A428 Black Cat to Caxton Gibbet improvements

TR010044

Volume 6

6.3 Environmental Statement

Appendix 13.7: Groundwater Risk Assessment

Planning Act 2008

Regulation 5(2)(a)

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

26 February 2021

Infrastructure Planning

Planning Act 2008

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

A428 Black Cat to Caxton Gibbet Improvements
Development Consent Order 202[ ]

Appendix 13.7: Groundwater Risk Assessment

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1 Introduction

1.1 Background

1.1.1 As the Government-owned company responsible for the operation, maintenance and improvement of England’s motorways and major A-roads, Highways England is proposing to undertake improvements to the A428 between the existing Black Cat roundabout and Caxton Gibbet roundabout (the Scheme), located to the east of Bedford.

1.1.2 The Scheme involves improving and upgrading the existing Trunk Road network through the construction of a new 10 mile (16km) dual 2-lane carriageway from the Black Cat roundabout to Caxton Gibbet roundabout, to be known as the A421 (hereafter referred to as the ‘new dual carriageway’) and in addition approximately 1.8 miles (3km) of tie-in works.

1.1.3 A full description of the A428 Black Cat to Caxton Gibbet improvements Scheme (the Scheme) is provided in **Chapter 2 The Scheme** of the Environmental Statement (ES) **[TR010044/APP/6.1]**. This report provides a groundwater risk assessment in support of the Development Consent Order (DCO) for the Scheme and is provided as an appendix to **Chapter 13, Road drainage and the water Environment [TR010044/APP/6.1]** and should be read in conjunction. **Annex 1** contains the full results of the groundwater quality monitoring undertaken in December 2020.

1.1.5 Annex 2 contains the qualitative risk assessment undertaken. **Figure 1** shows an overview of the Scheme.

1.1.6 The construction of the Scheme would involve civil engineering works including deep excavations such as cuttings, borrow pits and retaining wall structures, several of which may intercept groundwater and may, therefore, require temporary and or permanent groundwater dewatering/drainage management system to facilitate the Scheme.

1.1.7 The purpose of the groundwater risk assessment is to assess the potential impacts of the Scheme on the water environment (groundwater and surface water resources).

1.1.8 The assessment is based on the assessment methodology as set out in the Design Manual for Roads and Bridges (DMRB) *LA113 – Road Drainage and Water Environment (issued, March 2020*) (Ref 13-1), which considers and incorporates other relevant regulations and guidance documents currently used in many groundwater risk assessment settings such as the: Environment Agency's *Science Report SC040020/SR1 Hydrogeological Impact Appraisal for Dewatering Abstractions* (Ref 13-2); Defra/Environment Agency Guidance Document - *Groundwater Risk Assessment for your Environmental Permit* (Ref 13-3) and the ambitions of *Directive 2000/60/EC* (Ref 13-4) (the Water Framework Directive (WFD)).

1.1.9 The DMRB guidance sets out standard criteria for determining the value/importance of water features/receptors identified that are likely to be impacted by the Scheme. It also provides a risk assessment matrix that is designed to assess the overall magnitude of impact to groundwater and the effect significance while highlighting any sites at high risk, where additional mitigation measures may be required. The risk assessment matrix uses the Source-Pathway-Receptor (S-P-R) approach, which is used in many environmental impact assessment studies, as discussed in more detail in **Section 1**.

1.2 Scope of the assessment

1.2.1 This assessment covers the groundwater and surface bodies within the Order Limits for the Scheme. There are no WFD designated groundwater bodies beneath the Order Limits; however, the Order Limits lie within the WFD surface water body catchment of the River Great Ouse and its tributaries.

1.2.2 The assessment considers the following phases of the Scheme (described in **Chapter 2, The Scheme** of the Environmental Statement **[TR010044/APP/6.1]**):

Advanced and enabling works phases

a. Enabling works for utility diversions.

b. Diversion of high-risk utilities such as the diversion of the: Cadent HP Gas Main; CLH Oil Pipeline and lowering of the NG 540NB HP Gas Main.

c. Enabling works for main compounds.

Construction phase

a. Construction of the A1 underpass and associated bridge structures (piers and retaining walls) at the existing Black Cat Junction.

b. Construction of the River Great Ouse Viaduct and associated bridge structures including two cutting sections:

   i. Barford Road Cutting.

   ii. Alington Hill Cutting.

c. Construction of a bridge across the East Coast Main Line to Cambridge Road Junction and associated structures. Four cutting sections are proposed in this area:

   i. Potton Road Cutting.

   ii. Hen Brook Cutting.

   iii. Wintringham Brook Cutting.

   iv. Cambridge Road Cutting;

d. Construction of the Fox Brook bridge and associated structures including two cutting sections namely:

   i. Fox Brook Cutting.

   ii. Gallow Brook Cutting.

e. Construction of the Caxton Gibbet Junction bridge and associated structures including the Eltisley Junction Cutting.

f. Two proposed borrow pit excavations near the existing Black Cat roundabout area in the western part of the Order Limits and two other proposed borrow pits near the Caxton Gibbet area in the eastern part of the Order Limits.

1.2.3 During the advanced, enabling and construction phases, abstraction of groundwater may be required for dewatering purposes and to maintain dry working areas in pipeline trenches, cuttings and borrow pit excavations. Depending on the dewatering volumes, an abstraction licence will be required from the Environment Agency.

1.2.4 The potential impacts on groundwater include impacts on groundwater levels, flows, quality and flood risk, including considerations of:

a. Licensed and unlicensed groundwater abstractions.

b. Springs.

c. Surface waters in continuity with groundwater.

d. Groundwater dependent ecosystems (GWDTE).

e. Flood susceptible areas.

1.2.5 A separate WFD surface water assessment for the River Great Ouse (see **Appendix 13.1** of the Environmental Statement **[TR010044/APP/6.3]**) includes a review of the potential impacts of the Scheme on the surface water bodies and is therefore not considered as part of this groundwater risk assessment.

1.2.6 The assessment also considers the pollution risks to groundwater associated with routine discharges of runoff from the Scheme during its operational phase. This is further discussed in **Chapter 13, Road drainage and the water environment [TR010044/APP/6.1]** which includes a HEWRAT assessment (**Appendix 13.2**: Assessment of Road Runoff and Spillage Risk to Watercourses (HEWRAT) Assessment **[TR010044/APP/6.3]**) using the Highways England Water Risk Assessment Tool (HEWRAT), as presented in *LA 113* (Ref 13-1).

2 Study area for the groundwater risk assessment

2.2.1 The Study Area is defined by a 500 metre buffer around the Order Limits. However, an Extended Study Area of up to 1000 metre buffer from the edge of the Order Limits is applied where necessary, particularly where a water feature within the Order Limits is likely to be impacted and is in hydraulic continuity with a water feature outside the defined 500 metre Study Area.

2.2.2 The delineation of the Study Areas takes into consideration the Source-Pathway-Receptor approach, which identifies the potential ‘sources’ or ‘causes’ of effect (such as cuttings/excavations and other activities from the Scheme), the identified potential ‘receptors’ (Water features/Water bodies such as aquifers, licensed abstraction boreholes etc.) within the vicinity of the Scheme that could potentially be affected, and, the ‘pathways’ or ‘mechanisms’ (such as the unsaturated and saturated zone of the underlying geology, road drainage and other hydraulically connected systems to the Scheme) that can allow an effect to occur or through which an effect can be transmitted from a source to a receptor.

2.2.3 The delineation also takes into consideration the nature of the underlying geology (pathway) and hydrogeology (receptor) beneath the Scheme. **Figure 1** shows the Study Areas.

3 Baseline data sources and stakeholder engagement

3.1 Baseline data sources

3.1.1 The sources of data used to develop an understanding of the existing baseline groundwater environment and inform the groundwater risk assessment include, but are not limited to:

a. The Scheme-specific geotechnical ground investigation (GI) (Ref 13-5) which includes boreholes, trial pits and window sampling probeholes data, soil chemical analyses test results from the (2019/2020) ground investigation and geological sections produced from the GI data.

b. Groundwater level monitoring data collected between October 2019 and January 2021 from boreholes installed within the Study Area as part of the 2019/2020 GI.

c. Groundwater water quality samples collected in December 2020 at 24 selected groundwater sampling points within the Study Area as part of the 2019/2020 GI.

d. Aquifer hydraulic property parameters derived from both in-situ field tests (i.e. falling head tests and packer tests) and laboratory (i.e. particle size distribution) analyses carried out as part of the 2019/2020 GI and from the literature.

e. Historical borehole logs from the A421 Road Improvement Scheme and Breedon Quarry Mineral Resources Evaluation exploratory boreholes.

f. Existing ground elevation profile data and the proposed ground elevation profile for the Scheme.

g. Surface water surveys carried out within the Study Area between November 2017 and December 2019 as presented in Chapter 13 - Road Drainage and Water Environment. Seasonal surface water quality sampling/monitoring surface water quality monitoring carried out between September 2017 and August 2018.

h. Ecological surveys carried out within the Study Area.

i. British Geological Survey (BGS) online borehole records, geological and hydrogeological maps covering the Study Area (Geoindex) (Ref 13-6).

j. Environment Agency's Pollution Incidents; Landfills; Abstraction Licences; Discharge Licences; Groundwater Boreholes; Catchment Areas; Waste Management Areas; IPC/IPPC; Source Protection Zones (SPZ), Groundwater Vulnerability Zone.

k. Natural England Sites of Special Scientific Interests (SSSI), National Nature Reserves (NNRs), Special Areas of Conservation (SAC), Special Protection Areas (SPAs) and RAMSARs, County Wildlife Sites (CWS), Legally Protected Species.

l. Ordnance Survey Historical Maps – Landline and OS Raster maps.

m. Environmental data contained within the Department for Environment, Food and Rural Affairs (DEFRA) and Environment Agency Magic Online Interactive Map Application (Ref 13-7).

n. Bedfordshire district council records of private water supply boreholes.

3.2 Stakeholder engagement

3.2.1 Engagement meetings, discussions and communications (via emails) have been held with the Environment Agency to inform the approach and methodology of the groundwater risk assessment.

3.2.2 Consultation with the Environmental Health Department at the Central Bedfordshire Council to obtained records of all private water supply boreholes within the Study Area/Extended Study Area.

3.2.3 Engagement meetings and communications with landowners have been held to enable access to lands and monitoring boreholes in order to facilitate the groundwater monitoring programme and collection of groundwater quality samples.

4 Baseline geological and hydrogeological conditions of the Study Area

4.1 Superficial geology

4.1.1 The superficial geology beneath the Study Area/Extended Study Area comprises – Alluvium (AL) over River Terrace Deposits (RTD) over glacial Till (Oadby Member) (Till) (**Figure 2**). The thicknesses and presence of these deposits as determined from the detailed 2019/2020 GI and historical borehole logs are summarised below:

a. **Made Ground (MG)** – present within the Study Area/Extended Study Area comprising soft to stiff, brown, greyish and reddish-brown sandy, gravelly clay and gravelly silt with fragments of brick, flint, chalk, mudstone, ceramic, concrete and tarmac. The thickness ranges between 0.3m and 3.9m with an average thickness of 1.3m. Made ground is present in the existing Black Cat Quarry within the Study Area. It is described as reworked "quarry backfill" (backfill to quarry operations) comprising reject aggregates comprising materials predominantly loose orange brown clayey gravelly sand or yellow brown sandy gravel used to backfill the area following the excavation of River Terrace Deposits.

b. **Alluvium (AL)** – present only around the floodplain of the River Great Ouse within the Study Area/Extended Study Area (**Figure 2**). It comprises of brown or dark brown sandy slightly gravelly or slightly sandy gravelly clay, generally soft to firm but occasionally very soft or stiff. The thickness of the AL ranges between approximately 0.4m and 3.5m with an average thickness of 1.4m. Alluvium is concentrated in the river valleys in mainly in the western and central parts of the Study Area/Extended Study Area of the Scheme, particularly around the existing Black Cat Roundabout area. The GI logs also show that this deposit directly overlies the glacial Till in the area to the east of the River Great Ouse.

c. **River Terrace Deposits (RTD)** – is present only beneath the western part of the Study Area/Extended Study Area around the River Great Ouse (**Figure 2**). It comprises of either loose to medium dense, brown and orangish brown, clayey, gravelly sand or medium dense to dense sandy or very sandy flint gravel, commonly with a low flint cobbles content. The RTD is generally soft to firm, becoming firm to stiff at depth. The thickness of the RTD ranges between 0.1m and 14.6m with an average thickness of 2.7m.

d. **Glacial Till (Oadby Member) (Till)** – is present beneath the entire Study Area/Extended Study Area (**Figure 2**) and it generally comprises of cohesive weathered brown or reddish-brown clay with fine to coarse Chalk gravel in the upper layers, becoming mottled grey, grey and bluish-grey silty clay with depth. The vast majority of the Till is cohesive, with just a small fraction of the stratum comprising thin (typically less than 1m thick) layers of granular material. The thickness of the Till ranges between 0.2m and more than 30m with an average thickness of 5.2m.

4.2 Bedrock geology

4.2.1 The bedrock geology comprises undifferentiated mudstone of the Oxford Clay (OXF) over the Kellaways Formation (KF) in the western/central areas of the Study Area/Extended Study Area. In the east, the bedrock comprises undifferentiated mudstone of the West Walton and Ampthill Clay Formations over the Kellaways Formation (**Figure 3).**

4.2.2 The full thicknesses of the bedrock formations have not been proven in the region. However, a thickness of up to 17m was proven for the Oxford Clay in some of the 2019/2020 GI boreholes that fully penetrated the Oxford Clay into the underlying Kellaways Formation in the western part of the Scheme around the existing Black Cat roundabout. Thickness of up to 30m was also proven for the Oxford Clay in some boreholes.

4.2.3 The Kellaways Formation comprises silicate-sandstone or sandy mudstone and has been proved to a thickness of 4m. The proven thickness of the Kellaways Formation varies between 2m and 4.5m beneath the Study Area.

4.2.4 Stratigraphically, both the Oxford Clay and the West Walton/Ampthill Clay Formations overlie the Kellaways Formation, which is present beneath the entire Study Area. It is understood that all the deep excavations - borrow pits, cuttings, bridges and associated underground structures including piling for bridges and viaducts within the Scheme will terminate in the Oxford Clay/West Walton and Ampthill Clay Formations in order to avoid the pressurised groundwater present in the water-bearing sands of the Kellaways Formation.

4.3 Groundwater occurrence, level, flow direction and monitoring

Groundwater occurrence and levels

4.3.1 As shown in the geological sections (**Figure 4**) and the conceptual S-P-R illustrations in **Figure 5 A-D**, groundwater occurs beneath the entire Study Area with levels at varying depths as summarised below:

a. **Superficial**: Groundwater is present in the superficial deposits, principally in the RTD, with groundwater levels in the western part ranging from 0.5m to 5.5meters below ground level (m BGL), while in the central part of the Study Area, levels range from 0.5m to 9m BGL. In the eastern part of the Study Area near the Caxton Gibbet Junction area, limited groundwater occurs within the Till and groundwater levels range between 0.5m and 13m BGL as the ground elevation rises to over 60 meters above ordnance datum (mAOD).

b. While the Till is considered to be a low permeability stratum which restricts groundwater flow, groundwater occurs within the deposit where permeable layers are present. The Till was proved in 77 of the 83 boreholes drilled as part of the 2019/2020 GI with granular units of sand and gravel identified within the Till at varying depths. Water strikes were not reported for the majority of the granular units. A water strike was reported in 14 of the 83 boreholes. Only two of the water strikes were recorded at depths less than 10m BGL with the majority recorded at depths greater than 15m BGL, suggesting that the majority of the upper layers (<10m BGL) of the Till is generally dry except where there are granular units. , it is considered that this clay-rich deposit is of negligible importance for groundwater resources with limited connection to surface water.

c. The Environment Agency has designated the Alluvium and River Terrace Deposits as a Secondary A aquifer that is able to sustain local abstraction. In line with the DMRB criteria, a medium sensitivity value has been assigned to groundwater in the Alluvium and the River Terrace Deposits. In contrast, the Till has been designated as a Secondary Undifferentiated aquifer with limited groundwater potential by the Environment Agency. Based on these designations and in line with the DMRB criteria, a low sensitivity value has been assigned to the Till.

d. **Bedrock**: Groundwater occurrence in the bedrock is minimal. However, groundwater is present at depth in the sandy layers of the Kellaways Formation. The GI boreholes (BH203, BH207, BH209, BH211 and BH212) that intercepted this formation indicated that the groundwater in the Kellaways Formation is under confined conditions due to the overlying low permeability Oxford Clay/West Walton Clay Formations. The average depth at which groundwater was struck in the Kellaways Formation was 22.8m BGL, rising to an average of 17.9m BGL.

e. Due to the low permeability and the unproductive water-bearing potential of both the Oxford Clay and the West Walton Formation, there is no aquifer designation by the Environment Agency for both of these units. Similarly, the water-bearing sands within the Kellaway Formation are not considered by the Environment Agency as an aquifer of any significant importance, and as such has not assigned any aquifer designation to the water-bearing sands in the Kellaways Formations beneath the Study Area. Accordingly, assessment of impacts to any water-bearing sand layer in the bedrock beneath the Study Area is not included herein. In line with the DMRB criteria, a **low** sensitivity value has been assigned to the bedrock units.

Groundwater flow direction

4.3.2 Groundwater in the superficial deposits is in hydraulic continuity with the surface water system. The direction of groundwater flow in the superficial deposits varies across the Study Area (**Figure 2**) due to the presence of the surface watercourses, which act as groundwater discharge zones and the variable topography across the area.

4.3.3 To the west of the River Great Ouse, groundwater flow in the superficial aquifer units across the floodplain of the river is generally easterly/north easterly towards the northerly flowing River Great Ouse. Similarly, to the east of the river, groundwater flows westerly/north westerly, discharging to the river. In addition, there are localised northerly/north-westerly flow towards the river, particularly around the Alington Hill area where a groundwater flow divide is inferred as a result of the undulating nature of Alington Hill in relation to the surrounding lands and the variation in the groundwater hydraulic gradient from between the peak of the Alington Hill towards to the north and south of the hill as observed from the 2019/2020 GI monitoring boreholes.

4.3.4 A groundwater hydraulic gradient of 0.0112 towards the south has been estimated from the peak of the hill as observed from between BH234 with observed groundwater level of 47.61m AOD at the peak of the hill and BH228 with observed groundwater level of 20.97m AOD located approximately 2.37 kilometres (1.47 miles) from BH234 in the valley area to the southwest. Similarly, a groundwater hydraulic gradient of 0.0101 towards the north has been estimated from the peak of the hill as observed from between BH234 and BH237 with an observed groundwater level of 30.64m AOD located in the valley area to the north at approximately 1.68 kilometres (1.04 miles) from BH234 (**Figure 2**).

4.3.5 The bedrock (i.e. the Oxford Clay and West Walton Formation) directly beneath the superficial deposits is not water-bearing except for the sandy units in the Kellaways Formation. The limited GI groundwater level monitoring data for groundwater in the Kellaways Formation indicated that the direction of groundwater flow in the Kellaways Formation (bedrock) is similar to that of the superficial deposits.

Groundwater level monitoring

4.3.6 Groundwater level baseline monitoring has been ongoing since the commencement of the GI in October 2019 and has continued to date. Hydrographs produced from the groundwater level monitoring data for the RTD and the Till are presented in Annex 3A and 3B respectively. The results show that the groundwater level in the superficial deposits (both the RTD and the Till) is fairly stable (with minimum fluctuation of <1m) in most part of the monitoring period, but with some anomalous fluctuation (i.e. about 1-3 m in the RTD and 1-10 m in the Till) during the first two months of the monitoring period. The baseline groundwater level monitoring data has been used to inform the conceptual hydrogeological model and groundwater risk assessment.

Groundwater Quality

4.3.7 The baseline groundwater chemistry has been informed by the results of the in-situ groundwater quality testing and laboratory analyses carried out on water samples collected from 21 groundwater sampling points, comprising, boreholes and piezometers located at different locations across the Scheme. The locations of the groundwater sampling boreholes are presented in **Figure 6**. **Table 4-1** shows the location, sampling depths, geological unit/aquifer from which the samples were collected.

4.3.8 As shown in **Figure 6** and presented in **Table 4-1**, for reference and to help the reader, the groundwater sampling locations have been delineated across the Study Area into four different slides with Slide A consisting of boreholes located to the west of the Scheme, Slide B consisting of boreholes in the central-west of the Scheme, Slide C consisting of boreholes in the central-east of the Scheme and Slide D consisting of boreholes in the east of the Scheme.

4.3.9 The laboratory analyses were carried out to test for general water quality parameters including heavy metals, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs), pesticides and herbicides. The full laboratory analytical results of the groundwater samples collected in December 2020 and in-situ analytical results including the gas monitoring of volatile substances are presented in **Annex 1**.

4.3.10 The results show that the groundwater chemistry vary across the Study Area, which is expected as the response zones of the boreholes monitored were in different geological units. The in-situ pH recorded in December 2020 ranged between 7.47 and 8.99 pH units, temperature ranged between 8.54°C and 11.21°C, oxygen-reduction potential (ORP) ranged between -338 mV and 79.7 mV, readily dissolved oxygen (RDO) ranged between 6.19 mg/l to 0.05mg/l, and electrical conductivity ranged between 117.2µS/cm and 7307µS/cm as presented in **Annex 4**.

4.3.11 The groundwater analytical results have been compared to the UK Drinking Water Standards (UKDWS). It should be noted that the comparison of the results with the DWS has only been made in order to provide context to the reader and that these exceedances of such a stringent standard does not necessary imply that there are significant groundwater or soils contamination issues of concerns. The results of most of the parameters analysed were found to be below the DWS standards, with the exception of some parameters that exceeded the limit (highlighted in red for each borehole) as shown in **Table 4-2**.

4.3.12 As shown in **Table 4-2**, analytical result for groundwater quality sample taken from one of the sampling points (WS275) near a former fuel station in Wyboston area, located approximately 1.2 kilometres (0.7 miles) northeast from the centre of the existing Black Cat roundabout indicated potential hydrocarbon contamination of the groundwater with 1,2,4-Trichlorobenzene, 1,2,3-Trichlorobenzene, Naphthalene, Fluoranthene, Phenanthrene, Chrysene, Pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,i)perylene, Indeno(1,2,3-cd) pyrene (aq), Aliphatics >C21-C35, Aromatics >EC12-EC16, Aromatics >EC16-EC21, Aromatics >EC21-EC35 all exceeding the UKDWS.

4.3.13 Information received from the Environment Agency on 15 June 2020 following a request for information under the Freedom of Information Act 2000 and Environmental Regulations 2004 has also been used to inform the baseline groundwater conditions. The data indicated that there is no record of contaminated land, as defined under Part 2A of the Environmental Protection Act 1990 within the Study Area. The data also show that there are no land contamination issues, with respect to pollution of the water environment within the Study Area.

Table 4-1: Details of the groundwater quality sampling points

BH ID	Easting	Northing	Location Slide	Ground Elevation (m AOD)	Response Zone Upper (m)	Response Zone Lower (m)	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
BH203-1	515798.91	255382.74	A	20.73	1	4	1	4	River Terrace
BH224	516845.17	255342.2		22.404	4.5	10	4.5	9.5	Oxford Clay
BH275C-1	516104.07	255603.99		18.74	1	4	1	4	River Terrace
BH275C-2	516104.07	255603.99		18.74	20	24	20	24	Kellaways Clay
BH273-1	515878.88	255223.39		21.3	2	5	2	5	River Terrace
BH273-2	515878.88	255223.39		21.3	23	26	23	26	Kellaways Clay
BH206-1	515910.82	255282.46		21.16	1	4.5	1	4.5	River Terrace
BH285	515983.01	255191.99		19.827	10	11	10	11	Oxford Clay
WS275	516381.97	256554.46		18.65	1	4	1	4	River Terrace
BH234	519328	256325	B	51.461	2	8.5-	2	8.5	Glacial Till
BH230	518229	255470.99		23.061	6	9.5	6	9	Oxford Clay
BH237-1	519801.71	257851.3		32.963	6	7	6	7	Glacial Till
BH237-2	519801.71	257851.3		32.963	10	11	10	11	Oxford Clay

BH ID	Easting	Northing	Location Slide	Ground Elevation (m AOD)	Response Zone Upper (m)	Response Zone Lower (m)	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
BH240	520223.01	258462.99		18.344	3.5	10.5	4	10	Oxford Clay
BH239	520175.99	258514.01		18.58	6.5	10.5	7	10	Oxford Clay
BH251	523835.02	260562.01	C	48.309	2.7	4.7	2.7	4.2	Glacial Till
BH253	524252.99	260648.01	C	51.826	3	6	3	6	Glacial Till
BH256	524481.02	260755.03	C	52.776	13.5	16.5	13.5	16.5	Glacial Till
BH242	521065.02	259682	C	34.109	9	12	9	12	Glacial Till
BH249	522662.01	260200.01	C	47.502	6	10	6.5	9.5	Glacial Till
BH260	526460.99	260514.97	D	56.33	11	15	11.5	14.5	Glacial Till
BH261	526731.01	260380	D	57.512	2.5	6.5	3	6	Glacial Till
BH265	527379.01	260306.02	D	63.302	11.5	15.5	12	15	Glacial Till
BH271	529604.18	260807.24	D	64.612	15.5	22.5	16	22	Glacial Till

Table 4-2 Groundwater quality parameters that exceeded the UKDWS

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
Fluoride	mg/l	0.5	1.5	BH275C-2	A	1.67	20	24	Kellaways Clay
Sodium (Dis.Filt)	mg/l	0.076	200	BH275C-2	A	529	20	24	Kellaways Clay
				BH224		247	4.5	9.5	Glacial Till/Oxford Clay
				BH230	B	823	6	9	Oxford Clay
				BH234		339	2	8.5	Glacial Till
				BH237-1		316	6	7	Glacial Till
				BH237-2		427	10	11	Oxford Clay
				BH239		381	7	10	Oxford Clay
				BH240		305	4	10	Oxford Clay
				BH256	C	440	13.5	16.5	Glacial Till
				BH242		526	9	12	Glacial Till
				BH249		256	6.5	9.5	Glacial Till

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
				BH271	D	461	16	22	Glacial Till
				BH260		504	11.5	14.5	Glacial Till
				BH261		504	3	6	Glacial Till
Iron (Dis.Filt)	mg/l	0.019	0.2	BH203-1	A	4.35	1	4	River Terrace
				BH230	B	1.11	6	9	Oxford Clay
				BH237-1		5.43	6	7	Glacial Till
				BH237-2		3.65	10	11	Oxford Clay
				BH239		0.331	7	10	Oxford Clay
				BH240		0.823	4	10	Oxford Clay
				BH253	C	0.256	3	6	Glacial Till
				BH249		0.376	6.5	9.5	Glacial Till
Sulphate	mg/l	2	250	BH275C-1	A	422	1	4	River Terrace
				BH275C-2		906	20	24	Kellaways Clay

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
				BH203-1		262	1	4	River Terrace
				BH224		1670	4.5	9.5	Oxford Clay
				BH230	B	2690	6	9	Oxford Clay
				BH234		2110	2	8.5	Glacial Till
				BH237-1		2220	6	7	Glacial Till
				BH237-2		2090	10	11	Oxford Clay
				BH239		831	7	10	Oxford Clay
				BH240		1120	4	10	Oxford Clay
				BH253	C	1800	3	6	Glacial Till
				BH256		1200	13.5	16.5	Glacial Till
				BH242		1760	9	12	Glacial Till
				BH249		1510	6.5	9.5	Glacial Till
				BH271	D	786	16	22	Glacial Till
				BH260		964	11.5	14.5	Glacial Till

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
				BH261		1120	3	6	Glacial Till
Chloride	mg/l	2	250	BH275C-1	A	274	1	4	River Terrace
				BH275C-2		563	20	24	Kellaways Clay
				BH230	B	832	6	9	Oxford Clay
				BH234		662	2	8.5	Glacial Till
				BH237-1		376	6	7	Glacial Till
				BH237-2		434	10	11	Oxford Clay
				BH239		256	7	10	Oxford Clay
				BH256	C	464	13.5	16.5	Glacial Till
				BH242		587	9	12	Glacial Till
				BH271	D	828	16	22	Glacial Till
				BH265		779	12	15	Glacial Till
Nitrate as NO3	mg/l	0.3	50	BH251	C	70.2	2.7	4.2	Glacial Till
				BH261	D	75.5	3	6	Glacial Till

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
Ammoniacal Nitrogen as N (low	mg/l	0.01	1.5	BH237-2	B	1.8	10	11	Oxford Clay
				BH240		1.83	4	10	Oxford Clay
				BH239		3.07	7	10	Oxford Clay
Manganese (diss.filt)	µg/l	3	50	BH275C-1	A	860	1	4	River Terrace
				BH203-1		992	1	4	River Terrace
				BH285		222	10	11	-
				WS275		51.7	1	4	River Terrace
				BH273-1		83.1	2	5	River Terrace
				BH273-2		123	23	26	Kellaways Clay
				BH224		2050	4.5	9.5	Glacial Till/Oxford Clay
				BH230	B	743	6	9	Oxford Clay
				BH234		543	2	8.5	Glacial Till

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
				BH237-1		201	6	7	Glacial Till
				BH237-2		422	10	11	Oxford Clay
				BH240		542	4	10	Oxford Clay
				BH239		204	7	10	Oxford Clay
				BH253	C	449	3	6	Glacial Till
				BH242	C	132	9	12	Glacial Till
				BH249	C	68.3	6.5	9.5	Glacial Till
				BH271	D	172	16	22	Glacial Till
				BH265	D	110	12	15	Glacial Till
1,2,4-Trichlorobenzene	µg/l	0.01	0.1	BH275C-1	A	0.1	1	4	River Terrace
				BH203-1	A	0.1	1	4	River Terrace
				WS275	A	0.2	1	4	River Terrace -
				BH285	A	0.1	10	11	Oxford Clay

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
				BH224		0.1	4.5	9.5	Glacial Till/Oxford Clay
				BH230	B	0.1	6	9	Oxford Clay
1,2,3-Trichlorobenzene	µg/l	0.01	0.1	BH275C-1	A	0.1	1	4	River Terrace
				BH203-1		0.1	1	4	River Terrace
				WS275		0.258	1	4	River Terrace
				BH285		0.1	10	11	Oxford Clay
				BH224		0.1	4.5	9.5	Glacial Till/Oxford Clay
				BH230	B	0.1	6	9	Oxford Clay
Naphthalene (aq)	µg/l	0.01	6	WS275	A	19	1	4	River Terrace-
Fluoranthene (aq)	µg/l	0.005	4	WS275	A	85.1	1	4	River Terrace

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
Phenanthrene (aq)	µg/l	0.005	4	WS275	A	39.8	1	4	River Terrace
Chrysene (aq)	µg/l	0.005	7	WS275	A	37.8	1	4	River Terrace
Pyrene (aq)	µg/l	0.005	9	WS275	A	74.3	1	4	River Terrace
Benzo(a)anthracene (aq)	µg/l	0.005	3.5	WS275	A	41.2	1	4	River Terrace
Benzo(b)fluoranthene (aq)	µg/l	0.005	0.1	WS275	A	68.5	1	4	River Terrace
				BH224		0.125	4.5	9.5	Glacial Till/Oxford Clay
				BH230	B	0.112	6	9	Oxford Clay
				BH242	C	0.146	9	12	Glacial Till
Benzo(k)fluoranthene (aq)	µg/l	0.005	0.1	WS275	A	28.6	1	4	River Terrace-
Benzo(a)pyrene (aq)	µg/l	0.002	0.01	BH275C-1	A	0.0374	1	4	River Terrace

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
				BH203-1		0.0199	1	4	River Terrace
				BH224		0.0616	4.5	9.5	Glacial Till/Oxford Clay
				WS275		48	1	4	River Terrace-
				BH230	B	0.0616	6	9	Oxford Clay
				BH242	C	0.0843	9	12	Glacial Till
Dibenzo(a,h)anthracene (aq)	µg/l	0.005	0.07	WS275	A	7.29	1	4	River Terrace-
Benzo(g,h,i)perylene (aq)	µg/l	0.005	0.1	WS275	A	38.8	1	4	River Terrace-
Indeno(1,2,3-cd) pyrene (aq)	µg/l	0.005	0.1	WS275	A	34.1	1	4	River Terrace-
Aliphatics >C21-C35 (aq)	µg/l	10	300	WS275	A	4910	1	4	River Terrace-
Aromatics >EC12-EC16 (aq)	µg/l	10	90	WS275	A	200	1	4	River Terrace-

Parameters in exceedance	Unit	L.O.D	UK Drinking Water Standard (UKDWS)	Borehole ID	Location	Measured Concentration	Slotted Pipe Upper (m)	Slotted Pipe Lower (m)	Geology
Aromatics >EC16-EC21 (aq)	µg/l	10	90	WS275	A	657	1	4	River Terrace-
Aromatics >EC21-EC35 (aq)	µg/l	10	90	WS275	A	1820	1	4	River Terrace-

Hydraulic Parameters

4.3.14 Hydraulic conductivity or permeability (K) data for both the superficial deposits, including the made ground, and the bedrock have been estimated from both in-situ tests (Packer tests and falling head tests) and laboratory particle size distribution (PSD) and permeability testing from the 2019/2020 GI investigation boreholes (BH), window sampling probeholes (WS) and trial pits (TP). The values have been compared with values in the literature (https://www.geotechdata.info/parameter/permeability) (Millan et al. 2000). The results of the derived permeability values for the relevant superficial aquifer units and bedrock formation are as presented below:

a. **Alluvium**: A permeability (K) range of 1 x 10^{-8}m/sec to 4 x 10^{-4} m/sec has been estimated from PSD tests carried out on samples from boreholes BH285 and WS204.

   River Terrace Deposits: A permeability range between 2.4 x 10^{-3} m/sec and 3.0 x 10^{-5} m/sec was derived from three in-situ falling head tests undertaken in three boreholes (BH203, BH205 and BH210). A second test on BH203 showed negligible head loss over a 60-minute period, suggesting that locally the River Terrace Deposits may exhibit a low permeability. The results are generally similar to permeability values in the literature which range between (5 x 10^{-4}m/sec – 5 x 10^{-2}m/sec) for well graded sands and gravels and for uniform sand and gravel (4 x 10^{-3}m/sec – 0.4m/sec) https://www.geotechdata.info/parameter/permeability). A permeability range of 1 x 10^{-6} m/sec to 5 x 10^{-5} m/sec has been estimated from PSD tests carried out on samples from boreholes BH207, BH209, BH211 and trial pit TP366. Combining the results of the falling head tests and the PSD analyses, provides permeability values of lower quartile, average and upper quartile of 3 x10^{-6}m/sec, 2 x 10^{-4}m/sec and 3 x 10^{-4} m/sec respectively. For the purpose of the impact assessment, the average permeability value of 2 x 10^{-4}m/sec has been adopted as the representative permeability value for the River Terrace Deposit in the Study Area.

b. **Glacial Till**: A permeability value in the range of 9.0 x 10^{-11} m/sec to 3 x 10^{-9} m/sec has been estimated from consolidation testing (i.e. one-dimensional odometer and undrained tri-axial testing) carried out on boreholes BH207, BH209 (odometer test), BH209 (Tri-axial test) and BH211 and PSD tests. Also, permeability values of 1.48 x 10^{-3} m/sec and 5.68 x 10^{-3} m/ have been derived from in-situ packer tests carried out on two boreholes (BH205 and BH209) for the Till. The results from the packer tests are much higher than would be expected from a glacial Till, as literature values indicate a typical permeability for glacial Till to be less than 1 x 10^{-7} m/sec (McMillan et al.,2000). McMillan et al 2000, also gave a range of 1.8 x 10^{-8} m/sec to 3 x 10^{-7} m/sec for glacial Till.

The permeability values derived from the packer tests for the Till are higher than those for the overlying River Terrace Deposits. This is inconsistent with the lithology of the two units and the general absence of groundwater in the Till during drilling. It is considered that the permeability results from the packer tests in boreholes BH205 and BH209 are unreliable and do not provide a representative permeability value for the Till.

For the purpose of the impact assessment a permeability value of 1×10^{-7}m/sec has been adopted as the representative permeability value for the glacial Till.

c. **Oxford Clay/West Walton Formation:** A permeability range of 1.60×10^{-5} m/sec – 5.95×10^{-7} m/sec has been derived from in-situ packer tests carried out on five boreholes (BH203, BH204, BH205, BH208 and BH210) in the Oxford Clay. Additionally, a permeability range of 7.6×10^{-12} m/sec to 4.3×10^{-8} m/sec has been estimated from consolidation testing (i.e. one-dimensional odometer and undrained tri-axial testing) carried out on boreholes BH209 (odometer test), BH209 (Tri-axial test) and BH211. The in-situ test results again indicate permeability values for the Oxford Clay much higher than is generally expected suggesting that the packer test results are unreliable. In all analytical assessments, the Oxford Clay is considered to act as a barrier between the superficial deposits and the permeable sands within the underlying Kellaways Formation.

Groundwater Abstraction

4.3.15 Based on data received from the Environment Agency in June 2020 via a request for information under the Freedom of Information Act 2000 and Environmental Regulations 2004, it is noted that there are eight licensed groundwater abstraction boreholes within the vicinity of the Scheme. These are used mainly for spray irrigation and general farming/domestic, remedial/wetland support activities. The aquifer from which the licensed boreholes are abstracting from is unconfirmed due to lack of detailed logs/information for the abstraction boreholes. However, it is likely that these boreholes abstract from the aquifer within the superficial deposits (AL and RTD) in the floodplain of the River Great Ouse. The locations of the boreholes are shown in **Figure 7**.

4.3.16 Consultation with the Environmental Health Department at Central Bedfordshire Council confirmed that there are no private drinking water supply boreholes/abstractions within the Study Area/Extended Study Area.

4.3.17 As shown in **Figure 7**, the licensed groundwater abstractions are located mainly in the western part of the Study Area in the area of the River Terrace Deposits. The location and approximate distance of the abstractions to those Scheme elements with the potential to impact on groundwater are shown in **Table 4-3** below. Six licences are located within 2 kilometres (1.2 miles) of the Scheme. The closest licensed abstractions are two boreholes located approximately 1 kilometre (0.6 miles) from borrow pit C and a seepage catch pit located approximately 1.1 kilometres (0.7 miles) from borrow pit A. The distances of the abstractions in relation to each of the Scheme element has been taken into consideration in the groundwater risk assessment.

Table 4-3: Groundwater abstraction licences and approximate distances to key elements of the Scheme

Abstraction Licence No	Secondary Category	Use	Licensed Volume (m3/Annum)	NGR	Approx. Distance and Direction from the A1 Underpass Cutting	Approx. Distance and Direction from [BPA]	Approx. Distance and Direction from the [BPC]	Approx. Distance and Direction from the Barford Road Cutting	Approx. Distance and Direction from the Alington Hill Cutting
6/33/20/*G/0039	Borehole	Spray Irrigation – Direct	248	TL 165 568	1.5km (NW)	1.8km (NW)	1.2km (NW)	1.5km (NW)	2.9km (W)
6/33/20/*G/0039	Borehole	General Farming and Domestic	116	TL 165 568	1.5km (NW)	1.8km (NW)	1.2km (NW)	1.5km (NW)	2.9km (W)
6/33/20/*G/0039	Borehole	General Farming and Domestic	90.92	TL 164 566	1.3km (NW)	1.6km (NW)	1.0km (NW)	1.4km (NW)	3.0km (W)
6/33/20/*G/0039	Borehole	General Farming and Domestic	90.92	TL 164 566	1.3km (NW)	1.6km (NW)	1.0km (NW)	1.4km (NW)	3.0km (W)
6/33/20/*G/0134	Seepage Catch pit	Spray Irrigation – Direct	10,274	TL 1525 5660	1.4km (NW)	1.1km (NW)	1.4km (NW)	2.2km (NW)	4.1km (W)
6/33/20/*G/0134	Seepage Catch pit	General Farming and Domestic	45.5	TL 1525 5660	1.4km (NW)	1.1km (NW)	1.4km (NW)	2.2km (NW)	4.1km (W)

Abstraction Licence No	Secondary Category	Use	Licensed Volume (m3/Annum)	NGR	Approx. Distance and Direction from the A1 Underpass Cutting	Approx. Distance and Direction from [BPA]	Approx. Distance and Direction from the [BPC]	Approx. Distance and Direction from the Barford Road Cutting	Approx. Distance and Direction from the Alington Hill Cutting
AN/033/0022/001	Seepage Catch pit	General Use	19,630	TL 20245 62860	8.6km (NE)	8.0km (NE)	8.3km (NE)	8.2km (NE)	6.6km (NW)
6/33/19/*G/0105	Seepage Catch pit	General Farming and Domestic	45	TL 1603 5143	3.9km (S)	4.0km (S)	4.2km (S)	4.0km (S)	5.9km (SW)
6/33/19/*G/0105	Seepage Catch pit	Spray Irrigation – Direct	6,820	TL 1603 5143	3.9km (S)	4.0km (S)	4.2km (S)	4.0km (S)	5.9km (SW)
6/33/19/*G/0114	Seepage Catch pit	Spray Irrigation – Direct	5,000	TL 161 511	4.3km (S)	4.4km (S)	4.5km (S)	4.3km (S)	6.1km (SW)
AN/033/0012/010	Seepage Catch pit	Dewatering	57,8478	TL 12168 50709	6.0km (SW)	5.6km (SW)	6.3km (SW)	6.7km (SW)	9.1km (SW)
AN/033/0020/009	Seepage Catch pit	Spray Irrigation – Direct	15,712	TL 17235 57429	2.4km (NE)	2.8km (NE)	2.1km (NE)	2.1km (N)	2.4km (NW)

5 Key water features identified within the study area

5.1.1 The Study Area falls within the Anglian River Basin District, Great Ouse Upper and Bedford Management Catchment, and in the Great Ouse Lower and Cam Lower Operational Catchment.

5.1.2 The main water features (**Figure 7**) identified and considered relevant to the groundwater risk assessment are listed below:

a. The Secondary Aquifers of the Alluvium and River Terrace Deposits.

b. The Undifferentiated Aquifer within thin more permeable granular bands that may be present in the generally cohesive Till.

c. Licensed groundwater abstractions within the Study Area used for domestic and other purposes.

d. One local spring feature close to Alington Hill located at New Manor House Farm.

e. The surface water bodies of the River Great Ouse and its main tributaries which include the South Brook, Hen Brook and Fox Brook. Several other tributaries and named smaller watercourses including Stone Brook, River Kym, River Ivel, Begwary Brook, Duloe Brook, Gallow Brook, Bourn Brook, Colworth Brook, Rockham Ditch and unnamed ponds and field drains are also present within Study Area and Extended Study Area (**Figure 7**).

5.1.3 There are no groundwater-dependent ecological sites (GWDE) within the Extended Study Area.

5.1.4 There is no WFD groundwater body beneath the Extended Study Area. Also, there are no source protection zones (SPZ) within the Extended Study Area.

5.1.5 Taking into account the locations of the main elements and associated activities of the Scheme that are likely to impact on the water environment (groundwater and surface water receptors) and considering the S-P-R model, there is considered to be no plausible pathway by which the Scheme would impact on any WFD groundwater bodies and/or an SPZ in the region that is outside the Extended Study Area.

5.1.6 Furthermore, it is considered that the implementation of standard mitigation measures to control site runoff and spillages during the construction of the Scheme and the implementation of an appropriate drainage strategy during the operation of the Scheme would ensure that impacts to groundwater locally are prevented or minimised and that there would be no propagation to the more distant WFD groundwater body or SPZs. Therefore, assessment of impacts to WFD groundwater bodies and SPZs in the region is not included herein.

6 Approach to the groundwater risk assessment

6.1 Methodology and approach

6.1.1 The method adopted for undertaking this assessment is based on *LA113* (Ref 13-1). The approach also incorporates other relevant technical framework guidance documents for groundwater risk assessment listed in **Section 1.1.5**.

6.1.2 *LA113* (Ref 13-1) requires that the potential impacts (i.e. impacts resulting from flow barriers or dewatering activities, incidental spills and surface runoff) on groundwater flow, level and quality as a result of the Scheme should be assessed. *LA113* (Ref 13-1) provides guidance on establishing the value/importance of receptors and criteria for determining the impact magnitude and the significance of the effects as presented in Table 3.7 of *LA113* (Ref 13-1) and as discussed in the following Sections. The approach takes into account:

a. The development of a conceptual hydrogeological model of the Study Areas.

b. The source-pathway-receptor model linkages as further discussed below.

c. A tiered approach from qualitative risk screening to detailed quantitative risk assessment.

d. The identification of sources or potential hazards and impacts to groundwater from the Scheme, while examining the consequences and evaluating the significance of any risks as further discussed below.

Source-Pathway-Receptor

6.1.3 The groundwater risk assessment identifies the potential sources or 'causes' of effect (such as cuttings/excavations and the associated dewatering activities); the 'receptors' (water bodies) that could potentially be affected; and, the 'pathways' via which the source can affect the receptors. All three elements must be present before a potential impact (linkage) can be realised.

6.1.4 The assessment covers the advanced and enabling works, construction and operational phases of the Scheme.

a. The **first stage** of the assessment is to identify the sources of potential impact. Through a review of the Scheme's detailed design and buildability information, the advanced and enabling works, construction, operational and maintenance activities (the sources) that have the potential to impact on groundwater were identified. The Scheme includes embedded mitigation measures to address potential adverse impacts being incorporated into the design and construction.

b. The **next stage** is to identify the potential receptors, i.e., the water bodies that have the potential to be affected by the Scheme or vice versa. The identification of potential water receptors was undertaken through consultation with the Environment Agency, consultation with relevant local authorities such as the Local Health Environmental Officers, liaison with land owners, a review of the literature including maps (i.e. OS Maps and EA explorer Maps etc.) with information of water receptors/features in the area, and the baseline data available for the site from both historical and recent (2019/2020) data from the project specific ground investigation.

c. The **final stage** is to determine if there is an exposure pathway or a 'mechanism' allowing an effect to occur at the receptor and to assess the significance of any predicted effect.

Sources of Potential Impact

6.1.5 The potential sources of temporary impacts on groundwater from the construction of the Scheme are identified as:

a. Temporary dewatering or abstraction if required, altered drainage regimes diverting water away from groundwater-dependent receptors, or creating flow barriers, leading to reduced groundwater level and flow alteration and or potential groundwater flood risks.

b. Contamination risk to the underlying superficial and or bedrock aquifers; through:

   i. Excavation, and the subsequent deposition of soils, sediments, or other construction materials causing pollution including increased sediment generation and discharge to nearby water bodies during any dewatering activities.

   ii. Spillage of fuels or other contaminating liquids causing pollution.

   iii. Mobilisation of contaminants following disturbance and exposure of contaminated ground or groundwater, or through uncontrolled site runoff.

   iv. Release or leaching of substances (e.g. cement or grout) used in the retaining walls of cuttings, piers or foundations for bridge structures or overbridges, which may negatively impact groundwater quality.

6.1.6 The potential sources of permanent impacts on groundwater from the construction of the Scheme are identified as:

a. The presence of underground structures (piers or foundations) that could cause interference or barriers to groundwater flow and or level.

6.1.7 The presence of part of any permanent cuttings, and or tunnels below the seasonal groundwater level in the superficial geology requiring groundwater management, thereby interfering with the natural groundwater level and flow regime. This could lead to changes in groundwater levels and flow regime and or increased risk of groundwater flooding up hydraulic gradient of the associated structures and decreased groundwater levels down hydraulic gradient.

6.1.8 The potential sources of impact on groundwater from the operation of the Scheme are identified as:

a. Impacts arising from pollutants, e.g. oils from fuel combustion/accidental spillages and salts or herbicides from road maintenance due to an increase in discharges to the ground

b. Impacts arising from pollutants from incident response at cuttings and adjacent roads, e.g. oil and fuel spills from car accidents, fire-fighting foam.

c. Impacts from any long-term groundwater management plan that may be required in the vicinity of structures below the groundwater level.

Pathways

6.1.9 The pathways present or that potentially could be created by the Scheme are:

a. Infiltration and leaching of pollutants through the unsaturated zone of the superficial deposits.

b. The flow of groundwater through the superficial deposits.

c. Change in groundwater flow direction within the aquifers due to abstraction or dewatering activities.

d. Preferential flow pathways created by the construction of foundations for structures or the blockage of groundwater flow by Scheme elements.

Receptors

6.1.10 The sensitivity or importance of a water resource receptor needs to be taken into account to assess the significance of potential consequences of a hazard or impact occurring. Definitions of the level of sensitivity of potential receptors are based on their considered value and are presented in **Table 6-1** in accordance with the *DMRB LA113* requirement.

Table 6-1 Sensitivity/Importance of water receptors

Sensitivity / Importance	Criteria	Examples
Very High	Water resource with a nationally significant importance with limited potential for substitution	- Principal aquifer providing a regionally important resource and/or supporting a site protected under EC and UK habitat legislation - Groundwater supports a sensitive water dependent terrestrial ecosystem - SPZ1 for an abstraction for public water supply
High	Water resource with a locally significant attribute of high importance and limited potential for substitution	- Principal aquifer providing locally important resource or supporting a river ecosystem - Groundwater locally supports a water dependent terrestrial ecosystem - SPZ2 or SPZ3 for an abstraction for public water supply

Sensitivity / Importance	Criteria	Examples
Medium	Water resource with a high quality and rarity at a local scale; or Water resource with a medium quality and rarity at a regional or national scale	- Secondary aquifer providing potable water to a small population - An aquifer providing water adequate for agricultural and industrial use with limited connection to surface water
Low	Water resource with a low quality and rarity at a local scale	- Unproductive strata - Poor quality groundwater

6.1.11 The receptors of concern identified by their sensitivity/importance are given in **Table 6-2**.

Table 6-2 Identified receptors of concern

Sensitivity / Importance	Receptor	Reason for sensitivity and Importance
Very High	River Great Ouse	The River Great Ouse is a watercourse with a WFD classification shown in a RBMP and Q95 ≥ 1.0 m^3/s. Site protected/designated under EC or UK legislation (SAC, SPA, SSSI, Ramsar site, salmonid water)/Species protected by EC legislation. Ecology and Nature Conservation
Medium	Tributaries to River Great Ouse: South Book, Hen Brook, Fox Brook	Watercourses not having a WFD classification shown in a RBMP and Q95 >0.001m^3/s .
Medium	Secondary A aquifers of alluvium, river terrace deposits	- These superficial deposits support water supplies locally in the Study Area and contribute groundwater baseflow to the River Great Ouse and its tributaries. - These aquifers support local groundwater abstraction used for industrial and agricultural purposes
	Licensed groundwater abstractions for general agricultural purposes, domestic and other uses and private domestic water sources	- These abstractions (if present) provide water to a small population at a licensable rate greater than 20 m^3/d or less for the private sources with potential for substitution.

Sensitivity / Importance	Receptor	Reason for sensitivity and Importance
	Springs: Spring close to the Alington Hill at New Manor House	Provide discrete flow to a tributary to the River Great Ouse
Low	Unproductive aquifers of the Oxford Clay and West Walton Formation/ Ampthill Clay Formation	- These strata contain very limited groundwater, and the units are defined as unproductive aquifers with negligible importance for groundwater
	Secondary undifferentiated aquifers of Oadby member (Glacial Till)	- These superficial deposits do not support potable water supplies in the Study Area, but may contribute limited groundwater baseflow to the River Great Ouse and its tributaries

6.2 Qualitative assessment of risks

Introduction

6.2.1 The risk screening records an assessment of all the source-pathway-receptor linkages that occur or may occur as a result of the Scheme.

6.2.2 The magnitude of a potential impact is established based on the nature and extent of the proposed development and the likely degree of impact on the receptor. It is independent of the sensitivity of the receptor. Accordingly, the magnitude of the impact has been assigned based on the criteria presented in **Table 6-3** and as taken from *LA LA113* (Ref 13-1).

6.2.3 Detailed discussion of the magnitude of impacts assessed is given in this Section. The calculation of magnitude includes consideration of the embedded mitigation measures within the Scheme. Where additional mitigation measures are required, these are highlighted.

6.2.4 The Likelihood of a pathway/mechanism has been assessed based on the Scheme details, professional judgement and experience. The product of the Likelihood and the Magnitude of the impact provides the calculation of risk:

a. Risk = Likelihood that impact will occur multiplied by the Magnitude of an impact if it does occur.

6.2.5 Once the magnitude of impact (which can be beneficial or adverse) and the receptor sensitivity have been defined, the significance of the potential effect can be derived by combining the assessments of both the importance of the water resource and the magnitude of the impact in a simple matrix as shown in **Table 6-4**. Effects that are assessed to be large or very large are considered to be significant.

6.2.6 The scoring of the Likelihood and risk is described in **Table 6-5** and **Table 6-6** respectively.

Embedded Mitigation

6.2.7 Influencing the Scheme's design is a critical consideration to maximise the opportunities for delivering mitigation of impacts by avoidance of sensitive receptors wherever reasonably practicable or through minimising impacts.

6.2.8 Not included in this assessment is the Second Iteration Environmental Management Plan and First Iteration Environment Management Plan (EMP) **[TR010044/APP/6.8]** for the Scheme which will include requirements and additional mitigation measures to protect the surface water and groundwater bodies from potential impacts of pollution, and to mitigate the temporary and permanent effects on groundwater flows, levels and water quality during excavation and construction of foundations, underpass and cuttings/tunnels as far as is reasonably practicable.

Source-Pathway-Receptor linkages

6.2.9 The Scheme design and buildability information have been reviewed with respect to the hydrogeological conceptual model and the source-pathway-receptor linkages identified are detailed below. This is split into the six sub Sections of the Scheme and summarised below:

a. Section 1 – CH 211m to CH2490m – Black Cat Junction Works Area (**Figure 5A);**

b. Section 2 – CH 2490m to CH 3850m – River Great Ouse Viaduct to the East Coast Mainline (**Figure 5A**);

c. Section 3 – CH3850m to CH9390m – East Coast Mainline to Cambridge Road Junction (**Figure 5B**);

d. Section 4 – CH 9390m to CH 10370m – Cambridge Road Junction (**Figure 5C**)

e. Section 5 – CH 10370m to CH17250m – Cambridge Road Junction to Caxton Gibbet, including Eltisley Junction (**Figure 5C/Figure 5D**);

f. Section 6 – CH17250m to CH19137m – Caxton Gibbet (**Figure 5D**);

6.2.10 The conceptual illustrations of the source-pathway-receptor linkages identified along the six sub-sections of the Scheme are presented in **Figure 5A-D**.

Table 6-3 Magnitude of Impact

Magnitude	Criteria	Example		Risk Score
Major adverse	Results in loss of attribute and/or quality and integrity of the attribute	Surface Water:	Failure of both acute-soluble and chronic-sediment related pollutants in HEWRAT and compliance failure with EQS values. Calculated risk of pollution from a spillage ≥2% annually (spillage assessment). Loss or extensive change to a fishery. Loss of regionally important public water supply. Loss or extensive change to a designated nature conservation site. Reduction in water body WFD classification.	4
		Groundwater:	Loss of, or extensive change to, an aquifer. Loss of regionally important water supply. Potential high risk of pollution to groundwater from routine runoff - risk score >250 (Groundwater quality and runoff assessment). Calculated risk of pollution from spillages ≥2% annually (Spillage assessment). Loss of, or extensive change to GWDTE or base flow contribution to protected surface water bodies. Change in groundwater quality resulting in reduction in water body WFD classification. Loss or significant damage to major structures through subsidence or similar effects.	
Moderate adverse	Results in effect on integrity of attribute, or loss of part of attribute	Surface Water:	Failure of both acute-soluble and chronic-sediment related pollutants in HEWRAT but compliance with EQS values. Calculated risk of pollution from spillages ≥1% annually and <2 % annually. Partial loss in productivity of a fishery. Degradation of regionally important public water supply or loss of major commercial/industrial/agricultural supplies. Contribution to reduction in water body WFD classification.	3
		Groundwater:	Partial loss or change to an aquifer.	

Magnitude	Criteria	Example		Risk Score
			Degradation of regionally important public water supply or loss of significant commercial/ industrial/ agricultural supplies. Potential medium risk of pollution to groundwater from routine runoff - risk score 150-250. Calculated risk of pollution from spillages ≥1% annually and <2 % annually. Partial loss of the integrity of GWDTE. Contribution to reduction in water body WFD classification. Damage to major structures through subsidence or similar effects or loss of minor structures.	
Minor Adverse	Results in some measurable change in attributes, quality or vulnerability	Surface Water:	Failure of either acute soluble or chronic sediment related pollutants in HEWRAT. Calculated risk of pollution from spillages ≥0.5% annually and <1% annually. Minor effects on water supplies.	2
		Groundwater:	Potential low risk of pollution to groundwater from routine runoff - risk score <150 Calculated risk of pollution from spillages ≥0.5% annually and <1% annually Minor effects on an aquifer, GWDTEs, abstractions and structures	
Negligible	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity	The proposed project is unlikely to affect the integrity of the water environment.		
		Surface Water:	No risk identified by HEWRAT (pass both acute-soluble and chronic-sediment related pollutants). Risk of pollution from spillages <0.5%.	1
		Groundwater:	No measurable impact upon an aquifer and/or groundwater receptors and risk of pollution from spillages <0.5%.	
Minor beneficial	Results in some beneficial effect on	Surface Water:	HEWRAT assessment of either acute soluble or chronic-sediment related pollutants becomes pass from an existing site where the baseline was a fail condition.	N/A

Magnitude	Criteria	Example		Risk Score
	attribute or a reduced risk of negative effect occurring		Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is <1% annually).	
		Groundwater:	Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually). Reduction of groundwater hazards to existing structures. Reductions in waterlogging and groundwater flooding. Minor improvement in groundwater quality due to remediation of contaminated land.	
Moderate beneficial	Results in moderate improvement of attribute quality	Surface Water:	HEWRAT assessment of both acute-soluble and chronic-sediment related pollutants becomes pass from an existing site where the baseline was a fail condition. Calculated reduction in existing spillage by 50% or more (when existing spillage risk >1% annually). Contribution to improvement in water body WFD classification.	N/A
		Groundwater:	Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually). Contribution to improvement in water body WFD classification. Improvement in water body catchment abstraction management Strategy (CAMS) (or equivalent) classification. Support to significant improvements in damaged GWDTE.	
Major beneficial	Results in major improvement of attribute quality	Surface Water:	Removal of existing polluting discharge, or removing the likelihood of polluting discharges occurring to a watercourse. Improvement in water body WFD classification.	N/A
		Groundwater:	Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring. Increased recharge to an aquifer.	

Magnitude	Criteria	Example	Risk Score
		Improvement in water body WFD classification.	
No Change		No loss or alteration of characteristics, features or elements; no observable impact in either direction.	N/A

Table 6-4 Significance of effect

Environmental Value (Sensitivity)	Magnitude of impact (degree of change)				
	No Change	Negligible	Minor	Moderate	Major
Very High	Neutral	Slight	Moderate or Large	Large or Very Large	Very Large
High	Neutral	Slight	Slightly or Moderate	Moderate or Large	Large or Very Large
Medium	Neutral	Neutral or Slight	Slight	Slight or Moderate	Moderate or Large
Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or Moderate
Negligible	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight

Table 6-5 Likelihood of an SPR mechanism occurring

Score	Likelihood	Description	Example
1	Very Unlikely	Very unlikely to occur	Extreme set of circumstances required
2	Remote	Unlikely to occur	Site underlain by low permeability strata
3	Moderately Likely	Equally likely or unlikely	Controlled activity
4	Likely	More likely to occur than not	Failure of equipment is likely to lead to a release of pollutants
5	Almost Certain	Highly likely to occur	Uncontrolled activity

Table 6-6 Risk rating table

X		Magnitude			
		1	2	3	4
Likelihood	1	1	2	3	4
	2	2	4	6	8
	3	3	6	9	12
	4	4	8	12	16
	5	5	10	15	20

Score	Risk Rating
1-2	Very low
3-5	Low
6-12	Medium
15-20	High

6.3 Preliminary impact assessment

6.3.1 A conceptual hydrogeological model and conceptual illustration of the S-P-R (See **Figure 5A-D**) was developed using the baseline data to carry out a preliminary qualitative and quantitative assessment of the potential impacts of the Scheme on groundwater. A tiered-based screening approach in line with relevant environmental risk assessment has been applied:

a. **Tier 1** – Identification of all groundwater and surface water receptors including designated aquifers, licensed and unlicensed groundwater abstractions, designated and undesignated surface water bodies (Main rivers, streams, rivers, ditches and pond)

b. **Tier 2** – Preliminary qualitative screening assessment of impacts likely to arise from all potential deep excavations works – such as cuttings, borrow pits, piling, bridge structure and or trenches requiring groundwater dewatering/control activities likely to impact on identified water receptors.

c. **Tier 3** – Detailed quantitative assessment using empirical analytical calculation to further assess/quantify the impacts of potential dewatering activities on identified groundwater dependent receptors.

6.3.2 In accordance with the DMRB requirement, the preliminary Tier 2 assessment considered the potential impacts from the Scheme on groundwater from the perspective of impacts on groundwater level and flow. It also considered the potential impacts on groundwater quality arising from dewatering abstraction, routine runoff and/or incidental spillages from the construction and operational activities of the Scheme.

6.3.3 Details of the preliminary qualitative screening assessment of the cuttings and borrow pits are provided in **Table 6-7.** The assessment considers the elevation of the deepest point of each cutting and borrow pit against the maximum recorded groundwater level as measured from the GI monitoring boreholes installed in 2019/ 2020, including the available data from historical borehole records in the area between 1991 and 2015. It also considers the existing ground elevation against the proposed elevation profile of the Scheme while taking into consideration the geology and hydrogeology beneath the Scheme.

6.3.4 Accordingly, it was considered that provided best practice measures are followed in line with the First Iteration Environmental Management Plant **[TR010044/APP/6.8]**, the magnitude of impacts on groundwater level, flow and quality from the advanced and enabling works activities such as the preparation of the main construction compounds, trenching (narrow excavation to less than 1 – 3m below ground) for utilities (high-risk utility pipelines such as the Cadent HP Gas, CLH Oil pipeline) to facilitate the construction of the Scheme would be no more than **minor** with no further detailed qualitative or quantitative assessment required.

6.3.5 Additionally, it was considered that the elements of the Scheme that are likely to impact on groundwater level, flow and quality are mainly associated with potential deep excavations such as cuttings, borrow pits and retaining wall structures. Several of these may intercept groundwater and may, therefore, require temporary and/or permanent groundwater dewatering/drainage management system to facilitate the Scheme. Preliminary screening assessment of the Scheme design in relation to the conceptual hydrogeological model of the Study Area showed that:

a. The majority of the Scheme's elements such as cuttings, borrow pits and piling activities with the potential for excavation with associated dewatering fall in areas where the activities from these elements of the Scheme are unlikely to intercept or will only minimally intercept the groundwater table and as such the magnitude of the overall impact will only be minor resulting in neutral or slight significance effects with no further mitigation measures required. These are mainly related to the elements of the Scheme in the central and eastern parts of the Study Area where the structures are directly underlain by low permeability glacial Till and or impermeable Oxford Clay with limited groundwater potential and unproductive aquifer conditions. Accordingly, these elements of the Scheme are not considered further in the detailed analytical, quantitative impact assessment.

b. Some cuttings, borrow pits and piling activities fall in areas where the groundwater table is likely to be intercepted and with potential dewatering activities required where the magnitude of the overall impact may be minor or moderate resulting in slight or moderate significance effects with further mitigation measures and or quantitative impact assessment required. These are mainly related to those elements of the Scheme in the western part of the Study Area where these structures are directly underlain by the Alluvium and River Terrace Deposits. These elements of the Scheme are therefore considered further in the detailed analytical, quantitative impact assessment.

Qualitative assessment results

6.3.6 The impact assessment criteria and value of the identified water receptors as presented in Section 6.2 above and in accordance with the DMRB requirement have been used to assess and present the results of the qualitative assessment.

6.3.7 The results of the qualitative assessment as presented in **Table 6-7** show that apart from the Hen Brook Cutting and Fox Brook Cutting, which will be above the current maximum recorded groundwater level, the remaining cuttings and the two borrow pits BPA and BPC as shown in **Figure 2** and Figure 6A&B in the Black Cat area will intercept groundwater, requiring dewatering with the risk of modifying the groundwater level and flow paths in order to minimise the potential for groundwater flooding of the excavations.

6.3.8 However, based on a review of the groundwater conditions, the extent (i.e. depth and length) of the cutting sections, the low permeability nature of the underlying geology (the superficial glacial Till which represents over 70% of the superficial geology beneath the Scheme and the Oxford Clay) beneath the Scheme, the overall magnitude of the potential impact on groundwater flow, level, quality and the corresponding impact on all other identified water receptors during construction and operation of the Scheme will be no more than minor, resulting in a slight significant effect. This is particularly the case for those elements of the Scheme within the central and eastern parts of the Scheme underlain directly by the low permeability glacial Till with limited groundwater potential.

6.3.9 In terms of groundwater quality, taking into account the S-P-R approach, the potential groundwater pollution impacts as a result of incidental spillage, surface run-off or from dewatering activities during construction and or operation of the Scheme are likely to be localised. Therefore, the magnitude of impacts on the Secondary aquifers is also considered to be minor, resulting in a slight significant effect.

6.3.10 Based on the conceptual hydrogeological model and the qualitative screening assessment as presented in , it is considered that excavations for cuttings and borrow pits in the central and further east of the Scheme are unlikely to require significant dewatering given their shallow depth in relation to the water table/limited groundwater potential of the Till and thus can be managed using standard methods and are not considered in detail any further. In the western part of the Scheme, where the River Terrace Deposits are present, there a potential for more significant impacts on groundwater. Only the two borrow pits in the Black Cat area (sub-section 1), the Black Cat Junction A1 underpass cutting, the Barford Road cutting and the Alington Hill cutting are likely to impact on the groundwater level and flow regime in the River Terrace Deposits.

6.3.11 Consequently, localised dewatering with potential groundwater management control during construction would be required. Also, an adequate drainage system would be required during the operation of the Scheme as there is the potential for retaining walls or impermeable barriers in the cuttings to result in localised groundwater mounding with the potential risk of minor groundwater seepage and or flooding up gradient. This may also result in the localised variation in the natural groundwater flow regime. Accordingly, a more detailed analytical assessment of these three cuttings and the two borrow pits has been carried out and discussed in the subsequent sections.

Table 6-7 Cuttings and borrow pits groundwater impact preliminary qualitative screening assessment results

CUTTINGS										
Cutting Name	Scheme Section	Length of Cutting (m) [Data Source: Design Drawing]	Maximum Depth of Cutting (m)	Elevation of Existing Ground Level (m AOD)	Elevation at the Maximum Depth of Cutting (m AOD)	Maximum Recorded Groundwater Level (m AOD)	Depth of Cutting Below (-) Groundwater Table (m)	Effective Aquifer Thickness (m)	Anticipated Geology at Location of Cutting	Comment
Black Cat Junction A1 Underpass Cutting	Section 1	750	8	21.91	13.91	20.60	-6.68	4.89	Superficial - Alluvium, River Terrace and Glacial Till (Oadby Member) Bedrock - Oxford Clay	Further analytical quantitative assessment is required due to the presence of the RTD
Barford Road Cutting	Section 2	380	6.8	27.35	20.55	26.25	-5.70	4.90	Superficial - Glacial Till (Oadby Member) Bedrock- Oxford Clay	Further analytical quantitative assessment is required due to proximity to R. Great Ouse and shallow GWL

CUTTINGS										
Cutting Name	**Scheme Section**	**Length of Cutting (m) [Data Source: Design Drawing]**	**Maximum Depth of Cutting (m)**	**Elevation of Existing Ground Level (m AOD)**	**Elevation at the Maximum Depth of Cutting (m AOD)**	**Maximum Recorded Groundwater Level (m AOD)**	**Depth of Cutting Below (-) Groundwater Table (m)**	**Effective Aquifer Thickness (m)**	**Anticipated Geology at Location of Cutting**	**Comment**
Alington Hill Cutting East of ECML Railway	Section 2	1370	7.6	51.34	43.74	50.76	-7.0	6.42	Superficial - Glacial Till (Oadby Member) Bedrock- Oxford Clay	Further analytical quantitative assessment is required given the depth and length of the cutting and proximity to R. Great Ouse near and a nearby spring
Potton Road/B1046 Cutting and B1046 Junction	Section 3	860	6.76	36.1	29.34	30.81	-1.5	4.68	Superficial – Glacial Till (Oadby Member) Bedrock- Oxford Clay	No further analytical quantitative assessment is required due to limited groundwater in the Till

CUTTINGS										
Cutting Name	Scheme Section	Length of Cutting (m) [Data Source: Design Drawing]	Maximum Depth of Cutting (m)	Elevation of Existing Ground Level (m AOD)	Elevation at the Maximum Depth of Cutting (m AOD)	Maximum Recorded Groundwater Level (m AOD)	Depth of Cutting Below (-) Groundwater Table (m)	Effective Aquifer Thickness (m)	Anticipated Geology at Location of Cutting	Comment
Hen Brook Cutting	Section 3	200	1.5	29.48	27.98	24.5	N/A (GWL is 3.5 below the base of cutting	Not Applicable	Superficial - Glacial Till (Oadby Member) Bedrock- Oxford Clay	No further analytical quantitative assessment is required as the base of the cutting is above the water table
Wintringham Brook Cutting	Section 3	450	4.3	36.08	31.78	32.63	-0.9	12	Superficial - Glacial Till (Oadby Member) Bedrock- Oxford Clay	No further analytical quantitative assessment is required due to limited groundwater in the Till

CUTTINGS										
Cutting Name	**Scheme Section**	**Length of Cutting (m) [Data Source: Design Drawing]**	**Maximum Depth of Cutting (m)**	**Elevation of Existing Ground Level (m AOD)**	**Elevation at the Maximum Depth of Cutting (m AOD)**	**Maximum Recorded Groundwater Level (m AOD)**	**Depth of Cutting Below (-) Groundwater Table (m)**	**Effective Aquifer Thickness (m)**	**Anticipated Geology at Location of Cutting**	**Comment**
Cambridge Road Junction Cutting	Section 4	980	6.4	41.04	34.64	35.04	-0.4	26.44	Superficial - Glacial Till (Oadby Member) Bedrock- Oxford Clay	No further analytical quantitative assessment is required due to limited groundwater in the Till
Fox Brook Cutting	Section 5	400	1.6	54.06	52.42	43	N/A (GWL is 9.4 below the base of cutting	12.75	Superficial - Glacial Till (Oadby Member) Bedrock- Oxford Clay	No further analytical quantitative assessment is required as the base of the cutting is above the water table
Gallow Brook Cutting	Section 5	1440	4.2	58.49	54.34	54.99	-0.65	14.55	Superficial - Glacial Till (Oadby Member) Bedrock - West Walton	No further analytical quantitative assessment is required due to limited

CUTTINGS										
Cutting Name	**Scheme Section**	**Length of Cutting (m) [Data Source: Design Drawing]**	**Maximum Depth of Cutting (m)**	**Elevation of Existing Ground Level (m AOD)**	**Elevation at the Maximum Depth of Cutting (m AOD)**	**Maximum Recorded Groundwater Level (m AOD)**	**Depth of Cutting Below (-) Groundwater Table (m)**	**Effective Aquifer Thickness (m)**	**Anticipated Geology at Location of Cutting**	**Comment**
									Formation and Clay Formation (Undifferentiated Mudstone)	groundwater in the Till
Eltisley Junction Cutting	Section 5	990	3.9	63.76	59.86	60.76	-0.90	19.25	Superficial - Glacial Till (Oadby Member) Bedrock - West Walton Formation and Clay Formation (Undifferentiated Mudstone)	No further analytical quantitative assessment is required due to limited groundwater in the Till

BORROW PITS										
Borrow Pit Name	**Scheme Section**	**Area of Borrow Pit (m2)**	**Maximum Depth of Borrow Pit (m)**	**Existing Ground Elevation**	**Elevation of Maximum Proposed Depth of Pit (m)**	**Maximum Recorded Groundwater Level (m AOD)**	**Depth of Cutting Below Groundwater Table (m)**	**Approximate Effective Aquifer Thickness (m)**	**Anticipated Superficial Geology at Location of Cutting**	**Comment**
Borrow Pit A [BPA] Near Black Cat Roundabout	Section 1	85000	3	27	24	25.45	1.45	3	Superficial - Alluvium, River Terrace and Glacial Till (Oadby Member)	Further analytical quantitative assessment is required due to the presence of the RTD
Borrow Pit C [BPC] Near Black Cat Roundabout	Section 2	36000	7	17	10	15.6	5.60	2	Superficial - Alluvium, River Terrace and Glacial Till (Oadby Member)	Further analytical quantitative assessment is required due to the presence of the RTD

BORROW PITS										
Borrow Pit Name	**Scheme Section**	**Area of Borrow Pit (m2)**	**Maximum Depth of Borrow Pit (m)**	**Existing Ground Elevation**	**Elevation of Maximum Proposed Depth of Pit (m)**	**Maximum Recorded Groundwater Level (m AOD)**	**Depth of Cutting Below Groundwater Table (m)**	**Approximate Effective Aquifer Thickness (m)**	**Anticipated Superficial Geology at Location of Cutting**	**Comment**
Borrow Pit E [BPE] Near Caxton Gibbet Junction	Section 5	103000	3	62	59	60.45	1.45	2	Glacial Till (Oadby Member)	No further analytical quantitative assessment is required due to limited groundwater in the Till
Borrow Pit F [BPF] Near Caxton Gibbet Junction	Section 5	225000	2	62	60	60.6	0.60	2	Glacial Till (Oadby Member)	No further analytical quantitative assessment is required due to limited groundwater in the Till

6.4 Analytical assessment and calculations

6.4.1 To further assess the potential impacts of dewatering of the three cuttings and the two borrow pits in the western part of the Scheme, the likely volumes of groundwater that would be abstracted during dewatering and the radius/zone of influence of the pumping have been estimated based on the following approach and assumptions:

a. Groundwater in the River Terrace Deposits is in hydraulic continuity with the surface watercourses (i.e. Great River Ouse). This assumption is the basis of the quantitative analytical assessment for groundwater.

b. Groundwater inflow rates and the radius of influence have been calculated using the maximum drawdown required and the average saturated thickness of the aquifer at each location and the representative hydraulic conductivity values derived for the River Terrace Deposits and the glacial Till as presented in **Section 0**. These values have been used in all the analytical assessments.

c. The cuttings excavations are assumed to be open and any permanent works, such as retaining walls, do not form part of the quantitative assessment. While this may lead to an over-estimation of the rate and or the dewatering zone of influence, this precautionary approach is considered to be appropriate.

d. It is assumed that the aquifer in the superficial deposits is unconfined.

e. Lateral planar flow only for the cuttings is assumed given their lengths while a combination of planar and radial flow is assumed for the borrow pits, with no vertical flow through the base of any cuttings or borrow pits. It is assumed that the underlying glacial Till and/or the Oxford Clay/West Walton Clay act as impermeable barriers to vertical flow from underneath the superficial deposits.

   i. The radius/zone of influence for the purpose of the cuttings and borrow pits analytical calculation assessments have been estimated using the Sichardt empirical equation - $Ro = C(H-h_w)\sqrt{k}$, where:

      - k: Hydraulic conductivity (m/s)
      - H: Initial piezometric level in the aquifer at the maximum depth of the cutting (m)
      - h_w: Target drawdown level in the excavation at the maximum depth of the cutting(m)
      - R_o: Radius of influence (m)
      - C: Empirical calculation factor ranging between 1500 to 3000. (A conservative value of 2000 has been applied in all calculations given that 1500 to 2000 has been given in the literature for linear flow).

f. For the cutting assessment, planar groundwater flow has been assumed for both sides of the cutting - allowing for the cutting to be assessed as a long narrow system modelled as a continuous slot between wells. The inflow has been calculated using the planar flow formulae based on the work of Chapman (1959) where:

i. Fully penetrating slots, flow (Q):

- Unconfined conditions: $Q = (kx(H^2 - h_w^2))/L_o)$

ii. Partially penetrating slots, flow (Q):

- Unconfined conditions: $Q = [0.73 + 0.27\ P/H]\ \ (kx(H2 - h_w^2))/L_o)$
- Where:
  - L_o: distance of influence (obtained either manually or empirically using the Sichardt equation for R_o as discussed above)
  - x: linear length of the slot (i.e. of the cutting) (m)
  - k: Hydraulic conductivity (m/s)
  - H: Initial piezometric level in the aquifer (m)
  - h_w: target drawdown inside the excavation (m);
  - P: depth of penetration of the slot below the original water table in an unconfined aquifer.

g. For the borrow pits, the flow required to dewater each borrow pit has been calculated based on the assumption that groundwater inflow is only through each side of the borrow pit; assuming a rectangular borrow pit – allowing for the borrow pit to be modelled as a rectangular system with both planar and radial flow **(**see **Figure 9**); with no vertical inflows anticipated given the underlying low permeability bedrock. Therefore, groundwater inflow from all sides is calculated using Darcy's Equations:

h. Darcy's equation: [Q = TiW] where:

- i = P/Ro and T = kB
- T: Transmissivity (m^2/sec) of the aquifer
- k: Hydraulic conductivity (m/sec)
- B: Aquifer thickness (m)
- W: Perimeter of borrow pit (m)
- P: Drawdown required (m)
- Ro: radius of influence (m)

6.5 Cuttings dewatering impact assessment

Black Cat Roundabout A1 Underpass Cutting

6.5.1 The proposed Black Cat A1 Underpass cutting, located in the western part of the Study Area (**Figure 2** and **Figure 5A**), has been identified as a potential groundwater impact "high-risk" area due to the proposed deep (about 8m) excavation and the associated dewatering activities and groundwater control required during the construction and operation of this element of the Scheme.

6.5.2 At the location of the A1 underpass, ground investigation borehole logs and geological cross-section (**Figure 4**) show that the thickness of the superficial deposits is greatest at the location of the proposed cutting (6.0m and 6.2m respectively). Therefore, the thickness of the superficial deposits is assumed to be 6.2m (i.e. the Alluvium and the River Terrace Deposits combined).

6.5.3 The maximum depth of the Black Cat - A1 Underpass cutting is approximately 8m with a length of approximately 750m. The lowest drainage invert along the cutting is 13.91m AOD at Chainage 1620.

6.5.4 The ground elevation at the maximum depth of the cutting is at 21.91m AOD with the minimum base of the River Terrace Deposit at 15.71 m AOD (i.e. 6.2m BGL). Groundwater monitoring boreholes installed between 2019 and early 2020 and the historical borehole logs show that the groundwater level in the River Terrace Deposits varies between 20.60m AOD and 17.82m AOD in the vicinity of the A1 underpass. Based on this information, it is considered that the base of the cutting will be approximately 6.7m (see **Table 6-7**) below the groundwater level at an elevation of approximately 13.91m AOD, Accordingly, at this location, the cutting will intercept the full thickness of the Alluvium and the River Terrace Deposits, terminating approximately 1.8m into the low permeability Till. Therefore, groundwater level and flow within the superficial deposits will be affected by the cutting. Temporary dewatering of the groundwater would be required to maintain dry ground conditions during construction and an adequate groundwater management system will be required during operation of the Scheme.

6.5.5 Based on the above and applying an hydraulic conductivity value of 2.0×10^{-4} m/sec adopted for the RTD with a maximum saturated aquifer thickness of 4.89m, the maximum zone of influence is estimated empirically to be approximately 138m. The estimated inflow using the unconfined aquifer Chapman (1959) equation for a fully penetrating condition was calculated to be approximately 2,241 m3/day. This would be required to dewater the area and enable the construction of the A1 underpass cutting in dry conditions. However, taking into consideration the variation in the depth of the cutting, variation in land elevation in relation to groundwater level and effective saturated aquifer thickness along the full length of the cutting, applying the estimated zone of influence of 138m, an average saturated aquifer thickness of 3.95m and a corresponding maximum dewatering drawdown of 3.95m, the estimated inflow will be reduced to approximately 1,465 m3/day. The calculations are provided in **Annex 4**.

Assessment of impact on identified water features/receptors from A1 Underpass dewatering:

6.5.6 The River Terrace Deposits are designated a Secondary A aquifer that supports local abstractions. A medium sensitivity/importance value has been assigned to this aquifer as per the *LA113* (Ref 13-1) assessment criteria. Based on the estimated flow rates and the potential zone of influence, it is considered that the magnitude of any localised changes in groundwater level and flow due to the dewatering of the cutting is minor adverse, resulting in a slight significant effect on the groundwater level and flow within the Secondary A aquifer.

6.5.7 As shown in **Table 6-7**, given that the likely natural groundwater level in the area of the cutting is expected to be less than 2m BGL and taking into consideration the proposed drainage strategy for the Scheme, the magnitude of the potential risk of increased groundwater mounding/flooding up the hydraulic gradient of any barriers created by sealed system secant piled or retaining walls associated with the cutting during construction and operation is considered to be minor adverse, resulting in a slight significant effect.

6.5.8 As shown in **Figure 8**, there are no identified GWDTE in the vicinity of the proposed A1 underpass cutting; therefore, no impacts are anticipated.

6.5.9 No ground contamination has been reported or observed during the detailed 2019/2020 ground investigation for the Scheme. As shown in **Annex 1**, the baseline groundwater quality analytical results for most of the samples collected within the vicinity of the proposed cutting indicated no significant widespread groundwater contamination issues in the area. In one sampling point (WS275) (see **Table 2**) located approximately 1.2 kilometres (0.7 miles) north of the proposed A1 cutting in the vicinity of a former petrol filling station, hydrocarbon contamination was recorded in the River Terrace Deposits groundwater. This location is down hydraulic gradient of the cutting and is separated from the cutting by the South Brook, which will limit the extent of the impacts of any construction dewatering. The site also is outside the estimated 138m zone of influence. Accordingly, it is considered that the risk of groundwater quality impacts at the A1 Underpass cutting arising from the ingress of hydrocarbon contaminated groundwater from the north will be negligible and the significance of any impact will be slight. The risk of potential impacts on groundwater quality in the vicinity of the cutting during dewatering or other associated construction activities, including spillage and or remobilisation of any unidentified contaminants during excavations also is considered to be negligible provided best practice dewatering methodology, which will include groundwater quality monitoring is implemented as provided in the First Iteration EMP **[TR010044/APP/6.8]**.

6.5.10 The South Brook and the Rockham Ditch that flows approximately 470m north and 540m south respectively, from the centre of the cutting are the closest surface water bodies to the cutting. Both water bodies are of medium sensitivity and are likely to be receiving baseflow from the River Terrace Deposits, particularly in sections where their bed has not been modified. As they are outside the estimated 138m zone of influence, they are unlikely to be impacted by potential dewatering activities. However, it is anticipated that any water abstracted during dewatering will be discharged to these surface watercourses in order to minimise any potential baseflow impacts. Accordingly, the magnitude of the potential dewatering impact on groundwater baseflow to these watercourses is minor, resulting in a slight significant effect.

6.5.11 All other identified water features/receptors in this area, including the River Great Ouse located approximately 600m east of the A1 underpass and licensed abstractions are outside the calculated zone of influence and are therefore unlikely to be impacted by the proposed construction dewatering activities. Impacts during the operation of the Scheme from any permanent groundwater dewatering are likely to be similar or less significant than during the construction phase. It is anticipated that any drained groundwater due to flow interception by the A1 underpass will be discharged to the same watercourses where the groundwater would naturally discharge as baseflow.

Barford Road Cutting:

6.5.12 The Barford Road cutting is located on the summit of a ridge in the Barford Road area, approximately 8m above the floodplain of the River Great Ouse to the west. The maximum depth of the Barford Road Cutting is approximately 6.8m with a length of approximately 380m. The lowest drainage invert along the cutting is 20.55m AOD at Chainage 2660.

6.5.13 The ground elevation at the maximum depth of the proposed Barford Road cutting is 27.35m AOD. Groundwater monitoring data from the 2019/2020 GI (BH224, BH227, BH228 and BH283) indicate that the groundwater level varies between 26.25m AOD and 16.95m AOD in the vicinity of the cutting with a westerly flow direction towards the River Great Ouse. The significant variation in the groundwater level in the area is due to the undulating nature of the landform in the vicinity of the cutting. The base of the cutting will be 5.7m below the groundwater level. The 2019/2020 GI logs indicated a small discontinuous portion of both the Alluvium and a potentially higher River Terrace Deposits may be present within the vicinity of the cutting with the glacial Till being the predominant superficial deposit beneath the area with a thickness of up to 6m above the Oxford Clay. Accordingly, it is inferred that the cutting will intercept the full thickness of the Till, terminating approximately 0.8m into the Oxford Clay.

6.5.14 While the Till is considered to be a low permeability stratum which restricts groundwater flow, groundwater occurs within the deposit where permeable layers are present. The water-bearing granular units generally are thin (<1m). However, in one of the GI borehole (BH227) located within the vicinity of the Barford Road cutting a water-bearing gravelly sand band was present between 4.0m BGL and 6.0m BGL (i.e. approximately 2m thick). The groundwater level in borehole BH227 was 26.25m AOD (1.1m BGL). The invert of the Barford Road cutting will be approximately 4.90m below the groundwater level in the Till and approximately 0.8m below the base of the Till, terminating in the Oxford Clay.

6.5.15 Based on the above, the conceptual model at the location of the Barford Road cutting assumes that limited groundwater is present within the permeable layers of the Till while the underlying Oxford Clay acts as a vertical flow barrier beneath the Till. Based on this assumption, groundwater level and flow regime within the permeable layers of the Till is likely to be affected by dewatering activities during the construction and operation of the Barford Road cutting.

6.5.16 Accordingly, temporary dewatering of the groundwater would be required to maintain dry ground conditions during construction, and an adequate groundwater management system will be required during the construction and operation of the Scheme. For the purpose of the assessment an hydraulic conductivity value for the Till of 1 x 10^{-7}m/sec has been assumed.

6.5.17 Based on the above and applying the hydraulic conductivity value of 1.0x 10^{-7} m/sec adopted for the Till, with a maximum saturated aquifer thickness 4.9m, the maximum zone of influence is estimated empirically to be approximately 3.1m. The estimated inflow using the unconfined aquifer Chapman (1959) equation for a fully penetrating condition was calculated to be approximately 25 m^3/day. This would be required to dewater the area and enable construction of the Barford Road cutting in dry conditions. However, taking into consideration the variation in the depth of the cutting, variation in land elevation in relation to groundwater level and effective saturated aquifer thickness along the full length of the cutting, applying the estimated zone of influence of 3.1m, an average saturated aquifer thickness of 3.37m and a corresponding dewatering maximum drawdown of 3.37m, the estimated inflow will be reduced to approximately 12 m3/day. The calculations are provided in **Annex 5.**

Assessment of the impact on identified water features from the Barford Road cutting

6.5.18 The glacial Till is designated a Secondary undifferentiated aquifer that is only able to provide water for agricultural or industrial use with limited connection to surface water. A low sensitivity/importance value has been assigned to this aquifer as per the DMRB assessment criteria. Based on the estimated groundwater inflow volume of 25m^3/day and potential zone of influence, it is considered that the magnitude of the impact on groundwater level and flow due to dewatering of the cutting will be minor adverse, resulting in a localised slight significant effect on the groundwater level and flow regime within the permeable layers of the Till.

6.5.19 Given that the cutting is located at the summit of a ridge and taking into consideration the proposed drainage strategy for the Scheme, the magnitude of the potential risk of increased groundwater mounding/flooding up the hydraulic gradient of any barriers created by the retaining walls associated with the cutting during construction and operation is considered to be minor adverse, resulting a slight significant effect.

6.5.20 As shown in **Figure 8**, there are no GWDTE in the vicinity of the Barford Road cutting; therefore, no impacts are anticipated.

6.5.21 No ground contamination has been reported or observed during the detailed 2019/2020 ground investigation for the Scheme. As shown in Annex 1, the baseline groundwater quality analytical results for most of the samples collected within the vicinity of the proposed cutting indicated no significant groundwater contamination issues in the area. In one sampling point (BH224) (see Table 4-2) located approximately 170 west of the cutting, slightly elevated level of sodium, sulphate manganese and hydrocarbon (Benzo(k)fluoranthene and Benzo(a)pyrene) above the UKDWS were reported. This location is outside the zone of influence and is down hydraulic gradient of the cutting which will limit the extent of impacts of any construction dewatering. Accordingly, it is considered that the risk of potential impacts on groundwater quality in the vicinity of the cutting during dewatering or other associated construction activities, including incidental spillages and or remobilisation of any unidentified contaminants during excavation will be low, provided best practice dewatering and construction methodology, which will include groundwater quality monitoring is implemented as provided in the First Iteration EMP **[TR010044/APP/6.8]**. Accordingly, the overall magnitude of impact on groundwater quality and other water receptors arising from dewatering activities will be no more than minor adverse resulting in slight significance effect.

6.5.22 The River Great Ouse that flows approximately 200m west from the centre of the cutting is the closest surface water body to the cutting. The River Great Ouse is a designated Main River with very high sensitivity that is likely to be receiving a small proportion of baseflow from the superficial deposits in the area in comparison with the flow in the river. However, as the river falls outside the calculated 3.1m estimated zone of influence, it is unlikely to be impacted by potential dewatering abstraction at the proposed cutting. It is anticipated that any water abstracted during dewatering will likely be appropriately discharged to the river in order to minimise any potential flow impacts. Accordingly, a no change magnitude dewatering impact on the river is anticipated, resulting neutral significant effect.

6.5.23 All other identified water features/receptors in this area, including licensed abstractions are also outside the calculated zone of influence and are therefore unlikely to be impacted by dewatering during construction and operation of the Barford Road cutting.

Alington Hill Cutting

6.5.24 The Alington Hill cutting is located at the summit of Alington Hilll. The maximum depth of the Alington Hill cutting is approximately 7.6m with a length of approximately 1370m. The lowest drainage invert along the cutting is 38.78m AOD at Chainage 6260.

6.5.25 At the location of the cutting, the superficial deposits comprise a layer of Topsoil over glacial Till with maximum thicknesses of 1.20m and 7.20m respectively. The average depth to the base of the superficial deposits is approximately 7m BGL. Due to the undulating nature of the ground within the vicinity of the cutting, the ground elevation in the vicinity of the cutting varies significantly between 35m AOD and 50m AOD. The ground elevation at the maximum depth (7.6m) of the cutting is 51.34m AOD, which places the base of the cutting at 43.74m AOD at this location.

6.5.26 While the Till is a low permeability stratum which restricts groundwater flow, groundwater occurs within the deposit where permeable layers are present. The Till was proved in 77 of the 83 boreholes drilled as part of the 2019/2020 GI with granular units of sand and gravel identified within the Till at varying depths, generally at depths of more than 10m into the Till. Water strikes were not reported for the majority of the granular units.

6.5.27 No groundwater was struck in the superficial deposits during the drilling of the 2019/2020 GI boreholes (BH232, BH233, BH234, BH235 and BH236), except for BH237 and BH283 located to the north and south of the cutting which encountered groundwater at approximately 11m BGL (i.e. 22m AOD) and 4.3m BGL (i.e.17.29m AOD) respectively. However, a shallow groundwater level at 2.2m BGL (49.26m AOD), 0.70m BGL (47.61m AOD), 2.32m BGL (30.64m AOD) and 0.90m BGL (21.1m AOD) was subsequently recorded in BH233, BH234, BH237 and BH283 respectively during the on-going post-completion groundwater level monitoring. Consequently, given the installed water intake zone (screened section) of the boreholes which ranges between 2m – 8.5m BGL, it is assumed that the observed water levels in the GI boreholes are a representation of the groundwater level in the glacial Till.

6.5.28 Based on the above assumption, an extrapolation of the groundwater level indicates that the groundwater level in the glacial till varies between 50.76m AOD and 39m AOD in the vicinity of the Alington Hill cutting with a north-westerly groundwater flow direction towards the River Great Ouse. The base of the cutting is therefore 7.0m below the groundwater level at the maximum depth of the cutting. BH235 indicates that the glacial Till is about 7m thick at this location and is overlain by approximately 1m of Topsoil, while the Oxford Clay underlies the Till. Limited groundwater is present within permeable layers of the Till in the cutting while the Oxford Clay acts as an impermeable barrier beneath the Till. Accordingly, the groundwater level and flow regime within permeable layers of the Topsoil and the Till is likely to be affected by dewatering activities during the construction and operation of the Scheme.

6.5.29 Based on the above, applying the hydraulic conductivity value of 1.0 x 10^{-7}m/s adopted for the Till with a maximum saturated aquifer thickness of 6.42m, the maximum zone of influence is estimated empirically to be approximately 4.1m. The corresponding estimated inflow using the unconfined aquifer Chapman (1959) equation for a fully penetrating condition was calculated to be approximately 120m^3/day. This would be required to dewater the area and enable construction of the Alington Hill cutting in dry conditions. However, taking into consideration the variation in the depth of the cutting, variation in land elevation in relation to groundwater level and effective saturated aquifer thickness along the full length of the cutting, applying the estimated zone of influence of 4.1m, an average saturated aquifer thickness of 4.72m and a corresponding dewatering maximum drawdown of 4.72m, the estimated inflow will be reduced to approximately 65 m3/day. The calculations are provided in **Annex 5.**

Assessment of the impact on identified water features from the Alington Hill cutting

6.5.30 The glacial Till is designated a Secondary undifferentiated aquifer that is only able to provide water for agricultural or industrial use with limited connection to surface water. A low sensitivity/importance value has been assigned to this aquifer as per the DMRB assessment criteria. Based on the estimated inflow volume of 120m^3/day and potential zone of influence, it is considered that the magnitude of local impact on groundwater level and flow due to dewatering of the cutting will be negligible adverse, resulting in a localised slight significant effect on the groundwater level and flow regime within the permeable layers of the glacial Till.

6.5.31 Given that the cutting is located at the summit of a ridge and taking into consideration the proposed drainage strategy for the Scheme, the magnitude of the potential risk of increased groundwater mounding/flooding up the hydraulic gradient of any barriers created by any retaining walls associated with the cutting during construction and operation is considered to be minor adverse, resulting a slight significant effect.

6.5.32 As shown in **Figure 8**, there are no GWDTE in the vicinity of the Alington Hill cutting; therefore, no impacts are anticipated.

6.5.33 The River Great Ouse that flows approximately 1.7 kilometres (1.05 miles) northwest of the cutting is the closest surface water body to the cutting. Also, there is a spring located approximately 1.8 kilometres (1.1 miles) northwest of the cutting at an elevation of 16m AOD. These water features are outside the estimated zone of influence. Therefore, the magnitude of any potential dewatering impact on the river is considered to be no change, resulting in a neutral significant effect. Accordingly, taking into account the proposed drainage strategy for the Scheme, the significance of the effect is likely to remain the same during the operation of the Scheme.

6.5.34 All other identified water features/receptors including licensed abstractions are also outside the calculated zone of influence and are therefore unlikely to be impacted by dewatering during construction and operation of the Alington Hill cutting.

6.5.35 No ground contamination has been reported or observed during the detailed 2019/2020 ground investigation for the Scheme. As shown in **Annex 1**, the baseline groundwater quality analytical results for most of the samples collected within the vicinity of the proposed cutting indicated no significant groundwater contamination issues in the area. In two sampling points (BH239 and BH240) (see Table 2) located approximately 200 north of the cutting, slightly elevated level of sodium, sulphate, chloride, manganese, iron and ammoniacal nitrogen above the UKDWS were reported. The locations of the sampling points are outside the zone of influence and are both down hydraulic gradient of the cutting which will limit the extent of impacts of any construction dewatering. Accordingly, it is considered that the risk of potential impacts on groundwater quality in the vicinity of the cutting during dewatering or other associated construction activities, including incidental spillages and or remobilisation of any unidentified contaminants during excavation will be low, provided best practice dewatering and construction methodology, which will include groundwater quality monitoring is implemented as provided in the First Iteration EMP **[TR010044/APP/6.8]**. Accordingly, the overall magnitude of impact on groundwater quality and other water receptors arising from dewatering activities will be no more than minor adverse resulting in slight significance effect.

6.6 Borrow Pit dewatering impact assessment

6.6.1 Two borrow pits [BPA] and [BPC] located approximately 700m west and 350m northeast, respectively, from the centre of the existing Black Cat roundabout are planned in the western part of the Study Area (see **Figure 2**). The maximum anticipated depth and approximate surface area for BPA are 3m and 85,000m^2, while the maximum anticipated depth and approximate surface area for BPC are 7m and 36,000m^2.

Borrow Pit A [BPA]

6.6.2 The target material from this borrow pit is the River Terrace Deposits.

6.6.3 The ground elevation at the location of BPA is approximately 24m AOD. The area is underlain by at least 6m of superficial deposits comprising approximately 4m of River Terrace Deposits over at least 2m of glacial Till. The deposits extend laterally beyond the site boundaries and are underlain by the low permeability mudstone layer of the Oxford Clay which acts as a hydraulic barrier to flow.

6.6.4 Information reviewed which includes records from nearby BGS boreholes (TL15NE100, TL15NE97 and TL15NE60) and groundwater monitoring boreholes (BH203, BH206, BH207 and BH215) installed in 2019/2020 in the vicinity of the proposed borrow pit indicates that the average groundwater elevation at the borrow pit location is approximately 23m AOD (i.e. 1m BGL) with an easterly/north easterly flow direction towards the River Great Ouse.

6.6.5 Given the proposed depth (3m) of the pit and the shallow groundwater level at the location, a dewatering drawdown of at least 3m below the rest water level (i.e. 2m to the base of the pit, plus 1m below the base to maintain dry conditions in the working area of the pit) will be required to maintain a dry operational area irrespective of natural seasonal variations in the groundwater level.

6.6.6 It is assumed that there is hydraulic continuity between the River Terrace Deposit and the surface water bodies in the area, but that there is no hydraulic continuity between the deposits and the underlying Oxford Clay.

Impact assessment

6.6.7 Based on the above assumptions and applying the hydraulic conductivity value of 2.0×10^{-4}m/sec adopted for the River Terrace Deposits, using the Sichardt empirical equation, the calculated zone of influence is estimated to be approximately 85m from the edge of the borrow pit. An empirical factor (C) of 2000 has been applied in the Sichardt equation to calculate the radius of influence around the pits.

6.6.8 Based on the above, applying the hydraulic conductivity value of 2.0×10^{-4}m/sec adopted for the RTD and with an aquifer thickness of 3m (i.e. the approximate saturated aquifer thickness of the RTD at the site) the groundwater inflow volume required to dewater the borrow pit to the maximum drawdown of 2m plus an additional 1m below the base as a conservative measure to maintain dry ground conditions (i.e. 4m BGL (20m AOD)) has been estimated using the Darcy's equation to be 2,775m^3/day. This analytical assessment assumes that groundwater inflow will be through all sides of the borrow pit (i.e. flow is planar to the sides and radial to the corners) and assumes a single rectangular borrow pit excavation of approximately 620m by 137m (approx. 85,000m^2). The calculations are provided in **Annex 5**.

6.6.9 As the aquifer within the RTD is of medium sensitivity, the magnitude of impact on groundwater level and flow due to potential dewatering activities at BPA is considered to be minor adverse, resulting in a slight significance effect. However, in principle, the predicted groundwater inflow and the magnitude and effect significance are likely to be lower as the full extent of the borrow pit will not be worked at the same time, as a section (zone) of the pit may be opened up and material generated and backfilled before or while works are progressed in another zone.

6.6.10 For the identified surface water features/receptors, the Rockham Ditch that flows eastward along the southern boundary of the proposed borrow pit and the South Brook that flows eastwards, at approximately 290m to the north of the pit are the closest surface water receptors to the proposed borrow pit. Both water bodies are of medium sensitivity and are likely to be receiving baseflow from the River Terrace Deposits within the vicinity of the pit, particularly in sections where their bed has not been modified. The South Brook is unlikely to be impacted as it falls outside the estimated zone of influence. The Rockham Ditch is likely to be impacted by the lowering of groundwater around the borrow pit and would pose risks to this surface water receptor as it falls within the calculated dewatering zone of influence. However, it is anticipated that any water abstracted during dewatering of the borrow pit will be discharged to nearby surface water bodies (both the South Brook and the Rockham Ditch) in order to minimise any potential flow impacts. Accordingly, the magnitude of the potential dewatering impact on groundwater baseflow to these water bodies are considered to be minor, resulting in a slight significant effect.

6.6.11 The flood risks associated with the discharge of any groundwater pumped during the dewatering activities will be managed following an approved environmental permit and the First Iteration EMP **[TR010044/APP/6.8]**. This will ensure that any potential impacts of flooding due to the discharge of the pumped water will remain minor with slight significant effect.

6.6.12 No ground or groundwater contamination has been observed at or within the vicinity of the proposed borrow pit during the detailed 2019/2020 ground investigation for the Scheme. Groundwater quality analytical results (see **Annex 1**) for water samples collected within the vicinity of the proposed borrow pit indicated no significant widespread groundwater contamination issues in the area. In one sampling point (**WS275**) located approximately 1.4 kilometres (0.9 miles) northeast and down hydraulic gradient from the borrow pit, which indicated potential hydrocarbon groundwater contamination. As the site is outside the calculated dewatering zone of influence from the borrow pit, the magnitude of risk of mobilising hydrocarbon contaminated groundwater into the borrow pit from this area will be negligible, and the significance of any impact will be slight.

6.6.13 It is likely that the excavation of the borrow pit can act as a preferential pathway for any new contaminants to be mobilised into the groundwater and for unidentified nearby contaminants to be mobilised as a result of dewatering activities. However, the risk on groundwater quality is considered to be low provided best practice dewatering methodology which will include groundwater quality monitoring as provided in the First Iteration EMP **[TR010044/APP/6.8]** are followed. Accordingly, the magnitude of impact on groundwater quality arising from dewatering activities will be minor resulting in slight significance effect.

6.6.14 In addition, it is proposed that groundwater monitoring boreholes are drilled around the borrow pit to provide data on the effects of dewatering to confirm the predicted effects and to provide an early warning of any changes in groundwater quality as a result of dewatering.

6.6.15 It is understood that the borrow pit would be backfilled using natural inert materials obtained from the construction of the Scheme, which are considered unsuitable on engineering parameters. Accordingly, provided the backfill material is sampled and screened for contamination in line with the Scheme's materials management plan as detailed in **Chapter 10, Material Assets and Waste** of the Environmental Statement **[TR010044/APP/6.1]** and the First Iteration EMP **[TR010044/APP/6.8]**, the overall magnitude of potential impacts on water resources due to contaminant mobilisation associated with the excavation and backfilling of the borrow pit will be minor, resulting in a slight significant effect.

6.6.16 It is also considered that provided the borrow pit is backfilled with suitable materials the risk and potential impacts on groundwater and surface water quality and/or increased groundwater and / surface water flooding due to the backfilling will be minor resulting in a slight significant effect.

Borrow Pit C [BPC]

6.6.17 The target material from BPC is the glacial Till (Oadby Member), with an anticipated maximum depth for the borrow pit of 7m.

6.6.18 BPC will be located within a single field in the northern part of the former Breedon quarry site (see **Figure 2**) where most of the River Terrace Deposit has been extracted and the area backfilled with unsuitable aggregate, comprising soft to firm brown slightly sandy gravelly clay and fine sand. Historical borehole records: BH2015/20, BH2015/19; BH2015/18; BH2015/17; BH2015/16; BH2015/15 and BH2015/14 indicated that the average base of the RTD at this location is approximately 15m AOD, approximately 2m BGL. The records show that the initial thickness of the RTD before it was quarried was 2 – 3m. This thickness was also proved by a number of the 2019/2020 GI boreholes (BH275B, 275C, BH219, BH220) and trial pits (TP334 and TP365) located in the vicinity of the site where the RTD has not been quarried.

6.6.19 The ground elevation at the location of BPC is approximately 17m AOD. The RTD is underlain by at least approximately 10m of Till. Geological records show that the strata extend laterally beyond the BPC site boundaries and is underlain by the low permeability Oxford Clay which acts as a hydraulic barrier to vertical groundwater flow.

6.6.20 The historical borehole records BH2015/21, BH2015/20, BH2015/19, BH2015/18, BH2015/17, BH2015/16, BH2015/15, BH2015/14 and the 2019/2020 GI logs for TP334 and TP365 indicate that the average groundwater elevation at the proposed borrow pit location is 16.5m AOD, less than 1m BGL, with an easterly/north easterly flow direction towards the River Great Ouse. It is therefore assumed that, given the anticipated maximum depth (7m) of the pit and the potential shallow groundwater level at the location, dewatering would be required to maintain a dry operational area during excavation.

6.6.21 While the Till is likely to be a low permeability stratum which restricts groundwater flow, groundwater occurs within the deposit where thin permeable layers are present. Water strikes were not reported for the majority of the granular units, suggesting that the majority of the upper layers of the Till is dry except where the granular units present at the upper layer of the Till are in hydraulic continuity with the water-bearing RTD. The Till was proved in 37 of the 42 boreholes drilled within the vicinity of the former Breedon Quarry in 2015. The boreholes were drilled to prove the mineral resources and base of the RTD. The boreholes all terminated at approximately 1m into the underlying Till. In all of the boreholes, the Till was reported to be dry, apart from one borehole (BH2015/06) located in the southern part of the quarry which indicated the presence of water in a 0.1m thick blue grey, soft sandy silt at the top of the Till.

6.6.22 Accordingly, the conceptual model for the BPC analytical assessment, assumes that the combination of the saturated residual RTD (approximately 0.5m to 1m thick) and the saturated upper layer (approximately 0.5m) of the glacial Till is considered to be the potential water bearing horizon, while the lower section (<10 m BGL) of the glacial Till will act as a hydraulic barrier. Therefore, the saturated zone to be dewatered at BPC is estimated to be 1.5m and is likely to be hydraulically connected with the surface water bodies in the area. It is considered that there is no hydraulic continuity between the superficial deposits and the underlying Oxford Clay.

Impact assessment

6.6.23 Applying the maximum hydraulic conductivity value of **2.0 x 10^{-4} m/sec** in the Sichardt equation, for the approximately 1.5m saturated horizon of the RTD and the upper 0.5m of the glacial Till, the calculated zone of influence is estimated to be **42m**. The groundwater inflow volume required to dewater the borrow pit has been estimated using the Darcy's equation to **770 m^3/day.** This assessment assumes that groundwater inflow will be through all sides of the borrow pit (i.e. flow is planar to the sides and radial to the corners) and assumes a single rectangular borrow pit excavation of approximately 300m by 120m (approx. 36,000m^2). The calculations are provided in **Annex 5**.

6.6.24 As the RTD is of medium sensitivity, the magnitude of impact on groundwater level and flow due to potential dewatering activities at BPC is considered to be minor adverse, resulting in a slight significance effect. However, in principle, the predicted groundwater inflow and the magnitude and effect significance are likely to be lower as the full extent of the borrow pit will not be worked at the same time, as a section (zone) of the pit may be opened up and material generated and backfilled before or while works are progressed in another zone.

6.6.25 The nearest water receptors (watercourses) to the proposed borrow pit are South Brook, Rockham Ditch and the River Great Ouse located approximately 100m, 590m and 420m from the northern, southern and eastern boundaries of BPC respectively. Both the South Brook and the Rockham Ditch are of medium sensitivity while the River Great Ouse is of very high sensitivity. These watercourses are likely to be receiving baseflow from the River Terrace Deposits within the vicinity of the proposed borrow pit. As these watercourses are outside the estimated zone of influence, it is unlikely that the lowering of groundwater at the borrow pit would impact on these watercourses as a result of changes in the groundwater level (hydraulic gradient) and baseflow towards them. However, it is anticipated that any water abstracted during dewatering of the borrow pit will be discharged to these surface water bodies in order to minimise any potential flow impacts. Accordingly, the magnitude of the potential dewatering impact on groundwater baseflow to these water bodies are considered to be negligible, resulting in a slight significant effect.

6.6.26 Given the calculated inflow volume of approximately **770 m^3/day,** the flood risks associated with the discharge of any groundwater pumped during the dewatering activities will be managed following an approved environmental permit and the First Iteration EMP **[TR010044/APP/6.8]**. This will ensure that any potential impacts of flooding due to the discharge of the pumped water remain **minor** with **slight significant effect.**

6.6.27 No ground contamination has been observed at or within the vicinity of the proposed borrow pit during the detailed 2019/2020 ground investigation for the Scheme. Groundwater quality analytical results for water samples collected within the vicinity of the proposed borrow pit indicated no significant groundwater contamination issues, except for one sampling point (WS275) located approximately 900m northeast and down hydraulic gradient from the northern boundary of the borrow pit. This indicated localised hydrocarbon groundwater contamination. Analytical results from another borehole (BH275C-1) installed in the RTD located approximately 50m west of the borrow pit indicated elevated level of sulphate (420mg/l), chloride (274mg/l) manganese (860 µg/l) and benzo (a) pyrene (0.0374µg/l). There are a number of historical landfill sites to the northeast, north and northwest of the proposed borrow pit at approximately 480m, 1100m 1200m respectively from the proposed borrow pit. As these within and or marginally outside the estimated dewatering zone of influence from the borrow pit, there is a risk of remobilising potentially contaminated groundwater from these sites. However, in the absence of any significant groundwater contamination, the potential impact is considered to be **low to medium** provided best practice dewatering methodology which will include an effective groundwater quality monitoring as provided in the First Iteration EMP **[TR010044/APP/6.8]** is followed. Accordingly, the magnitude of impact on groundwater quality arising from dewatering activities will be **minor** resulting in **slight significance effect**.

6.6.28 In addition, it is proposed that groundwater monitoring boreholes are drilled around the borrow pit to provide data on the effects of dewatering to confirm the predicted effects and to provide an early warning of any changes in groundwater quality as a result of dewatering.

6.6.29 It is likely that the excavation of the borrow pit can act as a preferential pathway for any new contaminants to be mobilised into the groundwater and for unidentified nearby contaminants to be mobilised as a result of dewatering activities. However, the risk to groundwater quality is considered to be **low** provided best practice dewatering methodology which will include groundwater quality monitoring as provided in the First Iteration EMP **[TR010044/APP/6.8]** are followed. Accordingly, the magnitude of impact on groundwater quality arising from dewatering activities will be **minor** resulting in **slight significance effect**.

6.6.30 It is understood that the borrow pit would be backfilled using natural inert materials obtained from the construction of the Scheme, which are considered unsuitable on engineering parameters. Accordingly, provided the backfill material is sampled and screened for contamination in line with the Scheme's materials management plan as detailed in **Chapter 10 Material Assets and Waste** of the Environmental Statement **[TR010044/APP/6.1]** and the First Iteration EMP

[TR010044/APP/6.8], the overall magnitude of potential impacts on water resources due to contaminant mobilisation associated with the excavation and backfilling of the borrow pit will be **minor**, resulting in a **slight significant effect.**

6.6.31 It is also considered that provided the borrow pit is backfilled with suitable materials the risk and potential impacts on groundwater quality or of increased groundwater and / surface water flooding due to the backfilling is likely to be **minor** resulting in a **slight significant effect.**

6.7 Summary of the analytical assessment

6.7.1 Based on the analytical assessment carried out on the cuttings and borrow pits, the overall magnitude of potential impacts on groundwater flow and level during the construction of the Scheme are generally assessed to be **minor** resulting in overall **slight significance effects**. Potential impacts on groundwater quality through remobilisation of existing contaminants as a result of dewatering abstraction is considered to range between **low to medium**, provided best practice methodology in line with the First Iteration EMP **[TR010044/APP/6.8]** are followed. However, it is anticipated that the magnitude of the potential impacts and effects significance on groundwater during the construction and operation of the Scheme will be reduced further through the implementation of adequate mitigation measures, the proposed drainage strategy and First Iteration EMP **[TR010044/APP/6.8]** for the Scheme.

6.7.2 A summary of the analytical assessment for the elements of the Scheme, the predicted impact magnitude and effects significance is presented in **Table 6-8** below.

6.8 Piling impact assessment

6.8.1 Piling activities will be required for several civil engineering works for the Scheme and will include piling for viaducts, bridges (i.e. both road and pedestrian bridges), and associated bridge/temporary support structures. A detailed assessment of the impact magnitude and effects on groundwater is not considered in detail in this assessment as the final design for the structures, piling depths and types (whether bored piling or driven piling) are yet to be confirmed for the Scheme.

6.8.2 However, given the shallow groundwater conditions beneath most of the Scheme, it is anticipated that all piling will extend below the groundwater table and may cause local horizontal barriers to groundwater flow, resulting in groundwater levels immediately up hydraulic gradient of the works to rise above their natural levels. Any potential impacts on the groundwater level and flow regimes will be very localised as the groundwater will flow around the low permeability piles and will not affect the overall groundwater flow, given the likely sizes of the piles. Similarly, effects on groundwater quality from accidental spillages or runoffs resulting from piling activities will be very localised given the pollution control measures that will be implemented as part of the Scheme, the extent of the aquifer and the dilution available in the groundwater.

6.8.3 In all instances, adequate measures in line with best practice piling methodology (such as the use of continuous flight auger method (CFA) to prevent the creation of preferential pathways from the surface to the underlying groundwater) will be undertaken following liaison with the Environment Agency for the Scheme to ensure appropriate protection of the groundwater. Details of measures to prevent groundwater flooding and contamination, including a piling risk assessment and groundwater monitoring where necessary will be agreed with the Environment Agency before the commencement of any piling activities.

6.8.4 Based on the above, it is anticipated that the overall magnitude of the impacts from piling activities on groundwater during construction and operation of the Scheme will be **minor**, resulting in a **slight significant effect**.

6.9 Groundwater mitigation strategy

6.9.1 A Construction Dewatering Strategy (CDS) is proposed in order to mitigate the impacts of the dewatering activities on groundwater and surface water resources. The Construction Dewatering Strategy will be prepared by the Principal Contractor in accordance with this Groundwater Risk Assessment. Further details of the purposes of the CDS are presented in **Chapter 13, Road Drainage and the Water Environment**, of the Environmental Statement **[TR010044/APP/6.1]**. This strategy is secured through the First Iteration EMP **[TR010044/APP/6.8].**

6.9.2 The Construction Dewatering Strategy would also include a programme of water monitoring and controlled discharges of water abstracted during dewatering. It is anticipated that the groundwater monitoring process will be facilitated by the site-specific ground investigation (GI) boreholes installed between October 2019 and June 2020.

6.9.3 Where necessary, it is proposed that additional monitoring boreholes should be drilled at strategic points such as at around or near borrow pits and other areas of potential deep excavation with associated dewatering activities in order to ensure the monitoring process is effective. Automatic water level data loggers (or other suitable method) to facilitate continuous monitoring would be installed in selected monitoring boreholes at strategic locations.

6.9.4 It is proposed that if groundwater contains high concentrations of suspended fine sediment that this will be filtered by using storage basins (e.g. the proposed long term treatment ponds will be excavated first so they can be used for this purpose), and, in combination with other proprietary measures (e.g. lamella clarifiers).

6.10 Operational phase

6.10.1 During the operational phase of the Scheme, impacts on groundwater are likely to be similar or less than as in the construction phase, principally as the depth of the completed cuttings will be less than required for construction. In addition, there will be no requirement for dewatering of the borrow pits. Some level of permanent dewatering may be required to prevent groundwater ingress to the road and drainage systems for the Scheme. This is particularly the case at the Black Cat A1 underpass cutting which cuts through the full thickness of the Alluvium and River Terrace Deposits and where the completed level of the cutting would be permanently below the groundwater table. Several dewatering options are being considered to avoid the use of a permanent dewatering pumping scheme and to prevent or reduce the ingress of groundwater to the road and drainage systems for the Scheme. These would incorporate but not limited to measures such as groundwater flow path barriers, to be defined during the detailed design.

6.10.2 The main additional potential impacts largely are related to water quality due to the road drainage system. Impacts are likely to arise from the use of de-icing salt/chemicals on the road and potential incidental fuel and chemical spillages from road users. Impacts may also result from the use of firefighting chemicals during emergency firefighting events. The impact magnitude and effect significance will vary from one incidence to the other.

6.10.3 It is anticipated that the new drainage systems proposed for the Scheme will be designed to prevent and or minimise the risk of groundwater contamination from contaminated surface runoffs. Further detail of the proposed drainage system is given in the drainage strategy report (refer to **Appendix 13.3** of the Environmental Statement **[TR010044/APP/6.3]**).

Table 6-8: Summary of the Assessment of the Scheme Features Assessed

Scheme Element and Location	Estimated/ Calculated Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m^3/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Comment
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1)	138	1,465 - 2,241	Temporary dewatering or abstraction resulting to reduction in groundwater level and change in flow regime and loss of baseflow to surface water courses	Superficial - Secondary A aquifer	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				South Brook 450m north	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				Rockham Ditch 540m south	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further

Scheme Element and Location	Estimated/ Calculated Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m^3/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Comment
							prevent and or reduce the effect significance
			Introduction of new contaminants through accidental spillage and or surface runoff or remobilisation of existing contaminants following disturbance of contaminated ground or groundwater	Groundwater quality	Negligible	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
Barford Road Cutting	4.9	12 - 25	Temporary dewatering or abstraction resulting in reduction in groundwater level and change in flow regime and loss of baseflow to surface water courses	Superficial Secondary Undifferentiated aquifer	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				River Great Ouse 200m south	No Change	Neutral	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m^3/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Comment
				Groundwater level and flow regime	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
			Introduction of new contaminants through accidental spillage and or surface runoff or mobilisation of existing contaminants following disturbance of contaminated ground or groundwater	Groundwater quality	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
Alington Hill cutting	4.1	65 - 120	Temporary dewatering or abstraction resulting in reduction in groundwater level and change in flow regime and loss of baseflow to surface water courses	Superficial – Secondary Undifferentiated aquifer	Negligible adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				River Great Ouse 1.7km northwest	No Change	Neutral	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further

Scheme Element and Location	Estimated/ Calculated Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m^3/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Comment
							prevent and or reduce the effect significance
				Spring 1.8km northwest	No Change	Neutral	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
			Introduction of new contaminants through accidental spillage and or surface runoff or mobilisation of existing contaminants following disturbance of contaminated ground or groundwater	Groundwater quality	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m^3/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Comment
Black Cat [BPA]	85	2,775	Temporary dewatering or abstraction resulting in reduction in groundwater level and change in flow regime and loss of baseflow to surface water courses	Superficial - Secondary A aquifer	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				South Brook 290m north	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
			Introduction of new contaminants through accidental spillage and or surface runoff or mobilisation of existing contaminants following disturbance of	Groundwater quality	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m^3/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Comment
			contaminated ground or groundwater				
Black Cat [BPC]	42	770	Temporary dewatering or abstraction resulting in reduction in groundwater level and change in flow regime and loss of baseflow to surface watercourses	Superficial - Secondary A aquifer	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				South Brook and River Great Ouse 100m north and 420m east respectively	Negligible	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further prevent and or reduce the effect significance
			Introduction of new contaminants through accidental spillage and or surface runoff or mobilisation of existing	Groundwater quality	Minor adverse	Slight	Mitigation measures in the First Iteration EMP **[TR010044/APP/6.8]** will help to further

Scheme Element and Location	Estimated/ Calculated Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m^3/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Comment
			contaminants following disturbance of contaminated groundwater				prevent and or reduce the effect significance

7 References

Ref 13-1 Design Manual for Roads and Bridges: LA 113 Road drainage and the water environment (Revision 1). Highways England (2020). https://www.standardsforhighways.co.uk/prod/attachments/d6388f5f-2694-4986-ac46-b17b62c21727

Ref 13-2 Hydrogeological Impact Appraisal for Dewatering Abstractions – Science Report SC040020/SR1. Environment Agency (2007). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291080/scho0407bmae-e-e.pdf

Ref 13-3 Groundwater Risk Assessment for Your Environmental Permit. Environment Agency and Department for Environment, Food & Rural Affairs (2018). https://www.gov.uk/guidance/groundwater-risk-assessment-for-your-environmental-permit

Ref 13-4 Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. European Parliament and the Council of the European Union (2000). https://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF

Ref 13-5 A428 Black Cat to Caxton Gibbet Improvements Ground Investigation Report - HE551495-ACM-VGT-GEN_SW_Z_ZZ-RP-GE-0004 P02 S3 HAGDMS no. 31712. AECOM (2020).

Ref 13-6 Geoindex. British Geological Survey (2020). https://mapapps2.bgs.ac.uk/geoindex/home.html

Ref 13-7 MAGIC online interactive mapping. Department for Environment Food & Rural Affairs. https://magic.defra.gov.uk/magicmap.aspx

Figure 1 Overview of the Scheme and Study Area Showing Elements of the Scheme Assessed

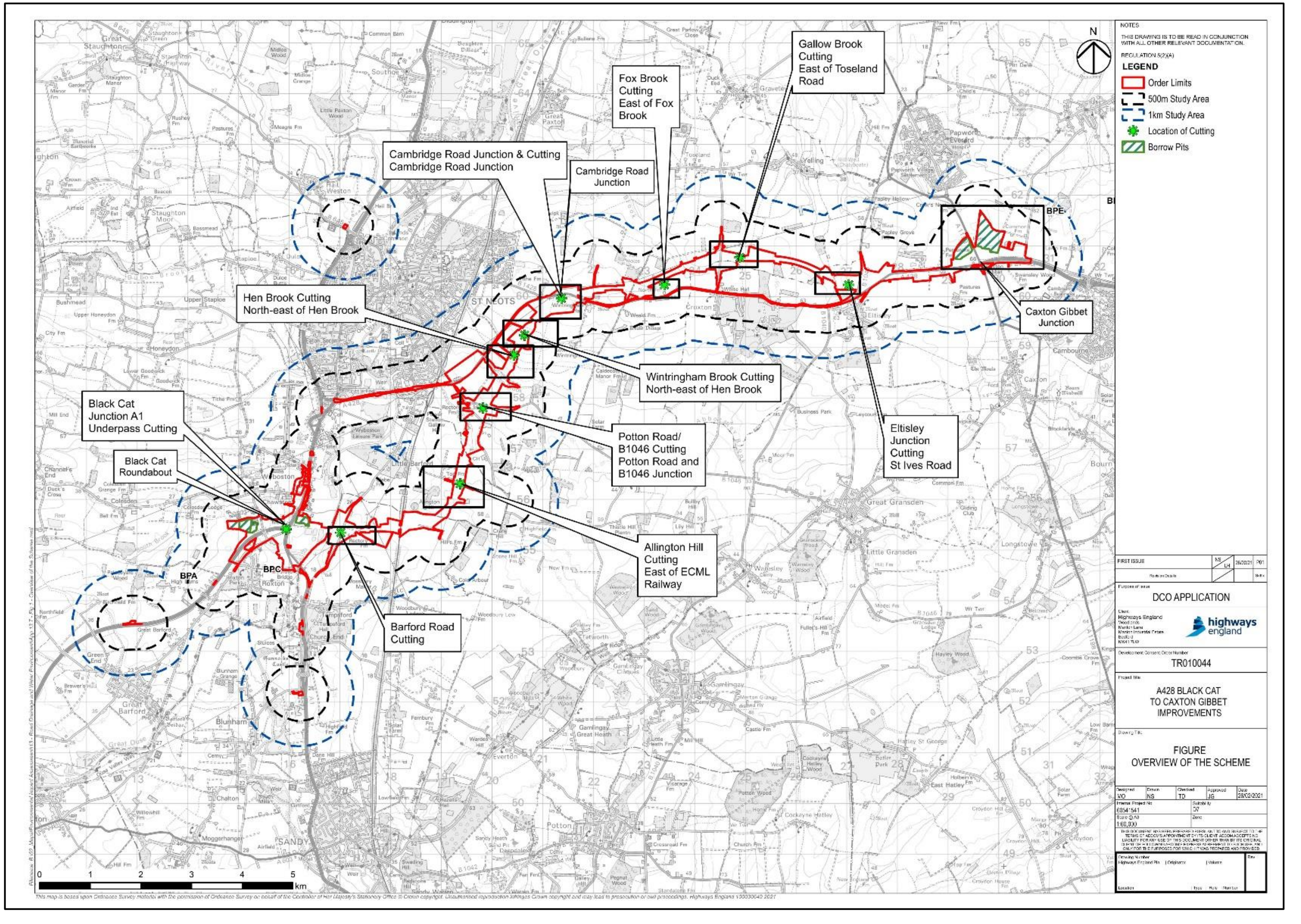


Figure 2 Superficial Geology beneath the Study Area and Extended Study Area

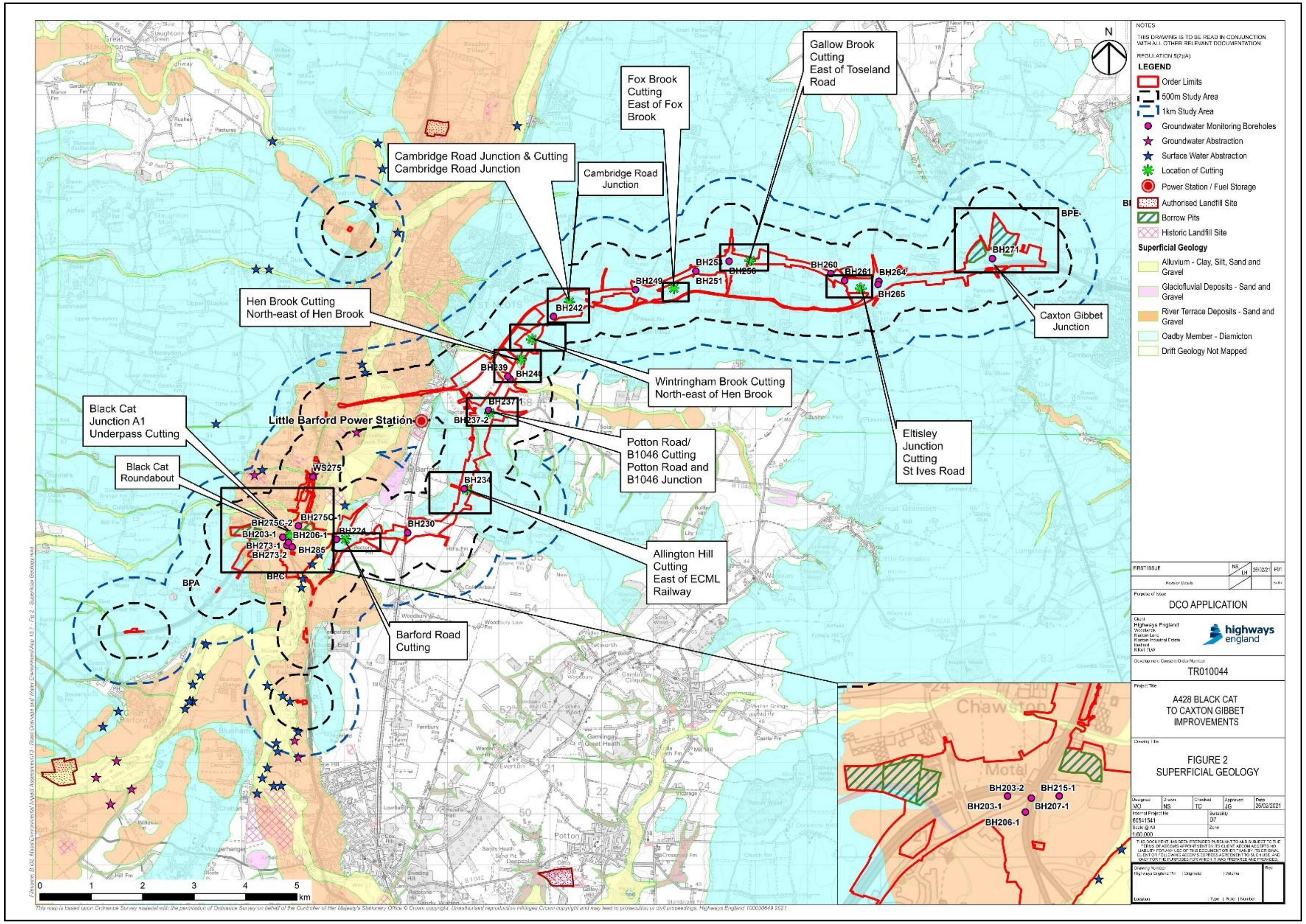


Figure 3 Bedrock Geology Beneath the Study Area

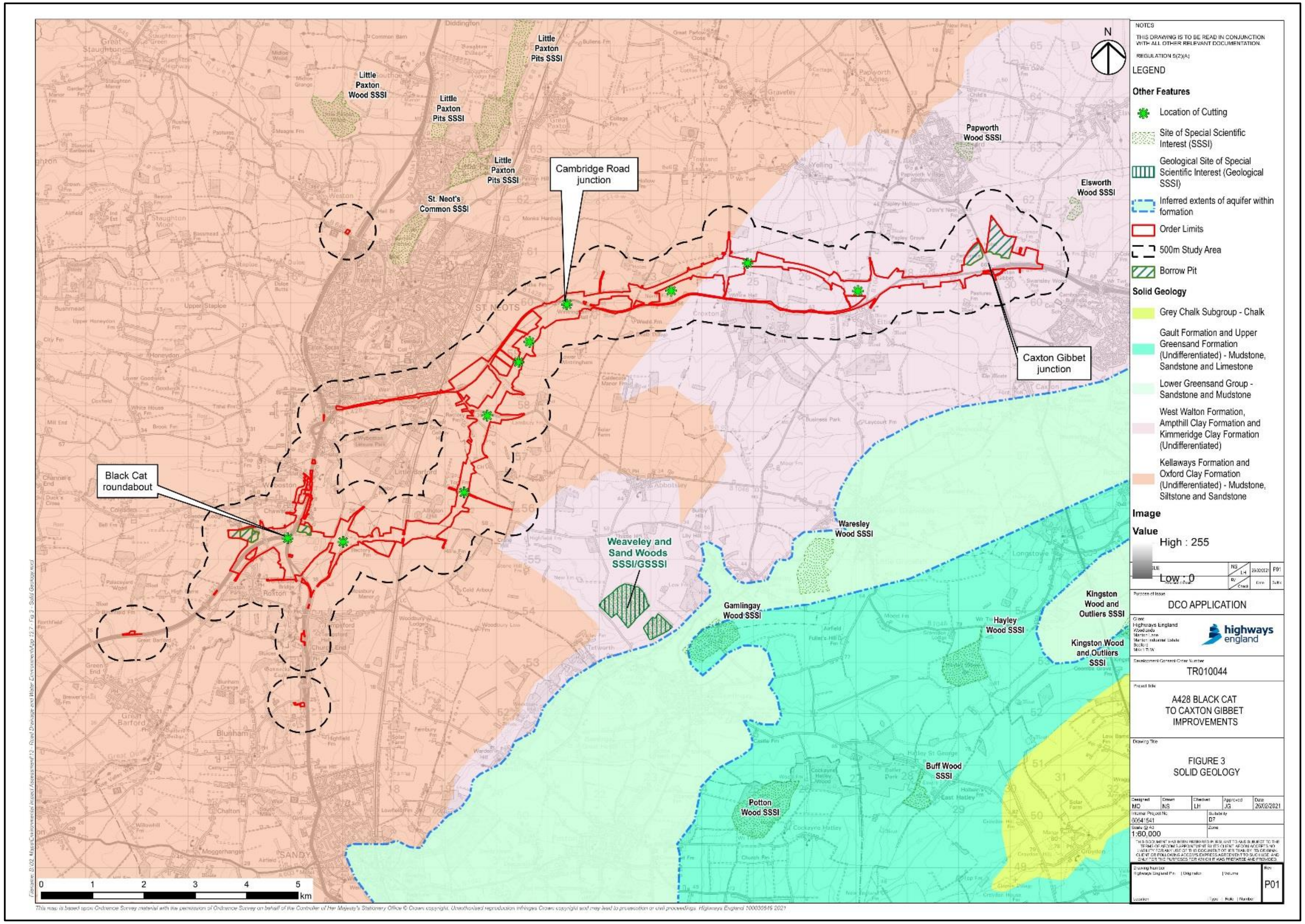
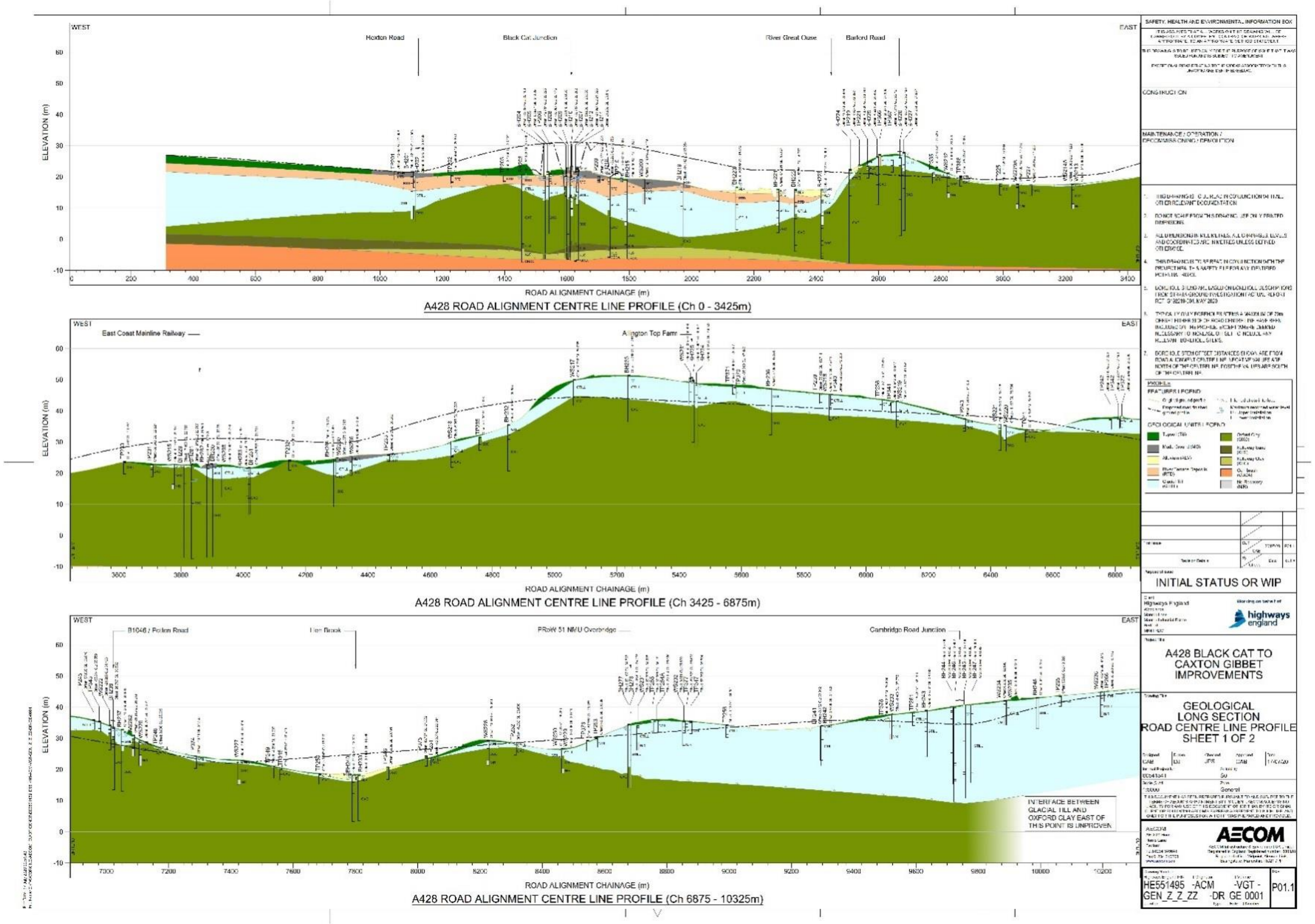


Figure 4 Ground Investigation Interpreted Geological Cross-Sections Beneath the Study Area



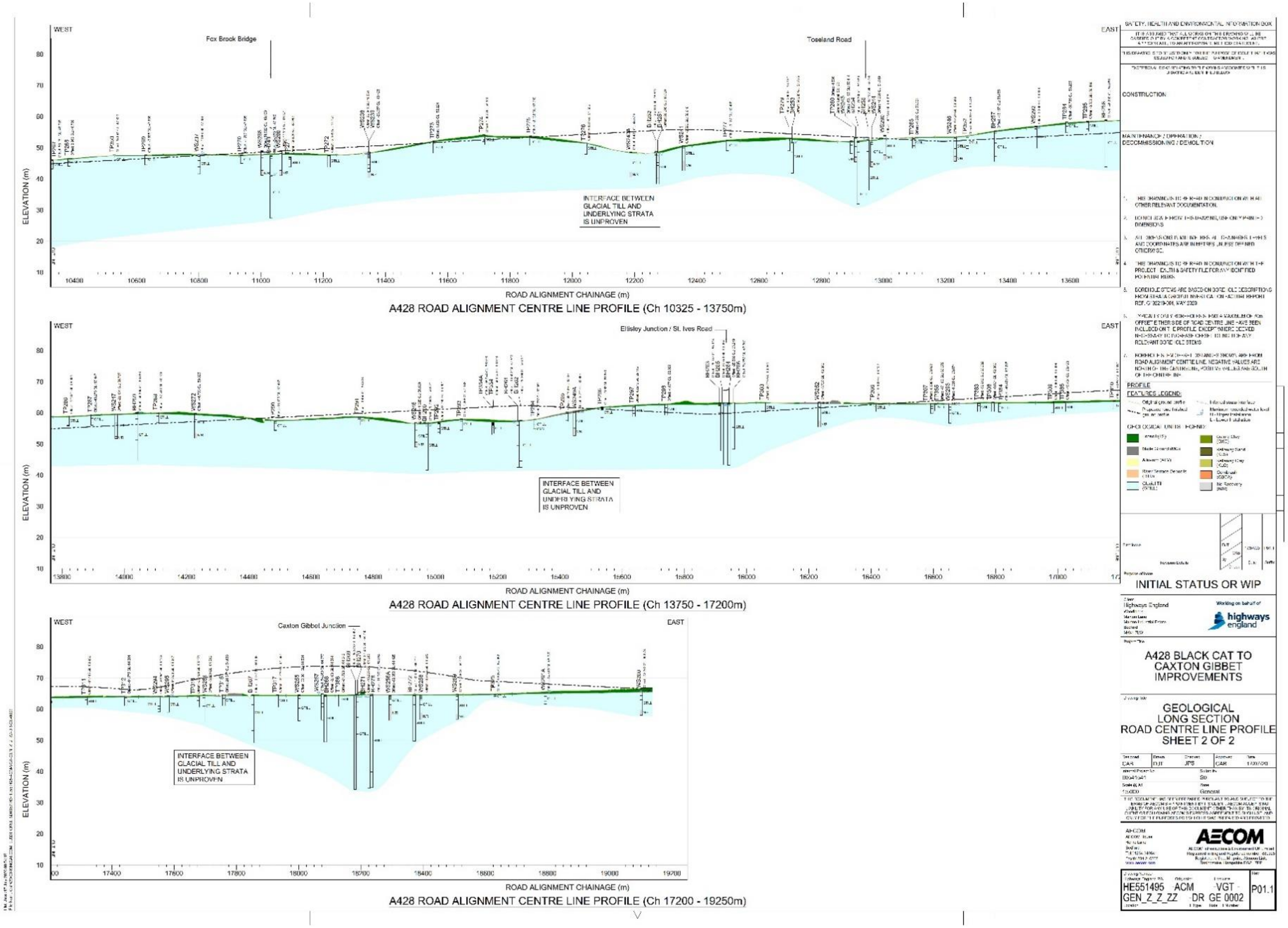
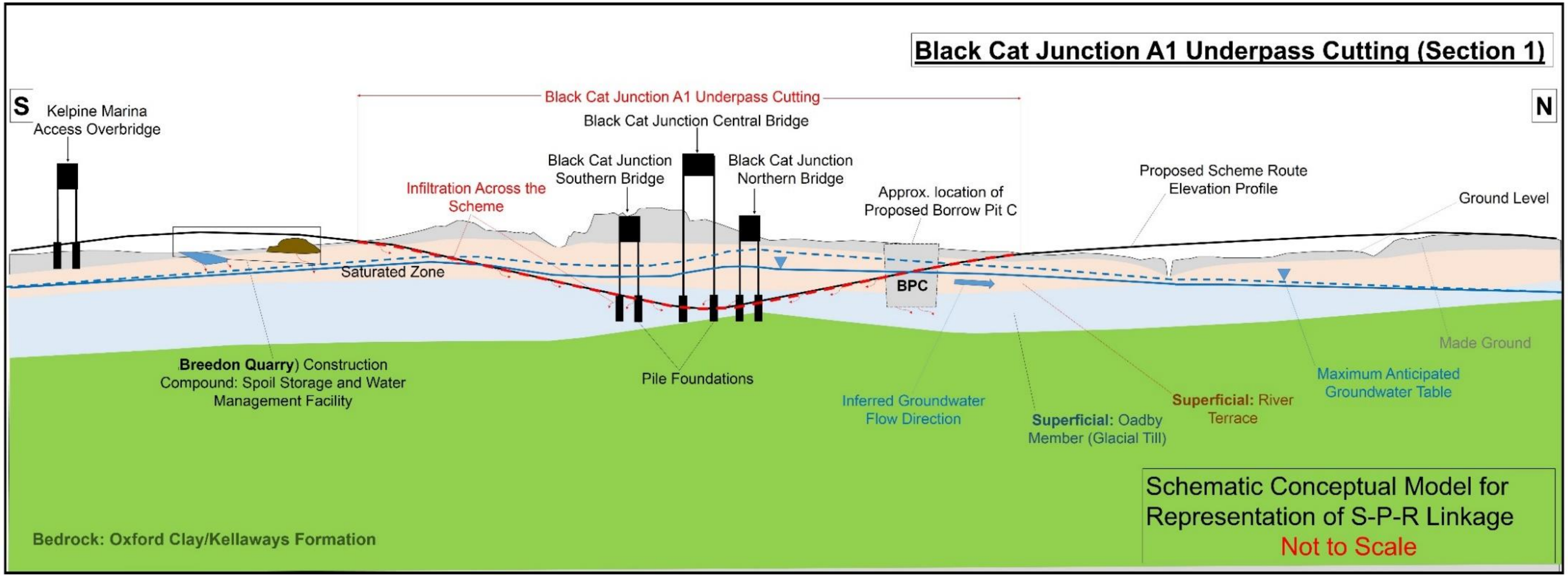

WEST
EAST
Fox Brook Bridge
Toseland Road
ELEVATION (m)
INTERFACE BETWEEN GLACIAL TILL AND UNDERLYING STRATA IS UNPROVEN
ROAD ALIGNMENT CHAINAGE (m)
A428 ROAD ALIGNMENT CENTRE LINE PROFILE (Ch 10325 - 13750m)
Eltisley Junction / St. Ives Road
A428 ROAD ALIGNMENT CENTRE LINE PROFILE (Ch 13750 - 17200m)
Caxton Gibbet Junction
A428 ROAD ALIGNMENT CENTRE LINE PROFILE (Ch 17200 - 19250m)
CONSTRUCTION
MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION
INITIAL STATUS OR WIP
Highways England
highways england
A428 BLACK CAT TO CAXTON GIBBET IMPROVEMENTS
GEOLOGICAL LONG SECTION ROAD CENTRE LINE PROFILE SHEET 2 OF 2
AECOM
HE551495 ACM VGT P01.1
GEN_Z_Z_ZZ DR GE 0002

Figure 5 A – D Conceptual Illustration of the S-P-R Model and the Groundwater Conditions beneath the Study Area

Figure 5A



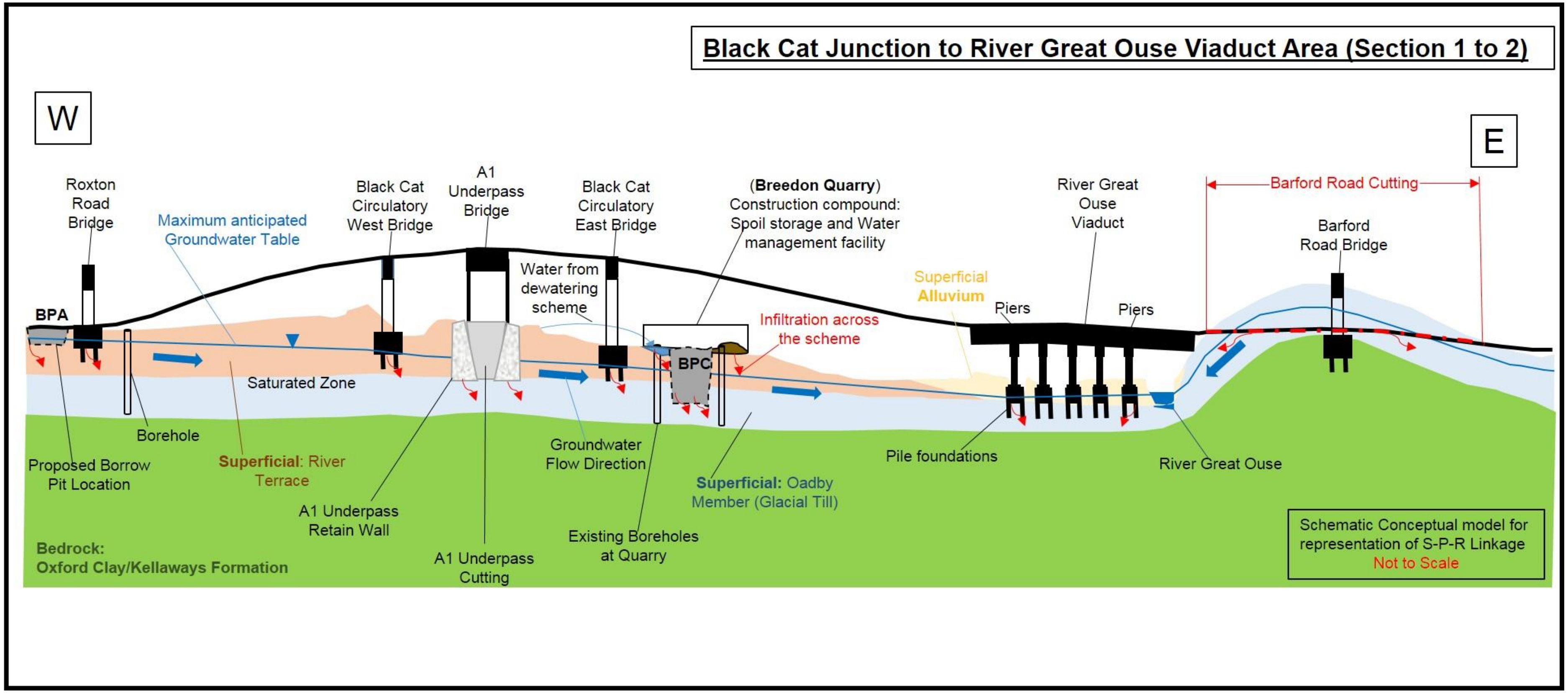

Black Cat Junction to River Great Ouse Viaduct Area (Section 1 to 2)
W
E
Roxton Road Bridge
BPA
Maximum anticipated Groundwater Table
Black Cat Circulatory West Bridge
A1 Underpass Bridge
Black Cat Circulatory East Bridge
Water from dewatering scheme
(Breedon Quarry) Construction compound: Spoil storage and Water management facility
BPC
Infiltration across the scheme
Superficial Alluvium
River Great Ouse Viaduct
Piers
Piers
Barford Road Cutting
Barford Road Bridge
Saturated Zone
Borehole
Proposed Borrow Pit Location
Superficial: River Terrace
A1 Underpass Retain Wall
A1 Underpass Cutting
Groundwater Flow Direction
Existing Boreholes at Quarry
Superficial: Oadby Member (Glacial Till)
Pile foundations
River Great Ouse
Bedrock: Oxford Clay/Kellaways Formation
Schematic Conceptual model for representation of S-P-R Linkage
Not to Scale

Figure 5B

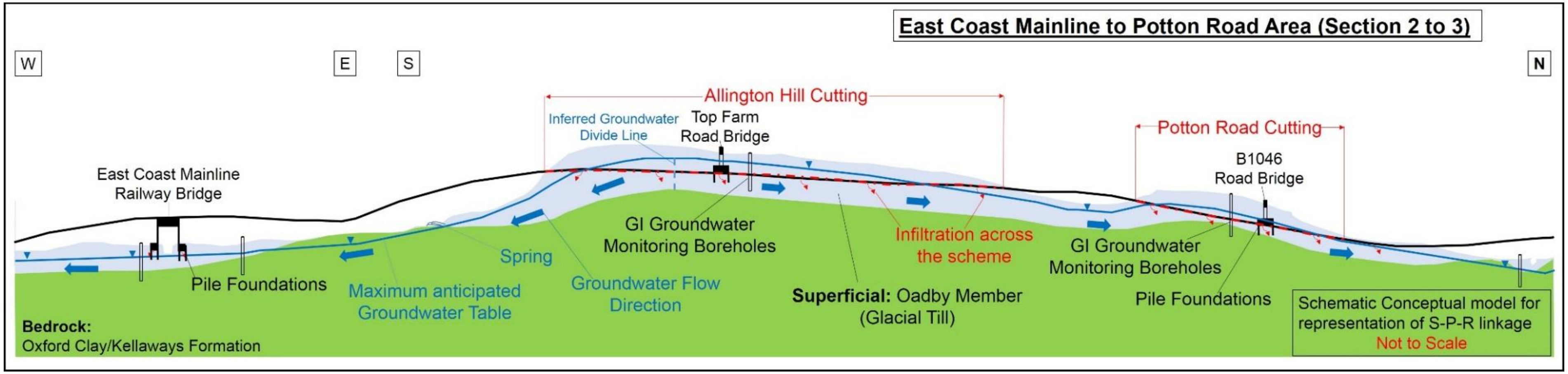


Figure 5C

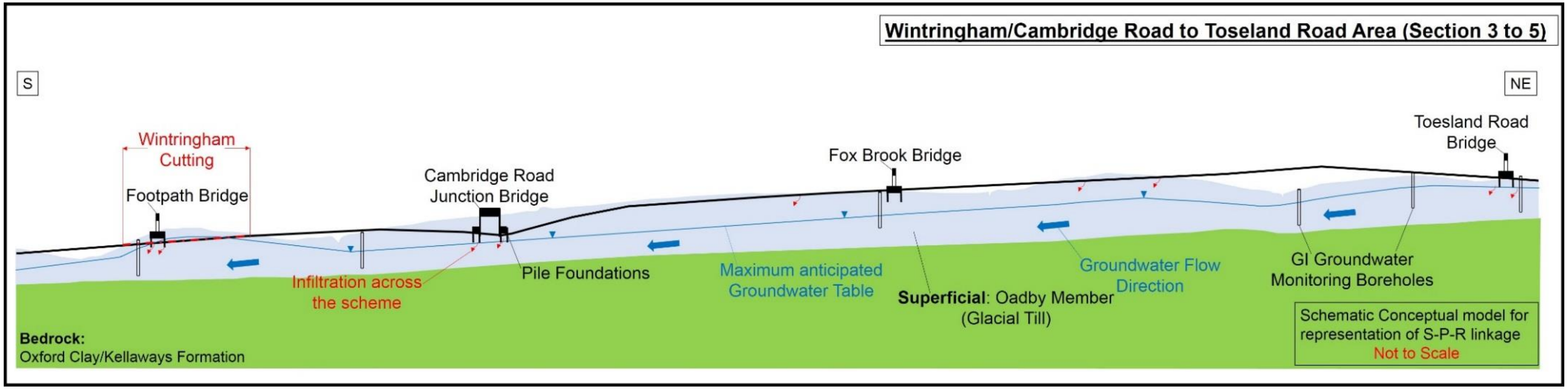


Figure 5D

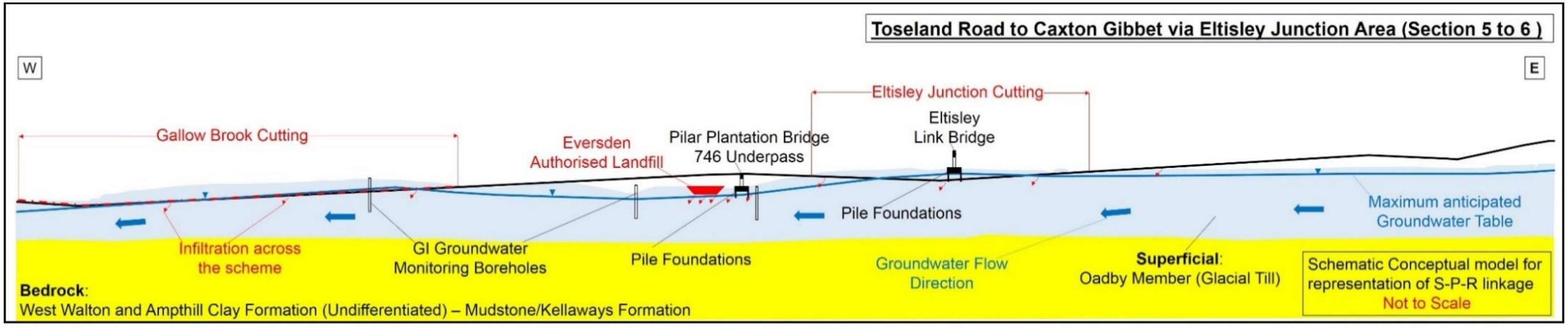

Toseland Road to Caxton Gibbet via Eltisley Junction Area (Section 5 to 6)
W
E
Eltisley Junction Cutting
Eltisley
Link Bridge
Gallow Brook Cutting
Eversden
Authorised Landfill
Pilar Plantation Bridge
746 Underpass
Pile Foundations
Maximum anticipated
Groundwater Table
Infiltration across
the scheme
GI Groundwater
Monitoring Boreholes
Pile Foundations
Groundwater Flow
Direction
Superficial:
Oadby Member (Glacial Till)
Schematic Conceptual model for
representation of S-P-R linkage
Not to Scale
Bedrock:
West Walton and Ampthill Clay Formation (Undifferentiated) – Mudstone/Kellaways Formation

Figure 6 Groundwater Quality Sampling Points within the Study Area

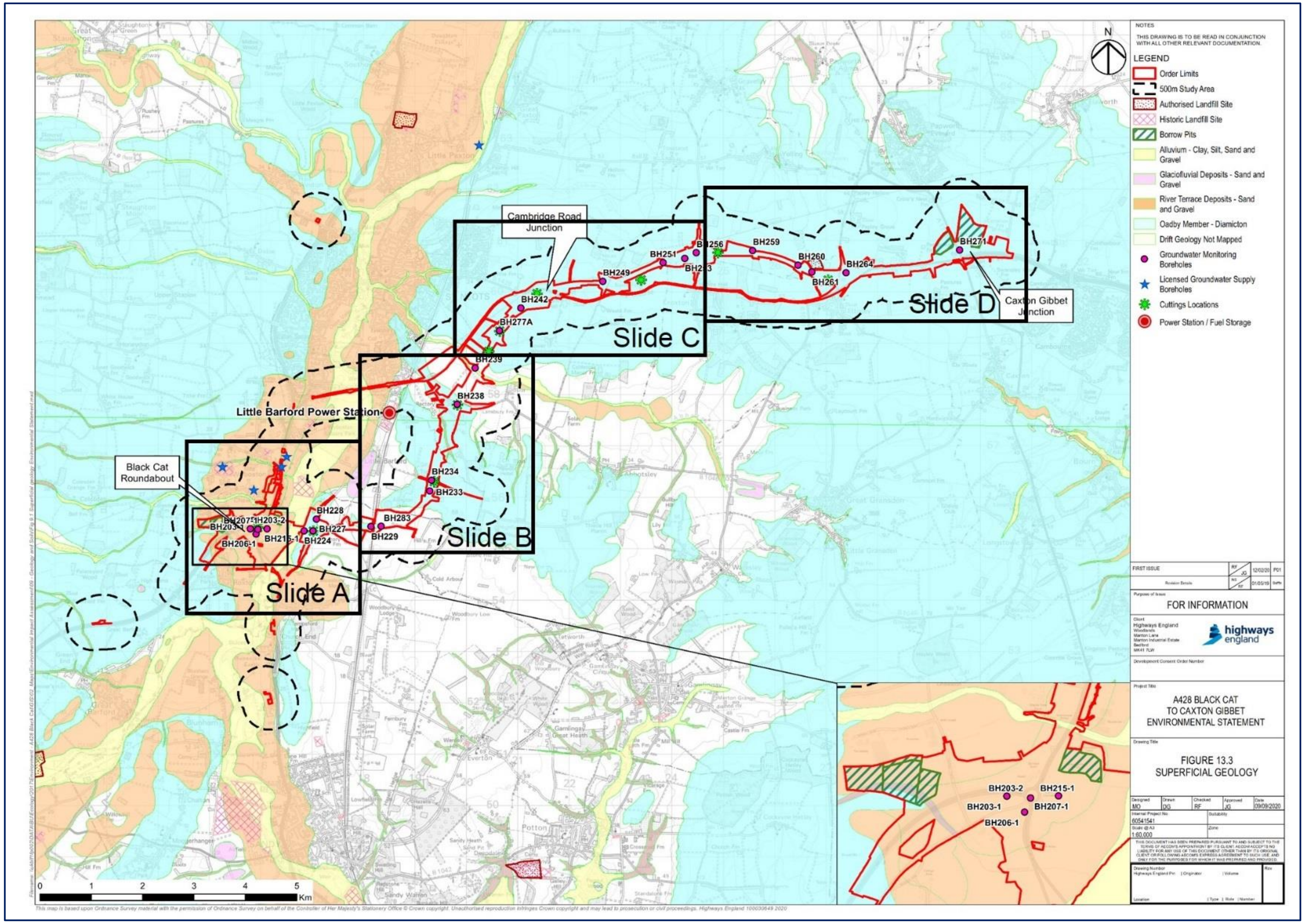


Figure 7 Key Water Features (Groundwater and Surface Water) within the Study Area

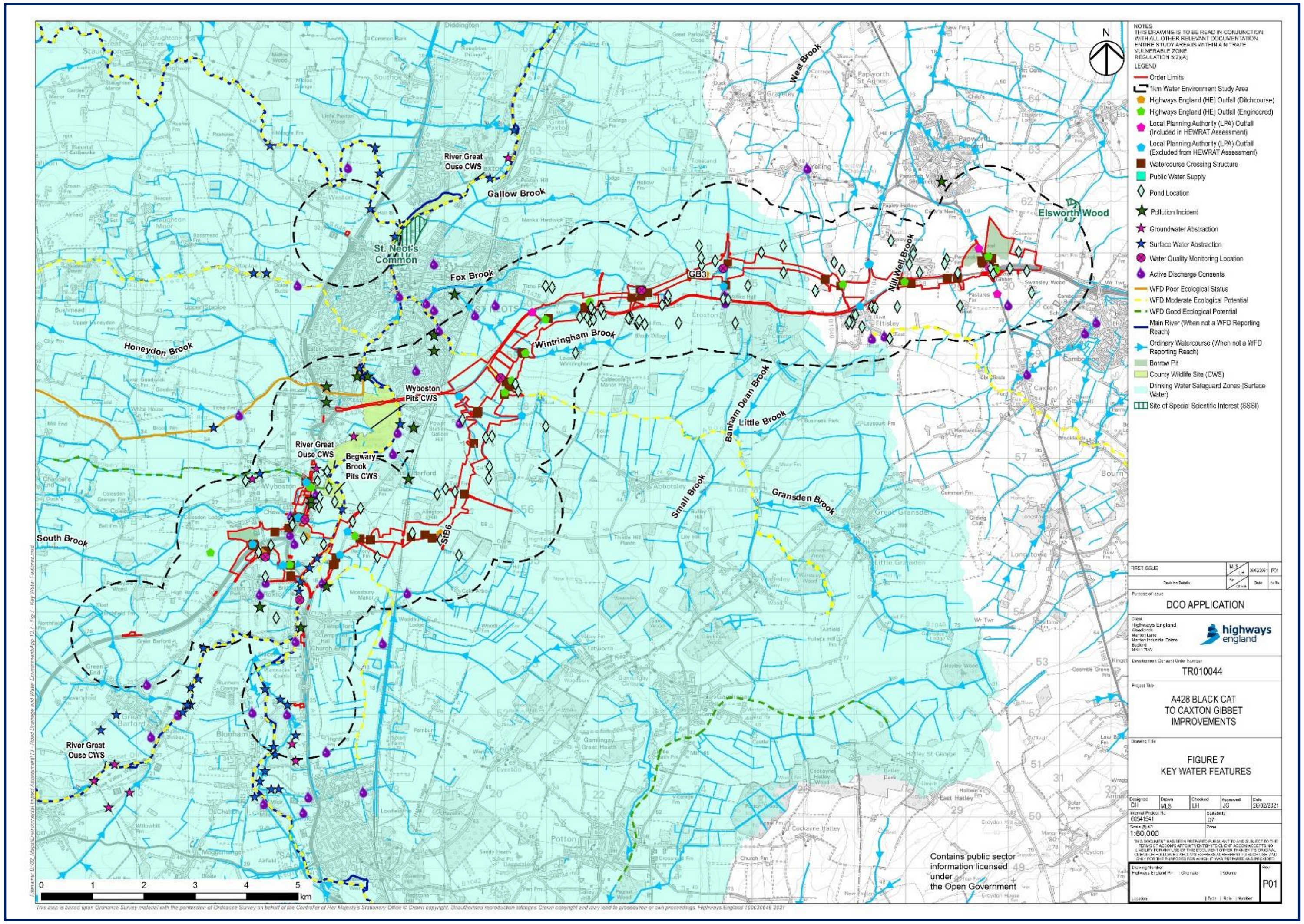


Figure 8 Designated Sites within the Study Area

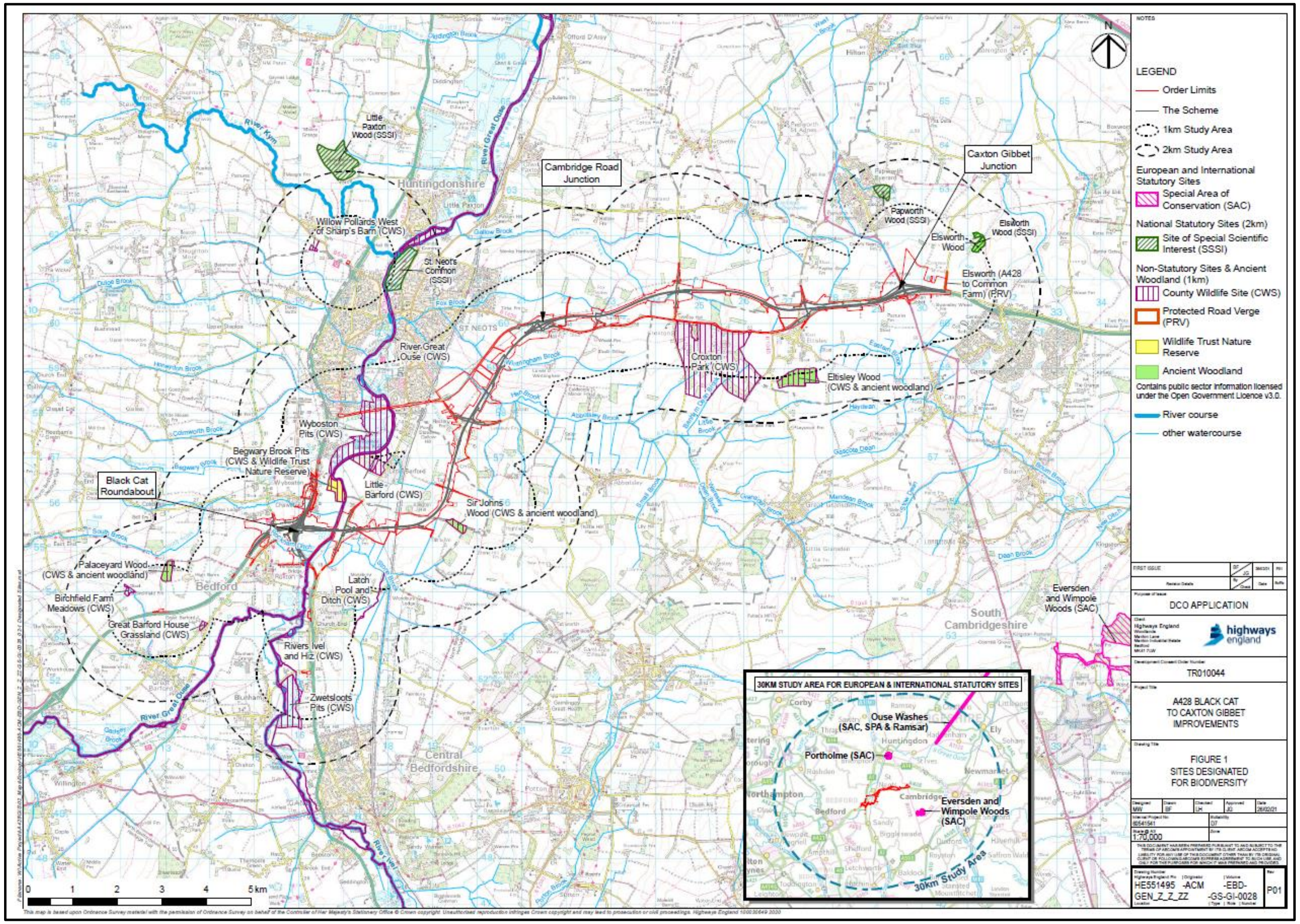
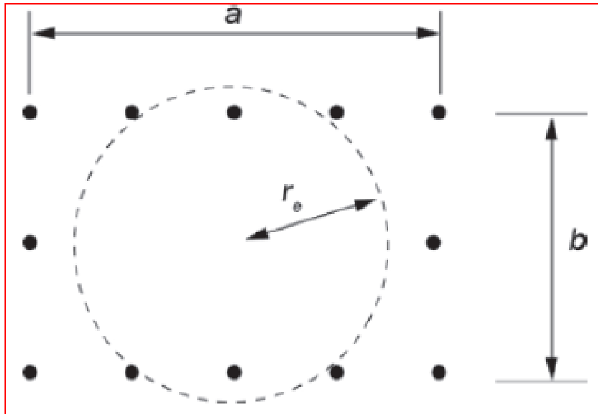


Figure 9 Analytical Conceptual Model for Cutting and Borrow Pit Dewatering Assessment

Cuttings Modelled as Long Narrow System of Continuous Slot Between Equivalent Wells

c) Long narrow system modelled as continuous slot between wells

Borrow Pits Modelled as Rectangular System of Equivalent Wells



b) Rectangular system modelled as equivalent well of radius, r_e

Annex 1 Full Suite Water Quality Analysis Results

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	Units	Limit of detection	DWS																								
Alkalinity, Total as CaCO3	mg/l	2	-	575	1210	225	286	283	222	11600	2060	1260	572	441	455	449	313	301	252	252	227	1570	161	143	512	320	184
Bicarbonate Alkalinity as HCO3	mg/l	2	-	701	1480	274	349	345	270	14100	2510	1540	698	538	555	548	382	368	308	308	277	1920	197	174	624	390	225
BOD, unfiltered	mg/l	1	-	14.7	6.05	**1**	**1**	**1**	**1**	21.1	6.78	**1**	3.04	**1**	**1**	**1**	**1**	2	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	2.77
Carbon, Organic (diss.filt)	mg/l	3	-	3.17	4.73	3.41	**3**	3.71	**3**	5.98	8.17	4.26	13.5	3.73	6.02	4.89	3.85	5.75	3.27	3.23	5.04	**3**	3.88	3.41	**3**	13.8	4.38
Ammoniacal Nitrogen as N (low	mg/l	0.01	1.5	1.37	0.526	1.24	**0.01**	0.013	**0.01**	0.0759	0.92	0.225	1.44	0.659	1.8	1.38	1.83	3.07	0.058	**0.01**	0.559	0.346	0.052	0.881	0.0524	0.472	0.715
Ammoniacal Nitrogen as NH3	mg/l	0.2	-	0.256	0.646	1.65	**0.2**	**0.2**	**0.2**	**0.2**	1.02	0.271	1.91	0.571	1.77	0.981	1.8	3.31	**0.2**	**0.2**	0.682	0.378	**0.2**	1.04	**0.2**	0.284	0.825
Fluoride	mg/l	0.5	1.5	**0.5**	0.622	1.67	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	0.604	**0.5**
COD, unfiltered	mg/l	7	-	2260	1340	24.9	12.4	**7**	19.5	3440	3680	196	90.6	926	39.5	22.5	**7**	16.5	12.6	**7**	71.8	93.4	19.4	44.4	**7**	69.6	58.2
Conductivity 20 deg.C	mS/cm	0.02	-	1.48	1.91	3.35	0.946	0.936	0.651	0.708	2.96	1.25	6.23	4.44	4.23	4.26	2.61	2.52	2.85	0.8	4.07	2.84	3.3	3.46	0.957	2.73	3.73
Dissolved solids, Total (meter)	mg/l	5	-	1170	1540	2830	710	762	527	562	2590	978	6050	3960	3620	3660	2220	1950	2550	632	4180	2700	2790	2670	775	2010	2820
Aluminium (tot.unfilt)	µg/l	10	-	19300	49500	53.4	498	298	2740	39000	81800	26700	12300	19900	748	430	412	242	92.6	585	1170	17700	192	158	1290	518	1670
Chromium, Trivalent (Low)	mg/l	0.0003	-	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	**0.0003**	**0.003**	**0.003**	**0.0003**	**0.003**	**0.003**	**0.0003**	**0.0003**	**0.003**	**0.0003**	**0.003**	**0.003**	**0.003**	**0.0003**	**0.0003**	**0.003**	0.00557
Arsenic (diss.filt)	µg/l	0.5	10	2.94	1.6	**0.5**	**0.5**	**0.5**	**0.5**	1.19	0.747	4.15	1.94	0.898	2.54	2.02	1	0.557	0.644	**0.5**	0.991	0.894	**0.5**	**0.5**	**0.5**	2.39	0.511
Arsenic (tot.unfilt)	µg/l	2	-	17.1	39.5	**2**	**2**	**2**	**2**	53.3	58.9	40.4	14.7	21.8	3.28	2.63	**2**	**2**	**2**	**2**	**2**	25.3	**2**	2.55	**2**	2.73	**2**

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	Units	Limit of detection	DWS																								
Boron (tot.unfilt)	µg/l	20	-	346	1030	2820	83.5	117	37.4	100	976	147	1320	788	1630	1460	2110	1340	1240	127	2460	1490	2550	1780	171	819	1950
Cadmium (diss.filt)	µg/l	0.08	5	0.08	0.08	0.08	0.08	0.08	0.08	0.383	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.119	0.08	0.08	0.08	0.08	0.08	0.08
Cadmium (tot.unfilt)	µg/l	0.5	-	0.537	3.96	0.5	0.5	0.5	0.5	1.18	3.94	0.736	0.677	0.63	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.671	0.5	0.5	0.5	0.5	0.5
Chromium (tot.unfilt)	µg/l	3	-	55.6	148	3	3	10.9	10.3	121	208	69.2	37.5	52.3	3	3	3	3	3	3	3.02	71.3	3	3	3.24	3	4.24
Chromium (diss.filt)	µg/l	1	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5.57
Copper (tot.unfilt)	µg/l	1	-	39.4	165	1	1	1.29	5.48	108	223	60.3	30.6	35.2	3	1.3	1.77	1.9	1	1.31	3.57	24.1	1	1	2.94	2.66	4.97
Cobalt (diss.filt)	µg/l	0.5	-	1.52	2.31	0.5	0.5	0.5	0.5	0.57	5.55	1.2	5.02	3.24	6.91	2.79	1.59	1.21	2.22	0.5	0.744	1.33	0.5	0.5	0.5	1.08	1.02
Lead (diss.filt)	µg/l	0.2	10	5.85	0.808	0.2	4.11	0.383	0.2	0.2	3.34	0.2	0.992	0.2	0.2	0.2	0.2	0.521	0.242	0.2	0.912	3.6	0.282	0.2	0.578	2.63	0.332
Nickel (tot.unfilt)	µg/l	1	-	65.5	287	1	2.3	2.71	8.34	199	458	90.8	42.1	50.6	12.5	5.66	6.25	9.56	6.72	2.09	11.2	61.5	3.21	2.57	5.46	8.62	9.29
Manganese (diss.filt)	µg/l	3	50	992	860	36.9	83.1	123	11.5	51.7	2050	222	743	543	422	201	542	204	449	3	132	68.3	22.5	172	15.8	38.8	110
Selenium (tot.unfilt)	µg/l	1	-	2.45	11.7	1	1	1	1	10.2	14.7	4.24	5.12	2.86	1	1	1	1	1.65	1.94	6.68	2.9	1	1	1	76.7	1
Nickel (diss.filt)	µg/l	0.4	20	5.16	7.04	0.4	2.96	1.7	1.24	3.87	11.8	2.75	10.1	8.49	9.7	5.45	2.74	9.03	4.8	0.776	7.51	6.09	1.81	1.56	1.52	7.7	5.76
Zinc (tot.unfilt)	µg/l	5	-	1060	901	5	5.47	14.3	53.7	361	2130	392	276	105	15.8	14.1	13.6	54	7.54	5.72	65.1	161	11	7.1	12.4	14	30.9
Silver (Tot. Unfilt.)	µg/l	1	-	1	6	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sodium (Dis.Filt)	mg/l	0.076	200	179	191	529	61.2	83.2	96.4	52.8	247	159	823	339	427	316	305	381	168	35.2	526	256	440	461	59.6	504	504
Magnesium (Dis.Filt)	mg/l	0.036	-	13.6	13.6	24.8	5.95	7.42	1.93	6.38	131	9.93	229	245	239	233	76.7	68.2	136	17.6	164	127	83.4	83.5	11.5	26.9	123
Potassium (Dis.Filt)	mg/l	0.2	-	5.24	7.05	17.2	2.61	3.35	1.81	19.7	23.7	4.11	54.7	17.2	29.8	25.2	22.2	29.1	7.8	1.37	18.6	9.26	15.2	11	1.96	12.2	14.5
Calcium (Dis.Filt)	mg/l	0.2	-	154	133	55.6	134	128	53	102	417	134	367	548	412	447	208	139	462	131	351	392	186	221	147	67	347
Iron (Dis.Filt)	mg/l	0.019	0.2	4.35	0.103	0.172	0.0852	0.0491	0.019	0.019	0.109	0.019	1.11	0.0501	3.65	5.43	0.823	0.331	0.256	0.019	0.0934	0.376	0.019	0.0589	0.1	0.0717	0.019

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	Units	Limit of detection	DWS																								
Hardness, Total as CaCO3	mg/l	0.35	-	704	2320	244	410	406	189	5740	3870	2160	2090	3070	2130	2620	870	733	2010	442	1800	2920	865	990	693	322	1410
Mercury (diss.filt)	µg/l	0.01	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mercury (tot.unfilt)	µg/l	0.02	-	0.0251	0.0563	0.02	0.02	0.02	0.02	0.1	0.02	0.02	0.0646	0.0602	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Nitrite as NO2	mg/l	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.554	0.075	0.05	0.05	0.05	0.05	0.05	0.776	0.05	0.05	0.248	0.05	0.05	0.076	0.05	3.27	0.05
Sulphate	mg/l	2	250	262	422	906	95.7	129	29.5	124	1670	159	2690	2110	2090	2220	1120	831	1800	152	1760	1510	1200	786	179	964	1120
Chloride	mg/l	2	250	242	274	563	105	117	98.6	38.8	193	215	832	662	434	376	158	256	107	12	587	194	464	828	58.8	223	779
Nitrate as NO3	mg/l	0.3	50	2.7	3.63	0.3	3.27	0.3	2.97	12.6	7.3	0.946	0.3	0.3	0.3	0.3	0.33	8.4	2.64	70.2	1.83	0.721	5.71	2.44	75.5	1.64	1.55
Turbidity	ntu	0.1	-	3910	3900	6.94	37.6	17.1	73.2	56400	18300	3270	755	850	77.6	62.2	19.1	10.6	8.23	32.3	104	3260	13.7	29.8	464	26.5	48.6
Phenol (low level)	µg/l	0.5	-	0.5	0.5	0.58	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cresols (low level)	µg/l	0.5	-	0.5	0.5	2.01	0.5	0.5	0.5	0.5	0.5	0.5	1.05	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Xylenols (low level)	µg/l	0.5	-	0.5	0.5	5.01	0.5	0.5	0.5	0.55	0.5	2.09	1.12	3.23	1.53	1.06	1.39	1.4	1.79	1.13	1.54	0.91	1.11	0.94	2.68	0.5	0.5
Sum of Detected Monohydric	µg/l	0.5	-	0.5	0.5	7.6	0.5	0.5	0.5	0.55	0.5	2.09	2.17	3.23	1.53	1.06	1.39	1.4	1.79	1.13	1.54	0.91	1.11	0.94	2.68	0.5	0.5
pH	pH Units	1	6.5 - 9.5	7.27	7.48	7.94	7.19	7.33	7.63	7.46	7.22	7.54	7.28	7.14	7.11	7.34	7.84	7.59	7.31	7.46	7.7	7.62	7.69	7.67	7.48	8.1	7.78
Cyanide, Total (low level)	µg/l	5	50	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cyanide, Free (low level)	µg/l	2.5	50	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Cyanide, Complex (low level)*	µg/l	5	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	Units	Limit of detection	DWS																								
Low Level Hexavalent	mg/l	0.003	-	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.006	0.003	0.003	0.003	0.003	0.006
Trifluralin	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
alpha-HCH	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
gamma-HCH (Lindane)	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Heptachlor	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Aldrin	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
beta-HCH	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Isodrin	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
delta-HCH	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Heptachlor epoxide	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
o,p'-DDE	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Endosulphan I	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
trans-Chlordane	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
cis-Chlordane	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
p,p'-DDE	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dieldrin	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
o,p'-DDD (TDE)	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Endrin	µg/l	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.02
o,p'-DDT	µg/l	0.01	-	0.01	0.02	0.02	0.02	0.02	0.02	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	**Units**	**Limit of detection**	**DWS**																								
p,p'-DDD (TDE)	µg/l	0.01	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Endosulphan II	µg/l	0.02	-	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	0.1	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
p,p'-DDT	µg/l	0.01	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	**0.01**	0.02	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**	**0.01**	**0.01**	0.02	0.04
o,p'-Methoxychlor	µg/l	0.01	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	**0.01**	0.02	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**	**0.01**	**0.01**	0.02	0.02
p,p'-Methoxychlor	µg/l	0.01	-	0.02	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.05
Endosulphan Sulphate	µg/l	0.02	-	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.02**	0.1	0.04	0.04	0.04	0.04	0.04	0.04	0.04	**0.02**	0.04	0.04	0.04	0.04	**0.02**	0.04
Permethrin I	µg/l	0.01	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Permethrin II	µg/l	0.01	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
1,3,5-Trichlorobenzene	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Hexachlorobutadiene	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
1,2,4-Trichlorobenzene	µg/l	0.01	**0.1**	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
1,2,3-Trichlorobenzene	µg/l	0.01	**0.1**	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.258	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Dichlorvos	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Dichlobenil	µg/l	0.01	-	0.1	0.1	0.0151	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Mevinphos	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Tecnazene	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Hexachlorobenzene	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Demeton-S-methyl	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Phorate	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Diazinon	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Triallate	µg/l	0.01	-	0.1	0.274	0.0349	**0.01**	0.02	0.015	0.2	0.291	0.1	0.1	0.0324	0.0162	0.0129	0.0153	0.0162	**0.01**	**0.01**	0.171	**0.01**	0.0322	0.0297	0.0416	0.0787	0.498

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	**Units**	**Limit of detection**	**DWS**																								
Atrazine	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Simazine	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Disulfoton	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Propetamphos	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Chlorpyriphos-methyl	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Dimethoate	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Pirimiphos-methyl	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Chlorpyriphos	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Methyl Parathion	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Malathion	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Fenthion	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Fenitrothion	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Triadimefon	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Pendimethalin	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	3.55
Parathion	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Chlorfenvinphos	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
trans-Chlordane	µg/l	0.01	-	0.1	0.1	**0.01**	**0.01**	0.02	**0.01**	0.2	0.1	0.1	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	Units	Limit of detection	DWS																								
cis-Chlordane	µg/l	0.01	-	0.1	0.1	0.01	0.01	0.02	0.01	0.2	0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ethion	µg/l	0.01	-	0.1	0.1	0.01	0.01	0.02	0.01	0.2	0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Carbophenothion	µg/l	0.01	-	0.1	0.1	0.01	0.01	0.02	0.01	0.2	0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Triazophos	µg/l	0.01	-	0.1	0.1	0.01	0.01	0.02	0.01	0.4	0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Phosalone	µg/l	0.01	-	0.1	0.1	0.01	0.01	0.02	0.01	0.8	0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Azinphos methyl	µg/l	0.02	-	0.2	0.2	0.02	0.02	0.04	0.02	1.6	0.2	0.2	0.2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Azinphos ethyl	µg/l	0.02	-	0.2	0.2	0.02	0.02	0.04	0.02	1.6	0.2	0.2	0.2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Dinitro-o-cresol	µg/l	0.1	-	0.1	0.1	1.13	0.1	0.1	0.1	10	10	0.11	3.44	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.218	0.142
Clopyralid	µg/l	0.04	-	0.04	0.04	0.04	0.04	0.04	0.04	4	4	0.04	0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
MCPA	µg/l	0.05	-	0.05	0.05	0.0565	0.05	0.05	0.05	5	5	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Mecoprop	µg/l	0.04	-	0.04	0.04	0.04	0.04	0.04	0.04	4	4	0.04	0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Dicamba	µg/l	0.04	-	0.04	0.04	0.04	0.04	0.04	0.04	4	4	0.04	0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
MCPB	µg/l	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	5	5	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2,4-DB	µg/l	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	10	10	0.1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2,3,6-Trichlorobenzoic acid	µg/l	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	5	5	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	Units	Limit of detection	D WS																								
Dichlorprop	µg/l	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	10	10	0.1	0.5	0.13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Triclopyr	µg/l	0.05	-	0.05	0.05	0.0767	0.05	0.05	0.05	5	5	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fenoprop (Silvex)	µg/l	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	10	10	0.1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2,4-Dichlorophen oxyacetic acid	µg/l	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	5	5	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2,4,5-Trichlorophen oxyacetic	µg/l	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	5	5	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Bromoxynil	µg/l	0.04	-	0.04	0.04	0.04	0.04	0.04	0.04	4	4	0.04	0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Benazolin	µg/l	0.04	-	0.04	0.04	0.04	0.04	0.04	0.04	4	4	0.04	0.2	0.04	0.04	0.04	0.04	0.08	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Ioxynil	µg/l	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	5	5	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pentachlorophenol	µg/l	0.04	-	0.04	0.04	0.04	0.04	0.04	0.04	4	4	0.04	0.2	0.04	0.04	0.04	0.04	0.08	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Fluoroxypyr	µg/l	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	10	10	0.1	0.5	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Naphthalene (aq)	µg/l	0.01	6	0.01	0.0257	0.01	0.01	0.01	0.01	19	0.0233	0.01	0.114	0.0584	0.0625	0.0593	0.0125	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Acenaphthene (aq)	µg/l	0.005	18	0.005	0.01	0.005	0.005	0.005	0.005	3.87	0.0168	0.005	0.00863	0.005	0.0149	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Acenaphthylene (aq)	µg/l	0.005	18	0.005	0.01	0.005	0.005	0.005	0.005	2.09	0.0168	0.005	0.00843	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Fluoranthene (aq)	µg/l	0.005	4	0.0319	0.101	0.005	0.005	0.005	0.005	85.1	0.145	0.0113	0.0833	0.005	0.005	0.005	0.005	0.005	0.00857	0.005	0.104	0.00633	0.00694	0.0163	0.005	0.0112	0.00786

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	Units	Limit of detection	DWS																								
Anthracene (aq)	µg/l	0.005	90	0.005	0.01	0.005	0.005	0.005	0.005	10.8	0.015	0.005	0.00644	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.00552	0.005	0.005	0.005	0.005	0.005	0.005
Phenanthrene (aq)	µg/l	0.005	4	0.0257	0.0849	0.005	0.005	0.005	0.005	39.8	0.172	0.00867	0.0339	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0242	0.005	0.005	0.0081	0.005	0.005	0.005
Fluorene (aq)	µg/l	0.005	12	0.00504	0.0161	0.005	0.005	0.005	0.005	2.62	0.0323	0.005	0.00688	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Chrysene (aq)	µg/l	0.005	7	0.0197	0.0516	0.005	0.005	0.005	0.005	37.8	0.0896	0.005	0.0553	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0729	0.005	0.005	0.005	0.005	0.005	0.005
Pyrene (aq)	µg/l	0.005	9	0.0294	0.169	0.0076	0.005	0.00643	0.00548	74.3	0.141	0.0212	0.107	0.005	0.005	0.005	0.005	0.005	0.00799	0.005	0.104	0.00761	0.00689	0.0141	0.005	0.0103	0.0161
Benzo(a)anthracene (aq)	µg/l	0.005	3.5	0.0143	0.0329	0.005	0.005	0.005	0.005	41.2	0.0537	0.005	0.0404	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0448	0.005	0.005	0.005	0.005	0.005	0.005
Benzo(b)fluoranthene (aq)	µg/l	0.005	0.1	0.0374	0.0765	0.005	0.005	0.005	0.005	68.5	0.125	0.005	0.112	0.005	0.005	0.005	0.005	0.005	0.0114	0.005	0.146	0.00524	0.005	0.005	0.005	0.00932	0.005
Benzo(k)fluoranthene (aq)	µg/l	0.005	0.1	0.0154	0.0321	0.005	0.005	0.005	0.005	28.6	0.047	0.005	0.0495	0.005	0.005	0.005	0.005	0.005	0.00559	0.005	0.0559	0.005	0.005	0.005	0.005	0.005	0.005
Benzo(a)pyrene (aq)	µg/l	0.002	0.01	0.0199	0.0374	0.002	0.002	0.002	0.002	48	0.0616	0.002	0.0616	0.002	0.002	0.002	0.002	0.002	0.00634	0.002	0.0842	0.0034	0.002	0.002	0.002	0.00589	0.002
Dibenzo(a,h)anthracene (aq)	µg/l	0.005	0.007	0.005	0.01	0.005	0.005	0.005	0.005	7.29	0.01	0.005	0.00554	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.018	0.005	0.005	0.005	0.005	0.005	0.005
Benzo(g,h,i)perylene (aq)	µg/l	0.005	0.1	0.0159	0.0459	0.005	0.005	0.005	0.005	38.8	0.0391	0.005	0.0409	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.077	0.005	0.005	0.005	0.005	0.005	0.005
Indeno(1,2,3-cd)pyrene (aq)	µg/l	0.005	0.1	0.0122	0.0317	0.005	0.005	0.005	0.005	34.1	0.0584	0.005	0.0407	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.066	0.005	0.005	0.005	0.005	0.005	0.005
PAH, Total Detected USEPA 16	µg/l	0.082	-	0.227	0.706	0.082	0.082	0.082	0.082	542	1.04	0.082	0.774	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.803	0.082	0.082	0.082	0.082	0.082	0.082
GRO Surrogate % recovery**	%		-	100	102	106	113	103	111	82	102	94	105	115	109	114	116	94	107	108	96	98	107	102	98	103	98
GRO >C5-C12	µg/l	50	-	50	50	50	50	50	50	52	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	**Units**	**Limit of detection**	**DWS**																								
Methyl tertiary butyl ether	µg/l	3	**-**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Benzene**	µg/l	7	**1**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**
Toluene	µg/l	4	**700**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Ethylbenzene	µg/l	5	**300**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
m,p-Xylene	µg/l	8	**190**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
o-Xylene	µg/l	3	**190**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Sum of detected Xylenes	µg/l	11	**-**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**
Sum of detected BTEX	µg/l	28	**-**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**	**28**
Aliphatics >C5-C6	µg/l	10	**15000**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C6-C8	µg/l	10	**15000**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C8-C10	µg/l	10	**300**	**10**	**10**	**10**	**10**	**10**	**10**	11	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C10-C12	µg/l	10	**300**	**10**	**10**	**10**	**10**	**10**	**10**	16	**10**	**10**	11	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C12-C16 (aq)	µg/l	10	**300**	**10**	20	**10**	**10**	**10**	**10**	200	56	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C16-C21 (aq)	µg/l	10	**300**	**10**	20	**10**	**10**	**10**	**10**	200	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C21-C35 (aq)	µg/l	10	**300**	**10**	20	**10**	**10**	**10**	**10**	4910	128	74	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	507

Location of Borehole				A									B						C					D			
Borehole name				BH203-1	BH275-1	BH275-2	BH273-1	BH273-2	BH206-1	WS275	BH224	BH285	BH230	BH234	BH237-2	BH237-1	BH240	BH239	BH253	BH251	BH242	BH249	BH256	BH271	BH261	BH260	BH265
Groundwater Depth bgl (m)				2.43	4.00	0.99	5.21	2.94	3.51	1.40	4.06	1.41	1.01	1.16	2.33	2.23	1.18	2.23	1.10	1.22	0.87	1.48	0.47	1.00	1.08	5.64	1.48
Analytical Parameter	**Units**	**Limit of detection**	**DWS**																								
Total Aliphatics >C12-C35 (aq)	µg/l	10	-	**10**	20	**10**	**10**	**10**	**10**	4910	184	74	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	507
Aromatics >EC5-EC7**	µg/l	10	1	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC7-EC8	µg/l	10	700	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC8-EC10	µg/l	10	300	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC10-EC12	µg/l	10	90	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC12-EC16 (aq)	µg/l	10	90	**10**	20	**10**	**10**	**10**	**10**	200	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC16-EC21 (aq)	µg/l	10	90	**10**	20	**10**	**10**	**10**	**10**	657	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC21-EC35 (aq)	µg/l	10	90	**10**	20	**10**	**10**	**10**	**10**	1820	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	98
Total Aromatics >EC12-EC35	µg/l	10	-	**10**	20	**10**	**10**	**10**	**10**	2480	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	98
Total Aliphatics & Aromatics	µg/l	10	-	**10**	16	33	**10**	**10**	13	7440	189	74	31	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	605
Aliphatics >C16-C35 Aqueous	µg/l	10	-	**10**	20	**10**	**10**	**10**	**10**	4910	128	74	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	507

Bold = Less than laboratory detection limit
(red) Exceeds Screening Standards
** Below minimum level of detection

Annex 2

TABLE A – QUALITATIVE RISK ASSESSMENT - BLACK CAT WORKS AREA

[Key: C0 – Construction Impact, S – Source, P – Pathway, R – Receptor]

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
C01	S1	Excavations and deposition of potentially contaminated soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Likely	Removal and use of topsoil, and excavated material for the construction of the Scheme – e.g. embankment, and new superficial grass land habitat at the proposed borrow pit location and the A1 underpass	Moderate adverse	With the use of the EMP, and required material testing to confirm concentrations there will be no measurable impact on the receptor quality	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Likely	Removal and use of topsoil, and excavated material for the construction of the Scheme – e.g. embankment, and new superficial grass land habitat at the proposed borrow pit location and the A1 underpass	Minor adverse	With the use of the EMP, and required material testing to confirm concentrations there will be no measurable impact on the receptor quality	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Unlikely	The removal of topsoil and excavation is not taking place near this receptor	Negligible	No impact anticipated	Very Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Use of excavated material at the River Great Ouse viaduct and storage of waste material at the black cat main compound with the flood plain of the river	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Secondary Superficial Deposit Aquifers	R6	River Great Ouse and Tributary	High	Moderately likely	Unlikely that any potentially contaminated leachate will arrive at the river	Negligible	Negligible to no impact anticipated	Low	Slight
C02	S2	Temporary and or permanent dewatering or abstraction resulting to reduction in groundwater level and change in flow regime	P3	Change in groundwater level and flow direction within the aquifer due to dewatering abstraction and creation of physical barrier	R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	Dewatering is required to facilitate the excavation of material from the borrow pit and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to the receptor	Negligible	No impact is anticipated	Very Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
			P3	Change in groundwater level and flow direction within the aquifer/alteration of base flow to the river due to dewatering abstraction and creation of physical barrier	R6	River Great Ouse and Tributary	High	Moderately likely	Dewatering is required to facilitate the excavation of material from the borrow pit and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to the receptor	Minor adverse	Potential impact is anticipated	Medium	Slight or moderate
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	No construction activities are occurring near any of these receptors. No SPZ is assigned to any of these sources	Negligible	No impact anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
			P2	Change in groundwater level and flow direction within the aquifer/alteration of base flow to the river due to dewatering abstraction and creation of physical barrier which may result in contaminant migrating to other areas	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill in the vicinity of the sites to spread within this receptor. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to spread within this receptor. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the	Negligible	Potential impact is anticipated	Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
						Underpass Area and Borrow Pit			aquifer the risk is likely to be low				
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
C02	S4	Spillage of Fuels or other contaminating liquids	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Moderately Likely	Construction is occurring into the saturated zone of the aquifer that is hydraulically linked to these receptors; however spills are likely to occur farther from these receptors	No change	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction is occurring into the saturated zone of the aquifer that is likely to be hydraulically connect with the river and its tributary	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
C05	S5	Presence of underground structures (Foundations, piers or cables) that could	P2	Flow of groundwater through the Secondary	R1	Superficial Secondary A Aquifer - underneath the	Medium	Moderately Likely	Piles are likely to extend below average high groundwater	Negligible	No measurable impact is anticipated	Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
		cause interference to groundwater flow regime		Superficial Deposit Aquifers		Black Cat A1 Underpass Area and Borrow Pit			levels for Bridges in an area of potentially contaminated land				
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Piles are likely to extend below average high groundwater levels for Bridges in an area of potentially contaminated land	Negligible	No measurable impact is anticipated	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Moderately Likely	No structures are proposed within close proximity of these receptors	Negligible	No measurable impact is anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	Medium	Moderately Likely	Piles for Bridges are likely to extend below average natural groundwater levels in an area of potentially contaminated land	Negligible	No measurable impact is anticipated	Low	Neutral
			P4	Preferential flow pathways / barriers created by the construction of foundations for structures	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Piles are likely to create preferential flow path through which potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass Area and Borrow Pit	Medium	Moderately Likely	Piles are likely to create preferential flow path through which potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral

TABLE B – QUALITATIVE RISK ASSESSMENT – RIVER GREAT OUSE TO EAST COAST WORKS AREA

[Key: C0 – Construction Impact, S – Source, P – Pathway, R – Receptor]

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
C01	S1	Excavations and deposition of potentially contaminated soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass area and river flood plain area.	Medium	Likely	Removal and use of topsoil, and excavated material for the construction of the Scheme – e.g. embankment, and new superficial grass land habitat at the River Great Ouse viaduct, cuttings and associated bridge	Moderate adverse	With the use of the EMP, and required material testing to confirm concentrations there will be no measurable impact on the receptor quality	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass area and river flood plain area.	Medium	Likely	Removal and use of topsoil, and excavated material for the construction of the Scheme – e.g. embankment, and new superficial grass land habitat at the River Great Ouse viaduct, cuttings and associated bridge	Minor adverse	With the use of the EMP, and required material testing to confirm concentrations there will be no measurable impact on the receptor quality	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Unlikely	The removal of topsoil and excavation is not taking place near this receptor	Negligible	No impact anticipated	Very Low	No change
					R6	River Great Ouse and Tributary	High	Moderately Likely	Use of excavated material at the River Great Ouse viaduct and storage of waste material at the temporary viaduct compound within the flood plain of the river	Negligible	No impact anticipated	Very Low	No change
			P2	Flow of groundwater through the Secondary Superficial Deposit Aquifers	R6	River Great Ouse and Tributary	High	Moderately likely	Unlikely that any potentially contaminated leachate will arrive at the river	Negligible	Negligible to no impact anticipated	Low	Slight
C02	S2	Temporary dewatering or abstraction resulting to reduction in groundwater level and change in flow regime	P3	Change in groundwater level and flow direction within the aquifer due to dewatering abstraction and creation of physical barrier at cuttings and viaduct location	R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	Dewatering is required to facilitate the excavation of material from the borrow pit and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to the receptor	Negligible	No impact is anticipated	Very Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
			P3	Change in groundwater level and flow direction within the aquifer/alteration of base flow to the river due to dewatering abstraction and creation of physical barrier at cuttings and viaduct location	R6	River Great Ouse and Tributary	High	Moderately likely	Dewatering is required to facilitate the excavation of material from cuttings (Barford road cutting) and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to the receptor	Minor adverse	Potential impact is anticipated	Medium	Slight or moderate
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass area and river flood plain area.	Medium	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass area and river flood plain area.	Medium	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	No construction activities are occurring near any of these receptors. No SPZ is assigned to any of these sources	Negligible	No impact anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
			P2	Change in groundwater level and flow direction within the aquifer/alteration of base flow to the river due to dewatering abstraction and creation of physical barrier	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass area and river flood plain area.	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to spread within this receptor. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to spread within this receptor. However,	Negligible	Potential impact is anticipated	Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
						Underpass area and river flood plain area.			given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low				
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
C02	S4	Spillage of Fuels or other contaminating liquids	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 Underpass area and river flood plain area.	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - Black Cat A1 Underpass area and river flood plain area.	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Moderately Likely	Construction is occurring into the saturated zone of the aquifer that is hydraulically linked to these receptors; however spills are likely to occur farther away from these receptors	No change	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction is occurring into the saturated zone of the aquifer at the river flood plain/riverbank that is	Minor	Potential impact is anticipated	Medium	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
									hydraulically connected with the river and its tributary Construction is occurring above the River Great Ouse				
C05	S5	Presence of underground structures (Foundations, piers or cables) that could cause interference to groundwater flow regime	P2	Flow of groundwater through the Secondary Superficial Deposit Aquifers	R1	Superficial Secondary A Aquifer - underneath the Black Cat A1 and river flood plain area	Medium	Moderately Likely	Piles are likely to extend below average high groundwater levels for Bridges in an area of potentially contaminated land	Negligible	No measurable impact is anticipated	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the Black Cat A1 Underpass Area and river flood plain area	Medium	Moderately Likely	Piles are likely to extend below average high groundwater levels for Bridges in an area of potentially contaminated land	Negligible	No measurable impact is anticipated	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Moderately Likely	No structures are proposed within close proximity of these receptors	Negligible	No measurable impact is anticipated	Low	Neutral
					R6	River Great Ouse	High	Moderately Likely	Piles/Pier for viaduct and bridge structures are likely to extend below average natural groundwater levels in an area of potentially contaminated land	Minor adverse	Potential impact is anticipated. However, impact is likely to be low provided the EMP for the Scheme is fully implemented	Low	Slight or Moderate
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Superficial Secondary A Aquifer - Black Cat A1 Underpass area and river flood plain area.	Medium	Moderately Likely	Piles are likely to create preferential flow path through potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - Black Cat A1 Underpass area and river flood plain area.	Medium	Moderately Likely	Piles are likely to create preferential flow path through potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral
					R6	River Great Ouse	High	Moderately Likely	Piles/Pier for viaduct and bridge structures are likely to extend below average natural	Minor adverse	Potential impact is anticipated. However, impact is likely to be low provided the EMP for	Low	Slight or Moderate

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
									groundwater levels in an area of potentially contaminated land		the Scheme is fully implemented		

TABLE C – QUALITATIVE RISK ASSESSMENT – EAST COAST MAINLINE TO CAMBRIDGE JUNCTION WORKS AREA

[Key: C0 – Construction Impact, S – Source, P – Pathway, R – Receptor]

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
C01	S1	Excavations and deposition of potentially contaminated soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Likely	Removal and use of topsoil, and excavated material for the construction of the Scheme – e.g. embankment, and new superficial grass land habitat at the EML bridge area and other bridges along the route	Moderate adverse	With the use of the EMP, and required material testing to confirm concentrations there will be no measurable impact on the receptor quality	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Likely	Removal and use of topsoil, and excavated material for the construction of the Scheme – e.g. embankment, and new superficial grass land habitat at the EML bridge area and other bridges along the route	Minor adverse	With the use of the EMP, and required material testing to confirm concentrations there will be no measurable impact on the receptor quality	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Unlikely	The removal of topsoil and excavation is not taking place near this receptor	Negligible	No impact anticipated	Very Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Use of excavated material at the EML embankment area	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Secondary Superficial Deposit Aquifers	R6	River Great Ouse and Tributary	High	Moderately likely	Likely or unlikely that any potentially contaminated leachate will arrive at the river	Negligible	Negligible to no impact anticipated	Low	Slight
C02	S2	Temporary dewatering or abstraction resulting to reduction in groundwater	P3	Change in groundwater level and flow direction within the aquifer due to dewatering	R3	Licensed and unlicensed groundwater	Medium	Moderately Likely	Dewatering is required to facilitate the excavation of material from cuttings (e.g. Potton road cutting, Hen Brook cutting, Wintringham Brook	Negligible	No impact is anticipated	Very Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
		level and change in flow regime		abstraction and creation of physical barrier at cuttings and viaduct location		abstraction boreholes			cutting etc.) and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to these receptors. However, these activities will occur farther from these receptors				
			P3	Change in groundwater level and flow direction within the aquifer/alteration of base flow to the river due to dewatering abstraction and creation of physical barrier at cuttings and viaduct location	R6	River Great Ouse And Tributary (Hen Brook, Wintringham Brook And Gallow Brook	High	Moderately likely	Dewatering is required to facilitate the excavation of material from cuttings (e.g. Potton road cutting, Hen Brook cutting, Wintringham Brook cutting etc.) and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to the receptor	Minor adverse	Potential impact is anticipated	Medium	Slight or moderate
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	No construction activities are occurring near any of these receptors. No SPZ is assigned to any of these sources	Negligible	No impact anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
			P2	Change in groundwater level and flow direction within the aquifer/alteration of base flow to the river due to dewatering abstraction and	R1	Superficial Secondary A Aquifer - underneath the EML utilities, bridge structures,	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to spread within this receptor. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the	Negligible	Potential impact is anticipated	Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
				creation of physical barrier		cuttings and river flood plain area			aquifer the risk is likely to be low				
					R2	Superficial Secondary undifferentiated Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to spread within this receptor. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
C02	S4	Spillage of Fuels or other contaminating liquids	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer – underneath the EML utilities, bridge structures, cuttings and river flood plain area.	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R3	Licensed and unlicensed Groundwater	Medium	Moderately Likely	Construction is occurring into the saturated zone of the aquifer that is hydraulically linked to these receptors; however spills are likely to	No change	No measurable impact is anticipated provided the EMP for the	Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
						abstraction boreholes			occur farther away from these receptors		Scheme is fully implemented		
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction is occurring into the saturated zone of the aquifer at the river flood plain/riverbank that is hydraulically connected with the river and its tributary	Minor	Potential impact is anticipated	Medium	Neutral
C05	S5	Presence of underground structures (Foundations, piers or cables) that could cause interference to groundwater flow regime	P2	Flow of groundwater through the Secondary Superficial Deposit Aquifers	R1	Superficial Secondary A Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Piles are likely to extend below average high groundwater levels for bridges in an area of potentially contaminated land	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer,	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Piles are likely to extend below average high groundwater levels for bridges in an area of potentially contaminated land	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer,	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Moderately Likely	No structures are proposed within close proximity of these receptors	Negligible	No measurable impact is anticipated	Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Superficial Secondary A Aquifer – underneath the EML utilities, bridge structures, cuttings and river flood plain area.	Medium	Moderately Likely	Piles are likely to create preferential flow path through potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer – underneath the EML utilities, bridge structures, cuttings and river flood plain area.	Medium	Moderately Likely	Piles are likely to create preferential flow path through potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral
					R6	River Great Ouse	High	Moderately Likely	Piles/Pier for viaduct and bridge structures are likely to extend below average natural groundwater levels in an area of potentially contaminated land	Minor adverse	Potential impact is anticipated. However, impact is likely to be low provided the EMP for	Low	Slight or Moderate

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
											the Scheme is fully implemented		

TABLE D – QUALITATIVE RISK ASSESSMENT – CAMBRIDGE JUNCTION TO CAXTON GIBBET INCLUDING ELTISLEY WORKS AREA

[Key: C0 – Construction Impact, S – Source, P – Pathway, R – Receptor]

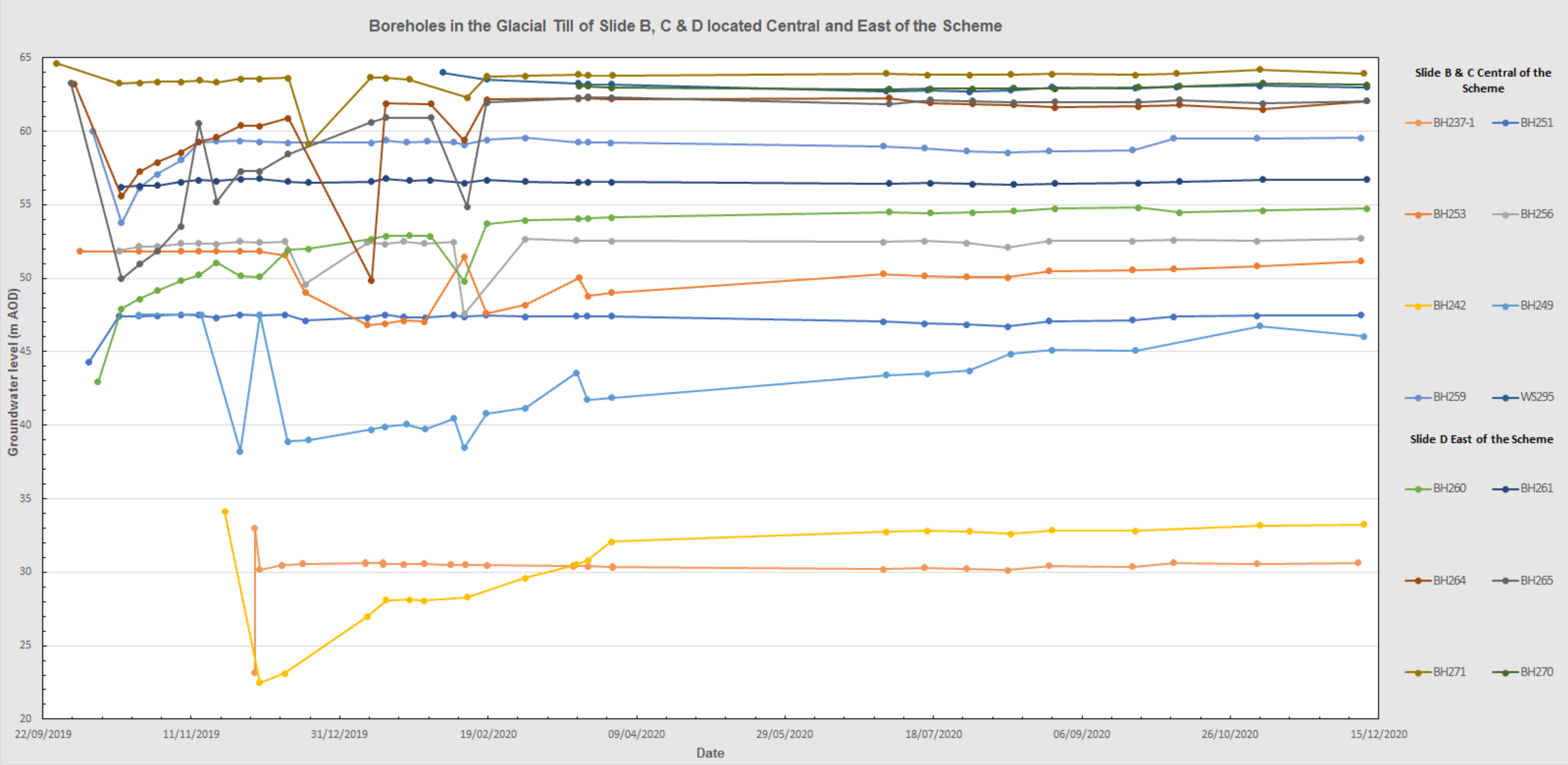
ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
C01	S1	Excavations and deposition of potentially contaminated soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R2	Superficial Secondary undifferentiated Aquifer – underneath cuttings and bridge structures, cuttings	Medium	Likely	Removal and use of topsoil, and excavated material for the construction of the Scheme – e.g. embankment, and new superficial grass land habitat at the bridge area and other bridges along the route	Minor adverse	With the use of the EMP, and required material testing to confirm concentrations there will be no measurable impact on the receptor quality	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Use of excavated material at the bridge embankment areas	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Secondary Superficial Deposit Aquifers	R6	River Great Ouse and its tributaries	High	Moderately likely	Unlikely that any potentially contaminated leachate will arrive at the river	Negligible	No impact anticipated	Very Low	Neutral
C02	S2	Temporary dewatering or abstraction resulting to reduction in groundwater level and change in flow regime	P3	Change in groundwater level and flow direction within the aquifer due to dewatering abstraction and creation of physical barrier at cuttings and viaduct location	R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	Dewatering is required to facilitate the excavation of material from cuttings (e.g. Fox Brook cutting, Eltisley cutting etc.) and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to these receptors. However, these activities will occur farther from these receptors	Negligible	No impact is anticipated	Very Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
			P3	Change in groundwater level and flow direction within the aquifer/alteration of base flow to the river due to dewatering abstraction and creation of physical barrier at cuttings and viaduct location	R6	River Great Ouse And Tributary (Hen Brook, Wintringham Brook and Gallow Brook	High	Moderately likely	Dewatering is required to facilitate the excavation of material from cuttings (e.g. Potton road cutting, Hen Brook cutting, Wintringham Brook cutting etc.) and the construction of cuttings/deep excavation works which can alter the groundwater flow and quantity to the receptor	Minor adverse	Potential impact is anticipated	Medium	Slight or moderate
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits									
					R2	Superficial Secondary undifferentiated Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	No construction activities are occurring near any of these receptors. No SPZ is assigned to any of these sources	Negligible	No impact anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction activities with potential groundwater dewatering activities are occurring in the vicinity of the receptor but no confirmed contaminated ground is likely to be intercepted.	Negligible	No impact anticipated	Low	Neutral
			P2	Change in groundwater level and flow direction within the aquifer/alteration of baseflow to the river due to dewatering abstraction and creation of physical barrier	R1	Superficial Secondary A Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to spread within this receptor. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer, the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to spread within this receptor. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral

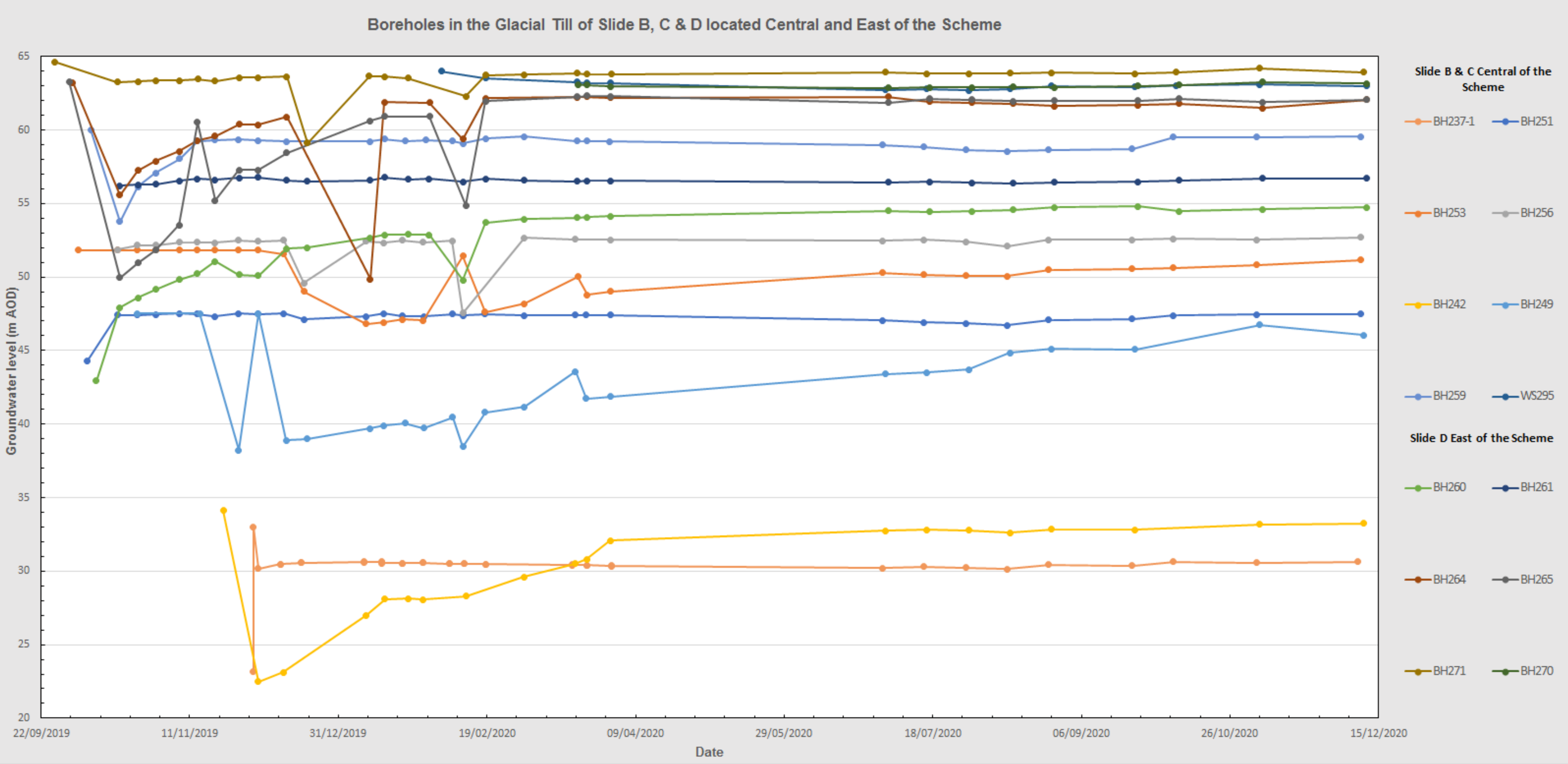
ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
					R3	Licensed and unlicensed groundwater abstraction boreholes	Medium	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Potential for dewatering activities to mobilise potentially contaminated inert groundwater from historical landfill within the vicinity of the sites to these receptors. However, given the proximity of the landfill to the potential dewatering sites and the dilution capacity of the aquifer the risk is likely to be low	Negligible	Potential impact is anticipated	Low	Neutral
C02	S4	Spillage of Fuels or other contaminating liquids	P1	Infiltration and leaching of pollutant through the unsaturated and saturated zone of the superficial deposits	R1	Superficial Secondary A Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer – underneath the EML utilities, bridge structures, cuttings and river flood plain area.	Medium	Moderately Likely	Construction is occurring into the unsaturated and saturated zone of the aquifer	Negligible	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Moderately Likely	Construction is occurring into the saturated zone of the aquifer that is hydraulically linked to these receptors; however spills are likely to occur farther away from these receptors	No change	No measurable impact is anticipated provided the EMP for the Scheme is fully implemented	Low	Neutral
					R6	River Great Ouse and Tributary	High	Moderately Likely	Construction is occurring into the saturated zone of the aquifer at the river flood plain/riverbank that is hydraulically connected with the river and its tributary	Minor	Potential impact is anticipated	Medium	Neutral
C05	S5	Presence of underground structures (Foundations, piers or cables) that could	P2	Flow of groundwater through the Secondary	R1	Superficial Secondary A Aquifer - underneath the EML utilities,	Medium	Moderately Likely	Piles are likely to extend below average high groundwater	Negligible	Pile construction methods will limit	Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Comment	Risk of Impact following Embedded Mitigation	Significance of Effect
		cause interference to groundwater flow regime		Superficial Deposit Aquifers		bridge structures, cuttings and river flood plain area			levels for bridges in an area of potentially contaminated land		creation of flow pathways to the aquifer,		
					R2	Superficial Secondary undifferentiated Aquifer - underneath the EML utilities, bridge structures, cuttings and river flood plain area	Medium	Moderately Likely	Piles are likely to extend below average high groundwater levels for bridges in an area of potentially contaminated land	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer,	Low	Neutral
					R3	Licensed and unlicensed Groundwater abstraction boreholes	Medium	Moderately Likely	No structures are proposed within close proximity of these receptors	Negligible	No measurable impact is anticipated	Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Superficial Secondary A Aquifer – underneath the EML utilities, bridge structures, cuttings and river flood plain area.	Medium	Moderately Likely	Piles are likely to create preferential flow path through potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral
					R2	Superficial Secondary undifferentiated Aquifer – underneath the EML utilities, bridge structures, cuttings and river flood plain area.	Medium	Moderately Likely	Piles are likely to create preferential flow path through potential contaminant can enter the aquifer	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and with implementation of the EMP there will be no measurable impact on the receptor quality	Low	Neutral
					R6	River Great Ouse	High	Moderately Likely	Piles/Pier for viaduct and bridge structures are likely to extend below average natural groundwater levels in an area of potentially contaminated land	Minor adverse	Potential impact is anticipated. However, impact is likely to be low provided the EMP for the Scheme is fully implemented	Low	Slight or Moderate

Annex 3A: Groundwater Level (m AOD) of Boreholes in the River Terrace Deposits of Slide A (West of the Scheme)



Annex 3B: Groundwater Level (m AOD) of Boreholes in the Glacial Till of Slide B, C & D (Central and East of the Scheme)



Annex 4 In-Situ Gas Monitoring Results

BH ID	Geology	Location	Date / Time	Amb. CH_4 (%)	Int. CH_4 (%)	Amb. CO_2 (%)	Int. CO_2 (%)	Amb. O_2 (%)	Int. O2 (%)	Amb. CO (ppm)	Int. CO (ppm)	Amb. H_2S (ppm)	Int. H_2S (ppm)	Amb. Balance (%)	Balance (%)	Internal Flow (L/hr)	VOC (ppm)
BH203-1	River Terrace	A	03/12/2020 12:31	0.1	0.2	0.1	1	21.2	20.7	0	0	0	0	78.6	78.5	0.1	0
BH275-1	River Terrace		03/12/2020 14:50	0.2	0.2	0.1	0.1	20.8	20.9	0	0	0	0	78.9	78.7	0	0
BH275-2	Kellaways Clay		-	0..2	0.2	0.1	0.2	20.8	20.8	0	0	0	0	78.9	78.9	0.3	0
WS275	-		10/12/2020 15:45	0.3	0.2	0.1	0.1	20.8	20.7	0	0	1	0	78.9	78.9	0	0
BH206-1	River Terrace		04/12/2020 09:05	0.2	0.2	0.1	1.7	21.1	19.2	0	2	0	0	78.6	78.7	0	0
BH285	-		09/12/2020 13:30	0.2	0.2	0.1	0.2	20.9	20.8	2	2	0	0	78.9	78.9	0	0
BH273-1	River Terrace		04/12/2020 08:54	0.1	0.1	0.1	2	21.8	19.4	0	0	0	0	77.9	78.3	0.1	0
BH273-2	Kellaways Clay		04/12/2020 08:55	0.1	0.2	0.1	0.8	20.7	20.3	1	0	0	0	78.7	78.7	0	0
BH224	Oxford Clay		07/12/2020 10:33	0.2	0.1	0.1	0.1	21.8	21.8	0	1	0	0	77.9	78	0.2	0
BH230	Oxford Clay	B	07/12/2020 14:00	0.1	0.2	0.1	0.1	20.8	20.8	1	0	0	0	78.1	78.9	-	0
BH234	-		07/12/2020 15:25	0.3	0.2	0.1	0.1	21	21	0	0	0	0	78.6	78.7	0.3	0
BH237-1	Glacial Till		08/12/2020 10:40	0.3	0.2	0.1	0.1	20.7	20.7	0	0	0	0	79	79.2	0	0
BH237-2	Oxford Clay		08/12/2020 09:40	0.3	0.1	0.1	0.1	20.7	20.7	0	0	0	0	79	79	0	0
BH239	Oxford Clay		08/12/2020 14:05	0.2	0.2	0.1	0.1	20.7	20.6	0	1	0	0	79	79.1	0.3	0
BH240	Oxford Clay		08/12/2020 12:20	0.2	0.2	0.1	0.1	20.8	20.7	1	1	0	0	78.9	78.8	0	0
BH251	Glacial Till	C	09/12/2020 09:05	0.1	0.2	0.1	0.1	20.7	20.7	1	2	0	0	79	79	0.1	0
BH253	Glacial Till		09/12/2020 11:28	0.2	0.2	0.1	0.2	20.8	20.7	0	1	0	0	78.9	78.8	0	0
BH256	Glacial Till		09/12/2020 12:05	0.2	0.2	0.1	0.1	20.8	20.7	1	0	0	0	79	79	0.2	0
BH242	Glacial Till		10/12/2020 09:00	0.3	0.2	0.1	0.1	20.9	20.4	1	0	0	0	78.8	79.2	0	0

BH ID	Geology	Location	Date / Time	Amb. CH_4 (%)	Int. CH_4 (%)	Amb. CO_2 (%)	Int. CO_2 (%)	Amb. O_2 (%)	Int. O2 (%)	Amb. CO (ppm)	Int. CO (ppm)	Amb. H_2S (ppm)	Int. H_2S (ppm)	Amb. Balance (%)	Balance (%)	Internal Flow (L/hr)	VOC (ppm)
BH249	Glacial Till		10/12/2020 11:40	0.2	0.1	0.1	0.1	20.7	20.7	0	0	0	0	79	79	0	0
BH271	Glacial Till	D	10/12/2020 14:00	0.2	0.2	0.1	0.1	20.8	20.7	0	0	0	0	78.9	79	0	0
BH260	Glacial Till		11/12/2020 09:50	0.2	0.2	0.1	0.3	20.8	20	0	6	0	0	79.1	79.5	0.2	0
BH261	Glacial Till		11/12/2020 09:15	0.2	0.2	0.1	0.1	20.7	20.7	0	1	0	0	79.1	79	0.1	0
BH264	Glacial Till		11/12/2020 14:55	0.2	0.2	0.1	0.1	20.9	20.8	0	0.1	0	0	78.9	78.9	0.1	0
BH265	Glacial Till		11/12/2020 13:25	0.2	0.2	0.1	0.3	20.8	20.4	1	1	0	0	78.9	79	0.2	0
			Min	0.1	0.1	0.1	0.1	20.7	19.2	0	0	0	0	77.9	78	0	0
			Average	0.2	0.18	0.1	0.33	20.9	20.6	0.36	0.72	0.04	0	78.78	78.87	0.09	0
			Max	0.3	0.2	0.1	2	21.8	21.8	2	6	1	0	79.1	79.5	0.3	0

Annex 4: In-Situ Water Quality Analysis Results

BH ID	Geology	Location	Date / Time	Electrical Conductivity (µS/cm)	pH (pH units)	Temperature (°C)	RDO (mg/l)	RDO (%Sat)	ORP (mV)	Total Dissolved Solids (ppt)
BH203-1	River Terrace	A	03/12/2020 12:31	1117.25	8.27	10.82	6.059	56.52	-12.53	0.72
BH275C-1	River Terrace		03/12/2020 14:50	-	-	-	-	-	-	-
BH275C-2	Kellaways Clay		03/12/2020 15:05	4626.70	8.61	8.94	1.36	11.9	-195.4	3.01
WS275	-		10/12/2020 15:45	758.00	8.38	10.8	3.31	29.84	-10.3	0.49
BH206-1	River Terrace		04/12/2020 09:05	907.10	8.99	9.71	1.50	13.21	16.5	0.59
BH285	-		09/12/2020 13:30	1450.10	8.25	11.2	3.29	-	-201.2	0.637
BH273-1	River Terrace		04/12/2020 08:54	117.2	8.54	9.94	5.50	48.87	79.7	0.76
BH273-2	Kellaways Clay		04/12/2020 08:55	1241.00	8.39	10.61	1.29	11.53	-	0.81
BH224	Oxford Clay		07/12/2020 10:33	3441.80	7.59	10.78	1.85	-	-114.3	2.22
BH230	Oxford Clay	B	07/12/2020 14:00	7307.00	7.87	8.54	3.30	28.86	-178	4.75
BH234	-		07/12/2020 15:25	4334.80	7.47	10.63	0.19	-	-20.9	-
BH237-1	Glacial Till		08/12/2020 10:40	4614.50	7.69	10.47	1.08	-	-65	>2
BH237-2	Oxford Clay		08/12/2020 09:40	4967.30	7.87	10.69	0.37	-	-114.1	>2
BH240	Oxford Clay		08/12/2020 12:20	2947.65	8.43	10.55	0.11	-	-203.7	1.319
BH239	Oxford Clay		08/12/2020 14:05	2764.30	8.53	10.84	0.05	-	-246.4	1.35
BH251	Glacial Till	C	09/12/2020 09:05	859.30	8.73	10.69	3.46	-	17.7	0.4

BH ID	Geology	Location	Date / Time	Electrical Conductivity (µS/cm)	pH (pH units)	Temperature (°C)	RDO (mg/l)	RDO (%Sat)	ORP (mV)	Total Dissolved Solids (ppt)
BH253	Glacial Till		09/12/2020 11:28	2857.00	7.84	10.78	6.19	-	-73.7	1.498
BH256	Glacial Till		09/12/2020 12:05	3670.20	7.62	10.87	3.21	-	-34.6	1.621
BH242	Glacial Till		10/12/2020 09:00	3999.00	8.05	11.11	0.07	-	-72.6	3.11
BH249	Glacial Till		10/12/2020 11:40	3302.00	8.14	10.12	3.95	35.49	-58.1	2.14
BH271	Glacial Till	D	10/12/2020 14:00	3895.10	7.64	10.64	0.10	1.08	-35.9	2.53
BH260	Glacial Till		11/12/2020 09:50	3008.41	7.97	11.17	2.02	-79.40	-78.7	1.96
BH261	Glacial Till		11/12/2020 09:15	1038.50	8.22	11.02	0.80	7.21	-338	0.67
BH265	Glacial Till		11/12/2020 13:25	4358.90	7.93	11.21	4.47	41.34	-	2.83
Drinking Water Standard				2500 at 20 °C	6.5-9.5	-	-	-	-	-
Minimum				117.2	7.47	8.54	0.05	-79.4	-338	0.4
Average				2938.4	8.13	10.53	2.33	17.2	-92.36	1.67
Maximum				7307	8.99	11.21	6.19	56.52	79.7	4.75

Annex 5 Cuttings and Borrow Pits Analytical Calculations

Blackcat/A1 Underpass Cutting Groundwater Inflow Estimation During Constrution		
Inflow assessment:		
Assumptions: - Unconfined aquifer condition - The cutting is fully penetrating the RTD - Flow is predominantly horizontal with no vertical flow from the underlying Till - Horizontal K>>K vertical - Cutting is modelled as a long line of closely spaced wells (or two parallel lines of wells) with flow from each side which can be modelled as slots using plane flow formulae by Chapman (1959)	**Equation for Inflow Estimation** Chapman Equatipon $Q = \frac{kx(H^2-h_w^2)}{L_0}$	
	AVERAGE PERMEABILITY	
Average depth of cutting =	**4.57**	
	Option 1: GWL=1.31m bgl	
Length of cutting =	750	m
Width of cutting =	20	m
		m
		m
Length of Cutting =	750	m
Permeability (k) =	2.00E-04	m/s
Maximum (H) =	4.89	m
hw =		m
Radius of influnce (Ro) or Zone of Influence (Lo) =	138	m
Radius of influnce (Ro) or Zone of Influence (Lo) =	138	
Unconfined fully penetrating: $Q = \frac{kx(H^2-h_w^2)}{L_0}$	2.59E-02	m3/s
	2,241	**m3/d**
Average effective saturated aquifer thickness H =	**3.95**	
Unconfined fully penetrating: $Q = \frac{kx(H^2-h_w^2)}{L_0}$	1.70E-02	m3/s
	1,465	**m3/d**

Alington Hill Cutting Groundwater Inflow Estimation During Constrution		
Inflow assessment:		
Assumptions: - Unconfined aquifer condition - The cutting is fully penetrating the Till - Flow is predominantly horizontal with no vertical flow from the underlying Till - Horizontal K>>K vertical - Cutting is modelled as a long line of closely spaced wells (or two parallel lines of wells) with flow from each side which can be modelled as slots using plane flow formulae by Chapman (1959)	**Equation for Inflow Estimation** Chapman Equatipon $Q = \frac{kx(H^2-h_w^2)}{L_0}$	
	LITERATURE PERMEABILITY	
	Option 1: GWL=0.58m bgl	
Length of Cutting =	1370	m
Permeability (k) =	1.00E-07	m/s
Maximum (H) =	6.42	m
hw =		m
Radius of influnce (Ro) or Zone of Influence (Lo) =	4.1	m
Radius of influnce (Ro) or Zone of Influence (Lo) =	4.1	
Unconfined fully penetrating: $Q = \frac{kx(H^2-h_w^2)}{L_0}$ **Q =**	1.39E-03	m3/s
Q =	**120**	**m3/d**
Average effective saturated aquifer thickness H =	4.70	m
Unconfined fully penetrating: $Q = \frac{kx(H^2-h_w^2)}{L_0}$ **Q =**	7.45E-04	m3/s
Q =	**64**	**m3/d**

Barford Road Cutting Groundwater Inflow Estimation During Constrution		
Inflow assessment:		
Assumptions: - Unconfined aquifer condition - The cutting is fully penetrating the Till - Flow is predominantly horizontal with no vertical flow from the underlying Till - Horizontal K>>K vertical - Cutting is modelled as a long line of closely spaced wells (or two parallel lines of wells) with flow from each side which can be modelled as slots using plane flow formulae by Chapman (1959)	**Equation for Inflow Estimation** Chapman Equatipon $Q = \frac{kx(H^2-h_w^2)}{L_0}$	
	LITERATURE PERMEABILITY	
	Option 1: GWL=1.10m bgl	
Length of Cutting =	380	m
Permeability (k) =	1.00E-07	m/s
Maximum (H) =	4.9	m
hw =		m
Radius of influnce (Ro) or Zone of Influence (Lo) =	3.10	m
Radius of influnce (Ro) or Zone of Influence (Lo) =	3.1	
Unconfined fully penetrating: $Q = \frac{kx(H^2-h_w^2)}{L_0}$	2.94E-04	m3/s
	25	**m3/d**
Average effective saturated aquifer thickness H =	**3.73**	m
Unconfined fully penetrating: $Q = \frac{kx(H^2-h_w^2)}{L_0}$	1.70E-04	m3/s
	15	**m3/d**

Borrow Pit A [BPA] Dewatering Calculation

Inflow assessment:

Assumptions:
- Unconfined aquifer condition
- The cutting is fully penetrating the Till
- Flow is predominantly horizontal with no vertical flow from the underlying Till
- Horizontal K>>K vertical
- Borrow pit excavation is modelled as a rectangular system of closely spaced wells with flow from each side of the system modelled as slots using flow formulae by Darcy

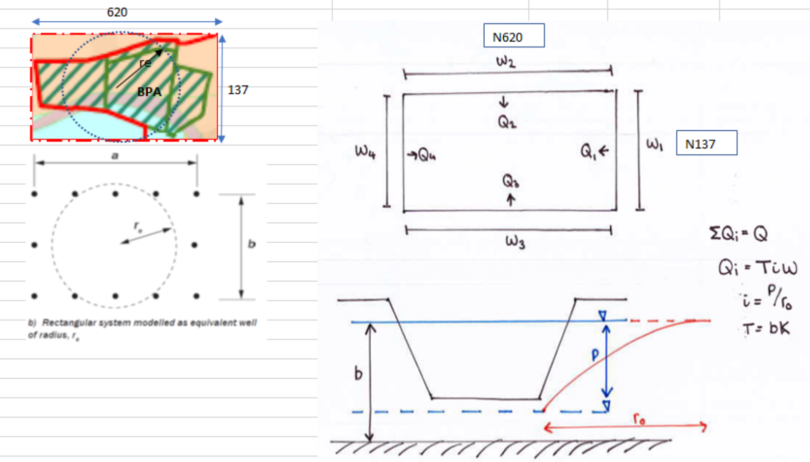
Equation for Inflow Estimation

$$R_o = C(H - h)\sqrt{k}$$

$$Q = TW\frac{P}{r_0}$$

Where $T = KB$

		Option 1: GWL = 1m BGL	
Length	Wa=	620.00	m
Width	Wb=	137.10	m
Hydraulic Conductivity	K=	2.00E-04	m/s
Water level in well after drawdown (i.e. at base of pit)	hw=	0.0	m
Height of saturated aquifer	H=	3.0	m
Target drawdown height	P=	3	m
Radius of Influence	Ro=	84.9	m
Radius of Influence	Ro=	84.9	m
Inflow $Q = TW\frac{P}{r_0}$	Q=	0.0321	m3/s
Inflow	Q=	**2,775**	**m3/d**
Volume of water to be dewatered	**Estimated inflow volume =**	**2,775**	m3



Borrow Pit C [BPC] Dewatering Calculation

Inflow assessment:

Assumptions:
- Unconfined aquifer condition
- The cutting is fully penetrating the RTD/ Upper Till
- Flow is predominantly horizontal with no vertical flow from the underlying Till
- Horizontal K>>K vertical
- Borrow pit excavation is modelled as a rectangular system of closely spaced wells with flow from each side of the system modelled as slots using flow formulae by Darcy

Equation for Inflow Estimation

$$R_o = C(H - h)\sqrt{k}$$

$$Q = TW\frac{P}{r_0}$$

Where $T = KB$

		Option 1: GWL = 1m BGL	
Length	Wa=	300.00	m
Width	Wb=	120.00	m
Hydraulic Conductivity	K=	2.00E-04	m/s
Water level in well after drawdown (i.e. at base of we	hw=	0.0	m
Height of saturated aquifer	H=	1.5	m
Target drawdown height	P=	1.5	m
Radius of Influence	Ro=	42.4	m
Radius of Influence	Ro=	42.4	m
Flow	Q=	0.0089	m3/s
Flow	Q=	**770**	**m3/d**
Volume of water to be dewatered	**Estimated inflow volume =**	770	m3