

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA3: Stone and Swynnerton

Water resources assessment (WR-002-003)

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA3: Stone and Swynnerton

Water resources assessment (WR-002-003)



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.

High Speed Two (HS2) Limited,
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA

Telephone: 08081 434 434

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.gov.uk/hs2

A report prepared for High Speed Two (HS2) Limited:

ARUP



High Speed Two (HS2) Limited has actively considered the needs of blind and partially sighted people in accessing this document. The text will be made available in full on the HS2 website. The text may be freely downloaded and translated by individuals or organisations for conversion into other accessible formats. If you have other needs in this regard, please contact High Speed Two (HS2) Limited.

© High Speed Two (HS2) Limited, 2017, except where otherwise stated.

Copyright in the typographical arrangement rests with High Speed Two (HS2) Limited.

This information is licensed under the Open Government Licence v2.0. To view this licence, visit www.nationalarchives.gov.uk/doc/open-government-licence/version/2 **OGL** or write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or e-mail: psi@nationalarchives.gsi.gov.uk. Where we have identified any third-party copyright information you will need to obtain permission from the copyright holders concerned.



Printed in Great Britain on paper containing at least 75% recycled fibre.

Contents

1	Introduction	1
1.1	Structure of the water resources and flood risk appendices	1
1.2	Scope, assumptions and limitations	1
1.3	Study area description and key features	2
2	Stakeholder engagement	4
3	Baseline data	5
3.1	Surface water	5
3.2	Groundwater	6
3.3	Groundwater – surface water interaction	12
3.4	Water dependent habitats	16
4	Site specific surface water assessments	17
4.1	Summary of assessment	17
5	Site specific groundwater assessments	20
5.1	Summary of assessment	20
5.2	Detailed assessment	34
6	References	46

List of figures

Figure 1: Location of Environment Agency groundwater level monitoring boreholes (Sherwood Sandstone Group)	7
Figure 2: Groundwater elevation (Sherwood Sandstone Group) in metres above ordnance datum (mAOD)	8
Figure 3: Conceptual cross-section through Swynnerton South cutting in proximity to the PWS	37
Figure 4: Conceptual hydrogeological long-section showing Swynnerton North cutting, Hatton South cutting and Hatton North cutting	39

List of tables

Table 1: Surface water abstractions	5
-------------------------------------	---

Table 2: Consented discharges to surface water	6
Table 3: Summary of groundwater abstractions in the Stone and Swynnerton area	10
Table 4: Discharge consents to groundwater	11
Table 5: Groundwater – surface water interaction	12
Table 6: Summary of potential impacts to surface water receptors	18
Table 7: Summary of potential groundwater impacts	21
Table 8: Summary of the Yarlet Central cutting parameters for the groundwater assessment	34
Table 9: Summary of the Yarlet North cutting parameters for the groundwater assessment	35
Table 10: Summary of the Meaford cutting parameters for the groundwater assessment	35
Table 11: Summary of the Swynnerton South cutting parameters for the groundwater assessment	36
Table 12: Summary of the Swynnerton North cutting parameters for the groundwater assessment	37
Table 13: Summary of the Hatton South cutting parameters for the groundwater assessment	40
Table 14: Summary of the Hatton North cutting parameters for the groundwater assessment	40

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 Stone and Swynnerton area (CA3), the area specific appendices comprise:
- a water resources assessment (this appendix); and
 - a flood risk assessment (Volume 5: Appendix WR-003-003).
- 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 Stone and Swynnerton area covers a section of the Proposed Scheme approximately 13.5km long. The spatial scope of the assessment was based upon the identification of surface water and groundwater features within 1km of the centre line of the route of the Proposed Scheme. 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 this 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, embankments and at grade sections, with two viaducts: the Filly Brook viaduct and the M6 Meaford viaduct.
- 1.2.4 This assessment covers the potential impacts of the Proposed Scheme on existing surface water and groundwater resources, including consideration of:
- surface waters⁴;

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

- 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 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 that the Stone and Swynnerton area does not include any highway realignments which meet these criteria and so an assessment of highway pollution has not been necessary in this community area.

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, except for Stone (to the north-east of the route) and Swynnerton (a small residential area to the south-west of the route).

1.3.2 The M6 motorway is a prominent feature in the study area, and is crossed by the route of the Proposed Scheme in the central area. The route is also crossed by the A51 Stone Road, the A519 Newcastle Road Bar Hill Road, several B roads and the Norton Bridge to Stone Railway.

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

- Filly Brook and Meece Brook and their associated tributary watercourses;
- the Sherwood Sandstone Group Principal aquifer;
- the Butterson Swynnerton Dykes Secondary A aquifer and the permeable superficial deposits Secondary A aquifers;
- the Mercia Mudstone Group Secondary B aquifer;

⁴ Ponds are not included in the water resources assessment, these are assessed as ecological receptors in Volume 2, South Cheshire 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

- two potential spring features within the area required for construction of the Proposed Scheme;
- two licensed public groundwater abstractions from the Sherwood Sandstone Group Principal aquifer;
- one licensed surface water abstraction from Filly Brook; and
- six unlicensed private groundwater abstractions which, based on their location, are assumed to be supplied by the Mercia Mudstone Secondary B aquifer.

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 private unlicensed water abstractions;
- Severn Trent Water Ltd, with regard the public groundwater abstractions and the water resources management plan within this and the adjacent areas; and
- private licensed and unlicensed abstraction owners (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, Stone and Swynnerton area report, Section 15. The receptor values attributed to each individual watercourse, based on the methodologies set out in the SMR², as applied in the WFD compliance assessment (Volume 5, Appendix WR-001-000) are also provided.
- 3.1.2 Table 1 summarises surface water abstractions within the study area. There is one licensed surface water abstraction, which is assessed as a high value receptor. The location of the abstraction is shown on Map WR-01-105. This abstraction is not used for public water supply (PWS). 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.

Table 1: Surface water abstractions

Name, licence number ⁶ (and map grid square)	Distance and direction from route	Abstraction source	Maximum annual abstraction quantity (m ³)	Maximum daily abstraction quantity (m ³)	Purpose
Private licensed supplies					
Stone golf course 03/28/01/0169 (13)	620m east of the route (160m north of the land required for construction of the Proposed Scheme)	Filly Brook	5,455	182	Industrial, commercial and public services

- 3.1.3 There are three consented discharges to surface water within the study area, as shown in Table 2. These have been assessed as low value receptors.

⁶ As shown on Map WR-01-105

Table 2: Consented discharges to surface water

Permit identifier (and map grid square)	Distance and direction from route	Discharge type	Receiving water body
T/01/11117/S C5 ⁷	600m north-east of the route (Adjacent to the land required for construction of the Proposed Scheme)	Sewage discharges - final/treated effluent - not water company	Tributary of the River Trent
T/01/35292/S C6 ⁷	300m west of the route (100m east of the land required for construction of the Proposed Scheme)	Sewage discharges - final/treated effluent - not water company	Tributary of the River Trent
T/02/35099/S H6 ⁸	590m west of the route (130m west of the land required for construction of the Proposed Scheme)	Sewage discharges - final/treated effluent - not water company	Meece Brook

3.2 Groundwater

- 3.2.1 A summary of the geological units present in the Stone and Swynnerton area is presented in Land Quality section in ES Volume 2, Stone and Swynnerton area report, Section 10. The hydrogeological characteristics of the geological units is summarised in the Water resources and flood risk section in Volume 2, Stone and Swynnerton area report, Section 15 and further detail is provided below.
- 3.2.2 Map WR-02-203 (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 five superficial aquifers within the study area. Alluvium, River Terrace Deposits, undifferentiated Glaciofluvial Deposits and Glaciofluvial Sheet Deposits are all classified as Secondary A aquifers by the Environment Agency. Head Deposits are classified as Secondary undifferentiated aquifers. The River Terrace Deposits do not occur within the land required for construction.
- 3.2.4 There are three bedrock aquifers in the study area. The Sherwood Sandstone Group is classified as a Principal aquifer, the Butterton-Swynnerton Dykes are classified as a Secondary A aquifer and the Mercia Mudstone Group is classified as a Secondary B aquifer.
- 3.2.5 There are four Environment Agency observation boreholes which monitor groundwater level in the Sherwood Sandstone Group within the study area, at Wing House, Stabhill, Upper Hatton Wood and Shelton under Harley. There are also Environment Agency observation boreholes which monitor groundwater level in the Sherwood Sandstone Group approximately 2km to the north-east (Swynnerton A and B) of the route, 3km to the south-west of the route (Standon), and 4km west of the

⁷ Map WR-01-104b. Discharges in the study area are listed from south to north.

⁸ Map WR-01-106a

route (Clowes Wood). Figure 1 shows the location of these monitoring boreholes and Figure 2 shows available groundwater level monitoring data plotted over time.

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

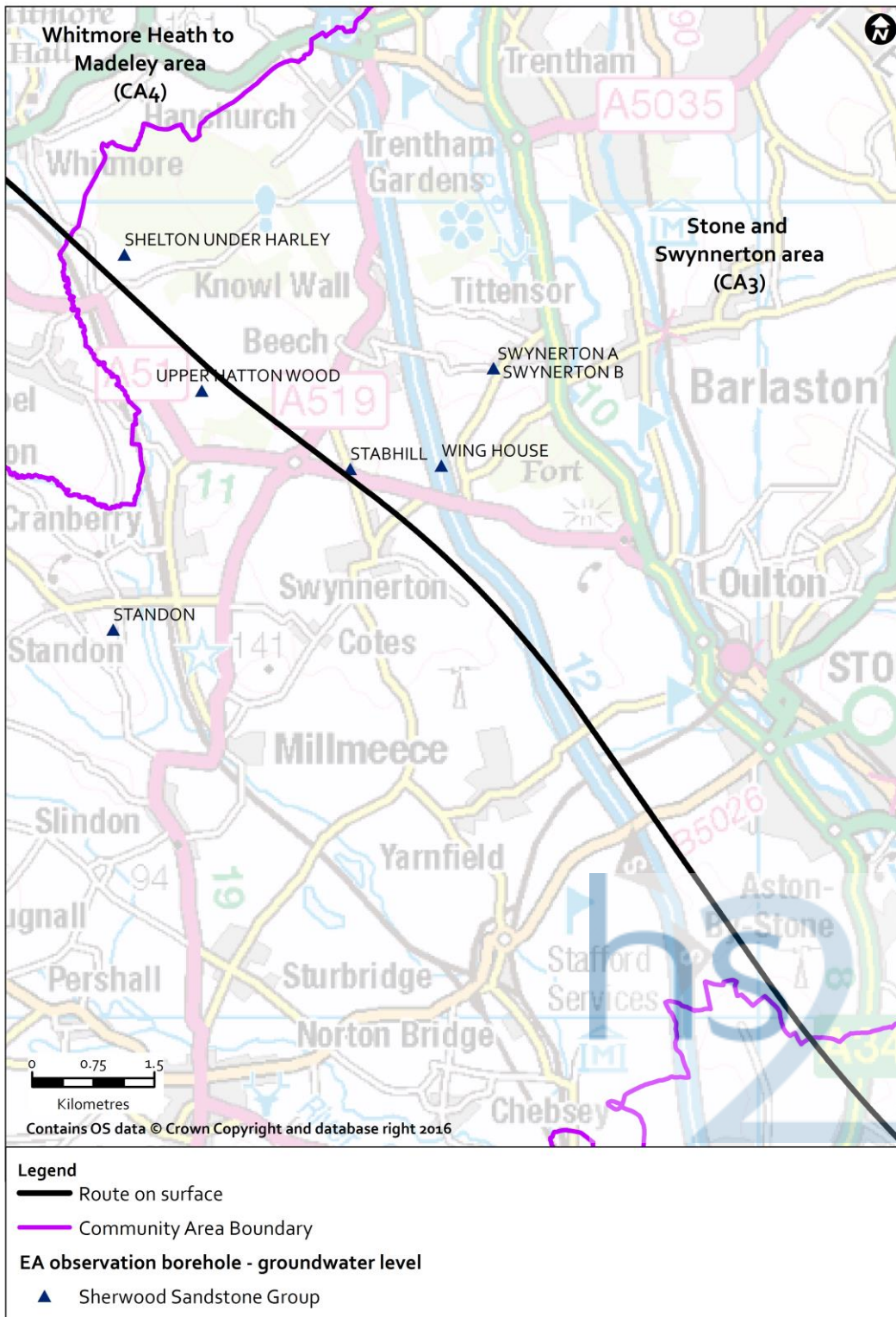
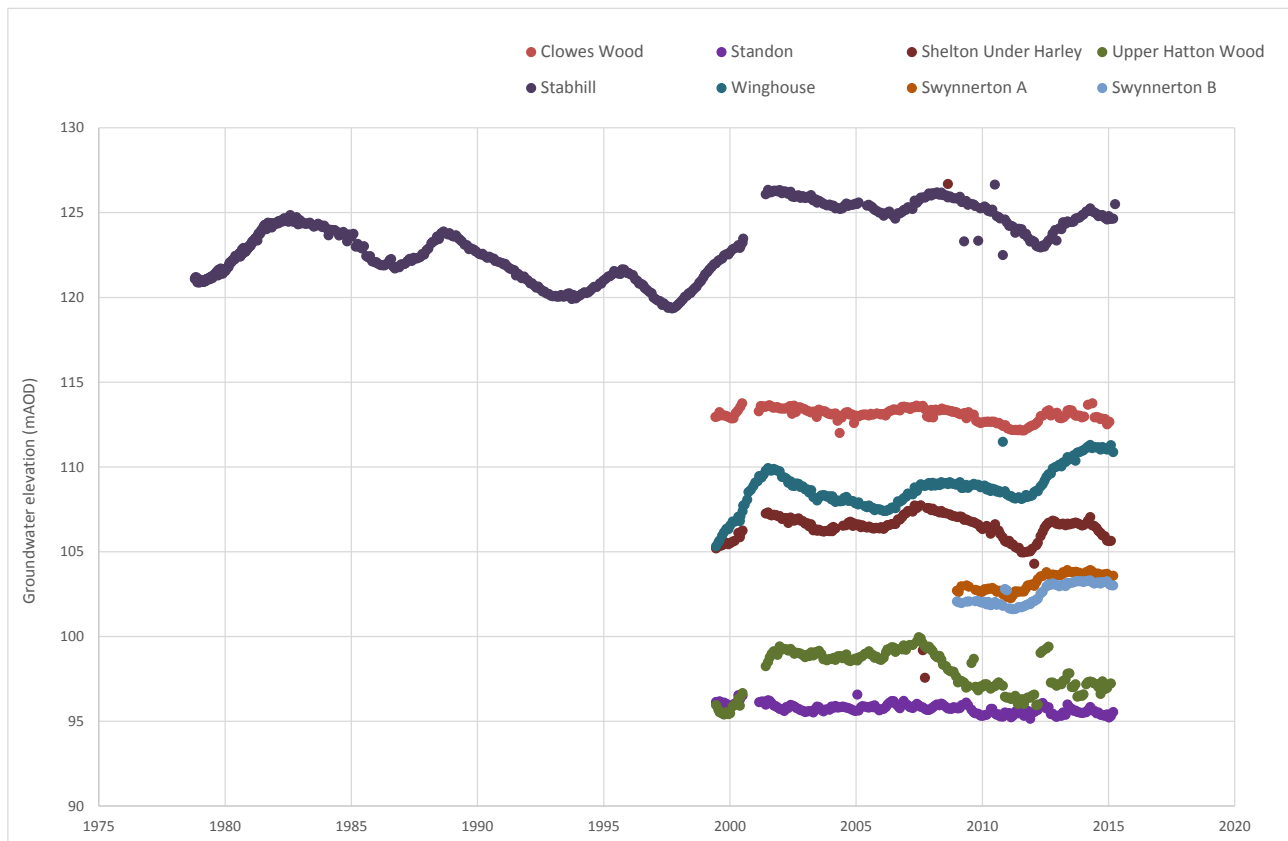


Figure 2: Groundwater elevation (Sherwood Sandstone Group) in metres above ordnance datum (mAOD)



- 3.2.6 The Environment Agency observation monitoring boreholes provide the best source of information for understanding groundwater levels in the Sherwood Sandstone Group at this location. In addition, information supplied by Severn Trent Water Ltd provides rest water level at the PWS near Whitmore (in the Whitmore Heath to Madeley area (CA4), just to the north of the Stone and Swynnerton area).
- 3.2.7 The collated data suggests that groundwater levels in the Sherwood Sandstone Group appear to be close to ground level in the valley bottom, but slightly further below ground level in the elevated areas, particularly where there is no superficial cover and recharge can occur directly to the bedrock. Water fluctuations at Environment Agency observation boreholes show a similar pattern, suggesting groundwater is responding in a similar way to weather and climatic conditions. The water level information does not show a clear groundwater flow direction across the aquifer in this area, but suggests that flow is controlled locally by topography, recharge to the aquifer where it is unconfined and local groundwater abstractions.
- 3.2.8 No groundwater monitoring data is available for the Secondary A and Secondary B aquifers in the study area. Water strikes recorded on borehole logs have been referred to for the purpose of the assessment. 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 a discharge points for converging groundwater flow in the area. Where groundwater levels are not known, they have been assumed to be at or close to ground level for the purpose of a precautionary assessment.

- 3.2.9 In the superficial Secondary A aquifers (Glaciofluvial Deposits, Alluvium and River Terrace Deposits) most groundwater flow is expected to be through the intergranular matrix of these unconsolidated deposits.
- 3.2.10 In the Butterton-Swynnerton Dykes Secondary A aquifer most groundwater flow is expected to occur through fractures or other discontinuities.
- 3.2.11 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 lenses called skerries. There may also be a small element of fracture flow.
- 3.2.12 Table 3 summarises groundwater abstractions in the study area and their locations are shown on Map WR-02-04.
- 3.2.13 There are two licensed groundwater abstractions near Swynnerton and Lower Hatton, both of which are for PWS. These have been assessed as very high value receptors.
- 3.2.14 The PWS near Swynnerton has three abstraction boreholes, each of which is protected by a SPZ. The SPZ are shown on Map WR-02-203. The SPZ₁ around each abstraction borehole have approximate radii of 70m and they are located outside of the land potentially required for construction, except the northern most portion of SPZ₁ which is adjacent to the M6 and a small patch of land potentially required for construction, which is associated with the small existing drain at this location. Any work within the SPZ₁ would be at grade and associated with minor drainage upgrades. The route of the Proposed Scheme is approximately 290m from the SPZ₁.
- 3.2.15 The PWS near Upper Hatton has three abstraction boreholes, each of which is protected by a SPZ. The SPZ location is shown on Map WR-02-203. One joined SPZ₁ is located around the three abstraction boreholes and is not crossed by the Proposed Scheme. The land required for construction of the Proposed Scheme extends into this area but only to allow for utility works within the existing footprint of the highway. The abstraction is approximately 700m to the south west of the route of the Proposed Scheme.
- 3.2.16 The SPZ₂ for the PWS near Whitmore is also crossed by the Proposed Scheme within the Stone and Swynnerton area, whilst the abstraction itself, a very high value receptor, is in the Whitmore Heath to Madeley area.
- 3.2.17 There are a no private licenced groundwater abstractions in the study area but there are a number of unlicensed private groundwater abstractions. These do not have mapped SPZs but, where they are used for potable water supply and some other purposes, they do have a nominal SPZ₁ of 50m⁹. These abstractions have all been assessed as high value receptors.
- 3.2.18 The unlicensed private water supply information has been provided by the local authority, SBC. Where land access has been available, surveys have been undertaken

⁹ Environment Agency (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>

to confirm abstraction details. Where the exact details of an abstraction are not known, a precautionary assessment has been undertaken.

- 3.2.19 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 unlicensed abstractions are registered with the local authority. These may also need to be protected.

Table 3: Summary of groundwater abstractions in the Stone and Swynnerton area

Name, map ID ²⁰ (and map grid square)	Distance and direction from route*	Abstraction source	Maximum annual abstraction quantity (m ³)	Maximum daily abstraction quantity (m ³)	Purpose	Number of boreholes
Public water supplies (PWS)						
PWS near Swynnerton Licence identifier confidential (E4, E5, SPZ1 location)	350m north-east of the route	Sherwood Sandstone Group	3,740,909	10,227	PWS	3
PWS near Hatton Licence identifier confidential (C6, SPZ1 location)	800m south-west of the route	Sherwood Sandstone Group	7,051,136	22,000	PWS	3
PWS near Whitmore Licence identifier confidential (B5, SPZ1 location)	30m west of the route This abstraction is located in the adjacent Whitmore Heath to Madeley area and impacts are also assessed in Volume 5, Appendix WR-002-004.	Wilmslow sandstone (of the Sherwood Sandstone Group)	363,000	2,420	PWS	2
Private unlicensed water supplies						
North Pirehill Farm Map ID: 3/GA/1 (H5)	150m north-east of the route (50m north-east of the land required for construction of the Proposed Scheme)	Unknown (assumed to be Mercia Mudstone Group)	Unknown	<20	Unknown	Unknown (only the location of the tap is known)

²⁰ Map grid squares (for SPZs), licence numbers (for licensed abstractions), and unique map identification (ID) numbers (for unlicensed groundwater abstractions) are stated to show feature locations on Map WR-02-203. Each group of abstraction features in the study area are listed from south to north.

Name, map ID ¹⁰ (and map grid square)	Distance and direction from route*	Abstraction source	Maximum annual abstraction quantity (m ³)	Maximum daily abstraction quantity (m ³)	Purpose	Number of boreholes
Walton Heath Farm Map ID: 3/GA/2 (G5)	200m north-east of the route (130m north-east of the land required for construction of the Proposed Scheme)	Unknown (assumed to be Mercia Mudstone Group)	Unknown	<20	Livestock	1
Little Micklow Map ID: 3/GA/3 (G5)	In the path of the route (within the land required for construction of the Proposed Scheme)	Unknown (assumed to be Mercia Mudstone Group)	Unknown	<20	Unknown	Unknown (only the location of the tap is known)
Micklow House Farm Map ID: 3/GA/4 (G5)	130m north-east of the route (30m south of the land required for construction of the Proposed Scheme)	Unknown (assumed to be Mercia Mudstone Group)	Unknown	<20	Unknown	Unknown (only the location of the tap is known)
Darlaston Grange Map ID: 3/GA/5 (F4)	770m north-east of the route (330m north-east of the land required for construction of the Proposed Scheme)	Unknown (assumed to be Mercia Mudstone Group)	Unknown	<20	Domestic	1
Darlaston Wood Farm Map ID: 3/GA/6 (F4)	760m north-east of the route (530m north of the land required for construction of the Proposed Scheme)	Unknown (assumed to be Mercia Mudstone Group)	Unknown	<20	Domestic	Unknown (only the location of the tap is known)

*Where more than one borehole is part of the licence, the location details of the borehole nearest to the route of the Proposed Scheme are provided

3.2.20 There are four consented discharges to groundwater in the study area and these have been assessed as low value receptors. These are summarised in Table 4.

Table 4: Discharge consents to groundwater

Permit identifier (and map grid square) ¹¹	Distance and direction from route	Discharge type	Receiving water body
WQ/72/2979 (H5)	270m north-east of the route (130m east of the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata

¹¹ Map WR-02-203. Discharges in the study area are listed from south to north.

Permit identifier (and map grid square) ¹¹	Distance and direction from route	Discharge type	Receiving water body
3/28/02/2273 (H5)	120m north-east of the route (within the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata
T/02/36273/SG (B5)	35m north-east of the route (within the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Groundwater
T/02/36272/SG (B5)	35m north-east of the route (within the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Groundwater

3.3 Groundwater – surface water interaction

3.3.1 Table 5 summarises the potential groundwater – surface water interactions identified within the study area.

3.3.2 Along with the main surface watercourses which could have connection with groundwater, potential 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-02-203 in the Volume 5 Water resources and flood risk Map Book. In the absence of site surveys the features have been assumed to comprise springs, which are high value receptors.

Table 5: Groundwater – surface water interaction

Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Watercourses				
Filly Brook and tributaries	Crossed by the route	Alluvium overlying Mudstone and Halite (Mercia Mudstone Group)	Variable (around 98m in proximity to the Stone IMB-R)	Filly Brook and its tributaries are likely to be hydraulically connected with the Alluvium and possibly with small discontinuous permeable layers in the Mercia Mudstone Group.

¹² Map WR-02-203. 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.

Appendix WR-002-003

Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Meece Brook	160m to the south-east of the route at the northern boundary of the Stone and Swynnerton area.	Alluvium overlying Wilmslow Sandstone Formation (Sherwood Sandstone Group)	106	The Meece Brook is likely to be in hydraulic connection with the Wilmslow Sandstone Formation, which is laterally continuous beneath the route in the northern part of the Stone and Swynnerton area.

Springs

Potential spring, Pirehill Cottage Farm (H5)	410m north-east of the route (adjacent to the land required for construction of the Proposed Scheme where there is an area of mitigation planting)	Mudstone and Halite (Mercia Mudstone Group)	113	Not surveyed. Assumed to be a high value receptor until this is verified by survey. It is assumed that the 'issue' is groundwater from a permeable layer in the Mercia Mudstone Group.
Potential spring, Service Area (i) (H6)	610m south-west of the route (240m west of the land required for construction of the Proposed Scheme)	Stafford Halite Formation (Mercia Mudstone Group)	120	Not surveyed. Assumed to be a high value receptors until this is verified by surveys. The 'issues' are likely to be land drainage features but taking a precautionary approach they are assumed to be groundwater issuing from the Mercia Mudstone Group.
Potential spring, Service Area (ii) H(6)	740m south-west of the route (400m west of the land required for construction of the Proposed Scheme)	Stafford Halite Formation (Mercia Mudstone Group)	111	
Potential spring, Service Area (iii) (H6)	870m south-west of the route (590m west of the land required for construction of the Proposed Scheme)	Stafford Halite Formation (Mercia Mudstone Group)	107	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is likely to be drainage from the M6 but taking a precautionary approach is assumed to be groundwater issuing from the Mercia Mudstone Group.
Potential spring, New House Farm (H5)	670m north-east of the route (440m north-west of the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	109	Not surveyed. Assumed to be a high value receptor until this is verified by survey. It is assumed that the 'issue' is groundwater from a permeable layer in the Mercia Mudstone Group.

Appendix WR-002-003

Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Potential spring, North Pirehill Farm (H5)	Adjacent to the route (Yarlet North cutting) (adjacent to the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	125	Not surveyed. Assumed to be a high value receptor until this is verified by survey. Assumed to be a high value receptor until this is verified by survey. The feature is not marked on the OS map, but there is a small pond feeding a watercourse flowing to the north-east. As this suggests a level of permanence that may indicate that the watercourse is spring fed, this feature has been included in the groundwater assessment following consultation with the Environment Agency.
Potential spring, west of the M6 (G6)	330m west of the route (105m north-east of the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	115	Not surveyed. The feature is not marked on the OS map but has been included in the assessment following consultation with the Environment Agency as it is possible that groundwater emerges at this location. It is considered more likely that the water feature marked on the OS map shows drainage from the M6.
Potential spring, Cold Norton (i) (G6)	740m south-west of the route (580m south-west of the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	104	Not surveyed. Assumed to be high value receptors until this is verified by surveys. It is assumed that the 'issues' are groundwater from permeable layers in the Mercia Mudstone Group.
Potential spring, Cold Norton (ii) (G6)	760m south-west of the route (680m south-west of the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	106	
Potential spring, Micklow Bungalow (G5)	230m north-east of the route (within the land required for construction of the Proposed Scheme - mitigation planting area)	Mudstone and Halite (Mercia Mudstone Group)	119	
Potential spring, Micklow House Farm (G5)	200m north-east of the route (within the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	107	
Potential spring, Moss Farm (i) (G6)	520m south-west of the nearest major feature of the Proposed Scheme (Stone Headshunt cutting) (115m south of the land required for construction of the	Peat	100	The survey did not identify a spring but a wet area of ground supporting marsh vegetation. Based on the results of the survey the feature has been assessed as a moderate value receptor.

Appendix WR-002-003

Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
	Proposed Scheme)			
Potential spring, Moss Farm (ii) (F6)	520m south-west of the nearest major feature of the Proposed Scheme (Stone Headshunt cutting) (adjacent to the land required for construction of the Proposed Scheme)	Peat	98	Not surveyed. Assumed to be a high value receptor until this is verified by survey.
Potential spring, Moss Farm (iii) (F6)	710m west of the nearest major feature of the Proposed Scheme (Stone Headshunt cutting) (110m north of the land required for construction of the Proposed Scheme)	Peat	99	
Potential spring, Darlaston Wood (F5)	310m north-east of the route (80m north of the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	124	Not surveyed. Assumed to be a high value receptor until this is verified by survey. It is assumed that the 'issue' is groundwater from a permeable layer in the Mercia Mudstone Group.
Potential spring, The Highlows (F5)	645m south-west of the nearest major feature of the Proposed Scheme (Stone IMB-R) (370m north of the land required for construction of the Proposed Scheme)	Glaciofluvial Deposits	122	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The Glaciofluvial Deposits are not continuous between the 'issue' and the Proposed Scheme and the 'issue' is not in hydraulically connected with the Proposed Scheme.
Potential spring, Darlaston Wood (ii) (F4)	520m north-east of the route (320m north of the land required for construction of the Proposed Scheme)	Mudstone and Halite (Mercia Mudstone Group)	135	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is up-gradient and not hydraulically connected with the Proposed Scheme.
Potential spring, Swynnerton Grange (E5)	625m south-west of the route (295m south-west of the land required for construction of the Proposed Scheme)	Glaciofluvial Sheet Deposits	119	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The Glaciofluvial Sheet Deposits are not continuous between the 'issue' and the Proposed Scheme and the 'issue' is not hydraulically connected with the Proposed Scheme.
Potential spring, Greathills	550m north-east of the route (730m north-east of the land required for construction of the	Helsby Sandstone Formation (Sherwood Sandstone	145	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is not hydraulically connected with

Feature (and map grid square) ¹²	Distance and direction from route	Formation	Elevation (m AOD)	Comments
(D4)	Proposed Scheme)	Group)		the Proposed Scheme.
Potential spring, Lodge Barn Cottage (C6)	675m south-west of the route (380m south-west of the land required for construction of the Proposed Scheme)	Wilmslow Sandstone Formation (Sherwood Sandstone Group)	130	Not surveyed. Assumed to be a high value receptor until this is verified by survey. It is assumed that the 'issue' is groundwater from the Sherwood Sandstone Group.
Potential spring, Little Rowe Farm (C6)	800m south-west of the route (690m south-west of the land required for construction of the Proposed Scheme)	Alluvium	100	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is not hydraulically connected with the Proposed Scheme.

3.4 Water dependent habitats

3.4.1 There are no designated water dependent habitats in the study area.

4 Site specific surface water assessments

4.1 Summary of assessment

- 4.1.1 Table 6 summarises the potential impacts and effects related to surface water features, including watercourses, abstractions and 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 Construction Practice (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 or adjacent to 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	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Watercourses									
Filly Brook	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)
Unnamed Tributary of Meece Brook2 Unnamed Tributary of Filly Brook Unnamed Tributary of River Trent 6	Moderate	- Realignments - 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)
Unnamed Tributary of Meece Brook1 Unnamed Tributary of River Trent 8	Low	- Realignments - 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.	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)
Surface water abstraction									
Licensed surface water abstraction 03/28/01/0169 Filly Brook (13) ⁶	High	- Norton Bridge to Stone Railway	Located 20m north of the land required for construction of the Proposed Scheme, and 820m downstream of the works at the Filly Brook viaduct. There is potential for a reduction in water quality at the abstraction location due to the possible mobilisation of contaminants from the construction area upstream. Reduction in local water quality has the potential to affect abstraction.	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)
Discharges to surface water									
Discharge	Low	- Pirehill Lane Access	Located adjacent to the land required for construction of the	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)

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	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
T/01/11117/S (C5) ⁷			Proposed Scheme at Staffordshire Fire and Rescue service HQ. This area will be used for access only and no works will be undertaken in this area, the potential for mobilisation of contaminants that could affect water quality at the discharge site is considered low.	Significance of effect - Negligible, not significant	construction	Significance of effect - Negligible, not significant		Significance of effect - Negligible, not significant	

5 Site specific groundwater assessments

5.1 Summary of assessment

- 5.1.1 Table 7 summarises all the potential impacts to hydrogeology (aquifers), abstractions and groundwater – surface water interactions.
- 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 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 5 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
Aquifers									
Head – Secondary undifferentiated aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - temporary works at Swynnerton North cutting transfer node - Swynnerton North cutting main compound	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.	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)
Alluvium - Secondary A aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Norton Bridge to Stone Railway – Stone IMB-R - Yarnfield North embankment - Meaford South embankment - Meaford North embankment - Temporary works such as stockpiles	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 or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	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)
		Construction involving deeper excavation (>1mbgl) including: - Filly Brook viaduct - Meaford cutting - M6 Meaford viaduct - Stone retaining wall 1 and 2 - Yarnfield Lane overbridge	Construction works have the potential to affect shallow groundwater quality during construction, however this will be very localised and temporary (See Section 5.2). Temporary and permanent dewatering impacts on the aquifer from Meaford cutting are assessed as negligible (see Section 5.2). Potential alteration of shallow groundwater flow pathways may occur around new below ground structures. Due to the location and minor extent of the	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 ¹³ .	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

¹³ Groundwater control/drainage measures are outlined in Volume 2, South Cheshire 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
			viaduct piers within the much larger area of aquifer, the impact on groundwater flow pathways will be negligible.						
River Terrace Deposits - Secondary A aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Common Lane (Swynnerton)	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary works are of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	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)
Glaciofluvial Deposits (Glaciofluvial Sheet Deposits and Glaciofluvial Deposits, Undifferentiated) - Secondary A aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Norton Bridge to Stone Railway - Meaford North embankment - temporary works such as stockpiling	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 of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	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)
Mercia Mudstone Group - Mudstone and Halite Stone - Secondary B aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - Yarlet embankment - Yarfield South embankment - Yarfield North embankment - Meaford South embankment - Meaford North embankment - temporary works such as stockpiling and compounds	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 of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	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)
		Construction involving deeper excavation (>1mbgl) including: - Yarlet Central cutting	The temporary works have the potential to affect groundwater flow and quality, although this is likely to be localised and temporary. Assessment of the impacts from cutting dewatering shows there will be negligible	Magnitude of impact - Moderate Significance of effect – Moderate adverse,	Implementation of measures described in the draft CoCP. Design of permanent structures will include	Magnitude of impact - Negligible Significance of effect - Negligible,	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not	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
		<ul style="list-style-type: none"> - Yarlet North cutting - Filly Brook viaduct - Meaford cutting - M6 Meaford viaduct - Stone retaining wall 1 and 2 - overbridges 	<p>impact on groundwater levels in the context of the aquifer (see Section 5.2).</p> <p>Potential alteration of shallow groundwater flow pathways may occur around below ground structures, however this will be localised (see Section 5.2).</p>	significant	groundwater control/drainage measures where required ¹³ .	not significant		significant	
Mercia Mudstone Group - Tarporley Siltstone Formation – Secondary B aquifer	Moderate	<p>Construction of above ground elements and shallow excavation (<1m) including:</p> <ul style="list-style-type: none"> - Swynnerton embankment 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Temporary and permanent works are of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.</p>	<p>Magnitude of impact - Minor</p> <p>Significance of effect – Minor adverse, not significant</p>	<p>Implementation of measures described in the draft CoCP.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
		<p>Construction involving deeper (>1mbgl) excavation including:</p> <ul style="list-style-type: none"> - Swynnerton South cutting 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Impacts on groundwater levels due to cutting dewatering will be negligible (see Section 5.2).</p>	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Moderate adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Design of permanent structures will include groundwater control/drainage measures where required¹³.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
Mercia Mudstone Group - Wilkesley Halite Member (Stafford Halite Member) – Secondary B aquifer	Moderate	<p>Construction involving deeper excavation (>1mbgl) including:</p> <ul style="list-style-type: none"> - Yarlet Central cutting 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Impacts on groundwater levels due to cutting dewatering will be negligible in the context of the aquifer (see Section 5.2).</p>	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Moderate adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Design of permanent structures will include groundwater control/drainage measures where required¹³.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
Sherwood Sandstone Group - Wilmslow Sandstone (Wildmoor Sandstone) – Principal aquifer	High	<p>Construction of above ground elements and shallow excavation (<1m) including:</p> <ul style="list-style-type: none"> - Hatton embankment - road diversions - temporary works including stockpiles and 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Temporary and permanent works are of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.</p>	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Moderate adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	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
		compounds							
		<p>Construction involving deeper excavation (>1mbgl) including:</p> <ul style="list-style-type: none"> - Swynnerton North cutting - Hatton South cutting - Hatton North cutting - Dog Lane overbridge - Rowe Farm overbridge 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Impacts on groundwater levels due to cutting dewatering will be negligible in the context of the aquifer (see Section 5.2).</p> <p>Potential alteration of shallow groundwater flow pathways may occur around overbridge foundations, however this will be localised (see Section 5.2).</p>	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Moderate adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Design of permanent structures will include groundwater control/drainage measures where required¹³.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
Sherwood Sandstone Group - Helsby Sandstone Formation (Bromsgrove Sandstone) – Principal aquifer	High	<p>Construction of above ground elements and shallow excavation (<1m) including:</p> <ul style="list-style-type: none"> - Swynnerton embankment - temporary works including stockpiles 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Temporary and permanent works are of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.</p>	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Moderate adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
		<p>Construction involving deeper excavation (>1mbgl) including:</p> <ul style="list-style-type: none"> - Swynnerton South cutting 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Impacts on groundwater levels due to cutting dewatering will be negligible (see Section 5.2).</p>	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Moderate adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Design of permanent structures will include groundwater control/drainage measures where required¹³.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
Sherwood Sandstone Group - Chester Formation (Kidderminster) – Principal aquifer	High	<p>Construction of above ground elements and shallow excavation (<1m) including:</p> <ul style="list-style-type: none"> - A51 Stone Road diversion - temporary works such as stockpiles and compounds 	<p>The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.</p> <p>Temporary and permanent works are of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.</p>	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Moderate adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	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
		Construction involving deeper excavation (>1mbgl) including: - Swynnerton North cutting	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Impacts on groundwater levels due to excavation of the cutting will be negligible (see Section 5.2).	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)
Butterton-Swynnerton Dykes - Paleogene igneous dykes – Secondary A aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - A51 Stone Road diversion - temporary works such as stockpiles and compounds	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 of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	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)
		Construction involving deeper excavation (>1mbgl) including: - Swynnerton North cutting	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Impacts on groundwater levels due to excavation of the cutting will be negligible (see Section 5.2).	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)

Abstractions

PWS near Swynnerton Licence identifier confidential (E4, E5, SPZ1 location) ¹⁰	Very high	Minor drainage upgrade – within existing channel. Works within SPZ1	There are currently no proposals for works within the SPZ1, but the land potentially required for construction includes the watercourse which is within the SPZ1, in case any upgrade works to the downstream culvert are required. If construction work is required in this area, there is a potential for a major impact on groundwater quality in proximity to the SPZ1.	Magnitude of impact - Major Significance of effect – Major adverse, significant	Implementation of measures described in the draft CoCP. Avoid work in the SPZ1 if practicably possible. If any construction works within this area are to be required, Severn Trent Water Ltd will be consulted.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		Permanent design features within SPZ2: - Swynnerton South cutting - Meaford north	Groundwater levels are expected to be significantly below the base of cuttings and at grade features (see Section 5.2) therefore there will be no impact on groundwater flow. Potential impacts on water quality are assessed as minor, on a precautionary basis due their location within the SPZ2.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Although the effects are expected to be negligible additional monitoring	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (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 - Swynnerton embankment			requirements are being agreed with Severn Trent Water Ltd and the Environment Agency to provide further confidence in the assessment.				
		Construction works within the SPZ2: - Swynnerton South cutting - Meaford North embankment - Swynnerton embankment - stockpile	Groundwater levels are expected to be significantly below the base of cuttings and at grade features (see Section 5.2) therefore there will be no impact on groundwater flow. Potential impacts on water quality are assessed as minor, on a precautionary basis due their location within the SPZ2.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Although the effects are expected to be negligible additional monitoring requirements are being agreed with Severn Trent Water Ltd and the Environment Agency to provide further confidence in the assessment.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		Construction work of key elements within the SPZ3: - Swynnerton North cutting	Groundwater levels are expected to be significantly below the base of cutting therefore there will be no impact on groundwater flow. Removal of topsoil or shallow material, and construction activity has potential to cause increased turbidity and impact on groundwater quality in the SPZ3 during construction, though there is significant unsaturated zone in the Sherwood Sandstone Group at this location.	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)
PWS near Hatton Licence identifier confidential (C6, SPZ1 location) ¹⁰	Very high	Construction works within SPZ1: - utility works within the existing highway boundary (Common Lane, (Swynnerton))	Utility works are expected to be minor and within the existing road footprint but have potential to impact on groundwater quality within the SPZ1.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. If any construction works within this area are required, Severn Trent Water Ltd will be consulted.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		Construction works within the SPZ2: - Common Lane (Swynnerton)	Works are expected to be minor and at grade/above ground but have potential to impact on groundwater quality within the SPZ2.	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)

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
		<p>Construction works within the SPZ3:</p> <ul style="list-style-type: none"> - Swynnerton North cutting - Hatton embankment - Hatton South cutting - stockpiles - compounds 	Removal of topsoil or shallow material, and construction activity has potential to cause increased turbidity and impact on groundwater quality in the SPZ3 during construction, though there is a significant unsaturated zone in the Sherwood Sandstone Group at this location.	<p>Magnitude of impact - Minor</p> <p>Significance of effect – Moderate adverse, significant</p>	Implementation of measures described in the draft CoCP.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary)
<p>PWS near Whitmore</p> <p>Licence identifier confidential (B5, SPZ1 location)¹⁰</p>	Very high	<p>Construction works within the SPZ2:</p> <ul style="list-style-type: none"> - Hatton South cutting - Bent Lane diversion - Bent Lane (South) realignment 	Groundwater levels are expected to be significantly below the base of cutting and at grade features (see Section 5.2), and no significant impacts on water quantity are expected. Potential impacts on water quality are assessed as moderate, on a precautionary basis due their location within the SPZ2.	<p>Magnitude of impact - Moderate</p> <p>Significance of effect – Major adverse, significant</p>	Implementation of measures described in the draft CoCP.	<p>Magnitude of impact - Minor</p> <p>Significance of effect – Moderate adverse, significant</p>	Due to construction work within the SPZ1 in the Whitmore Heath to Madeley area, additional mitigation is being agreed with Severn Trent Water Ltd and the Environment Agency for the construction phase. See Volume 2, Whitmore Heath to Madeley area report, Section 15.	<p>Magnitude of impact - Minor</p> <p>Significance of effect - Moderate, significant</p>	Construction (temporary)
<p>Unlicensed private water supply</p> <p>North Pirehill Farm</p> <p>3/GA/1</p> <p>(H5)¹⁰</p>	High	<ul style="list-style-type: none"> - Yarlet North cutting - Stone Rural Footpath 28 accommodation overbridge - temporary works including stockpiles 	The exact location of the abstraction is not known therefore it is assumed that removal of topsoil or shallow material, and construction activity has potential to cause increased turbidity and impact on groundwater quality. Dewatering of the cutting and local lowering of the groundwater table could also permanently impact the abstraction yield (see Section 5.2).	<p>Magnitude of impact - Major</p> <p>Significance of effect – Major adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Further investigation and monitoring. If detailed investigations by the nominated undertaker confirm a risk of temporary or permanent impact on the abstraction, alternative water supply arrangements would be agreed with the owners.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
<p>Unlicensed private water supply</p> <p>Walton Heath Farm</p> <p>3/GA/2</p> <p>(G5)¹⁰</p>	High	<ul style="list-style-type: none"> - Yarlet North cutting - Stone headshunt - temporary construction works including Yarlet North cutting satellite compound and a 	The geoindex log at this abstraction suggests the borehole is lined to 9.1mbgl, although water levels were not recorded. Removal of topsoil or shallow material, and construction activity has potential to cause increased turbidity and temporarily impact groundwater quality at the abstraction.	<p>Magnitude of impact - Major</p> <p>Significance of effect – Major adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Further investigation and monitoring. If detailed investigations by the nominated</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary)

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
		stockpile	(The permanent impact of the cuttings are assessed as negligible because abstraction is outside the area assessed as having the potential to be affected by changes in groundwater level. See Section 5.2).		undertaker confirm a risk of temporary impact on this supply, temporary replacement prior to commencement of construction, with a nearby alternative or a mains supply will be provided and in agreement with the landowner.				
Unlicensed private water supply Little Micklow 3/GA/3 (G5) ¹⁰	High	<ul style="list-style-type: none"> - Yarlet North cutting, - Stone headshunt - B5026 Eccleshall Road overbridge 	The exact location of the abstraction is not known but it is assumed to be within the footprint of the Proposed Scheme near Yarlet North cutting, based on the location of the tap, and will therefore be permanently lost. The abstraction currently supplies Little Micklow, which is scheduled for demolition.	<p>Magnitude of impact - Major</p> <p>Significance of effect – Major adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Further investigation and monitoring. Alternative water supply arrangements would be agreed with the owner if required.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
Unlicensed private water supply Micklow House Farm 3/GA/4 (G5) ¹⁰	High	<ul style="list-style-type: none"> - Yarlet North cutting - Stone headshunt - B5026 Eccleshall Road overbridge - temporary construction works including Yarlet North cutting satellite compound and a stockpile 	The exact location of the abstraction is not known therefore it is assumed that construction works could temporarily impact on water quality and local lowering of the groundwater table due to the cutting could permanently impact the abstraction yield.	<p>Magnitude of impact - Major</p> <p>Significance of effect – Major adverse, significant</p>	<p>Implementation of measures described in the draft CoCP.</p> <p>Further investigation and monitoring. If detailed investigations by the nominated undertaker confirm a risk of temporary or permanent impact on the abstractions, alternative water supply arrangements would be agreed with the owners.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary and permanent)
Unlicensed private water supply	High	<ul style="list-style-type: none"> - Meaford cutting - Meaford South 	The borehole location was confirmed during site surveys. No borehole logs or water level records are available. The abstraction is	Magnitude of impact - Minor	Implementation of measures described in	Magnitude of impact - Negligible	None required.	Magnitude of impact - Negligible	Construction (temporary)

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
Darlaston Grange 3/GA/5 (F4) ¹⁰		embankment - temporary construction works including compounds and a stockpile	outside of the cutting dewatering zone of influence and therefore abstraction yield is not expected to be impacted. However removal of topsoil or shallow material, and construction activity in proximity to the abstraction has potential to cause increased turbidity and impact on groundwater quality. Construction works will take place outside of the 250m SPZ2.	Significance of effect – Moderate adverse, significant	the draft CoCP. Further investigation and monitoring. If detailed investigations by the nominated undertaker confirm a risk of temporary impact on the supply, temporary replacement prior to commencement of construction, with a nearby alternative or a mains supply will be provided and in agreement with the relevant landowner.	Significance of effect - Negligible, not significant		Significance of effect - Negligible, not significant	
Unlicensed private water supply Darlastonwood Farm 3/GA/6 (F4) ¹⁰	High	- M6 Meaford viaduct - At grade construction works including compounds and stockpiles	The exact location of the abstraction is not known therefore it is assumed that construction works could temporarily impact on water quality.	Magnitude of impact - Major Significance of effect – Major adverse, significant		Magnitude of impact - Major Significance of effect - Major adverse, significant	None required.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)

Discharges to groundwater

WQ/72/2979 (H5) ¹⁰	Low	- Yarlet North cutting	The discharge is outside of the cutting dewatering zone of influence (see Section 5.2) and there will be negligible impact.	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	Not applicable
3/28/02/2273 (H5) ¹⁰	Low	- Yarley North cutting - Construction works	The discharge appears to be within the land required for construction, and may also be impacted by dewatering of the cutting. It is therefore assumed that the discharge will need to be decommissioned, a major impact.	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 adverse, not significant	Mitigation will be agreed with the owner.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
T/02/36273/SG (B5) ¹⁰	Low	- Hatton North cutting	The discharge is in the path of construction works and it is therefore assumed that it will need to be decommissioned, a major impact.	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 adverse, not significant	Mitigation will be agreed with the owner.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
T/02/36272/SG (B5) ¹⁰	Low	- Hatton North cutting	The discharge is in the path of construction works and it is therefore assumed that it will need to be decommissioned, a major impact.	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 adverse, not significant	Mitigation will be agreed with the owner.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (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
Groundwater – surface water interaction									
Filly Brook and tributaries	Very high	- Filly Brook viaduct - Meaford cutting - Stone IMB-R - Norton Bridge to Stone sidings	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Potential alteration of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers, the impact on groundwater flow pathways will be negligible in the context of baseflow to Filly Brook. The permanent impact of the cuttings are assessed as negligible because Filly Brook is outside the area assessed as having the potential to be affected by changes in groundwater level (see Section 5.2).	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)
		- Stone IMB-R - Meaford cutting - Norton Bridge to Stone Reception sidings - Yarnfield North embankment satellite compound - Yarnfield North embankment temporary worker accommodation - Stockpiles - All construction works.	The temporary works have the potential to affect shallow local groundwater quality and therefore quality of baseflow to Filly Brook.	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)
Meece Brook	Very high	- Hatton North cutting - Hatton South cutting - Dog Lane overbridge - Stockpiles	The temporary works have the potential to affect shallow local groundwater quality and therefore quality of baseflow to Meece Brook. Groundwater levels in the Sherwood Sandstone Group are expected to be below the base of the cuttings (see Section 5.2) and therefore there will be no impact on baseflow to Meece Brook due to dewatering of the cutting.	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)
Potential spring, Pirehill Cottage Farm (H5) ¹⁰	High	- Yarlet Central cutting - Stockpile - At grade construction works including mitigation	The nearby construction works and temporary stockpile have potential to impact groundwater quality which may be in hydraulic connection with the spring. The impact of the cutting is assessed as	Magnitude of impact - Minor Significance of effect – Moderate adverse,	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)

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
		planting	negligible because the potential spring is outside the area assessed as having the potential to be affected by changes in groundwater level (see Section 5.2).	significant		not significant		significant	
Potential spring, Service Area (i) (H6) ¹⁰	High	- Yarlet embankment - Yarlet embankment satellite compound - Stockpile	The spring is a significant distance from any construction works, and any impacts on water quality as a result of the nearest stockpile will be minor.	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)
Potential spring, Service Area (ii) (H6) ¹⁰	High	- Yarlet embankment and satellite compound - Stockpile	The spring is a significant distance from any construction works and impacts on water quality will be negligible.	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	Not applicable
Potential spring, Service Area (iii) (H6) ¹⁰	High	- Yarlet embankment - Yarlet embankment satellite compound - Stockpile	The spring is a significant distance from any construction works and impacts on water quality will be negligible.	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	Not applicable
Potential spring, New House Farm (H5) ¹⁰	High	- Yarlet North cutting	The temporary works have the potential to affect shallow local groundwater quality at the potential spring. The impact of the cutting is assessed as negligible because the potential spring is outside the area assessed as having the potential to be affected by changes in groundwater level (see Section 5.2).	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)
Potential spring, North Pirehill Farm (H5) ¹⁰	High	- Yarlet North cutting	The construction of Yarlet North cutting will result in the permanent loss of the potential spring feature to the north of Pirehill Farm, which may discharge from the Mercia Mudstone Group aquifer to a small pond. This pond will be lost as a result of construction of the Proposed Scheme. The impact is addressed by creation of replacement pond habitat elsewhere as described in the ecological mitigation proposals outlined in Section 8, Ecology and biodiversity, Volume 2, Stone and Swynnerton area report. The watercourse downstream of the pond, potentially affected by the loss of this spring, is a low value receptor. No significant effects related to the loss of this potential spring	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 (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
			feature are therefore anticipated.						
Potential spring, west of the M6 (G6) ¹⁰	High	- Yarlet North cutting - Stone Rural Footpath 28 accommodation overbridge and footpath - Stockpile	The water quality due to local temporary construction works such as stockpiling could have minor impact on groundwater issuing at the potential spring feature. The impact of the cutting is assessed as negligible because the potential spring is outside the area assessed as having the potential to be affected by changes in groundwater level (see Section 5.2).	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)
Potential spring, Cold Norton (i) (G6) ¹⁰	High	- Yarlet North cutting	The spring is a significant distance from any construction works therefore impacts on quality will be negligible. The impact of the cutting is assessed as negligible because the potential spring is outside the area assessed as having the potential to be affected by changes in groundwater level (see Section 5.2).	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	Not applicable
Potential spring, Cold Norton (ii) (G6) ¹⁰	High	- Yarlet North cutting	The spring is a significant distance from any construction works therefore impacts on quality will be negligible. The impact of the cutting is assessed as negligible because the potential spring is outside the area assessed as having the potential to be affected by changes in groundwater level (see Section 5.2).	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	Not applicable
Potential spring, Micklow Bungalow (G5) ¹⁰	High	- Construction works at B5026 Eccleshall Road and mitigation planting - Yarlet North cutting - Stone Rural Footpath 28 accommodation overbridge	The water quality due to local temporary construction works could have minor impact on groundwater issuing at the potential spring feature. The impact of the cutting is assessed as negligible because the potential spring is outside the area assessed as having the potential to be affected by changes in groundwater level (see Section 5.2).	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)
Potential spring, Micklow House Farm (G5) ¹⁰	High	- Yarlet North cutting - Stone Rural Footpath 28 accommodation overbridge - Construction works	The water quality due to local temporary construction works could have moderate impact on groundwater issuing at the potential spring feature. The impact of the cutting is assessed as negligible because the potential spring is outside the area assessed as having the potential to be affected by changes in	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)

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
			groundwater level (see Section 5.2).						
Potential spring, Moss Farm (i) (G6) ¹⁰	High	- Construction works at Norton Bridge to Stone Railway	The water quality due to local temporary construction works, although these are in the current footprint of the Norton Bridge to Stone Railway, could have minor impact on groundwater issuing at the potential spring feature.	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)
Potential spring, Moss Farm (ii) (F6) ¹⁰	High	- Construction works at Norton Bridge to Stone Railway	The water quality due to local temporary construction works, although these are in the current footprint of the Norton Bridge to Stone Railway, could have minor impact on groundwater issuing at the potential spring feature.	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)
Potential spring, Moss Farm (iii) (F6) ¹⁰	Moderate	- Construction works at Norton Bridge to Stone Railway	The water quality due to local temporary construction works, although these are in the current footprint of the Norton Bridge to Stone Railway, could have minor impact on groundwater issuing at the potential spring feature.	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)
Potential spring, Darlaston Wood (i) (F5) ¹⁰	High	- Meaford cutting - Stockpile - At grade construction works	The water quality due to local temporary construction works such as stockpiling could have minor impact on groundwater issuing at the potential spring feature. The impact of the cutting is assessed as negligible (see Section 5.2).	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)
Potential spring, Lodge Barn Cottage (C6) ¹⁰	High	- Swynnerton North cutting	Groundwater level is significantly below the level of the cutting, therefore construction impacts on water flow and quality at the potential spring will be negligible (see Section 5.2).	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	Not applicable

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 route of the Proposed Scheme. Within the Stone and Swynnerton area detailed assessments are presented demonstrating the likely impacts on groundwater from cuttings, and viaduct and overbridge piers. There are no tunnels or borrow pits in this area.

Impact on groundwater from cuttings

5.2.2 The location of cuttings is shown in Volume 2: Map Series CT-05 and Map Series CT-06. The cuttings which intersect aquifers have been initially characterised to determine whether groundwater elevations are likely to be above the base of the cutting. Parameters for the groundwater assessment of the cuttings are shown in Table 8 to Table 14 below. Where the groundwater elevation is not known or where the 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 has been undertaken.

Initial characterisation of cuttings

Yarlet Central cutting

Table 8: Summary of the Yarlet Central cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.77
Maximum depth (m)	17
Strata intercepted	Stafford Halite of the Mercia Mudstone Group, and Mudstone and Halite Stone of the Mercia Mudstone Group (Secondary B aquifer)
Lowest track level (mAOD)	127
Groundwater level(s) (mAOD)	There is no groundwater level monitoring in the vicinity of the cutting. For a precautionary assessment groundwater level is assumed to be ground level.
Principal receptors	Mercia Mudstone Group Secondary B aquifer

5.2.3 The cutting would penetrate the Mercia Mudstone Group Secondary B aquifer in an area where groundwater level may be shallow. Until further ground investigation information is available, a precautionary assessment has been undertaken, assuming groundwater levels are at ground level. Under this scenario groundwater flow in the vicinity of the cutting may be temporarily disrupted, as groundwater dewatering may be required during construction, and groundwater levels may be permanently lowered in the vicinity of the cutting. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

Yarlet North cutting

Table 9: Summary of the Yarlet North cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	2.02
Maximum depth (m)	17
Strata intercepted	Mudstone and Halite Stone of the Mercia Mudstone Group (Secondary B aquifer)
Lowest track level (mAOD)	106
Groundwater level(s) (mAOD)	There is no groundwater level monitoring in the vicinity of the cutting. For a precautionary assessment groundwater level is assumed to be ground level.
Principal receptors	<p>Mercia Mudstone Group Secondary B aquifer</p> <p>Private unlicensed abstractions: North Pirehill Farm, Walton Heath, Little Micklow, Micklow House Farm</p> <p>Springs</p> <p>Discharge to groundwater (3/28/02/2273)</p> <p>Tributary of Filly Brook</p>

5.2.4 The cutting would penetrate the Mercia Mudstone Group Secondary B aquifer in an area where groundwater level may be shallow. Until further ground investigation information is available, a precautionary assessment has been undertaken, assuming groundwater levels are at ground level. Under this scenario groundwater flow in the vicinity of the cutting may be temporarily disrupted, as groundwater dewatering may be required during construction, and groundwater levels may be permanently lowered in the vicinity of the cutting. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

Meaford cutting

Table 10: Summary of the Meaford cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.38
Maximum depth (m)	3
Strata intercepted	Mudstone and Halite Stone of the Mercia Mudstone Group (Secondary B aquifer)
Lowest track level (mAOD)	120
Groundwater level(s) (mAOD)	There is no groundwater level monitoring in the vicinity of the cutting. For a precautionary assessment groundwater level is assumed to be ground level.

Cutting parameters	Parameter details
Principal receptors	Mercia Mudstone Group Secondary B aquifer Springs Darlastonwood Farm private unlicensed abstraction Tributary of Filly Brook

5.2.5 The cutting would penetrate the Mercia Mudstone Group Secondary B aquifer in an area where groundwater level may be shallow. Until further ground investigation information is available, a precautionary assessment has been undertaken, assuming groundwater levels are at ground level. Under this scenario groundwater flow in the vicinity of the cutting may be temporarily disrupted, as groundwater dewatering may be required during construction, and groundwater levels may be permanently lowered in the vicinity of the cutting. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

Swynnerton South cutting

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

Cutting parameters	Parameter details
Length (km)	0.37
Maximum depth (m)	3
Strata intercepted	Helsby Formation and Wilmslow Formation of the Sherwood Sandstone Group (Principal aquifer) Tarpoley Siltstone of the Mercia Mudstone Group (Secondary B aquifer)
Lowest track level (mAOD)	147
Groundwater level(s) (mAOD)	There is no monitoring of groundwater in this aquifer in the vicinity of the cutting but based on the Sherwood Sandstone Group groundwater level monitoring boreholes further to the north and expected rest water levels at the Swynnerton abstraction boreholes groundwater levels are expected to be at least 25m below the base of the cutting.
Principal receptors	Sherwood Sandstone Group Principal aquifer Swynnerton PWS boreholes (SPZ2)

5.2.6 The cutting would penetrate the Sherwood Sandstone Group Principal aquifer in an area where the maximum groundwater levels are expected to be at least 25m below the base of the cutting. Groundwater flow will therefore not be disrupted.

5.2.7 The cross-section presented in Figure 3 demonstrates the spatial relationships between Swynnerton South cutting, the local geology, hydrogeology and the Swynnerton PWS abstraction boreholes.

5.2.8 Application of the CoCP will ensure materials and fluids used during construction are managed so that there is negligible impact on groundwater quality and therefore there will be no significant effect on the Swynnerton PWS.

5.2.9 It has been agreed with Severn Trent Water Ltd that additional monitoring will be undertaken in this area to provide further confidence in assessment of assumptions in relation to the PWS.

Figure 3: Conceptual cross-section through Swynnerton South cutting in proximity to the PWS

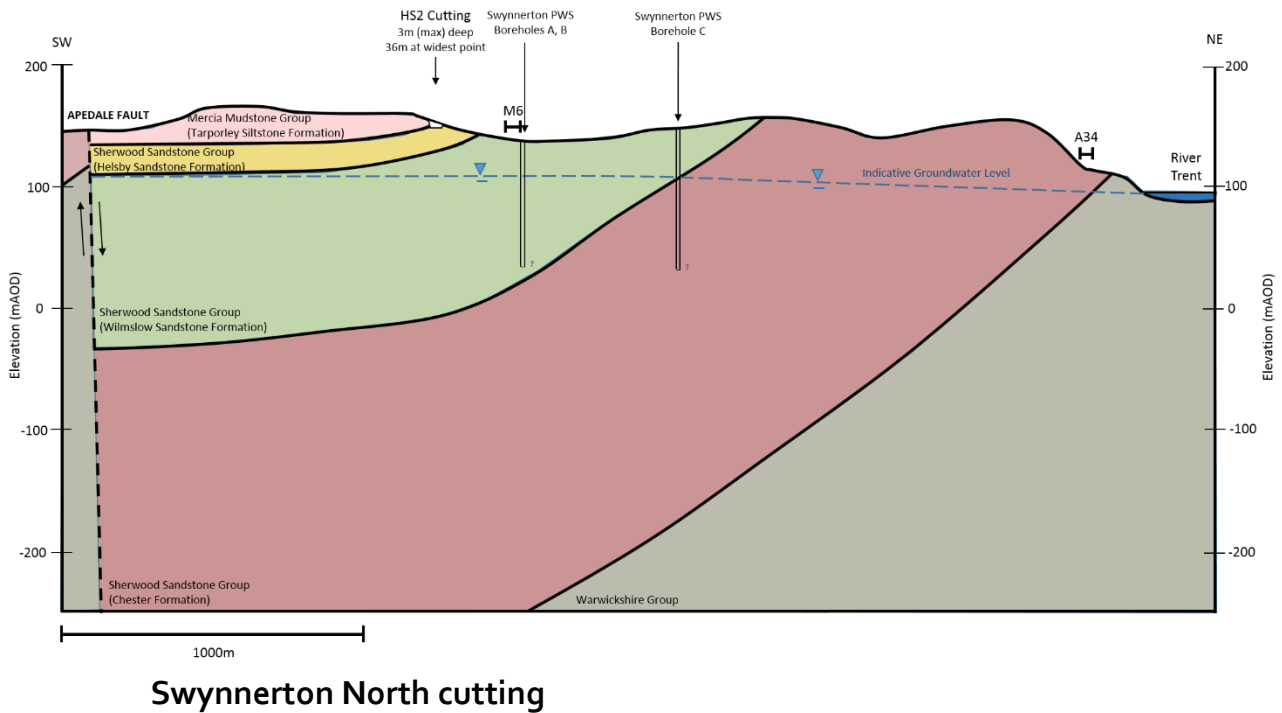


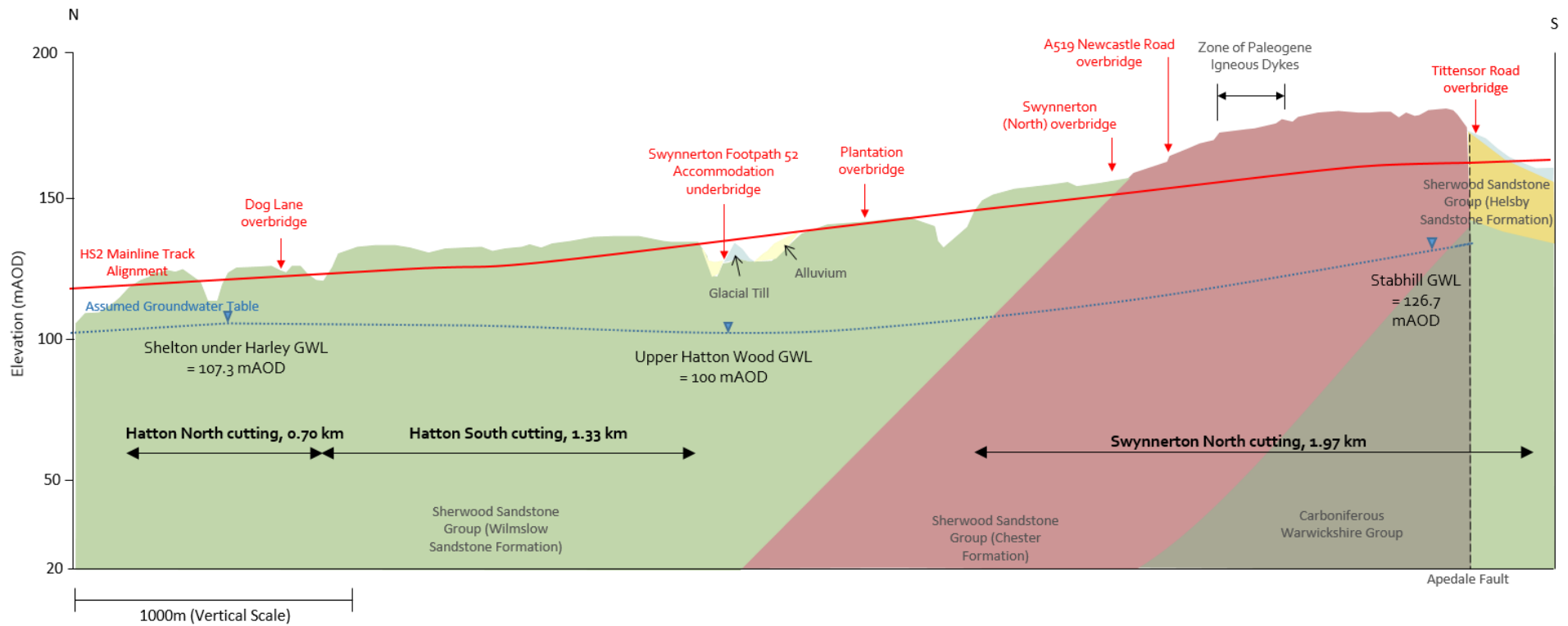
Table 12: Summary of the Swynnerton North cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.97
Maximum depth (m)	19
Strata intercepted	The Helsby Formation, Chester Formation and Wilmslow Formation of the Sherwood Sandstone Group (Principal aquifer), and the Butterton-Swynnerton Dykes (Secondary A aquifer).
Lowest track level (mAOD)	146
Groundwater level(s) (mAOD)	The Environment Agency groundwater level monitoring borehole at Stabhill, which monitors the Sherwood Sandstone Group is in close proximity to the cutting, has maximum groundwater levels recorded at 126.7mAOD.
Principal receptors	Sherwood Sandstone Group Principal Aquifer PWS near Hatton (SPZ3) Spring, Greathills

Cutting parameters	Parameter details
	Spring, Lodge Barn Cottage

- 5.2.10 Figure 4 shows the vertical profile of the HS2 route and a conceptualisation of the hydrogeology in the area between Swynnerton North cutting and Hatton North cutting.
- 5.2.11 The Swynnerton North cutting would penetrate the Sherwood Sandstone Group Principal aquifer in an area where the maximum groundwater levels are expected to be at least 19m below the base of the cutting. 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 negligible impact on groundwater quality and therefore there will be no significant effect on the Hatton PWS (which is located 800m to the south west).
- 5.2.12 It has been agreed with Severn Trent Water Ltd that additional monitoring will be undertaken in this area to provide further confidence in the assessment and assumptions in relation to the PWS.

Figure 4: Conceptual hydrogeological long-section showing Swynnerton North cutting, Hatton South cutting and Hatton North cutting



N.B. Where shown, all groundwater levels (GWL) presented are maximum observed levels.

Hatton South cutting

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

Cutting parameters	Parameter details
Length (km)	1.33
Maximum depth (m)	10
Strata intercepted	Wilmslow Formation of the Sherwood Sandstone Group (Principal aquifer).
Lowest track level (mAOD)	126
Groundwater level(s) (mAOD)	The Environment Agency groundwater level monitoring boreholes at Upper Hatton Wood and Shelton under Harley are in close proximity and monitor the Sherwood Sandstone Group. Maximum groundwater levels at Upper Hatton Wood are approximately 100mAOD, whereas at Shelton under Harley maximum water levels are 107.3mAOD.
Principal receptors	Sherwood Sandstone Group Principal Aquifer PWS near Hatton (SPZ3) PWS near Whitmore (SPZ3) in the Whitmore Heath to Madeley area Spring, Little Rowe Farm

5.2.13 The cutting would penetrate the Sherwood Sandstone Group Principal aquifer in an area where the maximum groundwater levels are expected to be at least 18m below the base of the cutting. 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 negligible impact on groundwater quality. The cutting will therefore have a negligible impact on the PWS near Hatton (which is located 1.1km to the south), the PWS near Whitmore (which is located 1.25km to the north west in the Whitmore Heath to Madeley area) and the potential spring near Little Rowe Farm (which is 820m from the cutting).

Hatton North cutting

Table 14: Summary of the Hatton North cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.69
Maximum depth (m)	5
Strata intercepted	Wilmslow Formation of the Sherwood Sandstone Group (Principal aquifer).
Lowest track level (mAOD)	119

Cutting parameters	Parameter details
Groundwater level(s) (mAOD)	The Environment Agency groundwater level monitoring boreholes at Upper Hatton Wood and Shelton under Harley are in close proximity and monitor the Sherwood Sandstone Group. Maximum groundwater levels at Upper Hatton Wood are approximately 100mAOD, whereas at Shelton under Harley maximum water levels are 107.3mAOD.
Principal receptors	Sherwood Sandstone Group Principal Aquifer PWS near Whitmore in the Whitmore Heath to Madeley area (SPZ2 and SPZ3 in the Stone and Swynnerton area)

5.2.14 The cutting would penetrate the Sherwood Sandstone Group Principal aquifer in an area where the maximum groundwater levels are expected to be at least 11m below the base of the cutting. Groundwater flow will therefore not be disrupted, and there will be no impact on water quantity at the PWS in the Whitmore Heath to Madeley area.

5.2.15 Application of the CoCP will ensure materials and fluids used during construction are managed so that there is negligible impact on groundwater quality. On a precautionary basis the potential temporary impact on water quality at the PWS near Whitmore is assessed as a minor, a moderate significant effect. The PWS is located 550m to the north-west in the Whitmore Heath to Madeley area and due to construction works taking place in this area within the SPZ1, a solution is being agreed with Severn Trent Water Ltd and the Environment Agency.

Assessment of cuttings below groundwater level

5.2.16 Assessment of the likely maximum zone of influence from dewatering of the cuttings which may be below existing groundwater level has been made using Sichardt's formula.

5.2.17 The methodology follows Environment Agency guidance¹⁴ and the methodology set out in CIRIA C750¹⁵, as summarised in the Environmental Impact Assessment Scope and Methodology Report (SMR) Addendum (Volume 5: Appendix CT-001-002).

5.2.18 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 1750¹⁶

¹⁴ Environment Agency (2007), *Hydrogeological impact appraisal for dewatering abstractions*

¹⁵ Preene, M., Roberts, T.O.L. and Powrie, W. (2016), *Groundwater control: design and practice*. CIRIA Publication C750

¹⁶ Cashman, P.M. and Preene, M. (2001), *Groundwater Lowering in Construction, a Practical Guide*

- 5.2.19 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.
- 5.2.20 Where an assessment of the zone of influence has been undertaken, cuttings are assumed to be open and any permanent engineering works such as retaining walls or drainage measures do not form part of the quantitative assessment.
- 5.2.21 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.

Yarlet Central cutting

- 5.2.22 Assuming a hydraulic conductivity of a mudstone with permeable halite stone or siltstone ($5 \times 10^{-8} \text{m/s}^{17}$). The maximum zone of influence from the cutting (Lo) is estimated at 6.7m. This is based on precautionary assessment using a maximum cutting depth of 17 m and a rest water level at ground level.
- 5.2.23 An impact distance of 6.7m is considered negligible in the context of the aquifer, and as there are no water dependent features within this extent (or indeed within 1km of the cutting), lowering of the water table at the cutting is assessed as having a negligible impact on the water environment.
- 5.2.24 Under the scenario of shallow groundwater levels, there would be little or no unsaturated zone and therefore a greater potential for impacts on groundwater quality during construction. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that any impacts on aquifer quality are negligible.
- 5.2.25 Further ground investigation and monitoring is required to confirm groundwater levels in this location. This will inform the detailed design and management of groundwater during construction.

Yarlet North cutting

- 5.2.26 Assuming a hydraulic conductivity of a mudstone with permeable halite stone or sandstone (to account for potential skerries) ($5 \times 10^{-7} \text{m/s}^{18}$). The maximum zone of influence from the cutting (Lo) is estimated at 21.0m. This is based on precautionary assessment using a maximum cutting depth of 17m and a rest water level at ground level.
- 5.2.27 The exact location of the private unlicensed water abstraction at North Pirehill Farm is not known and it is assumed that this could be impacted by lowering of the water table. Impact magnitude has been assessed as major and if further investigation by the nominated undertaker shows there is a potential risk to the supply this will be

¹⁷ 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

¹⁸ Domenico, P. A. and Schwartz, F. W. (1990), *Physical and chemical hydrogeology*. John Wiley & Sons

discussed with the landowner concerned, with a view to a permanent new supply being provided if necessary, such that there will be no significant effect.

- 5.2.28 The private unlicensed water abstraction at Walton Heath Farm is outside of the area of influence from dewatering of the cutting and therefore the quantity of water is not expected to be impacted. However, due to the proximity to the construction works, the quality of the groundwater could be impacted (see Table 7).
- 5.2.29 The exact location of the private unlicensed water abstraction at Little Micklow is not known, though it is assumed to be in the path of the route. This abstraction is assumed to be impacted by the cutting, and may require decommissioning during the construction phase. This will be discussed with the landowner concerned, with a view to a permanent new supply being provided if necessary, such that there will be no significant effect.
- 5.2.30 The exact location of the private unlicensed water abstraction at Micklow House Farm is not known. Taking a precautionary approach, it is therefore assumed to be within the area of influence from dewatering of the cutting and will be impacted. If further investigation by the nominated undertaker shows there is a potential risk to the supply this will be discussed with the landowner concerned, with a view to a permanent new supply being provided if necessary, such that there will be no significant effect
- 5.2.31 The potential spring feature to the north of North Pirehill Farm may supply a pond which will be lost due to its proximity to the cutting. The pond at this location will be replaced with new pond habitat elsewhere (Volume 2, Stone and Swynnerton area report, Section 8) for ecological mitigation. As the radial impact distance of the cutting is 21.0m there will be negligible impact on the low value downstream watercourse. Therefore, the impact on the potential spring feature is assessed as negligible.
- 5.2.32 The potential spring west of the M6, is outside of the area of influence of the cutting therefore lowering of groundwater at the cutting will have negligible impact on this feature.
- 5.2.33 The potential spring at Micklow Bungalow, is outside of the area of influence of the cutting therefore lowering of groundwater at the cutting will have negligible impact on this feature.
- 5.2.34 The potential spring at Micklow House Farm, is outside of the area of influence of the cutting therefore lowering of groundwater at the cutting will have negligible impact on this feature.
- 5.2.35 The discharge to groundwater (3/28/02/2273) is outside of the radius of influence, but due to its location within the land required for construction of the cutting, this has been assessed as having potential to be impacted, a major impact on a low value receptor. This effect is therefore assessed as minor, not significant.
- 5.2.36 The tributary of Filly Brook, to the north of Micklow House Farm is outside of the area of influence of the cutting therefore lowering of groundwater at the cutting will have negligible impact on this feature.

- 5.2.37 The Secondary B aquifer is laterally continuous and lowering of the water table at the cutting is assessed as having a negligible impact on the aquifer.
- 5.2.38 Under the scenario of shallow groundwater levels, there would be little or no unsaturated zone and therefore a greater potential for impacts on groundwater quality during construction. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that any impacts on aquifer quality are negligible.
- 5.2.39 Where abstractions are in close proximity to the land required for construction of the Proposed Scheme, potential risks to water quality during construction are still high, without further mitigation. Details of the significant effects for each abstraction, and additional mitigation measures, are provided in Table 7.
- 5.2.40 Further ground investigation and monitoring is required to confirm groundwater levels in this location. This will inform the detailed design and management of groundwater during construction.

Meaford cutting

- 5.2.41 Assuming a hydraulic conductivity of a mudstone with permeable halite stone or sandstone (to account for potential skerries) ($5 \times 10^{-7} \text{m/s}^{17,18}$). The maximum zone of influence from the cutting (Lo) is estimated at 3.7m. This is based on precautionary assessment using a maximum cutting depth of 3m and a rest water level at ground level.
- 5.2.42 The exact location of the private unlicensed water abstraction at Darlastonwood Farm is not known. Based on the location of the tap (which is known) it is assumed that this would be a significant distance from the cutting and outside of the zone of influence. The effect to water quantity has therefore been assessed as negligible, not significant. Potential impacts on quality are summarised in Table 7.
- 5.2.43 The potential spring to the north of North Pirehill Farm is assumed to be lost due to its proximity to the route, a major impact. The pond at this location will be lost and additional mitigation will include replacement of the pond habitat (see Ecology and biodiversity section, Volume 2, Stone and Swynnerton area report). Therefore, the residual effect will not be significant.
- 5.2.44 The only potential springs within 1km of the cutting are near Darlaston Wood (i and ii), The Highlows and Swynnerton Grange. These features are all a significant distance from the zone of influence of the cutting and therefore changes to groundwater levels due to cutting dewatering will not impact on groundwater level or flow at these locations.
- 5.2.45 The tributary of Filly Brook, to the south east of the M6 is 275m from the cutting and outside of the area of influence of the cutting, therefore the impact of lowering the groundwater at the cutting will be negligible.
- 5.2.46 The Secondary B aquifer is laterally continuous and lowering of the water table at the cutting is assessed as having a negligible impact on the aquifer.
- 5.2.47 Under the scenario of shallow groundwater levels, there would be little or no unsaturated zone and therefore a greater potential for impacts on groundwater

quality during construction. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that any impacts on aquifer quality are negligible.

5.2.48 Potential impacts on the water quality at Darlastonwood Farm are summarised in Table 7.

5.2.49 Further ground investigation and monitoring is required to confirm groundwater levels in this location. This will inform the detailed design and management of groundwater during construction.

Impact to groundwater quality from viaduct and overbridge piling

5.2.50 Piling can affect groundwater quality where the works are carried out in a formation with hydraulic connection to an aquifer, or in the aquifer itself. Underground works within aquifers can have a direct impact on any nearby groundwater sources. The main issues are considered to be losses of circulation fluid, turbidity resulting from the breakdown of in-situ aquifer material, and possible contamination by hydraulic fluids and greases from machinery. There is likely to be a more rapid transfer of these materials through fracture or fissure flow. Where such movement occurs in the catchment supplying a groundwater abstraction then degraded groundwater quality may make the source unsuitable for potable use. Such catchments are indicated by the SPZ1 and SPZ2 areas defined by the Environment Agency around all abstraction sites.

5.2.51 In the Stone and Swynnerton area there are no viaducts or overbridges within the SPZ1 or SPZ2 of the PWS.

5.2.52 There are three unlicensed private water abstractions within 250m of the overbridges. North Pirehill Farm unlicensed private water supply is in proximity to the Stone Rural Footpath 28 accommodation overbridge, and the Little Micklow and Micklow House Farm unlicensed private water abstraction are in proximity to the B5026 Eccleshall Road overbridge.

5.2.53 The potential impacts from the construction piling can be mitigated by using bentonite in the process to reduce fluid loss. Many methods of piling can also be facilitated by the use of temporary casing, which is generally more useful to stop losses to immediately adjacent watercourses. Implementation of the CoCP will ensure that materials in contact with groundwater will be selected, and method statements developed, to control any potential contaminants.

5.2.54 Nonetheless, there is a substantial residual risk that the groundwater quality at the private abstractions could be impacted during construction. The impact on these high value receptors is potentially major if there are significant fractures linking the overbridge foundation locations and the abstraction sites. As summarised in Table 7 there are also potential major impacts to groundwater quality associated with shallow constructions works in proximity to these abstraction sites. If further investigation by the nominated undertaker shows there is a potential risk to the supplies this will be discussed with the landowners concerned, with a view to a permanent new supply being provided if necessary, such that there will be no significant effect.

6 References

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

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*. Environment Agency.

Environment Agency (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>

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

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.

