Groundwater Risk Assessment

Hendre Farmhouse

Orchard Campsite, Monmouth, NP25 4DJ

On Behalf of

Ridgeway Contractors Ltd

Quality Management

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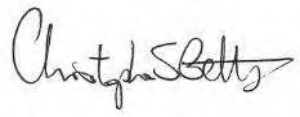
Reviewed and Authorized by:	Chris Betts BSc MSc FGS CGeol	
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1 Introduction

1.1 Background

Hydrogeo Ltd (Hydrogeo) has been commissioned by Ridgeway Contractors Ltd (the Client) to undertake a quantitative groundwater risk assessment for the installed treated effluent discharge to ground at the camping site situated on the grounds of Hendre Farmhouse (the Site). This is to meet Natural Resources Wales (NRW) request for further information for Permit Application PAN-026798.

The Site is located at Hendre Farmhouse Orchard Campsite, Wonastow, Monmouth, NP25 4DJ. The grid reference to the centre of the Site is 345830, 212407.

1.2 Data Sources & Third-Party Information

In completing this assessment, Hydrogeo has utilised the following information:

- British Geological Survey (BGS) online data;
- BGS 1:50,000 Geology Map Sheet 233 – Monmouth, Solid and Drift, 1981;
- EA – Annex J5 Appendix A: Infiltration Worksheet User Manual v2.0, 2014;
- EA – Groundwater Risk Assessment for Treated Effluent Discharges to Infiltration System v3.0, 2022.

1.3 Site Setting & Description

The location of the Site has been shown in Figure 1-1 and the sitting of the drainage ditch is shown in Figure 1-2.

Figure 1-1 – Site location

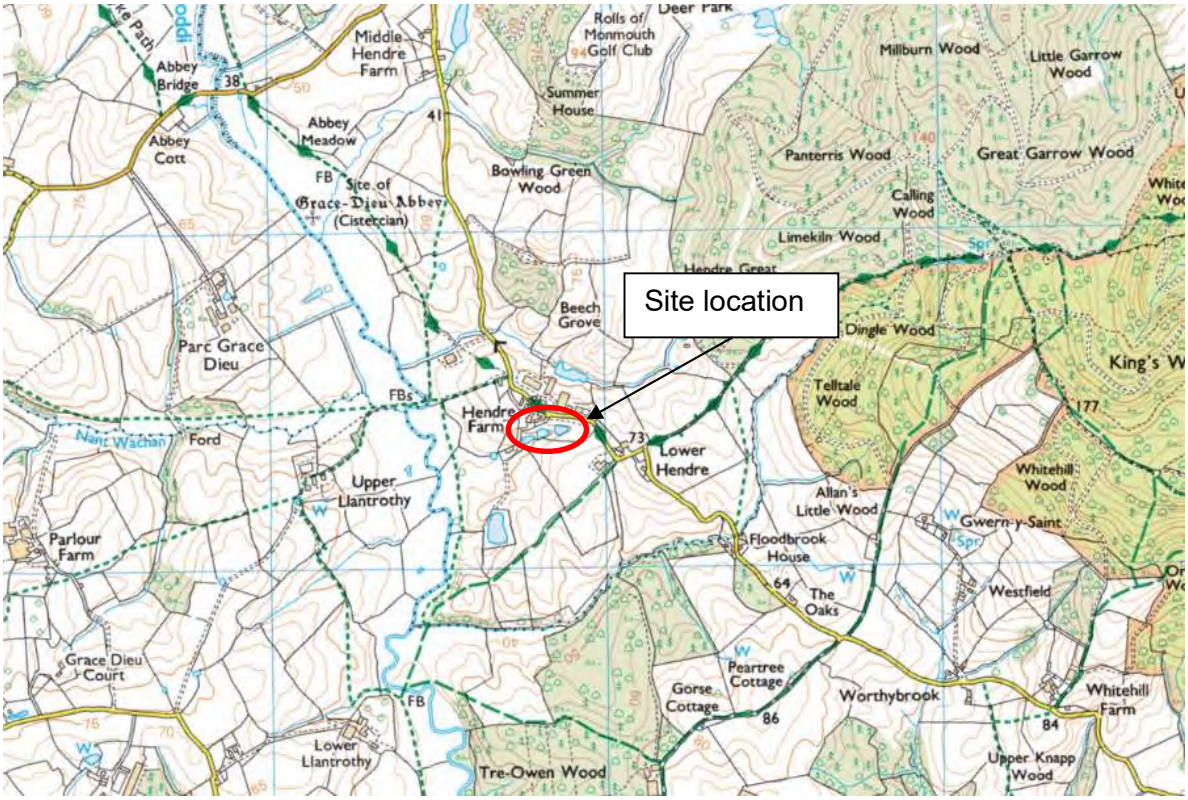


Figure 1-2 – Drainage ditch location

The Site is located in a rural setting surrounded by agricultural land to the east and south. To the north is Old Hendre Farm, consisting of multiple barns and Old Hendre Farm B&B and Holiday Lets. To the west is another agricultural barn, just beyond which is the River Trothy, running north to south.

The Site slopes west from 62m Above Ordnance Datum (AOD) at the eastern field boundary to 50mAOD at the western boundary.

The Site currently comprises a series of converted barn dwellings backing onto a large camping field with a line of 3 no. ponds in its centre.

The dwellings and camping facilities discharge to drainage ditch from a package treatment plant (PTP) as shown in Figure 1-2. The PTP is a WPL Diamond DMC9, which is designed to cater for a population of 70 persons, and has a total capacity of 15038 litres. It is capable of producing a final effluent discharge standard of 20mg/L of ammonia and a maximum of 6.6mg/L of phosphate. It is understood that the drainage ditch is gravel filled, ~25m long, ~1m wide and ~0.6m in thickness, positioned just south of the PTP.

1.4 Geology

Artificial Deposits

BGS data shows that the Site is not underlain by any known artificial deposits.

Superficial Geology

BGS data shows that the Site is not underlain by any known superficial deposits. The closest superficial deposits are Alluvial deposits shown following the River Trothy, ~250m west of the Site.

Bedrock Geology

According to the BGS, the Site is mapped as being underlain by bedrock of the Raglan Mudstone Formation (Siltstone and Mudstone Interbedded). The BGS describe the formation as *'red mudstones and silty mudstones with calcretes and sandstones'*, deposited in the Silurian period. These are coarse to fine grained rocks forming beds and lenses of deposits, reflecting deposition in channels, floodplains and levees of a river estuary in a coastal setting.

Mapped to the west of the Site is a long, thin unit of tuff known as the Townsend Tuff Bed. The BGS describe it as a '*composite unit of air-fall tuff with three recognisable tuff beds with intervening mudstones*', 3-4m in thickness.

Structural Geology

BGS mapping indicates there to be no faulted geology onsite or in the Site vicinity. Mapping also shows bedrock at the Site to be dipping roughly 20° to the south east.

Soil Characteristics

The soil beneath the Site is classed by the Soilscapes Land Information System (from the Cranfield Environment Centre) as *'slightly acid loamy and clayey soils with impeded drainage'.*

BGS Borehole Records

A single abstraction borehole is drilled at the eastern edge of the campsite field. A written record of the borehole is not available, however verbal description by the driller states it is ~60m deep, passing through numerous water-bearing sandstone layers, screened at depth with confined groundwater at its base. The borehole is located approximately 175m east, 11m in elevation upgradient of the PTP and drainage ditch.

There are 2 no. borehole records available online within 2km of the Site. Their details are outlined in Table 1-1 below.

Table 1-1 – Borehole details within 2km of the Site

Borehole Details	Observed Geology
BGS ID: SO41SE25 Location: 1km east Elevation: 80mAOD Date: August 2005 Screened between 24-48mBGL	▪ 0 – 50m: Red mudstone and sandstone bands [RAGLAN MUDSTONE FORMATION] Groundwater struck at a depth of 15m below ground level (mBGL). The rest water level was also 15mBGL (65mAOD).
BGS ID: SO41SE22 Location: 1.7km north Elevation: 65mAOD Date: January 1993 Screened between 39.62-76mBGL	▪ 0 – 2.43m: Brown medium grained overburden; ▪ 2.43 – 76m: Red marl with sandstone skerries [RAGLAN MUDSTONE FORMATION] Groundwater was struck at depths of 28.95mBGL and 51.80mBGL.

1.5 Hydrogeology

BGS mapping data indicates that the majority of the Site is underlain by the Raglan Mudstone Formation. This formation forms part of the Old Red Sandstone aquifer, which is a locally important aquifer across South-East Wales. Water storage and movement is typically found within the sandstone layers which are often laterally impersistent, resulting in limited storage and recharge. As such, yields may decrease with time and groundwater levels may decrease. The formation is classified as a Secondary A aquifer which are

aquifers with potential for local importance and may form a baseflow to local surface water systems. The bedrock aquifer is also classed has having a high vulnerability. Any water found within these deposits would be expected to be in hydraulic continuity with the River Trothy, Monnow and Wye as the catchment rivers for the area.

There is a paucity of borehole records in the Site vicinity. However, the 2 no. available borehole records outlined in Table 1-1 indicate deep groundwater levels in the Raglan Mudstone Formation, at between 15 - 52 mBGL. Due to the differing levels encountered in the records, a continuous groundwater level is not anticipated. This instead indicates that there are multiple water-bearing sandstone layers within the bedrock which may be confined by low permeability layers. This is supported by the driller's observations of the onsite borehole. There is also the potential for areas of perched groundwater within the deposits which can be supported above lenses of low permeability clay.

There are no groundwater levels recorded within the Site vicinity, the groundwater flow direction and gradient is therefore assumed to be approximate to the topographic gradient of the area, and the locale of the River Trothy. The topographic contours of the area show the ground rising to the east and falling to the south and west of the Site down to the River Trothy. Hence, the groundwater flow direction is anticipated to be south westwards. The topographic gradient is higher to the east and lower to the south and west, therefore an average gradient has been calculated which takes into account a larger distance to accommodate the changing gradient. This gradient has been calculated to be 0.093 by taking the change in elevation from 50mAOD to 40mAOD which covers a distance of 107m in the anticipated direction of groundwater flow.

1.6 Environmental Designations

The Site does not lie within any environmental designations, source protection zones or nitrate vulnerable zones.

1.7 Hydrology

Ordnance Survey and aerial imagery shows a line of 3 no. ponds at the centre of the Site. Moving east to west, the pond levels drop in elevation from 55mAOD to 51mAOD to 48mAOD over a distance of approximately 140m. Information provided by the Site owner state that the ponds are artificial and fed by springs. It is understood they were constructed by the Site owner, with no groundwater encountered during excavation of the ponds. Photographs of the ponds are shown in Figure 1-3 to Figure 1-5.

Figure 1-3 – Highest elevation pond

Figure 1-4 – Slope from uppermost pond (left) to middle pond)

Figure 1-5 – Middle pond (left) and lowest pond 2m lower than fence line (right)

There are 3 no. additional ponds in the Site vicinity all within the Hendre Farm ownership boundary. The first is located 107m east of the Site at 41mAOD, another 120m north at around 54mAOD, and the third 260m south of the Site at 50mAOD elevation.

Located around 300m west of the Site is the River Trothy, at an approximate elevation of 34mAOD. The surface water course flows north to south past the Site, before turning east to flow into the River Wye roughly 6km south east of the Site. The River Wye is designated as a Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC).

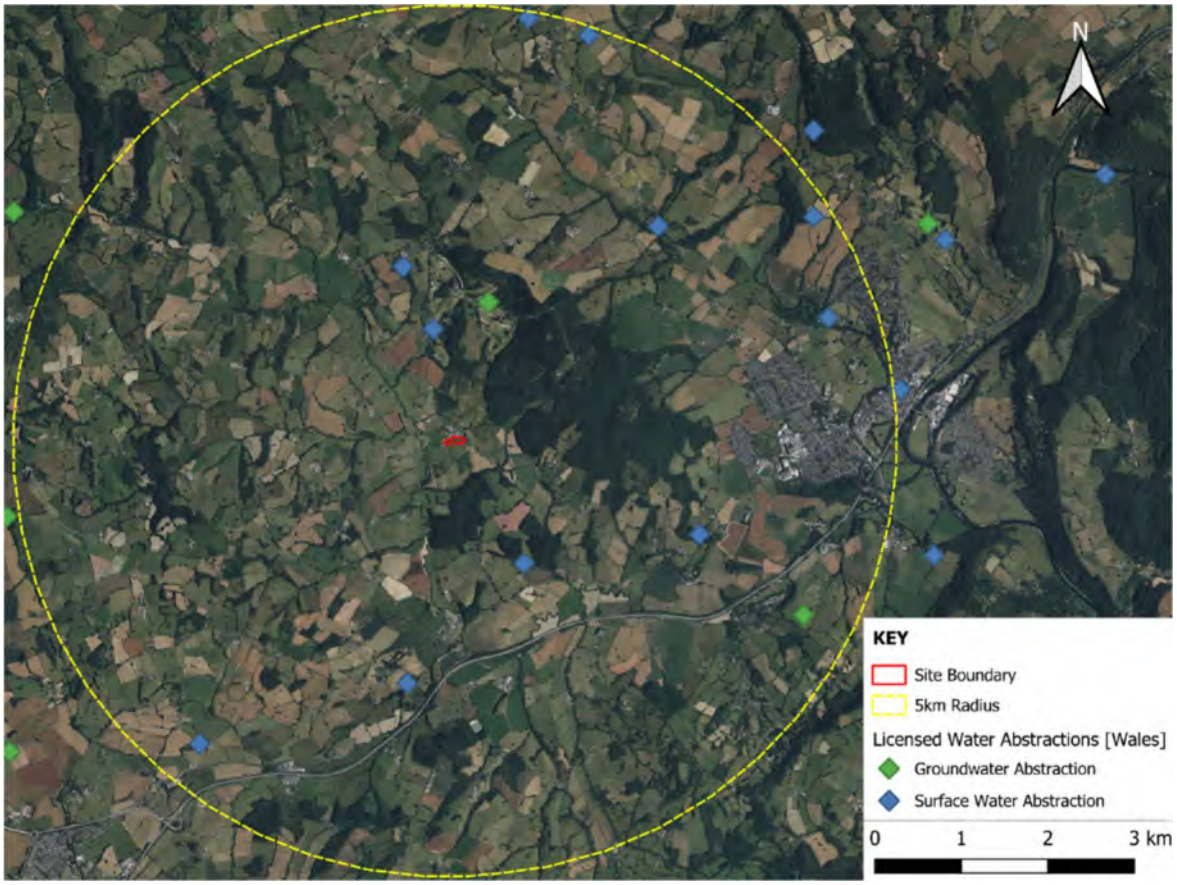
1.8 Licensed Water Abstractions

There are 2 no. licensed groundwater abstractions and 12 no. licensed surface water abstractions within 5km of the Site. No licensed abstractions are located within 1km of the Site. Their details are outlined in Table 1-2 and their locations are shown in Figure 1-66.

Table 1-2 – Details of licensed water abstractions within 5km of the Site

Distance	Abstraction Type	Purpose	Source
1.3km N	Surface	Unknown	Impoundment of River Trothy tributary
1.6km N	Ground	Industrial, commercial, public service	Borehole screened in Raglan Mudstone Formation
1.7km SE	Surface	Unknown	Impoundment of River Trothy tributary
2.0km N	Surface	Private amenity	Unnamed tributary of River Trothy
2.8km S	Surface	Unknown	Impoundment of River Trothy tributary
3.0km SW	Surface	Private amenity	Ditch at Redhill Farm
3.4km NE	Surface	Agriculture	River Monnow
4.5km E	Surface	Environmental	Leat off the River Monnow
4.5km E	Surface	Energy production	River Monnow
4.5km SE	Ground	Agriculture	Borehole screened in St Maughans Formation
4.7km SW	Surface	Unknown	Impoundment of Pontyrhydan Brook
4.9km NE	Surface	Public water supply	Unknown
4.9km N	Surface	Unknown	Impoundment of unknown stream
4.9km N	Surface	Unknown	Impoundment of River Monnow tributary

Figure 1-66 – Licensed water abstractions within 5km of the Site



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Site boundary not defined – taken as campsite field for purpose of radius construction

1.9 Private Water Abstractions

Monmouthshire County Council were contacted to enquire about the positions of any private water supplies within the Site vicinity. According to their records, there are 7 no. registered private water supplies within 1km of the Site. MCC state that as this area does not have a mains supply, so most, if not all, properties surrounding the Site will have a private supply. It should be noted that the onsite borehole detailed in Section 1.4 supplies Hendre Farmhouse and the associated campsite. As aforementioned, the borehole is located approximately 175m east, 11m in elevation upgradient of the PTP and drainage ditch.

It should also be noted that no properties or structures are present down gradient of the installed PTP and drainage ditch.

Other supplies can be found approximately 800m west of the Site, and 800m south east of the Site.

1.10 Water Quality Exemptions

There are 7 no. water quality exemptions registered within 500m of the Site. Of which, 5 no. are for discharges ≤2m³, and 2 no. are for discharges ≤5m³. Their locations are shown in Figure 1-7.

A total of 5 no. of the water quality exemptions are on the grounds of Hendre Farm.

Figure 1-7 – Water quality exemptions within 500m of the Site

Contains Bing satellite imagery © Microsoft 2023

Site boundary not defined – taken as campsite field for purpose of radius construction

2 Site Investigation

2.1 Introduction

Hydrogeo conducted a site investigation on the 9th January 2025 which saw the advancement of 3 no. trial pits across the Site.

The site investigation works were supervised by Hydrogeo and conducted in accordance with current guidance advocated by the regulatory authorities, including BS 5930:2015+A1:2020 Code of practice for site investigations.

The site investigation was conducted across the required site areas, with the positions of investigation informed by a prior desk-based study and onsite information provided by the Client team regarding the position of site services and drainage features.

The advanced trial pits allowed for the visual inspection and logging of subsurface materials in the top 3.6m, as well as observations for the presence of any shallow groundwater system. All pits were backfilled in arsing order before leaving the Site.

2.2 Objectives

The specific objectives of the site investigation were as follows:

- To establish the current ground conditions underlying the Site in the vicinity of the drainage ditch;
- To investigate the connectivity of underlying groundwater with the suspected onsite spring fed ponds.

2.3 Selection of Investigation Methods

The techniques adopted for the site investigation were chosen with consideration of the objectives and site constraints.

Mechanically excavated trial pits were advanced in accessible areas on the land surrounding the PTP and between the PTP and the ponds.

2.4 Site Investigation Positions

A total of 3 no. trial pits were advanced to between depths of 3.5m below ground level (mBGL) and 3.6mBGL.

The site investigation positions were discussed and agreed with the Client prior to the commencement of works. Drawing 1 shows the site investigation positions.

Trial pit positions were restricted by underground services (water pipes and electricity cables) running adjacent to the ponds and to the dwellings respectively.

2.5 Ground Conditions

Descriptions of the encountered strata and observations of groundwater levels and seepages are summarised below.

No visual or olfactory evidence of effluent from the drainage ditch was encountered during the progression of the site investigation.

The trial pits were advanced to the following depths:

- TP01: 3.5mBGL;
- TP02: 3.5mBGL;
- TP03: 3.6mBGL.

The encountered ground conditions in TP01 are shown in Table 2-1.

Table 2-1 Ground conditions TP01

Trial Pit Reference	Description of Strata
Reference: **TP01** Length: 2.5m Width: 0.5m Depth (mBGL): 3.5 NGR: 345796, 212401 Elevation: 51mAOD	▪ 0.00 – 0.12mBGL: Reddish brown silty clayey TOPSOIL with common rootlets; ▪ 0.12 – 2.54mBGL: Reddish brown silty CLAY with common subangular mudstone and siltstone cobbles and boulders, becoming sandier with depth [WEATHERED RAGLAN MUDSTONE FORMATION]; ▪ 2.54 – 3.50mBGL: Greyish brown sandy CLAY with uncommon sandstone and siltstone boulders [WEATHERED RAGLAN MUDSTONE FORMATION]. **Water observations:** All spoil returned to the surface dry. 30 minutes after excavation of TP01 ceased, a water seepage from the northside backwall of the pit at 2.5mBGL was noted from the contact between the silty CLAY and sandy CLAY horizon. After 2 hours, the minor seepage dried up, leaving the water level in the base of the pit at 3.1mBGL.

Photographs of TP01 are shown in Figure 2-1 to Figure 2-4.

Figure 2-1 TP01 excavation

Figure 2-2 TP01 spoil 3.5mBGL

Figure 2-3 TP01 start of water seepage

Figure 2-4 TP01 end of water seepage

The encountered ground conditions in TP02 are shown in Table 2-2.

Table 2-2 Ground conditions TP02

Trial Pit Reference	Description of Strata
Reference: **TP02** Length: 2.5m Width: 0.5m Depth (mBGL): 3.5 NGR: 345766, 212401 Elevation: 50mAOD	▪ 0.00 – 0.17mBGL: Reddish brown silty sandy TOPSOIL with common rootlets; ▪ 0.17 – 3.50mBGL: Reddish brown silty sandy CLAY with frequent subangular to subrounded mudstone and siltstone pebbles, cobbles and boulders, becoming increasingly sandier with depth [WEATHERED RAGLAN MUDSTONE FORMATION]. **Water observations:** All spoil returned to the surface dry. 2 hours after excavation of TP02 ceased, a water seepage from the westside backwall of the pit at 0.9mBGL was noted at the contact between an upper siltier and lower sandier horizon. The seepage quickly dried up, with minor water sitting in the base of the pit.

Photographs of TP02 are shown in Figure 2-5 to Figure 2-7.

Figure 2-5 TP02 excavation

Figure 2-6 TP02 spoil 3.5mBGL

Figure 2-7 TP02 minor water seepage

The encountered ground conditions in TP03 are shown in Table 2-3.

Table 2-3 Ground conditions TP03

Trial Pit Reference	Description of Strata
Reference: **TP03** Length: 2.5m Width: 0.5m Depth (mBGL): 3.6 NGR: 345754, 212402 Elevation: 50mAOD	▪ 0.00 – 0.20mBGL: Reddish brown silty sandy TOPSOIL with common rootlets; ▪ 0.20 – 3.60mBGL: Reddish brown silty sandy CLAY with frequent subangular to subrounded mudstone and siltstone pebbles, cobbles and boulders, becoming sandier with depth [WEATHERED RAGLAN MUDSTONE FORMATION]. **Water observations:** All spoil returned to the surface dry. 10 minutes after excavation of TP03 ceased, a water seepage from the southside backwall of the pit at 0.8mBGL was noted at the contact between an upper siltier and lower sandier horizon. The seepage quickly dried up, with minor water sitting in the base of the pit.

Photographs of TP03 are shown in Figure 2-8 to Figure 2-11.

Figure 2-8 TP03 excavation

Figure 2-9 TP03 spoil 3.6mBGL

Figure 2-10 TP03 water seepage

Figure 2-11 TP03 close up water seepage 0.8mBGL

2.6 Ground Conditions Summary

Topsoil / Subsoil

Natural soils were encountered in all pits to depths of between 0.12 – 0.20mBGL. The soils consisted of a reddish brown sandy silty CLAY with common rootlets.

Superficial Deposits

No superficial deposits were encountered in trial pits.

Bedrock

Very weathered bedrock was encountered at shallow depths across the Site. This consisted of a reddish brown silty sandy CLAY with common pebbles, cobbles and boulders of subangular to subrounded mudstone, siltstone and sandstone, which became increasingly sandy with depth.

Water Seepages

- TP01: Seepage after 30 minutes at 2.5mBGL from northside backwall of pit at contact between silty CLAY and sandy CLAY horizon. Seepage dry after 2 hours;
- TP02: Seepage noted after 2 hours at 0.9mBGL from westside backwall of pit at the contact between upper sandier and lower siltier horizon. Seepage instantly dry;
- TP03: Seepage noted after 10 minutes at 0.8mBGL from southside backwall of pit at the contact between an upper sandier and lower siltier horizon. Seepage instantly dry.

2.7 Groundwater Interpretation

A continuous groundwater level was not struck in any trial pits advanced during site investigations. Minor water seepages were encountered in all 3 no. pits. Seepages entered the pits from the contact between lower permeability silty CLAY and more permeable sandy CLAY horizons, all from differing levels (between 0.8 – 2.5mBGL) and compass directions (i.e. not all from the side trial pit sidewall direction). All excavations were left for sufficient time before the seepages dried.

TP01 was excavated at the same topographic level as the middle onsite pond, to determine if the water level in the pond is in connectivity with groundwater. The pit was advanced to 3.5mBGL, well below the water level of the pond, with only a water seepage noted towards the base of the pit.

TP02 was excavated between the PTP drainage ditch and the topographically lowest onsite pond to observe if a flow of water was present from the drainage ditch to the pond. The water level of the pond is ~2m lower than the surface level of TP02, which was advanced to a depth of 3.5mBGL. No flow of water from the direction (north) of the drainage ditch was observed in TP02 with only a minor water seepage noted.

TP03 was excavated at the end of the drainage ditch to investigate for seepages associated with flow from the drainage ditch and to investigate for the presence of a continuous groundwater level in continuity with the water level of the lowest pond. TP03 was advanced maximum depth of 3.6mBGL, at the same topographic level as TP02. No flow of water from the direction (east) of the drainage ditch was observed in TP03 with only a minor water seepage noted.

Based on the site investigation observations, the 3 no. onsite ponds appear to be spring fed from a higher elevation, and are not in hydraulic continuity with a shallow continuous groundwater body. The ponds support a water level all year therefore these appear to

have been constructed with a low permeability base. There is very limited potential for the ponds near the discharge to receive discharge from the installed PTP and drainage ditch. Hence, the ponds (closest to the drainage field) are not considered a receptor in treated effluent discharge modelling as they appear to be hydraulically isolated.

3 Groundwater Risk Assessment

3.1 Introduction

The installed foul drainage scheme for the comprises discharging treated effluent to ground via a drainage ditch.

The EA H1 Annex J5: Infiltration Worksheet has been used to assess the risk posed by discharging treated sewage effluent to ground at the site. The following sections of this report summarise the input values used in modelling and present the results.

Contaminant modelling has been based on total ammonia as N and total phosphate as P, with the results of the modelling compared with the UK Drinking Water Standard (DWS) and River Wye SAC (at Redbrook Bridge) target respectively to determine if the effluent discharge poses a risk to the surface water system and any other water receptors.

The literature data sources used for modelling are listed below:

- British Geological Survey (BGS) online data;
- BGS 1:50,000 Geology Map Sheet 231 – Monmouth, Solid and Drift, 1981;
- EA – Annex J5: Effluent discharge to groundwater User Manual v3.0, 2022;
- EA – Annex J5: Infiltration Worksheet User Manual v2.0, 2014;
- BGS historic borehole data (online);
- BGS 1:125,000 Hydrogeological Map of South Wales, 1986.

3.2 Conceptual Site Model

A conceptual site model (CSM) has been developed based on data collected during the site investigation and available published data. The model has been attached at Drawing 2, showing a simplified version of the geology and hydrogeology occurring beneath the Site.

3.3 Source Term

The contaminants ammonia (as total ammonia as N) and phosphate (as total phosphate as P) have been assessed. The Environmental Assessment Level (EAL) for total ammonia as N has been set as the UK DWS at 0.5mg/L. The EAL for total phosphate as P has been set as the River Wye SAC (at Redbrook Bridge) target at 0.039mg/L.

The concentration of ammonia and phosphate in the treated sewage effluent source term has been set at 20mg/L and 6.6mg/L respectively, based on information from WPL about the PTP.

The Site includes the discharge of treated effluent from a maximum of 70 no. persons using the campsite and dwellings to a drainage ditch. A maximum foul water discharge has been provided by the PTP manufacturer, at 3.75m^3/day.

3.4 Pathway

The treated foul effluent will be modelled as a zone of approximately 25m long in the direction of anticipated groundwater flow and 1m long perpendicular to the anticipated groundwater flow. The drainage ditch thickness is understood to be 0.6m. This has been based on information provided by the Client regarding the constructed drainage ditch, with an anticipated flow direction to the west based on the topographical contours.

The unsaturated zone thickness of 3m below the base of the drainage ditch is based on site investigations conducted by Hydrogeo at the Site. The unsaturated zone is likely to be greater than 3m, with only minor groundwater seepages noted in trial pits dug to 3.6mBGL near the drainage ditch. An unsaturated zone thickness of 3m has been chosen as a means of conservatism.

3.5 Receptors

The modelled receptor will be a pond (within the farmhouse ownership boundary) located 107m from the drainage ditch. This receptor has been set as the compliance point utilised in the modelling due to the change in elevation from the drainage ditch to the pond (50mAOD to 40mAOD) and the anticipated direction of groundwater flow.

The underlying Raglan Mudstone Formation Secondary A aquifer and the River Trothy are other environmental receptors and have been shown on the CSM in Drawing 2.

3.6 Modelling – Ammonia

Infiltration System

The worksheet input values used for the infiltration system have been listed in Table 3-1.

Table 3-1 – Infiltration system input values

Parameter	Value	Source	Comment
Concentration of total ammonia as N	20mg/L	Information from WPL about the PTP	Anticipated concentration within treated effluent
Number of persons	70	Information from WPL about the PTP	Maximum number of persons (dwelling + campsite)
Water use	150L per person per day	Flows and Loads 4	Standard residential / fully serviced tent site
Percolation rate	57.5 s/mm	Initial NRW L1 assessment	Average of values utilised by NRW in initial assessment
Discharge rate	3.75m³/day	Information from WPL about the PTP	Anticipated maximum daily discharge rate
Area of drainage field	25m²	Information provided by the Client	Understood to be 25m long x 1m wide

Attenuation in Unsaturated Zone

The worksheet input values used for attenuation in the unsaturated zone have been listed in Table 3-2.

Table 3-2 – Attenuation in unsaturated zone input values

Parameter	Value	Source	Comment
Drainage Layer			
Thickness	0.6m	BS 6297:2007 + A1:2008	Standard depth <1.0m, assumed thickness of 0.6m
Water-filled porosity	0.30	ConSim Parameter Database	Midway between min. and max. value for gravel
Bulk density	1.78 g/cm³	ConSim Parameter Database	Midway between min. and max. value for gravel

Half life	730 days	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 1-2 years
Soil-water partition coefficient	1.25 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Midway between suggested value 0.5-2 l/kg
Unsaturated Zone			
Thickness	3m	Hydrogeo site investigation (09/01/25)	Only minor water seepages encountered, 3m applied for conservatism
Water-filled porosity	0.235	ConSim Parameter Database	50% mid value between min. and max. total porosity for clay
Bulk density	1.7g/cm³	ConSim Parameter Database	Midway between min. and max. value for clay
Half life	730 days	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 2-5 years
Rapid flow	0	n/a	Assumed no rapid flow through unsaturated zone
Soil-water partition coefficient	1.25 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Midway between suggested value 0.5-2 l/kg

Dilution

The worksheet input values used for dilution have been listed in Table 3-3.

Table 3-3 – Dilution input values

Parameter	Value	Source	Comment
Length of drainage field in direction of groundwater flow	25m	Information provided by the Client	Understood to be 25m long x 1m wide
Saturated aquifer thickness	40m	BGS – Hydrogeology of Wales – The Old Red Sandstone aquifer - groundwater occurrences	Effective saturated thickness is ~40m. The spreadsheet calculates a mixing zone

Hydraulic conductivity	1.28m/day	BGS – Hydrogeology of Wales – The Old Red Sandstone aquifer - groundwater occurrences	Transmissivity of 51m²/day, assumed productive aquifer thickness of 40m
Hydraulic gradient	0.093	Topographic gradient/OS Map	Assumed groundwater gradient is approximate to topographic gradient
Length of drainage field perpendicular to groundwater flow	1m	Information provided by the Client	Understood to be 25m long x 1m wide
Background concentration	0mg/l	n/a	Assume no background total ammonia as N

Attenuation in Saturated Zone

The worksheet input values used for attenuation in the saturated zone have been listed in Table 3-4.

Table 3-4 – Attenuation in saturated zone input values

Parameter	Value	Source	Comment
Half life	1850 days	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 5 years (lower nitrification rates in the saturated zone)
Bulk density	1.7g/cm³	ConSim Parameter Database	Midway between min. and max. value for clay
Effective porosity	0.47	ConSim Parameter Database	Midway between min. and max. value for clay
Distance to compliance point	112m	QGIS measurement	Compliance point at lower elevation pond within ownership boundary in direction of groundwater flow
Soil-water partition coefficient	1.25 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Midway between suggested value 0.5-2 l/kg

3.7 Modelling – Phosphate

Phosphate Attenuation in Drainage Fields

A recent study of phosphorous attenuation at 24 no. septic systems over a 30-year period (Robertson et al, 2019)[1] has been reviewed. The study reports an average 90% retention of phosphorous concentration in the drainage fields for non-calcareous sediment. When taking into account the unsaturated and saturated zones, the reduction of phosphorous was found to average 97% at a 10m distance down hydraulic gradient under the same soil conditions. The groundwater depths for the 24 no. septic systems studied ranged between 1mBGL and 5mBGL, with an average of 1.9mBGL, higher than the level anticipated at the Site.

The authors of the study conclude that *"To successfully predict septic system P*[hosphorous] *loading at the watershed scale, models need to also include the important effect of P retention in the drainfields and not just focus on sorption".*

The reported 97% reduction at 10m downgradient of the discharge location is in accordance with the study undertaken by May et al. (2015)[2] and therefore the findings of the studies can be considered to be reliable.

According to guidance from NRW, private sewage treatment systems discharging domestic wastewater to ground which are located more than 50m from a SAC boundary, and which have a maximum daily discharge rate of less than 2m³ are unlikely to increase phosphate inputs.

Considering the slightly elevated discharge rate of 3.75m^3/day, the modelling of phosphate will be conducted to predict the phosphate concentration at the 107m compliance point.

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[1] Robertson, W. D., Van Stempvoort, D. R. & Schiff, S. L. (2019) *Review of phosphorous attenuation in groundwater plumes from 24 septic systems.* Science of the Total Environment 662. pp 640-652.

[2] May, L., Withers, P. J. Stratford, C., Bowes, M., Robinson, D. & Gozzard, E. 2015. *Development of a risk assessment tool to assess the significance of septic tanks around freshwater SSSIs: Phase 1 – Understanding better the retention of phosphorous in the drainage field.* Natural England Commissioned Reports, NECR171.

Infiltration System

The worksheet input values used for the infiltration system have been listed in Table 3-5.

Table 3-5 – Infiltration system input values

Parameter	Value	Source	Comment
Concentration of total phosphate as P	6.6mg/L	Information from WPL about the PTP	Anticipated maximum concentration within treated effluent
Number of persons	70	Information from WPL about the PTP	Maximum number of persons (dwelling + campsite)
Water use	150L per person per day	Flows and Loads 4	Standard residential / fully serviced tent site
Percolation rate	57.5 s/mm	Initial NRW L1 assessment	Average of values utilised by NRW in initial assessment
Discharge rate	3.75m³/day	Information from WPL about the PTP	Anticipated maximum daily discharge rate
Area of drainage field	25m²	Information provided by the Client	Understood to be 25m long x 1m wide

Attenuation in Unsaturated Zone

The worksheet input values used for attenuation in the unsaturated zone have been listed in Table 3-6.

Table 3-6 – Attenuation in unsaturated zone input values

Parameter	Value	Source	Comment
Drainage Layer			
Thickness	0.6m	BS 6297:2007 + A1:2008	Standard depth <1.0m, assumed thickness of 0.6m
Water-filled porosity	0.30	ConSim Parameter Database	Midway between min. and max. value for gravel
Bulk density	1.78 g/cm³	ConSim Parameter Database	Midway between min. and max. value for gravel
Half life	3.2 days	Iteratively derived	Calculated to retain 90% in drainage ditch

Parameter	Value	Source	Comment
Soil-water partition coefficient	1.25 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Midway between suggested value of 0.5-2 l/kg
Unsaturated Zone			
Thickness	3m	Hydrogeo site investigation (09/01/25)	Only minor water seepages encountered, 3m applied for conservatism
Water-filled porosity	0.235	ConSim Parameter Database	Half of midway between min. and max. value for clay
Bulk density	1.7g/cm³	ConSim Parameter Database	Midway between min. and max. value for clay
Half life	$1x10^{99}$ days	n/a	Very high value set – no degradation
Rapid flow	0	n/a	Assumed no rapid flow through unsaturated zone
Soil-water partition coefficient	1.25 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Midway between suggested value of 0.5-2 l/kg

In order to include in the model the effect of 90% phosphate retention in the drainage field, the half-life in the drainage layer has been iteratively derived (3.2 days) in order to calculate a concentration at the base of the drainage layer that is approximately 10% of the effluent concentration (0.66mg/L).

Dilution

The worksheet input values used for dilution have been listed in Table 3-7.

Table 3-7 – Dilution input values

Parameter	Value	Source	Comment
Length of drainage field in direction of groundwater flow	25m	Information provided by the Client	Understood to be 25m long x 1m wide
Saturated aquifer thickness	40m	BGS – Hydrogeology of Wales - groundwater occurrences	Effective saturated thickness is ~40m

Parameter	Value	Source	Comment
Hydraulic conductivity	1.28m/day	BGS – the physical properties of minor aquifers in England and Wales	Transmissivity of 51m²/day, assumed productive aquifer thickness of 40m
Hydraulic gradient	0.093	Topographic gradient/OS Map	Assumed groundwater gradient is approximate to topographic gradient
Length of drainage field perpendicular to groundwater flow	1m	Information provided by the Client	Understood to be 25m long x 1m wide
Background concentration	0mg/l	n/a	No testing undertaken, assume no background total ammonia as N

An informative is highlighted within the model spreadsheet which indicates that the area of the drainage field (width x length) is not equal to the area (A) specified in the infiltration system model. The informative states this may be OK if the drainage field is at angle to the flow direction, which is the case for this Site.

Attenuation in Saturated Zone

The worksheet input values used for attenuation in the saturated zone have been listed in Table 3-8.

Table 3-8 – Attenuation in saturated zone input values

Parameter	Value	Source	Comment
Half life	$1x10^{99}$ days	n/a	Very high value set – no degradation
Bulk density	1.7g/cm³	ConSim Parameter Database	Midway between min. and max. value for clay
Effective porosity	0.47	ConSim Parameter Database	Midway between min. and max. value for clay
Distance to compliance point	107m	QGIS measurement	Compliance point at lower elevation pond within ownership boundary in direction of groundwater flow

Parameter	Value	Source	Comment
Soil-water partition coefficient	1.25 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Midway between suggested value of 0.5-2 l/kg

In order to incorporate into the model the effect of 97% phosphate retention in groundwater 10m down gradient of the drainage field, the half-life in the saturated zone is iteratively derived in order to calculate a concentration at 10m down gradient that is approximately 3% of the effluent concentration (0.20mg/L). Using a very high value for the decay rate ($1x10^{99}$ days) results in a lower concentration than 3% due to the dilution.

3.8 Ammonia Model Results

The infiltration model for ammonia has been attached as Appendix A and the results are presented in Table 3-9.

The results of the modelling predict that:

- The concentration of total ammonia as N at the base of the unsaturated zone will exceed the EAL;
- The concentration of total ammonia as N in groundwater below the drainage ditch will exceed the EAL;
- The concentration of total ammonia as N at the compliance point 107m down hydraulic gradient of the drainage ditch location will fall below the EAL;
- The concentration of total ammonia as N will fall below the EAL at a point 66m down hydraulic gradient of the drainage ditch.

Table 3-9 – Ammonia model results

Parameter	Total Ammonia as N (mg/L)	Target concentration (mg/L)
Concentration at base of unsaturated zone	18.90	0.5
Concentration in groundwater below drainage ditch	10.70	
Concentration at compliance point (107m)	0.295	

3.9 Phosphate Model Results

The infiltration model for phosphate has been attached as Appendix B and the results are presented in Table 3-10.

The results of the modelling predict that:

- The concentration of total phosphate as P at the base of the unsaturated zone will exceed the EAL;
- The concentration of total phosphate as P in the groundwater below the drainage field will fall below the EAL;
- The concentration of total phosphate as P at the compliance point 107m down hydraulic gradient of the proposed drainage field location will fall below the EAL.

Table 3-10 – Phosphate model results

Parameter	Total Phosphate as P (mg/L)	Target concentration (mg/L)
Concentration at base of unsaturated zone	1.04	0.039
Concentration in groundwater below drainage field	0.059	
Concentration at compliance point (107m)	0.024	

3.10 Sensitivity Analysis – Degradation of Ammonia

Further modelling has been undertaken on a conservative basis in order to form a sensitivity analysis, with degradation of ammonia occurring only in the dissolved phase within the unsaturated and saturated zones and with no degradation occurring within the unsaturated and saturated zones.

The model inputs remain the same as shown in Table 3-1 to Table 3-4. The sensitivity analysis model results are presented in Table 3-11.

The results of the sensitivity analysis modelling with degradation only in the dissolved phase predict that:

- The concentration of total ammonia as N at the base of the unsaturated zone will exceed the EAL;
- The concentration of total ammonia as N in the groundwater below the drainage field will exceed the EAL;
- The concentration of total ammonia as N at the compliance point will fall below the EAL.

The results of the sensitivity analysis modelling with no degradation predict that:

- The concentration of total ammonia as N at the base of the unsaturated zone will exceed the EAL;
- The concentration of total ammonia as N in the groundwater below the drainage field will exceed the EAL;
- The concentration of total ammonia as N at the compliance point will fall below the EAL.

Table 3-11 – Degradation sensitivity analysis model results

Parameter	Total Ammonia as N (mg/l)	
	Degradation in dissolved phase only	No degradation
Concentration at base of unsaturated zone	19.90	20.00
Concentration in groundwater below drainage field	11.20	11.30
Concentration at compliance point	0.310	0.311

3.11 Sensitivity Analysis – Percolation Rate

It is understood that percolation testing was not conducted onsite during the drainage field construction, however the drainage field functions and accepts the discharge flow rate. In NRW's initial L1 Assessment of the treated effluent discharge to ground, a British Standard complaint range (Vp 15 – 100s/mm) was utilised.

A sensitivity analysis conducted for both ammonia and phosphate, where the 2 no. models were rerun at both 15s/mm and 100s/mm percolation rate. The analysis showed no change in total ammonia as N or total phosphate as P concentration at any stage of the modelling.

Hence, a midway value of 57.5s/mm was used for both ammonia and phosphate worksheets.

4 Summary and Conclusions

4.1 Summary

Hydrogeo Ltd (Hydrogeo) has been commissioned by Ridgeway Contractors Ltd (the Client) to undertake a quantitative groundwater risk assessment for the installed treated effluent discharge to ground at the camping site situated on the grounds of Hendre Farmhouse (the Site).

The purpose of the risk assessment is to investigate the risk of the treated effluent to ground to proven environmental receptors.

Site-specific modelling input values have been derived from site investigation findings, literature and available online resources.

4.2 Groundwater Risk Assessment

The Environment Agency Infiltration Worksheet v3.0 (2022) has been used to predict the concentration of total ammonia as N and total phosphate as P in the groundwater down hydraulic gradient of the drainage ditch.

The model predicts that the concentration of total ammonia as N at the 107m compliance point will fall below the UK Drinking Water Standard.

The model predicts that the concentration of total ammonia as N will fall below the UK Drinking Water Standard at a point 66m down hydraulic gradient.

The model predicts that the concentration of total phosphate as P at the 107m compliance point will fall below the River Wye SAC target (at Redbrook Bridge).

A sensitivity analysis model of the degradation of ammonia was undertaken which showed that, with no degradation occurring in the unsaturated and saturated zones, the concentration of total ammonia as N at the 107m compliance point would still fall below the UK Drinking Water Standard. Significant attenuation is anticipated within the bedrock and therefore this analysis is representative only.

The closest environmental receptor to the Site is the groundwater present within the Raglan Mudstone Formation Secondary A aquifer. The depth of groundwater below the Site was not recorded (only minor water seepages), so a conservative value of 3m was utilised in modelling. However, groundwater is anticipated to be deeper than this, as

indicated by deep groundwater levels in the Raglan Mudstone Formation, at between 15-52mBGL, encountered in nearby borehole records and the driller's observations of the onsite abstraction borehole (confined groundwater at ~60mBGL).

The closest sensitive environmental receptor to the Site is a pond (within the farmhouse ownership boundary) located at a lower elevation than the drainage ditch, 107m down hydraulic gradient. The next closest environmental receptor is the River Trothy, located ~240m down hydraulic gradient of the ditch.

4.3 Modelling Conclusions

Based on the modelled concentrations of total ammonia as N, and the anticipated greater thickness of the unsaturated zone, the risk posed to groundwater quality beneath the Site from the discharge of treated effluent to ground is considered to be Low.

Based on the modelled concentration of total ammonia as N falling below the UK DWS at the 112m compliance point, the risk posed to the environmental receptors (pond and River Trothy) from the discharge of treated effluent to ground at the Site is considered to be Low.

Based on the modelled concentration of total phosphate as P at the 107m compliance point falling below the River Wye SAC (at Redbrook Bridge) target, and using the maximum concertation value of phosphate (6.6mg/L) in effluent discharge as provided by WPL, the risk posed to environmental receptors and other groundwater dependent receptors from the discharge of treated effluent to ground at the Site is considered to be Low.

Drawings

Drawing 1

Site investigation plan

HYDROGEO

HYG1354 Hendre Farmhouse

DRAWING 1

Site Investigation Plan

KEY

- Site Boundary
- Trial Pit
- Drainage Ditch
- Inspection Chamber
- Package Treatment Plant
- Underground Pipe
- Indicative Groundwater Flow Direction

Contains Google Satellite imagery
© Google [2023]

Topographic contours constructed using 2m DTM data courtesy of DataMapWales LiDAR Data Download

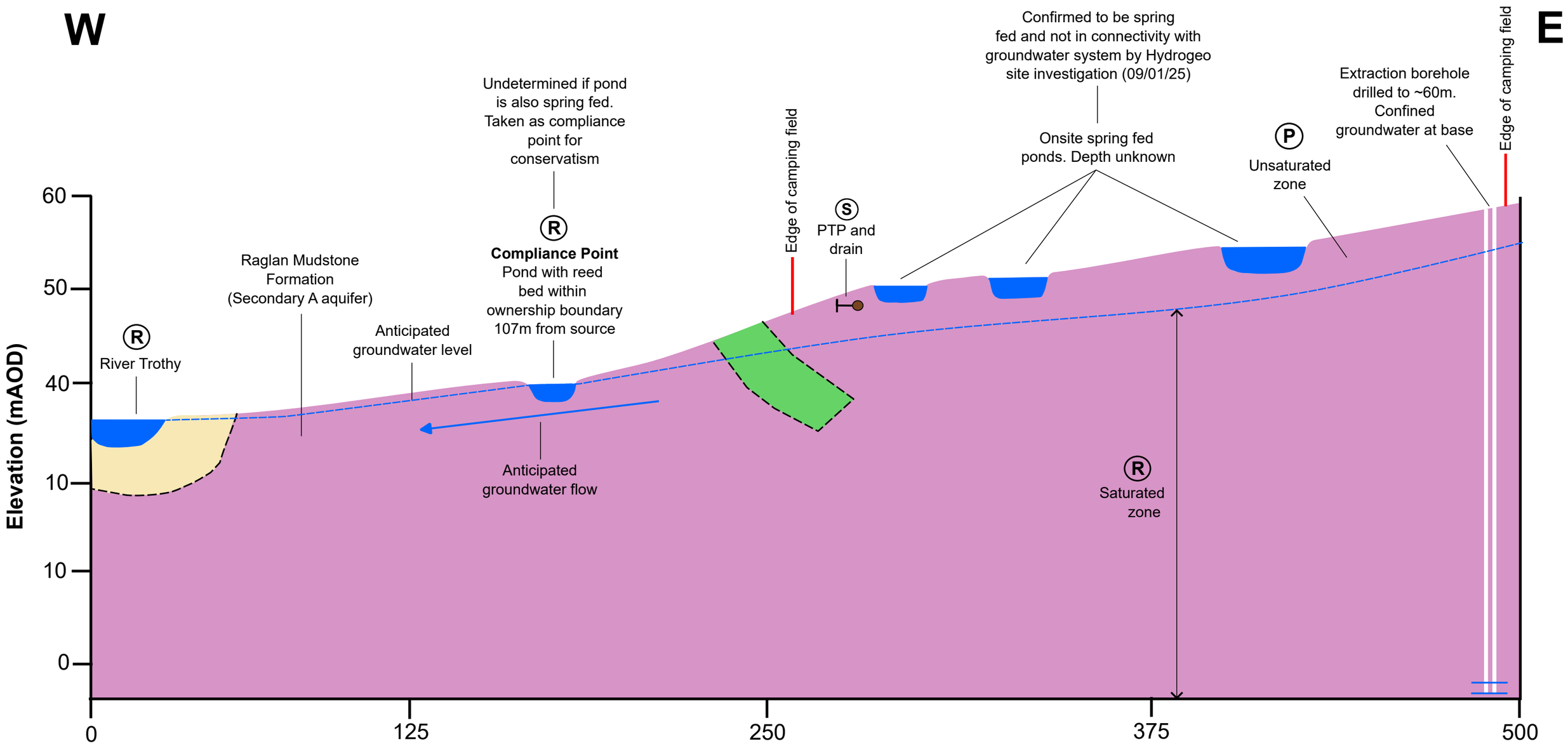
0 5 10 15 20 m

N

Date	By	Paper	Scale	Rev
January 2025	WO	A3	1:450	1

Drawing 2

Conceptual site model



KEY

- Alluvium
- Townsend Tuff
- Raglan Mudstone Formation

- S SOURCE
- P PATHWAY
- R RECEPTOR

HYDROGEO LTD
Unit 4 Waddington House
Llanover Business Centre
Llanover
Abergavenny
Monmouthshire
NP7 9HA

Project:	HYG1354
Client:	Ridgeway Contractors Ltd
Drawing Title:	Conceptual Site Model
Date:	January 2025
Drawing No:	2 Revision:1 Version 1
Scale:	Not to scale
Drawn:	WO
Notes:	

Appendices

Appendix A

Infiltration model - ammonia [Electronic]

Appendix B

Infiltration model – phosphate [Electronic]