A428 Black Cat to Caxton Gibbet improvements

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9.83 Groundwater Risk Assessment Technical Note

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1 Introduction

1.1.1 The Applicant has compiled this Technical Note to respond to the Environment Agency's (EA) comments made as part of **[RR-036]** to the Groundwater Risk Assessment (GWRA) **[APP-226]**. The GWRA was provided as part of the Environmental Statement in support of the DCO application for the A428 Black Cat to Caxton Gibbet Improvements (the "Scheme").

1.1.2 The Applicant has been in regular contact with the EA since April 2020 to discuss the content and objective of the GWRA for the Scheme.

1.1.3 The GWRA was submitted as Appendix 13.7: Groundwater Risk Assessment **[APP-226]** of Volume 6 of the Environmental Statement in February 2021 (herein referred to as the GWRA). This Technical Note should be read in conjunction with the GWRA which includes much of the background information referred to in this Technical Note. In **[RR-036]**, the EA raised several concerns regarding the potential impacts of the Scheme on groundwater resources and associated surface water bodies and the adequacy and representativeness of the information used in the GWRA.

1.1.4 As part of RR-036, the EA stated that: -

"The scheme has the potential to cause adverse impacts to the water environment during both construction and operational phases. The draft DCO seeks to disapply Section 24 of the Water Resources Act 1991(b). In order for us to agree to this we would need, in advance:

- *a satisfactory groundwater risk assessment*
- *an acceptable construction dewatering strategy containing all of the information that would normally be required for an abstraction licence application.*

We have previously engaged with the applicant regarding an earlier iteration of the groundwater risk assessment for the proposed scheme (Appendix 13.7 Groundwater Risk Assessment Report ***TR010044/APP/6.3****)."*

1.1.5 This Technical Note addresses the points raised by the EA in **[RR-036]** and also considers other specific points raised by the EA during a meeting held with the Applicant regarding the GWRA on 30 July 2021, in particular:

a. Concerns regarding the permeability values used in the GWRA.

b. The need for monitoring to determine actual impacts compared with assessment models.

c. Further assessment of the potential impact on Eversden-Eltisley Landfill.

d. A request that all options to avoid permanent dewatering are investigated fully.

1.1.6 This Technical Note is provided to address the comments/concerns of the EA, to provide additional ground and groundwater information collected after the submission of the GWRA, and to provide updated assessments of potential impacts based on the new information, including additional details of the preliminary design of the A1 Black Cat Underpass. Since the submission of the GWRA, additional in-situ permeability testing and assessment have been carried out to clarify how representative the parameters used in the GWRA are; another round of groundwater quality sampling has been undertaken; and the need for permanent dewatering at the A1 Black Cat Underpass has been reviewed in light of further design information. In particular:

a. A total of 15 in-situ borehole permeability tests have been undertaken, consisting of five tests in boreholes in the River Terrace Deposits; seven tests in boreholes in the Glacial Till; and three tests in boreholes in the Oxford Clay.

b. In June 2021, groundwater samples were collected from a total of 24 boreholes - six boreholes in the River Terrace Deposits; 11 boreholes in the Glacial Till; and nine boreholes in the Kellaways Clay and Oxford Clay.

c. Further details of the preliminary design for the A1 Black Cat Underpass, which included the use of secant pile walls and cut-off walls, have been developed (**see Appendix C**) to remove/mitigate the need for permanent groundwater pumping/dewatering.

2 Background Information

2.1.1 The Scheme involves improving and upgrading the existing Strategic Road Network through the construction of a new 16km dual 2-lane carriageway from the Black Cat roundabout to Caxton Gibbet roundabout, to be known as the A421.

2.1.2 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 systems to facilitate the Scheme. The GWRA assesses the potential impacts of the Scheme on the water environment (groundwater and surface water resources).

3 Ground Conditions

3.1 Geology and hydrogeology

3.1.1 A ground investigation carried out in 2019/2020 confirmed the published geological sequence below the Scheme to comprise a variety of superficial deposits overlying the Oxford Clay Formation (Peterborough Member) and the Kellaways Formation (bedrock). The superficial deposits comprise Topsoil, Made Ground, Alluvium, River Terrace Deposits and Glacial Till (Oadby Member). The Oxford Clay Formation was only proved at outcrop in the western part of the Scheme. Further details of the superficial deposits and the bedrock are provided in the GWRA **[APP-226]**.

3.1.2 The River Terrace Deposits are present in the western part of the Scheme principally within the floodplain of the River Great Ouse. The majority of the remainder of the Scheme is underlain by Glacial Till.

3.1.3 Groundwater is present in the superficial deposits, principally in the River Terrace Deposits, with groundwater levels ranging from 0.5m to 5.5m below ground level (m bgl). 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 is generally dry except where there are granular units typically at depth and this clay-rich deposit is of negligible importance for groundwater resources with limited connection to surface water.

3.1.4 The underlying Oxford Clay has a low permeability that restricts vertical groundwater flow and supports a perched groundwater in the overlying superficial deposits, in particular the River Terrace Deposits. Groundwater in the River Terrace Deposits is in hydraulic continuity with and provides baseflow discharge to the surface water systems along the Scheme.

3.2 Permeability

3.2.1 During the 2019/2020 ground investigation, permeability/hydraulic conductivity values for the River Terrace Deposits, the Glacial Till and the Oxford Clay were derived from a combination of in-situ borehole tests, laboratory tests and particle size distribution (PSD) analysis, particularly for the River Terrace Deposits. The results of the borehole tests are provided in the GWRA **[APP-226]**.

3.2.2 Permeability values of 2.4 x 10^{-3} m/sec and 3.0 x 10^{-5} m/sec were derived from in-situ falling head tests undertaken in boreholes BH205 and BH203 respectively in the River Terrace Deposits. The water level in a falling head test on a third borehole (BH210) also in the River Terrace Deposits varied very little, such that analysis was not possible and indicating a lower permeability than the other two tests. A permeability range of 1 x 10^{-6} m/sec to 5 x 10^{-5} m/sec was estimated from PSD tests. Combining the results of the falling head tests and the PSD analyses, provided permeability values of the 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 GWRA **[APP-226]**, the average permeability value of 2 x 10^{-}

^{4}m/sec was adopted as the representative regional permeability value for the River Terrace Deposits.

3.2.3 For the Glacial Till, permeability in the range of 9.0 x 10^{-11} m/sec to 3 x 10^{-9} m/sec was estimated from laboratory testing on four boreholes and PSD tests. Also, permeability values of 1.48 x 10^{-3} m/sec and 5.68 x 10^{-3} m/sec were derived from in-situ packer tests carried out on two boreholes. 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 63 of the 77 GI boreholes installed in the till during the 2019/2020 GI drilling. There are many issues associated with packer tests that can nullify the accuracy of the data and it is considered that the results from the packer tests were suspect/erroneous and did not provide a representative permeability value for the Glacial Till.

3.2.4 For the purpose of the GWRA **[APP-226]**, a conservative permeability value of 1 x 10^{-7}m/sec was adopted as the regional permeability value for the Glacial Till.

3.2.5 Packer tests were undertaken on five boreholes in the Oxford Clay. These were conducted to determine the in-situ permeability of the ground conditions around the Black Cat Interchange to aid in the design of structures. The permeability values varied between 5.95 x 10^{-7}m/sec and 6.53 x 10^{-4}m/sec. The results suggested that the permeability of the Oxford Clay was higher than that in the River Terrace Deposits, which is considered counter intuitive and did not reflect the actual lithological conditions.

3.2.6 In subsequent discussions, the EA raised concerns regarding the permeability values used in the assessments and in particular the accuracy of PSD-derived permeability values. It is accepted that permeability values derived from PSD analyses may not be accurate and that in-situ borehole testing provides more reliable results. As a result of the concerns expressed by the EA, additional permeability testing was carried out in June 2021 on a total of 15 boreholes, using a combination of falling head, rising head and slug tests. The calculations are presented in **Appendix A** and the results of the permeability tests are summarised in **Table 3-1, Table 3-2**, and **Table 3-3**.

3.2.7 The additional permeability tests undertaken on the River Terrace Deposits were completed on five boreholes located in the vicinity of the proposed Black Cat Interchange. The calculated permeability values varied between 8.96 x 10^{-6}m/sec and 1.9 x 10^{-4}m/sec, with an average permeability of 4.89 x 10^{-5}m/sec and a median value of 2.77 x 10^{-5}m/sec. When this data is combined with that derived from the two falling head tests completed in the earlier GI, the permeability varies between 8.96 x 10^{-6}m/sec and 2.4 x 10^{-3}m/sec, with an average of 3.82 x 10^{-4}m/sec.

3.2.8 The additional permeability tests undertaken on the Glacial Till were carried out on seven boreholes spread along the full length of the Scheme. The calculated permeability values varied between 5.96 x 10^{-9}m/sec and 1.16 x 10^{-6}m/sec, with an average permeability of 2.68 x 10^{-7}m/sec and a median value of 7.37 x 10^{-8}m/sec. These values are similar to that adopted for the Glacial Till in the earlier assessment of 1 x 10^{-7}m/sec. In many of the tests, the groundwater level was very slow to recover after the test, consistent with a low permeability. For example, **Figure 3-1** shows the slow recovery of the groundwater level in borehole BH271, located in the eastern part of the Scheme at the Caxton Gibbet junction, following the test. The slow recovery is consistent with the low permeability of the Till, in this case, 7.37 x 10^{-8}m/sec.

3.2.9 The three additional permeability tests undertaken on the Oxford Clay were carried out on boreholes in the western and central sections of the Scheme. The calculated permeability values varied between 4.12 x 10^{-8}m/sec and 1.4 x 10^{-7}m/sec, with an average permeability of 1.0 x 10^{-7}m/sec and a median value of 1.21 x 10^{-7}m/sec. These values are lower than those determined from the packer tests in the earlier ground investigation of 5.95 x 10^{-7}m/sec to 6.53 x 10^{-4}m/sec.

3.2.10 It is considered that the results from the more recent tests for the Glacial Till and the Oxford Clay are more reliable and representative. These have been used in the subsequent review of the GWRA to assess whether the revised permeability values have any significant impact on the conclusions made in the previous assessment. **Table 3-4** provides the permeability values that will be used in the assessments.

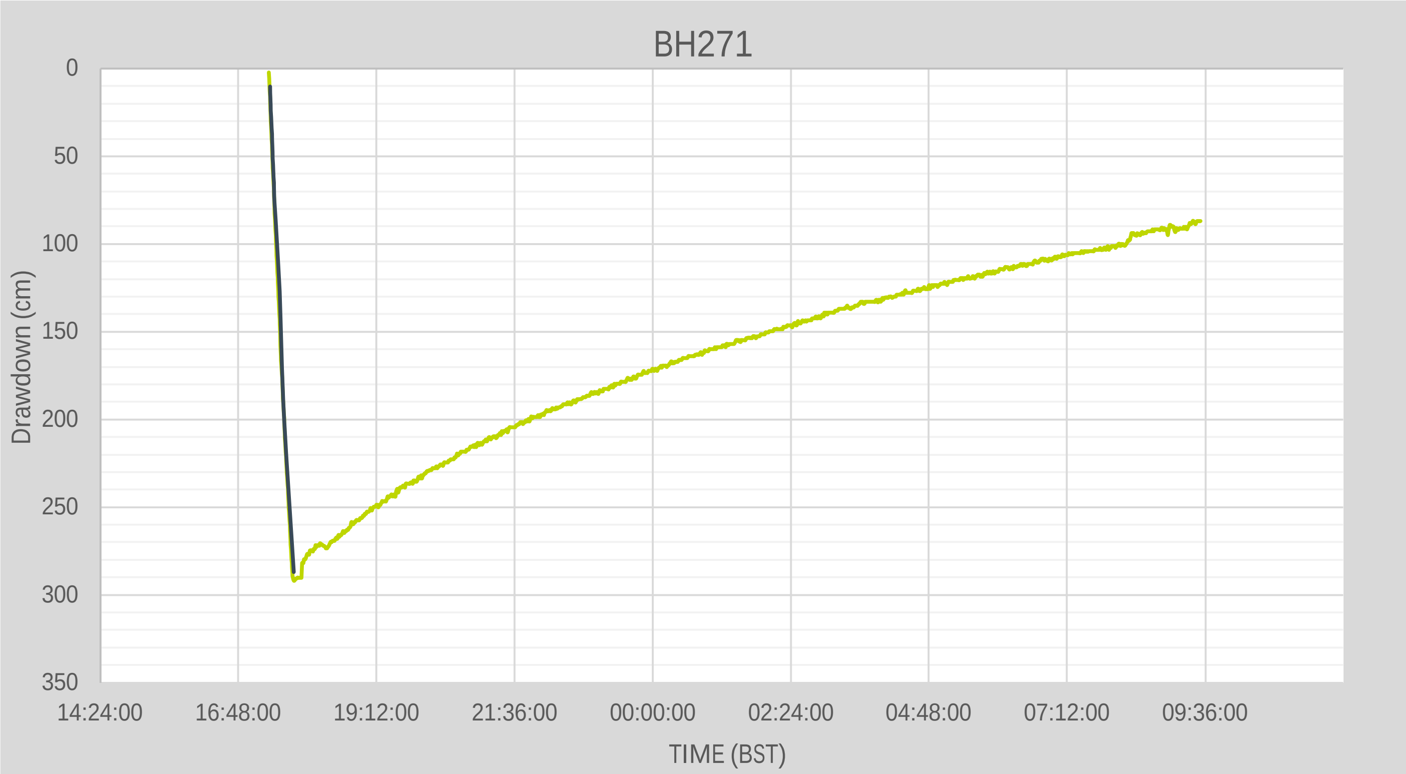


Figure 3-1: BH271 Permeability Test data

3.2.11 Based on the new permeability data, the potential impacts of dewatering during construction of the cuttings and borrow pits on groundwater flow and quality have been reviewed against the impacts determined in the previous GWRA. Details of the groundwater and surface water features which potentially could be impacted by the dewatering activities required for the construction and operation of the Scheme are provided in Sections 4 and 5 of the GWRA **[APP-226]**.

3.2.12 The assessment methodologies used to calculate the groundwater inflow rates and the extent of the cones/areas of influence created by the dewatering are provided in Section 6.4 of the GWRA **[APP-226]**. For the cuttings, planar groundwater flow was assumed whereas for the borrow pits, radial flow equations were used.

Table 3-1: River Terrace Deposits permeability test results 2021

Borehole name	Geology	Coordinates		Pumping Test Results						Falling Head test results		Rising Head test results			Average		Average	Max	Min
				T (m2/day)		S		K (m/sec)		K (m/sec)		K (m/sec)							
		Easting	Northing	Cooper-Jacob computed	Theis Computed	Cooper-Jacob computed	Theis Computed	Cooper-Jacob derived	Theis derived	Hvorselv computed	Bouwer-Rice computed	Cooper, Bredehoft & Papadopulos computed	Dagan computed	Hvorselv computed	T (m2/day)	S	K (m/sec)		
BH203-1	River Terrace	515798.9	255382.7	7.186	7.186	2.55E+00	2.55E+00	2.77E-05	2.77E-05						7.186	2.55E+00	2.7724E-05	2.7724E-05	2.7724E-05
BH206-1	River Terrace	515910.8	255282.5							8.63E-05	5.31E-05	1.60E-04	1.90E-04	1.60E-04	-	-	1.2988E-04	1.9000E-04	5.3113E-05
BH212	River Terrace	515980	255465	7.186	7.186	3.27E-03	3.27E-03	2.77E-05	2.77E-05	1.4025E-05	8.9626E-06	3.20E-05	2.90E-05	3.20E-05	7.186	3.27E-03	2.4484E-05	3.2000E-05	8.9626E-06
BH273-1	River Terrace	515878.9	255223.4							9.48E-05	6.68E-05	3.40E-05	3.00E-05	3.40E-05	-	-	5.1929E-05	9.4838E-05	3.0000E-05
BH275C-1	River Terrace	516104.1	255604	2.759	2.759	3.74E-03	3.74E-03	1.06E-05	1.06E-05						2.759	3.74E-03	1.0600E-05	1.0600E-05	1.0600E-05

Table 3-2: Glacial Till permeability test results 2021

Borehole name	Geology	Coordinates		Pumping Test Results			Falling head test results		Average		Average	Max	Min
				T (m2/day)	S	K (m/sec)	K (m/sec)						
		Easting	Northing	Hantush-Jacob (leaky) computed	Hantush-Jacob (leaky) computed	Hantush-Jacob (leaky) derived	Hvorselv computed	Bouwer-Rice computed	T (m2/day)	S	K (m/sec)		
BH271	Glacial Till	529604.2	260807.2	0.03822	0.694	7.37269E-08			0.03822	6.94E-01	7.37E-08	7.3727E-08	7.3727E-08
BH259	Glacial Till	525576	260800				7.35E-09	5.96E-09	-	-	6.6539E-09	7.3472E-09	5.9607E-09
BH285	Glacial Till	515983	255192	0.1006	2.89	1.16435E-06			0.1006	2.89E+00	1.1644E-06	1.1644E-06	1.1644E-06
BH246	Glacial Till	521451	2590966	0.06464	0.1328	2.49383E-07			0.06464	1.33E-01	2.4938E-07	2.4938E-07	2.4938E-07
BH242	Glacial Till	521065	259682	0.02939	0.6103	4.25203E-08			0.02939	6.10E-01	4.2520E-08	4.2520E-08	4.2520E-08
BH237-1	Glacial Till	519801.7	257851.3	0.09103	0.2433	3.01025E-07			0.09103	2.43E-01	3.0103E-07	3.0103E-07	3.0103E-07
BH234	Glacial Till	519328	256329	0.01923	0.4676	3.70949E-08			0.01923	4.68E-01	3.7095E-08	3.7095E-08	3.7095E-08

Table 3-3: Oxford Clay permeability test results 2021

Borehole name	Geology	Coordinates		Pumping Test Results			Average		Average	Max	Min
				T (m2/day)	S	K (m/sec)					
		Easting	Northing	Hantush-Jacob (leaky) computed computed	Hantush-Jacob (leaky) computed computed	Hantush-Jacob (leaky) dervived	T (m2/day)	S	K (m/sec)	K (m/sec)	K (m/sec)
BH230	Oxford Clay	518229	255471	0.0313	0.2604	1.20756E-07	0.0313	2.60E-01	1.2076E-07	1.2076E-07	1.2076E-07
BH224	Oxford Clay	516845.2	255342.2	0.06052	0.6725	1.40093E-07	0.06052	6.73E-01	1.4009E-07	1.4009E-07	1.4009E-07
BH239	Oxford Clay	520176	258514	0.02136	0.1491	4.12037E-08	0.02136	1.49E-01	4.1204E-08	4.1204E-08	4.1204E-08

Table 3-4: Permeability values used in the assessments

Unit	Permeability (m/sec)		
	Minimum	Average	Maximum
River Terrace Deposits	8.96×10^{-6}	3.82×10^{-4}	2.4×10^{-3}
Glacial Till	5.96×10^{-9}	2.68×10^{-7}	1.16×10^{-6}
Oxford Clay	4.12×10^{-8}	1.0×10^{-7}	1.4×10^{-7}

4 Groundwater Quality

4.1.1 The baseline groundwater chemistry has been informed from the results of groundwater samples collected from 21 groundwater monitoring points in December 2020 and from 24 samples collected in June 2021, comprising boreholes and piezometers located at different locations across the Scheme. The majority of the samples were collected from the same boreholes in each sampling round. The results from the December 2020 sampling were included in the GWRA **[APP-226]**. The results from the June 2021 sampling are included to validate the previous results. The locations of the groundwater sampling boreholes are presented in **Appendix B,** which also provides the analytical results with the borehole locations, sampling depths and the geological unit from which the samples were collected for both sampling rounds.

4.1.2 The analytical results have been compared against the Environmental Quality Standards (EQS) in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 or the UK Drinking Water Standards (UKDWS), where no EQS has been defined for specific determinands. Where parameters exceeded the limits, these are highlighted in red for each borehole in **Appendix B**. It should be noted that the comparison of the results with the UKDWS has only been made in order to provide context to the reader and that these exceedances of this more stringent standard do not necessarily imply that there are significant groundwater contamination issues of concern, particularly as there are no potable groundwater supply sources in the area of the Scheme.

River Terrace Deposits

4.1.3 Samples were collected from six boreholes BH203, BH206, BH212, BH273, BH275 and WS275, which facilitate sampling of the River Terrace Deposits. These boreholes are located in the western part of the Scheme in the vicinity of the Black Cat Interchange. In the December 2020 and June 2021 sampling rounds, samples were collected from all these boreholes except BH212, which was sampled only in the June 2021 sampling round.

4.1.4 The results show no evidence of significant contamination of the groundwater in the River Terrace Deposits apart from one location (WS275). Ammoniacal nitrogen and nitrate concentrations generally are low. Elevated sodium and chloride levels, both above the UKDWS of 250mg/l were reported for several of the samples.

4.1.5 The analytical results for the samples taken from sampling point WS275 showed evidence of contamination principally with hydrocarbons. This sampling point is located on a former petrol filling station in the Wyboston area, approximately 1.2km north from the centre of the existing Black Cat roundabout and approximately 750m north east of the northern extent of the proposed A1 Black Cat Underpass. The ammoniacal nitrogen concentration was higher than the other samples from the River Terrace Deposits at 1.75mg/l, whilst sodium and chloride concentrations were noticeably lower. The two samples from this location showed elevated concentrations of 1,2,4-Trichlorobenzene up to 0.2µg/l and 1,2,3-Trichlorobenzene up to 0.258µg/l. Total polycyclic aromatic hydrocarbons (PAHs) of 542µg/l and 52.9µg/l, and petroleum hydrocarbons in the ranges: Aliphatics $>C_{21}$-C_{35} (4.91mg/l); Aromatics $>EC_{12}$-EC_{16} (up to 0.2mg/l), $>EC_{16}$-EC_{21}, (up to 0.657mg/l); and $>EC_{21}$-EC_{35} (up to 1.82mg/l), all exceeded the respective UKDWS. The higher concentrations were reported for the sample taken in December 2020.

Glacial Till

4.1.6 Groundwater samples were collected from 13 boreholes BH234, BH237, BH242, BH249, BH253, BH256, BH260, BH261, BH265, BH271, BH275, BH285 and WS257, which facilitate sampling of the Glacial Till. Samples were collected from eight of these boreholes in both the December 2020 sampling round and in June 2021. Samples were collected from boreholes BH251, BH260, BH261 and BH265 only in December 2020 and from WS257 only in June 2021. The boreholes which were sampled are located along the whole length of the Scheme.

4.1.7 The groundwater quality in the Glacial Till is poor, with high concentrations of sodium, sulphate and chloride generally significantly exceeding the UKDWS Maximum Acceptable Concentration (MAC). As elevated concentrations are recorded in most of the boreholes, this is considered to reflect the natural groundwater quality in the low permeability material in which groundwater flow is very slow allowing reaction with the clay-rich materials. The maximum reported sodium concentration was 526mg/l in BH242 near the Cambridge Road crossing. The sulphate concentration was typically above 1500mg/l, with a maximum of 2220mg/l in borehole BH237(S) at the B1046 overbridge. The chloride concentration was often above 500mg/l, with a maximum of 828mg/l in borehole BH271 at the Caxton Gibbet junction.

4.1.8 PAHs, petrol hydrocarbons, volatile and semi-volatile organic compounds were not recorded above the respective limits of detection in all of the monitoring boreholes apart from borehole BH265, located at the St Ives Road overbridge, in which a low level of total petroleum hydrocarbons of 0.605mg/l was reported for the December 2020 sample.

Oxford Clay

4.1.9 Groundwater samples were collected from nine boreholes BH203, BH206, BH224, BH230, BH237, BH239, BH240, BH273 and BH275, which facilitate sampling of the bedrock. Samples were collected from seven of these boreholes in both the December 2020 sampling round and in June 2021. Samples were collected from boreholes BH203 and BH206 only in June 2021. The boreholes which were sampled are located mainly in the western and central parts of the Scheme.

4.1.10 The groundwater quality in the Oxford Clay is similar to that in the Glacial Till with elevated to high concentrations of sodium, sulphate and chloride often significantly above the guideline values. The maximum sodium concentration of 844mg/l, sulphate 2720mg/l and chloride 832mg/l were all reported for a sample from borehole BH230 at the East Coast Railway crossing. In addition, several of the samples reported elevated ammoniacal nitrogen above the UKDWS MAC of 1.5mg/l, up to a maximum of 3.15mg/l in borehole BH203 in the Black Cat area.

4.1.11 PAHs, petrol hydrocarbons, volatile and semi-volatile organic compounds were not recorded above the respective limits of detection in all of the monitoring boreholes apart from boreholes BH203, BH224 and BH230, in which low concentrations of PAHs were reported.

5 Cuttings Assessment Review and Update

5.1.1 There are a number of cuttings along the Scheme which will be below the groundwater level and hence will require dewatering to facilitate construction. The majority of the cuttings will be excavated in the Glacial Till and Oxford Clay, where it is considered likely that only small quantities of groundwater will need to be managed. Based on the results of the additional permeability tests, the impact of the construction dewatering on the surrounding groundwater conditions has been reviewed against the results of the previous GWRA **[APP-226]**.

5.1.2 The results of the qualitative assessment in the GWRA showed 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 in the Black Cat Interchange 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.

5.1.3 Based on the conceptual hydrogeological model, it is considered unlikely that excavations for cuttings and borrow pits in the central and eastern sections of the Scheme will require significant dewatering given their shallow depth in relation to the water table and the limited groundwater flow in the Glacial Till. In the western part of the Scheme, where the River Terrace Deposits are present, there is potential for more significant impacts on groundwater. It was considered that the two borrow pits in the Black Cat Interchange area together with the A1 Black Cat Underpass are likely to impact on the groundwater level and flow regime in the River Terrace Deposits. In addition, it was considered that groundwater control is likely to be required for the construction of the Barford Road and Alington Hill cuttings, which will be excavated in the Oxford Clay and Glacial Till.

5.1.4 Consequently, localised dewatering with potential groundwater management control during construction would be required for these elements of the Scheme. 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 localised variation in the natural groundwater flow regime.

5.1.5 Accordingly, a more detailed analytical assessment of these three cuttings and the two borrow pits has been carried out and is discussed in the subsequent sections.

5.2 A1 Black Cat Underpass

5.2.1 The Black Cat Interchange is underlain by the River Terrace Deposits, which comprise the principal water-bearing unit along the Scheme route. As part of the design for the Black Cat Interchange, the A1 will be re-routed and lowered into an underpass cutting beneath the existing ground level to form a continuous north to south route through the new road interchange junction. The underpass will be approximately 725m long and at the lowest point the carriageway surface is 8.8m below the existing ground level. The underpass will be excavated through the full thickness of the River Terrace Deposits into the underlying till, possibly extending locally into the Oxford Clay. From a groundwater perspective, this cutting is considered to present the most significant impact on groundwater and a detailed scheme of groundwater management will be required.

5.2.2 At the time of preparing the GWRA, given the absence of a detailed design for the A1 Black Cat Underpass, a worst-case scenario assessment of the design included a permanent groundwater dewatering solution, as it will not be possible to drain the cutting by gravity. Assuming a permeability of 2×10^{-4}m/sec originally adopted for the River Terrace Deposits, it was estimated that up to 1465m^3/day of groundwater could be pumped from the cutting to prevent flooding during the operation of the road. However, a permanent pumping solution was considered unsustainable and, in addition, the EA expressed their preference that a permanent groundwater pumping solution was avoided.

5.2.3 A preliminary detailed design, including the use of secant pile walls for the A1 Black Cat Underpass, has now been prepared, which removes the need for significant, permanent groundwater pumping. Along the deepest part of the cutting, secant pile walls up to 390m long on both the western and eastern sides of the cutting will be constructed. The piles will be founded in the Glacial Till or the Oxford Clay. North and south of the secant pile walls, a cement-bentonite slurry cut-off wall will be constructed, founded in the till and extending approximately 185m to the north and 150m to the south of the secant pile wall. **Appendix C** shows the proposed cutting design.

5.2.4 To quantify the impact of the barrier on groundwater flow in the River Terrace Deposits caused by the secant pile wall and the slurry cut-off trench, a MODFLOW simulation was undertaken. This showed that the groundwater level upstream of the barrier could rise by up to 0.9m in the average scenario. Meanwhile on the downstream side (east) there could be a decline in the groundwater level of up to 1.3m. The groundwater is diverted by the structure to the north and south with additional flow through the aquifer which will subtly change the groundwater flow to different reaches of the nearby surface watercourses.

5.2.5 A feature of the MODFLOW simulation is that both the maximum and minimum permeability values for the River Terrace Deposits are considered implausible for the uniform River Terrace Deposits scenario. The maximum permeability value requires a recharge rate much in excess of regional rainfall and thus is implausible. The minimum value is also problematic with the groundwater model being unable to achieve a stable solution. Accordingly, although the maximum permeability value of 2.4×10^{-3}m/sec has been used in the assessments, it is considered that this value is not representative of the River Terrace Deposits on a regional scale and that a lower permeability value would more closely represent the natural conditions.

5.2.6 At the proposed cutting, groundwater in the River Terrace Deposits generally flows east towards the River Great Ouse, approximately 600m east of the cutting. It is likely that the groundwater discharges to the flooded workings in Breedon Quarry to the west of the river before discharging as baseflow to the river. Based on the revised permeability range of 8.96 x 10^{-6}m/sec to 2.4 x 10^{-3}m/sec and an average of 3.82 x 10^{-4}m/sec for the River Terrace Deposits, it is calculated that the current groundwater flows across the proposed cutting is in the range 7.2m^3/day to 335 m^3/day with an average of 43m^3/day.

5.2.7 Approximately 470m north of the interchange is the South Brook, an easterly flowing tributary of the River Great Ouse. The South Brook is underlain by the River Terrace Deposits and it is likely that it receives baseflow discharge from the River Terrace Deposits. Approximately 540m south of the interchange is Rockham Ditch, another easterly flowing tributary of the River Great Ouse. It is likely that the Rockham Ditch also receives baseflow discharge from the River Terrace Deposits.

5.2.8 The secant pile wall and the cement-bentonite slurry cut-off walls will block the natural direction of groundwater flow, although it is likely that negligible quantities of groundwater will seep through imperfections in the pile walls. Performance targets for concrete lined tunnels include a seepage rate of 1 litre/day/m^2 of tunnel lining. Based on this seepage rate, it is estimated that less than approximately 5m^3/day could flow through the western wall of the cutting, which will be exempt from abstraction licensing. These small quantities of groundwater seepage from the River Terrace Deposits will be collected in the road drainage network and be directed to a pumping station located on the northern side of the interchange. Water collected in the pumping station will be pumped to a lagoon north of the interchange from where the water will infiltrate into the River Terrace Deposits or be discharged to the South Brook via attenuation pond BC2 located north west of the cutting. These elements of the scheme are included in the current scheme design and are shown on the respective works plans.

5.2.9 The design for the underpass will cause a reduction in the volume of groundwater baseflow to the River Great Ouse. It is predicted that upstream of the pile wall, the groundwater level will rise from its current level of approximately 18m AOD to approximately 19m AOD. The increased groundwater level and the barrier presented by the pile wall will divert the groundwater flow sub-parallel with the cutting. It is considered that groundwater in the River Terrace Deposits west of the cutting will flow to the north east and south east and discharge to the South Brook and the Rockham Ditch respectively. **Appendix D** provides the MODFLOW simulation of the A1 Black Cat Underpass. The results of a sensitivity analysis using the MODFLOW simulation for the varying permeability values for the River Terrace Deposits provided in **Table 3-4** are summarised in **Table 5-1**.

Table 5-1: Changes in groundwater discharge to watercourses

	Groundwater discharge (m³/day) Baseline		
	Maximum k	Average k	Minimum k
South Brook	6298	1620	29.1
Rockham Ditch	7085	1556	32.7
	Groundwater discharge (m³/day) Post-construction		
South Brook	6474	1644	28.9
Rockham Ditch	7079	1551	37.4

5.2.10 The results of the sensitivity analyses show that for all the modelled scenarios there are only negligible impacts on groundwater discharges to both South Brook and Rockham Ditch even for the extreme maximum permeability value. This is because the underpass ‘barrier’ does not significantly change the groundwater catchments to the two streams or to the River Great Ouse. There is a minor reduction in the catchment area draining to the River Great Ouse, which results in a small reduction in baseflow to the river and a small increase in groundwater flow to the South Brook. **Figure 5-1** and **Figure 5-2** show the groundwater catchments derived from the model for the current conditions and post-construction.

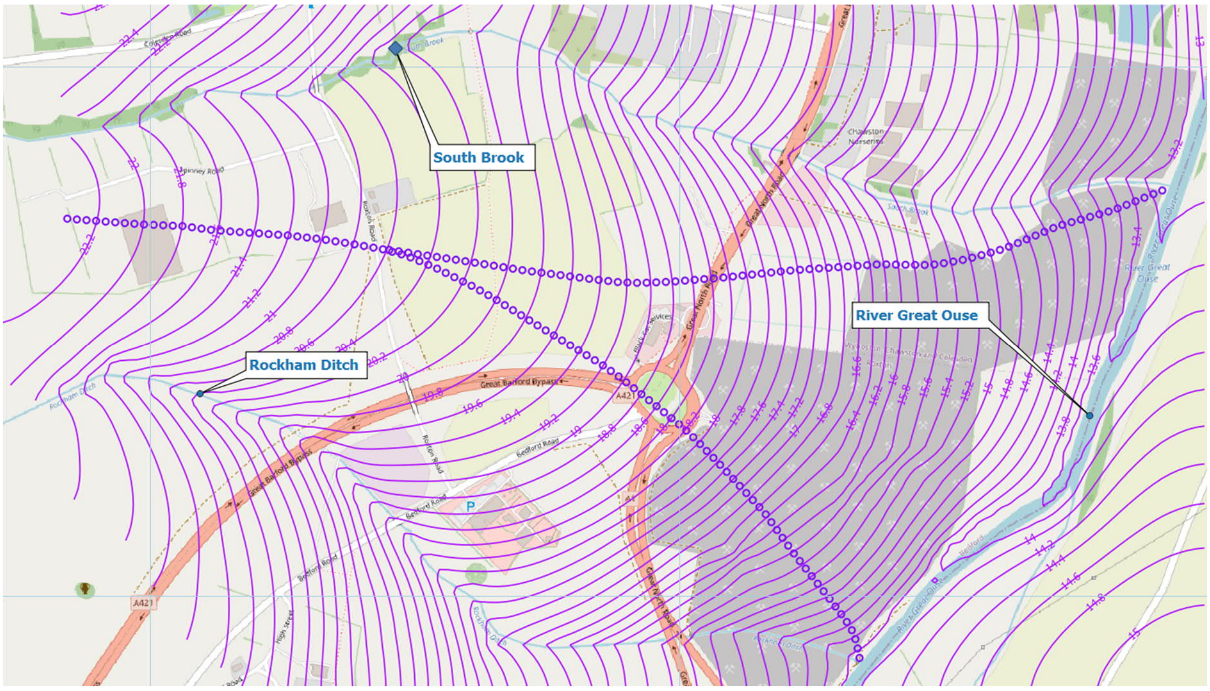


Figure 5-1: Groundwater catchments: Current conditions

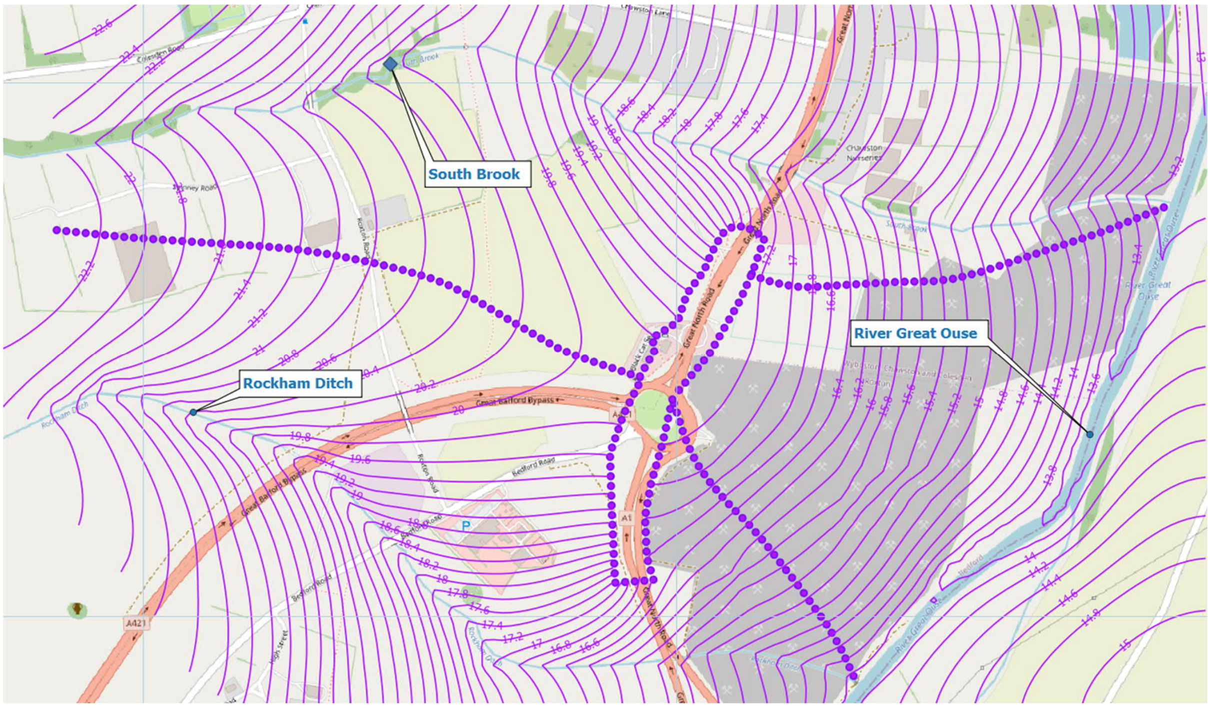


Figure 5-2: Groundwater catchments: Post construction

5.2.11 Based on the results of the model, it is considered that the maximum permeability value derived for the River Terrace Deposits of 2.4 x 10^{-3}m/sec is not representative of the regional aquifer. In order to calibrate the model using this permeability value requires a recharge rate in excess of 2.5m per annum, which is considered implausible for this part of eastern England.

5.2.12 The implications of the predicted changes in groundwater discharge to the South Brook and to the Rockham Ditch are discussed in the Flood Risk Assessment Technical Note. There will be a minor reduction in the volume of direct groundwater baseflow to the River Great Ouse. However, this water will discharge to the two local tributaries of the river, resulting in no overall loss in baseflow to the River Great Ouse.

5.2.13 The detailed preliminary design for the A1 Black Cat Underpass removes the requirement for permanent groundwater pumping to prevent flooding. It is unlikely that the negligible volume of groundwater that will seep through the barrier walls will significantly impact on the flow of the River Great Ouse, as this water will be discharged to a tributary of the river.

5.2.14 Whilst it is considered that during the operation of the Scheme, there will be no requirement for significant pumping of groundwater from the cutting, temporary dewatering will be needed during the construction period. As the pile walls on both sides of the cutting will be installed before excavation of the cutting starts, dewatering of the River Terrace Deposits will be limited to the River Terrace Deposits present within the footprint of the cutting. Once these have been removed, groundwater ingress to the cutting excavation will be negligible.

5.2.15 The cutting will be approximately 33m wide and 725m long with an average saturated thickness of the River Terrace Deposits of approximately 4m. If a porosity of 25% is assumed for the River Terrace Deposits, it is calculated that approximately 23,900m^3 of groundwater is present within the River Terrace Deposits remaining in the cutting between the pile walls. This water will need to be removed by pumping as the cutting progressively is excavated. It is estimated that it will take approximately 40 days to excavate the cutting. Based on this programme, it is estimated that on average approximately 600m^3/day of groundwater will be pumped from the excavation. This water will be discharged, following settlement to reduce the suspended solids concentration, to a nearby watercourse with suitable mitigation measures to manage any water pollution or physical risks as set out in the Outline Water Management Plan contained in the First Iteration Environmental Management Plan **[TR010044/APP/6.8v2]**.

5.2.16 The quality of the groundwater in the River Terrace Deposits generally is satisfactory. There is evidence of groundwater contamination at sampling point WS275, located approximately 750m north from the northern limit of the Black Cat Underpass, in which elevated hydrocarbons were reported. There are two easterly flowing streams between the location of WS275 and the A1 Black Cat underpass – the South Brook and Begwary Brook. It is likely that both streams are in hydraulic continuity with groundwater in the River Terrace Deposits. Accordingly, it is considered that contaminated groundwater in the vicinity of WS275 will flow south easterly and discharge to the Begwary Brook. It is unlikely that temporary dewatering for construction of the A1 Black Cat Underpass will influence the groundwater north of South Brook in the area of WS275 and hence it is considered that the risk of contaminated groundwater being drawn into the temporary dewatering scheme during the excavation for the A1 Black Cat Underpass is negligible.

5.2.17 The Black Cat A1 Underpass cutting presents the most significant risk to groundwater. However, given the preliminary design, which includes the use of secant pile walls to mitigate the need for permanent groundwater pumping the overall magnitude of the potential impact on groundwater flow, level, quality and the corresponding impact of the cutting on identified water receptors during construction and operation of the Scheme will be no more than **minor**, resulting in at worst a **slight** effect which is not significant. The use of secant pile walls to manage groundwater in the cutting will be included in the Second Iteration of the Environmental Management Plan.

5.2.18 The amended design for the A1 Black Cat Underpass cutting would reduce the predicted effect significance during the operational period from **slight** to **neutral**.

5.3 Barford Road Cutting

5.3.1 The Barford Road Cutting is located approximately 2km east of the Black Cat Interchange. The 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.

5.3.2 Boreholes BH225, BH226 and BH227 and trial pits TP335, TP366 and TP367 are located in the vicinity of the proposed cutting. Apart from trial pit TP366, all of the boreholes and trial pits proved a thin layer of topsoil overlying the Glacial Till. The till in this area is thin and the Oxford Clay bedrock was proved at depths between 1.5m (TP335) and 4.95m (BH227). The Oxford Clay was proved to a maximum depth of 25.1m in borehole BH227, a thickness of 20.15m. The base of the Oxford Clay was not proven in this area.

5.3.3 In trial pit TP366, to the south west of the cutting, a layer of orange-brown sand and gravel was proved below the topsoil layer. The sand and gravel was present to the base of the trial pit at 3.7m. In the 2019/2020 ground investigation, the sand and gravel was interpreted as River Terrace Deposit. Given the topography of the area, approximately 8m above the floodplain, it is considered that the sand and gravel is not connected with the River Terrace Deposits in the floodplain of the River Great Ouse to the west but may represent a higher level terrace deposit. The BGS plan shows an outcrop of the Third River Terrace in the vicinity of the Barford Road and it is likely that the sand and gravel proved in trial pit TP366 is part of this outcrop. Sand and gravel was not proved in any of the other boreholes and trial pits in this locality and hence it is considered that this unit is not widespread in this area and can be discounted from the assessment.

5.3.4 Based on an assessment of the geology of the area, it is considered that the cutting will pass through the full thickness of the Glacial Till extending into the underlying Oxford Clay.

5.3.5 Groundwater monitoring data from boreholes in the vicinity of the proposed cutting indicate that the groundwater level varies between 26.25m AOD and 16.95m AOD 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 a maximum of approximately 5.7m below the groundwater level and 0.8m below the base of the Till.

5.3.6 Based on the cutting design and applying the initial permeability value of $1.0x 10^{-7}$ m/sec adopted for the Glacial Till, with a maximum saturated aquifer thickness of 4.9m, the maximum zone of influence was estimated empirically to be approximately 3.1m. The estimated maximum inflow using the Chapman (1959) unconfined aquifer equation for a fully penetrating condition was calculated to be approximately $25m^3$/day. This would be required to dewater the area and enable construction of the Barford Road cutting in dry conditions.

5.3.7 However, taking into consideration the variation in the depth of the cutting, the variation in the land elevation in relation to the groundwater level and the variation in the saturated aquifer thickness along the full length of the cutting, applying an average saturated aquifer thickness of 3.37m and a corresponding dewatering maximum drawdown of 3.37m, the estimated inflow reduces to approximately $12m^3$/day.

5.3.8 Using the additional permeability values obtained for the till and hence assuming a permeability range of 5.96 x 10^{-9}m/sec to 1.16 x 10^{-6}m/sec, the estimated volume of groundwater inflow to the cutting during construction is in the range of approximately 4m^3/day to 50m^3/day, with an average of 24m^3/day. The maximum zone of influence is estimated to be approximately 10.6m.

5.3.9 No ground contamination has been reported or observed during the detailed 2019/2020 ground investigation for the Scheme in the Barford Road area. The groundwater quality analytical results for most of the samples collected in the vicinity of the proposed cutting indicated no significant groundwater contamination issues in the area. In one sampling point (BH224) in the Oxford Clay, located approximately 170m west of the cutting, slightly elevated levels of sodium, sulphate, manganese and PAHs (Benzo(k)fluoranthene and Benzo(a)pyrene) above the UKDWS were reported. As this location is outside the estimated zone of influence due to dewatering and down hydraulic gradient of the cutting, it is considered that it does not pose a risk to the quality of water pumped from the cutting during construction.

5.3.10 There are no Groundwater Dependent Terrestrial Ecosystems or other water receptors in the vicinity of the Barford Road cutting. The River Great Ouse that flows approximately 300m west from the centre of the cutting is the closest surface water body to the cutting. The river is a designated Main River with very high importance that is likely to be receiving a very small proportion of baseflow from the superficial deposits in the Barford Road area in comparison with the flow in the river. As the river falls outside the estimated zone of influence, it is unlikely to be impacted by potential dewatering abstraction at the proposed cutting. In addition, it is anticipated that any water abstracted during construction dewatering will be discharged to the river directly via nearby tributaries in order to minimise any potential flow impacts. Water discharged may need to be attenuated and treated prior to discharge in accordance with the mitigation measures described in the Outline Water Management Plan presented in the First Iteration Environmental Management Plan **[TR010044/APP/6.8v2]**.

5.3.11 No groundwater barriers or cut-off walls are proposed for the Barford Road cutting. To prevent instability of the side slopes from groundwater ingress from the till, it is proposed that slope drainage will be installed to address any localised groundwater inflows from more permeable pockets and horizons in the slopes. The slope drainage will connect with the road drainage, which flows by gravity. There will be no pumping of groundwater. As the invert of the road drains will be higher (approximately 1m) than the depth of excavation for the road construction, the groundwater level in the till will be depressed less and the rate of groundwater ingress will be lower than during construction. During the operational period, it is estimated that the rate of groundwater inflow to the Barford Road cutting road drainage system will be small at approximately 17m^3/day, which can easily be accommodated in the road drainage system.

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

5.3.13 Accordingly, the overall magnitude of impact on groundwater quality and other water receptors arising from construction dewatering activities and during operation

5.3.14 at the Barford Road cutting will be no more than **minor** adverse resulting in at worst a **slight** effect, which is not significant. Although an amended permeability has been used for the till, there is no change in the significance of the predicted effect on controlled waters compared with the conclusions in the GWRA.

5.4 Alington Hill Cutting

5.4.1 The Alington Hill cutting is located at the summit of Alington Hill. The maximum depth of the Alington Hill cutting is approximately 7.6m (43.7m AOD) with a length of approximately 1370m.

5.4.2 Boreholes BH234, BH235 and trial pit TP338 are at the location of the cutting. The two boreholes recorded a thin layer of topsoil (0.3m) overlying the Glacial Till, described as a soft, becoming stiff greyish brown, silty sandy gravelly clay. The till is underlain at a depth of 7.4m and 8.0m respectively by the Oxford Clay. The Oxford Clay was proved to a maximum depth of 20m. The log for trial pit TP338 shows a thin layer of topsoil (0.3m) overlying till to the base at 3.8m bgl. The upper section of the till is described as a clay with occasional pockets of sand to depth of 1.4m, over a stiff, brownish grey gravelly clay. Accordingly, it is inferred that the cutting will be excavated within the till, possibly locally terminating in the Oxford Clay.

5.4.3 Water was not struck in the boreholes or the trial pit. Based on an interpretation of the groundwater level monitoring, it is inferred that the groundwater level in the Glacial Till varies between 50.8m 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 groundwater level recorded in borehole BH234 in December 2020 was 1.16m below ground level (47.15m AOD) and 0.79m (47.52m AOD) in June 2021. Accordingly, the base of the cutting will be approximately 3.8m below the groundwater level. The groundwater level and flow regime within the Glacial Till is likely to be affected by dewatering activities during the construction and operation of the Scheme.

5.4.4 Based on the above and applying the hydraulic conductivity value of 1.0×10^{-7}m/sec originally adopted for the Glacial Till, the maximum zone of influence was estimated to be approximately 4.1m. The corresponding estimated inflow using the Chapman (1959) unconfined aquifer equation for a fully penetrating condition was calculated to be approximately 120m^3/day. Taking into consideration the variation in the depth of the cutting and the variation in the saturated thickness of the Glacial Till along the full length of the cutting, applying the estimated zone of influence of 4.1m and an average saturated aquifer thickness of 3.8m, the estimated inflow reduced to approximately 65 m^3/day.

5.4.5 A pumping test was carried out on borehole BH234 in June 2021. Analysis of the pumping test gave a permeability for the Glacial Till of 3.7 x 10^{-8}m/sec. Using the site-specific permeability value from borehole BH234, the estimated zone of influence is 2.5m and the estimated groundwater inflow rate from the till during construction of the cutting is 39m^3/day. Using the regional permeability range as shown in **Table 3-4** for the Glacial Till, the calculated rate of groundwater inflow to the cutting varies between 16m^3/day and 219m^3/day with a mean value of 105m^3/day. The maximum zone of influence is approximately 14m.

5.4.6 No ground contamination has been reported or observed at this location during the detailed 2019/2020 ground investigation for the Scheme. The baseline groundwater quality for two samples taken from borehole BH234 in the vicinity of the proposed cutting showed no significant groundwater contamination issues.

5.4.7 There are no Groundwater Dependent Terrestrial Ecosystems in the vicinity of the Alington Hill cutting. All other identified water features/receptors including licensed abstractions are also outside the maximum calculated zone of influence and are therefore unlikely to be impacted by dewatering during construction and operation of the Alington Hill cutting.

5.4.8 No groundwater barriers or cut-off walls are proposed for the Alington Hill cutting. To prevent instability of the side slopes from groundwater ingress from the till, it is proposed that slope drainage will be installed to address any localised groundwater inflows from more permeable pockets and horizons in the slopes. The slope drainage will connect with the road drainage, which flows by gravity. There will be no pumping of groundwater. As the invert of the road drains will be higher (approximately 1m) than the depth of excavation for the road construction, the groundwater level in the till will be depressed less and the rate of groundwater ingress will be lower than during construction. During the operational period, it is estimated that the rate of groundwater inflow to the Alington Hill cutting road drainage system will be approximately 29m^3/day, which can easily be accommodated in the road drainage system.

5.4.9 Given that the cutting is located at the summit of a ridge and taking into consideration the proposed drainage strategy for the road, the magnitude of the potential risk to water resources associated with the construction and operation of the cutting is considered to be **minor** adverse, resulting in at worst a **slight** effect, which is not significant.

5.4.10 Although an amended permeability has been used for the Glacial Till, there is no change in the significance of the predicted effect on controlled waters compared with the conclusions in the GWRA.

5.5 Eversden-Eltisley Landfill

5.5.1 The EA raised concerns regarding the impact of the road construction on the Eversden-Eltisley Landfill in the eastern part of the Scheme. The landfill is located on the northern side of the Scheme route. The landfill is a small site licensed for the disposal of inert wastes and uncontaminated soils and hence there is a low potential for leachate generation. In addition, given the low permeability nature of the surrounding Glacial Till, it is considered unlikely that leachate, if generated, will migrate significant distances from the landfill.

5.5.2 Boreholes BH260, BH261 and BH262 and trial pits TP292, TP293, TP353 and TP354 are located in the vicinity of the landfill. All these boreholes and trial pits proved a thin layer of topsoil overlying the Glacial Till, described as a firm to very stiff, grey sandy, silty, gravelly clay. The till was proved to a depth of 15.0m in the three boreholes. The base of the till was not proved. In borehole BH261, the till is overlain by a 1.15m thick layer of sandy gravelly clay, which is interpreted as alluvium.

5.5.3 No significant groundwater strikes were recorded. In borehole BH261, a water strike was recorded in the till at 3.5m depth, rising to 3.0m after 20 minutes. In trial pit TP293, a seepage was recorded near the base of the trial pit at 3.5m depth in a gravelly silt band in the till. In trial pit TP354, a groundwater strike was recorded at 1.2m depth in a pocket of sand and gravel, less than 0.3m thick. The groundwater level remained steady at 1.2m. No water was recorded in the other boreholes and trial pits. The groundwater level in borehole BH260 was 5.64m bgl (50.96m AOD) and in BH261 was 1.08m bgl (56.5m AOD) in December 2020.

5.5.4 The proposed road adjacent to the landfill either will be on a shallow embankment or at grade and no significant excavation is proposed along this section. In the absence of any significant excavations, it is considered that no dewatering will be required along this section of the Scheme route. Accordingly, it is unlikely that the construction and operation of the Scheme will impact on groundwater levels and flow in the Glacial Till and will not impact on the possible migration of leachate from the landfill.

5.5.5 Water samples were collected from boreholes BH260 and BH261 in December 2020. Access for additional sampling was refused in June 2021. The results of the analyses are provided at **Appendix B**. The groundwater quality is similar to that reported for other boreholes which facilitate monitoring of the Glacial Till, although the concentrations reported for BH261 generally are lower. The ammoniacal nitrogen concentration was 0.284mg/l and less than the limit of detection of 0.2mg/l in boreholes BH261 and BH260 respectively. The chloride concentration was 223mg/l in borehole BH260 and 58.8mg/l in borehole BH261, sodium 504mg/l and 59.6mg/l; and sulphate 964mg/l and 179mg/l respectively. Petroleum hydrocarbons were not reported above the limit of detection in either sample. Most VOC and SVOC compounds also were below the respective limits of detection. Very low polycyclic aromatic hydrocarbons were reported. The samples taken in December 2020 show no evidence of contamination attributed to leachate migration.

5.5.6 In the absence of any significant dewatering adjacent to the landfill, it is concluded that the risk of impacting on leachate migration is negligible and hence the Scheme does not pose a risk to groundwater quality in this area.

6 Summary

6.1.1 Based on a review of the groundwater conditions, the geometry (i.e. depth and length) of the cutting sections and the general low permeability nature of the underlying geology beneath the Scheme, the overall magnitude of the potential impact on groundwater flow, level, quality and the corresponding effect significance of the cuttings on identified water receptors during construction and operation of the Scheme will be no more than **minor**, resulting in a **slight** effect, which is not significant.

6.1.2 These findings and overall significance of effects are consistent with the findings presented in the GWRA **[APP-226]**.

6.1.3 As part of the Construction Dewatering Strategy to be agreed with the EA, a scheme of groundwater monitoring will be prepared to monitor the effects of the dewatering and to confirm the modelled/predicted impacts.

7 Borrow Pits Assessment Review and Update

7.1.1 Two borrow pits [BPA] and [BPC] are planned in the western part of the Scheme in the vicinity of the Black Cat Interchange. 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, respectively.

7.2 Borrow Pit A

7.2.1 Borrow Pit A is located approximately 700m west of the Black Cat Interchange. The borrow pit 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 of the Oxford Clay, which acts as a hydraulic barrier to vertical groundwater flow. The ground elevation at the borrow pit is approximately 24m AOD.

7.2.2 Information reviewed, which includes records from nearby BGS boreholes (TL15NE100, TL15NE97 and TL15NE60) and boreholes BH203, BH206, BH207 and BH215 drilled in the 2019/2020 ground investigation 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/south-easterly flow direction towards the Rockham Ditch and the River Great Ouse.

7.2.3 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 River Terrace Deposits, plus 1m below the base to maintain dry conditions in the working area of the pit) will be required. Therefore, it will be necessary to lower the groundwater level in the River Terrace Deposits by 2m to 3m.

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

7.2.5 Based on the above calculated zone of influence and applying the initial hydraulic conductivity value of 2.0 x 10^{-4}m/sec with an aquifer thickness of 3m (i.e. the approximate maximum saturated aquifer thickness of the River Terrace Deposits at the site), the groundwater inflow to dewater the borrow pit to the maximum drawdown of 2m plus an additional 1m below the base of the River Terrace Deposits to maintain dry ground conditions (i.e. 4m bgl (20m AOD)) was estimated using the Darcy equation to be 2,775m^3/day. The assessment assumed that groundwater inflow would be through all sides of the borrow pit with a perimeter of approximately 1500m.

7.2.6 The inflow rate was re-calculated using the amended permeability values for the River Terrace Deposits, as shown in **Table 3-4.** These gave a zone of influence between 18m and 294m and groundwater inflow rates of 587m^3/day to 9,614m^3/day with a mean rate of 3,835m^3/day. However, in practice, the predicted groundwater inflow and the magnitude of the effects are likely to be lower as the full extent of the borrow pit will not be worked at the same time. Sections of the pit may be opened up and material generated and backfilled before or while works are progressed in another part of the pit. Therefore, it is likely that the rates of pumping required will be significantly lower than estimated as only a part of the borrow pit will be excavated at any one time.

7.2.7 The Rockham Ditch, which flows easterly along the southern boundary of the proposed borrow pit and South Brook, which flows easterly, 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 importance and are likely to be receiving baseflow from the River Terrace Deposits. The Rockham Ditch is likely to be impacted by the lowering of groundwater in the borrow pit. However, it is anticipated that any water abstracted during dewatering of the borrow pit will be discharged to the Rockham Ditch, which will minimise any potential flow impacts. Accordingly, the magnitude of the potential dewatering impact on groundwater baseflow to the Rockham Ditch is considered to be **minor**, resulting in a **slight** effect, which is not significant.

7.2.8 The South Brook falls on the edge of the maximum estimated zone of influence of the dewatering to the north of the borrow pit. Any effects at this distance will be small and the impact on the flow of the stream will be negligible. Notwithstanding, to mitigate any impact, it is anticipated that a portion of the water abstracted during dewatering of the borrow pit will be discharged to the South Brook in accordance with the mitigation measures described in the Outline Water Management Plan presented in the First Iteration Environmental Management Plan **[TR010044/APP/6.8v2]**. Accordingly, the magnitude of the potential dewatering impact on groundwater baseflow to the South Brook is considered **negligible**, resulting in a **slight or neutral** effect, which is not significant. The magnitude of impact on groundwater level and flow due to potential dewatering activities at BPA is considered to be **minor** adverse.

7.2.9 No ground or groundwater contamination has been observed at or in the vicinity of the proposed borrow pit during the 2019/2020 ground investigation for the Scheme or from subsequent groundwater quality monitoring. Analytical results for groundwater samples collected from borehole BH203 in December 2020 and June 2021 in the vicinity of the proposed borrow pit showed no evidence of significant groundwater contamination. Accordingly, the magnitude of impact on groundwater quality arising from dewatering activities will be **minor**, resulting in a **slight or neutral** effect, which is not significant. Although an amended permeability has been used for the River Terrace Deposits, there is no change in the significance of the predicted effect on controlled waters compared with the conclusions in the GWRA.

7.2.10 In addition, it is proposed that groundwater monitoring boreholes be 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 resulting from dewatering. The locations of the monitoring boreholes will be included in the Construction Dewatering Strategy, and secured in the First Iteration of the Environmental Management Plan **[TR010044/APP/6.8v2]**.

7.3 Borrow Pit C

7.3.1 Borrow Pit C is located approximately 350m north east of the Black Cat Interchange adjacent to the eastern side of the A1. The ground elevation at the location of BPC is approximately 17m AOD. The target material from BPC is the Glacial Till, with an anticipated maximum depth for the borrow pit of 7m. BPC will be located within a single field in the northern part of the former Breedon Quarry where most of the River Terrace Deposit already has been extracted and the area backfilled with excavated material unsuitable for aggregate processing, comprising soft to firm brown slightly sandy gravelly clay and fine sand.

7.3.2 Historical borehole records from Breedon Quarry (BH2015/20, BH2015/19; BH2015/18; BH2015/17; BH2015/16; BH2015/15 and BH2015/14) indicated that the average base of the RTD in this area is approximately 15m AOD, approximately 2m bgl. The records show that the thickness of the RTD before it was quarried was 2m – 3m. This thickness was also proved by a number of the 2019/2020 ground investigation boreholes (BH275C, BH216, BH220) and trial pits (TP330, TP334 and TP365) located in the vicinity of the borrow pit where the River Terrace Deposits have not been quarried.

7.3.3 The River Terrace Deposits are underlain by at least approximately 10m of till. Geological records show that the till extends 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.

7.3.4 The historical borehole records BH2015/21, BH2015/20, BH2015/19, BH2015/18, BH2015/17, BH2015/16, BH2015/15, BH2015/14 from Breedon Quarry and the 2019/2020 ground investigation logs for borehole BH275C and trial pits TP334 and TP365 indicate that the groundwater level at the proposed borrow pit is approximately 16.5m AOD, less than 1m bgl. Groundwater in the River Terrace Deposits flows in an easterly and north easterly direction towards the River Great Ouse and to the South Brook respectively. Therefore, it is concluded that, given the anticipated maximum depth (7m) of the pit and the shallow groundwater level at the location, dewatering will be required to maintain a dry operational area during excavation.

7.3.5 Till was proved in 37 of the 42 boreholes drilled in the vicinity of the former Breedon Quarry in 2015. The boreholes were drilled to establish the mineral resources and the base of the River Terrace Deposits. 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 struck water in a 0.1m thick blue-grey, soft sandy silt at the top of the till.

7.3.6 Accordingly, the conceptual model for the BPC analytical assessment assumes that the combination of the saturated residual River Terrace Deposits (approximately 0.5m to 1m thick) and the saturated upper layer (approximately 0.5m) of the Glacial Till is the potential water-bearing horizon, while the lower section of the till acts as a hydraulic barrier. Therefore, the saturated thickness 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.

7.3.7 Applying the initial hydraulic conductivity value of 2.0 x 10^{-4}m/sec in the Sichardt equation for the 1.5m saturated River Terrace Deposits and the upper 0.5m of the Glacial Till, the calculated zone of influence was estimated to be 42m. The groundwater inflow volume required to dewater the borrow pit was estimated using the Darcy equation at approximately 770 m^3/day. The assessment assumes that groundwater inflow will be through all sides of the borrow pit with a perimeter of 840m. The calculations are provided in Annex 5 of the GWRA.

7.3.8 Applying the additional permeability values for the River Terrace Deposits, the revised zone of influence varies between 9m and 147m. The rate of groundwater inflow varies between 163m^3/day and 2,667m^3/day, with an average of 1,064m^3/day. However, in practice, the groundwater inflow rates and the magnitude and effect significance are likely to be significantly lower as the full extent of the borrow pit will not be worked at the same time, as sections of the pit may be opened up and material generated and backfilled before or while works are progressed in another part of the pit.

7.3.9 The nearest water receptors (watercourses) to the proposed borrow pit are South Brook, Rockham Ditch and the River Great Ouse, located respectively approximately 100m, 590m and 420m from the northern, southern and eastern boundaries of BPC. These watercourses are likely to be receiving baseflow from the River Terrace Deposits within the vicinity of the proposed borrow pit. As both the Rockham Ditch and the River Great Ouse are outside the estimated maximum zone of influence, it is unlikely that the lowering of groundwater at the borrow pit would impact these two watercourses due to changes in the groundwater level and baseflow towards them.

7.3.10 The South Brook is within the estimated maximum zone of influence of the dewatering at the borrow pit and the pumping will reduce the volume of baseflow discharging to the watercourse and potentially reverse the groundwater gradient causing water to seep from the stream into the groundwater.

7.3.11 However, it is anticipated that any water abstracted during dewatering of the borrow pit will be discharged, following settlement, to the South Brook, which will mitigate any adverse impacts on the flow in this stream. Accordingly, the magnitude of the potential dewatering impact on groundwater baseflow to the South Brook is considered to be **minor**, resulting in a **slight** effect, which is not significant.

7.3.12 Given the calculated inflow volumes of between approximately 163 m^3/day and 2,667m^3/day, the flood risks associated with the discharge of groundwater pumped during the dewatering activities to the South Brook will be managed in accordance with the measures contained in the First Iteration Environmental Management Plan **[TR010044/APP/6.8v2]**. This will ensure that any potential impacts of flooding due to the discharge of the pumped water remain **minor** with only a **slight** effect, which is not significant.

7.3.13 No ground contamination was observed at or within the vicinity of the proposed borrow pit during the 2019/2020 ground investigation. Groundwater quality analytical results for water samples collected from boreholes in the vicinity of the proposed borrow pit indicated no significant groundwater contamination issues. Analyses of samples from one borehole (WS275) located approximately 870m north from the northern boundary of the borrow pit indicated the presence of hydrocarbon contamination. There are two streams between the borrow pit and borehole WS275, the South Brook and the Begwary Brook, both of which are considered to be in hydraulic continuity with groundwater in the River Terrace Deposits. It is considered that these streams act as barriers to groundwater flow and that any contaminated groundwater in the area of WS275 cannot migrate to the borrow pit.

7.3.14 There are a number of historical landfill sites to the north east, north and north west of the borrow pit, approximately 480m, 1100m and 1200m, respectively, from the proposed borrow pit. These are outside the estimated dewatering zone of influence from the borrow pit and should not be impacted by the proposed dewatering. In the absence of any significant groundwater contamination, the potential impact of the dewatering on water quality is considered to be low provided that best practice dewatering methodology, which will include groundwater quality monitoring as provided in the First Iteration Environmental Management Plan **[TR010044/APP/6.8v2]** is followed. Accordingly, the magnitude of impact on groundwater quality arising from dewatering at the borrow pit will be **minor**, resulting in a **slight** effect, which is not significant.

7.3.15 As the River Terrace Deposits are of medium sensitivity, the magnitude of impact on groundwater level and flow due to dewatering activities at BPC is considered to be **minor** adverse, resulting in a **slight** effect, which is not significant. Although an amended permeability has been used for the River Terrace Deposits, there is no change in the significance of the predicted effect on controlled waters compared with the conclusions in the GWRA. 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. The locations of the monitoring boreholes will be included in the Construction Dewatering Strategy, in consultation with the EA and as secured in First Iteration of the Environmental Management Plan **[TR010044/APP/6.8v2]**.

7.3.16 It is understood that the borrow pits would be backfilled using natural inert materials obtained from the construction of the Scheme, which are considered unsuitable for engineering purposes. 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 **[APP-079]** and the First Iteration Environmental Management Plan **[TR010044/APP/6.8v2]**, the overall magnitude of potential impacts on water resources due to contaminant mobilisation associated with the excavation and backfilling of the borrow pits will be **minor**, resulting in a **slight or neutral** effect, which is not significant.

8 Construction Dewatering Strategy

8.1.1 In **[RR-036]**, the EA also requested that a Construction Dewatering Strategy be presented, containing all information that normally would be included in applications for abstraction licences. The EA made this request as the draft DCO seeks to disapply Section 24 of the Water Resources Act 1991(b).

8.1.2 Control measures to be adopted for the construction dewatering have been included in the First Iteration of the Environmental Management Plan **[TR010044/APP/6.8v2]**.

8.1.3 It is considered that due to continued iterations in the design of the Scheme, it is not possible to produce a detailed Construction Dewatering Strategy document at this stage. A Construction Dewatering Strategy will be included as part of the Second Iteration Environmental Management Plan to be produced post consent.

8.1.4 The Second Iteration Environmental Management Plan will be approved prior to the main construction work starting in late 2022. Prior to approval by the Secretary of State, the Environment Agency will have the opportunity to review the Second Iteration EMP and comment and provide feedback to ensure that all mitigation measures are included as appropriate.

9 Conclusions

9.1.1 Based on the further assessment of the likely impacts of dewatering associated with elements of the Scheme, the following conclusions can be drawn:

a. The Scheme is underlain by superficial deposits comprising River Terrace Deposits in the west and Glacial Till in the central and eastern parts of the route.

b. The Glacial Till thickens to the east, mainly from around the central part of the Scheme towards Caxton Gibbet.

c. The superficial deposits overlie the Oxford Clay.

d. Groundwater is present in the River Terrace Deposits and these deposits form the principal unit for groundwater importance along the Scheme.

e. Groundwater in the River Terrace Deposits generally flows towards the River Great Ouse valley and to easterly flowing tributaries such as the South Brook and Rockham Ditch.

f. There is limited groundwater present in the low permeability Glacial Till and the Oxford Clay.

g. The groundwater quality in the River Terrace Deposits generally is satisfactory when compared with the UKDWS and freshwater EQS. There is evidence of hydrocarbon contamination in one borehole to the north of the Scheme.

h. The groundwater quality in both the Till and the Oxford Clay is naturally poor, but there is no evidence of significant contamination from anthropogenic activities.

i. Additional aquifer testing on boreholes along the Scheme has given average permeability values for the River Terrace Deposits of 3.82 x 10^{-4}m/sec, for the till of 2.68 x 10^{-7}m/sec and for the Oxford Clay of 1.0 x 10^{-7}m/sec.

j. There are some structures and works associated with the Scheme where dewatering will be required to facilitate construction, including cuttings and borrow pits.

k. The main cutting with the most significant potential impact on groundwater is the A1 Black Cat Underpass which will cut through the full thickness of the River Terrace Deposits terminating in the Glacial Till/Oxford Clay. A preliminary design for this cutting negates the need for significant permanent groundwater pumping and limits the volume of material that needs to be dewatered during excavation of the cutting.

l. From a modelling exercise, it is concluded that the A1 Black Cat Underpass will have only a minor impact on groundwater flow in the River Terrace Deposits and on baseflow discharges to the South Brook, Rockham Ditch and River Great Ouse, as the underpass will not significantly modify the groundwater catchments to each watercourse.

m. It is concluded that negligible volumes (less than 5m^3/day) of groundwater will require pumping from the A1 Black Cat Underpass cutting during the operational period of the Scheme.

n. Both the Barford Road and Alington Hill cuttings will be excavated in the Glacial Till. It is concluded that only small volumes of groundwater will require to be managed during construction and that there will be no significant impacts on surrounding receptors.

o. It is concluded that construction of the road adjacent to the Eversden-Eltisley landfill will have no impact on leachate migration.

p. Using the amended permeability values for the River Terrace Deposits and the Glacial Till, the overall conclusions on significance for the construction and operation of the cuttings on groundwater remain the same as the previous findings presented in the GWRA **[APP-226]** (see **Table 5-1**).

q. With appropriate water management, it is concluded that the effect significance on groundwater flow and quality arising from dewatering activities at the proposed borrow pit BPA will be negligible consistent with the findings of the GWRA.

r. It is concluded that the effect significance on groundwater flow and quality arising from dewatering at borrow pit BPC will be minor, consistent with the findings of the GWRA.

s. Using the amended permeability values for the River Terrace Deposits and the Glacial Till, the overall significance of effects is no worse than the significance of effects reported in the GWRA **[APP-226]** (see **Table 5-1**).

9.1.2 **Table 9-1** provides a summary of the predicted impacts and effects from the revised assessment and a comparison with the original assessment presented in Chapter 13, Road Drainage and the Water Environment of the ES. As there is no material change in the resulting conclusions on significance, the original assessment remains valid.

Table 9-1: Summary of the Assessment of the Scheme Features Assessed

= Construction Phase; = Operational Phase (*Numbers in italics*) = Based on GWRA [APP-226]

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1) **Construction Phase**	*138*	*1,465 - 2,241*	Temporary dewatering or abstraction	Superficial - Secondary A aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
	0 – (based on revised assessment)	600 – (based on revised assessment)	Temporary dewatering of excavation between secant pile walls	Superficial - Secondary A aquifer	Negligible adverse	Slight	Secant pile walls will minimise groundwater inflow to cutting excavation. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1) **Operational Phase**	*138*	*1,465 - 2,241*	Permanent dewatering or abstraction	Superficial - Secondary A aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
	0 – (based on revised assessment)	<5 – (based on revised assessment)	Permanent dewatering - minor groundwater seepages through secant pile walls	Superficial - Secondary A aquifer	No change	Neutral	Secant pile wall will minimise groundwater inflow to excavation. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1)	*138*	*1,465 - 2,241*	Temporary dewatering or abstraction resulting in loss of direct baseflow to the river	River Great Ouse	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
Construction Phase	0 – (based on revised assessment)	600 – (based on revised assessment)	Temporary dewatering of excavation between secant pile walls	River Great Ouse	Negligible adverse	Slight	Secant pile walls will minimise groundwater inflow to cutting excavation. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1) **Operational Phase**	*138*	*1,465 - 2,241*	Permanent dewatering or abstraction resulting in loss of direct baseflow to the river	River Great Ouse	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
	0- (based on revised assessment)	<5 – (based on revised assessment)	Barrier to groundwater flow due to secant pile wall resulting in loss of direct	River Great Ouse	Negligible adverse	Slight	Secant pile wall will minimise groundwater inflow to excavation. Loss of flow compensated by additional baseflow to South Brook and

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			baseflow to the river				Rockham Ditch will reduce the effect significance. The use of secant pile walls to manage groundwater in the cutting will be included in the Second Iteration of the Environmental Management Plan.
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1) Construction Phase	138	1,465 - 2,241	Temporary dewatering or abstraction resulting in loss of baseflow discharge	South Brook 450m north	Minor adverse	Neutral	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
	0 – (based on revised assessment)	600 – (based on revised assessment)	Temporary dewatering of excavation between secant pile walls	South Brook 450m north	Minor adverse	Neutral	Water will be discharged from the excavation to the South Brook during cutting excavation

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1) **Operational Phase**	*138*	*1,465 - 2,241*	Permanent dewatering or abstraction resulting in loss of baseflow discharge	South Brook 450m north	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
	0- (based on revised assessment)	<5 – (based on revised assessment)	Barrier to groundwater flow due to secant pile wall resulting in additional baseflow to watercourse	South Brook 450m north	Minor beneficial	Slight	Secant pile wall will minimise groundwater inflow to cutting and result in additional baseflow to watercourse to reduce the effect significance
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1)	*138*	*1,465 - 2,241*	Temporary dewatering or abstraction resulting in loss of baseflow discharge	Rockham Ditch 540m south	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
Construction Phase	0 – (based on revised assessment)	600 – (based on revised assessment)	Temporary dewatering of excavation between secant pile walls resulting in loss of baseflow discharge	Rockham Ditch 540m south	Minor adverse	Neutral	N/A
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1) **Operational Phase**	*138*	*1,465 - 2,241*	Permanent dewatering or abstraction resulting in loss of baseflow discharge	Rockham Ditch 540m south	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
	0 – (based on revised assessment)	<5 (based on revised assessment)	Barrier to groundwater flow due to secant pile wall resulting in additional baseflow to watercourse	Rockham Ditch 540m south	Minor beneficial	Slight	Secant pile wall will minimise groundwater inflow to cutting and result in additional baseflow to watercourse to reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1) **Construction Phase**	*138*	*1,465 - 2,241*	Introduction of new contaminants through accidental spillages and/or surface runoff or remobilisation of existing contaminants following disturbance of contaminated ground or groundwater	Groundwater quality	Minor adverse	Slight	No evidence of existing contamination. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
	0 – (based on revised assessment)	600 – (based on revised assessment)	Introduction of new contaminants through accidental spillages and/or surface runoff or remobilisation	Groundwater quality	Negligible adverse	Neutral	No evidence of existing contamination. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			of existing contaminants following disturbance of contaminated ground or groundwater. Secant pile walls will minimise groundwater movement				
Black Cat A1 Underpass Cutting in the West of the Scheme (Section 1)	*138*	*1,465 - 2,241*	None. No evidence of existing ground or groundwater contamination.	Groundwater quality	Not applicable	Not applicable	No evidence of existing ground or groundwater contamination.
Operational Phase	0- (based on revised assessment)	<5 – (based on revised assessment)	None. Secant pile walls will minimise groundwater movement	Groundwater quality	Not applicable	Not applicable	No evidence of existing ground or groundwater contamination. Secant pile wall will minimise groundwater inflow to cutting

Scheme Element and Location	Estimated/ Calculated Maximum Extent of Influence (m) from Dewatering	Estimated Inflow range volume (m³/day) from Dewatering	Source of Impact	Closest Identified Water Receptor(s) and Distance	Predicted Impact Magnitude on Receptor	Resulting Effect Significance	Mitigation
Barford Road Cutting **Construction Phase**	*4.9* 10.6 – based on revised assessment	*12 – 25* 4 - 50 – based on revised assessment	Temporary dewatering or abstraction resulting in reduction in groundwater level and change in flow regime and loss of baseflow to surface watercourses	Superficial Secondary Undifferentiated aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				River Great Ouse 200m west	No Change	Neutral	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
			Introduction of new	Groundwater quality	Minor adverse	Slight	Embedded mitigation measures in the First

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			contaminants through accidental spillage and or surface runoff or mobilisation of existing contaminants following disturbance of contaminated ground or groundwater				Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
Barford Road Cutting **Operational Phase**	<10 – based on revised assessment	17 – based on revised assessment	Inflow of groundwater seepages from side slopes resulting in reduction in groundwater level and change in flow regime and loss of baseflow to	Superficial Secondary Undifferentiated aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				River Great Ouse 200m west	No Change	Neutral	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			surface watercourses				and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
Alington Hill cutting **Construction Phase**	*4.1* 13.8 – based on revised assessment	*65 – 120* 16 – 219 – based on revised assessment	Temporary dewatering or abstraction resulting in reduction in groundwater level and change in flow regime and loss of baseflow to surface watercourses	Superficial – Secondary Undifferentiated aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				River Great Ouse 1.7km northwest	No Change	Neutral	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
							and or reduce the effect significance
				Spring 1.8km northwest	No Change	Neutral	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
			Introduction of new contaminants through accidental spillage and or surface runoff or mobilisation	Groundwater quality	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			of existing contaminants following disturbance of contaminated ground or groundwater				
Alington Hill cutting **Operational Phase**	<14 – based on revised assessment	29 – based on revised assessment	Inflow of groundwater seepages from side slopes resulting in reduction in groundwater level and change in flow regime and loss of baseflow to surface watercourses	Superficial – Secondary Undifferentiated aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				River Great Ouse 1.7km northwest	No Change	Neutral	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
				Spring 1.8km northwest	No Change	Neutral	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
Black Cat [BPA]	*85* 294 – based on revised assessment	*2,775* 587 – 9,614 – based on revised assessment	Temporary dewatering or abstraction resulting in reduction in groundwater level and	Superficial - Secondary A aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			change in flow regime and loss of baseflow to surface watercourses	Rockham Ditch at the boundary of pit	Minor adverse	Slight	Water discharged to Rockham Ditch to minimise impact. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				South Brook 290m north	Minor adverse	Slight	Water discharged to South Brook to minimise impact. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
							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	No evidence of existing ground or groundwater contamination. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
Black Cat [BPC]	*42* 147 – based on revised assessment	*770* 163 – 2,667 - based on revised assessment	Temporary dewatering or abstraction resulting in reduction in groundwater level and	Superficial - Secondary A aquifer	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			change in flow regime and loss of baseflow to surface watercourses	South Brook 100m north	Minor adverse	Slight	Water discharged to South Brook to minimise impact. Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				River Great Ouse 420m	Negligible	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance
				Groundwater level and flow regime	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]** will help to further prevent and or reduce the effect significance

Scheme Element and Location	Estimated/ Calculated Maximum 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	Mitigation
			Introduction of new contaminants through accidental spillage and or surface runoff or mobilisation of existing contaminants following disturbance of contaminated groundwater	Groundwater quality	Minor adverse	Slight	Embedded mitigation measures in the First Iteration EMP **[TR010044/APP/6.8v2]**will help to further prevent and or reduce the effect significance

Appendix A

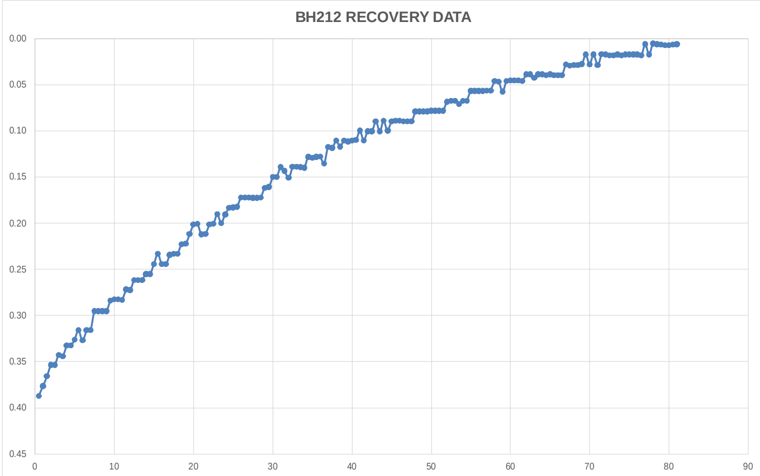
Permeability test calculations

BH212 – (River Terrace Deposits) Permeability Test Result

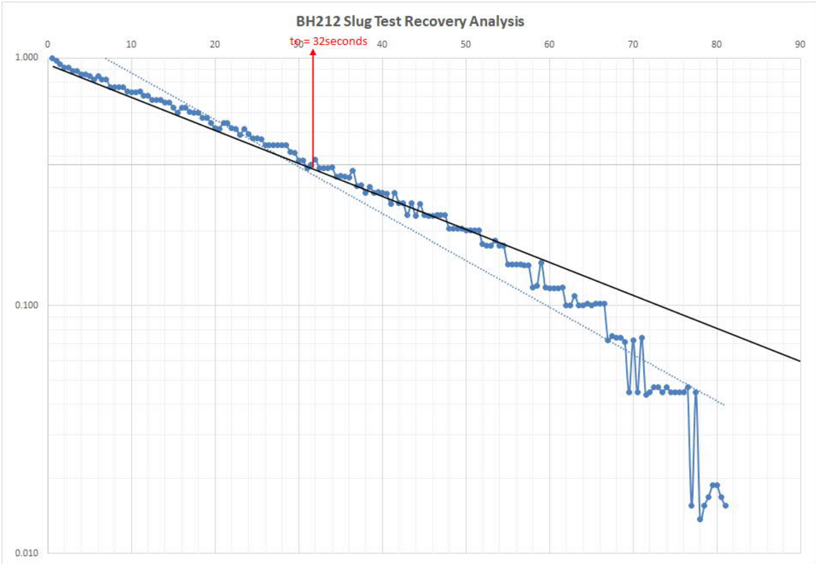
Time (s)	Water Le	Drawdow	s/smax
0.5	3.437	0.39	1.000
1	3.426	0.38	0.972
1.5	3.416	0.37	0.944
2	3.404	0.35	0.914
2.5	3.404	0.35	0.914
3	3.393	0.34	0.886
3.5	3.394	0.34	0.889
4	3.383	0.33	0.859
4.5	3.383	0.33	0.859
5	3.376	0.33	0.843
5.5	3.366	0.32	0.816
6	3.377	0.33	0.844
6.5	3.366	0.32	0.816
7	3.366	0.32	0.816
7.5	3.345	0.30	0.763
8	3.345	0.30	0.763
8.5	3.345	0.30	0.763
9	3.345	0.30	0.763
9.5	3.334	0.28	0.733
10	3.332	0.28	0.730
10.5	3.332	0.28	0.730
11	3.333	0.28	0.732
11.5	3.322	0.27	0.702
12	3.323	0.27	0.704
12.5	3.312	0.26	0.676
13	3.312	0.26	0.676
13.5	3.312	0.26	0.676
14	3.305	0.26	0.659
14.5	3.305	0.26	0.659
15	3.294	0.24	0.631
15.5	3.283	0.23	0.602
16	3.294	0.24	0.631
16.5	3.294	0.24	0.631
17	3.284	0.23	0.605
17.5	3.283	0.23	0.602
18	3.283	0.23	0.602
18.5	3.273	0.22	0.576
19	3.272	0.22	0.574
19.5	3.262	0.21	0.547
20	3.251	0.20	0.520
20.5	3.251	0.20	0.519
21	3.262	0.21	0.548
21.5	3.262	0.21	0.547
22	3.251	0.20	0.520
22.5	3.251	0.20	0.519
23	3.240	0.19	0.491
23.5	3.250	0.20	0.517
24	3.241	0.19	0.492
24.5	3.233	0.18	0.474
25	3.233	0.18	0.472
25.5	3.232	0.18	0.471
26	3.222	0.17	0.445
26.5	3.222	0.17	0.445
27	3.222	0.17	0.445
27.5	3.223	0.17	0.446
28	3.223	0.17	0.446
28.5	3.222	0.17	0.445
29	3.212	0.16	0.418
29.5	3.211	0.16	0.415
30	3.200	0.15	0.387
30.5	3.200	0.15	0.387
31	3.189	0.14	0.359
31.5	3.194	0.14	0.371
32	3.201	0.15	0.389
32.5	3.189	0.14	0.358
33	3.189	0.14	0.358
33.5	3.189	0.14	0.359
34	3.190	0.14	0.361
34.5	3.178	0.13	0.332
35	3.179	0.13	0.334
35.5	3.178	0.13	0.332
36	3.178	0.13	0.330
36.5	3.186	0.14	0.350
37	3.168	0.12	0.304
37.5	3.168	0.12	0.306
38	3.160	0.11	0.285
38.5	3.167	0.12	0.303
39	3.160	0.11	0.285
39.5	3.162	0.11	0.289
40	3.160	0.11	0.285
40.5	3.160	0.11	0.284

Time (s)	Water Le	Drawdow	s/smax
41	3.150	0.10	0.258
41.5	3.160	0.11	0.285
42	3.151	0.10	0.260
42.5	3.151	0.10	0.260
43	3.140	0.09	0.232
43.5	3.151	0.10	0.260
44	3.139	0.09	0.230
44.5	3.150	0.10	0.258
45	3.140	0.09	0.232
45.5	3.139	0.09	0.230
46	3.139	0.09	0.230
46.5	3.140	0.09	0.232
47	3.140	0.09	0.232
47.5	3.140	0.09	0.232
48	3.129	0.08	0.204
48.5	3.129	0.08	0.204
49	3.129	0.08	0.204
49.5	3.129	0.08	0.204
50	3.128	0.08	0.202
50.5	3.128	0.08	0.202
51	3.128	0.08	0.202
51.5	3.128	0.08	0.202
52	3.119	0.07	0.177
52.5	3.117	0.07	0.174
53	3.117	0.07	0.174
53.5	3.121	0.07	0.184
54	3.117	0.07	0.174
54.5	3.117	0.07	0.174
55	3.107	0.06	0.147
55.5	3.107	0.06	0.147
56	3.107	0.06	0.147
56.5	3.107	0.06	0.147
57	3.106	0.06	0.145
57.5	3.106	0.06	0.145
58	3.096	0.05	0.119
58.5	3.097	0.05	0.121
59	3.108	0.06	0.149
59.5	3.096	0.05	0.119
60	3.095	0.05	0.117
60.5	3.095	0.05	0.117
61	3.095	0.05	0.117
61.5	3.096	0.05	0.119
62	3.089	0.04	0.100
62.5	3.089	0.04	0.100
63	3.092	0.04	0.109
63.5	3.089	0.04	0.100
64	3.089	0.04	0.100
64.5	3.090	0.04	0.102
65	3.089	0.04	0.100
65.5	3.090	0.04	0.102
66	3.090	0.04	0.102
66.5	3.090	0.04	0.102
67	3.078	0.03	0.072
67.5	3.079	0.03	0.076
68	3.079	0.03	0.074
68.5	3.079	0.03	0.074
69	3.078	0.03	0.071
69.5	3.067	0.02	0.045
70	3.078	0.03	0.072
70.5	3.067	0.02	0.045
71	3.079	0.03	0.074
71.5	3.067	0.02	0.044
72	3.067	0.02	0.045
72.5	3.068	0.02	0.047
73	3.068	0.02	0.047
73.5	3.067	0.02	0.045
74	3.068	0.02	0.047
74.5	3.067	0.02	0.045
75	3.067	0.02	0.045
75.5	3.067	0.02	0.045
76	3.067	0.02	0.045
76.5	3.068	0.02	0.047
77	3.056	0.01	0.016
77.5	3.067	0.02	0.045
78	3.055	0.01	0.014
78.5	3.056	0.01	0.016
79	3.057	0.01	0.017
79.5	3.057	0.01	0.019
80	3.057	0.01	0.019
80.5	3.057	0.01	0.017
81	3.056	0.01	0.016

BH212 - Drawdown (h) recovery data



BH212 - Head ratio (h/h_{max}) versus time



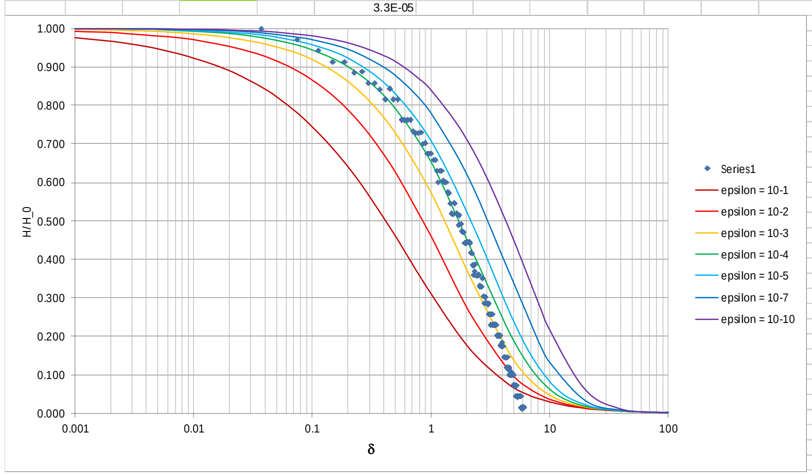
BH212 - Hvorslev Slug-Test Computed Permeability Analysis Method

$[K = r^2 \ln (L/R)/2Lt_{37}]$

BH212 - RIVER TERRACE DEPOSITS			
PARAMETERS		**Units**	**Description**
to =	32	Seconds	Time it takes for water level to rise or fall to 37% of the initial change
r =	0.0375	(m)	Radius of Screen
r^2=	0.0014	(m2)	Radius of Screen
R =	0.0375	(m)	Radius of Casing
L =	3	(m)	Length of Screen
L/R =	80	Dimensionless	
ln(L/R)	4.3820	Dimensionless	
r^2ln(L/R)	0.0062		
2Lto	192		
K = r^2ln(L/R)/2Lto	**3.2E-05**	**m/sec**	**Computed Permeability**
	2.8E+00	**m/day**	**Computed Permeability**

BH212 – Sensitivity Check of Computed Permeability Using Cooper Computed Specific Storage Method

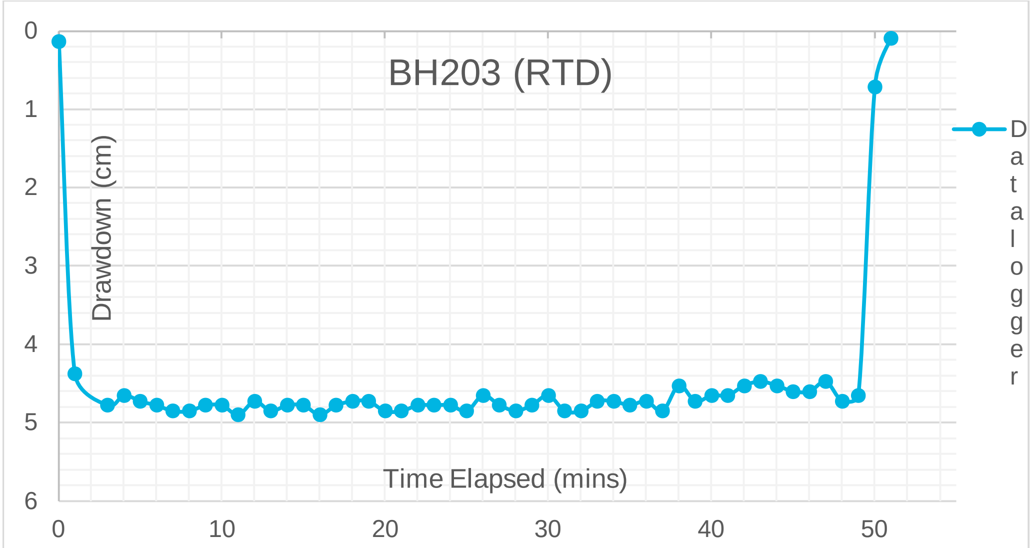
r_s [L]	r_c [L]	b [L]	K [L/T]		Best fit epsilon [ ]
0.0375	0.0375	3	3.5E-05		1.0E-04
			3.2E-05		S_s [1/L] computed from best fit epsilon
					3.3E-05



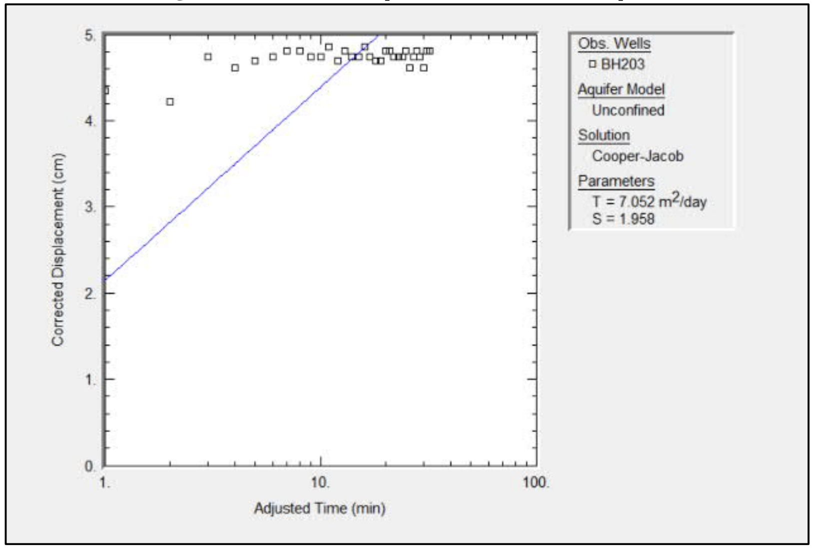
BH203-1 – (River Terrace Deposits) Permeability Test Result

TIME ELAPSED (MINS) SINCE START OF TEST	Drawdown (cm)
0.0	0.13
1.0	4.375
2.0	4.25
3.0	4.775
4.0	4.65
5.0	4.725
6.0	4.775
7.0	4.85
8.0	4.85
9.0	4.775
10.0	4.775
12.0	4.725
13.0	4.85
14.0	4.775
15.0	4.775
17.0	4.775
18.0	4.725
19.0	4.725
20.0	4.85
21.0	4.85
22.0	4.775
23.0	4.775
24.0	4.775
25.0	4.85
27.0	4.775
28.0	4.85
29.0	4.775
31.0	4.85
32.0	4.85
37.0	4.85
50.0	0.71
51.0	0.09

BH203-1 – Drawdown and Recovery Data from Pumping Test



BH203-1 AQTESOLV Cooper-Jacob Computed Solution Method



BH203-1 – Cooper-Jacob Pumping-Test Derived Permeability Analysis

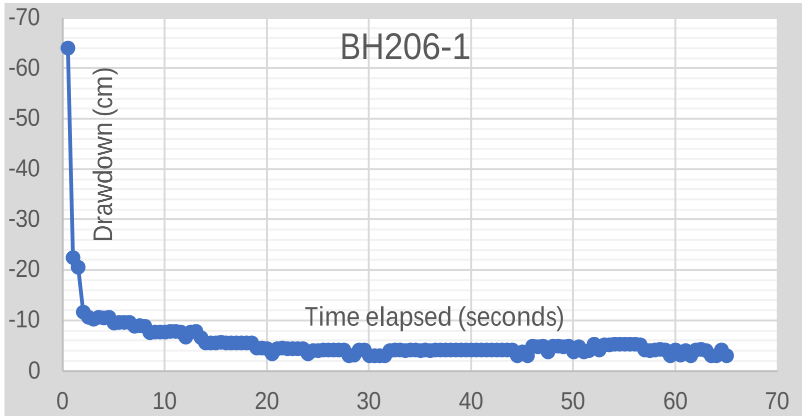
$$T = \frac{2.303Q}{4\pi\Delta s}$$

BH203 - RIVER TERRACE DEPOSITS			
Parameters		Units	Description
r	0.025	m	Radius of Screen
R	0.025	m	Radius of Casing
L	3	m	Length of screen
b	3	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Cooper-Jacob (unconfined) T	7.186	m2/day	Computed Transmissivity
K = T/b	2.77238E-05	m2/sec	Derived Permeability

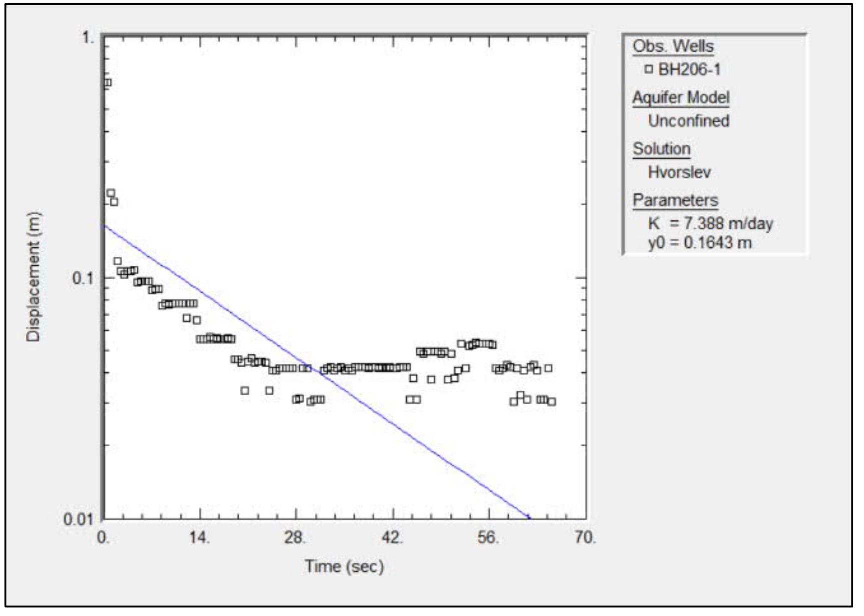
BH206-1 – (River Terrace Deposits) Permeability Test Result

Time elapsed	Displacement (m)	Drawdown (cm)
0.5	0.6403	-64.03
1	0.2246	-22.46
1.5	0.20595	-20.595
2	0.11635	-11.635
2.5	0.1064	-10.64
3	0.1028	-10.28
3.5	0.1064	-10.64
4	0.10565	-10.565
4.5	0.1069	-10.69
5	0.0956	-9.56
5.5	0.0961	-9.61
6	0.0961	-9.61
6.5	0.0961	-9.61
7	0.0885	-8.85
7.5	0.08975	-8.975
8	0.089	-8.9
8.5	0.07645	-7.645
9	0.0777	-7.77
9.5	0.07695	-7.695
10	0.0777	-7.77
10.5	0.0782	-7.82
11	0.0782	-7.82
11.5	0.0777	-7.77
12	0.0675	-6.75
12.5	0.0777	-7.77
13	0.0782	-7.82
13.5	0.06625	-6.625
14	0.05545	-5.545
14.5	0.05545	-5.545
15	0.05545	-5.545
15.5	0.0567	-5.67
16	0.05545	-5.545
16.5	0.0562	-5.62
17	0.05545	-5.545
17.5	0.05545	-5.545
18	0.0562	-5.62
18.5	0.05545	-5.545
19	0.0455	-4.55
19.5	0.0455	-4.55
20	0.04425	-4.425
20.5	0.03395	-3.395
21	0.04475	-4.475
21.5	0.046	-4.6
22	0.04425	-4.425
22.5	0.04475	-4.475
23	0.04475	-4.475
23.5	0.04425	-4.425
24	0.03395	-3.395
24.5	0.04115	-4.115
25	0.04115	-4.115
25.5	0.0419	-4.19
26	0.0419	-4.19
26.5	0.0419	-4.19
27	0.0419	-4.19
27.5	0.0419	-4.19
28	0.0311	-3.11
28.5	0.0316	-3.16
29	0.0419	-4.19
29.5	0.0419	-4.19
30	0.03035	-3.035
30.5	0.0311	-3.11
31	0.0311	-3.11
31.5	0.0311	-3.11
32	0.04115	-4.115
32.5	0.0419	-4.19
33	0.0424	-4.24
33.5	0.04115	-4.115
34	0.0419	-4.19
34.5	0.0424	-4.24
35	0.04115	-4.115
35.5	0.0419	-4.19
36	0.04115	-4.115
36.5	0.0424	-4.24
37	0.0424	-4.24
37.5	0.0424	-4.24
38	0.0424	-4.24
38.5	0.0419	-4.19
39	0.0424	-4.24
39.5	0.0424	-4.24
40	0.0419	-4.19
40.5	0.0424	-4.24
41	0.0419	-4.19
41.5	0.0424	-4.24
42	0.0419	-4.19
42.5	0.0419	-4.19
43	0.0424	-4.24
43.5	0.0424	-4.24
44	0.0424	-4.24
44.5	0.0311	-3.11
45	0.0383	-3.83
45.5	0.0311	-3.11
46	0.0491	-4.91
46.5	0.04835	-4.835
47	0.0491	-4.91
47.5	0.03755	-3.755
48	0.0491	-4.91
48.5	0.0491	-4.91
49	0.04835	-4.835
49.5	0.0491	-4.91
50	0.03755	-3.755
50.5	0.04835	-4.835
51	0.0383	-3.83
51.5	0.04115	-4.115
52	0.0531	-5.31
52.5	0.0419	-4.19
53	0.05185	-5.185
53.5	0.0526	-5.26
54	0.05385	-5.385
54.5	0.0531	-5.31
55	0.0531	-5.31
55.5	0.0531	-5.31
56	0.0531	-5.31
56.5	0.0526	-5.26
57	0.0419	-4.19
57.5	0.04115	-4.115
58	0.0419	-4.19
58.5	0.04315	-4.315
59	0.0424	-4.24
59.5	0.03035	-3.035
60	0.0419	-4.19
60.5	0.03235	-3.235
61	0.04115	-4.115
61.5	0.0311	-3.11
62	0.0424	-4.24
62.5	0.04315	-4.315
63	0.04115	-4.115
63.5	0.0311	-3.11
64	0.0311	-3.11
64.5	0.0419	-4.19
65	0.03035	-3.035

BH206-1 Slug test Data Falling Head



BH206-1 AQTESOLV Hvorslev Computed Solution Method Slug Test



BH203-1 – Hvorslev Slug Test Computed Permeability Analysis

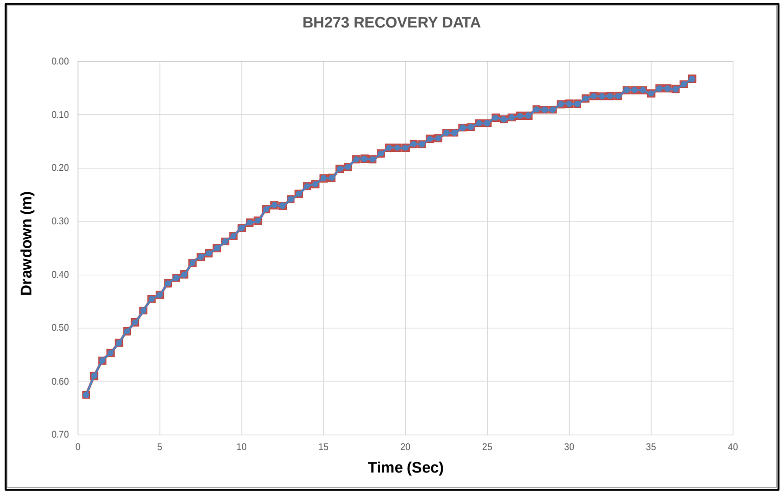
BH206-1 - RIVER TERRACE DEPOSITS			
Parameters		Units	Description
r	0.05	m	Radius of Screen
R	0.05	m	Radius of Casing
L	3.5	m	Length of screen
b	3.5	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
H(0)	0.6403	m	Initial max displacement
H	2.72	m	Static water level
d	0	m	depth of top of screen from static water level
Hvorslev (unconfined) K	8.63	m/sec	Computed Transmissivity

BH273-1 – (River Terrace Deposits) Permeability Test Result

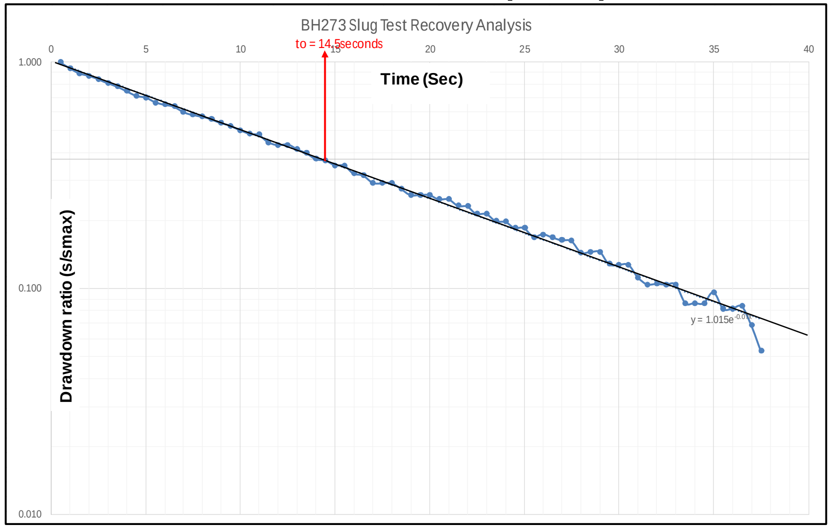
Time (s)	Water Level (m)	Drawdown s (m)	s/smax	δ
0.5	3.516	0.63	1.000	0.2112
1	3.480	0.59	0.943	0.4224
1.5	3.451	0.56	0.897	0.6336
2	3.437	0.55	0.874	0.8448
2.5	3.418	0.53	0.844	1.056
3	3.396	0.51	0.809	1.2672
3.5	3.379	0.49	0.782	1.4784
4	3.357	0.47	0.747	1.6896
4.5	3.336	0.45	0.712	1.9008
5	3.328	0.44	0.700	2.112
5.5	3.306	0.42	0.666	2.3232
6	3.296	0.41	0.649	2.5344
6.5	3.290	0.40	0.639	2.7456
7	3.268	0.38	0.604	2.9568
7.5	3.257	0.37	0.586	3.168
8	3.250	0.36	0.575	3.3792
8.5	3.240	0.35	0.560	3.5904
9	3.228	0.34	0.540	3.8016
9.5	3.217	0.33	0.523	4.0128
10	3.203	0.31	0.500	4.224
10.5	3.192	0.30	0.483	4.4352
11	3.189	0.30	0.477	4.6464
11.5	3.167	0.28	0.443	4.8576
12	3.160	0.27	0.431	5.0688
12.5	3.161	0.27	0.433	5.28
13	3.149	0.26	0.414	5.4912
13.5	3.139	0.25	0.397	5.7024
14	3.124	0.23	0.374	5.9136
14.5	3.120	0.23	0.368	6.1248
15	3.109	0.22	0.351	6.336
15.5	3.109	0.22	0.349	6.5472
16	3.091	0.20	0.322	6.7584
16.5	3.088	0.20	0.316	6.9696
17	3.074	0.18	0.293	7.1808
17.5	3.073	0.18	0.292	7.392
18	3.074	0.18	0.293	7.6032
18.5	3.063	0.17	0.276	7.8144
19	3.052	0.16	0.259	8.0256

Time (s)	Water Level (m)	Drawdown s (m)	s/smax	δ
19.5	3.052	0.16	0.259	8.2368
20	3.052	0.16	0.259	8.448
20.5	3.045	0.15	0.248	8.6592
21	3.045	0.16	0.248	8.8704
21.5	3.035	0.15	0.232	9.0816
22	3.034	0.14	0.230	9.2928
22.5	3.024	0.13	0.214	9.504
23	3.024	0.13	0.214	9.7152
23.5	3.014	0.12	0.199	9.9264
24	3.013	0.12	0.197	10.1376
24.5	3.006	0.12	0.185	10.3488
25	3.006	0.12	0.185	10.56
25.5	2.996	0.11	0.169	10.7712
26	2.999	0.11	0.174	10.9824
26.5	2.995	0.11	0.168	11.1936
27	2.992	0.10	0.164	11.4048
27.5	2.992	0.10	0.163	11.616
28	2.980	0.09	0.144	11.8272
28.5	2.981	0.09	0.145	12.0384
29	2.981	0.09	0.145	12.2496
29.5	2.970	0.08	0.128	12.4608
30	2.970	0.08	0.127	12.672
30.5	2.970	0.08	0.127	12.8832
31	2.960	0.07	0.112	13.0944
31.5	2.955	0.07	0.104	13.3056
32	2.956	0.07	0.105	13.5168
32.5	2.955	0.07	0.104	13.728
33	2.955	0.07	0.104	13.9392
33.5	2.944	0.05	0.086	14.1504
34	2.944	0.05	0.086	14.3616
34.5	2.944	0.05	0.086	14.5728
35	2.950	0.06	0.097	14.784
35.5	2.941	0.05	0.081	14.9952
36	2.941	0.05	0.081	15.2064
36.5	2.942	0.05	0.083	15.4176
37	2.933	0.04	0.069	15.6288
37.5	2.923	0.03	0.053	15.84

BH273-1 - Drawdown (h) recovery data



BH273-1 - Head ratio (s/s_{max}) versus time



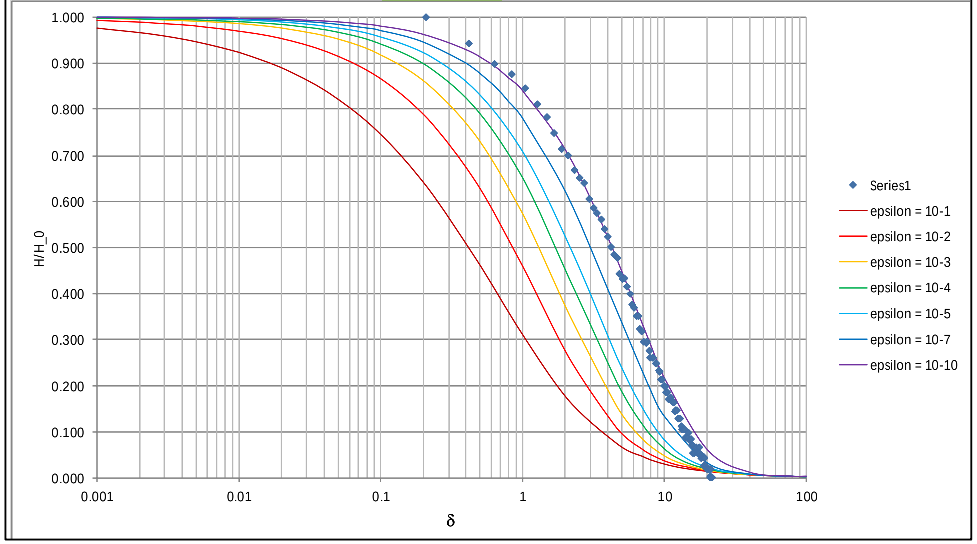
BH273-1 - Hvorslev Slug-Test Computed Permeability Analysis Method

$$[K = r^2 \ln (L/R)/2Lt_{37}]$$

BH273 RIVER TERRACE DEPOSITS			
PARAMETERS		**Units**	**Description**
to =	14.5	Seconds	Time it takes for water level to rise or fall to 37% of the initial change
r =	0.0250	(m)	Radius of Screen
r^2=	0.0006	(m2)	Radius of Screen
R =	0.025	(m)	Radius of Casing
L =	3	(m)	Length of Screen
L/R =	120	Dimensionless	
ln(L/R)	4.7875	Dimensionless	
$r^2\ln(L/R)$	0.0030		
2Lto	87		
K = $r^2\ln(L/R)/2Lto$	**3.4E-05**	**m/sec**	**Computed Permeability**
	3.0E+00	**m/day**	**Computed Permeability**

BH273-1 – Sensitivity Check of Computed Permeability Using Cooper Computed Specific Storage Method

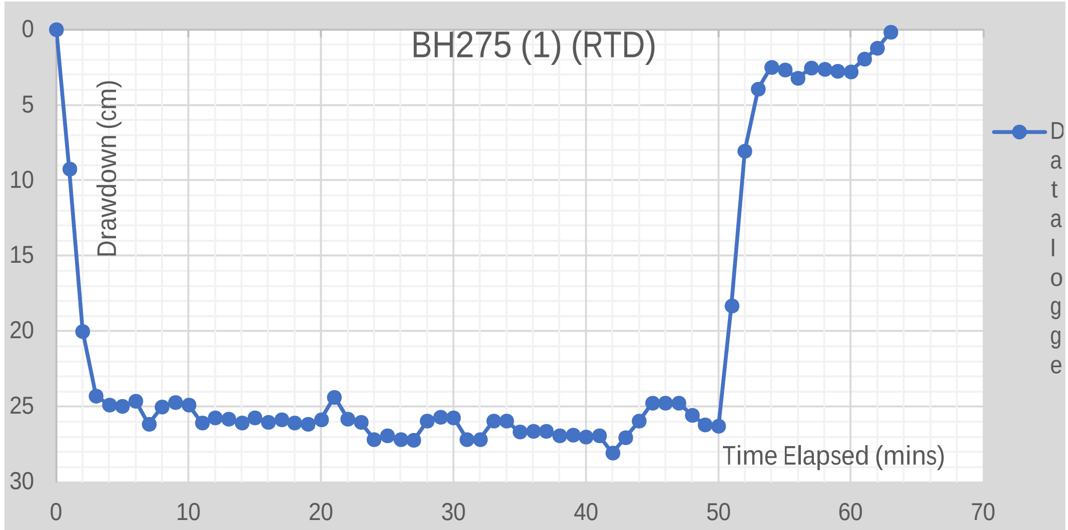
r_s [L]	r_c [L]	b [L]	K [L/T]		Best fit epsilon [ ]
0.025	0.025	3	8.8E-05		1.0E-10
			3.4E-05		S_s [1/L] computed from best fit epsilon
					3.3E-11



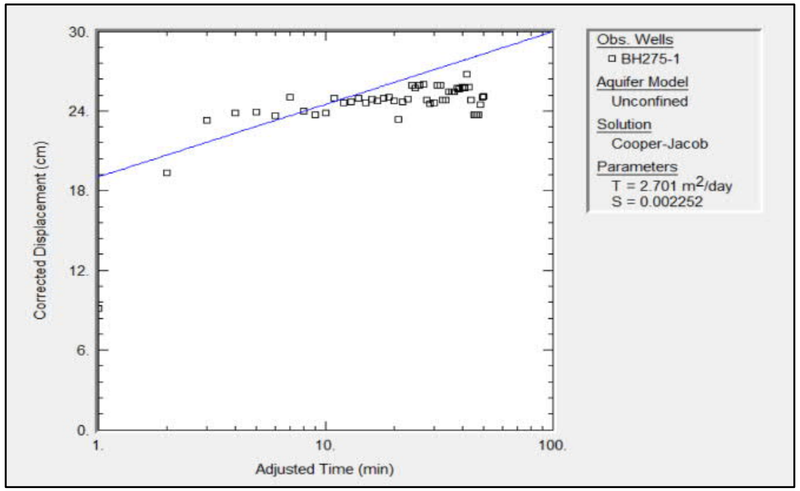
BH275C-1 – (River Terrace Deposits) Permeability Test Result

DATE/TIME (MINUTES)	Drawdown (cm)
1	0.1
2	9.245
3	19.995
4	24.295
5	24.88
6	24.955
7	24.645
8	26.16
9	25.005
10	24.72
11	24.88
12	26.085
13	25.725
14	25.8
15	26.085
16	25.725
17	26.035
18	25.85
19	26.085
20	26.16
21	25.85
22	24.37
23	25.8
24	26.035
25	27.155
26	26.92
27	27.155
28	27.23
29	25.96
30	25.675
31	25.725
32	27.155
33	27.155
34	25.96
35	25.96
36	26.67
37	26.62
38	26.62
39	26.905
40	26.855
41	26.98
42	26.905
43	28.06
44	27.03
45	25.96
46	24.755
47	24.755
48	24.755
49	25.55
50	26.195
51	26.27
52	18.305
53	8.04
54	3.925
55	2.495
56	2.67
57	3.205
58	2.545
59	2.62
60	2.745
61	2.795
62	1.95
63	1.23
64	0.16

BH275C-1 – Drawdown and Recovery Data from Pumping Test



BH275C-1 - AQTESOLV Hvorslev Computed Solution Method Slug Test



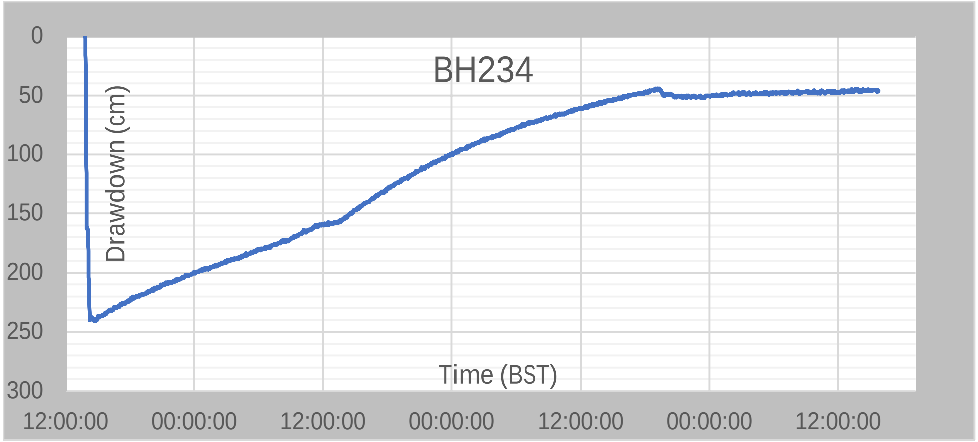
BH275C-1 – Cooper-Jacob Pumping-Test Derived Permeability Analysis

BH275C-1 - RIVER TERRACE DEPOSITS			
Parameters		Units	Description
r	0.025	m	Radius of Screen
R	0.025	m	Radius of Casing
L	3	m	Length of screen
b	3	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Cooper-Jacob (unconfined) T	2.579	m2/day	Computed Transmissivity
K = T/b	1.06E-05	m2/sec	Derived Permeability

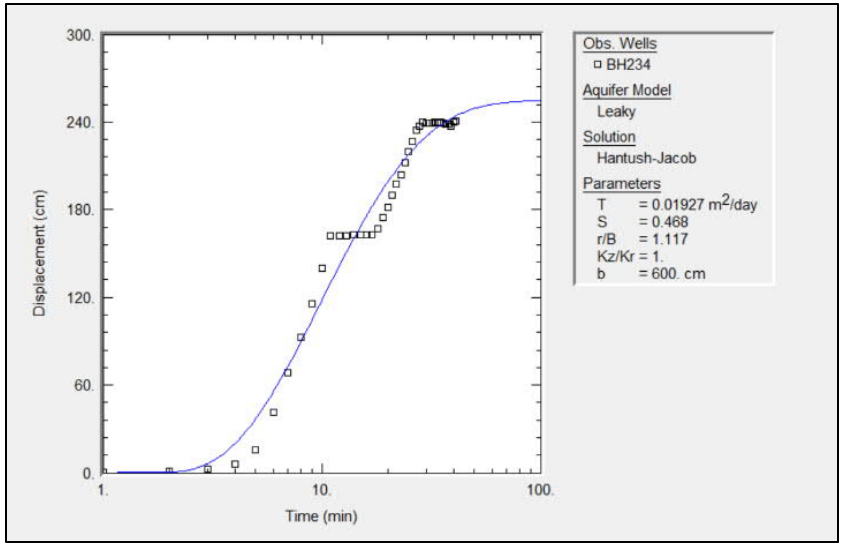
BH234 – (Glacial Till) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	0.075
2	0.795
3	2.51
4	5.815
5	15.895
6	41.285
7	68.4
8	92.81
9	115.625
10	140.06
11	162.28
12	162.33
13	161.97
14	163
15	162.925
16	163
17	163.05
18	166.865
19	174.745
20	181.63
21	189.795
22	197.675
23	203.54
24	212.5
25	220.095
26	226.67
27	234.55
28	237.42
29	239.805
30	239.57
31	239.445
32	239.57
33	239.62
34	239.57
35	239.62
36	239.57
37	238.375
38	238.5
39	237.47
40	239.82
41	240.59
300	218.875
2000	103.36
4429	45.38

BH234 - Drawdown and Recovery Data from Pumping Test



BH234 – AQTESOLV Hantush-Jacob Computed Solution Method



BH234 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

$$s = \frac{Q}{4\pi T}\int_{u}^{\infty}\frac{e^{-y-r^2/4B^2y}}{y}dy \quad (1)$$

$$u = \frac{r^2 S}{4Tt} \quad (2)$$

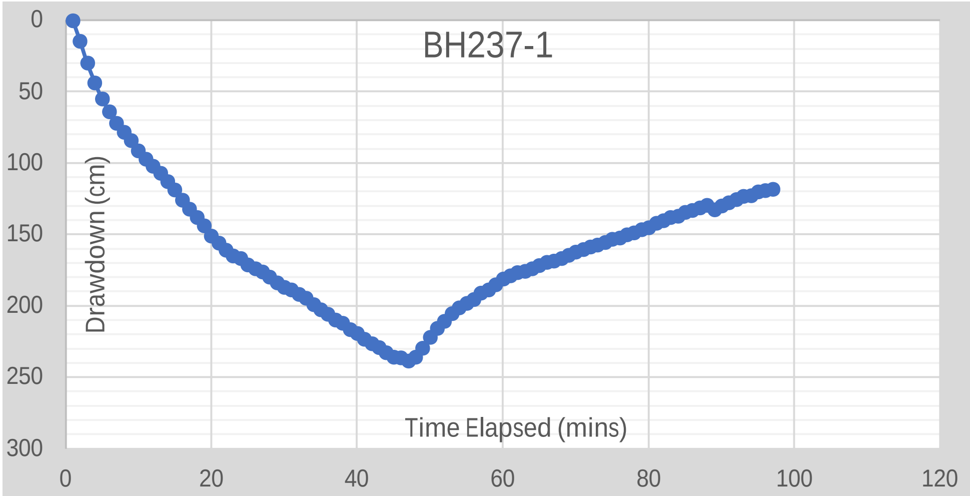
$$B = \sqrt{\frac{Tb'}{K'}} \quad (3)$$

BH234 – Glacial Till			
Parameters		Units	Description
r	0.025	m	Radius of Screen
R	0.025	m	Radius of Casing
L	6	m	Length of screen
b	6	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.01923	m2/day	Computed Transmissivity
K = T/b	3.71E-08	m2/sec	Dervived Permeability

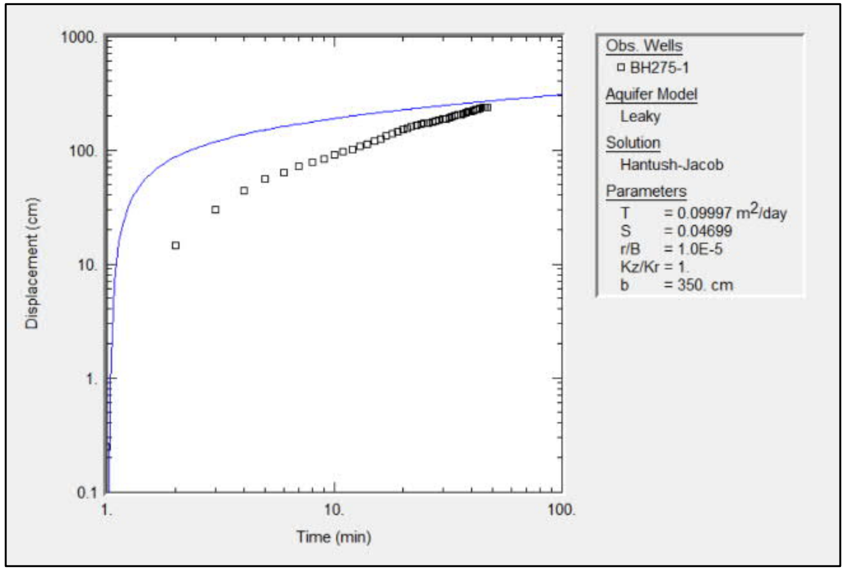
BH237-1– (Glacial Till) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	0.25
2	14.53
3	29.865
4	43.56
5	55.08
6	63.855
7	72.105
8	78.245
9	84.16
10	91.38
11	97.31
12	101.895
13	106.98
14	112.72
15	118.81
16	125.98
17	132.07
18	137.8
19	144.015
20	151.11
21	155.77
22	160.73
23	165.08
24	166.88
25	171.13
26	173.99
27	176.19
28	179.73
29	183.67
30	186.89
31	188.73
32	191.91
33	194.545
34	199.205
35	202.785
36	205.805
37	209.595
38	212.03
39	216.455
40	219.19
41	223.44
42	226.31
43	229.105
44	232.45
45	235.755
46	236.465
47	238.665
48	235.805
49	229.405
50	221.875
51	215.785
52	210.765
53	205.395
54	201.405
55	198.175
56	195.305
57	191.055
58	188.905
59	185.04
60	181.1
61	178.875
62	176.725
63	175.73
64	173.93
65	171.655
66	169.555
67	168.56
68	166.695
69	164.445
70	162.395
71	160.37
72	158.455
73	157.45
74	155.35
75	153.435
76	152.48
77	150.28
78	148.615
79	146.465
80	145.32
81	142.09
82	140.3
83	138.15
84	137.155
85	134.21
86	133.08
87	131.415
88	129.55
89	132.62
90	130.035
91	127.475
92	125.25
93	123.175
94	122.505
95	120.23
96	119.235
97	118.08

BH237-1- Drawdown and Recovery Data from Pumping Test



BH237-1 - AQTESOLV Hantush-Jacob Computed Solution Method



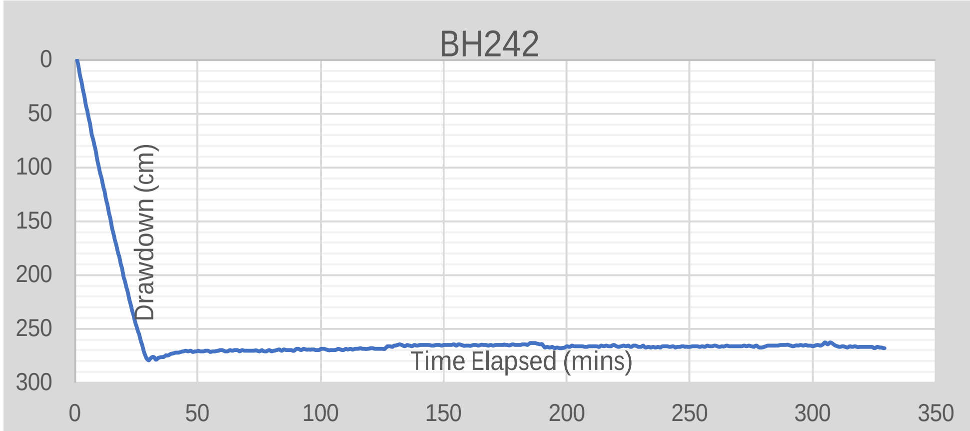
BH237-1 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH237-1 - Glacial Till			
Parameters		Units	Description
r	0.025	m	Radius of Screen
R	0.025	m	Radius of Casing
L	3.5	m	Length of screen
b	3.5	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.019103	m2/day	Computed Transmissivity
K = T/b	3.01E-07	m2/sec	Derived Permeability

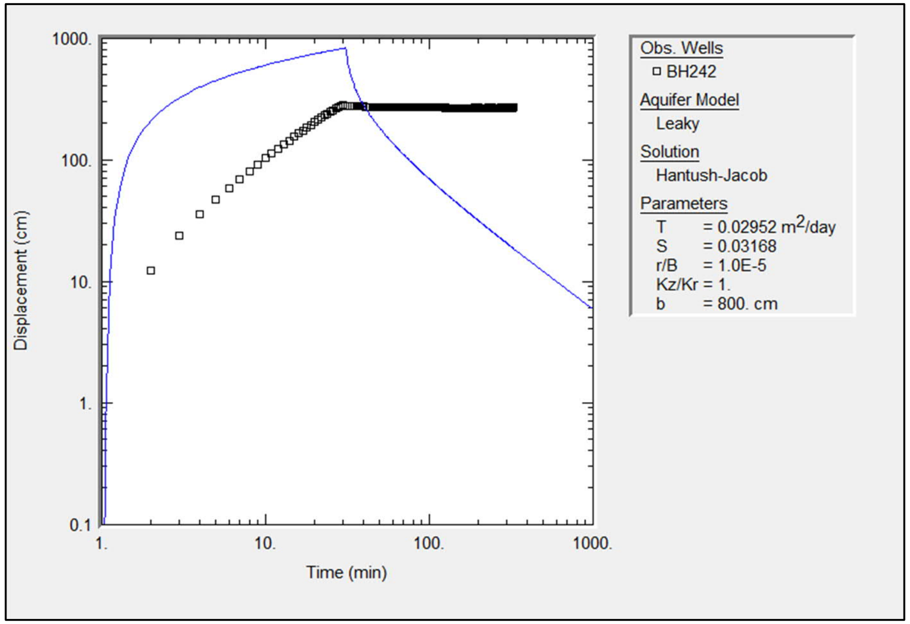
BH242– (Glacial Till) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	0
2	12.18
3	23.65
4	35.83
5	46.94
6	58.05
7	69.52
8	79.265
9	90.97
10	102.195
11	111.75
12	121.89
13	132.94
14	142.57
15	153.845
16	164.245
17	173.79
18	182.7
19	192.73
20	202.225
21	211.01
22	220.73
23	230.41
24	238.96
25	247.2
26	254.895
27	262.015
28	270.02
29	276.345
30	278.855
329	267.615

BH242- Drawdown and Recovery Data from Pumping Test



BH242 - AQTESOLV Hantush-Jacob Computed Solution Method



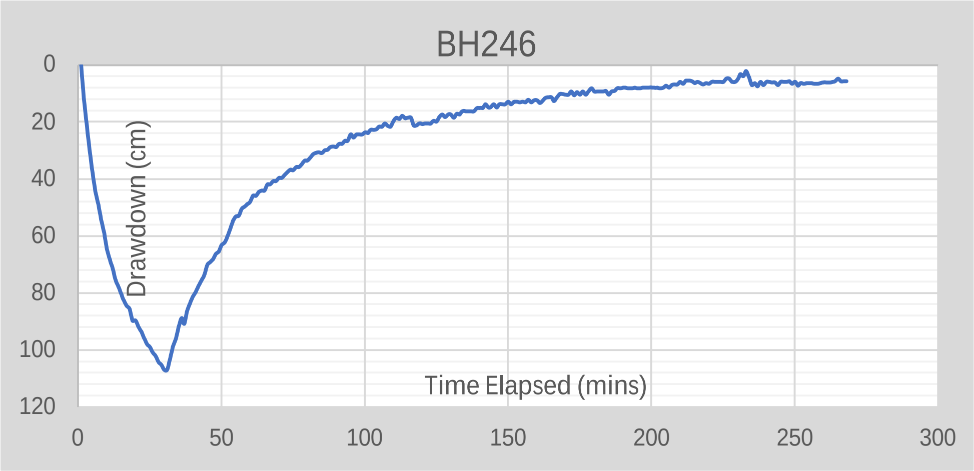
BH242 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH242 - Glacial Till			
Parameters		Units	Description
r	0.025	m	Radius of Screen
R	0.025	m	Radius of Casing
L	8	m	Length of screen
b	8	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.02939	m2/day	Computed Transmissivity
K = T/b	4.25E-08	m2/sec	Derived Permeability

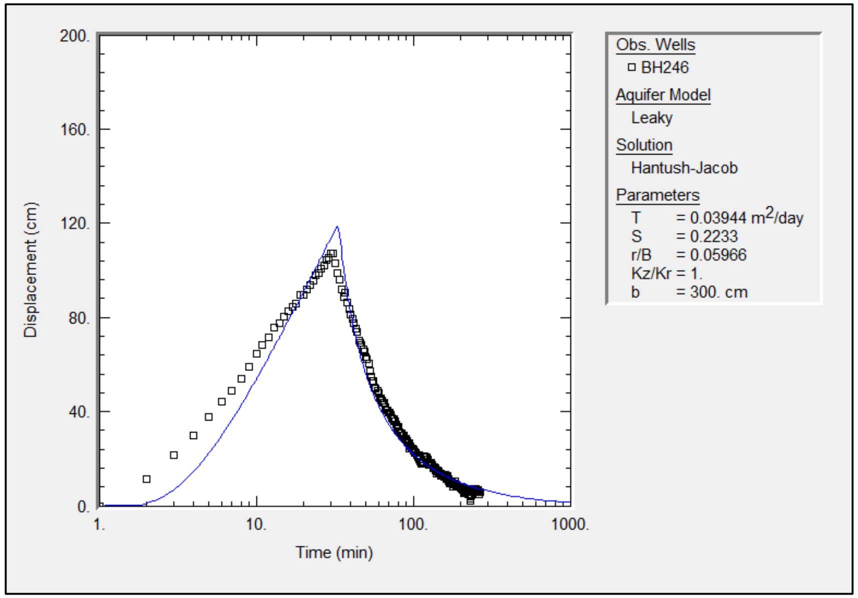
BH246 – (Glacial Till) Permeability Test Result

TIME (MINUTES ElAPSED)	Drawdown (cm)
1	0
2	11.42
3	21.375
4	29.74
5	37.865
6	44.155
7	49.04
8	54.06
9	58.955
10	64.45
11	68.39
12	71.31
13	75.56
14	77.635
15	80.505
16	82.605
17	84.445
18	85.775
19	89.64
20	89.515
21	91.74
22	93.54
23	95.69
24	97.84
25	98.835
26	100.875
27	102.03
28	104.18
29	105.175
30	106.965
31	106.965
268	5.675

BH246 - Drawdown and Recovery Data from Pumping Test



BH246 - AQTESOLV Hantush-Jacob Computed Solution



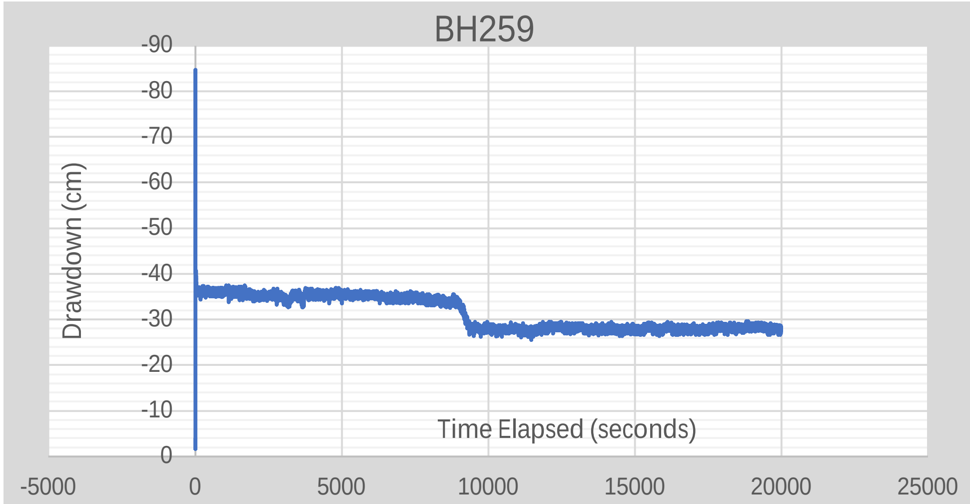
BH246 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH246 - Glacial Till			
Parameters		Units	Description
r	0.0375	m	Radius of Screen
R	0.0375	m	Radius of Casing
L	3	m	Length of screen
b	3	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.03943	m2/day	Computed Transmissivity
K = T/b	1.52E-07	m2/sec	Derived Permeability

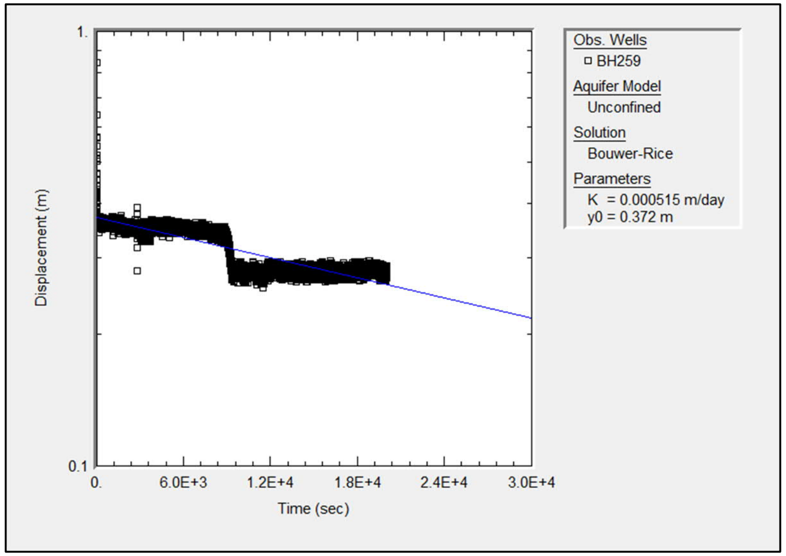
BH259 – (Glacial Till) Permeability Test Result

Time elapsed (half seconds)	Displacement (m)
0.5	0.84695
1	0.5093
1.5	0.47065
2	0.6419
2.5	0.57095
3	0.57095
3.5	0.5022
4	0.51725
4.5	0.5667
5	0.5057
5.5	0.4699
6	0.5165
6.5	0.54285
7	0.45325
7.5	0.42045
8	0.42765
8.5	0.43175
9	0.46705
9.5	0.44195
10	0.42045
10.5	0.42405
11	0.42405
11.5	0.42405
12	0.41745
12.5	0.42045
13	0.42095
13.5	0.41745
14	0.41695
14.5	0.4146
15	0.41745
15.5	0.4217
16	0.411
16.5	0.41385
17	0.4074
17.5	0.41385
18	0.40255
18.5	0.40615
19	0.40615
19.5	0.40665
20	0.40665
20.5	0.40665
21	0.4002
21.5	0.4002
22	0.3947
22.5	0.3947
23	0.38875
23.5	0.38825
24	0.39545
24.5	0.38825
25	0.38515
25.5	0.38155
26	0.38825
26.5	0.3875
27	0.3875
27.5	0.3803
28	0.38105
28.5	0.37795
29	0.3803
29.5	0.37395
30	0.38155
60	0.3517
20035	0.27055

BH259 - Slug test Data Falling Head



BH259 - AQTESOLV Bouwer-Rice Computed Solution



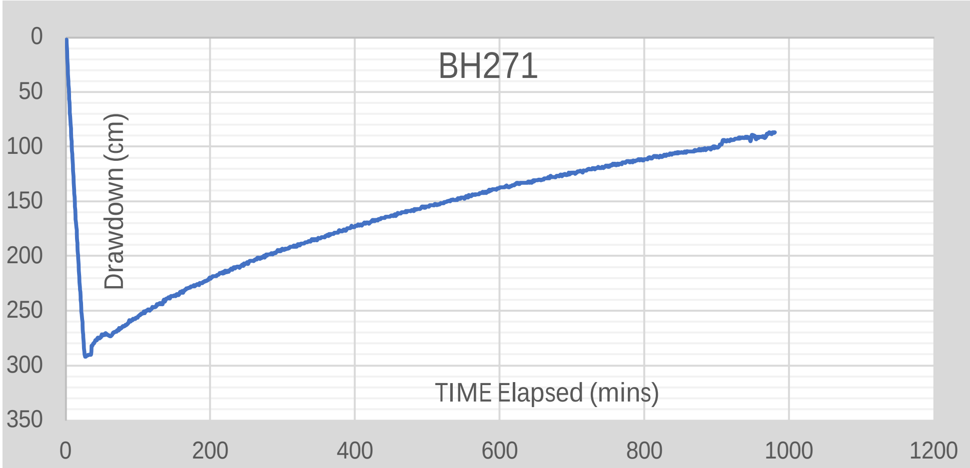
BH259 – Bouwer-Rice Slug-Test Computed Permeability Analysis Method

BH259 Glacial Till			
Parameters		Units	Description
r	0.0375	m	Radius of Screen
R	0.0375	m	Radius of Casing
L	9	m	Length of screen
b	9	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
H (0)	0.84695	m	Initial max displacement
H	0.74	m	Static water level
d	0	m	depth of top of screen from static water level
Hvorslev (unconfined) K	5.96E-09	m/sec	Computed Transmissivity

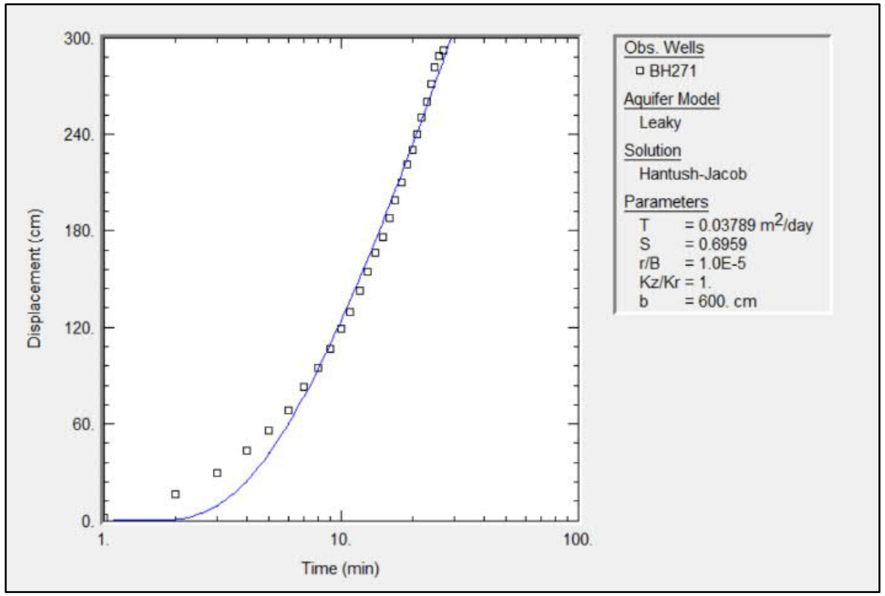
BH271 – (Glacial Till) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	2.075
2	16.045
3	29.79
4	43.35
5	56.25
6	68.49
7	82.82
8	95
9	106.345
10	119.245
11	129.71
12	142.61
13	154.565
14	166.26
15	176.3
16	187.76
17	198.87
18	210.39
19	221.015
20	230.325
21	239.72
22	250.11
23	260.2
24	271.3
25	281.65
26	288.86
27	291.73
980	86.78

BH271 - Drawdown and Recovery Data from Pumping Test



BH271 - AQTESOLV Hantush-Jacob Computed Solution



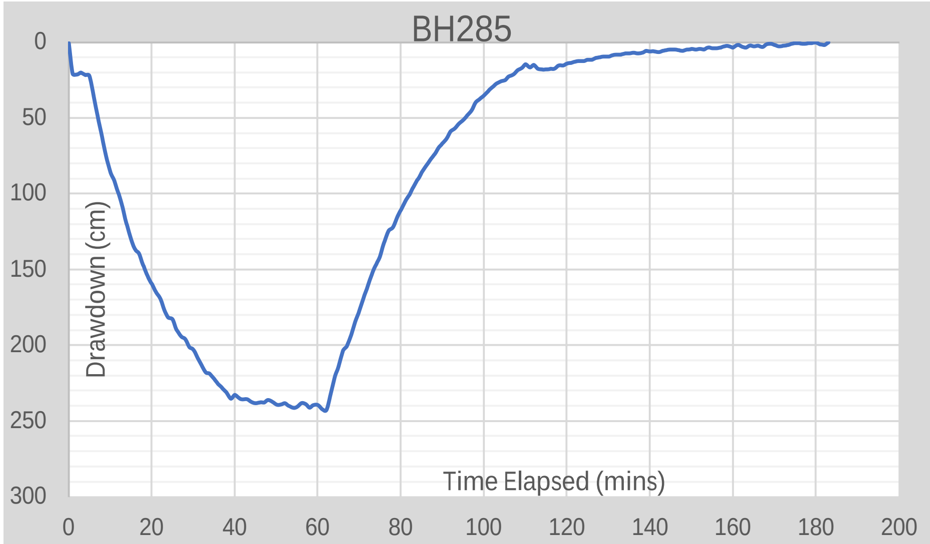
BH271 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH271 – Glacial Till			
Parameters		Units	Description
r	0.025	m	Radius of Screen
R	0.025	m	Radius of Casing
L	1	m	Length of screen
b	1	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.03822	m2/day	Computed Transmissivity
K = T/b	7.37E-8	m2/sec	Derived Permeability

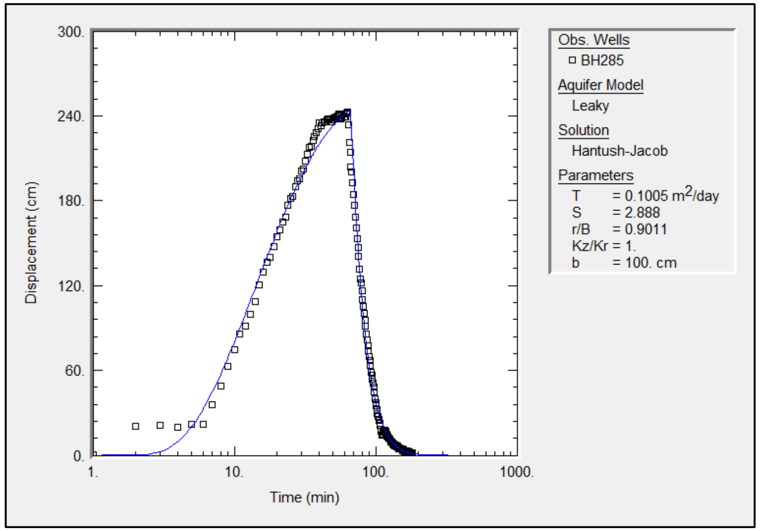
BH285 – (Glacial Till) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	0.36
2	20.705
3	21.065
4	20.06
5	21.625
6	21.86
7	35.955
8	48.73
9	62.71
10	74.94
11	85.565
12	91.37
13	99.97
14	108.855
15	120.635
16	129.51
17	136.805
18	139.625
19	147.915
20	154.19
21	159.61
22	164.705
23	168.645
24	176.535
25	181.47
26	182.91
27	189.585
28	193.835
29	195.635
30	201.005
31	202.72
32	208.175
33	212.835
34	217.895
35	218.615
36	222.27
37	225.375
38	228.285
39	231.105
40	235.045
41	232.82
42	234.92
43	235.565
44	235.565
45	237.355
46	238.15
47	237.555
48	237.48
49	236.05
50	237.07
51	238.86
52	239.145
53	238.15
54	239.815
55	241.245
56	240.535
57	238.025
58	238.435
59	241.01
60	239.22
61	239.505
62	241.73
63	242.735
183	1.67

BH285 - Drawdown and Recovery Data from Pumping Test



BH285 - AQTESOLV Hantush-Jacob Computed Solution



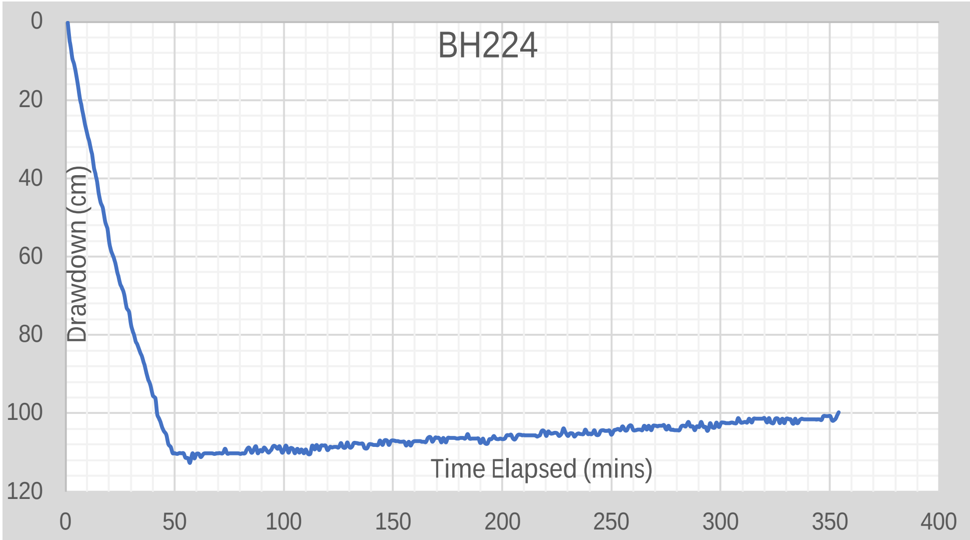
BH285 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH285 – Glacial Till			
Parameters		Units	Description
r	0.025	m	Radius of Screen
R	0.025	m	Radius of Casing
L	1	m	Length of screen
b	1	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.1005	m2/day	Computed Transmissivity
K = T/b	1.16E-6	m2/sec	Derived Permeability

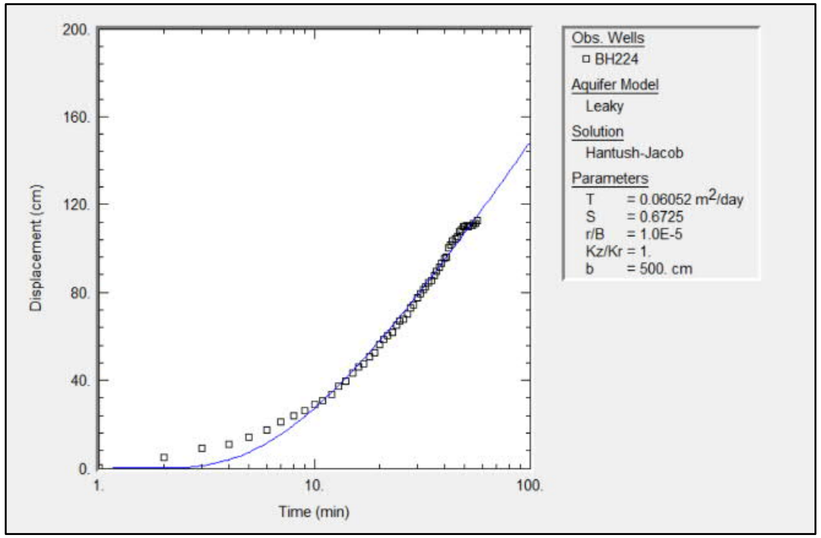
BH224 – (Oxford Clay) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	0.2
2	4.9
3	9.15
4	10.875
5	14.22
6	17.45
7	21.03
8	23.665
9	26.175
10	29.035
11	30.825
12	33.695
13	37.275
14	39.425
15	43.375
16	45.875
17	47.675
18	50.66
19	52.76
20	56.475
21	58.55
22	60.29
23	62.005
24	64.825
25	66.9
26	68.045
27	70.32
28	72.99
29	74.185
30	77.415
31	79.28
32	81.48
33	82.5
34	84.35
35	85.42
36	87.52
37	89.72
38	91.46
39	93.25
40	95.45
41	96.12
42	100.42
43	101.5
44	103.34
45	104.485
46	105.365
47	107.64
48	108.585
49	110.1
50	110.1
51	110.325
52	110.1
53	110.225
54	110.225
55	111.295
56	111.42
57	112.55
354	99.62

BH224 - Drawdown and Recovery Data from Pumping Test



BH224 - AQTESOLV Hantush-Jacob Computed Solution



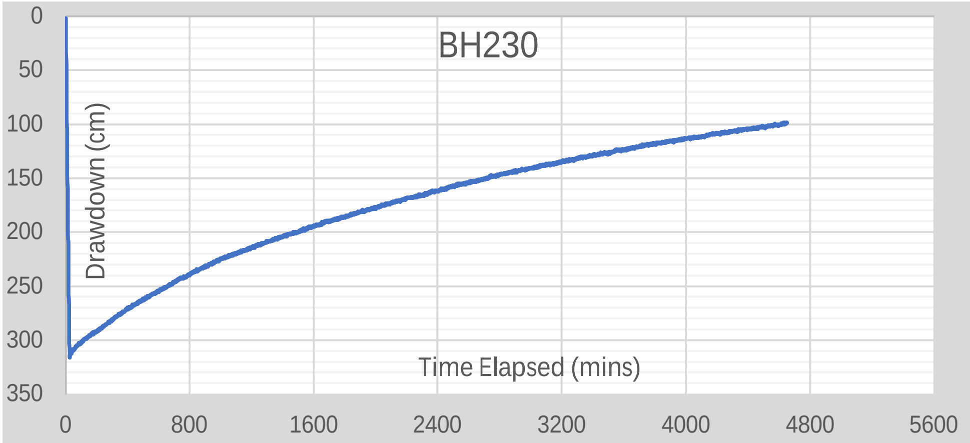
BH224 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH224 – Oxford Clay			
Parameters		Units	Description
r	0.0375	m	Radius of Screen
R	0.0375	m	Radius of Casing
L	1	m	Length of screen
b	1	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.06052	m2/day	Computed Transmissivity
K = T/b	1.4E-07	m2/sec	Derived Permeability

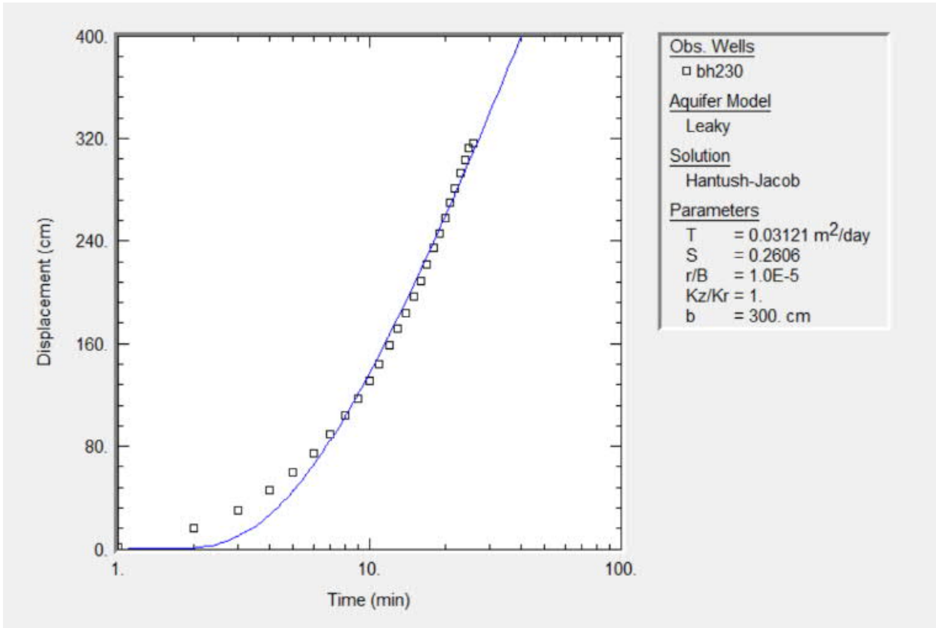
BH230 – (Oxford Clay) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	1.44
2	16.08
3	30.46
4	45.945
5	59.365
6	74.13
7	89.54
8	103.795
9	117.49
10	130.74
11	143.875
12	158.615
13	171.64
14	183.83
15	196.37
16	208.86
17	221.4
18	234.585
19	245.77
20	257.59
21	269.78
22	281.165
23	292.635
24	303.1
25	312.655
26	315.875
4651	98

BH230 - Drawdown and Recovery Data from Pumping Test



BH230 - AQTESOLV Hantush-Jacob Computed Solution



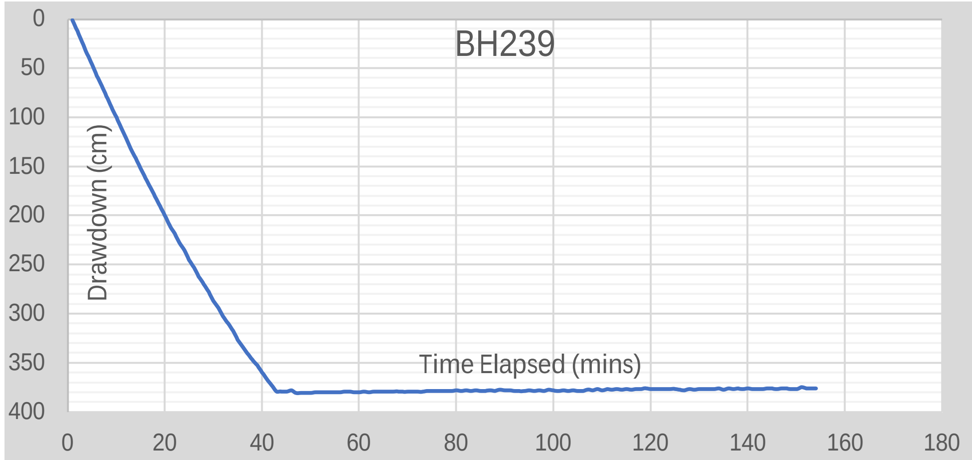
BH230 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH230 – Oxford Clay			
Parameters		Units	Description
r	0.0375	m	Radius of Screen
R	0.0375	m	Radius of Casing
L	3	m	Length of screen
b	3	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.03121	m2/day	Computed Transmissivity
K = T/b	1.20E-07	m2/sec	Derived Permeability

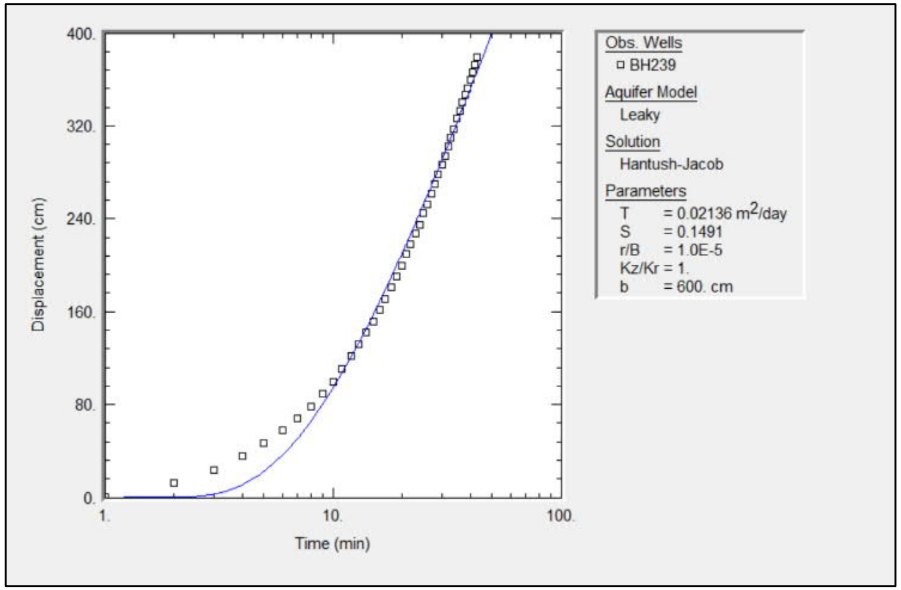
BH239 – (Oxford Clay) Permeability Test Result

TIME (MINUTES EIAPSED)	Drawdown (cm)
1	0.72
2	12.265
3	23.365
4	35.195
5	46.305
6	57.415
7	67.68
8	78.12
9	89.305
10	99.98
11	110.555
12	121.355
13	132.055
14	141.85
15	151.58
16	161.845
17	171.24
18	180.675
19	190.28
20	199.315
21	209.83
22	218.355
23	227.665
24	235.02
25	244.815
26	252.755
27	261.715
28	269.83
29	277.835
30	286.745
31	293.965
32	302.515
33	309.725
34	317.44
35	326.04
36	333.2
37	340.06
38	346.51
39	352.675
40	359.41
41	366.58
42	372.385
43	378.835
154	375.63

BH239 - Drawdown and Recovery Data from Pumping Test



BH239 - AQTESOLV Hantush-Jacob Computed Solution



BH239 - Hantush-Jacob Pumping-Test Derived Permeability Analysis

BH239 – Oxford Clay			
Parameters		Units	Description
r	0.05	m	Radius of Screen
R	0.05	m	Radius of Casing
L	1	m	Length of screen
b	1	m	Derived thickness of aquifer
Kv/Kh	1	Dimensionless	Hydraulic Conductivity Anisotropy Ratio
Type of test	Single well	Dimensionless	Type of Pumping Test
Well configuration	Vertical, full penetration	Dimensionless	
Unit	Pumped Aquifer	Dimensionless	Unit pumped from
Hantush-Jacob (leaky) T	0.02136	m2/day	Computed Transmissivity
K = T/b	4.12E-08	m2/sec	Derived Permeability

Appendix B

Groundwater Quality 2020 and 2021

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Alkalinity, Total as CaCO3	mg/l	2	-	-	575	270	1210	260	286	295	222	210	11600	1360	260
Bicarbonate Alkalinity as HCO3	mg/l	2	-	-	701		1480		349		270		14100		
BOD, unfiltered	mg/l	1	-	-	14.7	1	6.05	1	1	1	1	1	21.1	2.28	6.36
Carbon, Organic (diss.filt)	mg/l	3	-	-	3.17	4.49	4.73	3.82	3	4.09	3	5.87	5.98	7.38	3.27
Ammoniacal Nitrogen as N (low	mg/l	0.01	1.5	-	1.37	0.277	0.526	1.18	0.01	0.01	0.01	0.01	0.0759	1.75	0.017
Ammoniacal Nitrogen as NH3	mg/l	0.2	-	-	0.256	0.287	0.646	1.53	0.2	0.2	0.2	0.2	0.2	2.21	0.2
Fluoride	mg/l	0.5	1.5	3	0.5	0.5	0.622	1.56	0.5	0.5	0.5	0.5	0.5	0.5	0.5
COD, unfiltered	mg/l	7	-	-	2260	13.7	1340	46.4	12.4	7	19.5	30.2	3440	941	68.4
Conductivity 20 deg.C	mS/cm	0.02	-	-	1.48	1.67	1.91	3.34	0.946	0.937	0.651	3.33	0.708	0.582	0.888
Dissolved solids, Total (meter)	mg/l	5	-	-	1170	1210	1540	2350	710	622	527	2430	562	419	821
Aluminium (tot.unfilt)	µg/l	10	-	-	19300	38.2	49500	3210	498	71.6	2740	43	39000	192000	81
Chromium, Trivalent (Low)	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
Arsenic (diss.filt)	µg/l	0.5	10	-	2.94	1.51	1.6	0.5	0.5	0.5	0.5	0.5	1.19	1.41	0.5

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Arsenic (tot.unfilt)	µg/l	2	-	-	17.1	**2**	39.5	**2**	**2**	**2**	**2**	**2**	53.3	267	**2**
Boron (tot.unfilt)	µg/l	20	-	-	346	598	1030	2540	83.5	62.5	37.4	**20**	100	1200	50.9
Cadmium (diss.filt)	µg/l	0.08	**5**	**0.45**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	0.383	**0.08**	**0.08**
Cadmium (tot.unfilt)	µg/l	0.5	-	-	0.537	**0.5**	3.96	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	1.18	30	**0.5**
Chromium (tot.unfilt)	µg/l	3	-	-	55.6	**3**	148	9.99	**3**	**3**	10.3	**3**	121	751	**3**
Chromium (diss.filt)	µg/l	1	-	-	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	1.29	**1**
Copper (tot.unfilt)	µg/l	1	-	-	39.4	**1**	165	5.25	**1**	**1**	5.48	13	108	732	1.1
Cobalt (diss.filt)	µg/l	0.5	-	-	1.52	1.38	2.31	**0.5**	**0.5**	**0.5**	**0.5**	0.691	0.57	**0.5**	**0.5**
Lead (diss.filt)	µg/l	0.2	**10**	**14**	5.85	**0.2**	0.808	**0.2**	4.11	**0.2**	**0.2**	**0.2**	**0.2**	0.595	**0.2**
Nickel (tot.unfilt)	µg/l	1	-	-	65.5	2.61	287	7.96	2.3	**1**	8.34	1.79	199	782	1.14
Manganese (diss.filt)	µg/l	3	**50**	-	992		860		83.1		11.5		51.7		
Selenium (tot.unfilt)	µg/l	1	-	-	2.45	**1**	11.7	**1**	**1**	**1**	**1**	**1**	10.2	60	**1**
Nickel (diss.filt)	µg/l	0.4	**20**	**34**	5.16	2.17	7.04	**0.4**	2.96	**0.4**	1.24	1.44	3.87	1.25	0.635
Zinc (tot.unfilt)	µg/l	5	-	-	1060	5.35	901	39.5	5.47	**5**	53.7	51.6	361	1920	6.15
Silver (Tot. Unfilt.)	µg/l	1	-	-	**1**	**1**	6	**1**	**1**	**1**	**1**	**1**	**1**	60	**1**
Sodium (Dis.Filt)	mg/l	0.076	**200**	-	179	232	191	532	61.2	70.2	96.4	423	52.8	31.1	15.7
Magnesium (Dis.Filt)	mg/l	0.036	-	-	13.6	14.6	13.6	23.4	5.95	4.5	1.93	5.61	6.38	5.58	7.56
Potassium (Dis.Filt)	mg/l	0.2	-	-	5.24	5.32	7.05	15.6	2.61	2.08	1.81	4	19.7	20.7	2.84

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Calcium (Dis.Filt)	mg/l	0.2	-	-	154	139	133	57	134	120	53	155	102	91.2	179
Iron (Dis.Filt)	mg/l	0.019	0.2	-	4.35	1.34	0.103	0.378	0.0852	0.019	0.019	0.019	0.019	0.0375	0.0961
Hardness, Total as CaCO3	mg/l	0.35	-	-	704	448	2320	277	410	373	189	456	5740	8460	506
Mercury (diss.filt)	µg/l	0.01	1	0.07	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	0.02	0.0563	0.02	0.02	0.02	0.02	0.02	0.1	0.573	0.02
Nitrite as NO2	mg/l	0.05	-	-	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.089
Sulphate	mg/l	2	250	-	262	439	422	842	95.7	69.4	29.5	46.5	124	53.1	92.4
Chloride	mg/l	2	250	-	242	190	274	488	105	112	98.6	983	38.8	37.8	40.7
Nitrate as NO3	mg/l	0.3	50	-	2.7	0.837	3.63	0.3	3.27	9.31	2.97	4.28	12.6	21.5	151
Turbidity	ntu	0.1	-	-	3910	10.5	3900	43	37.6	9.81	73.2	5.52	56400	11400	4.53
Phenol (low level)	µg/l	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	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	0.5	0.5	0.5	0.5	0.5	0.5	0.55	0.5	0.5
Sum of Detected Monohydric	µg/l	0.5	-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.55	0.5	0.5
pH	pH Units	1	6.5-9.5	6-9	7.27	7.57	7.48	8	7.19	7.43	7.63	7.66	7.46	7.57	7.48
Cyanide, Total (low level)	µg/l	5	50	5	5	5	5	5	5	5	5	5	5	5	5
Cyanide, Free (low level)	µg/l	2.5	50	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS / MAC											
Cyanide, Complex (low level)*	µg/l	5	-	-	5	5	5	5	5	5	5	5	5	5	5
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
Trifluralin	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
alpha-HCH	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
gamma-HCH (Lindane)	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
Heptachlor	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
Aldrin	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.02
beta-HCH	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
Isodrin	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
delta-HCH	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
Heptachlor epoxide	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
o,p'-DDE	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
Endosulphan I	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
trans-Chlordane	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
cis-Chlordane	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01
p,p'-DDE	µg/l	0.01	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.01

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Dieldrin	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.02	**0.01**
o,p'-DDD (TDE)	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.02	**0.01**
Endrin	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.04	0.02
o,p'-DDT	µg/l	0.01	-	-	**0.01**	0.02	0.02	**0.01**	0.02	**0.01**	0.02	**0.01**	0.05	0.04	0.02
p,p'-DDD (TDE)	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.02	**0.01**
Endosulphan II	µg/l	0.02	-	-	**0.02**	**0.02**	**0.02**	0.06	**0.02**	**0.02**	**0.02**	**0.02**	0.1	0.04	**0.02**
p,p'-DDT	µg/l	0.01	-	-	**0.01**	0.03	**0.01**	0.02	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.06	0.03
o,p'-Methoxychlor	µg/l	0.01	-	-	**0.01**	0.02	**0.01**	0.03	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.06	0.03
p,p'-Methoxychlor	µg/l	0.01	-	-	0.02	0.03	0.05	**0.01**	0.05	0.02	0.05	0.02	0.05	0.08	0.03
Endosulphan Sulphate	µg/l	0.02	-	-	0.04	**0.02**	0.1	**0.02**	0.1	**0.02**	0.1	**0.02**	0.1	0.04	0.04
Permethrin I	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.02	**0.01**
Permethrin II	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.05	0.02	**0.01**
1,3,5-Trichlorobenzene	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Hexachlorobutadiene	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
1,2,4-Trichlorobenzene	µg/l	0.01	**0.1**	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
1,2,3-Trichlorobenzene	µg/l	0.01	**0.1**	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.258	0.1	**0.01**
Dichlorvos	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Dichlobenil	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Mevinphos	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Tecnazene	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Hexachlorobenzene	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Demeton-S-methyl	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Phorate	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Diazinon	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Triallate	µg/l	0.01	-	-	0.1	**0.01**	0.274	0.02	**0.01**	**0.01**	0.015	**0.01**	0.2	0.1	**0.01**
Atrazine	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Simazine	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Disulfoton	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Propetamphos	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Chlorpyriphos-methyl	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Dimethoate	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Pirimiphos-methyl	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Chlorpyriphos	µg/l	0.01	-	-	0.1	**0.01**	0.1	0.055	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Methyl Parathion	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Malathion	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Fenthion	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Fenitrothion	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Triadimefon	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Pendimethalin	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Parathion	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Chlorfenvinphos	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
trans-Chlordane	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.02	**0.01**
cis-Chlordane	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.02	**0.01**
Ethion	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Carbophenothion	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.2	0.1	**0.01**
Triazophos	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.4	0.1	**0.01**
Phosalone	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.8	0.1	**0.01**
Azinphos methyl	µg/l	0.02	-	-	0.2	**0.02**	0.2	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	1.6	0.2	**0.02**
Azinphos ethyl	µg/l	0.02	-	-	0.2	**0.02**	0.2	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	1.6	0.2	**0.02**

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS											
				MAC											
Dinitro-o-cresol	µg/l	0.1	-	-	**0.1**		**0.1**		**0.1**		**0.1**		10		
Clopyralid	µg/l	0.04	-	-	**0.04**	0.3	**0.04**	0.3	**0.04**	**0.03**	**0.04**	0.09	4	0.3	0.3
MCPA	µg/l	0.05	-	-	**0.05**	0.1	**0.05**	0.1	**0.05**	**0.01**	**0.05**	**0.01**	5	0.1	0.1
Mecoprop	µg/l	0.04	-	-	**0.04**		**0.04**		**0.04**		**0.04**		4		
Dicamba	µg/l	0.04	-	-	**0.04**	0.3	**0.04**	0.3	**0.04**	**0.03**	**0.04**	**0.03**	4	0.3	0.3
MCPB	µg/l	0.05	-	-	**0.05**	0.2	**0.05**	0.2	**0.05**	**0.02**	**0.05**	**0.02**	5	0.2	0.2
2,4-DB	µg/l	0.1	-	-	**0.1**	0.2	**0.1**	0.2	**0.1**	**0.02**	**0.1**	**0.02**	10	0.2	0.2
2,3,6-Trichlorobenzoic acid	µg/l	0.05	-	-	**0.05**	1	**0.05**	1	**0.05**	0.1	**0.05**	0.1	5	1	1
Dichlorprop	µg/l	0.1	-	-	**0.1**		**0.1**		**0.1**		**0.1**		10		
Triclopyr	µg/l	0.05	-	-	**0.05**	0.3	**0.05**	0.3	**0.05**	0.15	**0.05**	**0.03**	5	0.3	0.3
Fenoprop (Silvex)	µg/l	0.1	-	-	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.01**	**0.1**	**0.01**	10	**0.1**	**0.1**
2,4-Dichlorophenoxyacetic acid	µg/l	0.05	-	-	**0.05**	0.1	**0.05**	0.1	**0.05**	**0.01**	**0.05**	**0.01**	5	0.4	0.1
2,4,5-Trichlorophenoxyacetic	µg/l	0.05	-	-	**0.05**	0.1	**0.05**	0.1	**0.05**	**0.01**	**0.05**	**0.01**	5	0.1	0.1

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Bromoxynil	µg/l	0.04	-	-	**0.04**	0.1	**0.04**	0.1	**0.04**	**0.01**	**0.04**	**0.01**	4	0.1	0.1
Benazolin	µg/l	0.04	-	-	**0.04**	0.5	**0.04**	0.5	**0.04**	0.05	**0.04**	0.05	4	0.5	0.5
Ioxynil	µg/l	0.05	-	-	**0.05**	0.1	**0.05**	0.1	**0.05**	**0.01**	**0.05**	**0.01**	5	0.1	0.1
Pentachlorophenol	µg/l	0.04	-	-	**0.04**		**0.04**		**0.04**		**0.04**		4		
Fluoroxypyr	µg/l	0.1	-	-	**0.1**	0.2	**0.1**	0.2	**0.1**	**0.06**	**0.1**	**0.1**	10	0.2	0.2
Naphthalene (aq)	µg/l	0.01	**6**	**130**	**0.01**	**0.01**	0.0257	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	19	0.0164	**0.01**
Acenaphthene (aq)	µg/l	0.005	**18**	-	**0.005**	**0.005**	0.01	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	3.87	0.156	**0.005**
Acenaphthylene (aq)	µg/l	0.005	**18**	-	**0.005**	**0.005**	0.01	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	2.09	0.13	**0.005**
Fluoranthene (aq)	µg/l	0.005	**4**	**0.12**	0.0319	**0.005**	0.101	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	85.1	7.49	**0.005**
Anthracene (aq)	µg/l	0.005	**90**	**0.1**	**0.005**	**0.005**	0.01	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	10.8	0.932	**0.005**
Phenanthrene (aq)	µg/l	0.005	**4**	-	0.0257	**0.005**	0.0849	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	39.8	3.15	**0.005**
Fluorene (aq)	µg/l	0.005	**12**	-	0.00504	**0.005**	0.0161	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	2.62	0.199	**0.005**
Chrysene (aq)	µg/l	0.005	**7**	-	0.0197	**0.005**	0.0516	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	37.8	4.08	**0.005**
Pyrene (aq)	µg/l	0.005	**9**	-	0.0294	**0.005**	0.169	0.027	**0.005**	**0.005**	0.00548	**0.005**	74.3	6.89	**0.005**

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Benzo(a)anthracene (aq)	µg/l	0.005	3.5	-	0.0143	0.005	0.0329	0.005	0.005	0.005	0.005	0.005	41.2	4.02	0.005
Benzo(b)fluoranthene (aq)	µg/l	0.005	0.1	0.02	0.0374	0.005	0.0765	0.005	0.005	0.005	0.005	0.005	68.5	7.38	0.005
Benzo(k)fluoranthene (aq)	µg/l	0.005	0.1	0.017	0.0154	0.005	0.0321	0.005	0.005	0.005	0.005	0.005	28.6	2.84	0.005
Benzo(a)pyrene (aq)	µg/l	0.002	0.01	0.27	0.0199	0.002	0.0374	0.002	0.002	0.002	0.002	0.002	48	5.66	0.002
Dibenzo(a,h)anthracene (aq)	µg/l	0.005	0.07	-	0.005	0.005	0.01	0.005	0.005	0.005	0.005	0.005	7.29	0.985	0.005
Benzo(g,h,i)perylene (aq)	µg/l	0.005	0.1	0.0082	0.0159	0.005	0.0459	0.005	0.005	0.005	0.005	0.005	38.8	4.57	0.005
Indeno(1,2,3-cd)pyrene (aq)	µg/l	0.005	0.1	-	0.0122	0.005	0.0317	0.005	0.005	0.005	0.005	0.005	34.1	4.41	0.005
PAH, Total Detected USEPA 16	µg/l	0.082	-	-	0.227	0.082	0.706	0.082	0.082	0.082	0.082	0.082	542	52.9	0.082
GRO Surrogate % recovery**	%		-	-	100	111	102	111	113	100	111	101	82	113	108
GRO >C5-C12	µg/l	50	-	-	50	50	50	50	50	50	50	50	52	50	50
Methyl tertiary butyl ether	µg/l	3	-	-	3	3	3	3	3	3	3	3	3	3	3
Benzene**	µg/l	7	1	50	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
Ethylbenzene	µg/l	5	300	-	5	5	5	5	5	5	5	5	5	5	5

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
m,p-Xylene	µg/l	8	190	-	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
Sum of detected Xylenes	µg/l	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
Aliphatics >C5-C6	µg/l	10	15000	-	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
Aliphatics >C8-C10	µg/l	10	300	-	10	10	10	10	10	10	10	10	11	10	10
Aliphatics >C10-C12	µg/l	10	300	-	10	10	10	10	10	10	10	10	16	10	10
Aliphatics >C12-C16 (aq)	µg/l	10	300	-	10	10	20	10	10	10	10	10	200	10	10
Aliphatics >C16-C21 (aq)	µg/l	10	300	-	10	10	20	10	10	10	10	10	200	10	10
Aliphatics >C21-C35 (aq)	µg/l	10	300	-	10	10	20	10	10	10	10	10	4910	10	10
Total Aliphatics >C12-C35 (aq)	µg/l	10	-	-	10	10	20	10	10	10	10	10	4910	10	10
Aromatics >EC5-EC7**	µg/l	10	1	-	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

Geology					River Terrace										
Location of Borehole					A	A	A	A	A	A	A	A	A	A	A
Borehole name					BH203-S		BH275-S		BH273-S		BH206-S		WS275		BH212
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					2.43	2.31	4.00	1.82	5.21	3.24	3.51	2.97	1.40	1.53	3.05
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Aromatics >EC8-EC10	µg/l	10	**300**	**-**	**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**
Aromatics >EC12-EC16 (aq)	µg/l	10	**90**	**-**	**10**	**10**	20	**10**	**10**	**10**	**10**	**10**	200	**10**	**10**
Aromatics >EC16-EC21 (aq)	µg/l	10	**90**	**-**	**10**	**10**	20	**10**	**10**	**10**	**10**	**10**	657	**10**	**10**
Aromatics >EC21-EC35 (aq)	µg/l	10	**90**	**-**	**10**	**10**	20	**10**	**10**	**10**	**10**	**10**	1820	**10**	**10**
Total Aromatics >EC12-EC35	µg/l	10	**-**	**-**	**10**	**10**	20	**10**	**10**	**10**	**10**	**10**	2480	**10**	**10**
Total Aliphatics & Aromatics	µg/l	10	**-**	**-**	**10**	**10**	16	**10**	**10**	**10**	13	**10**	7440	**10**	**10**
Aliphatics >C16-C35 Aqueous	µg/l	10	**-**	**-**	**10**	**10**	20	**10**	**10**	**10**	**10**	**10**	4910	**10**	**10**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Alkalinity, Total as CaCO3	mg/l	2	-	-	908	225	324	283	295	227
Bicarbonate Alkalinity as HCO3	mg/l	2	-	-		274		345		
BOD, unfiltered	mg/l	1	-	-	15.9	**1**	**1**	**1**	**1**	3
Carbon, Organic (diss.filt)	mg/l	3	-	-	12	3.41	4.9	3.71	3.05	6.05
Ammoniacal Nitrogen as N (low	mg/l	0.01	**1.5**	-	3.15	1.24	0.286	0.013	0.012	0.778
Ammoniacal Nitrogen as NH3	mg/l	0.2	-	-	1.57	1.65	0.271	**0.2**	**0.2**	0.899
Fluoride	mg/l	0.5	**1.5**	**3**	1.65	1.67	**0.5**	**0.5**	**0.5**	1.54
COD, unfiltered	mg/l	7	-	-	1950	24.9	**7**	**7**	19.2	61
Conductivity 20 deg.C	mS/cm	0.02	-	-	3.21	3.35	1.75	0.936	0.917	2.57
Dissolved solids, Total (meter)	mg/l	5	-	-	2310	2830	1260	762	626	1800
Aluminium (tot.unfilt)	µg/l	10	-	-	30300	53.4	149	298	914	1120
Chromium, Trivalent (Low)	mg/l	0.003	-	-	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**
Arsenic (diss.filt)	µg/l	0.5	**10**	-	2.6	**0.5**	3	**0.5**	**0.5**	**0.5**
Arsenic (tot.unfilt)	µg/l	2	-	-	64.9	**2**	**2**	**2**	**2**	**2**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Boron (tot.unfilt)	µg/l	20	-	-	2370	2820	737	117	73.1	1890
Cadmium (diss.filt)	µg/l	0.08	**5**	**0.45**	**0.08**	**0.08**	0.48	**0.08**	**0.08**	**0.08**
Cadmium (tot.unfilt)	µg/l	0.5	-	-	3	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Chromium (tot.unfilt)	µg/l	3	-	-	92.6	**3**	**3**	10.9	**3**	3.83
Chromium (diss.filt)	µg/l	1	-	-	**1**	**1**	6	**1**	**1**	**1**
Copper (tot.unfilt)	µg/l	1	-	-	144	**1**	**1**	1.29	3.61	**1**
Cobalt (diss.filt)	µg/l	0.5	-	-	**0.5**	**0.5**	3	**0.5**	**0.5**	**0.5**
Lead (diss.filt)	µg/l	0.2	**10**	**14**	**0.2**	**0.2**	1.2	0.383	**0.2**	**0.2**
Nickel (tot.unfilt)	µg/l	1	-	-	238	**1**	2.44	2.71	4.69	4.17
Manganese (diss.filt)	µg/l	3	**50**	-		36.9		123		
Selenium (tot.unfilt)	µg/l	1	-	-	6.77	**1**	**1**	**1**	**1**	**1**
Nickel (diss.filt)	µg/l	0.4	**20**	**34**	1.15	**0.4**	2.4	1.7	1.24	**0.4**
Zinc (tot.unfilt)	µg/l	5	-	-	6800	**5**	**5**	14.3	24.9	52.3
Silver (Tot. Unfilt.)	µg/l	1	-	-	6	**1**	**1**	**1**	**1**	**1**
Sodium (Dis.Filt)	mg/l	0.076	**200**	-	509	529	261	83.2	81.5	379
Magnesium (Dis.Filt)	mg/l	0.036	-	-	15	24.8	11.2	7.42	6.34	18.3
Potassium (Dis.Filt)	mg/l	0.2	-	-	12.8	17.2	6.3	3.35	2.89	13.8
Calcium (Dis.Filt)	mg/l	0.2	-	-	39.9	55.6	147	128	143	59.3

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Iron (Dis.Filt)	mg/l	0.019	**0.2**	-	0.165	0.172	0.114	0.0491	**0.019**	0.102
Hardness, Total as CaCO3	mg/l	0.35	-	-	750	244	445	406	397	266
Mercury (diss.filt)	µg/l	0.01	**1**	**0.07**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.0541
Mercury (tot.unfilt)	µg/l	0.02	-	-	0.0517	**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**
Sulphate	mg/l	2	**250**	-	849	906	351	129	91.7	619
Chloride	mg/l	2	**250**	-	423	563	237	117	115	361
Nitrate as NO3	mg/l	0.3	**50**	-	**0.3**	**0.3**	1.19	**0.3**	8.09	**0.3**
Turbidity	ntu	0.1	-	-	12000	6.94	15.9	17.1	45.3	119
Phenol (low level)	µg/l	0.5	-	-	**0.5**	0.58	**0.5**	**0.5**	**0.5**	1.24
Cresols (low level)	µg/l	0.5	-	-	**0.5**	2.01	**0.5**	**0.5**	**0.5**	6.19
Xylenols (low level)	µg/l	0.5	-	-	**0.5**	5.01	**0.5**	**0.5**	**0.5**	9.03
Sum of Detected Monohydric	µg/l	0.5	-	-	**0.5**	7.6	**0.5**	**0.5**	**0.5**	16.5
pH	pH Units	1	**6.5-9.5**	**6-9**	8.06	7.94	7.48	7.33	7.43	7.88
Cyanide, Total (low level)	µg/l	5	**50**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Cyanide, Free (low level)	µg/l	2.5	**50**	**5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Cyanide, Complex (low level)*	µg/l	5	-	-	**5**	**5**	**5**	**5**	**5**	**5**
Low Level Hexavalent	mg/l	0.003	-	-	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**
Trifluralin	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
alpha-HCH	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
gamma-HCH (Lindane)	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Heptachlor	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Aldrin	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
beta-HCH	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Isodrin	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
delta-HCH	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Heptachlor epoxide	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
o,p'-DDE	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Endosulphan I	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
trans-Chlordane	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
cis-Chlordane	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
p,p'-DDE	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Dieldrin	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
o,p'-DDD (TDE)	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Endrin	µg/l	0.01	-	-	0.2	**0.01**	0.02	**0.01**	**0.01**	**0.01**
o,p'-DDT	µg/l	0.01	-	-	0.2	0.02	**0.01**	0.02	0.02	**0.01**
p,p'-DDD (TDE)	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Endosulphan II	µg/l	0.02	-	-	0.4	**0.02**	0.06	**0.02**	**0.02**	**0.02**
p,p'-DDT	µg/l	0.01	-	-	0.2	**0.01**	0.02	**0.01**	0.03	**0.01**
o,p'-Methoxychlor	µg/l	0.01	-	-	0.2	**0.01**	0.03	**0.01**	0.02	**0.01**
p,p'-Methoxychlor	µg/l	0.01	-	-	0.4	0.05	**0.01**	0.05	0.03	0.02
Endosulphan Sulphate	µg/l	0.02	-	-	0.4	0.1	**0.02**	0.1	**0.02**	**0.02**
Permethrin I	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Permethrin II	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
1,3,5-Trichlorobenzene	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Hexachlorobutadiene	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
1,2,4-Trichlorobenzene	µg/l	0.01	**0.1**	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
1,2,3-Trichlorobenzene	µg/l	0.01	**0.1**	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Dichlorvos	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Dichlobenil	µg/l	0.01	-	-	**0.01**	0.0151	**0.01**	0.02	**0.01**	**0.01**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Mevinphos	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Tecnazene	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Hexachlorobenzene	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Demeton-S-methyl	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Phorate	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Diazinon	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Triallate	µg/l	0.01	-	-	0.0375	0.0349	**0.01**	0.02	**0.01**	0.0283
Atrazine	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Simazine	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Disulfoton	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Propetamphos	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Chlorpyriphos-methyl	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Dimethoate	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Pirimiphos-methyl	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Chlorpyriphos	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Methyl Parathion	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Malathion	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Fenthion	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Fenitrothion	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Triadimefon	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Pendimethalin	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Parathion	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Chlorfenvinphos	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
trans-Chlordane	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	0.02	**0.01**	**0.01**
cis-Chlordane	µg/l	0.01	-	-	0.2	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Ethion	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Carbophenothion	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Triazophos	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Phosalone	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**
Azinphos methyl	µg/l	0.02	-	-	**0.02**	**0.02**	**0.02**	0.04	**0.02**	**0.02**
Azinphos ethyl	µg/l	0.02	-	-	**0.02**	**0.02**	**0.02**	0.04	**0.02**	**0.02**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC						
Dinitro-o-cresol	µg/l	0.1	-	-		1.13		**0.1**		
Clopyralid	µg/l	0.04	-	-	0.09	**0.04**	0.3	**0.04**	0.3	0.15
MCPA	µg/l	0.05	-	-	**0.01**	0.0565	0.1	**0.05**	0.1	0.075
Mecoprop	µg/l	0.04	-	-		**0.04**		**0.04**		
Dicamba	µg/l	0.04	-	-	**0.03**	**0.04**	0.3	**0.04**	0.3	**0.03**
MCPB	µg/l	0.05	-	-	**0.02**	**0.05**	0.2	**0.05**	0.2	**0.02**
2,4-DB	µg/l	0.1	-	-	**0.02**	**0.1**	0.2	**0.1**	0.2	**0.02**
2,3,6-Trichlorobenzoic acid	µg/l	0.05	-	-	0.1	**0.05**	1	**0.05**	1	0.1
Dichlorprop	µg/l	0.1	-	-		**0.1**		**0.1**		
Triclopyr	µg/l	0.05	-	-	**0.03**	0.0767	0.3	**0.05**	0.3	0.3
Fenoprop (Silvex)	µg/l	0.1	-	-	**0.01**	**0.1**	**0.1**	**0.1**	**0.1**	**0.01**
2,4-Dichlorophenoxyacetic acid	µg/l	0.05	-	-	**0.01**	**0.05**	0.1	**0.05**	0.1	0.056
2,4,5-Trichlorophenoxyacetic	µg/l	0.05	-	-	**0.01**	**0.05**	0.1	**0.05**	0.1	**0.01**

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS						
				MAC						
Bromoxynil	µg/l	0.04	-	-	**0.01**	**0.04**	0.1	**0.04**	0.1	**0.01**
Benazolin	µg/l	0.04	-	-	0.05	**0.04**	0.5	**0.04**	0.5	0.05
Ioxynil	µg/l	0.05	-	-	**0.01**	**0.05**	0.1	**0.05**	0.1	**0.01**
Pentachlorophenol	µg/l	0.04	-	-		**0.04**		**0.04**		
Fluoroxypyr	µg/l	0.1	-	-	**0.02**	**0.1**	0.2	**0.1**	0.2	**0.1**
Naphthalene (aq)	µg/l	0.01	**6**	**130**	0.0727	**0.01**	**0.01**	**0.01**	**0.01**	0.71
Acenaphthene (aq)	µg/l	0.005	**18**	-	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	0.0202
Acenaphthylene (aq)	µg/l	0.005	**18**	-	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
Fluoranthene (aq)	µg/l	0.005	**4**	**0.12**	<u>0.255</u>	**0.005**	**0.005**	**0.005**	**0.005**	0.0165
Anthracene (aq)	µg/l	0.005	**90**	**0.1**	0.0422	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
Phenanthrene (aq)	µg/l	0.005	**4**	-	0.181	**0.005**	**0.005**	**0.005**	**0.005**	0.0858
Fluorene (aq)	µg/l	0.005	**12**	-	0.0295	**0.005**	**0.005**	**0.005**	**0.005**	0.0455
Chrysene (aq)	µg/l	0.005	**7**	-	0.176	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
Pyrene (aq)	µg/l	0.005	**9**	-	0.27	0.0076	**0.005**	0.00643	0.0151	0.0364

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS						
				MAC						
Benzo(a)anthracene (aq)	µg/l	0.005	3.5	-	0.136	0.005	0.005	0.005	0.005	0.005
Benzo(b)fluoranthene (aq)	µg/l	0.005	0.1	0.02	0.442	0.005	0.005	0.005	0.005	0.005
Benzo(k)fluoranthene (aq)	µg/l	0.005	0.1	0.017	0.185	0.005	0.005	0.005	0.005	0.005
Benzo(a)pyrene (aq)	µg/l	0.002	0.01	0.27	0.299	0.002	0.002	0.002	0.002	0.002
Dibenzo(a,h)anthracene (aq)	µg/l	0.005	0.07	-	0.005	0.005	0.005	0.005	0.005	0.005
Benzo(g,h,i)perylene (aq)	µg/l	0.005	0.1	0.0082	0.259	0.005	0.005	0.005	0.005	0.005
Indeno(1,2,3-cd)pyrene (aq)	µg/l	0.005	0.1	-	0.242	0.005	0.005	0.005	0.005	0.005
PAH, Total Detected USEPA 16	µg/l	0.082	-	-	2.59	0.082	0.082	0.082	0.082	0.915
GRO Surrogate % recovery**	%		-	-	107	106	109	103	107	98
GRO >C5-C12	µg/l	50	-	-	50	50	50	50	50	50
Methyl tertiary butyl ether	µg/l	3	-	-	3	3	3	3	3	3
Benzene**	µg/l	7	1	50	7	7	7	7	7	7
Toluene	µg/l	4	700	-	4	4	4	4	4	4
Ethylbenzene	µg/l	5	300	-	5	5	5	5	5	5

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS						
				MAC						
m,p-Xylene	µg/l	8	190	-	8	8	8	8	8	8
o-Xylene	µg/l	3	190	-	3	3	3	3	3	3
Sum of detected Xylenes	µg/l	11	-	-	11	11	11	11	11	11
Sum of detected BTEX	µg/l	28	-	-	28	28	28	28	28	28
Aliphatics >C5-C6	µg/l	10	15000	-	10	10	10	10	10	10
Aliphatics >C6-C8	µg/l	10	15000	-	10	10	10	10	10	10
Aliphatics >C8-C10	µg/l	10	300	-	10	10	10	10	10	10
Aliphatics >C10-C12	µg/l	10	300	-	10	10	10	10	10	10
Aliphatics >C12-C16 (aq)	µg/l	10	300	-	10	10	10	10	10	10
Aliphatics >C16-C21 (aq)	µg/l	10	300	-	10	10	10	10	10	10
Aliphatics >C21-C35 (aq)	µg/l	10	300	-	10	10	10	10	10	10
Total Aliphatics >C12-C35 (aq)	µg/l	10	-	-	10	10	10	10	10	10
Aromatics >EC5-EC7**	µg/l	10	1	-	10	10	10	10	10	10
Aromatics >EC7-EC8	µg/l	10	700	-	10	10	10	10	10	10

Geology					Kellaways Clay					
Location of Borehole					A	A	A	A	A	A
Borehole name					BH203-D	BH275-D		BH273-D		BH206-D
Year					2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					1.82	0.99	1.62	2.94	3.26	2.97
Analytical Parameter	Units	Limit of detection	DWS	EQS						
				MAC						
Aromatics >EC8-EC10	µg/l	10	**300**	-	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC10-EC12	µg/l	10	**90**	-	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC12-EC16 (aq)	µg/l	10	**90**	-	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC16-EC21 (aq)	µg/l	10	**90**	-	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC21-EC35 (aq)	µg/l	10	**90**	-	**10**	**10**	**10**	**10**	**10**	**10**
Total Aromatics >EC12-EC35	µg/l	10	-	-	**10**	**10**	**10**	**10**	**10**	**10**
Total Aliphatics & Aromatics	µg/l	10	-	-	21	33	**10**	**10**	**10**	13
Aliphatics >C16-C35 Aqueous	µg/l	10	-	-	**10**	**10**	**10**	**10**	**10**	**10**

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Alkalinity, Total as CaCO3	mg/l	2	-	-	2060	300	572	560	455	445	313	318	301	447	373
Bicarbonate Alkalinity as HCO3	mg/l	2	-	-	2510		698		555		382		368		
BOD, unfiltered	mg/l	1	-	-	6.78	**1**	3.04	**1**	**1**	**1**	**1**	3	2	2.4	**1**
Carbon, Organic (diss.filt)	mg/l	3	-	-	8.17	5.54	13.5	13	6.02	6.05	3.85	3.93	5.75	4.8	5.16
Ammoniacal Nitrogen as N (low	mg/l	0.01	**1.5**	-	0.92	0.306	1.44	1.58	1.8	1.51	1.83	1.58	3.07	1.89	0.229
Ammoniacal Nitrogen as NH3	mg/l	0.2	-	-	1.02	0.244	1.91	2.19	1.77	1.87	1.8	1.93	3.31	2.14	**0.2**
Fluoride	mg/l	0.5	**1.5**	**3**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
COD, unfiltered	mg/l	7	-	-	3680	74.9	90.6	38.7	39.5	24.8	**7**	16.1	16.5	30.5	153
Conductivity 20 deg.C	mS/cm	0.02	-	-	2.96	2.87	6.23	6.74	4.23	4.66	2.61	2.78	2.52	4.19	3.51
Dissolved solids, Total (meter)	mg/l	5	-	-	2590	3080	6050	6200	3620	4540	2220	2440	1950	3640	3130
Aluminium (tot.unfilt)	µg/l	10	-	-	81800	3250	12300	604	748	233	412	895	242	107	14900
Chromium, Trivalent (Low)	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**
Arsenic (diss.filt)	µg/l	0.5	**10**	-	0.747	0.544	1.94	2.68	2.54	2.06	1	1.11	0.557	**0.5**	3.33
Arsenic (tot.unfilt)	µg/l	2	-	-	58.9	2.77	14.7	3.63	3.28	2.83	**2**	2.34	**2**	**2**	13.3

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS											
				MAC											
Boron (tot.unfilt)	µg/l	20	-	-	976	692	1320	1440	1630	1900	2110	2120	1340	2390	422
Cadmium (diss.filt)	µg/l	0.08	**5**	**0.45**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
Cadmium (tot.unfilt)	µg/l	0.5	-	-	3.94	**0.5**	0.677	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	0.702
Chromium (tot.unfilt)	µg/l	3	-	-	208	9.63	37.5	**3**	**3**	**3**	**3**	**3**	**3**	**3**	33.9
Chromium (diss.filt)	µg/l	1	-	-	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Copper (tot.unfilt)	µg/l	1	-	-	223	6.15	30.6	1.19	3	1.28	1.77	1.12	1.9	**1**	28.9
Cobalt (diss.filt)	µg/l	0.5	-	-	5.55	3.71	5.02	5.72	6.91	5.76	1.59	2.16	1.21	2.63	7.86
Lead (diss.filt)	µg/l	0.2	**10**	**14**	3.34	**0.2**	0.992	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	0.521	**0.2**	0.346
Nickel (tot.unfilt)	µg/l	1	-	-	458	18.4	42.1	12.9	12.5	9.66	6.25	5.29	9.56	5.09	61.6
Manganese (diss.filt)	µg/l	3	**50**	-	2050		743		422		542		204		
Selenium (tot.unfilt)	µg/l	1	-	-	14.7	**1**	5.12	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Nickel (diss.filt)	µg/l	0.4	**20**	**34**	11.8	9.76	10.1	9.36	9.7	8.67	2.74	2.43	9.03	3.92	22.8
Zinc (tot.unfilt)	µg/l	5	-	-	2130	41.7	276	6.69	15.8	10.7	13.6	15.9	54	11.3	111
Silver (Tot. Unfilt.)	µg/l	1	-	-	6	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Sodium (Dis.Filt)	mg/l	0.076	**200**	-	247	210	823	844	427	470	305	320	381	491	260
Magnesium (Dis.Filt)	mg/l	0.036	-	-	131	115	229	234	239	230	76.7	77.6	68.2	137	125
Potassium (Dis.Filt)	mg/l	0.2	-	-	23.7	24.8	54.7	55.6	29.8	30.3	22.2	22.5	29.1	31.8	4.51
Calcium (Dis.Filt)	mg/l	0.2	-	-	417	434	367	371	412	391	208	186	139	244	473

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS											
				MAC											
Iron (Dis.Filt)	mg/l	0.019	**0.2**	-	0.109	**0.019**	1.11	1.67	3.65	1.83	0.823	0.973	0.331	0.765	2.66
Hardness, Total as CaCO3	mg/l	0.35	-	-	3870	1680	2090	1930	2130	2060	870	839	733	1250	2300
Mercury (diss.filt)	µg/l	0.01	**1**	**0.07**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.0291
Mercury (tot.unfilt)	µg/l	0.02	-	-	**0.02**	**0.02**	0.0646	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	0.061
Nitrite as NO2	mg/l	0.05	-	-	0.554	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	0.776	**0.05**	**0.05**
Sulphate	mg/l	2	**250**	-	1670	1510	2690	2720	2090	1980	1120	1140	831	1500	1330
Chloride	mg/l	2	**250**	-	193	174	832	828	434	473	158	161	256	447	518
Nitrate as NO3	mg/l	0.3	**50**	-	7.3	3.3	**0.3**	**0.3**	**0.3**	**0.3**	0.33	**0.3**	8.4	**0.3**	**0.3**
Turbidity	ntu	0.1	-	-	18300	335	755	21.7	77.6	19.3	19.1	24.3	10.6	9.17	2290
Phenol (low level)	µg/l	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**	1.05	**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**	1.12	**0.5**	1.53	**0.5**	1.39	**0.5**	1.4	**0.5**	**0.5**
Sum of Detected Monohydric	µg/l	0.5	-	-	**0.5**	**0.5**	2.17	**0.5**	1.53	**0.5**	1.39	**0.5**	1.4	**0.5**	**0.5**
pH	pH Units	1	**6.5-9.5**	**6-9**	7.22	7.32	7.28	7.12	7.11	7.19	7.84	7.52	7.59	7.37	7.15
Cyanide, Total (low level)	µg/l	5	**50**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Cyanide, Free (low level)	µg/l	2.5	**50**	**5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS											
				MAC											
Cyanide, Complex (low level)*	µg/l	5	-	-	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Low Level Hexavalent	mg/l	0.003	-	-	**0.003**	**0.003**	**0.003**	0.004	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**
Trifluralin	µg/l	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**	**0.01**	**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**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Heptachlor	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.02	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Aldrin	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	**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**	**0.01**	**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**	**0.01**	**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**	**0.01**	**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**	**0.01**	**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**	**0.01**	**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**	**0.01**	**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**	**0.01**	**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**	**0.01**	**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**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS											
				MAC											
Dieldrin	µg/l	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**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Endrin	µg/l	0.01	-	-	**0.01**	**0.01**	**0.01**	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
o,p'-DDT	µg/l	0.01	-	-	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02
p,p'-DDD (TDE)	µg/l	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**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
p,p'-DDT	µg/l	0.01	-	-	**0.01**	0.03	**0.01**	0.03	**0.01**	0.06	**0.01**	0.02	**0.01**	0.02	0.03
o,p'-Methoxychlor	µg/l	0.01	-	-	**0.01**	0.02	**0.01**	0.03	**0.01**	0.04	**0.01**	0.02	**0.01**	0.02	0.03
p,p'-Methoxychlor	µg/l	0.01	-	-	0.05	0.03	0.05	0.03	0.02	0.06	0.02	0.02	0.02	0.02	0.03
Endosulphan Sulphate	µg/l	0.02	-	-	0.1	**0.02**	0.1	0.04	0.04	0.04	0.04	**0.02**	0.04	**0.02**	**0.02**
Permethrin I	µg/l	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**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
1,3,5-Trichlorobenzene	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Hexachlorobutadiene	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
1,2,4-Trichlorobenzene	µg/l	0.01	**0.1**	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
1,2,3-Trichlorobenzene	µg/l	0.01	**0.1**	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Dichlorvos	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Dichlobenil	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Mevinphos	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Tecnazene	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Hexachlorobenzene	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Demeton-S-methyl	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Phorate	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Diazinon	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Triallate	µg/l	0.01	-	-	0.291	0.02	0.1	0.04	0.0162	0.0172	0.0153	0.0116	0.0162	0.01	0.1
Atrazine	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Simazine	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Disulfoton	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Propetamphos	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Chlorpyriphos-methyl	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Dimethoate	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Pirimiphos-methyl	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Chlorpyriphos	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Methyl Parathion	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Malathion	µg/l	0.01	-	-	0.1	0.02	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Fenthion	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Fenitrothion	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Triadimefon	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Pendimethalin	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Parathion	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Chlorfenvinphos	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
trans-Chlordane	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
cis-Chlordane	µg/l	0.01	-	-	0.1	**0.01**	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Ethion	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Carbophenothion	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Triazophos	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Phosalone	µg/l	0.01	-	-	0.1	0.02	0.1	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	0.1
Azinphos methyl	µg/l	0.02	-	-	0.2	0.04	0.2	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	0.2
Azinphos ethyl	µg/l	0.02	-	-	0.2	0.04	0.2	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	0.2

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	**Units**	**Limit of detection**	**DWS**	**EQS**											
				MAC											
Dinitro-o-cresol	µg/l	0.1	-	-	10		3.44		**0.1**		**0.1**		**0.1**		
Clopyralid	µg/l	0.04	-	-	4	0.3	0.2	**0.003**	**0.04**	0.3	**0.04**	**0.03**	**0.04**	**0.03**	0.3
MCPA	µg/l	0.05	-	-	5	0.1	0.25	0.1	**0.05**	0.1	**0.05**	**0.01**	**0.05**	**0.01**	0.1
Mecoprop	µg/l	0.04	-	-	4		0.2		**0.04**		**0.04**		**0.04**		
Dicamba	µg/l	0.04	-	-	4	0.3	0.2	0.3	**0.04**	0.3	**0.04**	**0.03**	**0.04**	**0.03**	0.3
MCPB	µg/l	0.05	-	-	5	0.2	0.25	0.2	**0.05**	0.2	**0.05**	**0.02**	**0.05**	**0.02**	0.2
2,4-DB	µg/l	0.1	-	-	10	0.2	0.5	0.2	**0.1**	0.2	**0.1**	**0.02**	**0.1**	**0.02**	0.2
2,3,6-Trichlorobenzoic acid	µg/l	0.05	-	-	5	1	0.25	1	**0.05**	1	**0.05**	0.1	**0.05**	0.1	1
Dichlorprop	µg/l	0.1	-	-	10		0.5		**0.1**		**0.1**		**0.1**		
Triclopyr	µg/l	0.05	-	-	5	0.3	0.25	0.3	**0.05**	0.3	**0.05**	**0.03**	**0.05**	**0.03**	0.3
Fenoprop (Silvex)	µg/l	0.1	-	-	10	**0.1**	0.5	**0.1**	**0.1**	**0.1**	**0.1**	**0.01**	**0.1**	**0.01**	**0.1**
2,4-Dichlorophenoxyacetic acid	µg/l	0.05	-	-	5	0.1	0.25	0.1	**0.05**	0.1	**0.05**	**0.01**	**0.05**	**0.01**	0.1
2,4,5-Trichlorophenoxyacetic	µg/l	0.05	-	-	5	0.1	0.25	0.1	**0.05**	0.1	**0.05**	**0.01**	**0.05**	**0.01**	0.1

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
Bromoxynil	µg/l	0.04	-	-	4	0.1	0.2	0.1	0.04	0.1	0.04	0.01	0.04	0.01	0.1
Benazolin	µg/l	0.04	-	-	4	0.5	0.2	0.5	0.04	0.5	0.04	0.05	0.08	0.05	0.5
Ioxynil	µg/l	0.05	-	-	5	0.1	0.25	0.1	0.05	0.1	0.05	0.01	0.05	0.01	0.1
Pentachlorophenol	µg/l	0.04	-	-	4		0.2		0.04		0.04		0.08		
Fluoroxypyr	µg/l	0.1	-	-	10	0.2	0.5		0.1	0.2	0.1	0.02	0.2	0.02	0.2
Naphthalene (aq)	µg/l	0.01	6	130	0.0233	0.0261	0.114	0.292	0.0625	0.0265	0.0125	0.0336	0.01	0.01	0.01
Acenaphthene (aq)	µg/l	0.005	18	-	0.0168	0.005	0.00863	0.0201	0.0149	0.005	0.005	0.005	0.005	0.005	0.005
Acenaphthylene (aq)	µg/l	0.005	18	-	0.0168	0.005	0.00843	0.00801	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Fluoranthene (aq)	µg/l	0.005	4	0.12	0.145	0.00997	0.0833	0.0208	0.005	0.005	0.005	0.005	0.005	0.005	0.1
Anthracene (aq)	µg/l	0.005	90	0.1	0.015	0.005	0.00644	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.00753
Phenanthrene (aq)	µg/l	0.005	4	-	0.172	0.005	0.0339	0.0519	0.005	0.005	0.005	0.005	0.005	0.005	0.0324
Fluorene (aq)	µg/l	0.005	12	-	0.0323	0.005	0.00688	0.0381	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Chrysene (aq)	µg/l	0.005	7	-	0.0896	0.005	0.0553	0.0122	0.005	0.005	0.005	0.005	0.005	0.005	0.062
Pyrene (aq)	µg/l	0.005	9	-	0.141	0.00888	0.107	0.0276	0.005	0.005	0.005	0.005	0.005	0.005	0.102

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS											
				MAC											
Benzo(a)anthracene (aq)	µg/l	0.005	**3.5**	-	0.0537	**0.005**	0.0404	0.0123	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	0.055
Benzo(b)fluoranthene (aq)	µg/l	0.005	**0.1**	**0.02**	0.125	**0.005**	0.112	0.0205	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	0.141
Benzo(k)fluoranthene (aq)	µg/l	0.005	**0.1**	**0.017**	0.047	**0.005**	0.0495	0.00871	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	0.055
Benzo(a)pyrene (aq)	µg/l	0.002	**0.01**	**0.27**	0.0616	**0.002**	0.0616	0.0135	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	0.0944
Dibenzo(a,h)anthracene (aq)	µg/l	0.005	**0.07**	-	0.01	**0.005**	0.00554	0.00658	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	0.0152
Benzo(g,h,i)perylene (aq)	µg/l	0.005	**0.1**	**0.0082**	0.0391	**0.005**	0.0409	0.0165	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	0.0807
Indeno(1,2,3-cd)pyrene (aq)	µg/l	0.005	**0.1**	-	0.0584	**0.005**	0.0407	0.0116	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	0.0637
PAH, Total Detected USEPA 16	µg/l	0.082	-	-	1.04	**0.082**	0.774	0.56	**0.082**	**0.082**	**0.082**	**0.082**	**0.082**	**0.082**	0.809
GRO Surrogate % recovery**	%		-	-	**102**	**107**	**105**	**103**	**109**	**92**	**116**	**99**	**94**	**105**	**99**
GRO >C5-C12	µg/l	50	-	-	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Methyl tertiary butyl ether	µg/l	3	-	-	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Benzene**	µg/l	7	**1**	**50**	**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**
Ethylbenzene	µg/l	5	**300**	-	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**

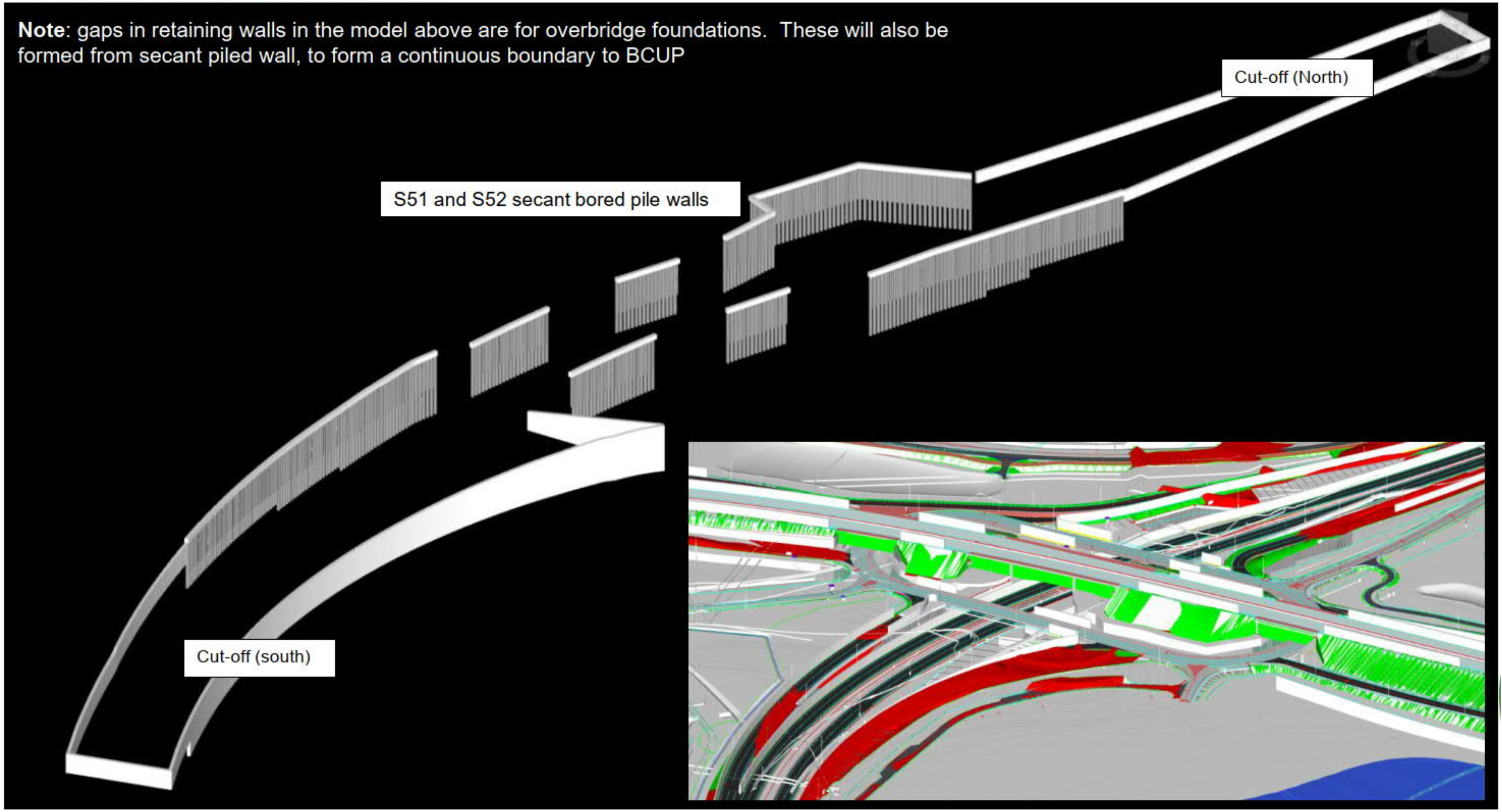
Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS MAC											
m,p-Xylene	µg/l	8	**190**	-	**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**
Sum of detected Xylenes	µg/l	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**
Aliphatics >C5-C6	µg/l	10	**15000**	-	**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**
Aliphatics >C8-C10	µg/l	10	**300**	-	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C10-C12	µg/l	10	**300**	-	**10**	**10**	11	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aliphatics >C12-C16 (aq)	µg/l	10	**300**	-	56	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	17
Aliphatics >C16-C21 (aq)	µg/l	10	**300**	-	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	64
Aliphatics >C21-C35 (aq)	µg/l	10	**300**	-	128	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	205
Total Aliphatics >C12-C35 (aq)	µg/l	10	-	-	184	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	286
Aromatics >EC5-EC7**	µg/l	10	**1**	-	**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**

Geology					Oxford Clay										-
Location of Borehole					A	A	B	B	B	B	B	B	B	B	D
Borehole name					BH224		BH230		BH237-D		BH240		BH239		WS257
Year					2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2021
Groundwater Depth bgl (m)					4.06	5.40	1.01	0.86	2.33	2.61	1.18	1.56	2.23	2.30	2.00
Analytical Parameter	Units	Limit of detection	DWS	EQS											
				MAC											
Aromatics >EC8-EC10	µg/l	10	**300**	**-**	**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**
Aromatics >EC12-EC16 (aq)	µg/l	10	**90**	**-**	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC16-EC21 (aq)	µg/l	10	**90**	**-**	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Aromatics >EC21-EC35 (aq)	µg/l	10	**90**	**-**	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Total Aromatics >EC12-EC35	µg/l	10	**-**	**-**	20	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Total Aliphatics & Aromatics	µg/l	10	**-**	**-**	189	**10**	31	**10**	**10**	**10**	**10**	**10**	**10**	**10**	286
Aliphatics >C16-C35 Aqueous	µg/l	10	**-**	**-**	128	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	269
Bold = Less than laboratory detection limit															
Exceeds Screening Standards															
** Below minimum level of detection															
Exceeds EQS standards															

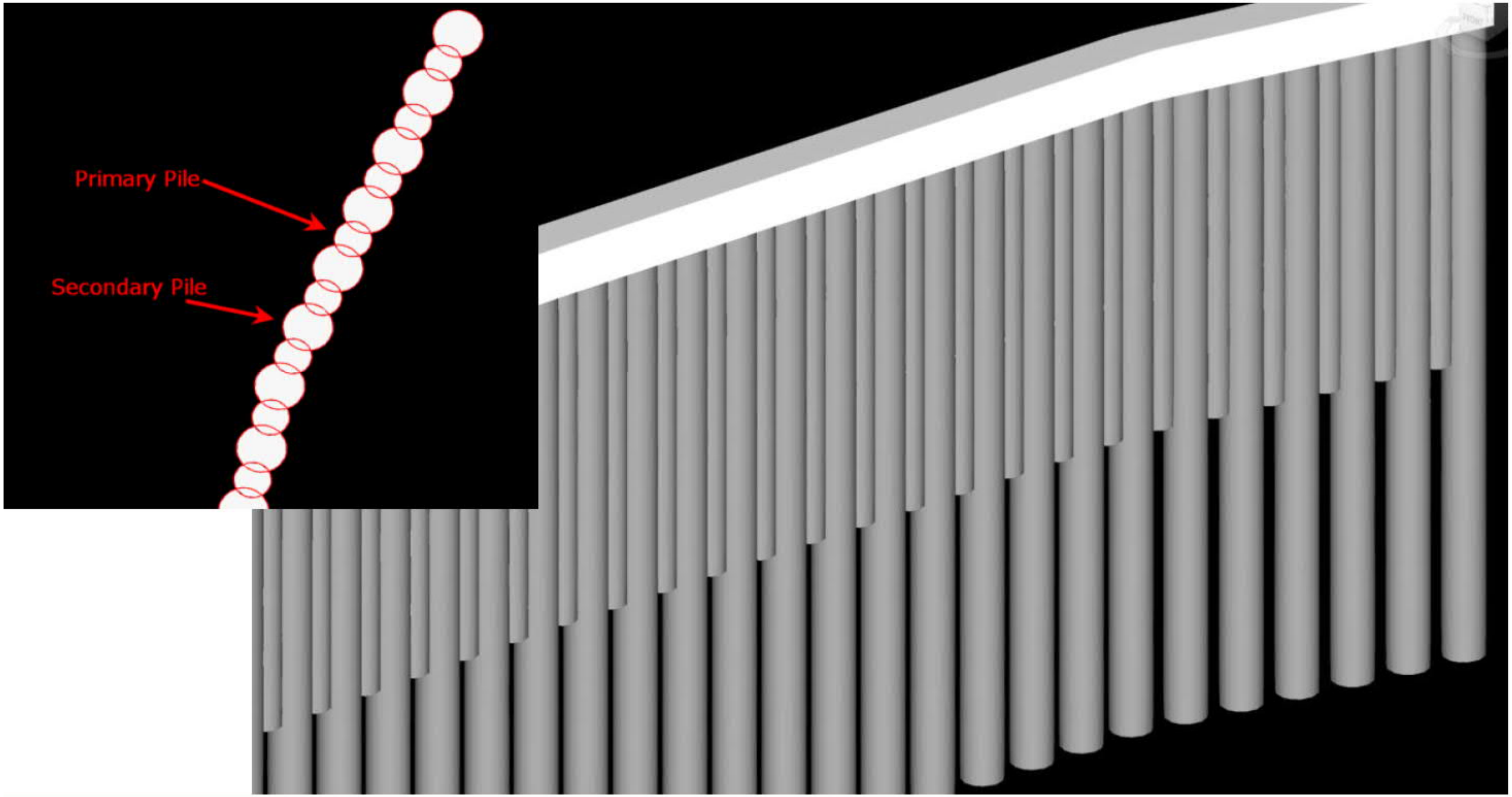
Appendix C

A1 Black Cat Underpass preliminary detailed design

Secant Piled Wall Details:



Secant Piled Wall Details:



Appendix D

MODFLOW simulation of A1 Black Cat Underpass

1 Introduction

1.1.1 A simple steady state USGS Modflow has been prepared to investigate how the River Terrace Deposits (RTD) aquifer system may respond to the construction of an underpass incorporating cut-off walls and other structures that penetrate the superficial aquifer in the valley of the River Great Ouse.

2 Model set-up

2.1 Conceptual Model

2.1.1 The conceptual model of the aquifer system of interest in the vicinity of the Black Cat Underpass simplifies the geology into a single groundwater unit, the River Terrace Deposits (RTD), unconfined to the surface with the base being defined by the geometry of the glacial till and Oxford Clay bedrock. Recharge to the aquifer occurs by infiltration through the soil zone into the sand and gravel layers in the RTD. The groundwater flows towards local water courses and the River Great Ouse where it emerges as baseflow. The geometry of the base of the aquifer was defined by site investigation boreholes mainly located between the proposed underpass and the River Great Ouse. These indicate that the base of the groundwater unit is deepest near the river and at a higher elevation away from the alignment of the river.

2.1.2 The construction of an underpass structure at Black Cat incorporates sections of secant piles and cement-bentonite cut-off walls which fully penetrate the aquifer and are toed into the underlying argillaceous strata. This forms a complete blockage of the aquifer system. Where the underpass is excavated the aquifer is removed. When the structure is in place recharge will continue to feed the groundwater in the RTD west of Black Cat, but the flow that was formerly through the location of the underpass will be impounded by the piles. The groundwater level will rise, and then groundwater will flow parallel to the underpass either in a northerly or southerly direction. Whereas on the down gradient side of the underpass the groundwater will no longer flow into the area and consequently groundwater levels will decline.

2.2 Numerical Model

2.2.1 A single layer model has been used to represent the RTD aquifer unit of interest at Black Cat. The underlying Oxford Clay and till is considered to be an aquiclude and forms the base of the model.

2.2.2 The modal domain extends sufficiently east from Black Cat to include the whole of the surface outcrop of the RTD aquifer as shown on the BGS 1:50k mapping. The eastern extent of the aquifer lies to the east of the River Ouse, it is not incorporated into the model, rather the model is truncated to the east of the River Great Ouse. All groundwater flow converges on this river or its tributaries and hence it forms a groundwater divide. The northern and southern extent of the model is sufficient to include the whole of the area drained between South Brook and Rockham Ditch. The northern boundary was extended to incorporate the whole of the surface water catchment of South Brook. The southern model boundary lies within the possible surface and groundwater catchment of Rockham Ditch. Therefore, the model should only be used to assess the groundwater conditions within the section of the aquifer that lies between the River Great Ouse to the east, South Brook to the north and Rockham Ditch to the south. Moreover, the total baseflow to the River Great Ouse and Rockham Ditch is not assessed and will be underestimated in absolute terms, but relative changes due to the construction are not altered by the selected model domain.

2.2.3 The River Great Ouse is represented as a fixed head at 14mOD in the south to 12mOD in the north in the cells that are along the alignment of the watercourse. These cells are the lowest head in the model and permit baseflow to leave the model from the RTD. Since there are no abstraction cells in the groundwater model there can be no condition in which the fixed heads could become a source of water into the model.

2.2.4 The cells along the alignment of the easterly flowing minor watercourses (South Brook, Rockham Ditch etc) are represented as drain cells with an elevation obtained from the local topography. This permits groundwater to leave the model as baseflow to these cells.

2.2.5 The surface elevation has been taken from a LIDAR dataset. Anomalous areas of high elevation in the dataset have been removed so that the elevation in the model represents ground level not the height of buildings or trees.

2.2.6 The base of the hydrogeological unit is determined by the function within GWVistas using the base of the RTD / top of the till or Oxford Clay as the elevation.

2.2.7 Model grid uses 20m cells over the domain which are refined to a 5m grid in the vicinity of the Black Cat underpass. There being a total of 181 rows, 151 columns and 1 layer.

2.2.8 The origin of the Model is at 514600, 254800 (TL146548) using the British National Grid Coordinate system.

2.2.9 The cells with no superficial aquifer are designated as no flow cells.

2.2.10 The model was constructed using GWVistas and run using the USGS MODFLOW 2000 code and the GMG solver.

2.2.11 The model uses uniform hydraulic properties over the whole model domain. Since the model is one layer and solved in steady state conditions only, this can be represented as a single value of hydraulic conductivity/permeability.

2.2.12 Similarly, the same rate of recharge is applied over the whole of the model domain.

2.2.13 In the existing condition the aquifer is represented across the area of the Black Cat underpass. Whereas in the post construction condition the aquifer is impounded by the structure. To represent this condition the cells in the model in the underpass are changed from active cells to no-flow or in-active cells.

3 Model Calibration

3.1.1 The model was calibrated based on the water levels measured for the RTD in the ground investigation observation locations in the vicinity of the Black Cat site. The hydraulic conductivity was set to a single value that is consistent with that determined from field testing. The different values used as the hydraulic conductivity for the model are the basis of the different scenarios investigated to provide a sensitivity analysis.

3.1.2 For a given hydraulic conductivity the recharge value was adjusted to achieve the observed head distribution in the Black Cat project area.

3.1.3 **Figure 3-1** shows the comparison of the modelled groundwater levels against the actual recorded groundwater levels for the RTD in m AOD. This is based on a hydraulic conductivity of 33m/day (3.82 x 10^{-4}m/sec), the average hydraulic conductivity value.

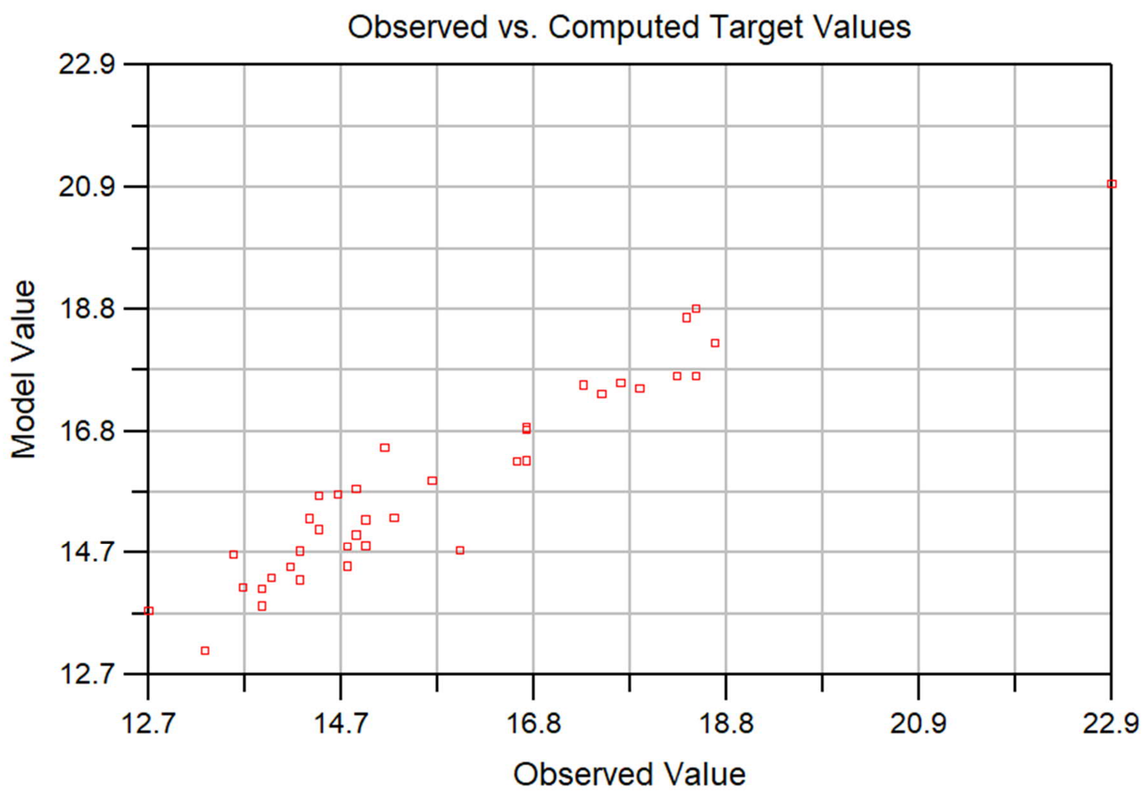


Figure 3-1 Comparison of observed and modelled groundwater levels in the RTD

4 Model Scenarios

Table 4-1 Modelled Hydraulic Conductivity Scenarios

	Hydraulic Conductivity		Recharge	
Scenario	**(m/s)**	**(m/d)**	**(m/d)**	**(mm/a)**
1. Average k (original)	4.89 x 10-5	4.22	2x10-4	73
2. Average k (revised)	3.82 x 10-4	33.0	1.5x10-3	547
3. Maximum k (original)	1.90 x 10-4	16.41	7x10-4	256
4. Minimum k	8.96 x 10-6	0.77	3x10-5	11 *
5. Extreme k	2.40 x 10-3	207.4	7x10-3	2555 *

* These scenarios are considered implausible for the uniform RTD scenario. The extreme hydraulic conductivity requires a recharge rate much greater than the regional rainfall (long term average in the range 500 to 700mm) and thus is implausible. The minimum value is also problematic with the groundwater model being unable to achieve a stable solution, moreover this value is much smaller than what is expected.

5 Figures illustrating the groundwater model Set up

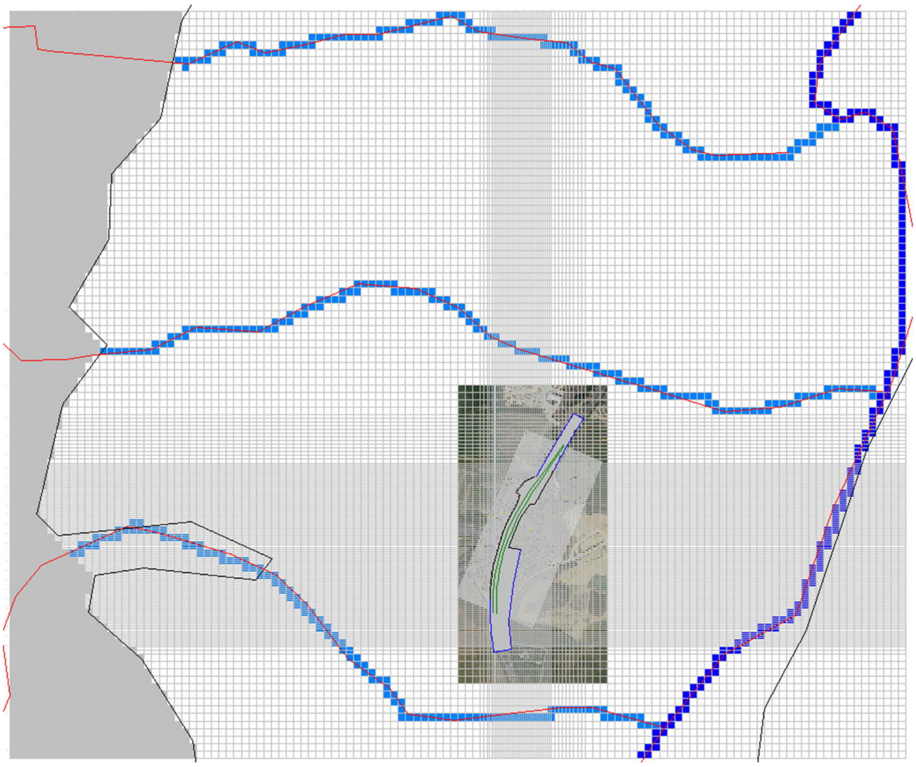


Figure 5-1 Model grid (light blue cells=drain cells, dark blue cells=fixed head cells, grey=no flow cell) The grid refinement occurs in the vicinity of the proposed Black Cat underpass

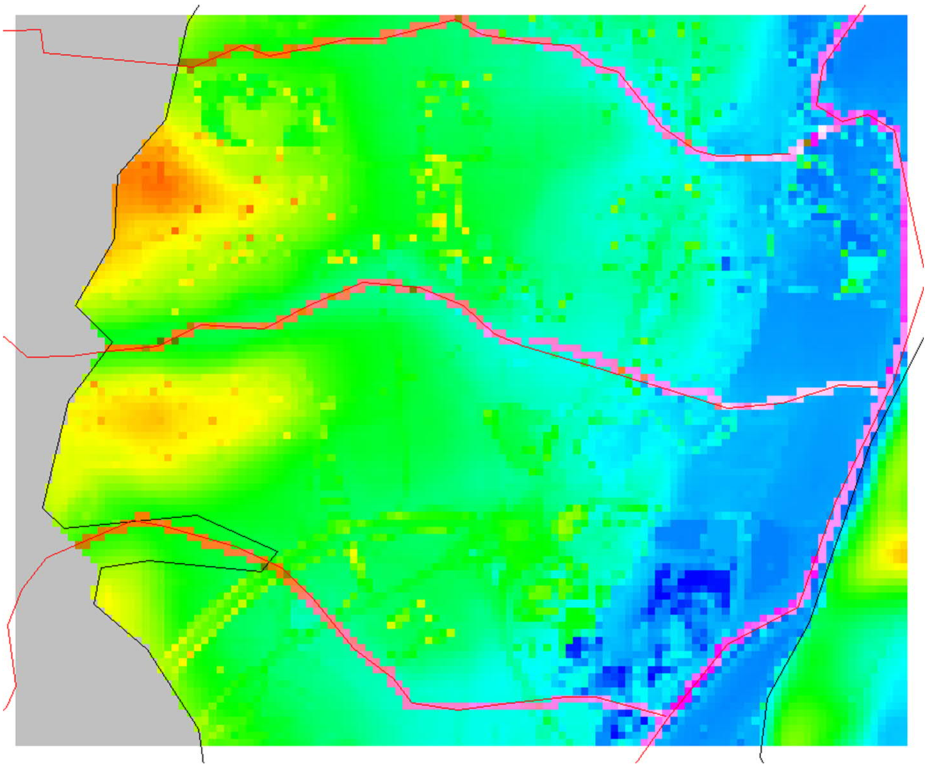


Figure 5-2 Top elevation of cells in the model (reds/browns=highest elevation, blues=lowest elevation

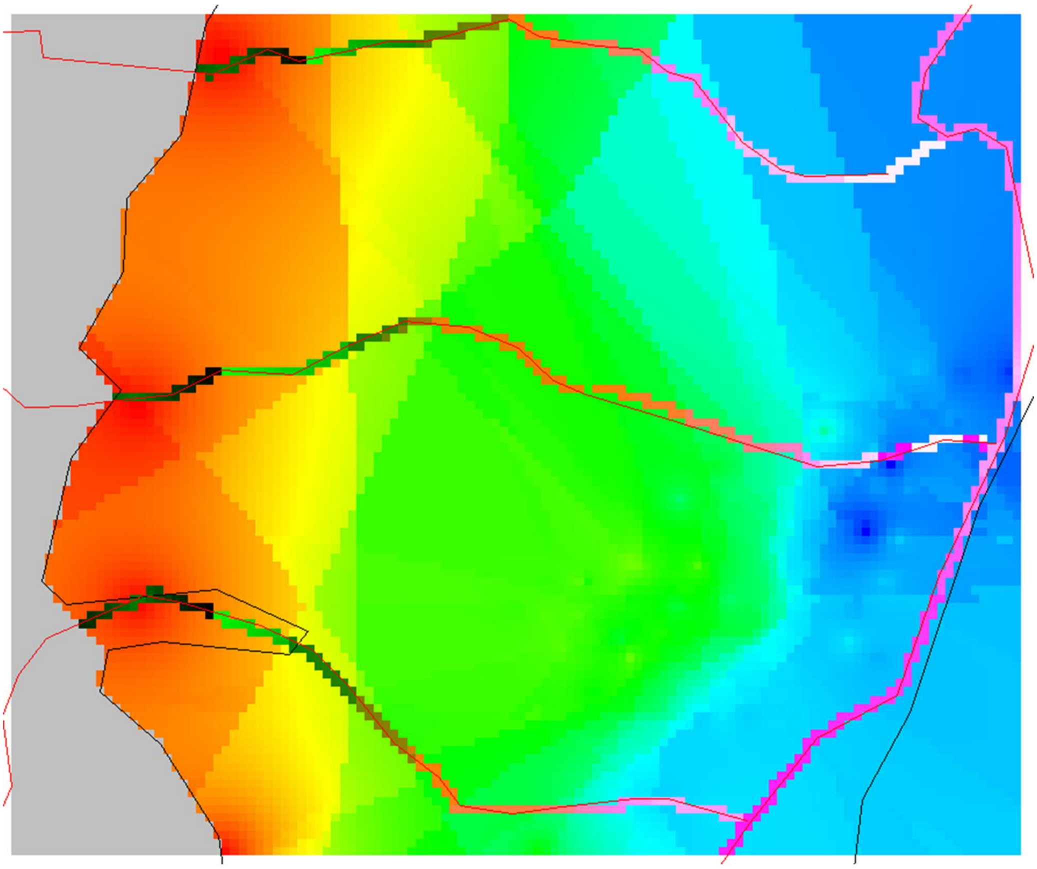


Figure 5-3 Base elevation of cells in the model (reds/browns=highest elevation, blues=lowest elevation

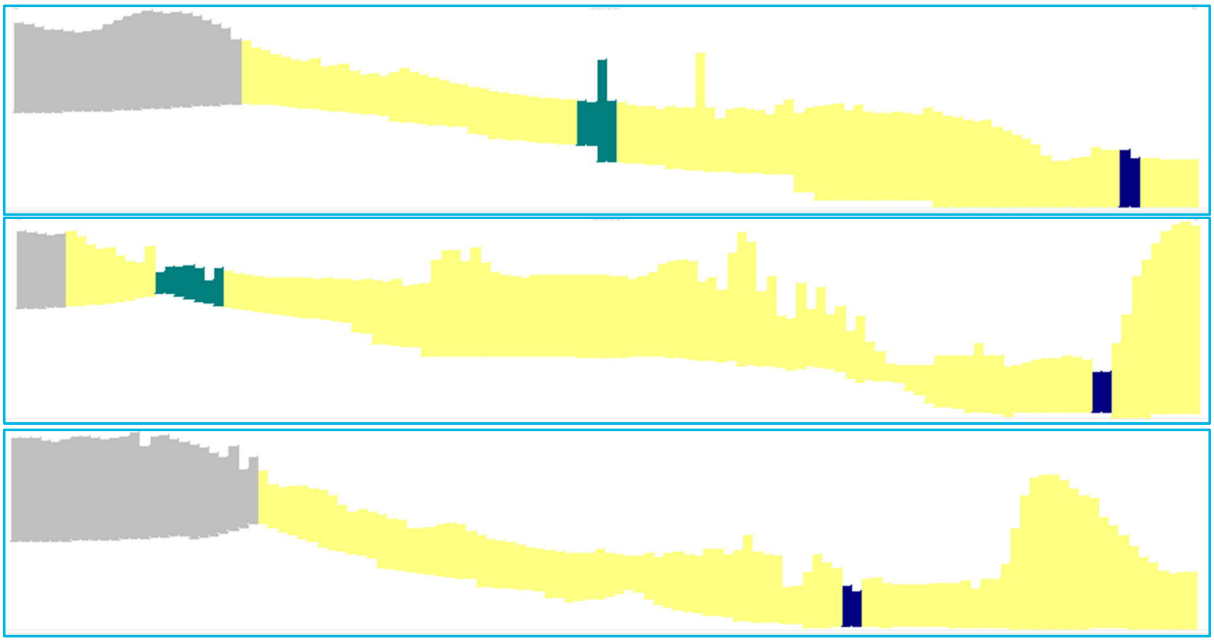


Figure 5-4 West to East sections across the model. Yellow=active flow cells. Grey=no-flow cells. Dark blue=River Great Ouse constant head cells. Teal=drain cells of minor watercourses. Top section along row 1 the northern extent of model. Middle section along row 100 and passes through the centre of the Black Cat junction. Lower section along row 181 the southern extent of the model.

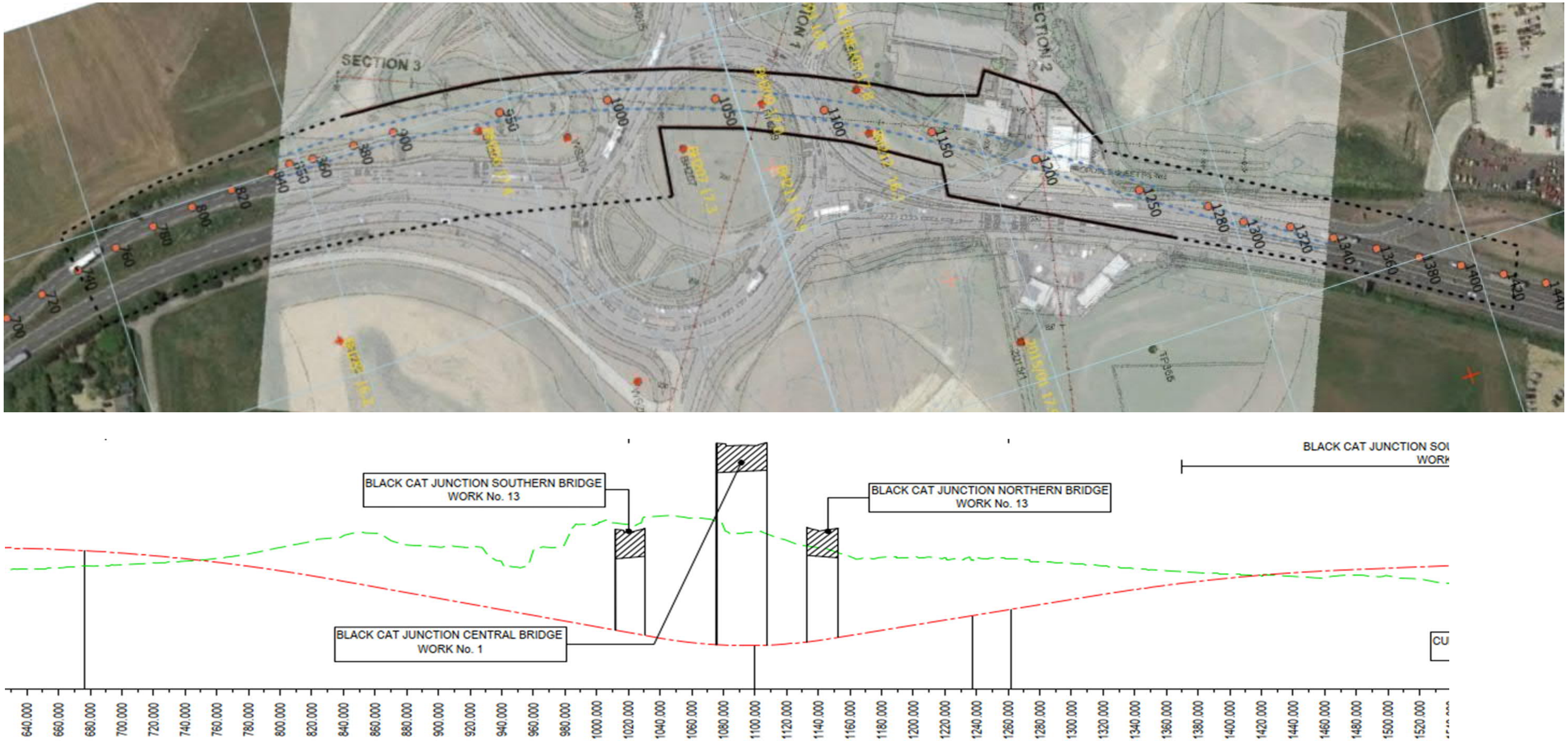


Figure 5-5 Long Section - representation of the Black Cat underpass in the groundwater model. 100m grid is BNG. Chainage as annotated brown circles. Solid black line=secant pile wall. Dashed black line=assumed cut off walls. The enclosed area is designated as no flow cells in the constructed scenarios. Cut off walls extend to 740m in south and 1420m chainage to the north of the underpass.

6 Model Scenario Results

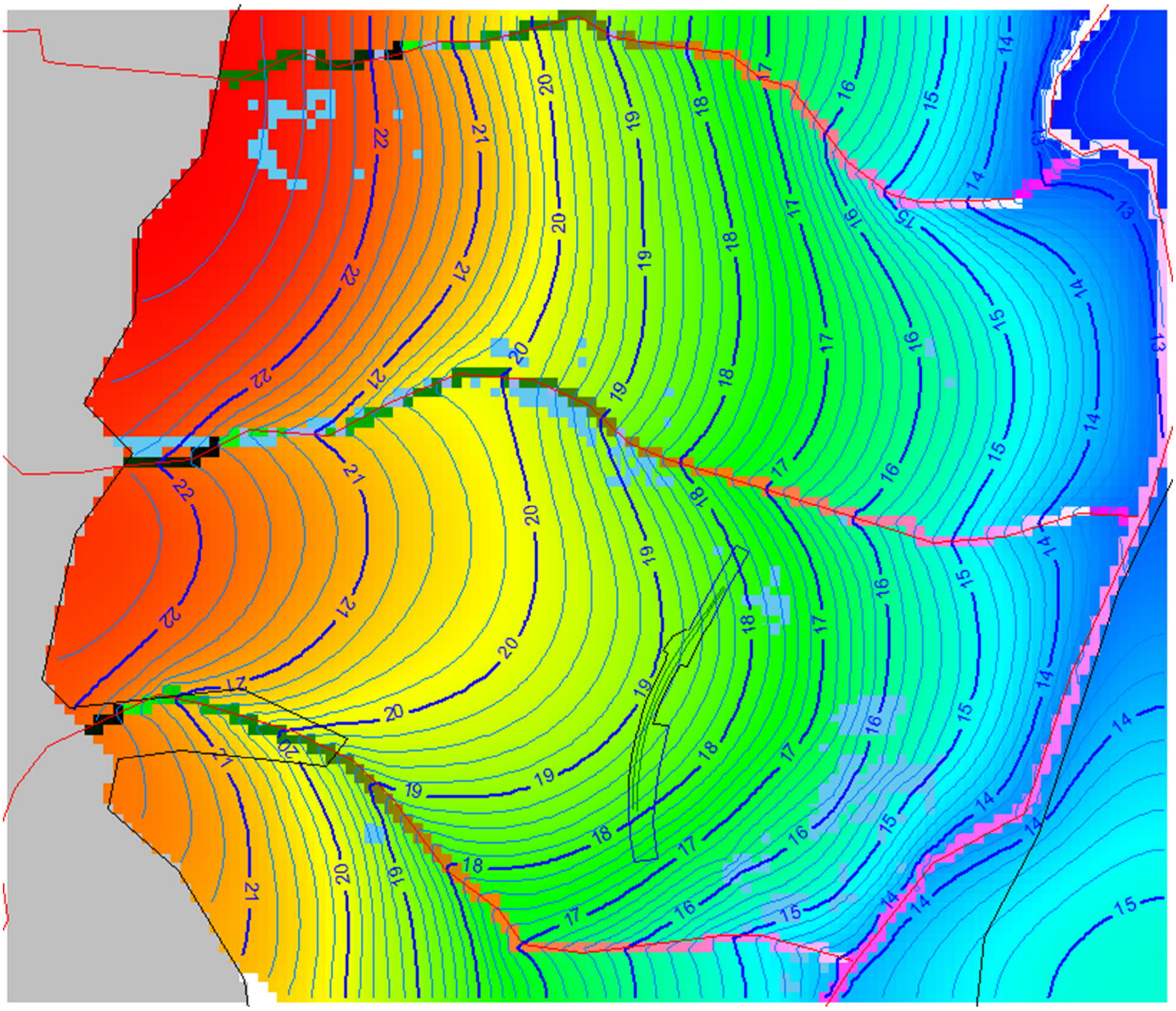


Figure 6-1 Existing Situation. Scenario 1 (average) Groundwater Contours (blue cells=water level at surface)

a. Position of underpass marked but not implemented in model.

b. Drain cells along the west-east flowing watercourses receive groundwater baseflow as indicated by the Vee of contours.

c. Area of groundwater flooding in the low ground of gravel quarries to the east of underpass.

d. Groundwater flooding apparent along reach of South Brook from 18m to 20mAOD elevation.

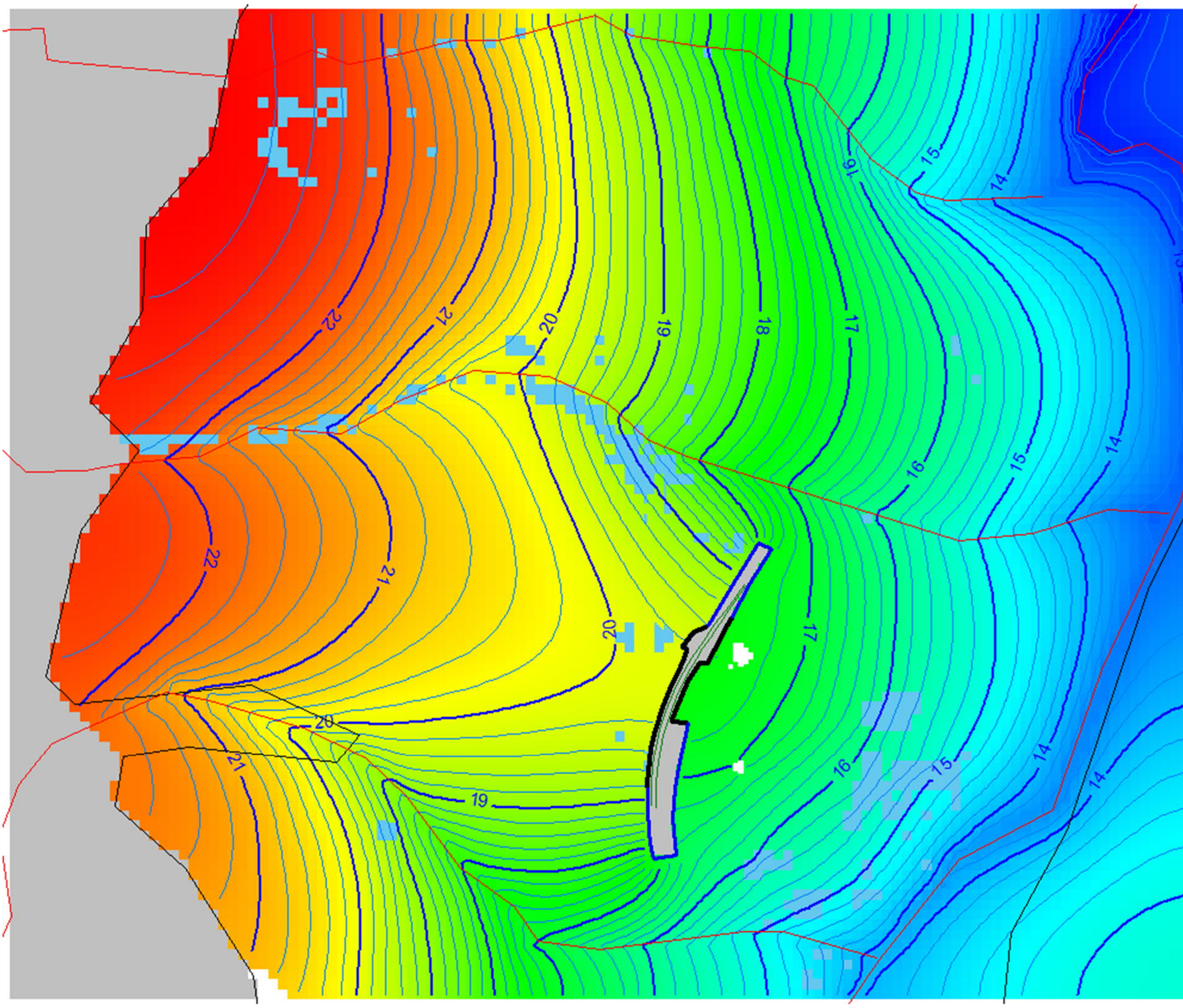


Figure 6-2 Future Groundwater head contours for Scenario 1 (average) conditions with the Black Cat underpass in position.

Colours in active cells represent the head elevation (red=high, blue=low) Grey= no flow cells, note the area of no flow implemented in the location of the underpass and cut off walls. Light blue cells distributed over the model but particularly along the topographic low along South Brook and in patches of open water east of the underpass. The positions are almost identical to the existing conditions scenario. Dry cells are white, two small patches lie to the east of the underpass where the groundwater head is lower than the base of the aquifer

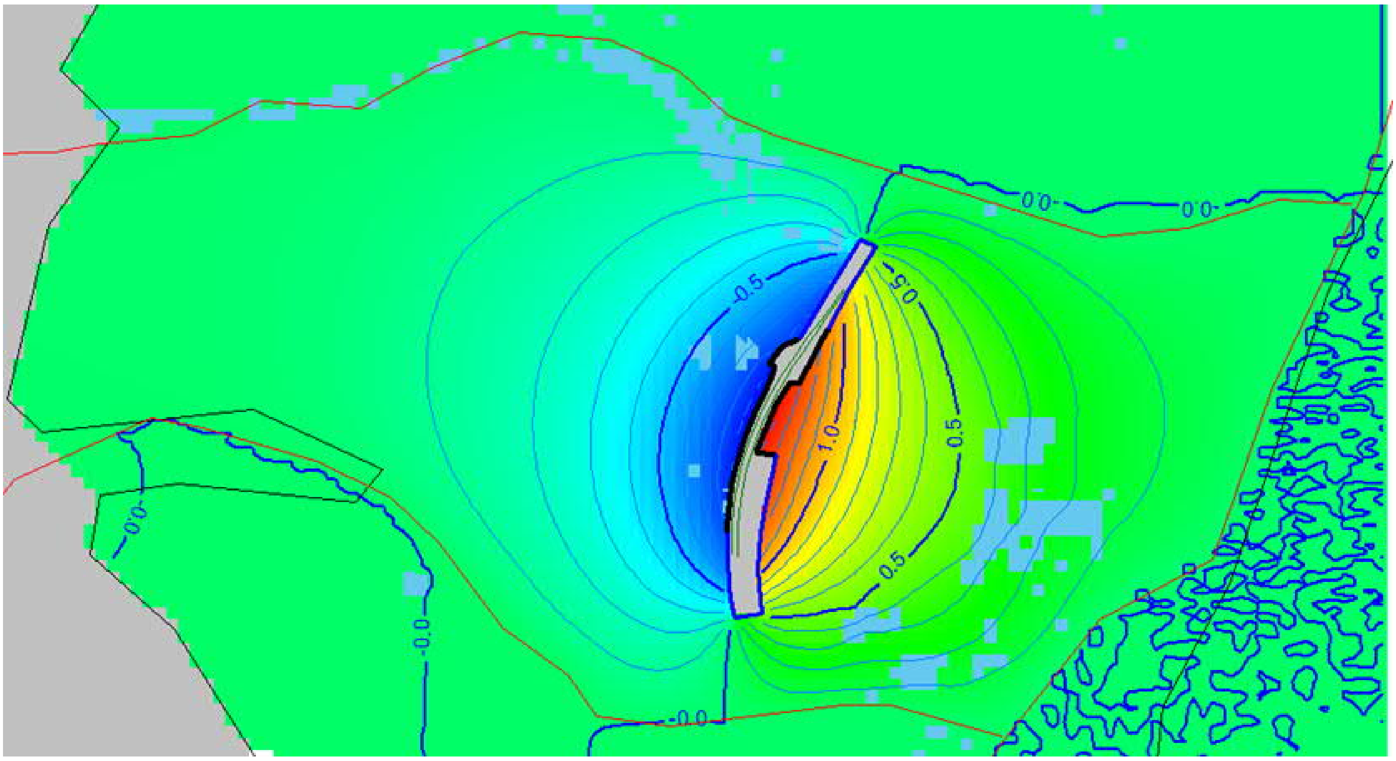


Figure 6-3 Scenario 1, average conditions. Difference in steady state head between existing and constructed conditions.

Notes:

- Grey cells are no-flow
- Flooded cells are blue
- Changes near zero cause strange patterns of no consequence
- Rise in level is blue and negative
- Fall in level is red/orange and positive (drawdown)

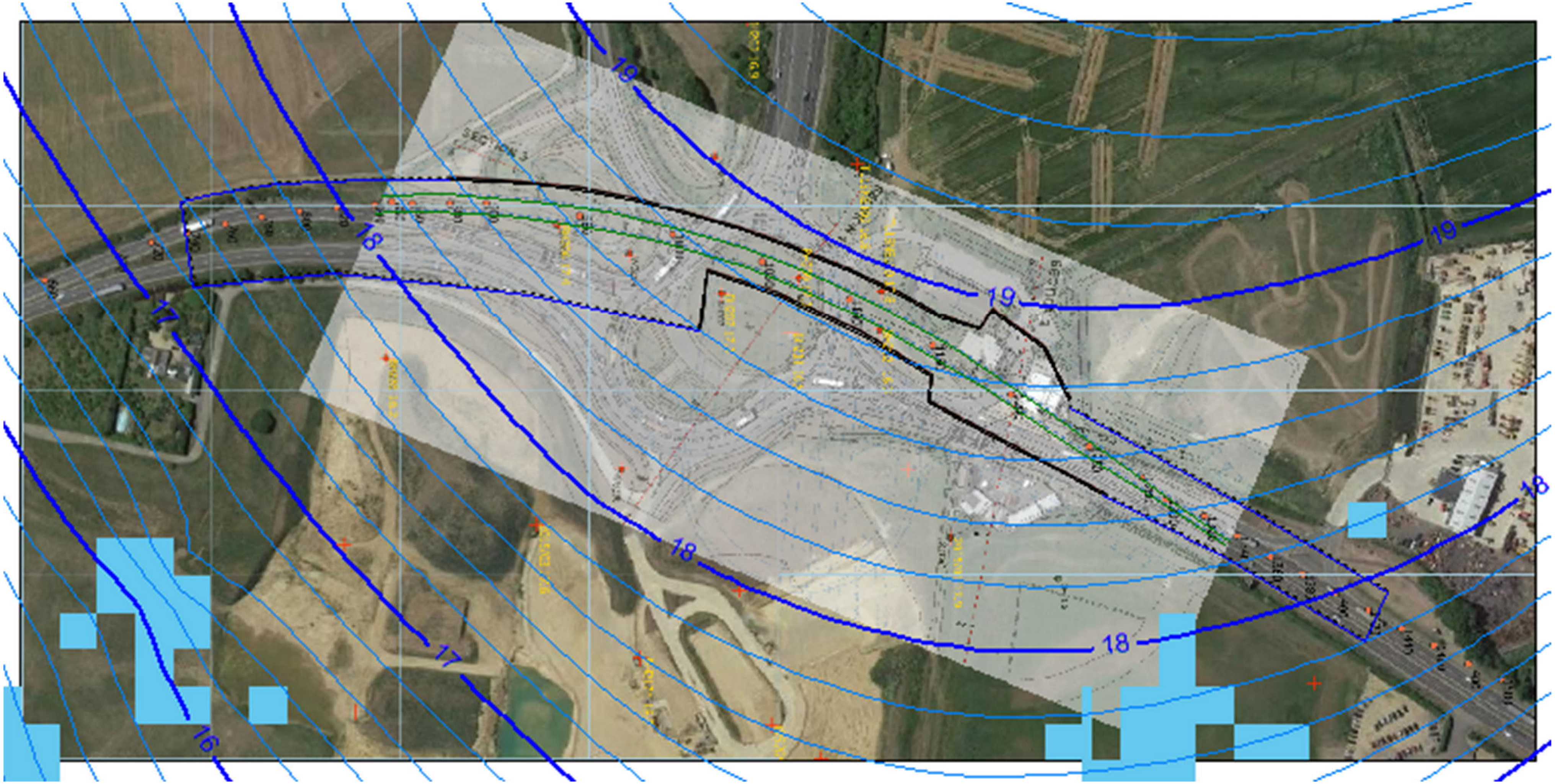


Figure 6-4 Scenario 1. Average hydraulic conductivity for the existing condition in the vicinity of the proposed underpass, existing conditions

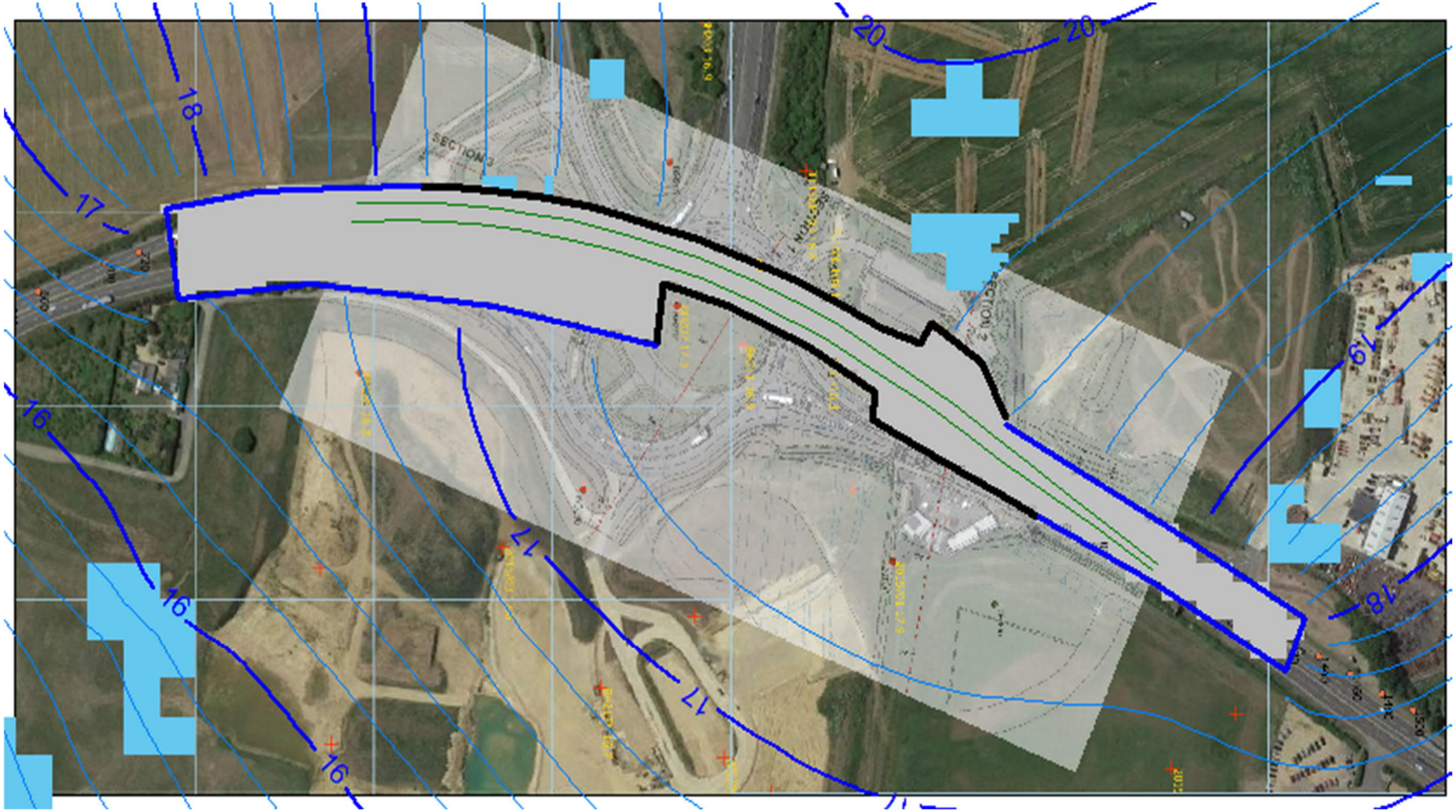


Figure 6-5 Scenario 1. Average hydraulic conductivity for the future post-construction condition in the vicinity of the proposed underpass

7 Groundwater Flux

7.1.1 The groundwater flux is determined in three reaches:

a. South Brook to Cut off wall (northern)

b. Underpass (central)

c. Stream to Cut off wall (southern)

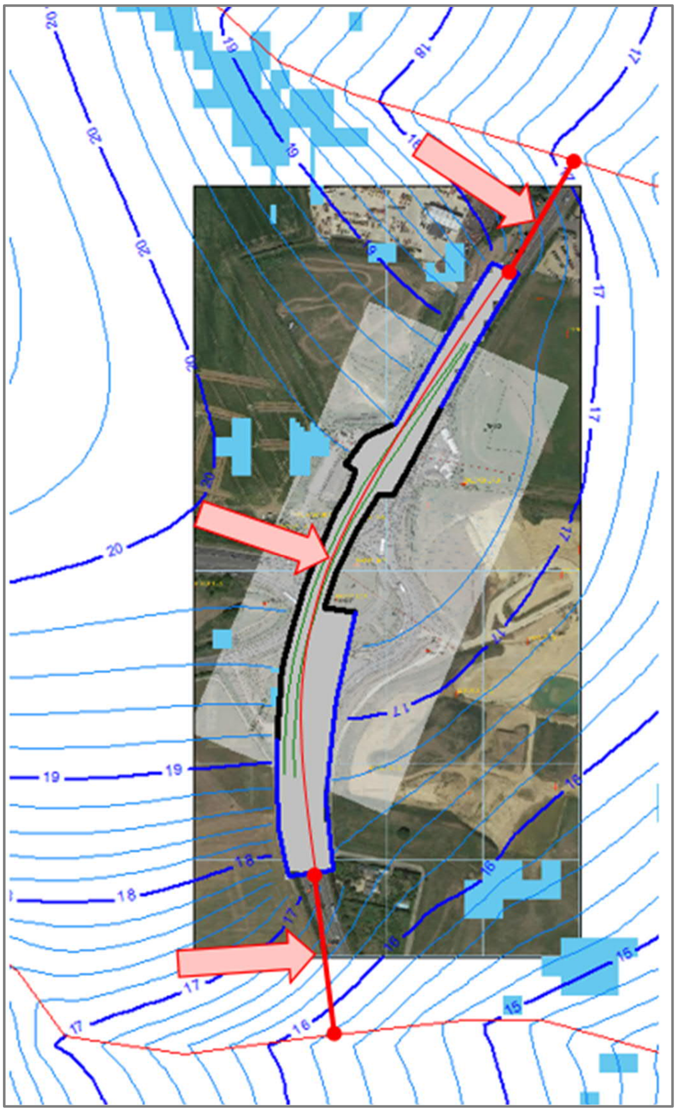


Figure 7-1 Locations of Groundwater Flux determinations

7.1.2 Observations:

a. Overall, the underpass blockage to the RTD has little impact on water balance.

b. The recharge to aquifer declines slightly due to the impervious surface of underpass (but this rainfall will be pumped to water courses)

c. GW flux to north and south of underpass increases slightly.

d. GW flow to streams has net decline (lower recharge)

e. GW flow to streams west of underpass may increase slightly and to east of underpass may decline slightly. There may be marginally more impact on Rockham Ditch to the south of the underpass than South Brook to the north of the underpass.

f. Magnitude of fluxes depends upon the recharge rate/hydraulic conductivity scenario used.

g. Subtle changes where groundwater baseflow to streams emerges in different scenarios.

h. The magnitude of the changes is small as a percentage of the initial groundwater flow.

i. The baseflow to Rockham Ditch is underestimated because not all of the catchment lies with the model domain.

Table 7-1 Groundwater baseflow to watercourses simulated in different scenarios

Watercourse	Scenario	Baseline Conditions (m^3/d)	Future Conditions (m^3/d)	Change (m^3/d)
South Brook	2	1620	1644	+24
	3	736	748	+12
	1	219	222	+3
Rockham Ditch	2	1556	1551	-5
	3	724	721	-3
	1	220	209	-11
Other Drain	2	1165	1169	+4
	3	539	543	+4
	1	154	155	+1
River Ouse	2	1956	1891	-65
	3	933	901	-32
	1	257	248	-9

Scenarios 4 and 5 have non convergent solutions resulting in gross mass balance errors

Note Scenario parameters are:

	Hydraulic Conductivity		Recharge	
Scenario	**(m/s)**	**(m/d)**	**(m/d)**	**(mm/a)**
1. Average k (original)	4.89 x 10-5	4.22	2x10-4	73
2. Average k (revised)	3.82 x 10-4	33.0	1.5x10-3	547
3. Maximum k (original)	1.90 x 10-4	16.41	7x10-4	256
4. Minimum k	8.96 x 10-6	0.77	3x10-5	11
5. Extreme k	2.40 x 10-3	207.4	7x10-3	2555

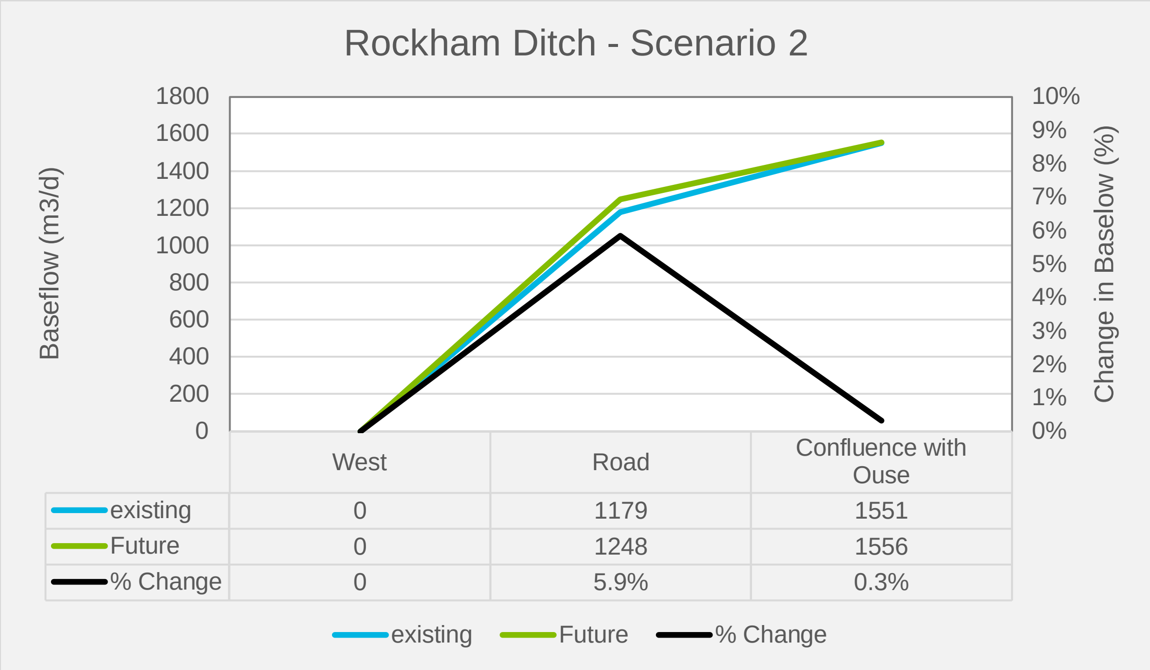
Table 7-2 Water Balance Scenario 1, Average hydraulic properties (original)

Mass Balance	Existing Conditions	Future Conditions	Change
Flux Far North (m3/d)	99.0	99.0	0
Flux North (m3/d)	10.7	12.9	+2.2
Flux Central (m3/d)	42.1	5.9	-36.2
Flux South (m3/d)	13.2	14.1	+0.9
Flux Far South (m3/d)	5.0	5.1	+0.1
Recharge (m3/d)	839	833	-6
GW->Great Ouse (m3/d)	257	248	-9
GW->Other (m3/d) **GW-> South Brook (west / east of road)** **GW-> Rockham Ditch (west / east of road)**	154 219 140/79 220 170/50	155 222 151/71 209 169/40	+1 +3 +11/-8 -11 -1/-10
Hydraulic Conductivity (m/d)	4.22		
Recharge Rate (m/d)	2x10-4		
TOTAL INFLOWS	**839** recharge	**833** recharge	-6
TOTAL OUTFLOWS	257 rivers 593 drains **850**	248 rivers 586 drains **834**	-16

NOTE: Mass balance error in Modflow less than 1.5%

Table 7-3 Water Balance Scenario 2, average hydraulic properties (revised)

Mass Balance	Existing Conditions	Future Conditions	Change
Flux North (m3/d)	82	100	+18
Flux Central (m3/d)	322	45	-277
Flux South (m3/d)	102	109	+7
Recharge (m3/d)	6295	6252	-43
GW->Great Ouse (m3/d)	1956	1891	-65
GW->Other (m3/d) GW-> South Brook (west / east of road) GW-> Rockham Ditch (west / east of road)	1165 1620 1028 / 592 1556 1179 / 377	1169 1644 1116/ 528 1551 1248 / 303	+4 +24 +88/ -64 -5 +69 / -74
Hydraulic Conductivity (m/d)	33		
Recharge Rate (m/d)	1.5x10-3		
TOTAL INFLOWS	**6295** recharge	**2252** recharge	-43
TOTAL OUTFLOWS	1956 rivers 4341 drains **6297**	1891 rivers 4364 drains **6255**	-42



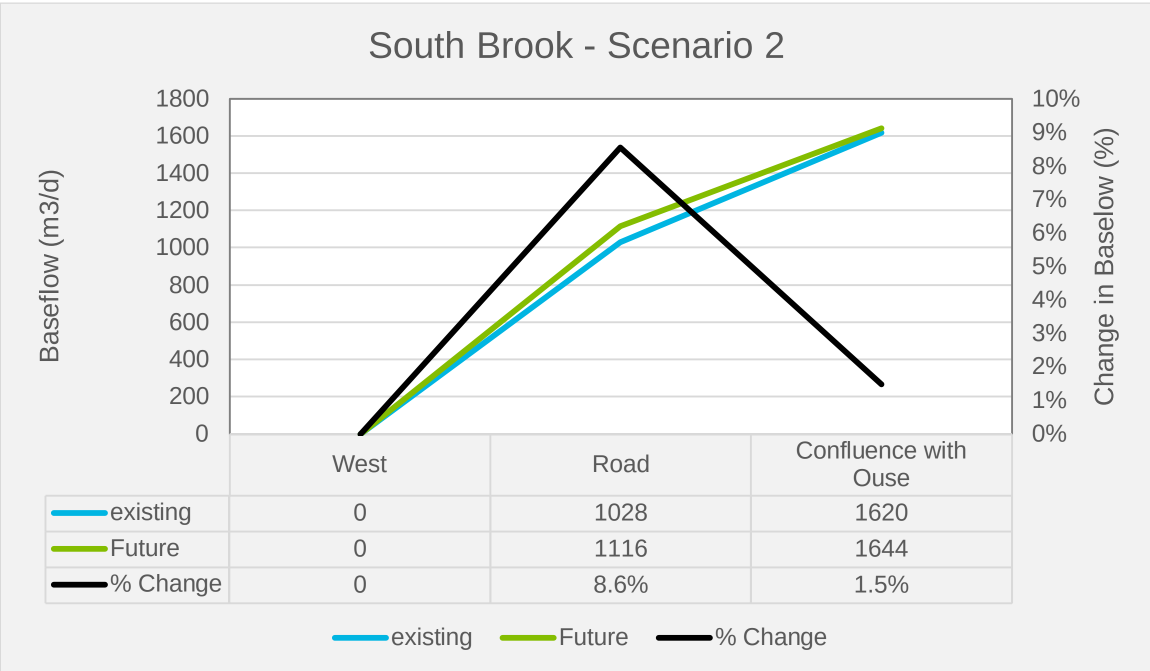


Figure 7-2 Diagram to illustrate the change in baseflow aggregation along the South Brook and Rockham Ditch

Table 7-4 Water Balance Scenario 3, maximum permeability (original)

Mass Balance	Existing Conditions	Future Conditions	Change
Flux Far North (m3/d)	379.4	379.4	0
Flux North (m3/d)	39.5	49.1	+9.6
Flux Central (m3/d)	155.4	21.5	-133.9
Flux South (m3/d)	49.5	53.3	+3.8
Flux Far South (m3/d)	19.5	19.6	+0.1
Recharge (m3/d)	2937	2918	-19
GW->Great Ouse (m3/d)	933	901	-32
GW->Other (m3/d) GW-> South Brook (west / east of road) GW-> Rockham Ditch (west / east of road)	539 736 462/274 724 546/178	543 748 505/243 721 580/141	+4 +12 +43/-31 -3 +34/-37
Hydraulic Conductivity (m/d)	16.41		
Recharge Rate (m/d)	7x10-4		
TOTAL INFLOWS	**2937** recharge	**2918** recharge	-19
TOTAL OUTFLOWS	933 rivers 1999 drains **2932**	901 rivers 2012 drains **2913**	-19

8 Groundwater Catchments

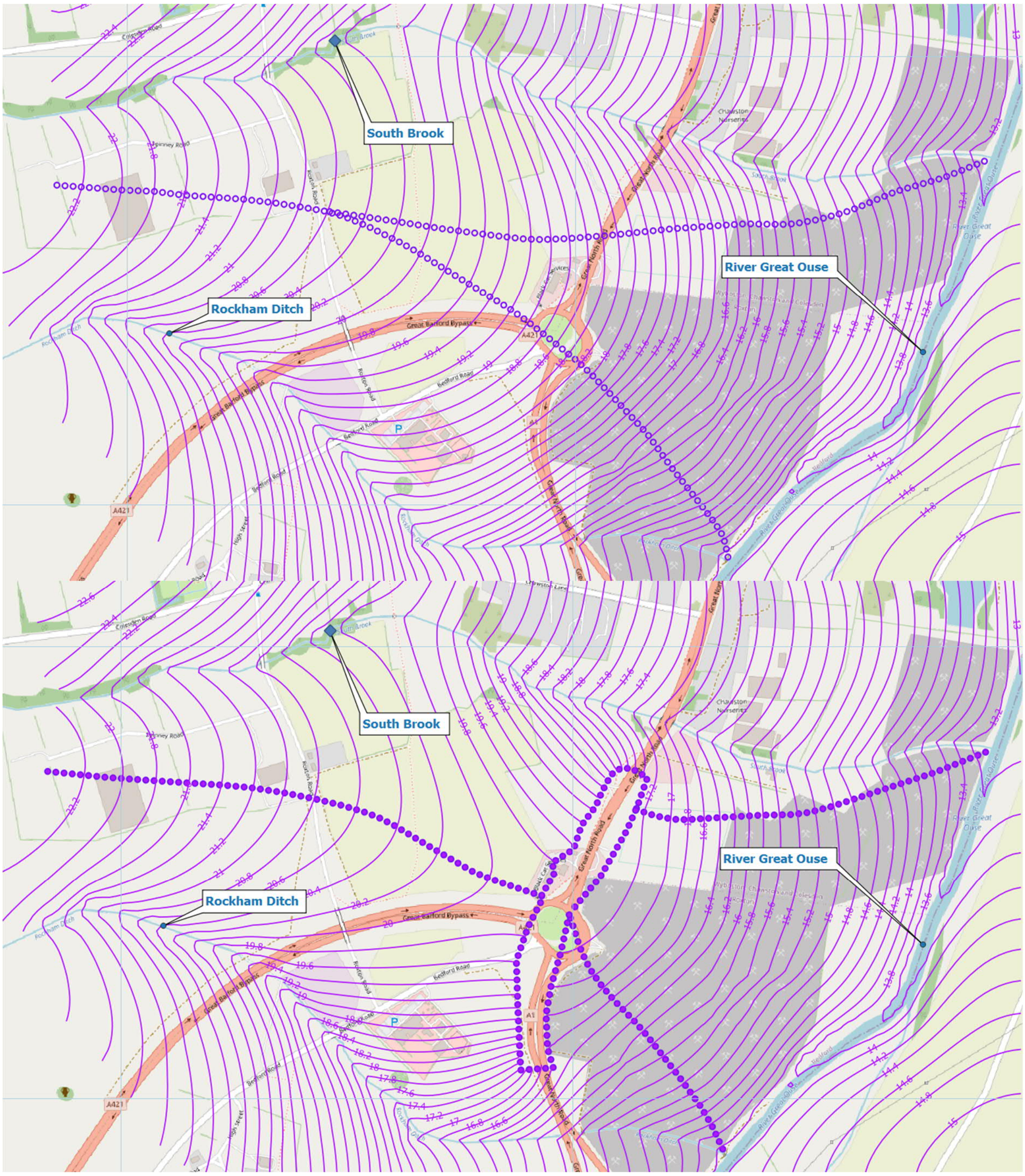


Figure 8-1 Groundwater Catchments (Scenario 2) Delineated based upon the groundwater flow convergent upon reaches of watercourses. Top image = Existing conditions. Bottom image = Post construction conditions.

Notes:

- There is a portion of the aquifer in the current condition to the west of the A1 that drains to the River Great Ouse. In the constructed condition there is no groundwater flow from west of the A1 Underpass directly to the River Great Ouse.
- The shape of the catchments is modified in the vicinity of the underpass by the existence of no flow cells.