Quantitative Groundwater Risk Assessment

Llanellen Care Home

Llanellen Court, Llanellen, NP7 9HT

On Behalf of

Morspan Holdings Ltd

Quality Management

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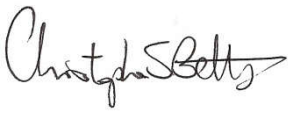
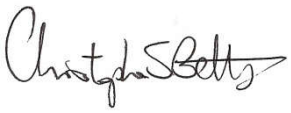
Reviewed and Authorized by:	Chris Betts BSc MSc FGS CGeol	
Calculations Approved by:	Chris Betts BSc MSc FGS CGeol	
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1 Introduction

1.1 Background

Hydrogeo Ltd (Hydrogeo) has been commissioned by Morspan Holdings Ltd (the Client) to undertake a quantitative groundwater risk assessment for the proposed treated effluent discharge to ground at the redundant agricultural buildings located with Llanellen Court (the Site).

The Site is located at Llanellen Court, Llanellen, NP7 9HT. The grid reference to the centre of the Site is 330180, 210572.

The development proposal is for the conversion of the redundant agricultural building into a 40-bed care home with associated car parking and gardens. The proposed Site layout has been attached as Appendix A.

It is proposed that the foul effluent from the development will be discharged to ground following treatment in a package treatment plant (PTP). The proposed PTP is a Klargester BioDisc Commercial Sewage Treatment Plant BJ model which is capable of producing a final effluent discharge standard of 5mg/l of ammonia and 2mg/l of phosphate.

This report has been progressed in support of planning application DM/2021/01644. Natural Resources Wales (NRW) have requested a groundwater risk assessment for the discharge of treated foul effluent to ground and the potential risk posed to environmental receptors.

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 232 – Abergavenny, Solid and Drift, 1990;
- 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 Site boundary is shown in Figure 1-2.

Figure 1-1 – Site location.

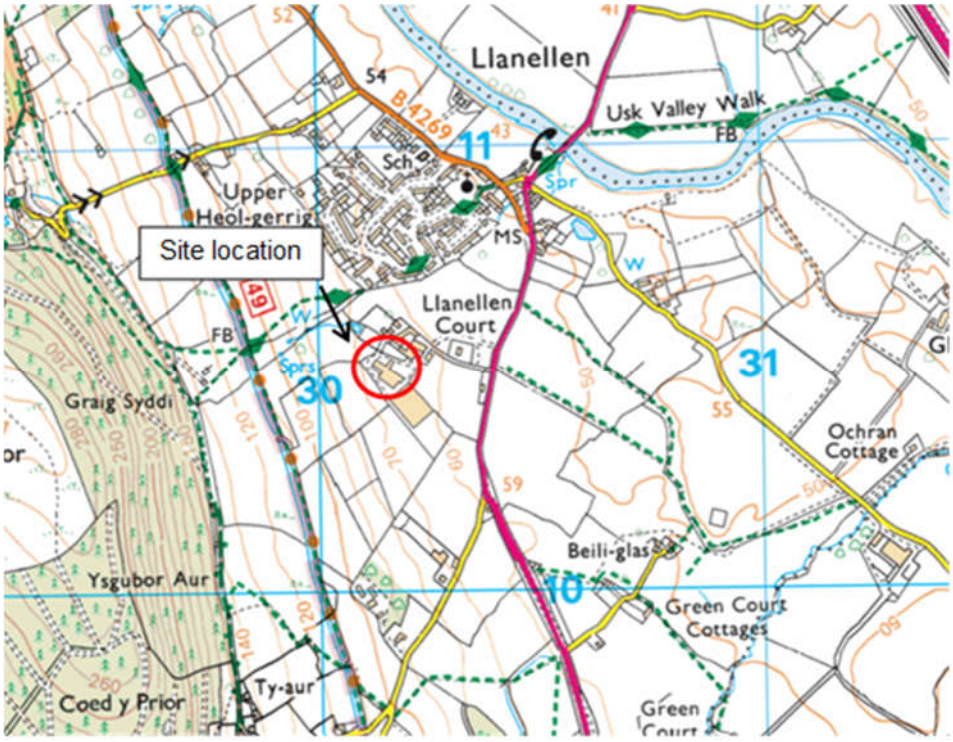


Figure 1-2 – Site boundary.

The Site is located in a rural setting surrounded by agricultural land to the east and west, a residential farmhouse to the north and disused poultry sheds to the south.

The Site slopes gently east from 68m Above Ordnance Datum (AOD) in the north-west to 62mAOD in the south-east.

The Site currently comprises a disused agricultural poultry unit made up of 2 buildings with a compacted gravel track around the perimeter, and a field to the south-east across an access road.

1.4 Previous Reporting

Hydrogeo previously undertook a Treated Effluent Drainage Strategy Report in August 2023. This report included a site investigation consisting of 6no. percolation pits and 1no. trial pit. Percolation testing of the pits indicated the Site is suitable for a drainage field, with an average percolation rate (Vp) of 32 s/mm. The trial pit showed the absence of groundwater beneath the Site to 1.8mbgl.

1.5 Geology

Artificial Deposits

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

Superficial Geology

The Site is mapped as being predominantly underlain by Glaciofluvial Sand and Gravel from the Devensian period. The BGS describes this deposit as *"mainly coarse-grained sediments deposited by meltwater streams, locally with lenses of silt, clay or organic material".*

An area, approximately 4m wide, along the western Site boundary is mapped as being underlain by Till from the Devensian period. The BGS describes this deposit as *"an unsorted mixture of clay, sand, gravel and boulders deposited directly by and underneath a glacier".*

The superficial deposits underlying the Site have been shown in Figure 1-3.

Figure 1-3 – Superficial deposits beneath the Site.

Contains British Geological Survey materials [C10/018] © NERC 2024.
Contains Bing satellite imagery © Microsoft 2024.

Bedrock Geology

The Site is mapped as being underlain by interbedded argillaceous rocks and sandstone of the St Maughan's Formation. This formation is described by the BGS as *"interbedded purple, brown and green sandstones and red mudstones with intraformational conglomerates containing calcrete clasts".*

Observed Geology

During the previous site investigation undertaken by Hydrogeo in March 2023, the following geology was observed:

- Ground level – 0.3m brown sandy gravelly CLAY with rootlets [Topsoil];
- 0.3m – 0.6m light brown sandy CLAY with rounded cobbles [Glaciofluvial Sheet Deposits];
- 0.6m – 1.8m light brown CLAY with subangular cobbles from 1.5m [weathered St Maughan's Formation].

Soil Characteristics

The soil beneath the Site is classed by the UK Soil Observatory as *"Freely draining slightly acid loamy soils".*

BGS Borehole Records

There are 4no. borehole records available online within 1km of the Site. Their details are outlined in Table 1-1 below.

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

BH Details	Observed Geology
BGS ID: SO31SW103 Location: 493m SE Elevation: 58mAOD Geology: Glaciofluvial Sheet Deposits, St Maughan's Formation	▪ 0 – 0.4 brown sandy pebbly TOPSOIL ▪ 0.4 – 6.4m red brown clayey coarse GRAVEL ▪ 6.4 – 6.6m red brown very clayey pebbly fine SAND
BGS ID: SO21SE298 Location: 682m NW Elevation: 113mAOD Geology: Till, St Maughan's Formation	▪ 0 – 0.9m TOPSOIL ▪ 0.9 – 2.5m MADE GROUND ▪ 2.5 – 5.6m loose clayey SAND with cobbles and boulders ▪ 5.6 – 7.5m fine to coarse SAND and GRAVEL ▪ 7.5 – 8.1m stiff red brown sandy CLAY
BGS ID: SO30NW60 Location: 805m SW Elevation: 119mAOD Geology: Till, St Maughan's Formation	▪ 0 – 0.4m TOPSOIL ▪ 0.4 – 59.4m red marls Water struck at 21, 32 & 56mbgl. Rest water level at 33mbgl.
BGS ID: SO20NE128 Location: 818m SW Elevation: 144mAOD Geology: Till, St Maughan's Formation	▪ 0 – 0.5m MADE GROUND ▪ 0.5 – 6m brown CLAY ▪ 6 – 42m medium hard red marls ▪ 42 – 60m medium hard red/grey marls with sandstone bands Water struck at 46mbgl. Rest water level at 42.3mbgl.

1.6 Hydrogeology

BGS mapping data indicates that the majority of the Site is underlain by Glaciofluvial Sheet Deposits. These are classified as a Secondary A aquifer which are aquifers with potential for local importance and may form a baseflow to local surface water systems. Any water found within these deposits would be expected to be in hydraulic continuity with the River Usk as the catchment river for the area.

No borehole records within the Site vicinity indicate the presence of groundwater within the Glaciofluvial Sheet Deposits, therefore a continuous groundwater level is not anticipated. However, there is the potential for areas of perched groundwater within the deposits which can be supported above lenses of low permeability clay.

Any groundwater within the Glaciofluvial Sheet Deposits is likely to be vulnerable to surface pollution, which may then pollute the River Usk if the water is in hydraulic continuity.

The Till deposits found at the western edge of the Site are classified as a Secondary Undifferentiated aquifer. Due to the clay content, the Till has low permeability and typically confines water within underlying aquifers and limits recharge. No Till deposits are anticipated beneath the proposed drainage field location and as such any underlying groundwater will not be confined.

The St Maughan's Formation bedrock underneath the Site has been classified as a Secondary A aquifer. 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 nearest borehole record to the Site with groundwater information records water strikes at 21, 32 and 56mbgl within the St Maughan's Formation, with a rest water level at 33mbgl. This indicates that there are multiple water-bearing sandstone layers within the bedrock which may be confined by low permeability layers. Another borehole record with groundwater information records a water strike at 46mbgl within the St Maughan's Formation with a rest water level at 42mbgl, indicating that some of the water-bearing sandstone layers are confined under-pressure.

Beneath the Site, the groundwater level is anticipated to be within the bedrock at approximately 20mbgl (40mAOD). This is based on the depth to groundwater seen in local borehole records and the presence of the River Usk at approximately 35mAOD down gradient of the Site.

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. The topographic contours of the area show the ground rising to the west and falling to the east of the Site, and so the groundwater flow direction is anticipated to be eastwards. The topographic gradient is higher to the west and lower to the east, 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 0.083 by taking the change in elevation from 80mAOD to 60mAOD which covers a distance of 241m in the anticipated direction of groundwater flow.

1.7 Environmental Designations

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

1.8 Hydrology

Ordnance Survey mapping indicates the presence of springs 240m north-east of the Site at an elevation of 90-100mAOD. The springs form a small unnamed stream which flows eastwards to a small pond located 125m north of the Site at an approximate elevation of 68mAOD. The Monmouthshire and Brecon canal is located 304m to the west of the Site at an elevation of 110mAOD. These features are at a higher elevation than the proposed drainage field which will be at approximately 65mAOD.

The main river is the River Usk, located 625m north-east of the Site at an approximate elevation of 35mAOD, which flows south-eastwards. The River Usk is designated as a Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC).

1.9 Licensed Water Abstractions

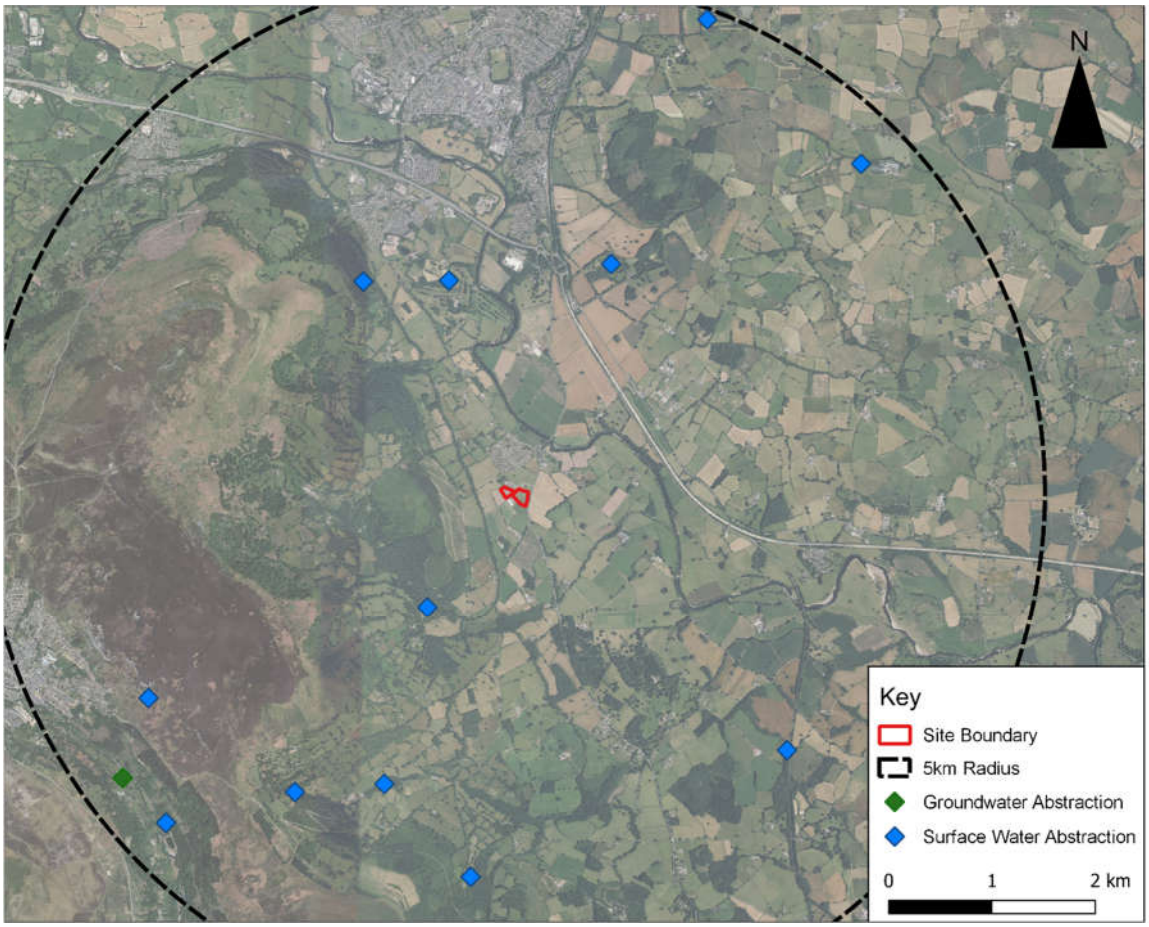
There is 1no. licensed groundwater abstraction and 12no. licensed surface water abstractions within 5km of the Site. No licensed abstractions are located within 1km of the Site. Their details are outlined in Table 1-2 and their locations are shown in Figure 1-4.

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

Distance	Abstraction Type	Purpose	Source
1.4km SW	Surface	Public water supply	Groundwater fed spring
2.1km N	Surface	Commercial irrigation	Unnamed tributary of River Usk
2.4km N	Surface	Agriculture	Groundwater fed spring
2.5km N	Surface	Horticulture	Nant Craf Stream
3.1km SW	Surface	Hydroelectric power generation	Gwenffrwd stream
3.6km SW	Surface	Unknown	Gwenffrwd stream
3.7km SW	Surface	Agriculture	Groundwater fed spring

Distance	Abstraction Type	Purpose	Source
3.7km SE	Surface	Agriculture	Ochram Brook
4.0km SW	Surface	Public water supply	Groundwater fed spring
4.6km SW	Surface	Public water supply	Afon Lwyd
4.6km SW	Ground	Public water supply	Castell Coch Limestone Formation
4.7km NE	Surface	Agriculture	Groundwater fed spring
5.0km NE	Surface	Agriculture	Pond

Figure 1-4 – Licensed water abstractions within 5km of the Site.



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1.10 Private Water Abstractions

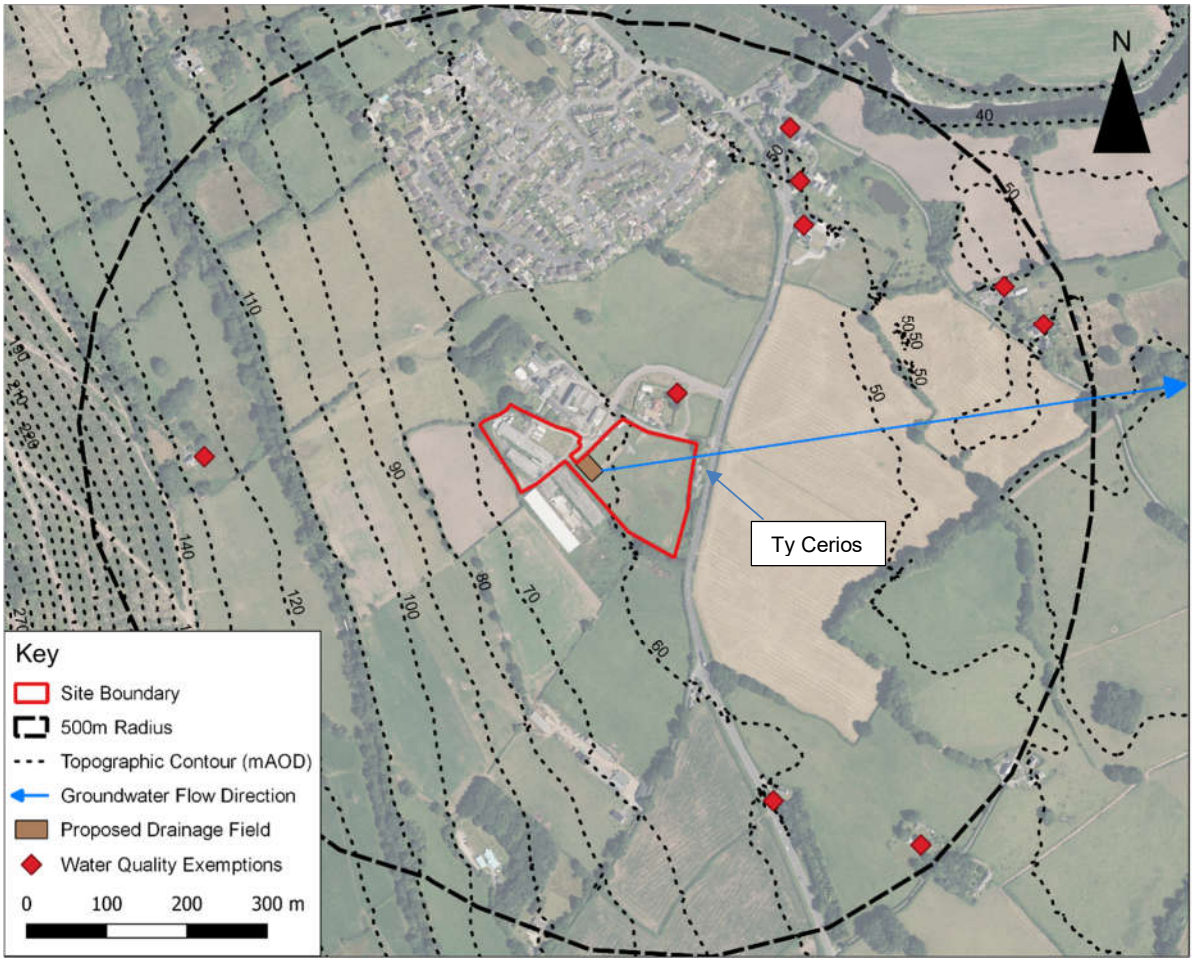
Monmouthshire County Council were contacted to enquire about the positions of any private water supplies within the Site vicinity. According to their records, there are 3no. registered private water supplies within 1km of the Site. 2no. of these are located approximately north-west of the Site between 750m and 1km away and 1no. of these is located approximately south-west of the Site between 750m and 1km away.

1.11 Water Quality Exemptions

There are 9no. water quality exemptions registered within 500m of the Site. These are all for discharge to ground of $\leq 2m^3$. Their locations are shown in Figure 1-5. The nearest water quality exemption is located 132m from the proposed drainage field. However, this exemption is not located directly down hydraulic gradient of the drainage field and therefore interaction between discharges would not be expected.

The property Ty Cerios is understood to have foul drainage to a septic tank and soakaway. The exact position is unknown, however it is expected to be approximately 120m to the east of the drainage field.

Figure 1-5 – Water quality exemptions within 500m of the Site.



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2 Groundwater Risk Assessment

2.1 Introduction

The proposal for the drainage scheme for the development includes discharging treated effluent to ground via a drainage field.

The EA H1 Annex J5: Infiltration Worksheet has been used to assess the risk posed by discharging treated sewage effluent to the underlying geology. 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 Usk SAC target respectively to determine if the effluent discharge poses a risk to the surface water system and any other water receptors.

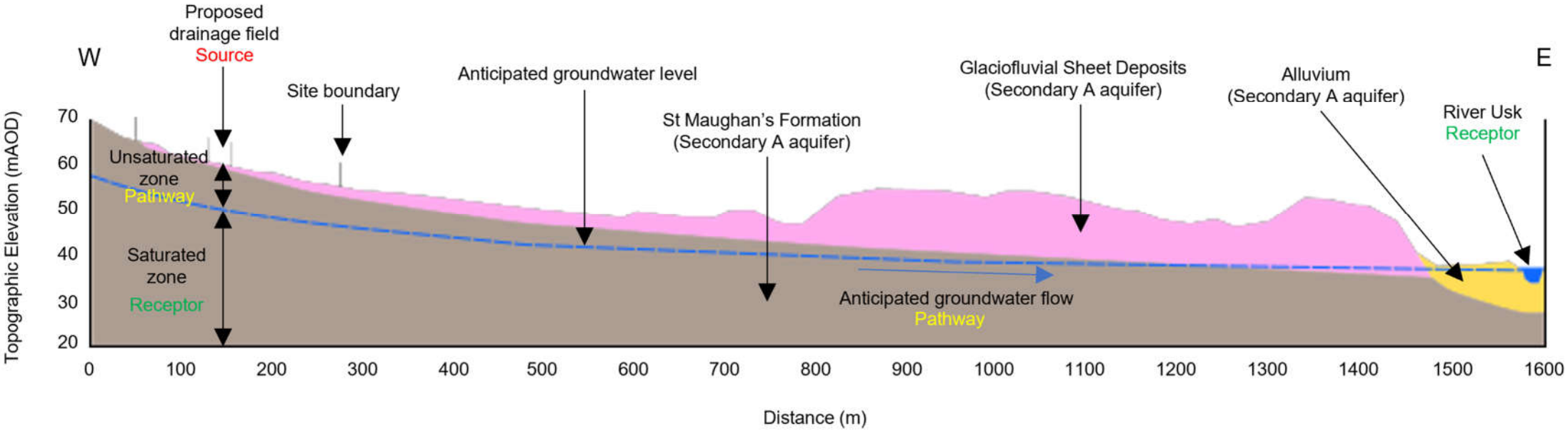
The literature data sources used for modelling are listed below:

- British Geological Survey (BGS) online data;
- BGS 1:50,000 Geology Map Sheet 232 – Abergavenny, Solid and Drift, 1990;
- 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.

2.2 Conceptual Site Model

A conceptual site model (CSM) has been developed based on available site investigation and published data. The model has been shown visually in Figure 2-1 as a simplified version of the geology and hydrogeology occurring beneath the Site.

Figure 2-1 – Generalised Conceptual Site Model.



2.3 Source Term

The contaminants ammonia (as total ammonia as N) and phosphate (as total phosphate as P) have been used in modelling. 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 Usk SAC target at 0.05mg/l.

The concentration of ammonia and phosphate in the treated sewage effluent source term has been set at 5mg/l and 2mg/l respectively, based on information from Klargester about the proposed PTP.

The proposal at the Site includes the discharge of treated effluent from 40no. residents and associated staff in the care home to a drainage field. A maximum total foul water discharge from the proposed development has been calculated using the Flows and Loads 4 – Sizing Criteria, Treatment Capacity for Sewage Treatment Systems by British Water. The expected loading has been calculated to be 16m³/day, including an allowance for visitors.

2.4 Pathway

The treated foul effluent will be modelled as a zone of approximately 26.8m long in the direction of anticipated groundwater flow and 30.3m long perpendicular to the anticipated groundwater flow.

This has been calculated from the drainage field design in the Treated Effluent Drainage Strategy Report (Hydrogeo, 2023) with an anticipated flow direction to the east based on the topographical contours.

The unsaturated zone thickness of 6m below the base of the drainage field is based on the nearest borehole record to the Site. The drainage field thickness has been designed to be 0.6m. This borehole, located 493m south-east of the Site, was drilled to a maximum depth of 6.6m and no water was encountered. Other local borehole records and the level of the nearest river indicate that the unsaturated zone thickness is likely to be greater, at approximately 20m, however as this has not been proven at the Site the minimum 6.6m has been used.

2.5 Receptors

The modelled receptor will be the River Usk located 1.4km from the proposed drainage field in the direction of anticipated groundwater flow.

A compliance point at the edge of the ownership boundary in the direction of anticipated groundwater flow has been used. This compliance point is 112m from the proposed drainage field.

The underlying St Maughan's Formation Secondary A aquifer is another environmental receptor and has been shown on the CSM in Figure 2-1.

2.6 Modelling – Ammonia

Infiltration System

The worksheet input values used for the infiltration system have been listed in Table 2-1.

Table 2-1 – Infiltration system input values.

Parameter	Value	Source	Comment
Concentration of total ammonia as N	5mg/l	Information from Klargester about proposed PTP	Anticipated concentration within treated effluent
Number of persons	45.7	Flows and Loads 4	Residents and average staff per day
Water use	350L per person per day	Flows and Loads 4	Care home residents
Percolation rate	32 s/mm	Previous site investigation	Average of percolation test results by Hydrogeo, March 2023
Discharge rate	16m³	Flows and Loads 4	Number of persons x water use
Area of drainage field	314m²	Previous reporting	Drainage field design produced by Hydrogeo, August 2023

Attenuation in Unsaturated Zone

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

Table 2-2 – 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	0.25	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 20-30%
Bulk density	1.7 g/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 1-2 years
Soil-water partition coefficient	0.5 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 0.5-2 l/kg
Unsaturated Zone			
Thickness	6m	BGS borehole records	Closest proven unsaturated zone 6.6m, anticipated to be greater
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	0.5 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 0.5-2 l/kg

Dilution

The worksheet input values used for dilution have been listed in Table 2-3.

Table 2-3 – Dilution input values.

Parameter	Value	Source	Comment
Length of drainage field in direction of groundwater flow	26.8m	Previous reporting	Drainage field design produced by Hydrogeo, August 2023
Saturated aquifer thickness	20m	n/a	Unproven, nominal value
Hydraulic conductivity	1.02m/day	BGS – the physical properties of minor aquifers in England and Wales	Transmissivity of 51m²/day, assumed productive aquifer thickness of 50m
Hydraulic gradient	0.083	Topographic gradient/OS Map	Assumed groundwater gradient is approximate to topographic gradient
Length of drainage field perpendicular to groundwater flow	30.3m	Previous reporting	Drainage field design produced by Hydrogeo, August 2023
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 2-4.

Table 2-4 – 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
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 edge of ownership boundary in direction of groundwater flow
Soil-water partition coefficient	0.5 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 0.5-2 l/kg

2.7 Modelling – Phosphate

Phosphate Attenuation in Drainage Fields

A recent study of phosphorous attenuation at 24no. septic systems over a 30-year period (Robertson et al, 2019) 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 24no. septic systems studied ranged between 1mbgl and 5mbgl, with an average of 1.9mbgl. these groundwater depths are less than 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 model is then used to predict the phosphate concentration at the 112m compliance point.

[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.

Infiltration System

The worksheet input values used for the infiltration system have been listed in Table 2-5.

Table 2-5 – Infiltration system input values.

Parameter	Value	Source	Comment
Concentration of total phosphate as P	2mg/l	Information from Klargester about proposed PTP	Anticipated concentration within treated effluent
Number of persons	45.7	Flows and Loads 4	Residents and average staff per day
Water use	350L per person per day	Flows and Loads 4	Care home residents
Percolation rate	32 s/mm	Previous site investigation	Average of percolation test results by Hydrogeo, March 2023
Discharge rate	16m³	Flows and Loads 4	Number of persons x water use
Area of drainage field	314m²	Previous reporting	Drainage field design produced by Hydrogeo, August 2023

Attenuation in Unsaturated Zone

The worksheet input values used for attenuation in the unsaturated zone have been listed in Table 2-6.

Table 2-6 – 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	0.25	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 20-30%
Bulk density	1.7 g/cm³	ConSim Parameter Database	Midway between min. and max. value for clay
Half life	3.2 days	Iteratively derived	Calculated to retain 90% in drainage field
Soil-water partition coefficient	0.5 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 0.5-2 l/kg
Unsaturated Zone			
Thickness	6m	BGS borehole records	Closest proven unsaturated zone 6.6m, anticipated to be greater
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	0.5 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 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 (0.2mg/l).

Dilution

The worksheet input values used for dilution have been listed in Table 2-7.

Table 2-7 – Dilution input values.

Parameter	Value	Source	Comment
Length of drainage field in direction of groundwater flow	26.8m	Previous reporting	Drainage field design produced by Hydrogeo, August 2023
Saturated aquifer thickness	20m	n/a	Unproven, nominal value
Hydraulic conductivity	1.02m/day	BGS – the physical properties of minor aquifers in England and Wales	Transmissivity of 51m²/day, assumed productive thickness of 50m
Hydraulic gradient	0.083	Topographic gradient	Assumed groundwater gradient is approximate to topographic gradient
Length of drainage field perpendicular to groundwater flow	30.3m	Previous reporting	Drainage field design produced by Hydrogeo, August 2023
Background concentration	0mg/l	n/a	No testing undertaken, assume no background phosphate

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 2-8.

Table 2-8 – 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	112m	QGIS measurement	Compliance point at edge of ownership boundary in direction of groundwater flow
Soil-water partition coefficient	0.5 l/kg	Effluent discharge user manual (H1 Annex J5: Appendix A)	Suggested value 0.5-2 l/kg

In order to include in 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 (0.06mg/l). Using a very high value for the decay rate ($1x10^{99}$ days) results in a lower concentration than 3% due to the dilution.

2.8 Ammonia Model Results

The infiltration model for ammonia has been attached as Appendix B and the results are presented in Table 2-9.

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 the groundwater below the drainage field will exceed the EAL by a nominal amount;
- The concentration of total ammonia as N at the compliance point 112m down hydraulic gradient of the proposed drainage field location will fall below the EAL;

- The concentration of total ammonia as N will fall below the EAL at a point 63m down hydraulic gradient of the proposed drainage field.

Table 2-9 – Ammonia model results.

Parameter	Total Ammonia as N (mg/l)
Concentration at base of unsaturated zone	4.38
Concentration in groundwater below drainage field	0.545
Concentration at compliance point (112m)	0.365

2.9 Phosphate Model Results

The infiltration model for phosphate has been attached as Appendix C and the results are presented in Table 2-10.

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 112m down hydraulic gradient of the proposed drainage field location will fall below the EAL.

Table 2-10 – Phosphate model results.

Parameter	Total Phosphate as P (mg/l)
Concentration at base of unsaturated zone	0.204
Concentration in groundwater below drainage field	0.0254
Concentration at compliance point (112m)	0.0180

2.10 Sensitivity Analysis – Degradation

Further modelling has been undertaken on a conservative basis in order to form a sensitivity analysis, with degradation 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 2-1 to Table 2-4. The sensitivity analysis model results have been attached as Appendix D and are presented in Table 2-11.

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 2-11 – 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	4.86	5.00
Concentration in groundwater below drainage field	0.605	0.623
Concentration at compliance point	0.420	0.441

2.11 Sensitivity Analysis – Unsaturated Zone Thickness

Further modelling has been undertaken on a conservative basis for the unsaturated zone, with the unsaturated zone thickness being set to the maximum proved thickness on site. During the previous site investigation works undertaken by Hydrogeo a trial pit was excavated to 1.8mbgl and no groundwater was encountered. The thickness of the drainage field will remain as 0.6m as previously modelled, and the unsaturated zone thickness beneath the drainage field will be set as 1.2mbgl. All other input values remain the same as detailed in Table 2-1 to Table 2-8. The sensitivity analysis model results have been attached as Appendix E and are shown in Table 2-12.

The results of the sensitivity analysis modelling for total ammonia as N 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 concentration of total ammonia as N will fall below the EAL at a point 80m down hydraulic gradient.

The results of the sensitivity analysis modelling for total phosphate as P 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 will fall below the EAL.

Table 2-12 – Unsaturated zone thickness sensitivity analysis model results.

Parameter	Concentration (mg/l)	
	Total Ammonia as N	**Total Phosphate as P**
Concentration at base of unsaturated zone	4.82	0.204
Concentration in groundwater below drainage field	0.600	0.0254
Concentration at compliance point	0.402	0.0180

3 Summary and Conclusions

3.1 Summary

Hydrogeo Limited (Hydrogeo) has been commissioned by Morspan Holdings Ltd (the Client) to undertake a quantitative Groundwater Risk Assessment for a proposed treated effluent discharge to ground at the redundant agricultural buildings located with Llanellen Court (the Site).

The purpose of the risk assessment is to investigate the suitability of the Site for a drainage field with respect to the level of potential risk to environmental receptors.

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

3.2 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 proposed drainage field.

The model predicts that the concentration of total ammonia as N will fall below the UK Drinking Water Standard at a point 68m down hydraulic gradient.

The model predicts that the concentration of total ammonia as N at the 112m compliance point will fall below the UK Drinking Water Standard.

The model predicts that the concentration of total phosphate as P at the 112m compliance point will fall below the River Usk SAC target.

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 112m 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.

A sensitivity analysis model of the thickness of the unsaturated zone was undertaken with the unsaturated zone thickness set as the maximum proven thickness at the Site (1.8m). The model predicted that the concentration of total ammonia as N at the 112m compliance

point would still fall below the UK Drinking Water Standard, and that the concentration of total phosphate as P would still fall below the River Usk SAC target.

The closest environmental receptor to the Site is the groundwater present within the St Maughan's Formation Secondary A aquifer. The depth of groundwater below the Site has been modelled at 6.6mbgl based on the closest borehole record, however depth to groundwater is anticipated to be greater than this.

The closest sensitive environmental receptor to the Site is the River Usk, located 1.4km down hydraulic gradient of the proposed drainage field.

3.3 Modelling Conclusions

Based on the modelled concentration of total ammonia as N in the groundwater beneath the Site exceeding the UK DWS by a nominal amount, 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 River Usk environmental receptor from the discharge of treated effluent to ground at the Site is considered to be Very Low.

Based on the modelled concentration of total phosphate as P in the groundwater beneath the Site and at the 112m compliance point falling below the River Usk SAC target, the risk posed to the River Usk and other groundwater dependent receptors from the discharge of treated effluent to ground at the Site is considered to be Very Low.

Based on the risk assessment predicted results the treated effluent is predicted to degrade significantly before reaching the expected location of the Ty Cerios septic tank discharge (120m distance), and any cumulative impact on the groundwater quality will be negligible.

Appendices

Appendix A

Proposed Site layout plan

N

NORTH

Planning Permission for Conversion of Existing Buildings into Care Home DC/2008/01305 22 Dec 2009. Expired Dec 2014

Existing Hedgerow and trees to remain

Existing Trees

Existing Hedgerow and trees to remain

Existing cottages

Private garden

Private garden

Existing access to be retained and resurfaced with tarmac

Existing Hedgerow

Private garden

Existing Hedgerow and trees to remain

Existing Hedgerow

Existing Hedgerow

Staff Parking

21

18

17

12

11

8

1

5

6

7

Lawn

Lawn

Lawn

Pergola seating area

Bicycle parking

ENTRANCE

Mini Bus/ Ambulance Space

Proposed location for underground packaged treatment plant

Existing Hedgerow and trees to remain

Existing Trees

ENCLOSED GARDEN (for elderly mentally infirm)

Lawn

Terrace

Courtyard

Timber fence and gates to enclose E.M.I garden

Existing stock proof post & wire boundary fence

7mtrs

Fence enclosing garden set back from existing boundary to maintain existing natural habitat along boundary

Access Road

Extant Planning Permission for New Access Road DC/2008/01304 27 Aug 2009. Construction of Road complete. Junction onto A4042 approved by Welsh Government.

Turning Head

Unloading area

2400

600

1800

Timber trellis

Vertical close boarded timber fence

Fence to enclosed garden area

Scale 1:75

Herringbone pattern perforated pipework out fall drainage field installed below ground

Existing Trees

Existing Hedgerow and trees to remain

Lawn

Bin Store

Pergola seating area

Lawn

Lawn

Screen Planting

Proposed location for underground rainwater storage tank.

Planning Permission already granted for Conversion to Close Care Apartments DC/2015/00983 26 April 2017

Extant Planning Permission for Conversion to Close Care Apartments DC/2010/00981 4 May 2012

PROPOSED SITE PLAN

Scale 1:200

BAT MITIGATION NOTES

An Ecological Survey Report has been provided by Just Mammals Ltd ref: JM8421 dated: September 2021.

The Ecological report confirms that Evidence of a single roost for a common pipistrelle bat was found in 'shed A'.

Because all Bats are protected species a European Protected Species (EPS) Licence will be needed from NRW (Natural Resources Wales) before any roof work can start.

An ecological Method Statement and supervision by qualified ecologist will be required.

Refer to Just Mammals Ltd report ref: JM8421 dated: September 2021 for details of Mitigation measures as follows:-

A minimum of 3no. Bat boxes suitable for crevice roosting bats ref: Schwegler 1FF will be provided in different positions and orientations, in a suitable position on an existing mature tree. The bat boxes will be installed prior to the start of work, and will remain in-situ following the completion of the conversion works. The location for the bat boxes will be determined in consultation with the ecologist appointed to the project to ensure a suitable position which considers links to adjacent habitat.

Long term provision for crevice roosting bats to be provided to 'shed A' as part of the conversion. Bat access points to be provided at high level to the space behind the gable end timber cladding boards at roof level on the South East facing gable end. The Bat access points size to be 18x50mm located 750mm from the apex.

All external lighting will face downwards and be set on timers.
The External Lighting will be limited so that Bats are not disturbed. Subtle low output downlights wall mounted alongside entrance door and recessed downlights to be used in the soffit of the canopy over the doors. Low level bollard lights to the parking area. shown on plan as • B High level Security/flood lights must not be installed.

EXISTING HEDGEROW AND TREES

In accordance with the Ecology Survey Report by Just Mammals ref: JM8421 dated: Sept 2021 the existing hedgerow and trees around the site perimeter to the North & West boundaries will remain. Temporary Heras fencing will be erected to provide an exclusion zone and keep personnel, machinery & building materials away from the hedges & trees during the proposed conversion works.

In accordance with paragraph 10.12 on page 9 of Just Mammals Ecology Report there will be a one in three year management programme for hedge trimming, as well as a 3 year rotation plan with all other similar hedgerows under the same ownership. The management programme to retain the existing hedgerows in a tall and bushy condition.

ECOLOGICAL ENHANCEMENT

The proposals will Include Bat and Bird nesting boxes 3no. Schwegler 1FF Bat boxes and 1no. Schwegler 1B bird nest box to provide ecological enhancement.

Woodcrete boxes are specified as these have a much longer life span than timber. Woodcrete nest boxes are made from a breathable blend of wood, concrete and clay which will not rot, leak, crack or warp, whilst preventing condensation and maintaining more constant temperatures inside than wooden bird boxes.

New planting will include native species trees and plants with berries to attract birds, and flowers to attract pollinators. New planting will be chosen from The Royal Horticultural Society publication 'Plants for Pollinators'.

THIS DRAWING Revision A HAS ALREADY BEEN APPROVED. PLANNING PERMISSION Ref DC/2008/01305 dated 22 Dec 2009. Expired Dec 2014

Rev	Description	Date
B	Notes to confirm ecology mitigation. Biodiversity Enhancements.	29.06.22
A	Additional parking spaces & Mini bus/ambulance space enlarged. Additional dedicated staff parking area, Enclosed garden for elderly mentally infirm	27.03.09

Buckle Chamberlain Partnership Ltd.
Architects & Architectural Technologists.

Mill House, Llancayo Court, Llancayo, Usk, Monmouthshire NP15 1HY
Tel: 01291 672264
01291 673424
Fax: 01291 671050
Email: enquiries@bucklechamberlain.co.uk

Client	Morspan Holdings Ltd.
Project	Proposed Conversion of Redundant Agricultural Buildings into Care Home at Llanellen Court, Llanellen, Abergavenny.
Drawing	Care Home Site Layout Plan
Date	July 2008
Scale	1:200 @ A1
Drawn by	GaG
Checked by	RAC
Status	
Drawing No	339 [BD] 04 B

Appendix B

Infiltration Worksheet model – Total Ammonia as N

Groundwater risk assessment for treated effluent discharges to infiltration systems

Infiltration Worksheet , Release v3.0

Date of Workbook Issue: March 2022

This worksheet has been produced in combination with the document: H1 Annex J5 User Manual version 2.0 (Environment Agency, 2014).

IMPORTANT: To enable MS Excel worksheet, click the Microsoft Office Button  cl... Excel Options, click Add-Ins. In the Manage box, select Excel Add-ins. Click Go. Select **Analysis ToolPak** and **Analysis ToolPak-VBA** (to calculate error functions)

Details to be completed for each assessment

Site Name:	**Llanellen Care Home**			
Site Address:	**Llanellen Court, Llanellen, NP7 9HT**			
Completed by:	**Isobel Zelly**			
Date:	**12 01 2024**		**Version:**	**1**
Substance	**Ammonia (N)**			
Environmental Standard (C_T)	**0.5**	**mg/l**	**Origin of C_T:**	**UK DWS**

This spreadsheet has been developed as a tool to assist groundwater risk assessment for effluent discharges to infiltration systems. The following worksheets are available:

Site details entered on this page are automatically copied to each worksheet.
The worksheet uses the following colour coding:

	Worksheet option with pull down menu
	Data entry
	Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
	Data carried forward from an earlier worksheet
	Calculation

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

Infiltration Worksheet

Infiltration System

This sheet allows user to enter effluent concentration and details of infiltration system

Substance		**Ammonia (N)**		From introduction sheet
Compliance value or environmental standard	C_T	**5.00E-01**	**mg/l**	From introduction sheet

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry				
Concentration of substance in discharge (entering infiltration system)	C_e	5.00E+00	mg/l	Klagester BioDisc technical specifications
Type of treatment plant		**Package treatment plant**		
Water use and percolation rate (for use only with septic tanls and package treatment plants)				
Number of persons	p	4.57E+01		Flows and Loads 4
Water use		3.50E+02	litres/person/day	Flows and Loads 4
Percolation rate	Vp	3.20E+01	s/mm	Percolation testing by Hydrogeo 21/03/2023
Specify discharge (Q1) or calculate based on use (Q2)		**Specified discharge Q1**		
Discharge rate	Q1	1.60E+01	m^3/d	Flows and Loads 4
Calculated discharge	Q2	1.60E+01	m^3/d	*Value specifed by user and not calculated*
Area of drainage fied and hydraulic loading				
Specify area of drainage field or calculate based on percolation rate		**Specify**		
Enter area of drainage field	A	3.14E+02	m^2	Drainage field design by Hydrogeo 14/08/2023
Calculated area of drainage field	A	2.92E+02	m^2	*Value specifed by user and not calculated*
Calculated infiltration rate	Inf	5.10E-02	m/d	

Site being assessed:	Llanellen Care Home
Completed by:	Isobel Zelly
Date:	12 01 2024
Version:	1

Infiltration Worksheet

Attenuation unsaturated zone

This sheet calculates attenuation factor for the unsaturated zone; concentration at base of unsaturated zone and discharge consent limit

Contaminant		**Ammonia (N)**		From introduction sheet
Compliance value or environmental standard	C_T	**5.00E-01**	mg/l	From introduction sheet
Concentration of substance in substance in discharge (entering infiltration system)	C_e	**5.00E+00**	mg/l	From infiltration sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Drainage Layer					
Infiltraton rate	**Inf**	**5.10E-02**	**m/d**	From infiltration sheet	
Thickness of drainage layer	S_1	6.00E-01	m	BS 6297:2007 + A1:2008	
Water filled porosity	θ_1	2.50E-01	fraction	Infiltration worksheet manual Appendix A	
Bulk density	ρ_1	1.70E+00	g/cm^3	ConSim Parameter Database	
Calculated dispersivity	D_1	6.00E-02	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	7.30E+02	days	Infiltration worksheet manual Appendix A	
Calculated decay rate	λ_1	9.50E-04	days^{-1}	calculated (very low value set if no degradation)	*Calculated from half life (above)*
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_1	5.00E-01	l/kg	Infiltration worksheet manual Appendix A	
Entry for organic chemicals (option)					
Fraction of organic carbon (in soil)	foc_1	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_1	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_1**	**5.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_1	4.40E+00			
Unretarded travel time (no dispersion)	tu_1	2.94E+00	d		
Unretarded travel time (with dispersion)	tu_1	2.65E+00	d		
Retarded travel time (with dispersion)	tr_1	1.17E+01	d		
Attenuation factor	AFu_1	1.01E+00			
Unsaturated Zone					
Thickness of unsaturated zone below drainage field	S_2	6.00E+00	m	BGS borehole records	
Water filled porosity	θ_2	2.35E-01	fraction	ConSim Parameter Database	
Bulk density of unsaturated zone	ρ_2	1.70E+00	g/cm^3	ConSim Parameter Database	
Calculated dispersivity	D_2	6.00E-01	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	7.30E+02	days	Infiltration worksheet manual Appendix A	
Calculated decay rate	λ_2	9.50E-04	days^{-1}	calculated (very low value set if no degradation)	*Default value of 1/10^99 used*
Fraction of rapid flow through unsaturated zone	B	0.00E+00	fraction	*n/a*	
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_2	5.00E-01	l/kg	Infiltration worksheet manual Appendix A	
Entry for organic chemicals (option)					
Fraction of organic carbon (in soil)	foc_2	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_2	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_2**	**5.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_2	4.62E+00			
Unretarded travel time (no dispersion)	tu_2	2.77E+01	d		
Unretarded travel time (with dispersion)	tu_2	2.49E+01	d		
Retarded travel time (with dispersion)	tr_2	1.15E+02	d		
Attenuation factor	AFu_2	1.13E+00			
Total unretarded travel time	$tu_1 + tu_2$	3.06E+01	d		
Total retarded travel time	$tr_1 + tr_2$	1.41E+02	d		

Attenuation factor and discharge consent limit

Drainage layer attenuation factor	**AFu_1**	**1.01E+00**	
Unsaturated zone attenuation factor	**AFu_2**	**1.13E+00**	
Concentration at base of drainage layer	**C_{dl}**	**4.94E+00**	**mg/l**
Concentration at base of unsaturated zone	**C_{wt}**	**4.38E+00**	**mg/l**
		and	

Site being assessed:	Llanellen Care Home
Completed by:	Isobel Zelly
Date:	12 01 2024
Version:	1

Infiltration Worksheet

Dilution

This sheet calculates the dilution factor for groundwater dilution below the drainage field.
Substance concentration in groundwater and discharge consent limit

Substance		**Ammonia (N)**		From introduction sheet
Compliance value or environmental standard	**C_T**	**5.00E-01**	**mg/l**	From introduction sheet
Source concentration	**C_e**	**5.00E+00**	**mg/l**	From infiltration sheet
Concentration at base of drainage layer	**C_{wt}**	**4.38E+00**	**mg/l**	From atten_unsatzone sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Infiltration	Inf	5.10E-02	m/d	From infiltration sheet
Area of drainage field	A	3.14E+02	m^2	From infiltration sheet
Entry for groundwater flow below site				
Length of drainage field in direction of groundwater flow	L	2.68E+01	m	**Drainage field design by Hydrogeo 14/08/2023**
Saturated aquifer thickness	da	2.00E+01	m	**n/a**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+01	m/d	**Literature value**
Hydraulic gradient of water table	i	8.30E-02	fraction	**Topographic contours**
Width of drainage field perpendicular to groundwater flow	w	3.03E+01	m	**Drainage field design by Hydrogeo 14/08/2023**
Background concentration of substance in groundwater up-gradient of site	Cu	0.00E+00	mg/l	**n/a**
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**		
Enter mixing zone thickness	Mz	5.00E+00	m	*Not valid - Value calculated*
Calculated mixing zone thickness	Mz	4.39E+00	m	

w * L (812.04) does not equal area (A) of drainage field (314) - check parameters used (this may be OK if drainage field at angle to flow direction)

Groundwater flow (mixing zone) below drainage field	Gw	112.51	m^3/d	

Dilution factor and discharge consent limit

Dilution Factor	**DF**	**8.031781537**		
Headroom Factor	**HF**	**8.031781537**		
Unsaturated zone attenuation factor	**AFu**	**1.13E+00**		From infiltration sheet
Concentration in groundwater below drainage field	**C_{gw}**	**5.45E-01**	**mg/l**	
		or		
Environmental Permit limit value	**EPL_2**	**4.58327958**	**mg/l**	

Site being assessed:	Llanellen Care Home
Completed by:	Isobel Zelly
Date:	12 01 2024
Version:	1

Concentration immediately downgradient of drainage field exceeds target concentration

Infiltration Worksheet

Attenuation in saturated zone

This sheet calculates attenuation factor for the saturated zone; substance concentration at downgradient compliance point and discharge consent limit

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Substance		**Ammonia (N)**		From introduction sheet
Compliance value or environmental standard	**C_T**	**5.00E-01**	mg/l	From introduction sheet
Source concentration	**C_o**	**5.00E+00**	mg/l	From infiltration sheet
Dilution Factor	**DF**	**8.03E+00**		from dilution sheet
Unsaturated zone attenuation factor	**AFu**	**1.13E+00**		From atten_unsatzone sheet

	Variable	Value	Unit	Source of parameter value
Concentration in groundwater below drainage field	Cgw	5.45E-01	mg/l	from dilution sheet
Option to select degradation	Degradation occurs - sorbed and dissolved phases			
Half life for degradation of substance	$t_{1/2}$	1.85E+03	days	Infiltration worksheet manual Appendix A
Calculated decay rate	λ	3.75E-04	$days^{-1}$	calculated (very low value set if no degradation)
Width of drainage field	w	3.03E+01	m	from dilution sheet
Mixing zone thickness	Mz	4.39E+00	m	from dilution sheet
Bulk density of aquifer materials	ρ	1.70E+00	g/cm^3	*ConSim Parameter Database*
Effective porosity of aquifer	n	4.70E-01	fraction	*ConSim Parameter Database*
Hydraulic gradient	I_{corr}	9.48E-02	fraction	from dilution sheet (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.02E+01	m/d	from dilution sheet
Distance to compliance point	x	1.12E+02	m	*QGIS measurement to edge of ownership bound*
Option to select time	Use steady state (recommended)			
Enter time	t	1.00E+02	days	time variant options only
Time since pollutant entered groundwater	t	1.00E+99		
Parameters values determined from options				
Partition coefficient	Kd	5.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	4.69E+00	m	*see options*
Transverse dispersivity	az	4.69E-01	m	*see options*
Vertical dispersivity	ay	4.69E-02	m	*see options*

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	2.06E+00	m/d
Retardation factor	Rf	2.81E+00	fraction
Decay rate used	λ	3.75E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	I_{corr}	9.48E-02	fraction
Rate of contaminant flow due to retardation	u	7.33E-01	m/d
Attenuation factor	**AFs**	**1.49E+00**	**fraction**

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	5.00E-01	l/kg

Entry for organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Soil water partition coefficient	Kd	5.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

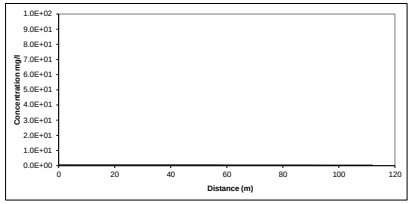
Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity (m)	**ax**	1.00E-12	1.12E+01	4.69E+00
Transverse dispersivity (m)	**az**	1.00E-12	1.12E+00	4.69E-01
Vertical dispersivity (m)	**ay**	1.00E-13	1.12E-01	4.69E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x



Calculated concentrations for distance-concentration graph

From calculation sheet

Distance m	Concentration mg/l
0	5.5E-01
5.6	5.44E-01
11.2	5.42E-01
16.8	5.40E-01
22.4	5.37E-01
28.0	5.32E-01
33.6	5.25E-01
39.2	5.16E-01
44.8	5.06E-01
50.4	4.94E-01
56.0	4.82E-01
61.6	4.70E-01
67.2	4.57E-01
72.8	4.45E-01
78.4	4.32E-01
84.0	4.20E-01
89.6	4.09E-01
95.2	3.97E-01
100.8	3.86E-01
106.4	3.76E-01
112.0	3.65E-01

Site being assessed:	Llanellen Care Home
Completed by:	0
Date:	00-Jan-00
Version:	0

Attenuation and Dilution factors and discharge consent limit

Dilution Factor	**DF**	**8.03E+00**		
Unsaturated zone attenuation factor	**AFu**	**1.13E+00**		
Saturated zone attenuation factor	**AFs**	**1.49E+00**		
Concentration in groundwater at compliance point	**C_{dcp}**	**0.365295483**	**mg/l**	**below compliance value**
		or		
Environmental Permit limit value	**EPL_3**	**6.84E+00**	**mg/l**	**Discharge limit for discussion with Environment Agency**
Distance to compliance point		**112**	**m**	

Concentration at compliance point below target concentration

Infiltration Worksheet

Summary of calculations for concentration of substance in groundwater

No input required,values taken from previous worksheets

Summary of compliance data, attenuation and dilution factors

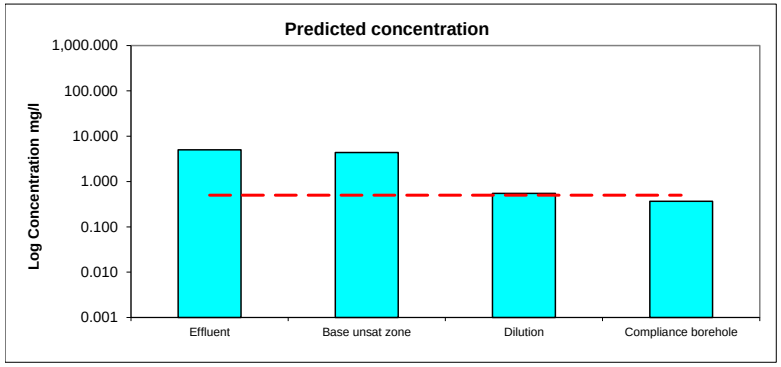
Substance		**Ammonia (N)**	
Effluent concentration	C_e	5.00E+00	mg/l
Compliance value or environmental standard	C_T	0.50	mg/l
Distance to compliance point		112.00	m
Attenuation factor - unsat zone	AFu	1.13E+00	
Dilution Factor	DF	8.03E+00	
Attenuation factor- sat zone	AFs	1.49E+00	

Predicted concentrations at compliance point based on proposed effluent concentration

Concentration at base of unsaturated zone	C_{wt}	4.38E+00	mg/l	Attenuation in unsaturated zone only
Concentration in groundwater below drainage field	C_{gw}	5.45E-01	mg/l	Dilution taken into account
Concentration in groundwater at compliance point	C_{dcp}	3.65E-01	mg/l	Attenuation in saturated zone taken into account

Provisional Environmental Permit limit values

Based on attenuation in unsaturated zone	EPL_1	5.71E-01	mg/l	
Based on attenuation in unsaturated zone and dilution	EPL_2	4.58E+00	mg/l	
Based on dilution and attenuation in unsaturated and saturated zone	EPL_3	6.84E+00	mg/l	**Discharge limit for discussion with Environment Agency**



Appendix C

Infiltration Worksheet model – Total Phosphate as P

Groundwater risk assessment for treated effluent discharges to infiltration systems

Infiltration Worksheet , Release v3.0

Date of Workbook Issue: March 2022

This worksheet has been produced in combination with the document: H1 Annex J5 User Manual version 2.0 (Environment Agency, 2014).

IMPORTANT: To enable MS Excel worksheet, click the Microsoft Office Button  cl... Excel Options, click Add-Ins. In the Manage box, select Excel Add-ins. Click Go. Select **Analysis ToolPak** and **Analysis ToolPak-VBA** (to calculate error functions)

Details to be completed for each assessment

Site Name:	**Llanellen Care Home**			
Site Address:	**Llanellen Court, Llanellen, NP7 9HT**			
Completed by:	**Isobel Zelly**			
Date:	**15 01 2024**		**Version:**	**1**
Substance	**Phosphate**			
Environmental Standard (C_T)	**0.05**	**mg/l**	**Origin of C_T:**	**River Usk SAC Target**

This spreadsheet has been developed as a tool to assist groundwater risk assessment for effluent discharges to infiltration systems. The following worksheets are available:

Site details entered on this page are automatically copied to each worksheet.
The worksheet uses the following colour coding:

	Worksheet option with pull down menu
	Data entry
	Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
	Data carried forward from an earlier worksheet
	Calculation

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

Infiltration Worksheet

Infiltration System

This sheet allows user to enter effluent concentration and details of infiltration system

Substance		**Phosphate**		From introduction sheet
Compliance value or environmental standard	C_T	**5.00E-02**	**mg/l**	From introduction sheet

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry				
Concentration of substance in discharge (entering infiltration system)	C_e	2.00E+00	mg/l	Klagester BioDisc technical specifications
Type of treatment plant		**Package treatment plant**		
Water use and percolation rate (for use only with septic tanls and package treatment plants)				
Number of persons	p	4.57E+01		Flows and Loads 4
Water use		3.50E+02	litres/person/day	Flows and Loads 4
Percolation rate	Vp	3.20E+01	s/mm	Percolation testing by Hydrogeo 21/03/2023
Specify discharge (Q1) or calculate based on use (Q2)		**Specified discharge Q1**		
Discharge rate	Q1	1.60E+01	m^3/d	Flows and Loads 4
Calculated discharge	Q2	1.60E+01	m^3/d	*Value specifed by user and not calculated*
Area of drainage fied and hydraulic loading				
Specify area of drainage field or calculate based on percolation rate		**Specify**		
Enter area of drainage field	A	3.14E+02	m^2	Drainage field design by Hydrogeo 14/08/2023
Calculated area of drainage field	A	2.92E+02	m^2	*Value specifed by user and not calculated*
Calculated infiltration rate	Inf	5.10E-02	m/d	

Site being assessed:	Llanellen Care Home
Completed by:	Isobel Zelly
Date:	15 01 2024
Version:	1

Infiltration Worksheet

Attenuation unsaturated zone

This sheet calculates attenuation factor for the unsaturated zone; concentration at base of unsaturated zone and discharge consent limit

Contaminant		**Phosphate**		From introduction sheet
Compliance value or environmental standard	C_T	**5.00E-02**	mg/l	From introduction sheet
Concentration of substance in substance in discharge (entering infiltration system)	C_e	**2.00E+00**	mg/l	From infiltration sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Drainage Layer					
Infiltraton rate	**Inf**	**5.10E-02**	**m/d**	From infiltration sheet	
Thickness of drainage layer	S_1	6.00E-01	m	BS 6297:2007 + A1:2008	
Water filled porosity	θ_1	2.50E-01	fraction	Infiltration worksheet manual Appendix A	
Bulk density	ρ_1	1.70E+00	g/cm^3	ConSim Parameter Database	
Calculated dispersivity	D_1	6.00E-02	m	calculated	
Option to select degradation	**Degradation occurs - sorbed and dissolved phases**				
Half life for degradation of substance	$t_{1/2}$	3.20E+00	days	Derived to retain 90%	
Calculated decay rate	λ_1	2.17E-01	days^{-1}	calculated (very low value set if no degradation)	*Calculated from half life (above)*
Enter method of defining partition co-efficient (using pull down list)	**User specified value for partition coefficient**				
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_1	5.00E-01	l/kg	Infiltration worksheet manual Appendix A	
Entry for organic chemicals (option)					
Fraction of organic carbon (in soil)	foc_1	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_1	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_1**	**5.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_1	4.40E+00			
Unretarded travel time (no dispersion)	tu_1	2.94E+00	d		
Unretarded travel time (with dispersion)	tu_1	2.65E+00	d		
Retarded travel time (with dispersion)	tr_1	1.17E+01	d		
Attenuation factor	AFu_1	9.82E+00			
Unsaturated Zone					
Thickness of unsaturated zone below drainage field	S_2	6.00E+00	m	BGS borehole records	
Water filled porosity	θ_2	2.35E-01	fraction	ConSim Parameter Database	
Bulk density of unsaturated zone	ρ_2	1.70E+00	g/cm^3	ConSim Parameter Database	
Calculated dispersivity	D_2	6.00E-01	m	calculated	
Option to select degradation	**Degradation occurs - sorbed and dissolved phases**				
Half life for degradation of substance	$t_{1/2}$	1.00E+99	days	n/a	
Calculated decay rate	λ_2	6.93E-100	days^{-1}	calculated (very low value set if no degradation)	*Default value of 1/10^99 used*
Fraction of rapid flow through unsaturated zone	B	0.00E+00	fraction	*n/a*	
Enter method of defining partition co-efficient (using pull down list)	**User specified value for partition coefficient**				
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_2	5.00E-01	l/kg	Infiltration worksheet manual Appendix A	
Entry for organic chemicals (option)					
Fraction of organic carbon (in soil)	foc_2	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_2	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_2**	**5.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_2	4.62E+00			
Unretarded travel time (no dispersion)	tu_2	2.77E+01	d		
Unretarded travel time (with dispersion)	tu_2	2.49E+01	d		
Retarded travel time (with dispersion)	tr_2	1.15E+02	d		
Attenuation factor	AFu_2	1.00E+00			
Total unretarded travel time	$tu_1 + tu_2$	3.06E+01	d		
Total retarded travel time	$tr_1 + tr_2$	1.41E+02	d		

Attenuation factor and discharge consent limit

Drainage layer attenuation factor	**AFu_1**	**9.82E+00**	
Unsaturated zone attenuation factor	**AFu_2**	**1.00E+00**	
Concentration at base of drainage layer	**C_{dl}**	**2.04E-01**	**mg/l**
Concentration at base of unsaturated zone	**C_{wt}**	**2.04E-01**	**mg/l**
		and	

Site being assessed:	Llanellen Care Home
Completed by:	Isobel Zelly
Date:	15 01 2024
Version:	1

Infiltration Worksheet

Dilution

This sheet calculates the dilution factor for groundwater dilution below the drainage field.
Substance concentration in groundwater and discharge consent limit

Substance		**Phosphate**		From introduction sheet
Compliance value or environmental standard	C_T	**5.00E-02**	**mg/l**	From introduction sheet
Source concentration	C_e	**2.00E+00**	**mg/l**	From infiltration sheet
Concentration at base of drainage layer	C_{wt}	**2.04E-01**	**mg/l**	From atten_unsatzone sheet

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry				
Infiltration	Inf	5.10E-02	m/d	From infiltration sheet
Area of drainage field	A	3.14E+02	m^2	From infiltration sheet
Entry for groundwater flow below site				
Length of drainage field in direction of groundwater flow	L	2.68E+01	m	**Drainage field design by Hydrogeo 14/08/2023**
Saturated aquifer thickness	da	2.00E+01	m	**n/a**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+01	m/d	**Literature value**
Hydraulic gradient of water table	i	8.30E-02	fraction	**Topographic contours**
Width of drainage field perpendicular to groundwater flow	w	3.03E+01	m	**Drainage field design by Hydrogeo 14/08/2023**
Background concentration of substance in groundwater up-gradient of site	Cu	0.00E+00	mg/l	**n/a**
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**		
Enter mixing zone thickness	Mz	5.00E+00	m	*Not valid - Value calculated*
Calculated mixing zone thickness	Mz	4.39E+00	m	

w * L (812.04) does not equal area (A) of drainage field (314) - check parameters used (this may be OK if drainage field at angle to flow direction)

Groundwater flow (mixing zone) below drainage field	Gw	112.51	m^3/d	

Dilution factor and discharge consent limit

Dilution Factor	**DF**	**8.031781537**		
Headroom Factor	**HF**	**8.031781537**		
Unsaturated zone attenuation factor	**AFu**	**1.00E+00**		From infiltration sheet
Concentration in groundwater below drainage field	C_{gw}	**2.54E-02**	**mg/l**	**below compliance value**
		or		
Environmental Permit limit value	EPL_2	**3.941823086**	**mg/l**	**discussion with**

Site being assessed:	Llanellen Care Home
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Date:	15 01 2024
Version:	1

Concentration immediately downgradient of drainage field below target concentration

Infiltration Worksheet

Attenuation in saturated zone

This sheet calculates attenuation factor for the saturated zone; substance concentration at downgradient compliance point and discharge consent limit

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Substance		Phosphate		From introduction sheet
Compliance value or environmental standard	C_T	5.00E-02	mg/l	From introduction sheet
Source concentration	C_o	2.00E+00	mg/l	From infiltration sheet
Dilution Factor	DF	8.03E+00		from dilution sheet
Unsaturated zone attenuation factor	AFu	1.00E+00		From atten_unsatzone sheet

	Variable	Value	Unit	Source of parameter value
Concentration in groundwater below drainage field	Cgw	2.54E-02	mg/l	from dilution sheet
Option to select degradation	Degradation occurs - sorbed and dissolved phases			
Half life for degradation of substance	$t_{1/2}$	1.00E+99	days	Derived to retain 97%
Calculated decay rate	λ	6.93E-100	$days^{-1}$	calculated (very low value set if no degradation)
Width of drainage field	w	3.03E+01	m	from dilution sheet
Mixing zone thickness	Mz	4.39E+00	m	from dilution sheet
Bulk density of aquifer materials	ρ	1.70E+00	g/cm^3	*ConSim Parameter Database*
Effective porosity of aquifer	n	4.70E-01	fraction	*ConSim Parameter Database*
Hydraulic gradient	I_{corr}	9.48E-02	fraction	from dilution sheet (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.02E+01	m/d	from dilution sheet
Distance to compliance point	x	1.12E+02	m	*QGIS measurement to edge of ownership bound*
Option to select time	Use steady state (recommended)			
Enter time	t	1.00E+02	days	time variant options only
Time since pollutant entered groundwater	t	1.00E+99		
Parameters values determined from options				
Partition coefficient	Kd	5.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	4.69E+00	m	*see options*
Transverse dispersivity	az	4.69E-01	m	*see options*
Vertical dispersivity	ay	4.69E-02	m	*see options*

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	2.06E+00	m/d
Retardation factor	Rf	2.81E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	I_{corr}	9.48E-02	fraction
Rate of contaminant flow due to retardation	u	7.33E-01	m/d
Attenuation factor	AFs	1.41E+00	fraction

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	5.00E-01	l/kg

Entry for organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Soil water partition coefficient	Kd	5.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

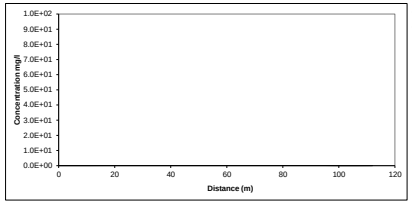
Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity (m)	ax	1.00E-12	1.12E+01	4.69E+00
Transverse dispersivity (m)	az	1.00E-12	1.12E+00	4.69E-01
Vertical dispersivity (m)	ay	1.00E-13	1.12E-01	4.69E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x



Calculated concentrations for distance-concentration graph

From calculation sheet

Distance m	Concentration mg/l
0	2.5E-02
5.6	2.54E-02
11.2	2.54E-02
16.8	2.54E-02
22.4	2.53E-02
28.0	2.51E-02
33.6	2.49E-02
39.2	2.45E-02
44.8	2.41E-02
50.4	2.36E-02
56.0	2.31E-02
61.6	2.25E-02
67.2	2.20E-02
72.8	2.15E-02
78.4	2.09E-02
84.0	2.04E-02
89.6	1.99E-02
95.2	1.94E-02
100.8	1.89E-02
106.4	1.84E-02
112.0	1.80E-02

Site being assessed:	Llanellen Care Home
Completed by:	0
Date:	00-Jan-00
Version:	0

Attenuation and Dilution factors and discharge consent limit

Dilution Factor	DF	8.03E+00		
Unsaturated zone attenuation factor	AFu	1.00E+00		
Saturated zone attenuation factor	AFs	1.41E+00		
Concentration in groundwater at compliance point	C_{dcp}	0.017988772	mg/l	below compliance value
		or		
Environmental Permit limit value	EPL_3	5.56E+00	mg/l	Discharge limit for discussion with Environment Agency
Distance to compliance point		112	m	

Concentration at compliance point below target concentration

Infiltration Worksheet

Summary of calculations for concentration of substance in groundwater

No input required,values taken from previous worksheets

Summary of compliance data, attenuation and dilution factors

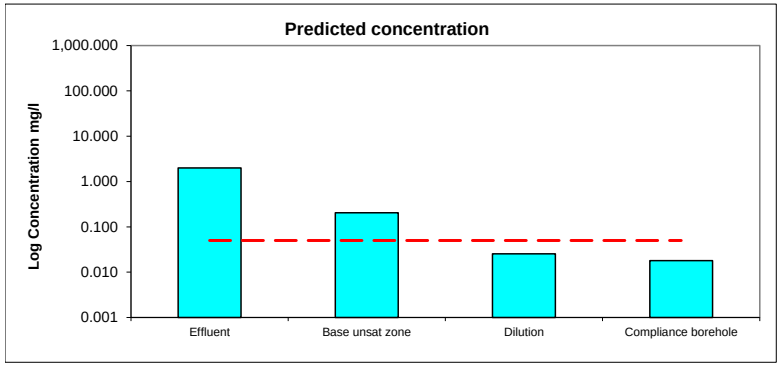
Substance		**Phosphate**	
Effluent concentration	C_e	2.00E+00	mg/l
Compliance value or environmental standard	C_T	0.05	mg/l
Distance to compliance point		112.00	m
Attenuation factor - unsat zone	AFu	1.00E+00	
Dilution Factor	DF	8.03E+00	
Attenuation factor- sat zone	AFs	1.41E+00	

Predicted concentrations at compliance point based on proposed effluent concentration

Concentration at base of unsaturated zone	C_{wt}	2.04E-01	mg/l	Attenuation in unsaturated zone only
Concentration in groundwater below drainage field	C_{gw}	2.54E-02	mg/l	Dilution taken into account
Concentration in groundwater at compliance point	C_{dcp}	1.80E-02	mg/l	Attenuation in saturated zone taken into account

Provisional Environmental Permit limit values

Based on attenuation in unsaturated zone	EPL_1	4.91E-01	mg/l	
Based on attenuation in unsaturated zone and dilution	EPL_2	3.94E+00	mg/l	**Discharge limit for discussion with Environment Agency**
Based on dilution and attenuation in unsaturated and saturated zone	EPL_3	5.56E+00	mg/l	**Discharge limit for discussion with Environment Agency**



Appendix D

Sensitivity analysis model results – Degradation

Infiltration Worksheet

Summary of calculations for concentration of substance in groundwater

No input required,values taken from previous worksheets

Summary of compliance data, attenuation and dilution factors

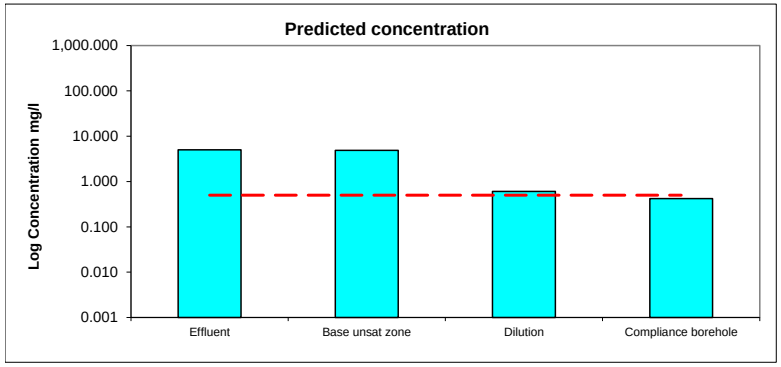
Substance		**Ammonia (N)**	
Effluent concentration	C_e	5.00E+00	mg/l
Compliance value or environmental standard	C_T	0.50	mg/l
Distance to compliance point		112.00	m
Attenuation factor - unsat zone	AFu	1.03E+00	
Dilution Factor	DF	8.03E+00	
Attenuation factor- sat zone	AFs	1.44E+00	

Predicted concentrations at compliance point based on proposed effluent concentration

Concentration at base of unsaturated zone	C_{wt}	4.86E+00	mg/l	Attenuation in unsaturated zone only
Concentration in groundwater below drainage field	C_{gw}	6.05E-01	mg/l	Dilution taken into account
Concentration in groundwater at compliance point	C_{dcp}	4.20E-01	mg/l	Attenuation in saturated zone taken into account

Provisional Environmental Permit limit values

Based on attenuation in unsaturated zone	EPL_1	5.15E-01	mg/l	
Based on attenuation in unsaturated zone and dilution	EPL_2	4.13E+00	mg/l	
Based on dilution and attenuation in unsaturated and saturated zone	EPL_3	5.95E+00	mg/l	**Discharge limit for discussion with Environment Agency**



Infiltration Worksheet

Summary of calculations for concentration of substance in groundwater

No input required,values taken from previous worksheets

Summary of compliance data, attenuation and dilution factors

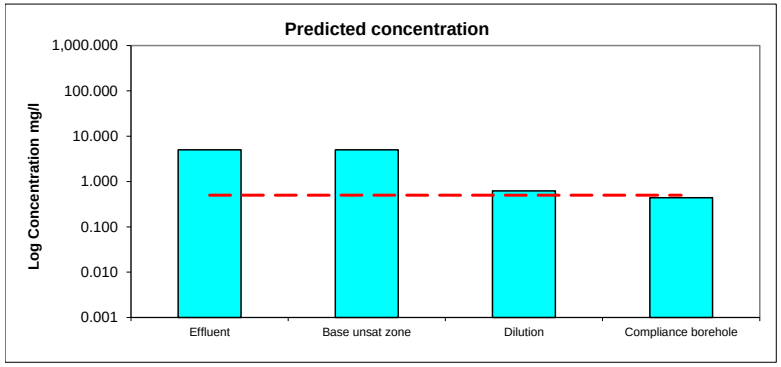
Substance		**Ammonia (N)**	
Effluent concentration	C_e	5.00E+00	mg/l
Compliance value or environmental standard	C_T	0.50	mg/l
Distance to compliance point		112.00	m
Attenuation factor - unsat zone	AFu	1.00E+00	
Dilution Factor	DF	8.03E+00	
Attenuation factor- sat zone	AFs	1.41E+00	

Predicted concentrations at compliance point based on proposed effluent concentration

Concentration at base of unsaturated zone	C_{wt}	5.00E+00	mg/l	Attenuation in unsaturated zone only
Concentration in groundwater below drainage field	C_{gw}	6.23E-01	mg/l	Dilution taken into account
Concentration in groundwater at compliance point	C_{dcp}	4.41E-01	mg/l	Attenuation in saturated zone taken into account

Provisional Environmental Permit limit values

Based on attenuation in unsaturated zone	EPL_1	5.00E-01	mg/l	
Based on attenuation in unsaturated zone and dilution	EPL_2	4.02E+00	mg/l	
Based on dilution and attenuation in unsaturated and saturated zone	EPL_3	5.66E+00	mg/l	**Discharge limit for discussion with Environment Agency**



Appendix E

Sensitivity analysis model results – Unsaturated zone thickness

Infiltration Worksheet

Summary of calculations for concentration of substance in groundwater

No input required,values taken from previous worksheets

Summary of compliance data, attenuation and dilution factors

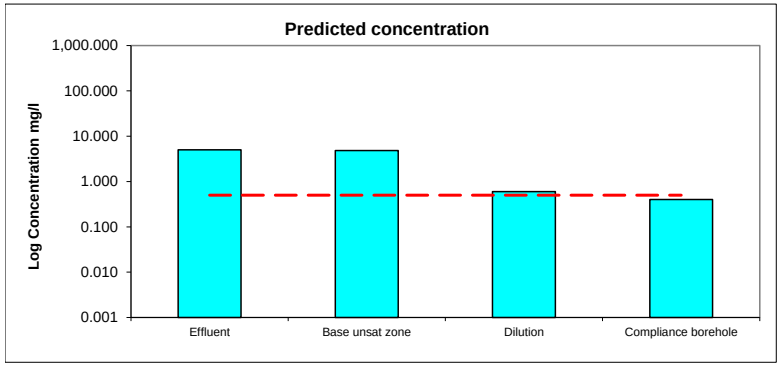
Substance		**Ammonia (N)**	
Effluent concentration	C_e	5.00E+00	mg/l
Compliance value or environmental standard	C_T	0.50	mg/l
Distance to compliance point		112.00	m
Attenuation factor - unsat zone	AFu	1.02E+00	
Dilution Factor	DF	8.03E+00	
Attenuation factor- sat zone	AFs	1.49E+00	

Predicted concentrations at compliance point based on proposed effluent concentration

Concentration at base of unsaturated zone	C_{wt}	4.82E+00	mg/l	Attenuation in unsaturated zone only
Concentration in groundwater below drainage field	C_{gw}	6.00E-01	mg/l	Dilution taken into account
Concentration in groundwater at compliance point	C_{dcp}	4.02E-01	mg/l	Attenuation in saturated zone taken into account

Provisional Environmental Permit limit values

Based on attenuation in unsaturated zone	EPL_1	5.19E-01	mg/l	
Based on attenuation in unsaturated zone and dilution	EPL_2	4.17E+00	mg/l	
Based on dilution and attenuation in unsaturated and saturated zone	EPL_3	6.22E+00	mg/l	**Discharge limit for discussion with Environment Agency**



Infiltration Worksheet

Summary of calculations for concentration of substance in groundwater

No input required,values taken from previous worksheets

Summary of compliance data, attenuation and dilution factors

Substance		**Phosphate**	
Effluent concentration	C_e	2.00E+00	mg/l
Compliance value or environmental standard	C_T	0.05	mg/l
Distance to compliance point		112.00	m
Attenuation factor - unsat zone	AFu	1.00E+00	
Dilution Factor	DF	8.03E+00	
Attenuation factor- sat zone	AFs	1.41E+00	

Predicted concentrations at compliance point based on proposed effluent concentration

Concentration at base of unsaturated zone	C_{wt}	2.04E-01	mg/l	Attenuation in unsaturated zone only
Concentration in groundwater below drainage field	C_{gw}	2.54E-02	mg/l	Dilution taken into account
Concentration in groundwater at compliance point	C_{dcp}	1.80E-02	mg/l	Attenuation in saturated zone taken into account

Provisional Environmental Permit limit values

Based on attenuation in unsaturated zone	EPL_1	4.91E-01	mg/l	
Based on attenuation in unsaturated zone and dilution	EPL_2	3.94E+00	mg/l	**Discharge limit for discussion with Environment Agency**
Based on dilution and attenuation in unsaturated and saturated zone	EPL_3	5.56E+00	mg/l	**Discharge limit for discussion with Environment Agency**