L_o = distance of influence from linear structure (m)

k = hydraulic conductivity (m/s)

h = drawdown (m)

C = empirical calculation factor taken to be 1750¹⁸

5.2.12 Hydraulic conductivity values from the high end of the range, presented in literature, have been used in the assessment, to provide a conservative estimate of the dewatering zone of influence. Where groundwater levels are not known, the worst case assumption, that groundwater is at ground level, has been used.

5.2.13 Where the assessment of the zone of influence has been undertaken, cuttings are assumed to be open and any permanent works such as retaining walls or drainage measures do not form part of the quantitative assessment.

¹⁶ Environment Agency, (2007), Hydrogeological impact appraisal for dewatering abstractions

¹⁷ Preene, M., Roberts, T.O.L. and Powrie, W. (2016), Groundwater control: design and practice. CIRIA Publication C750.

¹⁸ P.M. Cashman and M. Preene (2001) Groundwater Lowering in Construction, a Practical Guide

- 5.2.14 Based on these precautionary assumptions, the zone of influence is likely to be overestimated. However, for the purpose of this preliminary assessment, this precautionary approach is considered to be appropriate.

Moreton cutting

- 5.2.15 Assuming a hydraulic conductivity value of $1 \times 10^{-6} \text{ m/s}^{19}$ for both the Glacial Till (where present) and the Mercia Mudstone Group, the maximum zone of influence from the cutting is 29.2m. This is based on a maximum cutting depth of 18.9m and a rest water level at 3m bgl. The Mercia Mudstone Group extends more than 50m below the cutting depth and is laterally extensive. Therefore potential local changes in groundwater level to the maximum cutting depth are assessed as negligible, not significant in terms of impact on the Secondary B aquifer.
- 5.2.16 There are likely to be thin groundwater bearing horizons within the Mercia Mudstone Group which may not be laterally extensive. Further ground investigation and monitoring is required to confirm groundwater levels in this location, and whether there are any skerry bands likely to be impacted by the cutting. This will inform the detailed design and management of groundwater during construction.
- 5.2.17 The ground elevation between the BGS borehole log at Moreton Grange, approximately 95m south of the route of the Proposed Scheme, and Moreton cutting is broadly flat. Whilst the elevation of the borehole headworks are not noted on the BGS borehole log, depth to groundwater is approximately 3m bgl; the pump is placed at 30m bgl and the groundwater bearing strata, described as 'marl with sandstone layers' is between 20-30m bgl. The average cutting depth is 9.7m and the maximum cutting depth is 18.9m (approximately 400m from the abstraction). The cutting base is therefore above the groundwater bearing strata, and the abstraction is outside the calculated zone of influence. However further ground investigation and monitoring is required to confirm groundwater levels in this location, and whether the skerry bands are likely to be affected by the cutting. This will inform the detailed design and management of groundwater during construction.
- 5.2.18 The spring to the south-west of Moreton House is outside the calculated zone of influence and there are no other recorded groundwater dependant features within the calculated zone of influence.

Brancote South cutting

- 5.2.19 Assuming a hydraulic conductivity value of $1 \times 10^{-6} \text{ m/s}^{19}$ for the Mercia Mudstone Group and a hydraulic conductivity value of $1 \times 10^{-5} \text{ m/s}^{20}$ for the Sherwood Sandstone Group, the maximum zone of influence from the cutting is 31.2m in the Mercia Mudstone Group and 24.7m in the Sherwood Sandstone Group. This is based on a maximum cutting depth of 17m bgl and rest water level at the surface in the Mercia Mudstone Group, and a maximum cutting depth of 13.3m bgl and a rest water level at 10m bgl in the Sherwood Sandstone Group. Both the Mercia Mudstone Group and the

¹⁹ Based on the high end value for bulk testing within the Mercia Mudstone Group. Engineering geology of British rocks and soils, Mudstones of the Mercia Mudstone Group RR/01/02

²⁰ Geometric mean for bulk testing results from the Bromsgrove Sherwood Sandstone Group, The physical properties of major aquifers in England and Wales, Technical Report WD/97/34, EA R& D Publication 8 – West Midlands

Sherwood Sandstone Group extend more than 50m below the cutting depth and are laterally extensive. Therefore potential local changes in groundwater level to the maximum cutting depth are assessed as negligible, not significant in terms of impact on the Secondary B aquifer or the Principal aquifer.

- 5.2.20 There are likely to be thin groundwater bearing horizons within the Mercia Mudstone Group which may not be laterally extensive. Further ground investigation and monitoring is required to confirm groundwater levels in this location, and whether there are any skerry bands likely to be affected by the cutting. This will inform the detailed design and management of groundwater during construction.
- 5.2.21 The abstraction at Upper Hanyards will be decommissioned as a result of the scheme and therefore will not be affected by Brancote South cutting. The abstraction at Ingestre Park Golf Course is located outside the maximum radius of influence calculated for the Brancote South cutting. There are no other recorded groundwater dependant features within the calculated zone of influence.

Hopton North cutting

- 5.2.22 Assuming a hydraulic conductivity value of $1 \times 10^{-5} \text{m/s}^{20}$ for the Sherwood Sandstone Group and a hydraulic conductivity value of $1 \times 10^{-6} \text{m/s}^{19}$ for the Mercia Mudstone Group, the maximum zone of influence from the cutting is 25m in the Mercia Mudstone Group and 127m in the Sherwood Sandstone Group. This is based on a maximum cutting depth of 17m bgl and rest water level at the surface. There are no groundwater features recorded within these zones of influence.
- 5.2.23 There are likely to be thin groundwater bearing horizons within the Mercia Mudstone Group which may not be laterally extensive. Further ground investigation and monitoring is required to confirm groundwater levels in this location, and whether there are any skerry bands likely to be affected by the cutting. This will inform the detailed design and management of groundwater during construction.

Yarlet South cutting

- 5.2.24 Assuming a hydraulic conductivity value of $1 \times 10^{-6} \text{m/s}^{19}$ for the Stafford Halite, the maximum zone of influence from the cutting is 38.5m. This is based on a maximum cutting depth of 21m and a rest water level at ground surface. The Stafford Halite is part of the Mercia Mudstone Group which extends more than 50m below the cutting depth and is laterally extensive. Therefore potential local changes in groundwater level to the maximum cutting depth are assessed as negligible, not significant in terms of impact on the Secondary B aquifer.
- 5.2.25 There are likely to be thin groundwater bearing horizons within the Stafford Halite which may not be laterally extensive. Therefore further ground investigation and monitoring is required to confirm groundwater levels in this location, and whether there are any skerries likely to be affected by the cutting. This will inform the detailed design and management of groundwater during construction.
- 5.2.26 There are no recorded groundwater dependant features within the calculated zone of influence.

6 Site specific highways drainage assessments

6.1 Introduction

6.1.1 The majority of highway works comprise minor realignments, with no significant increase in impermeable paved areas. The Proposed Scheme makes provision for two methods for draining these new sections of highway: direct runoff to soakaway and drainage via an attenuation pond to an existing watercourse. An assessment has been made of whether the highway works proposed have implications for pollution risk within the Colton to Stone area.

6.2 Methodology and assessment criteria

Routine runoff pollution risk

6.2.1 Where highway drainage is discharged to local watercourses, the assessment for determining whether routine runoff is likely to have a detrimental impact on water quality uses the Highways England's (HE) (formerly Highways Agency) Water Risk Assessment Tool, HAWRAT, Method A in Volume 11, Section 3, Part 10 HD 45/09 of the Design Manual for Road and Bridges (DMRB). Where highway realignments are to discharge to curb side ditches which do not have a baseflow, the Groundwater Assessment (Method C) in Volume 11, Section 3, Part 10 HD 45/09 of the DMRB has been used.

6.2.2 The significance of the impact of the predicted effects on surface water and groundwater receptors has been assessed in accordance with the methodology described in the SMR, Volume 5: Appendix CT-001-001.

Spillage pollution risk

6.2.3 In addition to assessing the potential for adverse effects of routine surface water runoff from highways, an assessment of the potential spillage risk to water quality should also be undertaken qualifying highway realignment. The methodology for assessing spillage risk follows the Spillage Risk Assessment (Method D) presented in Volume 11, Section 3, Part 10 HD 45/09 of the DMRB.

6.3 Assessments

Screening results

6.3.1 A screening exercise identified the need for three routine runoff and pollution risk assessments in the Colton to Stone area. These are related to the modifications to the A51 Lichfield Road, A518 Weston Road, and A34 Stone Road as shown in Figure 3, Figure 4 and Figure 5.

Figure 3: A51 Lichfield Road Realignment

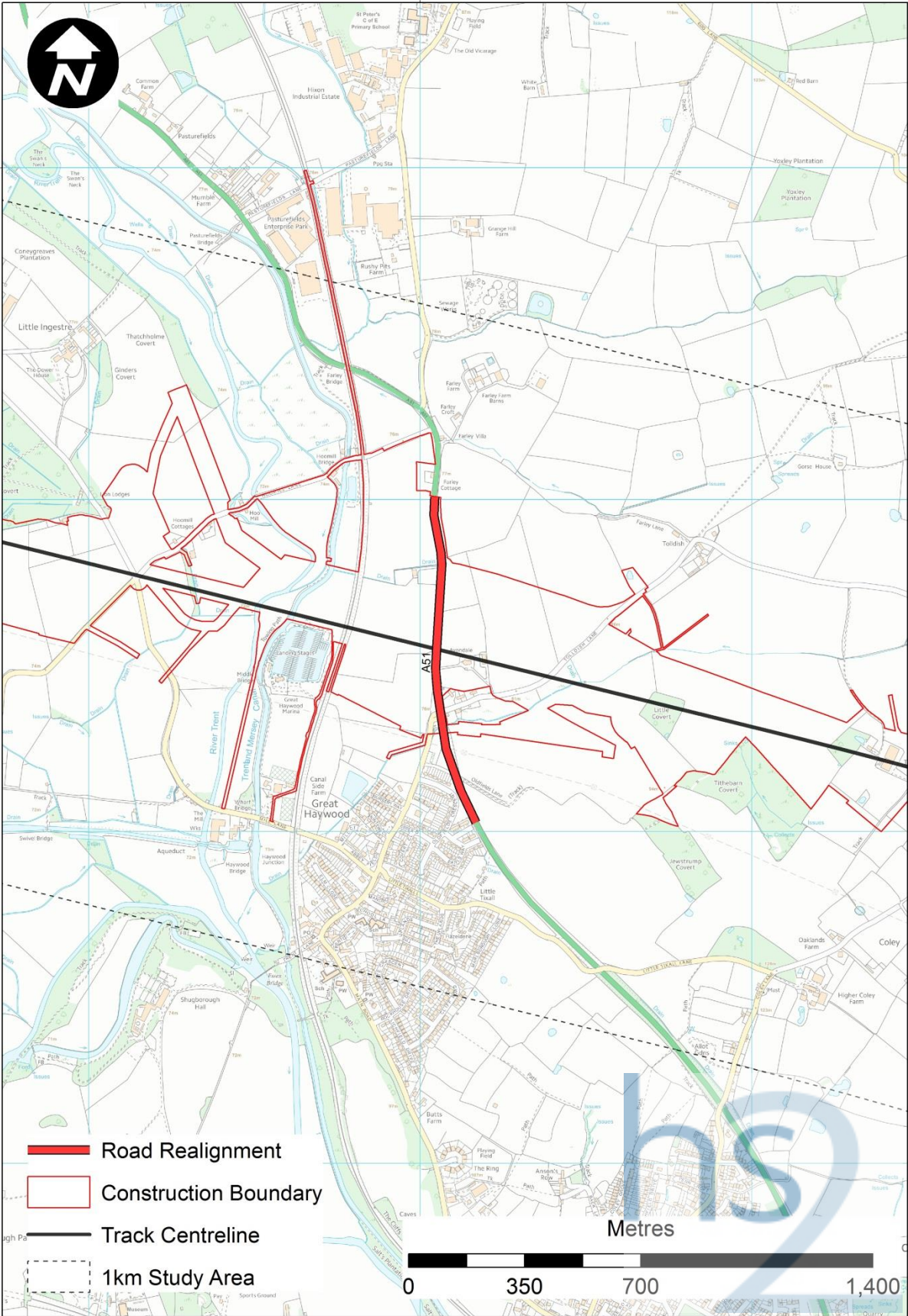


Figure 4: A518 Weston Road Realignment

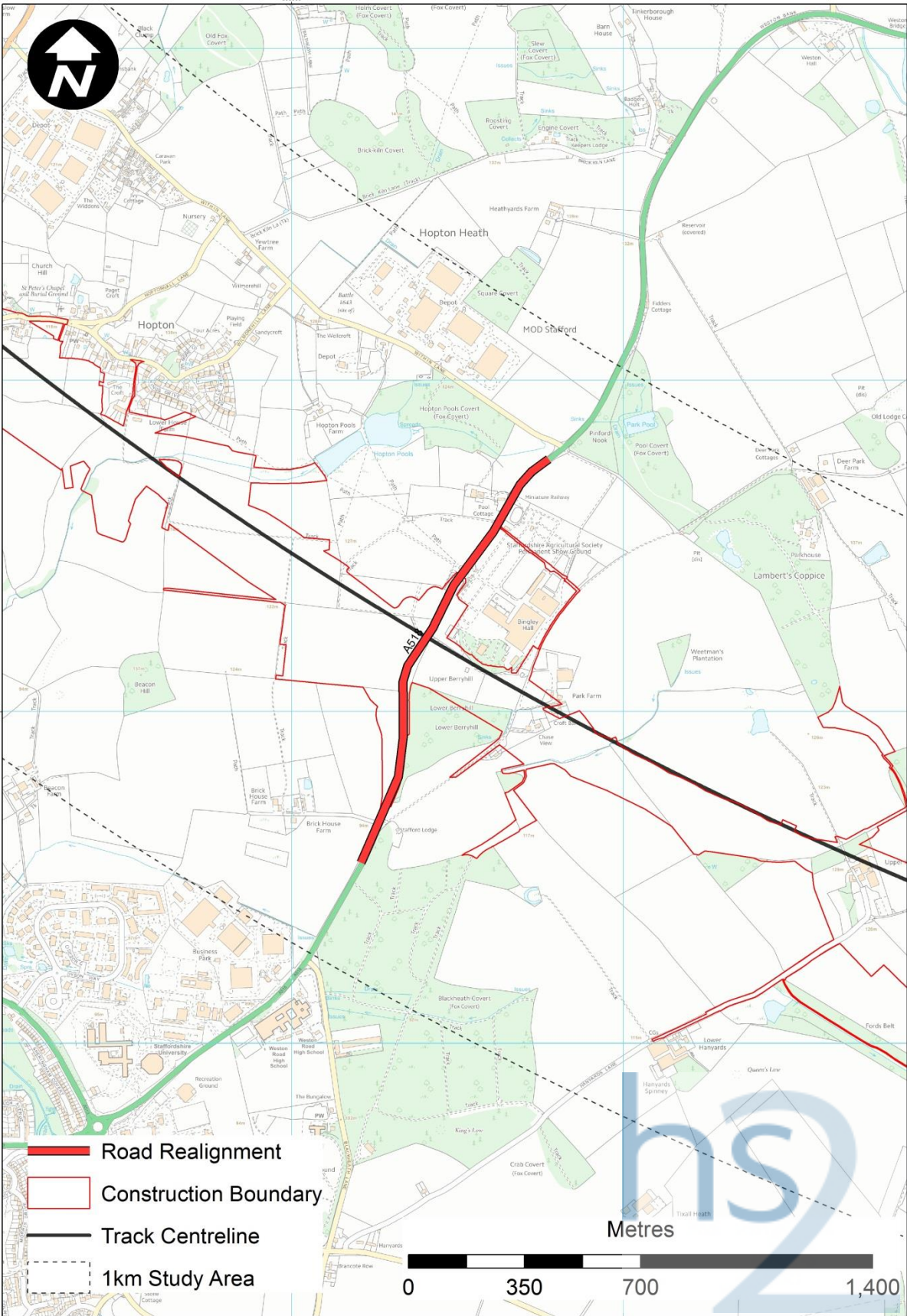
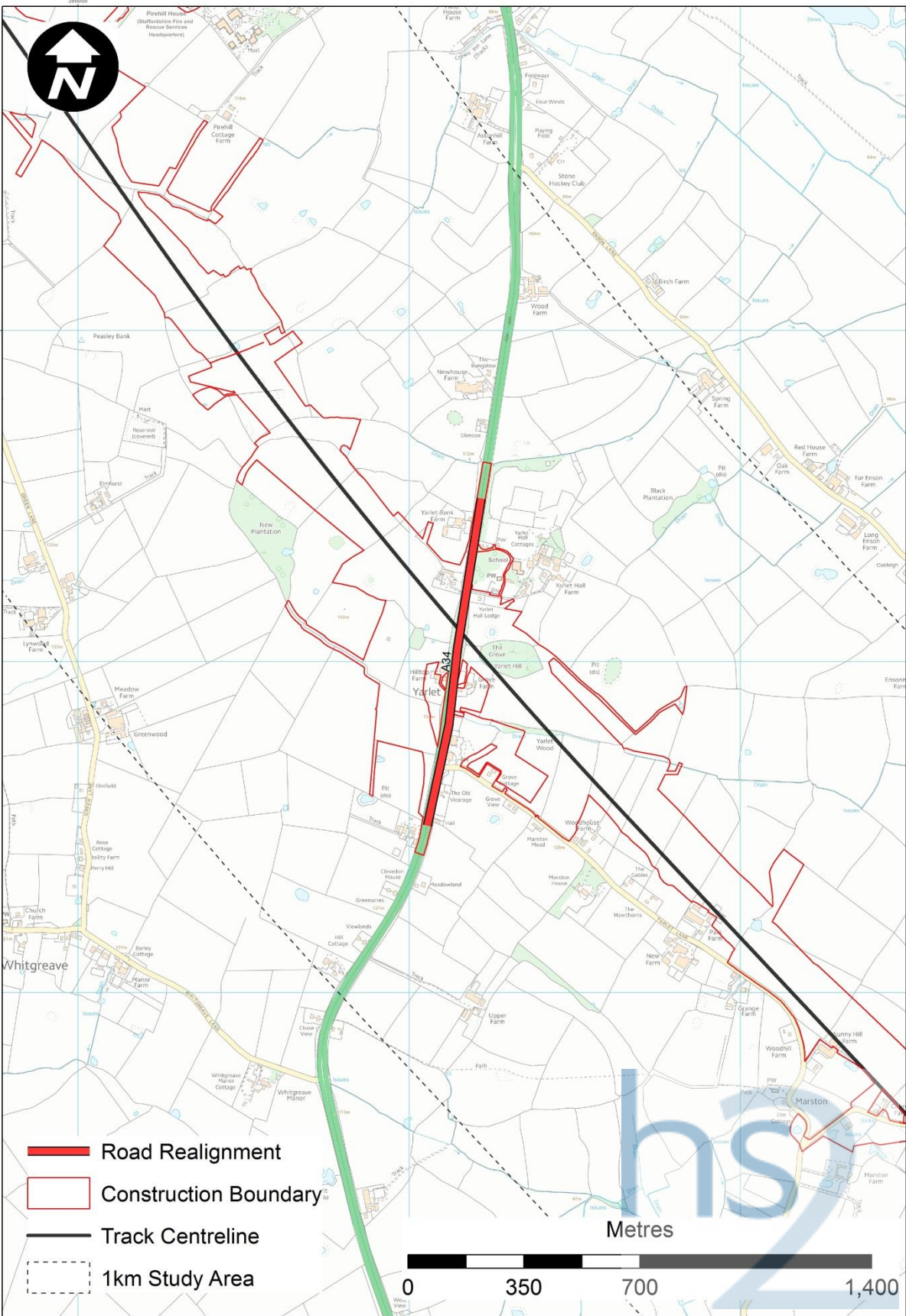


Figure 5: A34 Stone Road Realignment



Routine runoff pollution risk

A51 Lichfield Road

- 6.3.2 The modification to the A51 Lichfield Road between Great Haywood and Ingestre involves the realignment of the carriageway along a total length of 1.15km and complete replacement of the existing drainage. The road passes over the River Trent floodplain, surrounded by farmland and grassland to the east and west and Great Haywood to the south. It is proposed to construct like for like highway drainage comprising kerbside linear gully drains that will soak away to groundwater. The groundwater aquifer underlying this length of the A51 Lichfield Road is a Secondary B aquifer of local importance, which is a moderate value receptor.

A518 Weston Road

- 6.3.3 The modification to the A518 Weston Road between Stafford and Weston involves the realignment of the carriageway along a total length of 1.21km and complete replacement of the existing drainage. The road is on a hill at the north-eastern boundary of Stafford and is surrounded by farmland and grassland to the east, west and north. It is proposed to construct like for like highway drainage comprising kerbside linear gully drains that will soak away to groundwater. This area is underlain by a Secondary B aquifer of local importance, which is a moderate value receptor.

A34 Stone Road

- 6.3.4 The modification to the A34 Stone Road at Yarlet, between Stafford and Stone involves the realignment of the carriageway along a total length of 0.96km and complete replacement of the existing drainage. The road passes through grassland in Yarlet and is situated on a hill. It is proposed to construct like for like highway drainage comprising kerbside linear gully drains that will soak away to groundwater. This area is underlain by a Secondary B aquifer of local importance, which is a moderate value receptor.

Assessment results

- 6.3.5 The assessment results identified that the magnitude of the impacts of routine runoff from these three proposed highway realignments would be negligible. The receptors are in all three cases of moderate value. The proposals will therefore not result in significant effects. All three highway realignments fall into the medium risk category. The DMRB guidance suggests that a precautionary approach should be adopted in such circumstances and additional measures may be required to mitigate the risk of deterioration in groundwater quality. Such measures would be considered at the detailed design stage in consultation with the relevant highway authority.

Highways Spillage Risk Assessment

- 6.3.6 The evaluation of spillage risk for the A51 Lichfield Road, A518 Weston Road and A34 Stone Road is presented in Table 14 below. The risk of a serious pollution incident occurring is identified to be negligible in all cases. These highway realignments will not result in significant effects related to spillage risk and no further mitigation is required.

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Table 14: Spillage risk assessment of A51 Lichfield Road, A518 Weston Road and A34 Stone Road²³

Water body type	A51 Lichfield Road	A518 Weston Road	A34 Stone Road	Notes
Length of road draining to outfall (km)	1.15	1.21	0.96	The length of the road was measured based on CP2+ general arrangement drawings.
Road Type (A-road or Motorway)	A	A	A	
If A road, is site urban or rural?	Rural	Rural	Rural	
Junction type	Cross road	No junction	No junction	
Location	< 1 hour	< 1 hour	< 1 hour	A response time of less than 1 hour is expected for emergency services.
Traffic flow (AADT two way)	50,000	50,000	50,000	The traffic flow (AADT two way) upper limit of 50,000 was used, as worst case.
% HGV	2	1.4	3	The percentage of HGV traffic was selected from the AADT HGV hotspot situated nearest to the A51 Lichfield Road alteration.
Spillage factor (no/109HGVkm/year)	0.88	0.29	0.29	The spillage factor was taken from Table D1.1 as presented in Volume 11 Section 3 Part 10 HD 45/09 of the DMRB.
Risk of accidental spillage	0.0004%	0.0001	0.0005	This represents the total annual probability of a spillage.
Risk of pollution incident	0.02%	0.0027%	0.01%	This represents the total annual probability of a spillage causing a pollution incident.
Is risk greater than 0.01?	Y	N	N	This is the considered overall risk for the length of the realignment.

²³ This table provides a summary of the spillage risk calculations derived using the HAWRAT spillage risk spreadsheet available from <http://www.hagdms.com/index.cfm?fuseaction=help.download>

7 References

- British Geological Survey (1997), *The physical properties of major aquifers in England and Wales*, Technical Report WD/97/34, Environment Agency R&D Publication 8.
- British Geological Survey, (2002), *Engineering geology of British rocks and soils, Mudstones of the Mercia Mudstone Group*, Research Report RR/01/02.
- Cashman, P.M. and Preene, M. (2001), *Groundwater Lowering in Construction, a Practical Guide*.
- Design Manual for Roads and Bridges, *Road Drainage and the Water Environment*. Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 10, HD45/09
- Domenico, P. A. and Schwartz, F. W. (1990), *Physical and chemical hydrogeology*. John Wiley & Sons.
- Environment Agency, (2007), *Hydrogeological impact appraisal for dewatering abstractions*.
- Gov.uk (2017), *Protect groundwater and prevent groundwater pollution*. Available online at: <https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution>
- Lewis, M. A., Cheney, C. S. and O'Douchartaigh, B. E. (2006) *Guide to permeability indices*. British Geological Survey Open Report, CR/06/160N. 29pp.
- Preene, M., Roberts, T.O.L. and Powrie, W. (2016), *Groundwater control: design and practice*. CIRIA Publication C750.

