# Castle Farm, Llangibby Estate: Nutrient neutrality assessment

P23585_R1_REV1
May 2023

# Document Control

## Title

Castle Farm, Llangibby Estate: Nutrient neutrality assessment

## Client

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## Reference

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## Status

Final

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# 1. Introduction

## 1.1. Instruction

Yellow Sub Geo Ltd (Yellow Sub) was instructed by Crestwood Environmental Ltd (the Client) on behalf of Christopher Knock (the Agent) who is working for Llangibby Estate (the ultimate Client) to undertake a nutrient assessment for a planning application for a proposed residential development at Castle Farm, Llangibby Estate (the Site). Instruction to proceed in accordance with Yellow Sub proposal P23585_P1 was confirmed by email from the Client on the 4th of April 2023.

## 1.2. Background

Based on information provided by the Client, two previous reports were submitted to Natural Resources Wales (NRW) in relation to proposed foul drainage on Site. These reports comprised a Groundwater Risk Assessment (H+H Drainage, December 2022) and a Tier 1 Groundwater Risk Assessment (CE-CF-2260-RP01-Final v2, Crestwood Environmental Ltd, March 2023). These reports were submitted to appeal a Section 5 Notice from NRW that was issued to Llangibby Estate (dated 31st January 2023). Both reports have been deemed insufficient for the following reasons:

- The H+H drainage assessment (December 2022) does not meet the standards of a Detailed Quantitative Risk Assessment (DQRA).
- Owing to the location being in the catchment of a Special Area of Conservation (SAC) and the proximity of the discharge to nearby watercourses the exemption of the 15m$^3$ discharge does not apply.
- The assessment must demonstrate nutrient neutrality as per planning guidance in relation to development or water discharge permit proposals. In addition to phosphorus the assessment must demonstrate that there will be no impact from Biochemical Oxygen Demand (BOD) or Nitrates (Ammonia).
- The consultant has assessed both discharges together as one, but each discharge is unique and flows to separate watercourses to the north and to the south. The discharges, therefore, should be assessed individually.
- The consultant states that: "It is inferred that due to the lithology of the bedrock, migration of pollutants to groundwater is vertically restricted due to the presence of impermeable layers in the sequence, specifically the mudstone towards the top of the strata. Dispersion of fluids is also restricted laterally due to the presence of faulting." This is confusing, the discharge effluent (pollutants) cannot be both vertically and laterally restricted because it needs to go somewhere. It is presumed that due to the topography and geology described, the discharges would migrate via fractures and bedding planes to the springs and streams to the north-northeast and south, for the north and south discharges, respectively.
- Given the geology, topography and nearby streams and springs, it is unlikely that the effluent would travel in shallow groundwater 1.8km east to the River Usk without emerging in one or more of the nearby surface water features. Geoscience predict that the effluent, attenuated or not, would more likely migrate to the nearest down-gradient surface waters and not directly into the River Usk. Please ask the consultant to provide more evidence as to why they think this would not be the case.
- There is no evidence being used to back up the statement that lateral migration is restricted. The shallow bedrock is almost certain to have fracture, fissure, and bedding plane migration pathways, which likely connect to the many nearby springs, issues.
- The consultant states that: "The aquifer on which the Site is located is classified as a Secondary A. As such, it comprises of impermeable layers and is a minor aquifer." A

> Secondary A Aquifer is not a minor aquifer; as defined earlier in the report: "Secondary A aquifers comprise permeable layers that can support local water supplies, and may form an important source of base flow to rivers"

NRW have identified that the River Usk SAC catchment is one of the most important for wildlife in the United Kingdom and currently there are high levels phosphorus input to this water environment which may result in eutrophication. In 2021, River Usk has highest level of phosphate failures across all Wales-wide SAC rivers with 88% of waterbodies failing their target range. Whilst much of the nutrient input comes from agricultural sources it is also acknowledged that wastewater from existing housing and other development adds to this. NRW have noted that one way to address additional loading from new development is to achieve nutrient neutrality. This is a mechanism by which the additional nutrient load imposed by new development is offset by a corresponding reduction in nutrient loading from other sources. In this manner, proposed developments do not add to existing nutrient burdens, and hence can be considered to be acceptable in line with the requirements of the Conservation of Habitats and Species Regulations 2017 (as amended).

## 1.3. Scope of works

Based on the above, this report presents a nutrient assessment in accordance with the latest NRW guidance, together with a discussion regarding suitable and available mitigation measures which may be implemented to address the additional nutrient loading represented by the proposed development.

## 1.4. Limitations

This report is provided in accordance with the conditions defined in Appendix A.

As at present, Monmouthshire Council do not have a nutrient loading calculation tool, so the Carmarthenshire County Council calculator has been used. Carmarthenshire County Council have produced an accepted methodology for calculating existing and proposed nutrient loads specific to phosphates together with considerations for providing suitable mitigation measures to off-set resulting additional loads.

# 2. The Site

## 2.1. The Proposed Development

The Site is approximately 0.9ha in size and lies to the north of Llangibby village, west of Usk Road from which it is accessed (see Figure 2-1). It sits within a wider agricultural setting under the same land ownership.

The Site currently comprises a number of residential and agricultural buildings surrounded by grazing and pastureland within the wider site area. There are currently 4No. residential units on Site:

1. Stables House - 3 bed
2. Stables Flat - 2 bed
3. Fishermans Cottage - 3 bed
4. The bungalow - 3 bed

The Proposed Development comprises the conversion of additional existing agricultural buildings (south range) and part of the north range (see Figure 2-2) into 5No. new dwellings. Development of the northern range building falls under planning application ref. DM/2023/00038 involving the construction of a 3-bed house within the footprint of the previously converted north range. Development in the south falls under planning application ref. DM/2023/00046 and comprises the conversion of the south range building (currently a vacant agricultural building) and the adjacent bull shed and wood store into 4No. dwellings.

*Figure 2-1 Site location plan*

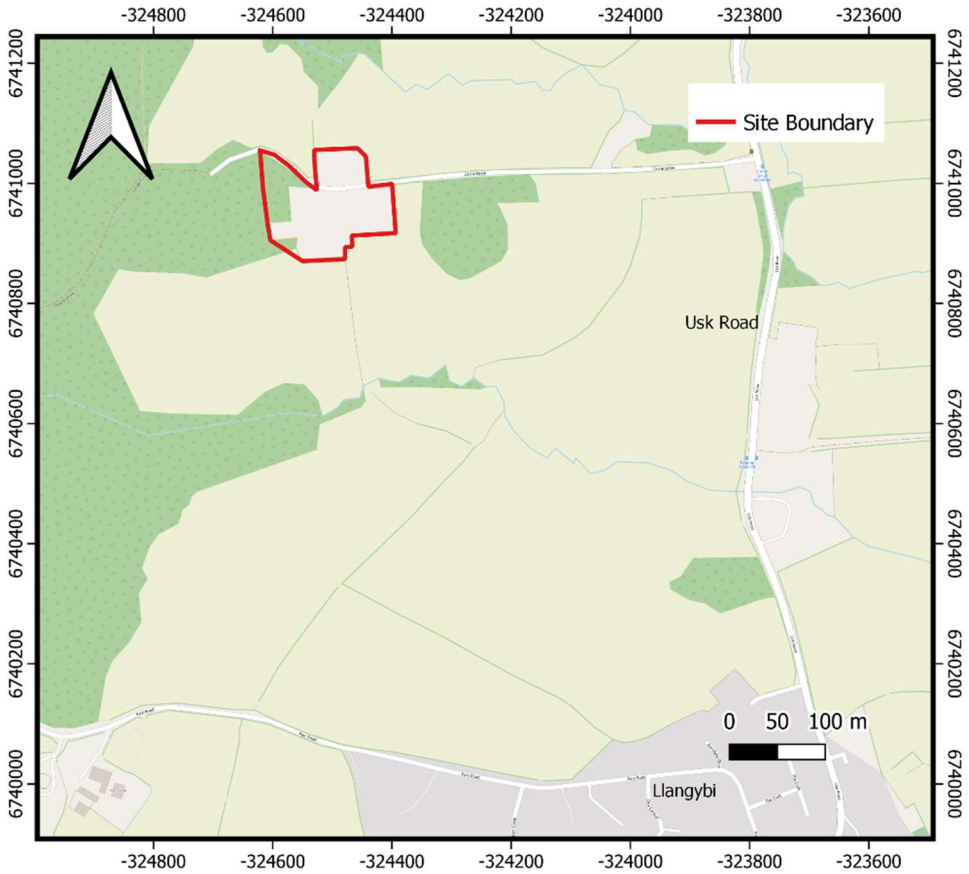
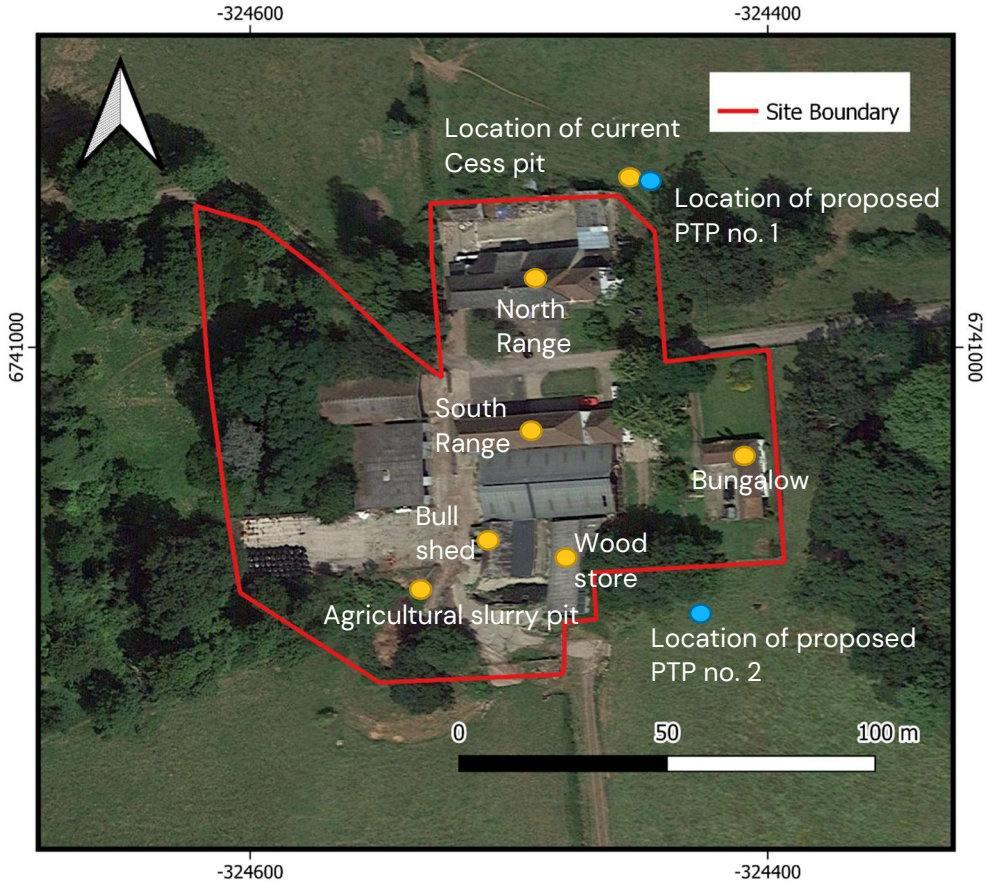


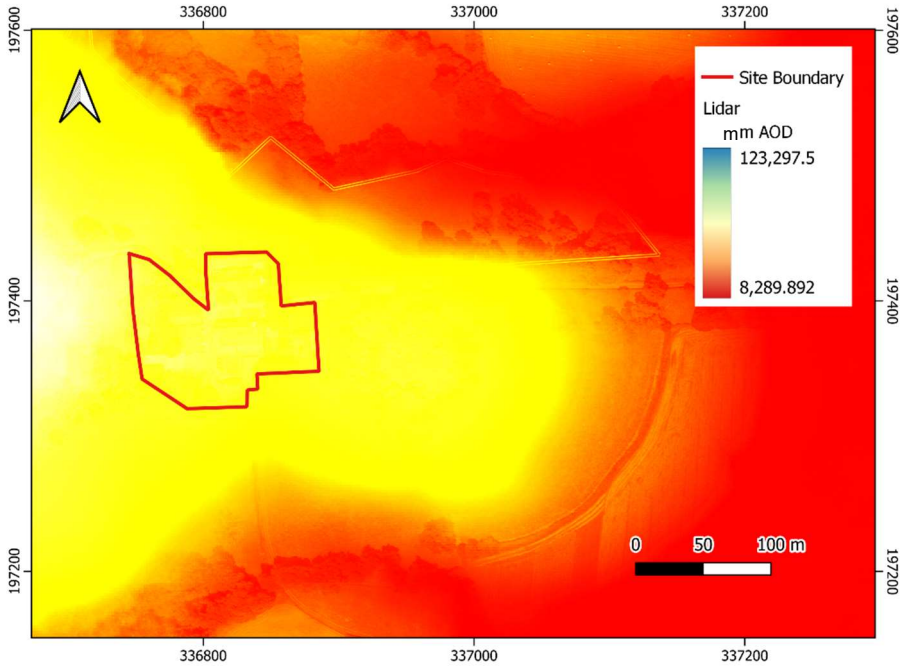
*Figure 2-2 Site layout plan*




## 2.2. Topography

Topographically the Site is split into two distinct areas with a ridge line running approximately east to west along the access road. This effectively places the northern range and southern range in separate catchments with the surrounding fields also sloping to the north and south either side of the ridge line (see Figure 2-3). It was noted on Site that the northern section of Site had a steeper incline than the southern portion.

*Figure 2-3 LIDAR at 2m resolution for Site*



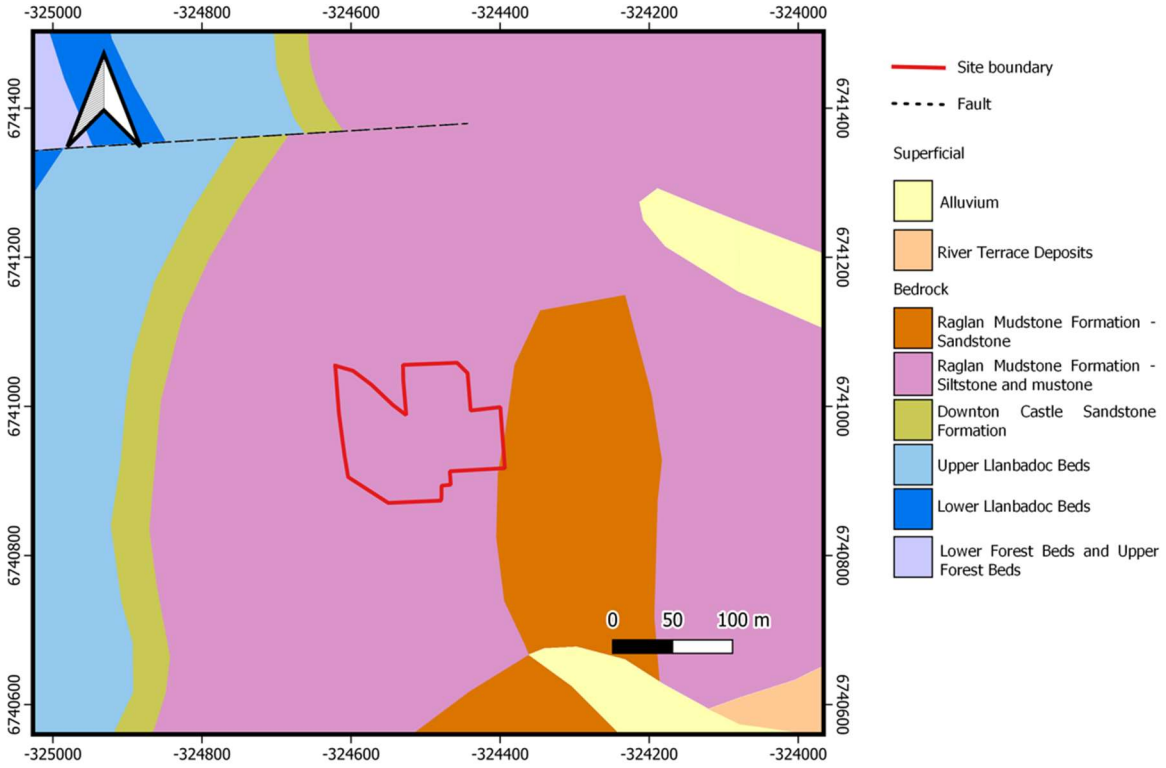

## 2.3. Geology

According to British Geological Survey (BGS) 1:50,000 scale mapping, the geological sequence underlying the Site is as follows (see Figure 2-4):

- Superficial geology: Absent
- Solid geology: Raglan Mudstone Formation (mudstone, siltstone and sandstone)

An intrusive investigation was undertaken on Site in December 2022 for infiltration testing however engineering logs of ground conditions encountered were not recorded. During the Site walkover, loose sub-angular cobbles of reddish-brown mudstone were noted on the ground surface adjacent to the December 2022 backfilled trial pits.

*Figure 2-4 Bedrock and superficial geology*




## 2.4. Hydrology and hydrogeology

According to NRW the Site lies within Flood Zone 1 (see Figure 2-5) and is considered to be at low risk of flooding from rivers and sea as well as from surface water. However, the channels to the north and south of the Site, associated with the two unnamed watercourses are within Flood Zone 3 for surface water and small watercourses (high risk).

Bedrock beneath Site is classified by the EA as a Secondary A Aquifer. These comprise permeable layers that can support local water supplies and may form an important source of base flow to rivers.

The two aforementioned unnamed ordinary watercourses run approximately 85m north and 140m south of the Site. The northern watercourse emanates from springlines in the west forming a ponded area north-west of the Site. It then runs eastwards forming a tributary of the Dowlais Brook which confluences with the River Usk approximately 2.2km southeast of Site. The southern watercourse also emerges from a springline in the west running eastwards but discharging to ground (sinks) before it reaches the Dowlais Brook. Both streams were noted by the landowner to have seasonal fluctuations of volume, however neither stream has ever dried up. The Site lies within the southern-most freshwater catchment of the River Usk SAC (see Figure 2-6).

*Figure 2-5 NRW flood risk data*

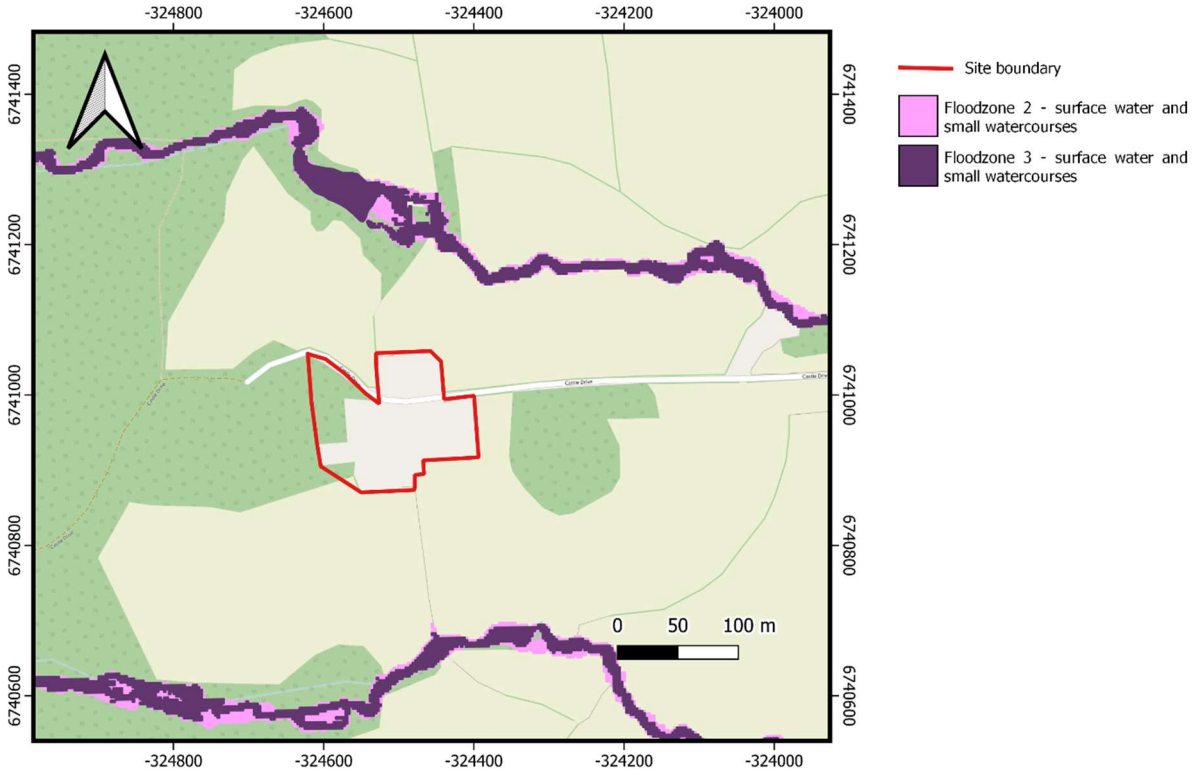
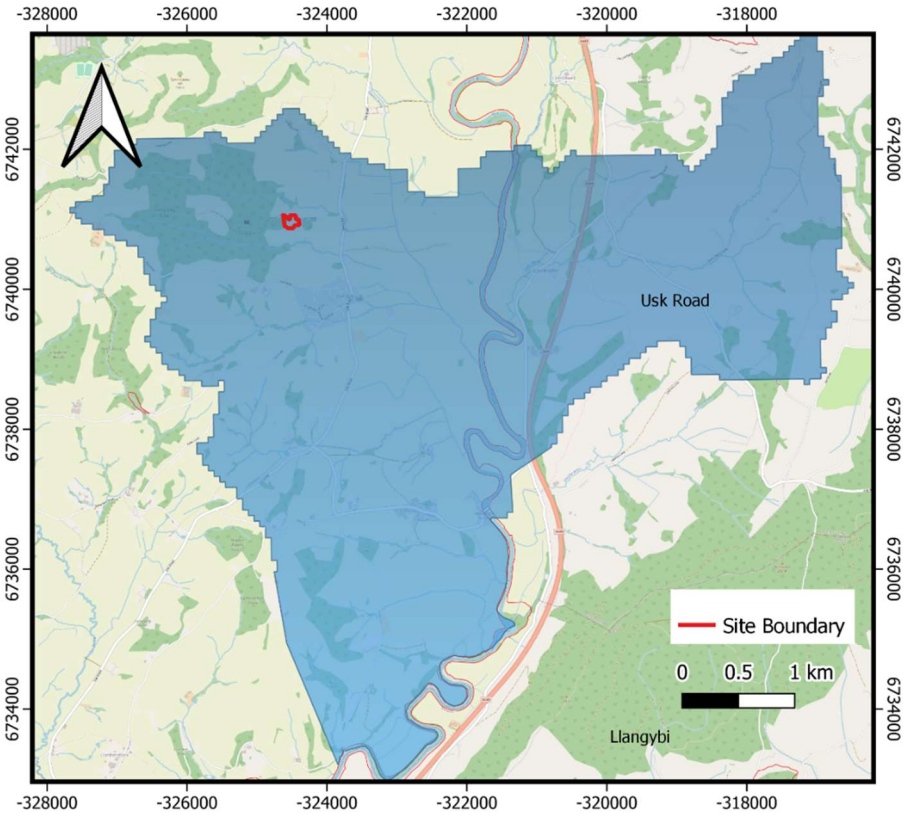



*Figure 2-6 Site hydrological catchment delineation*

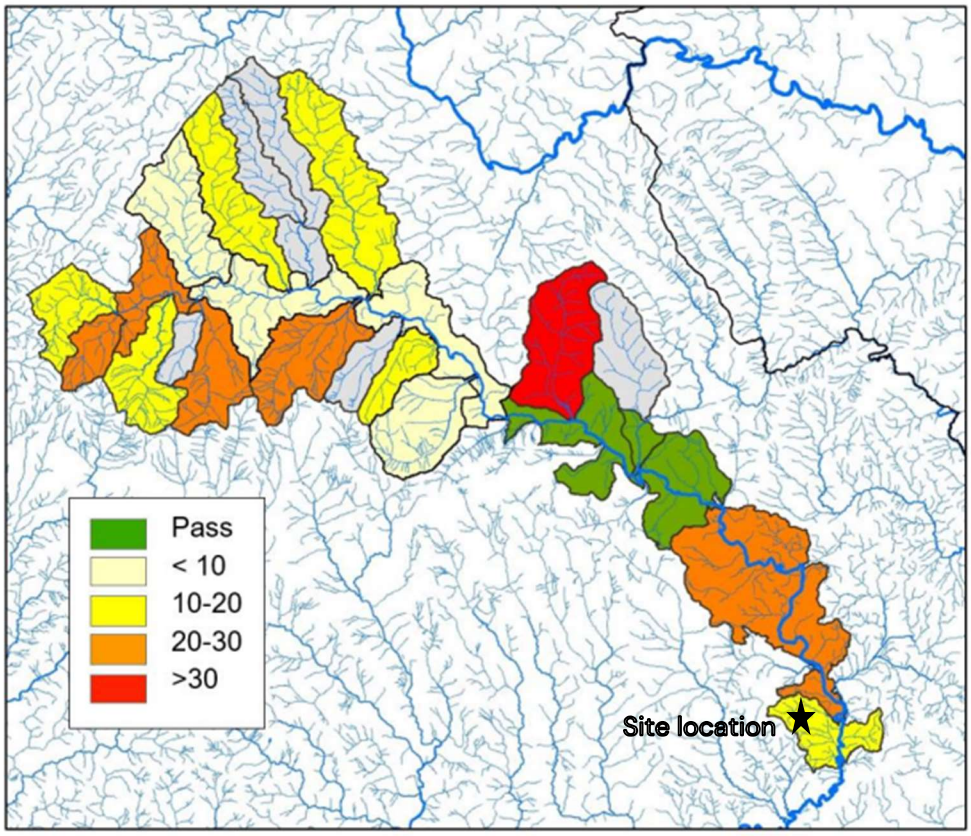


## 2.5. Environmental designations

The River Usk (Afon Wysg) is located approximately 1.8km east of the Site which is designated as a Site of Special Scientific Interest (SSSI) and SAC. As shown in Figure 2-6, the Site falls within the hydrological catchment of the River Usk and is therefore subject to adhering to NRW's position statement and requirements surrounding additional nutrient discharges into groundwater and surface water bodies.

NRW note that the River Usk has the highest level of phosphate failures across all Wales-wide SAC rivers with 88% of waterbodies failing their target range (see Figure 2-7)

*Figure 2-7 River Usk SAC compliance against phosphorus targets ($\mu gl^{-1}$)*




## 2.6. Existing infrastructure

### 2.6.1. Potable

We understand from the Site owners that potable water is supplied from a borehole on Site. No further information was provided regarding this.

### 2.6.2. Surface water

We understand that all surface water runoff from roofs, roads, parking areas etc currently discharges to ground. No further information was provided regarding this.

### 2.6.3. Foul

Currently the three existing residential units within the northern range along with the bungalow located in the southern range are connected to a single cess pit located to the north-east of the northern range (see Figure 2-2). We understand that this arrangement was a condition of the

planning permission granted in 1997 (ref: MO1525) which included a cess pit and associated soakaway system/ drainage field built to meet the requirements of the 1983 British Standard BS6297:1983. Currently this arrangement discharges untreated effluent to ground via shallow soakaways.

## 2.7. Proposed infrastructure

Foul drainage from the existing and proposed development will flow into 2No. new Package Treatment Plants (PTP) to BSEN 12566: 2005 Part III 1No. for the northern range and 1No. for the southern range (see Figure 2-2).

The PTPs will comprise Klargester BioDisc BD units, each with a capacity of 7,490 litres (consisting of 5,230 litres in the primary settlement tank and 2,260 litres in the secondary settlement tank). The waste undergoes first and second stage treatment processes between the primary and secondary settlement tanks prior to final treated effluent discharge to a shallow drainage field.

# 3. Phosphorus Calculations

## 3.1. Introduction

As noted above, the calculations presented herein are underpinned by the methodology set out by Carmarthenshire County Council (CCC) (2022). The calculation process is split into four stages, with Stage 1 dependent on whether foul sewage is discharged to a Wastewater Treatment Works, or, as it is in this case, a PTP. When a phosphorus surplus is the result of development, mitigation is required. Stage 2 considers the existing land uses, Stage 3 the proposed land uses and finally Stage 4 considers the phosphorus budget and any additional loading which may require mitigation. As the new PTPs to be installed will drain into separate watercourses, the northern and southern ranges have been split into separate calculations and assessed both independently and cumulatively below.

## 3.2. Stage 1 – New phosphorus load calculation

Where possible, Site-specific parameters have been used which have been supplemented with Carmarthenshire County Council (CCC) approved scientific and literature values where required. These are summarised in Table 3-1 and Table 3-2 below with areas used shown in drawings P23585_R1_D01, P23585_R1_D02 and P23585_R1_D03 at the end of this report.

*Table 3-1 Stage 1: North PTP calculations*

| Input parameter | Measurement | Value | Unit |
|---|---|---|---|
| Date of first occupancy | Taken from date of granted planning permission for the North Range (old stables) | 03/09/1997 | Date |
| Existing Development | Existing accepted phosphorus loading | 3 | Residential dwellings |
| Development Proposal | Development that will increase the population served by a wastewater system | 1 | Residential dwelling |
| Population | Number of people per property | 2.3 persons | Carmarthenshire Council recommended population value per proposed dwelling |
| Wastewater treatment works | Klargester BioDisc BD Package Treatment Plant (PTP) | 0.3 | mg TP/litre |
| Additional population | Single additional dwelling | 2.3 | persons |
| Wastewater by development | | 276 | Litres/day |
| **Annual wastewater TP load** | | **0.03** | **Kg TP/yr** |

*Table 3-2 Stage 1: South PTP calculations*

| Input parameter | Measurement | Value | Unit |
|---|---|---|---|
| Date of first occupancy | Data unavailable as construction / conversion still awaiting planning permission | Unknown | Date |
| Existing Development | Existing accepted phosphorus loading | 1 | Residential dwelling |
| Development Proposal | Development that will increase the population served by a wastewater system | 4 | Residential dwellings |
| Population | Number of people per property | 2.3 persons | Carmarthenshire Council recommended population value per proposed dwelling |
| Wastewater treatment works | Klargester BioDisc BD Package Treatment Plant (PTP) | 0.3 | Mg TP/litre |
| Additional population | Number of properties x number of people per property | 9.7 | persons |
| Wastewater by development | | 1,104 | Litres/day |
| **Annual wastewater TP load** | | **0.12** | **Kg TP/yr** |

## 3.3. Stage 2 – Annual phosphorus load from existing land use

The existing Site and immediate surrounding area uses are predominantly pastureland with a small percentage used for residential dwellings and associated farming infrastructure as summarised in Table 3-3 for the north and Table 3-4 for the south below.

*Table 3-3 Stage 2: North existing land use calculations*

| Input parameter | Measurement | Value | Unit | Justification |
|---|---|---|---|---|
| Soil type | Taken from Soilscapes online mapping | Freely draining | - | From CCC guidance |
| Average annual rainfall | Falls in range 1,100.1-1,200 | 1,110.70 | mm | From met office UK climate averages in Usk |
| Existing Land Use type area | Lowland grazing | 3.9961 | Ha | Site specific - measured from GIS. |
| | Residential land | 0.047 | | |
| | Woodland | 0.189 | | |
| | Lowland grazing | 0.7 | Kg TP/year | |

| Input parameter | Measurement | Value | Unit | Justification |
|---|---|---|---|---|
| Existing Land Use type area | Residential land | 0.11 | | Calculated by CCC nutrient budget calculator |
| | Woodland | 0 | | |
| | **Total** | **0.82** | **Kg TP/year** | |

*Table 3-4 Stage 2: South existing land use calculations*

| Input parameter | Measurement | Value | Unit | Justification |
|---|---|---|---|---|
| Soil type | Taken from Soilscapes online mapping | Freely draining | - | From CCC guidance |
| Average annual rainfall | Falls in range 1,100.1-1,200 | 1,110.70 | mm | From met office UK climate averages in Usk |
| Existing Land Use type area | General cropping | 4.8232 | Ha | Site specific - measured from GIS. Agricultural buildings classified as 'mixed'. Slurry pit classed as 'residential' as no suitable alternative exists |
| | Slurry pit (Residential land) | 0.0137 | | |
| | Residential land | 0.0143 | | |
| | Mixed | 0.0525 | | |
| | Lowland grazing | 7.8821 | | |
| | Woodland | 0.9016 | | |
| Existing Land Use type area | General cropping | 0.64 | Kg TP/year | Calculated by CCC nutrient budget calculator |
| | Slurry pit (Residential land) | 0.03 | | |
| | Residential land | 0.03 | | |
| | Less Favoured Area grazing | 1.39 | | |
| | Woodland | 0.02 | | |
| | **Total** | **2.12** | **Kg TP/year** | |

## 3.4. Stage 3 – Annual phosphorus load from new land use

The proposed Site uses are predominantly the same as the existing uses with a minor reduction in mixed agriculture use which correlates with an increase residential use with the 5No. additional residential dwellings as summarised in Table 3-5 and Table 3-6 below. The slurry pit on Site will be infilled however the calculation tool has no specific land use type for this, so the phosphate budget from new land use may be lower than it calculated as.

*Table 3-5 Stage 3: North proposed Site use calculations*

| Input parameter | Measurement | Value | Unit | Justification |
|---|---|---|---|---|
| Existing Land Use type area | Woodland | 0.189 | Ha | Site specific - measured from GIS. Agricultural buildings to be demolished or converted. Residential land to increase. |
| | Residential land | 0.047 | | |
| | Lowland grazing | 3.9961 | | |
| Existing Land Use type area | Woodland | 0 | Kg TP/year | Calculated by CCC nutrient budget calculator |
| | Residential land | 0.11 | | |
| | Lowland grazing | 0.7 | | |
| | **Total** | **0.82** | **Kg TP/year** | |

*Table 3-6 Stage 3: South proposed Site use calculations*

| Input parameter | Measurement | Value | Unit | Justification |
|---|---|---|---|---|
| Existing Land Use type area | General cropping | 4.8232 | Ha | Site specific - measured from GIS. Agricultural buildings to be demolished or converted. Slurry pit to be removed. Residential land to increase. |
| | Residential land | 0.0313 | | |
| | Lowland grazing | 7.8821 | | |
| | Woodland | 0.9016 | | |
| Existing Land Use type area | General cropping | 0.64 | Kg TP/year | Calculated by CCC nutrient budget calculator |
| | Residential land | 0.07 | | |
| | Lowland grazing | 1.39 | | |
| | Woodland | 0.02 | | |
| | **Total** | **2.12** | **Kg TP/year** | |

## 3.5. Stage 4 – Phosphorus load balance

Based on the data from steps 1, 2 and 3 the proposed nutrient load balance may be calculated. Positive figures indicate the need for mitigation measures to be implemented whilst negative figures indicate a deficit (i.e. improvement to baseline). The calculation is summarised in Table 3-7 and Table 3-8 including a 20% buffer as required by NRW.

*Table 3-7 Stage 4: North phosphorus load balance calculation*

| Measurement | Value | Unit | Justification |
|---|---|---|---|
| P loading to WwTw | 0.03 | Kg TP /yr | From Stage 1 |
| Net P loading from land | 0 | Kg TN /yr | Stage 3 - Stage 2 |
| P budget | 0.03 | Kg TN /yr | Step 1 + Step 2 |
| P budget + 20% precautionary buffer | 0.04 | Kg TN /yr | NRW requirement |
| **Total annual phosphorus load to mitigate** | **0.04** | **TP/year** | |

*Table 3-8 Stage 4: South phosphorus load balance calculation*

| Measurement | Value | Unit | Justification |
|---|---|---|---|
| P loading to WwTw | 0.12 | Kg TP /yr | From Stage 1 |
| Net P loading from land | 0 | Kg TN /yr | Stage 3 - Stage 2 |
| P budget | 0.12 | Kg TN /yr | Step 1 + Step 2 |
| P budget + 20% precautionary buffer | 0.14 | Kg TN /yr | NRW requirement |
| **Total annual phosphorus load to mitigate** | **0.14** | **TP/year** | |

Table 3-7 and Table 3-8 show positive values of 0.04 kg TN/ yr and 0.14 kg TN/ yr respectively which would typically be indicative of potential nutrient impacts due to the proposed development. However, the above scenarios and calculations do not allow for two important on-Site factors:

- The northern range currently includes an old cess pit and drainage field which allows untreated effluent to leach into the ground; and,
- The southern range includes a large below ground slurry tank which is currently being decommissioned and will not be replaced.

However, as the Site falls within the SAC catchment of the River Usk, further reduction in phosphorus and other nutrients needs to be quantitatively delineated, hence a detailed quantitative risk assessment utilising a combination of techniques (including the Environment Agency's Remedial Targets Methodology (P20) spreadsheets) is undertaken in Section 5.

# 4. PTP nutrient reduction

Additional loading of other nutrients (as well as phosphorus) including ammoniacal nitrogen (nitrates) and increased biological oxygen demand (BOD) is expected with increased effluent loads. However, when compared to the current baseline, the use of 2No. modern PTPs will significantly reduce the concentrations of all nutrients within the final treated effluent. Table 4-1 summarises the efficiency of rate of the Klargester Biodisc PTP with additional chemical dosing which, when compared to the baseline existing infrastructure of raw untreated effluent being discharged shows that there will be significant improvement. Klargester Biodisc PTP certifications can be found in Appendix C.

*Table 4-1 Klargester Biodisc PTP specification*

| Element / compound | Biodisc removal efficiency |
|---|---|
| Biological oxygen demand (BOD) | 98% |
| Chemical oxygen demand (COD) | 95.9% |
| Suspended solids | 95.6% |
| Ammonium nitrogen | 92.1% |
| Nitrogen | 71.1% |
| Phosphorus | 95.4% |

Table 4-2 below, shows the reduction of nutrient parameters from an average baseline to removal by three different treatment options. The biodisc PTP with chemical dosing can clearly be demonstrated as the most efficient option.

*Table 4-2 Klargester Biodisc PTP specification*

| Element / compound | Average domestic sewage conventional parameters (U.S. EPA, 1994b) (mg/L) (Agency, 1995) (Agency, 1995)[1] | Septic tank discharge (mg/l)[2] | Package treatment plant (mg/l)[2] | Biodisc PTP plus chemical dosing (mg/l) |
|---|---|---|---|---|
| BOD | 6,480 | 368 | 55 | 6 |
| Chemical oxygen demand (COD) | 31,900 | 677 | 210 | 31 |
| Suspended solids | 12,862 | NV* | NV* | 15 |
| Ammonium nitrogen | 97 | 104 | 89 | 3 |

[1] EPA, 1995. Process Design Manual Land Application of Sewage Sludge and Domestic Septage. Pp. 129.
[2] GOV.UK effluent analysis. Available at: https://www.gov.uk/government/publications/values-for-groundwater-risk-assessments/septic-tank-and-package-treatment-plants-liquid-effluent-pollutants-and-typical-concentrations

| Element / compound | Average domestic sewage conventional parameters (U.S. EPA, 1994b) (mg/L) (Agency, 1995) (Agency, 1995)[1] | Septic tank discharge (mg/l)[2] | Package treatment plant (mg/l)[2] | Biodisc PTP plus chemical dosing (mg/l) |
|---|---|---|---|---|
| BOD | 6,480 | 368 | 55 | 6 |
| Nitrogen (total kjeldahl) | 588 | NV* | NV* | 17.9 |
| Phosphorus | 210 | 15.8 | 10.5 | 0.3 |

*No value

# 5. Land Quality Assessment: DQRA

## 5.1. DQRA Modelling for controlled waters (wider environment)

### 5.1.1. Introduction and rationale

A process of computer modelling of the behaviour of dissolved phase contamination for phosphorus and ammoniacal nitrogen has been undertaken using the Environment Agency P20 Worksheets Version 3.2 (EA 2013). The models have been run assuming a steady-state (i.e. the source does not decline over time). The model calculation sheets are provided in Appendix D.

The critical environmental receptors close to Site are the northern and southern unnamed streams, both of which fall into the encompassing SAC catchment zone of the River Usk. The model has therefore been constructed to represent the potential contaminant linkage between the Site and the northern and southern streams.

#### *5.1.1.1. Input parameters*

The following tables set out the input parameters used for the P20 modelling, and the rationale for choice of each.

*Table 5-1 DQRA input parameters for CoPCs*

| Constituent of concern | Half – life (days) | Target concentration (mg/l) |
|---|---|---|
| Phosphorus (P) | 1E+100 (does not degrade) | 0.04 (WFD 'Good' Status for low alkalinity lowland[3]) |
| Ammoniacal nitrogen (NH4) | 365 - 2,190 [4] | 0.6 |

*Table 5-2 DQRA input parameters (physical parameters)*

| Parameter | Comment | Chosen value |
|---|---|---|
| Initial contaminant concentration at plume core | Ammonia Nitrogen treated effluent concentration, from Klargester datasheet | 3mg/l |
| | Phosphorus treated effluent concentration, from Klargester datasheet | 0.3mg/l |
| Half-life for degradation of contaminant in the water | Ammonia nitrogen literature value | 1277.5 |
| | Phosphorus literature value | N/A – does not degrade |
| Area of contaminant source ($m^2$) | Estimated extent of soakaway drainage fields | 20$m^2$ |
| Width of plume (m) | Width of conjectured source area (soakaway drainage field) | 20 |
| Plume thickness (m) | Assumed from average depth to groundwater, allowing model room for vertical dispersion | 2 |
| Saturated aquifer thickness (m) | Assumed value based on local geology | 5 |
| Dispersivity (%) | Model defaults | 10%,1%,0.1% |

[3] WFD, 2013. Updated recommendations on phosphorus standards for rivers. River Basin Management (2015-2021).

[4] EA NC/02/49 (2003). Range for sands and gravels

| Parameter | Comment | Chosen value |
|---|---|---|
| Bulk density of aquifer material (g/cm$^3$) | Assumed value, has little impact on remedial target value (RTV) | 2 |
| Water filled porosity of aquifer (fraction) | Assumed value, has little impact on RTV | 0.3 |
| Air filled porosity of aquifer (fraction) | Assumed value, has little impact on RTV | 0.1 |
| Effective porosity (fraction) | Assumed value as 100% of water filled porosity | 0.3 |
| Hydraulic gradient (fraction) | Northern side = Difference between water level of the river (30m AOD) and height of the development (50m AOD) divided by the length between the two (85m) | 0.2353 |
| | Southern side = Difference between water level of the river (30m AOD) and height of the development (50m AOD) divided by the length between the two (140m) | 0.1428 |
| Hydraulic conductivity of aquifer (m/day) | Literature value (Tellam and Lloyd 1981)[5] | 0.1 |
| Distance to compliance point (m) | Northern PTP to the northern stream | 85m |
| | Southern PTP to the southern stream | 140m |
| Time since pollutant entered groundwater (days) | Steady state | 1x10$^{100}$ |

### 5.1.2. Results

Table 5-3 summarises the results of the DQRA modelling process.

*Table 5-3 P20 DQRA modelling results*

| Contaminant | Site location | Remedial target (mg/l) | Concentration of contaminant at compliance point (mg/l) |
|---|---|---|---|
| Phosphorus | North range | 0.168 | **0.0716** |
| | South range | 0.413 | **0.0291** |
| Ammoniacal N as NH4 | North range | 15.6 | **0.116** |
| | South range | 389 | **0.00463** |

Both phosphorus and ammoniacal nitrogen show values far below their remedial targets or target concentrations at compliance point, i.e. the two streams. Both contaminants also have initial contaminant concentrations below the remedial targets prior to any degradation taking place, due to the contaminants having been treated by the chemical dosing of the PTP prior to discharge to the environment.

### 5.1.3. Demonstrating betterment

Currently the baseline on Site comprises a brick-lined cess pit built at least 25 years ago with adjacent shallow drainage field plus a large below ground agricultural waste slurry pit. Both waste storage and disposal methods currently employed on Site result in the discharge of raw untreated effluent to ground which may impact the groundwater and nearby unnamed streams

[5] Tellam, J. H. and Lloyd, J.W. 1981. Hydrogeology of British onshore non-carbonate mudrocks. Quarterly journal of Engineering Geology, Vol. 14, 347-355.

to the north and south of the Site which eventually converge with the River Usk. Whilst construction of a further 5No. dwellings on Site will increase effluent loading, the installation of two new PTPs, in combination with the removal of the current cess pit and slurry pit will result in betterment for the Site with contaminant concentrations at compliance point shown to be minimal and far below remedial targets (Table 4-4).

Once the development is completed, no untreated effluent will be discharged from the Site and instead effluent will be treated with a significant reduction in BOD, COD, suspended solids, phosphorus and ammoniacal nitrogen (shown in Table 5-4 below) before being discharged into the proposed drainage fields. Therefore, when comparing the baseline (raw effluent discharge) with the future scenario (final treated effluent) it can clearly be demonstrated that not only is nutrient neutrality achieved, but betterment is provided.

*Table 5-4 Demonstrating betterment*

| | | | North range | | South range |
|---|---|---|---|---|---|
| Average occupancy rate | Persons per dwelling | | 2.3 | | 2.3 |
| Water usage | litres/person/day | | 120 | | 120 |
| Pre-development dwellings | No. | | 3 | | 1 |
| Post-development dwellings | No. | | 4 | | 5 |
| Total effluent pre-development | litres/ day | | 828 | | 276 |
| Total effluent post-development | litres/ day | | 1104 | | 1380 |
| | | **Pre-development** | **Post-development** | **Pre-development** | **Post-development** |
| BOD | kg/day | 305 | 6.6 | 102 | 8.3 |
| Chemical oxygen demand (COD) | kg/day | 561 | 34.2 | 187 | 42.8 |
| Ammonium nitrogen | Persons per dwelling | 86 | 3.3 | 29 | 4.1 |
| Phosphorus | litres/person/day | 13 | 0.3 | 4 | 0.4 |

# 6. Conclusions and recommendations

## 6.1. Conclusions

Based on the work undertaken to inform this report, sufficient information and assessment has been presented herein to demonstrate that:

- The proposed development is to include two Klargester package sewage treatment plants (PTPs) which, with chemical dosing, provide significant treatment of effluent.
- Detailed quantitative modelling (P20) of phosphate and ammonia indicate that any impact this effluent may have on the nearest watercourses will be below the threshold for Good as defined in the Water Framework Directive. As such, this effluent will not prevent the watercourse's status achieving Good.
- Indeed, due to the improved effluent quality that the PTPs will deliver when compared with the current septic tank arrangement, the effluent from both the North Range and South Range will be significantly better than is currently the case, despite the additional new residential properties. This is true of phosphate, ammonia, BOD and COD.
- The betterment being delivered by the development is further enhanced by the fact that a slurry pit is being decommissioned and infilled as part of the development, thus reducing the nutrient sources on site still further.

## 6.2. Recommendation

Due to the betterment demonstrated, and the lack of significant impact to the nearest watercourses, no further action is recommended with respect to the assessment of the impact of effluent from the proposed development on the River USK SAC.

Once installed, the PTP shall need to be maintained in accordance with the manufacturer's instruction, including the necessary chemical dosing to achieve the required treatment.

.

# Figures


- Site Boundary - 0.9 Ha
- Woodland - 0.9016 Ha
- Pasture land - 4.8232 Ha
- Grazing land - 7.8821 Ha
- Residential buildings - 0.0143 Ha
- Agricultural buildings - 0.0525 Ha
- Slurry pit - 0.0137 Ha

Figure Title
**South range land cover pre-development, Castle Farm, Llangibby Estate**

Client
**Crestwood Environmental**

Drawing Number
**P23585_R1_D01**

Scale
**1:3,600**

Original
**A4**

Project Number
**P23585**

Drawn
**ACW**

Checked
**JEM**

Date
**18/04/2023**

Site Location
**Llangibby Estate**

YELLOW SUB GEO


- Site Boundary - 0.9 Ha
- Woodland - 0.9016 Ha
- Pasture land - 4.8232 Ha
- Grazing land - 7.8821 Ha
- Residential buildings - 0.0313 Ha

Figure Title
**South range land cover post-development, Castle Farm, Llangibby Estate**

Client
**Crestwood Environmental**

Drawing Number
**P23585_R1_D02**

Scale
**1:3,600**

Original
**A4**

Project Number
**P23585**

Drawn
**ACW**

Checked
**JEM**

Date
**18/04/2023**

Site Location
**Llangibby Estate**

YELLOW SUB GEO


- Site Boundary - 0.9 Ha
- Woodland - 0.189 Ha
- Grazing land - 3.9961 Ha
- Residential buildings - 0.047 Ha

Figure Title
**North range land cover pre- and post-development, Castle Farm, Llangibby Estate**

Client
**Crestwood Environmental**

Drawing Number
**P23585_R1_D03**

Scale
**1:2,900**

Original
**A4**

Project Number
**P23585**

Drawn
**ACW**

Checked
**JEM**

Date
**18/04/2023**

Site Location
**Llangibby Estate**

YELLOW SUB GEO

# Appendices

# Appendix A Report conditions

# Report Conditions

This report has been prepared by Yellow Sub Geo Ltd. (Yellow Sub Geo) in its professional capacity as soil and groundwater specialists, with reasonable skill, care and diligence within the agreed scope and terms of contract and taking account of the manpower and resources devoted to it by agreement with its client and is provided by Yellow Sub Geo solely for the internal use of its client.

The advice and opinions in this report should be read and relied on only in the context of the report, taking account of the terms of reference agreed with the client. The findings are based on the information made available to Yellow Sub Geo at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology, and practices as at that time. They do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

Where necessary and appropriate, the report represents and relies on published information from third party, publicly and commercially available sources which is used in good faith of its accuracy and efficacy. Yellow Sub Geo cannot accept responsibility for the work of others.

Site investigation results necessarily rely on tests and observations within exploratory holes only. The inherent variation in ground conditions mean that the results may not be representative of ground conditions between exploratory holes. Yellow Sub Geo take no responsibility for variation in ground conditions between exploratory positions.

This report is confidential to the client. The client may submit the report to regulatory bodies, where appropriate. Should the client wish to release this report to any other third party for that party's reliance, Yellow Sub Geo may, by prior written agreement, agree to such release, if it is acknowledged that Yellow Sub Geo accepts no responsibility of any nature to any third party to whom this report or any part thereof is made known. Yellow Sub Geo accepts no responsibility for any loss or damage incurred as a result, and the third party does not acquire any rights whatsoever, contractual, or otherwise, against Yellow Sub Geo except as expressly agreed with Yellow Sub Geo in writing. Yellow Sub Geo reserves the right to withhold and/ or negotiate the transference of reliance on this report, subject to legal and commercial review.



Registered in England and Wales with Company No. 10888960 at Rabble Studio, 103 Bute Street, Cardiff, CF10 5AD.

# Appendix B Photographic plates

| | North range | | South rnage |
|---|---|---|---|
| Project | Castle Farm, Llangibby Estate | Date | 11/04/23 |
| Project No. | P23585 | Engineer | ACW |
| Client | Crestwood Environmental | Comments | |

| | Current drainage in the north of Site | | Northern stream |
|---|---|---|---|
| Project | Castle Farm, Llangibby Estate | Date | 11/04/23 |
| Project No. | P23585 | Engineer | ACW |
| Client | Crestwood Environmental | Comments | |

| | Drainage fields to the south | | Stream to the south |
|---|---|---|---|
| Project | Castle Farm, Llangibby Estate | Date | 11/04/23 |
| Project No. | P23585 | Engineer | ACW |
| Client | Crestwood Environmental | Comments | |

| | | | |
|---|---|---|---|
| | Agricultural slurry pit | | Back of south range building and bungalow garden |
| Project | Castle Farm, Llangibby Estate | Date | 11/04/23 |
| Project No. | P23585 | Engineer | ACW |
| Client | Crestwood Environmental | Comments | |

# Appendix C Klargester BioDisc BD specification

# Certificate

353.02C02

**Kingspan Water & Energy Ltd.**
College Road North, Aston Clinton, Aylesbury, HP22 5EW, UK

**EN 12566-3, Annex B**
Small wastewater treatment systems for up to 50 PT

**Small wastewater treatment system BioDisc +P**
Rotating Biological Contactor (RBC) in a GRP tank with chemical dosing equipment

Test report PIA2019-353B47.02
This test certificate is a revised version of test certificate no. 353.02C01.

| | | | |
|---|---|---|---|
| Nominal organic daily load (influent) | 0.28 kg $BOD_5$/d | | |
| Nominal hydraulic daily load | 0.9 m³/d | | |
| Material | GRP | | |
| Treatment efficiency | | Efficiency | Effluent |
| (nominal sequences) | COD | 95.9 % | 31 mg/l |
| | $BOD_5$ | 98.0 % | 6 mg/l |
| | $N_{tot}$* | 71.1 % | 17.9 mg/l |
| | $NH_4$-N* | 92.1 % | 3.0 mg/l |
| | $P_{tot}$ | 95.4 % | 0.3 mg/l |
| | SS | 95.6 % | 15 mg/l |
| Electrical consumption | 1.5 kWh/d | | |

*determined for temperatures ≥ 12 ° C in the bioreactor

Performance tested by:

**PIA – Prüfinstitut für Abwassertechnik GmbH**
Hergenrather Weg 30
52074 Aachen
Germany

This document replaces neither the declaration of performance nor the CE marking.

PIA - Sustainable Certification
geprüft - tested - testé

Notified Body No.: 1739

Martina Wemmer December 2020

Water Management Solutions

Kingspan

7 YR WARRANTY PERIOD

Klargester

# BioDisc® BA-BE Sewage Treatment Plant



kingspan.co.uk/klargester

Kingspan®

# Klargester BioDisc®
# Domestic Sewage Treatment Plant

## Support from start to finish from our expert team


* Dimensions illustrated here are applicable to the BA and BB models only.

# Choosing the right sewage treatment plant for your home with Kingspan Klargester

Kingspan Klargester provides relevant advice and support throughout the wastewater treatment purchasing process based on our in-depth local knowledge and expertise. We offer comprehensive free site visits, professional installation options (optional extra) and expert aftersales care through our national network of accredited installers and engineers.

BioDisc is 100% compliant with European standard EN 12566-3

## I'm a homeowner - what do I need to consider before choosing my treatment plant?

The Kingspan Klargester BioDisc sewage treatment system is available to suit all types of domestic applications, catering for single and multi-house properties. BioDisc is engineered to treat wastewater to a very high standard and offers affordable lifetime costs compared to other treatment processes.

Our team will guide you through:
- Size of treatment plant required
- Ground conditions around the plant
- Wastewater discharge options
- Invert level options

## Why BioDisc®?

With strict Environment Agency standards, it's more important than ever to choose a sewage treatment plant that delivers peace of mind with reliable treatment of wastewater.

The Kingspan Klargester BioDisc is built on the back of 65 years' experience and offers the following benefits:

7 YEAR WARRANTY**

## Product benefits

- Affordable lifetime running costs
- Trusted and reliable performance
- Odour free
- Silent Operation

BioDisc is one of the few systems in the UK which doesn't make use of an air pump (used in an 'aerated' system) which means minimal odour being released. This is verified by an independent odour sampling report (available on request).

At a recent site, our expert team concluded that the domestic BioDisc has the same level of noise as the average ambient background noise outside (between 40-55 decibels).*


**Typical aerated system**
Decibel equivalent to a coffee grinder machine

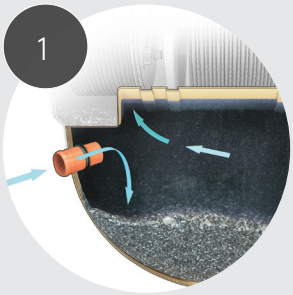
**Domestic BioDisc**
Decibel equivalent to a modern refrigerator

* This is a representative figure based on a commercial BioDisc plant.

Register your guarantee online at **kingspan.co.uk/klargesterguarantee** to arrange your service and enjoy an extended seven year guarantee period.**

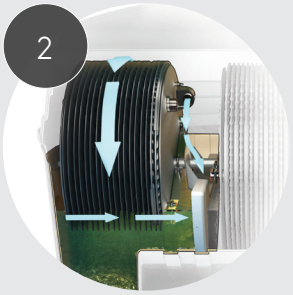
** For BA and BB BioDisc models only, when registered online - terms and conditions apply.
Visit: https://www.kingspan.com/gb/en-gb/products/wastewater-management/warranty-terms

# How it works



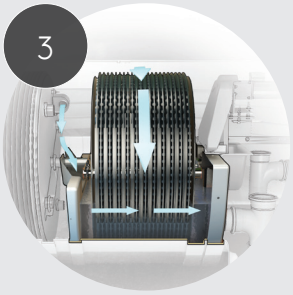

## Primary settlement tank

Wastewater and sewage flows into the primary settlement tank where the large solids are retained for future removal.



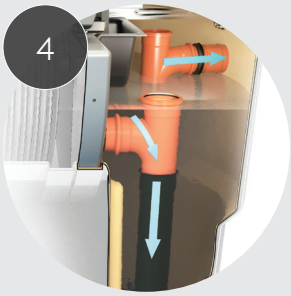

## First stage biological treatment

The liquor and fine solids then flow into the Biological Treatment Zone 1 where the first stage of treatment occurs.




## Second stage biological treatment

The liquor is then fed forward at a controlled rate into Biological Treatment Zone 2 for further treatment.

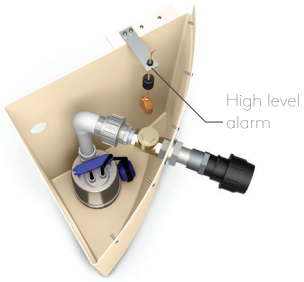

## Final settlement tank

The clean liquid passes into the final settlement tank where it can be discharged to ground or water course.

Control panel and beacon featuring alarm* and digital display to signal that your system is working optimally (beacon and alarm optional extras).

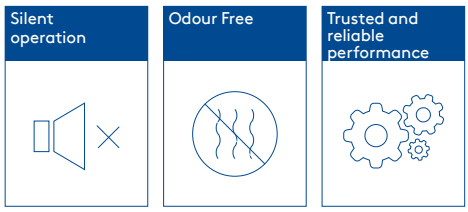
## SmartServ Pro

Ask us about our SmartServ Pro remote monitoring solution (optional extra). With early fault detection, SmartServ Pro lets you know when your system needs serviced, giving you peace of mind. Find out more at helpingyou@kingspan.com




**Integrated Pump System** also available (for pumped systems only). Our technical team will guide you through the best options for your site.

Book your free site visit from our expert Klargester team at **klargester@kingspan.com** or visit **kingspan.co.uk/klargester**




## Technical Specifications

| Model Reference | BA | BAX | BB | BC | BD | BE |
|---|---|---|---|---|---|---|
| Population Equivalent | 8 | 12 | 16 | 24 | 33 | 47 |
| Maximum Daily BOD5 (g BOD5) | 360 | 540 | 720 | 1080 | 1500 | 2100 |
| Maximum Daily Flow (m3) | 1.2 | 1.8 | 2.4 | 3.6 | 5 | 7 |
| Maximum Daily Ammonia (g NH4) | 48 | 72 | 96 | 144 | 200 | 280 |
| Overall Diameter (mm) | 1995 | 1995 | 1995 | 2450 | 2450 | 2450 |
| Length (mm) | N/A | N/A | N/A | N/A | 3340 | 3340 |
| Inlet Invert depth (mm) | 450/750/1250 | 450/750/1250 | 450/750/1250 | 600/1100 | 600/1100 | 600/1100 |
| Depth Below Inlet Invert (mm) | 1400 | 1400 | 1400 | 1400 | 1820 | 1820 |
| Outlet Invert Depth (mm) | 1315 | 1315 | 1315 | 1735 | 1735 | 1735 |
| Overall Height (mm) | 2160/2460/2960 | 2160/2460/2960 | 2160/2460/2960 | 2825/3325 | 2825/3325 | 2825/3325 |
| Height to Rim of Cover (mm) | 1945/2245/2745 | 1945/2245/2745 | 1945/2245/2745 | 2485/2985 | 2485/2985 | 2485/2985 |
| Empty Weight (kg) | 310/325/380 | 335/350/405 | 335/350/405 | 650/750 | 1100/1200 | 1200/1300 |
| Standard Power Supply | 1 phase | 1 phase | 1 phase | 1 phase | 1 phase | 1 phase |
| Motor Rating – Single Phase (Watts) | 60 | 60 | 60 | 173 | 253 | 253 |
| Full Load Current - Single Phase (amps) | 0 | 0 | 0 | 1 | 1 | 1 |
| Optional Power Supply | N/A | N/A | N/A | 3 phase | 3 phase | 3 phase |
| Motor Rating – 3 Phase (Watts) | N/A | N/A | N/A | 90 | 90 | 90 |
| Full Load Current - 3 Phase (amps) | N/A | N/A | N/A | 0.38 | 0.38 | 0.38 |
| Sludge Return Pump Rating (Watts) | 250 | 250 | 250 | 250 | 250 | 250 |

### Invert level options

Three standard drain invert level options are available from stock to match the site topography and where applicable, minimise the excavation depth. The BA, BB and BA-X models are available with an integral pump to move the effluent from the point of treatment, if site level demands.

## Environment Agency regulations

As an off-mains homeowner, you must comply with the General Binding Rules by ensuring your treatment system is maintained properly and does not cause pollution. These rules state that you must arrange regular maintenance for your system, via a trusted service provider. Kingspan Service can help with expert servicing and alarm packages – email **helpingyou@kingspan.com**

## Protect your investment with our Service and Maintenance Plans

We recommend that you service your BioDisc sewage treatment plant **once a year**. Under Environment Agency regulations, it's now your responsibility to ensure smooth running of your plant.

Our in house Service department offer a range of service packages including Gold, Silver and Bronze to cater for all homeowners' needs.

To find out more about how you could benefit from a tailored service package from Kingspan, call us on **0333 240 6868** or email **helpingyou@kingspan.com**

For further technical information & videos on the BioDisc treatment plant visit our website at**kingspan.co.uk/klargester**

# Contact Details

## UK

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**www.kingspan.co.uk/klargester**

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T: NI: 028 3836 4600 | ROI: 0818 543 500
E: helpingyou@kingspan.com
**www.kingspanservice.com**



03/2023_v5_5010.02

# Appendix D P20 calculations

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)**

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Ammoniacal nitrogen NH4 | | from Level 1 |
| Target Concentration | $C_T$ | 6.00E-01 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 3.00E+00 | mg/l | *Treated water concentration, from Klargester datasheet* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.28E+03 | days | *Literature value* |
| Calculated decay rate | $\lambda$ | 5.43E-04 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 2.00E+01 | m | *Assumed drainage field 20x20* |
| Plume thickness at source | Sy | 2.00E+00 | m | *Assumed* |
| Saturated aquifer thickness | da | 5.00E+00 | m | *Assumed* |
| Bulk density of aquifer materials | ρ | 2.00E+00 | $g/cm^3$ | *Literature value* |
| Effective porosity of aquifer | n | 3.00E-01 | fraction | *Assumed* |
| Hydraulic gradient | i | 2.35E-01 | fraction | *0.2353 north 0.1428 south* |
| Hydraulic conductivity of aquifer | K | 1.00E-01 | m/d | *Literature value (Tellam and Lloyd 1981)* |
| Distance to compliance point | x | 8.50E+01 | m | *Distance to nearest watercourse* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 4.00E-01 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 8.50E+00 | m | *see options* |
| Transverse dispersivity | az | 8.50E-01 | m | *see options* |
| Vertical dispersivity | ay | 8.50E-02 | m | *see options* |

**Calculated Parameters**

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 7.84E-02 | m/d |
| Retardation factor | Rf | 3.67E+00 | fraction |
| Decay rate used | λ | 5.43E-04 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 2.14E-02 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 1.16E-01 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **2.60E+01** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **1.56E+01** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **85** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **1.16E-01** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

| | | | |
|---|---|---|---|
| Soil water partition coefficient | Kd | 4.00E-01 | l/kg |

***Entry for non-polar organic chemicals (option)***

| | | | |
|---|---|---|---|
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |

***Entry for ionic organic chemicals (option)***

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg |
| pH value | pH | | |
| acid dissociation constant | pKa | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Soil water partition coefficient | Kd | 4.00E-01 | l/kg |

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

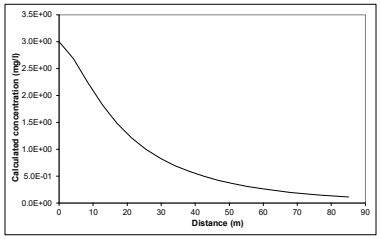
Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 8.50E+00 | 4.06E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 8.50E-01 | 4.06E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 8.50E-02 | 4.06E-02 | |

**Note values of dispersivity must be > 0**

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

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




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Castle Farm |
| Completed by: | Anneliese Whiteley |
| Date: | ####### |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 3.0E+00 |
| 4.3 | 2.69E+00 |
| 8.5 | 2.24E+00 |
| 12.8 | 1.82E+00 |
| 17.0 | 1.48E+00 |
| 21.3 | 1.22E+00 |
| 25.5 | 1.00E+00 |
| 29.8 | 8.34E-01 |
| 34.0 | 6.98E-01 |
| 38.3 | 5.88E-01 |
| 42.5 | 4.98E-01 |
| 46.8 | 4.24E-01 |
| 51.0 | 3.62E-01 |
| 55.3 | 3.11E-01 |
| 59.5 | 2.68E-01 |
| 63.8 | 2.31E-01 |
| 68.0 | 2.00E-01 |
| 72.3 | 1.74E-01 |
| 76.5 | 1.52E-01 |
| 80.8 | 1.32E-01 |
| 85.0 | 1.16E-01 |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)**

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Ammoniacal nitrogen NH4 | | from Level 1 |
| Target Concentration | $C_T$ | 6.00E-01 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 3.00E+00 | mg/l | *Treated water concentration, from Klargester datasheet* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.28E+03 | days | *Literature value* |
| Calculated decay rate | $\lambda$ | 5.43E-04 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 2.00E+01 | m | *Assumed drainage field 20x20* |
| Plume thickness at source | Sy | 2.00E+00 | m | *Assumed* |
| Saturated aquifer thickness | da | 5.00E+00 | m | *Assumed* |
| Bulk density of aquifer materials | ρ | 2.00E+00 | $g/cm^3$ | *Literature value* |
| Effective porosity of aquifer | n | 3.00E-01 | fraction | *Assumed* |
| Hydraulic gradient | i | 1.43E-01 | fraction | *0.2353 north 0.1428 south* |
| Hydraulic conductivity of aquifer | K | 1.00E-01 | m/d | *Literature value (Tellam and Lloyd 1981)* |
| Distance to compliance point | x | 1.40E+02 | m | *Distance to nearest watercourse* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 4.00E-01 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.40E+01 | m | *see options* |
| Transverse dispersivity | az | 1.40E+00 | m | *see options* |
| Vertical dispersivity | ay | 1.40E-01 | m | *see options* |

**Calculated Parameters**

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 4.76E-02 | m/d |
| Retardation factor | Rf | 3.67E+00 | fraction |
| Decay rate used | λ | 5.43E-04 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 1.30E-02 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 4.63E-03 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **6.48E+02** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **3.89E+02** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **140** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **4.63E-03** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — 4.00E-01 l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species — $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg

pH value — pH

acid dissociation constant — pKa

Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 4.00E-01 l/kg

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

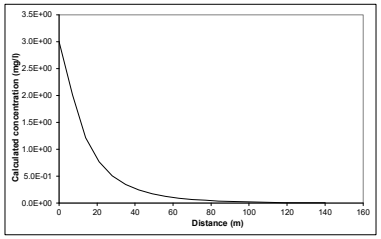
Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 1.40E+01 | 5.24E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 1.40E+00 | 5.24E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 1.40E-01 | 5.24E-02 | |

**Note values of dispersivity must be > 0**

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

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




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Castle Farm |
| Completed by: | Anneliese Whiteley |
| Date: | ####### |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 3.0E+00 |
| 7.0 | 2.02E+00 |
| 14.0 | 1.21E+00 |
| 21.0 | 7.69E-01 |
| 28.0 | 5.10E-01 |
| 35.0 | 3.50E-01 |
| 42.0 | 2.46E-01 |
| 49.0 | 1.76E-01 |
| 56.0 | 1.27E-01 |
| 63.0 | 9.35E-02 |
| 70.0 | 6.93E-02 |
| 77.0 | 5.18E-02 |
| 84.0 | 3.89E-02 |
| 91.0 | 2.94E-02 |
| 98.0 | 2.23E-02 |
| 105.0 | 1.71E-02 |
| 112.0 | 1.31E-02 |
| 119.0 | 1.00E-02 |
| 126.0 | 7.74E-03 |
| 133.0 | 5.98E-03 |
| 140.0 | 4.63E-03 |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

Environment Agency

| Input Parameters (using pull down menu) | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Phosphorus | | from Level 1 |
| Target Concentration | $C_T$ | 4.00E-02 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 3.00E-01 | mg/l | *Treated water concentration, from Klargester datasheet* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | *Literature value* |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 2.00E+01 | m | *Assumed drainage field 20x20* |
| Plume thickness at source | Sy | 2.00E+00 | m | *Assumed* |
| Saturated aquifer thickness | da | 5.00E+00 | m | *Assumed* |
| Bulk density of aquifer materials | ρ | 2.00E+00 | $g/cm^3$ | *Literature value* |
| Effective porosity of aquifer | n | 3.00E-01 | fraction | *Assumed* |
| Hydraulic gradient | i | 2.35E-01 | fraction | *0.2353 north 0.1428 south* |
| Hydraulic conductivity of aquifer | K | 1.00E-01 | m/d | *Literature value (Tellam and Lloyd 1981)* |
| Distance to compliance point | x | 8.50E+01 | m | *Distance to nearest watercourse 85m nor* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 4.00E-01 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 8.50E+00 | m | *see options* |
| Transverse dispersivity | az | 8.50E-01 | m | *see options* |
| Vertical dispersivity | ay | 8.50E-02 | m | *see options* |

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — 4.00E-01 l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species — $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg

pH value — pH

acid dissociation constant — pKa

Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 4.00E-01 l/kg

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

Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | ax | 0.00E+00 | 8.50E+00 | 4.06E+00 | m |
| **Transverse dispersivity** | az | 0.00E+00 | 8.50E-01 | 4.06E-01 | m |
| **Vertical dispersivity** | ay | 0.00E+00 | 8.50E-02 | 4.06E-02 | |

**Note values of dispersivity must be > 0**

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

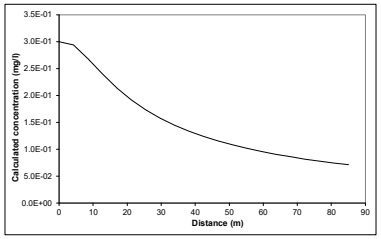
Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$ ; az = ax/10, ay = ax/100 are assumed

| Calculated Parameters | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 7.84E-02 | m/d |
| Retardation factor | Rf | 3.67E+00 | fraction |
| Decay rate used | λ | 6.93E-101 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 2.14E-02 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 7.16E-02 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **4.19E+00** | |

## Remedial Targets

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **1.68E-01** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **85** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **7.16E-02** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Castle Farm |
| Completed by: | Anneliese Whiteley |
| Date: | ####### |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 3.0E-01 |
| 4.3 | 2.94E-01 |
| 8.5 | 2.69E-01 |
| 12.8 | 2.40E-01 |
| 17.0 | 2.14E-01 |
| 21.3 | 1.92E-01 |
| 25.5 | 1.73E-01 |
| 29.8 | 1.58E-01 |
| 34.0 | 1.45E-01 |
| 38.3 | 1.34E-01 |
| 42.5 | 1.24E-01 |
| 46.8 | 1.16E-01 |
| 51.0 | 1.08E-01 |
| 55.3 | 1.02E-01 |
| 59.5 | 9.60E-02 |
| 63.8 | 9.08E-02 |
| 68.0 | 8.62E-02 |
| 72.3 | 8.20E-02 |
| 76.5 | 7.82E-02 |
| 80.8 | 7.47E-02 |
| 85.0 | 7.16E-02 |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

Environment Agency

### Input Parameters (using pull down menu)

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Phosphorus | | from Level 1 |
| Target Concentration | $C_T$ | 4.00E-02 | mg/l | from Level 1 |

### Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

### Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 3.00E-01 | mg/l | *Treated water concentration, from Klargester datasheet* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | *Literature value* |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 2.00E+01 | m | *Assumed drainage field 20x20* |
| Plume thickness at source | Sy | 2.00E+00 | m | *Assumed* |
| Saturated aquifer thickness | da | 5.00E+00 | m | *Assumed* |
| Bulk density of aquifer materials | ρ | 2.00E+00 | $g/cm^3$ | *Literature value* |
| Effective porosity of aquifer | n | 3.00E-01 | fraction | *Assumed* |
| Hydraulic gradient | i | 1.43E-01 | fraction | *0.2353 north 0.1428 south* |
| Hydraulic conductivity of aquifer | K | 1.00E-01 | m/d | *Literature value (Tellam and Lloyd 1981)* |
| Distance to compliance point | x | 1.40E+02 | m | *Distance to nearest watercourse 85m nor* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 4.00E-01 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.40E+01 | m | *see options* |
| Transverse dispersivity | az | 1.40E+00 | m | *see options* |
| Vertical dispersivity | ay | 1.40E-01 | m | *see options* |

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 4.76E-02 | m/d |
| Retardation factor | Rf | 3.67E+00 | fraction |
| Decay rate used | λ | 6.93E-101 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 1.30E-02 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 2.91E-02 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.03E+01** | |

### Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient Kd 4.00E-01 l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer foc — fraction

Organic carbon partition coefficient Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species $K_{oc,i}$ — l/kg

pH value pH

acid dissociation constant pKa

Fraction of organic carbon in aquifer foc — fraction

Soil water partition coefficient Kd 4.00E-01 l/kg

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

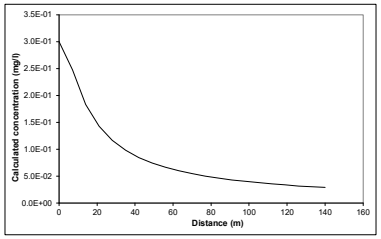
Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 1.40E+01 | 5.24E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 1.40E+00 | 5.24E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 1.40E-01 | 5.24E-02 | |

**Note values of dispersivity must be > 0**

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

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




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 3.0E-01 |
| 7.0 | 2.48E-01 |
| 14.0 | 1.84E-01 |
| 21.0 | 1.43E-01 |
| 28.0 | 1.17E-01 |
| 35.0 | 9.84E-02 |
| 42.0 | 8.50E-02 |
| 49.0 | 7.48E-02 |
| 56.0 | 6.67E-02 |
| 63.0 | 6.02E-02 |
| 70.0 | 5.49E-02 |
| 77.0 | 5.04E-02 |
| 84.0 | 4.66E-02 |
| 91.0 | 4.33E-02 |
| 98.0 | 4.05E-02 |
| 105.0 | 3.80E-02 |
| 112.0 | 3.58E-02 |
| 119.0 | 3.38E-02 |
| 126.0 | 3.21E-02 |
| 133.0 | 3.05E-02 |
| 140.0 | 2.91E-02 |

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Castle Farm |
| Completed by: | Anneliese Whiteley |
| Date: | ####### |
| Version: | 1 |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Remedial Target** | **4.13E-01** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | |
| **Distance to compliance point** | **140** | **m** | |
| **Concentration of contaminant at compliance point** | $C_{ED}/C_0$ **2.91E-02** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.