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Yorkshire Green Energy Enablement (GREEN) Project

Volume 5

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Physical Effects on Ground Water (Focus Areas)

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Version History

Date	Version	Status	Description / changes
01/11/2022	A	FINAL	First Issue

Appendix 5.3.10B

Assessment of physical effects on groundwater (Focus Areas)

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1. Section B: Shipton Cable Sealing End Compounds (CSECs)

Conceptual Hydrogeological Site Model

Site name	Section B: Shipton CSECs Site
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Infrastructure

Infrastructure type and excavation depths	Proposed infrastructure as shown in Figure 3.2, Volume 5, Document 5.4.3 . Excavation depths/construction methods as described in Chapter 3: Description of the Project, Volume 5.2, Document 5.2.3 .
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Excavation depths (for example, for underground cables) assumed to be 2m below ground level (BGL).

Superficial geology

Unit	<ul style="list-style-type: none"> Alne Glaciolacustrine Formation. Sutton Sand Formation.
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Description	<ul style="list-style-type: none"> Alne Glaciolacustrine: Laminated clay with silt (varved) and subordinate fine-grained sand beds, plus minor marginal sand and gravel. Sutton Sand Formation: fine grained silty sand.
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Thickness	<ul style="list-style-type: none"> Alne Glaciolacustrine: Up to 9.4m, based on ground investigation. Sutton Sand Formation: Up to 6.1m, based on ground investigation.
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Bedrock geology

Unit	Sherwood Sandstone. (Mercia Mudstone encountered during ground investigation (Borehole STBH01) at depth 21m BGL)
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Description	Sandstone, red, yellow and brown, part pebbly; conglomeratic in lower part; pebbles generally extraformational quartz and quartzite, with some intraformational clasts; subordinate red mudstone and siltstone.
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Thickness	Variable, maximum > 1,500m.
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Superficial aquifer	-		
Designation	Unproductive Strata.		
Hydraulic conductivity	10 ⁻⁹ to 10 ⁻⁶ m/s.		
Specific yield	0.08		
Bedrock aquifer designation	Triassic Rocks (Undifferentiated)		
Designation	Principal.		
Description	Principal aquifer, sandstone up to 600m thick and yielding up to 125l/s. Quality good but hard and becomes saline beneath confining Mercia Mudstone.		
SPZ	Inner Zone (Source Protection Zone 1) located c.130m north of the Order Limits.		
Hydraulic conductivity	10 ⁻¹⁰ – 10 ⁻⁵ m/s.		
Storage	10 ⁻⁴ (confined) and <0.15 (unconfined).		
Specific Yield	0.27.		
Superficial groundwater levels	5.51m Above Ordnance Datum (AOD) at STBH01 (9.4m BGL) and 5.83m AOD at STBH02 (9m BGL). N.B. Borehole locations and logs are provided in, Chapter 10, Appendix 5.3.10E, Volume 5.3, Document 5.3.10.		
Bedrock groundwater levels	< -7m AOD		
Surface water features			
Operational Catchment	Ouse Upper Yorkshire		
Location (distance from Site)	740m west	1.24km north	1.7km south-west
Type (spring, drain, river)	Stream (Moor Gutter).	Stream (Backrein Beck).	Drain (Pennels Drain).
Base Flow Index (BFI)	0.45		
Abstractions			
Location (distance from nearest Project activity that could involve dewatering)	167 north-east (Newlands Farm).		
Type (PrWS, licenced abstraction)	Licensed abstraction – agricultural.		
Abstraction rates	45m ³ /day.		
Geology	Sherwood Sandstone.		

Radius of Influence (ROI) calculation

Confined / unconfined

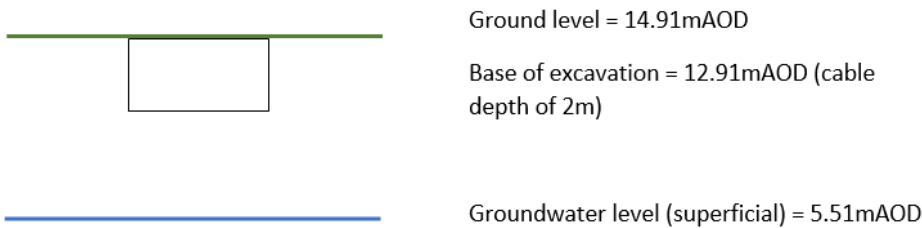
Confined.

Analytical equation used

Dupuit-Theim (Confined Aquifer Conditions).

Diagram

Shipton



1.1 ROI Calculation

1.1.1 The aquifer in this location, the Sherwood Sandstone, is confined beneath a moderately impermeable superficial deposit layer (clay and silt). To best represent the laminated clay and sand deposits found here, hydraulic conductivity values within the basal till range were selected to derive the ROI. Inflow rates have also been provided under transient states, with a period of 30 days used. To install the proposed infrastructure, multiple excavations would be required, with the most substantial likely to be circa 2m deep trenching to install the proposed underground cable. The ROI under the above conditions would be expected to be between around 1m and around 26m. Excavation inflow rates are predicted to be less than 1l/s under all conditions.

Impacts of dewatering on the water environment

Abstractions and Groundwater

1.1.2 The closest abstraction is at Newlands Farm, which is 167m north-east of the northern proposed northern Shipton CSEC. The abstraction rate at this private water supply is 45m³/day (0.52l/s) and it is abstracting from groundwater in the Sherwood Sandstone aquifer. The bedrock aquifer groundwater level will be deeper than -7m AOD where bedrock is first encountered; this is below the excavation depth (14.8m AOD). During ground investigation, groundwater was encountered at approximately 9m BGL (5.83m AOD) which is within the superficial deposits. Therefore, there is sufficient evidence to suggest that any dewatering would be limited to the Alne Glaciolacustrine Formation so there will not be any effect on the groundwater in the bedrock aquifer or the abstractions.

Surface Water

- 1.1.3 It is possible that shallow dewatering from an excavation in the superficial deposits could affect baseflow to nearby streams, though this does not include comparative elevations between the excavation and nearby watercourses.
- 1.1.4 Identified surface water features are outside of the ROI and unlikely to be impacted – the ROI is a maximum of around 26m and the nearest surface water feature is the Moor Gutter 740m west. There is a low risk to the surface water catchment (Hurns Gutter from Source to River Ouse) at this site.

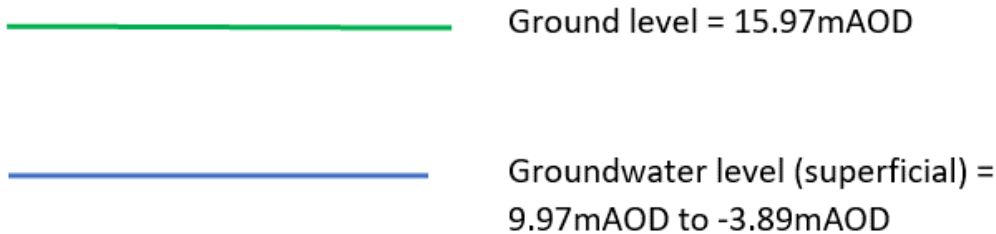
2. Section B: Overton Substation

Conceptual Hydrogeological Site Model	
Site name	Overton Substation.
Infrastructure	
Infrastructure type and excavation depths	Proposed infrastructure as shown on Figure 3.2, Volume 5, Document 5.4.3 . Excavation depths for substation not known in advance of detailed design, but reasonably assumed to be less than 4m as a worst-case, based on construction practicability.
Superficial geology	
Unit	Alne Glaciolacustrine Formation followed by Vale of York Formation
Description	<ul style="list-style-type: none"> Alne Glaciolacustrine: Laminated clay with silt (varved) and subordinate fine-grained sand beds, plus some marginal sand and gravel. Vale of York: Glacial Till with interbedded sand, gravel and laminated clay.
Thickness	<ul style="list-style-type: none"> Alne Glaciolacustrine: Up to 22m thick based on ground investigation. Vale of York: Up to 8.7m thick based on ground investigation.
Bedrock geology	
Unit	Sherwood Sandstone Group.
Description	Sandstone, red, yellow and brown, part pebbly; conglomeratic in lower part; pebbles generally extraformational quartz and quartzite, with some intraformational clasts; subordinate red mudstone and siltstone.
Thickness	Variable, maximum > 1,500m
Superficial aquifer	-
Designation	Unproductive Strata.
Hydraulic conductivity	10^{-9} to 10^{-6} m/s.
Storage	0.08.
Bedrock aquifer designation	Triassic Rocks (Undifferentiated)

Designation	Principal aquifer, sandstone up to 600m thick and yielding up to 125l/s. Quality good but hard and becomes saline beneath confining Mercia Mudstone.			
SPZ	-			
Hydraulic conductivity	10 ⁻¹⁰ – 10 ⁻⁵ m/s.			
Storage	10 ⁻⁴ (confined) and < 0.15 (unconfined).			
Specific Yield	0.27.			
Superficial groundwater levels	8.61m AOD (5m BGL) at OSBH02. 5.11m AOD (8.50m BGL) at OSBH02. -3.89m AOD (17.50m BGL) at OSBH02. 9.97m AOD (6m BGL) at OSBH03. 6.97m AOD (9m BGL) at OSBH03. N.B. Borehole logs and locations are provided in Chapter 10, Appendix 5.3.10E, Volume 5.3, Document 5.3.10.			
Bedrock groundwater levels	Sherwood Sandstone encountered in OSBH02 between -8.89m AOD (22.4m BGL) and -16.39m AOD (30m BGL) did not coincide with any groundwater strikes. Therefore, it can be inferred that bedrock groundwater level is below -16.39m AOD.			
Surface water features				
Operational Catchment	Ouse Upper Yorkshire			
Location (distance from Site)	450m south-east	340m west	1.73km south-west	1km west
Type (spring, drain, river)	Hurns Gutter (stream).	Drain.	River Ouse.	Overton Wood.
BFI	0.45.			
Abstractions				
Location (distance from proposed substation)	None (within 2km radius).			
Type (PrWS, licenced abstraction)	-			
Abstraction rates	-			
Geology	-			

Diagram

Overton



2.1 Context

- 2.1.1 The aquifer in this location, the Sherwood Sandstone, is confined beneath low permeability glaciolacustrine deposits which behave as an aquitard. The clay and silt content impedes vertical migration and has been recorded as having depths of up to 18m (OSBH02), followed by the more permeable Vale of York formation. There are no abstraction sites (licensed or private water supply) within 2km of the Order Limits in this area so the cone of depression caused by the pumping/dewatering would not capture groundwater supply points. A drain and stream are within 500m of the Order Limits and critically, groundwater supply contributes to 45% of the flow within the catchment as a whole (Hurns Gutter from source to River Ouse).

2.2 Impact of dewatering on the water environment

Abstractions and Groundwater

- 2.2.1 During the ground investigation, shallow groundwater was encountered in the Alne Glaciolacustrine Formation between 5m BGL and 17.50m BGL. It is likely that excavation into the Alne Glaciolacustrine beyond 5m BGL will require dewatering, but this should not impact groundwater abstractions within the Sherwood Sandstone.
- 2.2.2 Groundwater levels in the bedrock in this location are inferred to be below -16.39m AOD. The dimensions and depths of substation construction excavations are not known in advance of detailed engineering design. A qualitative assessment suggests that there would only be groundwater ingress from the Sherwood Sandstone into the excavation if the excavation was taken to below -16.39m AOD. This would be 30m BGL so this possibility is discounted (should foundations be required to this depth, then they would typically be piled rather than requiring excavation and dewatering).

Surface Water

- 2.2.3 It is possible that shallow dewatering from an excavation in the superficial deposits (such as the substation construction excavation) could affect baseflow to nearby streams. The design excavation depth will be specified at detailed design stage (post-consent), so a check of comparative elevations between the excavation and nearby watercourses cannot be made. However, the nearest watercourse is 340m away so the risk of a dewatering effect being experienced by that watercourse is low.

3. Section D: Tadcaster CSECs Site

Conceptual Hydrogeological Site Model

Site name	Tadcaster Cable Sealing End Compounds (CSEC) Site
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Infrastructure

Infrastructure type and excavation depths	<p>Infrastructure as shown in Figure 3.4, Volume 5, Document 5.4.3. Excavation depths/construction methods as described in Chapter 3: Description of the Project, Volume 5.2, Document 5.2.3.</p> <p>Specifically:</p> <p>The installation of foundations for new pylons will require four excavations of around 3.1m x 3.1m area and 3.4m depth per pylon (one excavation for each leg).</p> <p>Underground cables will involve 2m deep trenches. This is precautionary, as it may be that the cables are installed by horizontal directional drilling (HDD) due to the presence of underground utilities, in which case excavations would only be needed at starter pits.</p> <p>CSECs may require dig out / foundation excavations to a nominal 2m depth</p>
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Superficial geology

Unit	Exposed bedrock.
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Description	-
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Thickness	-
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Bedrock geology

Unit	Brotherton Formation.
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Description	Limestone, dolomitic, grey with abundant Calcinema.
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Thickness	0-20m.
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Superficial aquifer

Designation	Superficial deposits are mapped to be absent.
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Hydraulic conductivity (m s ⁻¹)	-
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Storage	-
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Bedrock aquifer	Zechstein Group
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Designation	Principal.
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Description	Significant regional dolomitised limestone aquifer up to 300m thick near Durham. Locally yielding up to 50 l/s of very hard water.
SPZ	Zone III Total Catchment (SPZ3) and Zone II Outer Protection Zone (SPZ2).
Hydraulic conductivity (m s ⁻¹)	10 ⁻⁹ – 10 ⁻⁵
Storage	3.4 x 10 ⁻⁶ to 4.0 x 10 ⁻³ .
Specific Yield	0.14.
Superficial groundwater levels	-
Bedrock groundwater levels	Long term groundwater level data taken from a borehole at Brick House Farm, dating from 1979 to 2004, show the groundwater level to be between around 10m AOD and 16.6m AOD. Groundwater level within magnesium limestone in the vicinity of the location is typically around 10m AOD.

Surface water features

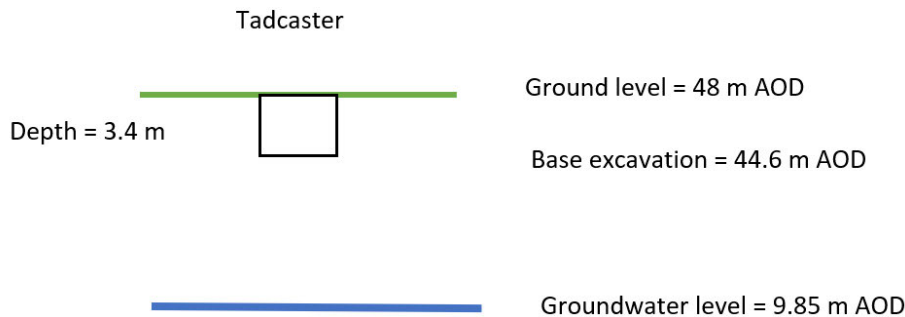
Operational Catchment	Wharfe Lower
Location (distance from Site)	1.84km south-east.
Type (spring, drain, river)	Stream (Cock Beck).

Abstractions

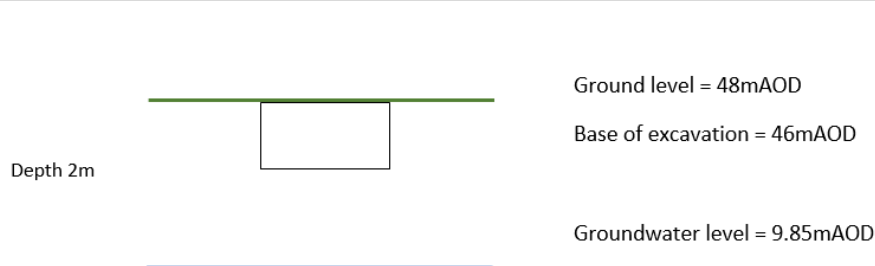
Location (distance from Site <2km)	1.08km south-east.	1.71km north-west.	1.3km south.	1.9km west.	140m east.	1.6km south-east.	1.9km south-west.
Type (Private Water Supply (PrWS), licensed abstraction)	Licensed Abstraction.	Licensed Abstractions (3).	Licensed Abstractions (PrWS).				
Abstraction rates	61.37m ³ /day.	855m ³ /day.	--				
Geology	Magnesian Limestone	Magnesian Limestone	Magnesian Limestone				

Diagram

Pylon



CSEC and underground cables



- 3.1.1 To install the proposed infrastructure at the Tadcaster CSECs site, various shallow excavations would be required (around 3.4m depth for pylons and nominally 2m depth for underground cables and CSECs). The proposed new infrastructure is in a recharge area for the Wharfe Magnesian Limestone groundwater body, with discharge areas into the Cock Beck Catchment (a tributary of the River Wharfe to the north). Since there are no superficial deposits in this area or confining strata, the depth of the excavation would be (for the majority) directly into the Brotherton Formation.
- 3.1.2 The closest abstraction is at Brick House Farm, which is 138m east of the easternmost of the two proposed CSEC. The abstraction rate at this private water supply is unknown, but it is likely to be abstracting from the dolomite aquifer at greater depths. It is unlikely that the Brick House Farm well will influence groundwater ingress in the vicinity of the proposed infrastructure.

3.2 Impacts of dewatering on the water environment

- 3.2.1 Though the excavation would be into the bedrock, the potential for any effect on the groundwater resource from shallow dewatering can be discounted since the static groundwater elevation in this location is approximately 10m AOD, whereas the base of excavations would generally be around 45m AOD, well above the groundwater elevation in the aquifer. Dewatering in excavations would be to combat direct rainfall, as the groundwater body is much deeper and would not be encountered.
- 3.2.2 It is important to note that this assessment does not include comparative elevations between the excavation and nearby watercourses. However, the nearest surface water body is 1.84km south and is unlikely to be affected.

4. Section F: Monk Fryston Area: Proposed substation and pylons

Conceptual Hydrogeological Site Model	
Site name	Monk Fryston Substation and proposed pylons
Infrastructure	
Infrastructure type and excavation depths	<p>Proposed infrastructure as shown in Figure 3.6, Volume 5, Document 5.4.3. Excavation depths/construction methods as described in Chapter 3: Description of the Project, Volume 5.2, Document 5.2.3.</p> <p>The infrastructure relevant to the assessment is the proposed new Monk Fryston Substation and nearby new pylons / temporary structures.</p> <p>Pylon excavations will be approximately 3.4m deep, over an area of 3.1m x 3.1m (four excavations per pylon and limited by the depth at which piling would be a more suitable method).</p> <p>The excavation depth for the installation of substation foundations is not known in advance of detailed design but is reasonably assumed to be less than 4m as a worst-case, based on construction practicability.</p>
Superficial geology	
Unit	Harrogate Till Formation.
Description	Slightly sandy clay with localised large sandstone blocks.
Thickness	Generally, up to 8m. Based on ground investigation, up to 6.1m.
Bedrock geology	
Unit	Brotherton Formation.
Description	Limestone, dolomitic, grey with abundant Calcinema.
Thickness	0-20m in general. Up to 13.6m based on the ground investigation.
Superficial aquifer	
Designation	Secondary (undifferentiated).
Hydraulic conductivity (m s ⁻¹)	10 ⁻¹² to 10 ⁻⁶ .
Specific Yield	0.06.

Bedrock aquifer designation	Zechstein Group
Designation	Principal (Aire and Don Magnesian Limestone)
SPZ	-
Hydraulic conductivity (m s ⁻¹)	10 ⁻⁹ to 10 ⁻⁵ .
Storage	3.4 x 10 ⁻⁶ to 4.0 x 10 ⁻³ .
Specific Yield	0.14.
Superficial groundwater levels	33.18m AOD (3.5m BGL) at MFBH02 from ground investigation. 32.51m AOD (4.4m BGL) at MFBH03A from ground investigation.
Bedrock groundwater levels	From the ground investigation, groundwater was not encountered in the limestone bedrock. In MFBH01, limestone bedrock (Brotherton Formation) was recorded from 3.70m BGL (33.62m AOD) to 16.10m BGL (21.22m AOD). In MFBH02, no groundwater was encountered within the Brotherton Formation from 6.40m BGL (30.28m AOD) to 20m BGL (16.68m AOD). In MBH03A, no groundwater was encountered within the Brotherton Formation between 8.76m BGL (28.56m AOD) and 20.08m BGL (16.83m AOD). Therefore, it can be inferred that bedrock groundwater levels are below 16.68m AOD.

Surface water features

Operational catchment	Aire Lower
Location (distance from Site)	390m south-east and 960m south-east.
Type (spring, drain, river)	Drain

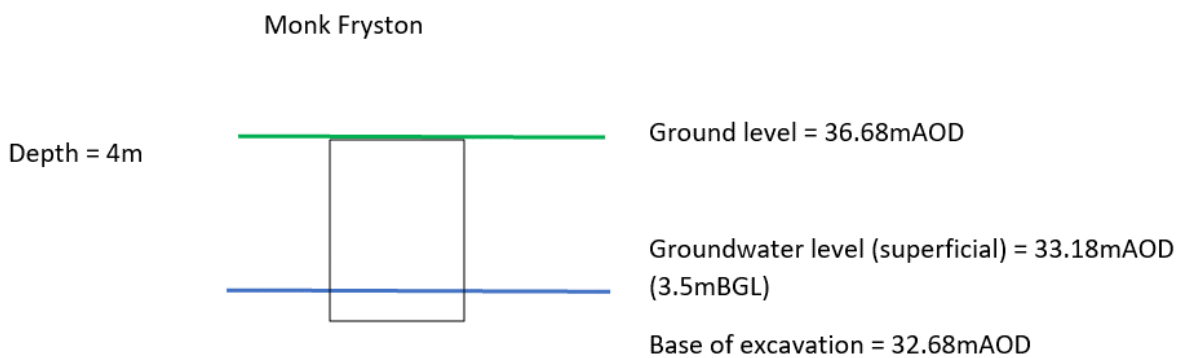
Abstractions

Location (distance from Site)	1.25km east.	1.23km north-west.	1.53km south-west.	1.26km north-west.	1.61km south.	280m west, 1.9km north-east, 1.6km south - west.	1.1km south-west.
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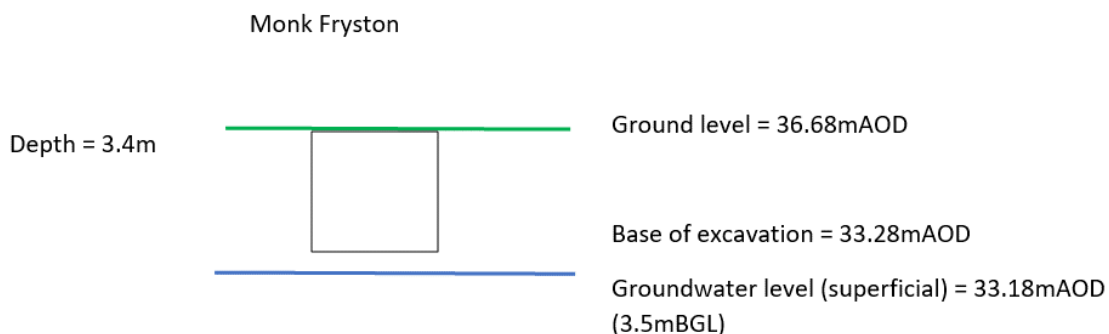
Type (PrWS, licensed abstraction)	Licensed Abstraction	Licensed Abstraction (2)	Licensed Abstraction	Licensed Abstraction	Licensed Abstraction	PrWs	Licensed Abstraction
Abstraction rates	200m ³ /day	22.73 m ³ /day	137 m ³ /day	22.73 m ³ /day	1233 m ³ /day		137 m ³ /day
Geology	Magnesian Limestone						
Radius of Influence (ROI) calculation							
Confined / unconfined	Confined.						
Analytical equation used	Dupuit-Thiem (Confined Aquifer Conditions).						

Diagram

Substation (where excavation depth taken as a nominal 4m)



Pylon pads (additional depth beyond 3.4m at corner pads for foundations, limited by depth at which piling would be more practicable)



4.1 Context

- 4.1.1 The proposed new infrastructure falls within the Aire Lower operational river basin catchment which extends from Goole to Otley. The river catchment in which the proposed substation is located is the Aire from River Calder to River Ouse, whose catchment envelops a 125km² area and extends 69km in length. The groundwater body underlying the proposed new Monk Fryston Substation site is confined by the Harrogate Till Formation which is up to 8m thick in some areas. Groundwater levels tend to coincide with the upper boundary of the dolomitised limestone. The proposed new infrastructure does not fall into a Source Protection Zone though the groundwater body is designated as having medium to high vulnerability. Nearby surface and groundwater receptors are drains within 1km of the proposed new infrastructure and a private water supply and two licensed abstractions (agricultural) 280m to the west of the nearest proposed pylon and up hydraulic gradient from the proposed excavation. The aquifer in this location, the dolomitised limestone of the Zechstein group, is confined beneath the Harrogate Till Formation which has a low permeability.

4.2 Substation

- 4.2.1 The dimensions and depths of the foundation excavations for the substation to be constructed at Monk Fryston are subject to determination following detailed engineering design, so a qualitative assessment has been carried out.

Impacts of dewatering on the water environment

Abstractions and Groundwater

- 4.2.2 Any groundwater encountered at shallower depths is indicative of a perched water body within the clay and dewatering would not impact abstraction points that abstract groundwater from the underlying Magnesian Limestone.

Surface Water

- 4.2.3 It is important to note that any shallow dewatering from the superficial geology could affect baseflow to water courses in the vicinity of the excavation. Additionally, this assessment does not compare the elevations in nearby watercourses with the excavation elevation.

4.3 Pylons

- 4.3.1 The construction of six pylons along a 1.19km path adjacent to the Selby Fork Interchange would entail six distinct excavation areas, one at each pylon. Each excavation area would be within a pylon footprint of approximately 10m x 10m (indicative only and may vary depending on pylon type). It is assumed that pad foundations are used, rather than piles. This is a precautionary assumption when considering possible dewatering effects.
- 4.3.2 Using the Dupuit-Theim, an estimation of inflows into the anticipated excavations can be derived with a respectable degree of accuracy. Likewise, under the theorem's assumptions, we can obtain a ROI with regard to the dimensions of the pit. Inflow rates have also been provided under transient state with literature hydraulic conductivities for the geology and with a time period of 30 days.

- 4.3.3 Values for hydraulic conductivity were taken from literature to reflect the properties of the sandy clay found here. Preliminary inflow calculations suggest that an ROI between 0m and 18m (mean of 4m), dependent on hydraulic conductivity, would be reasonable to assume at this stage for four excavations (dimensions of 3.1m x 3.1m x 3.4m) at each pylon. Using the Dupuit-Theim analysis, inflow rates into the excavations are anticipated to be less than 1l/s under almost all conditions.

Impacts of dewatering on the water environment

Abstractions and Groundwater

- 4.3.4 The closest abstraction is west of the A1(M), directly south of the Selby Fork interchange (280m north-west of the nearest proposed pylon). The abstraction rate at this private water supply is not known although licensed abstractions in the vicinity currently abstract at a rate of 22.73m³/day (0.26l/s) for agricultural use. The groundwater abstracted here is from the underlying magnesium limestone (fracture flow). Ground investigation did not record any groundwater within bedrock to final borehole depth of 20m BGL. This is equivalent to 16.68m AOD which is well below the depth of the proposed excavation (around 33m AOD) and as such any shallow dewatering will have no effect on the groundwater in the bedrock aquifer or abstractions from the bedrock aquifer. During the ground investigation, shallow groundwater was encountered between 33.18m AOD and 32.51m AOD which is below or 0.18m above the depth of the excavation as well.

Surface Water

- 4.3.5 It is possible that shallow dewatering from an excavation in the superficial deposits could affect baseflow to nearby streams, though this assessment does not include comparative elevations between the excavation and nearby watercourses.
- 4.3.6 However, the nearest surface water feature (a drain, 390m to the south-east) is outside of the calculated ROI (maximum of 18m) so it is unlikely that dewatering of the superficial deposits will affect the baseflow of the water feature. Quantitative analysis suggests that there is a low risk to surface water bodies as a result of shallow dewatering.

National Grid plc
National Grid House,
Warwick Technology Park,
Gallows Hill, Warwick.
CV34 6DA United Kingdom

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