PAP/2023/0071

ENVIRONMENT

Enviromena Project Management UK Limited
Nailcote Farm
Warwickshire
Drainage Strategy

April 2024

Notice

All comments and proposals contained in this report, including any conclusions, are based on information available to BWB Consulting during investigations. The conclusions drawn by BWB Consulting could therefore differ if the information is found to be inaccurate or misleading. BWB Consulting accepts no liability should this be the case, nor if additional information exists or becomes available with respect to this scheme.

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P01	27/01/23	S2	William James BEng (Hons), MSc	Matthew Bailey BSc (Hons)	Keith Alger BSc (Hons) MSc
P02	10/02/23	S2	William James BEng (Hons), MSc	Matthew Bailey BSc (Hons)	Keith Alger BSc (Hons) MSc
P03	16/02/23	S2	William James BEng (Hons), MSc	Matthew Bailey BSc (Hons)	Keith Alger BSc (Hons) MSc
P04	17/02/23	S2	William James BEng (Hons), MSc	Matthew Bailey BSc (Hons)	Keith Alger BSc (Hons) MSc
P05	07/03/23	S2	William James BEng (Hons), MSc	Matthew Bailey BSc (Hons)	Keith Alger BSc (Hons) MSc
P06	22/11/23	S2	Matthew Bailey BSc (Hons)	Lucy Reeves BSc (Hons)	Keith Alger BSc (Hons) MSc
P07	25/04/24	S2	Matthew Bailey BSc (Hons)	David Gray BEng (Hons)	Keith Alger BSc (Hons) MSc

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1. INTRODUCTION

1.1 This Drainage Strategy (DS) has been produced by BWB Consulting on behalf of Enviromena Project Management UK Limited in respect of a planning application for a proposed temporary solar farm at Nailcote Farm, Warwickshire.

1.2 A Flood Risk Assessment (FRA) has been developed for the Site (reference NFW-BWB-ZZ-XX-RP-YE-0001_FRA) and this DS accompanies this overarching document.

1.3 This DS is intended to support a full planning application (PAP/2023/0071) and as such the level of detail included is relevant for the type of application and type of development proposed.

1.4 It is understood that this SDS (dated April 2024) will be resubmitted to the live planning application “PAP/2023/0071”. Therefore, the drainage guidance at the time of the planning application validation (24/02/2023) will be used for the latest drainage strategy.

1.5 The Lead Local Flood Authority (LLFA) initially raised an objection to the proposed drainage strategy, outlined within the DS (reference: NFW-BWB-ZZ-XX-RP-CD-0001_DS_S2-P05), which was previously submitted as part of the planning application (PAP/2023/0071). BWB provided a response outlining further information following consultation with the LLFA (reference: NFW-BWB-ZZ-XX-RP-CD-0002_LLFA Letter_S2-P01, dated 26/10/2023), which resulted in the LLFA removing their objection, with conditions. The letter produced by BWB has been provided as Appendix 1.

1.6 Since the previous revision of this report (reference: NFW-BWB-ZZ-XX-RP-CD-0001_DS_S2-P06), dated November 2023, a site visit has been undertaken with the LLFA, Fillongley Flood Group, the Client and BWB Consulting on 18/03/2024. Following this site meeting, the LLFA’s position remained unchanged (i.e., granted approval, subject to conditions).

1.7 As part of the on-site discussion, the inclusion of detention basins within the development, linked to the existing watercourses, was discussed as a form of natural flood management to assist with flood risk to the village of Fillongley, located approximately 800m to the north of the application site.

1.8 Although the LLFA’s position on the development proposals remains unchanged without the addition of detention basins within the development, the proposals have been revised to include several temporary detention basins within the site. The Site is bound to the north by agricultural fields, to the east by agricultural fields and an unnamed ordinary watercourse (UOW). The south boundary of the Site is bound by the M6 motorway and Fillongley Shooting Club, the west of the Site is bound by Meriden Road (B4102).

1.9 The Proposed Development is for the construction of a temporary Solar Farm, to include the installation of ground-mounted solar panels together with associated works, equipment, and necessary infrastructure. The existing Site access is via a dirt track off Meriden Road (B4102) and is proposed to be retained as part of the development. A proposed Site development plan and sections of the associated structures are included as Appendix 2.

1.10 The location of the Site is illustrated within Figure 1.1, with contextual information provided within Table 1.1.

Table 1.1: Site Details

Site Name	Nailcote Farm
Location	Warwickshire
NGR (approx.)	SP 276 860
Application Site Area (ha)	62.2 (Approx.)
Development Type	Solar Farm
Anticipated Lifespan	40 years
Lead Local Flood Authority	Warwickshire County Council
Local Planning Authority	North Warwickshire Borough Council
Environment Agency Area	West Midlands
Planning Application	PAP/2023/0071

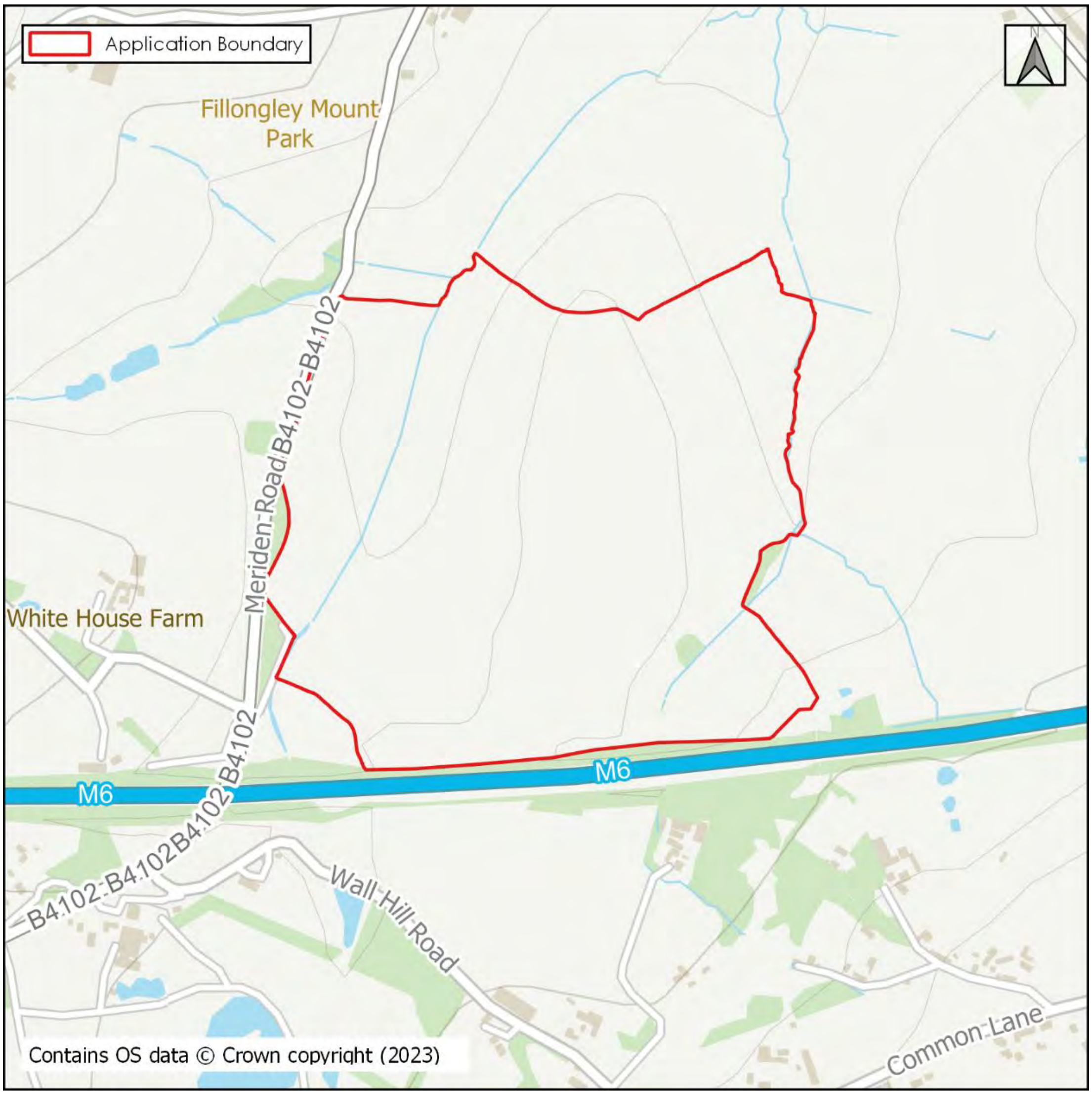


Figure 1.1: Site Location

Relevant Drainage Guidance

<u>'Flood Risk & Sustainable Drainage Local guidance for developers'</u>[1]

1.11 Warwickshire County Council's 'Flood Risk & Sustainable Drainage Local guidance for developers' has been reviewed in the development of this report. The key points from this document are as follows:

i. Restrict vehicular movements on Site to designated access tracks. In doing so, the risk of soil compaction is minimised and limited to specific locations. The applicant is to design the vehicular access tracks to be permeable.

[1] Flood Risk & Sustainable Drainage Local guidance for developers available at: https://api.warwickshire.gov.uk/documents/WCCC-1039-95

ii. Specify what type of vegetation will be planted across the Site and how will it be managed/ maintained in perpetuity. The ideal situation is that vegetation is grassed and is kept reasonably high or grazed by livestock. Good vegetation cover will limit the transfer of sediments and slow the flow of water.

iii. Incorporate above- or below- ground surface water attenuation features to capture runoff from the panels. There are two basic ways as follows:

a. IDEAL - Gravel filter trenches positioned under the drip line of each solar panel. Typically, these are French drains 300mm x 300mm filled with a granular material to capture and store runoff from the panels. These will encourage infiltration and provide betterment in terms of reducing surface water runoff.

b. MINIMUM - Above ground swales positioned strategically around the development to capture surface water runoff from the panels as water flows downslope. The exact dimensions and number of swales required will depend upon the situation but are likely to be acceptable where designed in accordance with CIRIA SuDS Manual. Excavated material should be deposited on the downslope bank.

iv. Provide attenuation measures for the areas of hardstanding (i.e. electrical infrastructure or kiosks). This should be done in the normal way (i.e. calculate greenfield runoff rate, calculate increase in impermeable area, conduct storage estimate to work out storage volume).

1.12 Within the ‘Flood Risk Recommendations’ section of the SFRA it states that ‘An appropriate buffer strip must be maintained along fluvial corridors respectively, to ensure that maintenance of the channel can be undertaken;’.

Peak Rainfall

1.13 Predicted future changes in peak rainfall intensity caused by climate change are provided by the EA[2], with a range of projections applied to River Basin District Management Catchments.

1.14 The Site falls within the Tame Anker and Mease Management Catchment. Table 1.2 identifies the relevant peak rainfall climate change allowances from this Management Catchment.

[2] Environment Agency, Flood risk assessments: climate change allowances: Environment Agency, Flood risk assessments: climate change allowances: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Last Accessed January 2023.

Table 1.2: Peak Rainfall Climate Change Allowances for the Tame Anker and Mease Management Catchment

Tame Anker and Mease Management Catchment Allowance	Total Potential Change **Anticipated for the '2050s'** (Lifetime up to 2060)	Total Potential Change **Anticipated for the '2070s'** (2061 to 2125)
1 in 30-Year Rainfall Event		
Upper End	35%	35%
Central	20%	25%
1 in 100-Year Rainfall Event		
Upper End	40%	40%
Central	20%	25%

1.15 The future increase in rainfall will need to be considered when designing a development to ensure its drainage system is sufficient for its lifetime and that it does not increase flood risk elsewhere. When determining the appropriate allowance(s) the anticipated lifespan of the development should be considered.

1.16 Table 1.3 provides a summary of the EA's guidance on determining the appropriate allowance(s).

Table 1.3: Application of Appropriate Peak Rainfall Climate Change Allowances

Area Assessed	Anticipated Development Life Span		
	up to 2060	between 2061 and 2100	up to or beyond 2100*
Development Sites^ Assess the 1 in 30-year and 1 in 100-year storm events with the respective climate change allowance(s) applied. Development to be designed so that with the climate change allowance applied to the 1 in 100-year storm: there is no increase in flood risk elsewhere. the development will be safe from surface water flooding	Use the Central Allowance for the 2050s	Use the Central Allowance for the 2070s+	Use the Upper End Allowance for the 2070s+
Urban Catchments Assess the flood risk at the 1 in 30-year and 1 in 100-year storm events with the respective allowance(s) applied.			
Rural Catchments <5km² Assess the flood risk at the 1 in 30-year and 1 in 100-year storm events with the respective central climate change allowances applied.			
Rural Catchments >5km²	Direct rainfall analysis is not appropriate, use flood flow estimation methods.		

**Includes all residential developments*
^the Lead Local Flood Authority may have local standards that also need to be considered.
+unless the 2050s allowance is greater.

1.17 The development Site has an anticipated lifespan of 40 years. Therefore, the Central allowance for the '2070s' epoch will need to be considered in the design of the associated drainage infrastructure. Although the 2070s epoch central allowance should be used for the climate change calculations in line with national guidance, to provide a conservative assessment for this scheme, the upper end allowance has been used. At the discharge of conditions design stage, the use of the 2070s epoch central allowance may be discussed for use with the LLFA and Local Planning Authority.

2. EXISTING CONDITIONS

Site location and land use

2.1 The Site is bound to the north by agricultural fields, to the east by agricultural fields and an unnamed ordinary watercourse (UOW). The south boundary of the Site is bound by the M6 motorway and Fillongley Shooting Club, Meriden Road (B4102) binds the west of the Site.

2.2 The site currently comprises agricultural land.

Topography

2.3 A topographical Survey (Appendix 3) shows the levels within the Site to undulate; however, the Site generally falls from the high points located at the centre of the Site towards the southern boundary and the ditches located within the Site to the east and west. The levels at the Site range from the highest point at approximately 148.7m Above Ordnance Datum (AOD) in the southern centre of the Site to approximately 122.3m AOD in the northeast Site corner.

2.4 The existing Site access levels range from 132.7m AOD to 133.6m AOD.

Existing watercourses / ditches within and adjacent to site

2.5 There are several watercourses and ditches within the Site, as shown on Figure 2.1.

2.6 The main watercourse on the Site is the Bourne Brook, which enters in the southwestern corner and exits along the northern boundary. There is also an Unnamed Ordinary Watercourse (UOW) within the Site, which enters in the southeast and follows the eastern Site boundary.

2.7 Several ditches can be found across the Site. One of these, located in the centre of the Site, seems to have no connection to the surrounding ditches. Another ditch, within the southern portion of the Site, connects to the some of the ditches found on the western Site boundary.

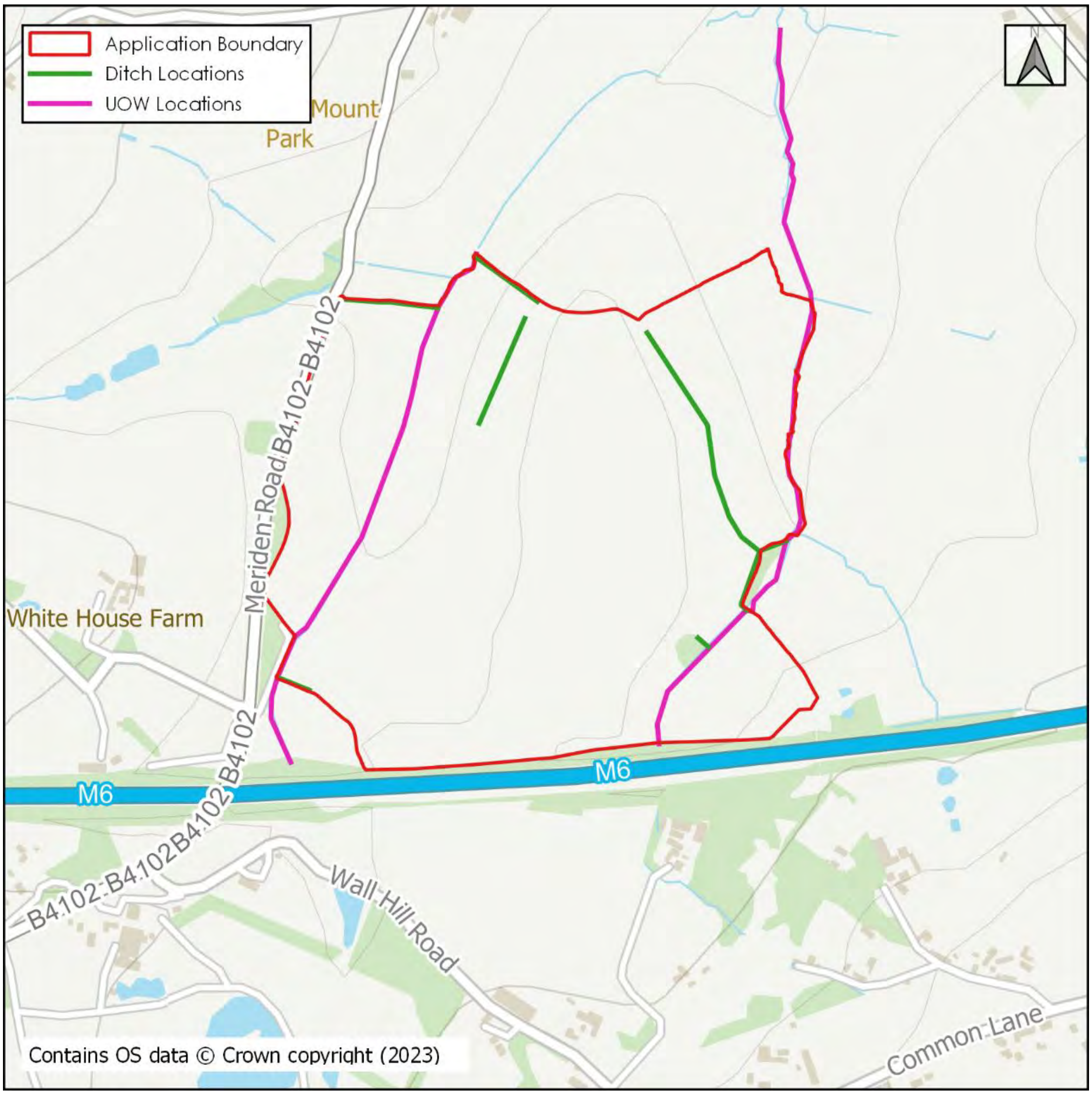


Figure 2.1 **Location of ditches and UOW's**

Geology

2.8 British Geological Survey (BGS) mapping shows the Site predominantly to be underlain by Keresley Member - Sandstone, a small pocket along the eastern UOW is underlain by Keresley Member – Argillaceous rocks and sandstone and conglomerate, interbedded.

2.9 Within the Site there are three superficial deposits. Along the north-western boundary there are deposits of Alluvium – clay, silt sand and gravel. A large area of Thrussington Member – Diamicton is located in the middle of the Site from the south boundary to the northern boundary. Along the UOW to the south of the Site there are traces of glaciolacustrine deposits, mid Pleistocene, clay, and silt. Rest of the Site has no recorded superficial deposits.

2.10 The geology is also supported by the report published by DUNELM Geotechnical & Environmental (report number: D10836).

2.11 Details on the bedrock geology and superficial deposits is included within Figure 2.2.

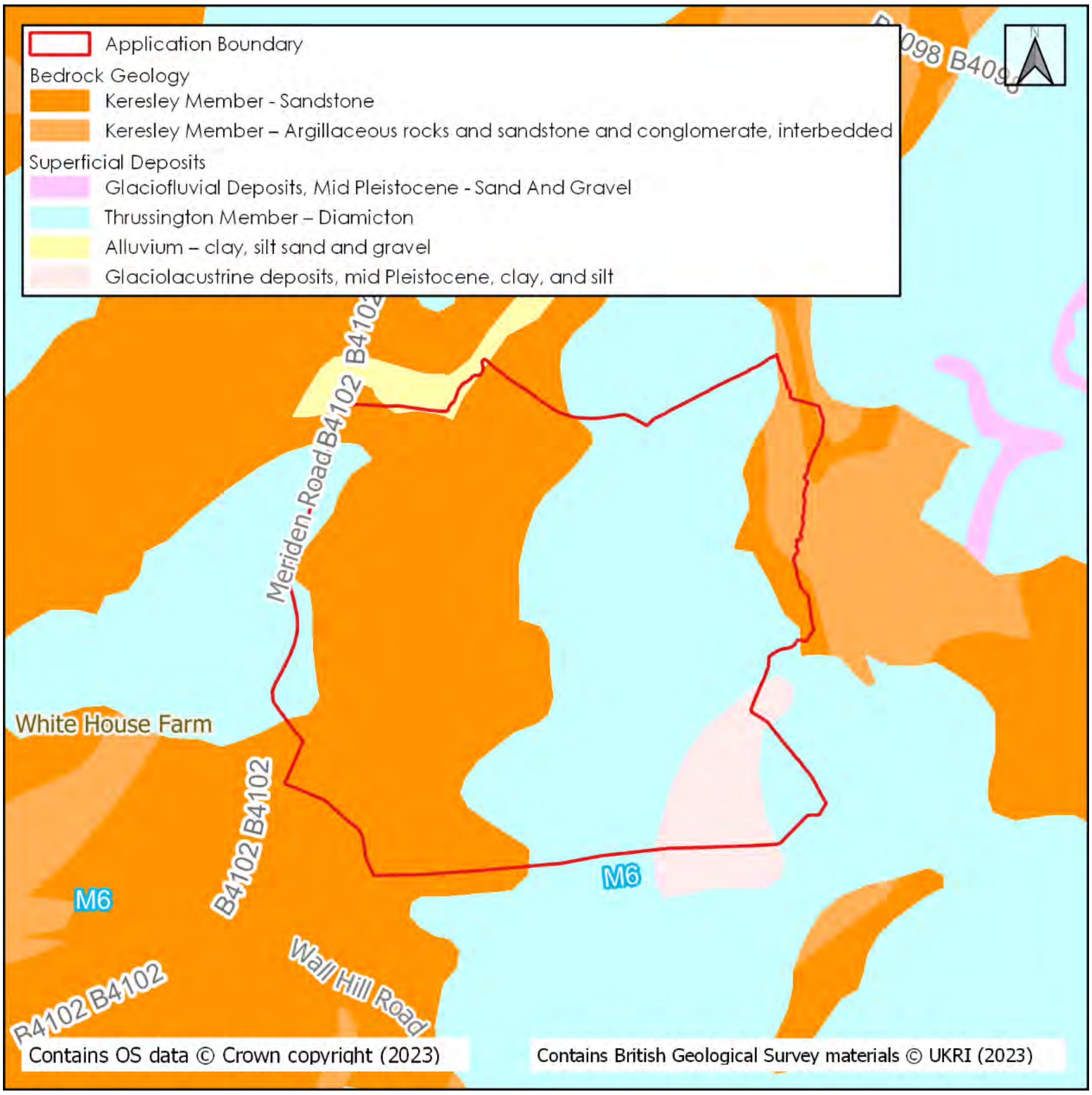


Figure 2.2: Bedrock Geology and Superficial Deposits

2.12 The EA designates the bedrock to be a principal aquifer, this means the bedrock holds a significant amount of groundwater that is used to support water supply, base flows to rivers, lakes, and wetlands on a strategic scale.

2.13 Areas of superficial deposits are classed as unproductive strata. There are several areas within the Site (mainly the central area of the Site) which is classed as a Secondary (undifferentiated) Aquifer, this means that the superficial deposit contains both characteristic traits of Secondary A and Secondary B Aquifers. There is also an area which seems to align with the area of Alluvium which is classed as a Secondary A Aquifer which is defined as a permeable layer which can support local water supplies and may form a base flow of a river.

2.14 A review of BGS borehole logs identifies records of two previous boreholes located within the Site, these are SP28NE128 and SP28NE68, which were excavated to depths of 705.24m and 716.57m, respectively. These show no recorded of ground water being struck. The Site is located in a Groundwater Source Protection Zone III.

3. DRAINAGE PROPOSALS

Surface Water Drainage

Solar Farm Research

3.1 The proposed surface water drainage strategy is based upon research on 'Hydrologic Response of Solar Farms'[3] (Cook and McCuen, 2013) and is supported by guidance published on 'Biodiversity Guidance for Solar Developments'[4] (BRE, 2014) and 'Technical Information Note TIN101: Solar Parks: Maximising Environmental Benefits'[5] (Natural England, 2011).

3.2 In summary, Cook and McCuen identify that the development of solar panels over a grassy field does not have a significant effect on the volume of runoff, the peak discharge, nor the time to peak. During the study, the runoff volume was found to increase slightly but not enough to require storm-water management facilities.

3.3 However, Cook and McCuen found that if the ground cover under the panels is gravel or bare ground, owing to design decisions or lack of maintenance, the peak discharge may increase significantly with storm water management needed. Additionally, the kinetic energy of water draining from the panels was found to be greater than that of typical rainfall, which increases the risk of erosion of soil at the base of panels.

3.4 Cook and McCuen recommend that the grass beneath the panels be well maintained or that a buffer strip (i.e., interception swale) be placed after the most downgradient row of panels, in order to maintain a drainage regime as close to existing conditions as possible.

3.5 BRE recognise that in most solar farms "*because panels are raised above the ground on posts, greater than 95% of a field utilised for solar farm development is still accessible for plant growth*". Therefore, it is considered that the majority of the site will remain as 'soft'/permeable surface post-development, with grassland around and underneath the solar arrays.

3.6 Natural England have stated in reference to solar developments that "*the key to avoiding increased run-off and soil into watercourses is to maintain soil permeability and vegetation cover. Permeable land surfaces underneath and between panels should be able to absorb rainfall as long as they are not compacted and there is some vegetation to bind the soil surface.*"

[3] Hydrologic Response of Solar Farms, Journal of Hydrologic Engineering (Cook and McCuen, 2013)
[4] Biodiversity Guidance for Solar Development (BRE, 2014)
[5] TIN101: Solar Parks: Maximising Environmental Benefits (Natural England, 2011)

3.7 Based on the above research, the proposed surface water drainage strategy for the proposed solar arrays aims to minimise the compaction of soil during the construction and operation of the proposed development and incorporate a robust landscaping strategy to keep the areas beneath the panels as 'grassy' as possible during the lifetime of the development. These mitigation measures should be detailed within a Construction Environmental Management Plan (CEMP) and landscape strategy for the proposed development.

3.8 As an additional resilience measure, it is proposed that interception swales are constructed at the most downgradient row of panels to act as a form of mitigation and betterment, should the ground beneath the panels become patchy or bare during the lifetime of the development.

Construction and Operational Mitigation Measures

3.9 In order to minimise the compaction of soil during the construction phase, the temporary construction Site compound will be positioned as close as possible to the Site access to minimise the number of Heavy Goods Vehicles (HGVs) driving through the Site.

3.10 It is recommended that during construction only light machinery is used to install the solar arrays and ancillary equipment where possible. Vehicle movements should be minimised, and low ground pressure vehicles are recommended during wet weather working.

3.11 If necessary, to alleviate the effects of any compaction during the construction process, any affected areas should be chisel ploughed or harrowed and seeded prior to the solar farm becoming active.

3.12 During the operation of the solar farm, maintenance of the panels will be infrequent, minimal and will only require light machinery. Therefore, the operation of the Site is unlikely to significantly decrease the infiltration potential of the soil compared to its pre-development condition.

3.13 During the first few years of the solar farm becoming live, it is recommended that regular inspections of the planting and soil are undertaken to confirm that the grass is growing properly and is not bare or compacted. Any required remedial work should be completed as soon as possible.

Additional Resilience Mitigation Measures

3.14 Based on the mitigation proposed above, no formal surface water drainage system is necessary to manage the surface water flows emanating from the solar panels.

3.15 However, as an additional resilience measure, it is proposed to construct interception swales at the most downgradient row of solar panels to interrupt and slow potential channelised flows, enhance and promote the infiltration and interception capacity of the development, and help convey surface water over a greater surface area.

3.16 The location of the proposed swales is provided on the Conceptual Drainage Strategy provided as Appendix 4. Further details on the proposed swales are also provided further on within this section.

3.17 In the event of exceedance of the proposed swales, exceedance flows will follow the existing topography either into nearby watercourses or off Site onto third-party land. However, it should be noted that these exceedance flows will provide a degree of betterment on flooding on the existing scenario.

Ancillary Equipment and Roads

3.18 Although the solar panel arrays can be managed without the need for formal surface water drainage management, the ancillary equipment and roads should be assessed for their impact on the surface water runoff rates and volumes post-development.

3.19 New roads should be constructed using either Type 1 gravel, grass tracks or permeable materials so that the roads do not have an adverse impact on post-development surface water runoff rates and volumes.

3.20 If any new roads are proposed with typical impermeable surfacing, the runoff from the roads will need to me managed by a suitable surface water drainage system.

3.21 There is an existing informal parking area at the site entrance that is proposed to be retained. If the parking area is to be formalised, it should be re-surfaced with a permeable surface type, such as plastic reinforced type 1 aggregate. If the parking area is proposed to be surfaced with impermeable surfacing, a surface water drainage strategy will be required for this portion of the development.

3.22 Based on a review of the proposed masterplan, it is anticipated that the impermeable footprint of the ancillary equipment associated with the development will cover approximately 362m^2 (0.04ha), which is approximately 0.1% of the total proposed development area (62.2ha).

3.23 An assessment of the pre and post development runoff rates for the Site has been undertaken using the IH-124 method in MicroDrainage and are outlined in Table 3.1, with supporting calculations provided in Appendix 5.

Table 3.1: Existing & Proposed Runoff Rates

Return Period (Yr.)	Existing Greenfield Runoff Rate (l/s)	Post-Development Unmitigated Runoff Rate (l/s)	Post-Development Increase	
			l/s	%
1	20.4	20.5	0.1	0.5
QBAR	24.6	24.7	0.1	0.4
30	48.2	48.3	0.1	0.2
100	63.2	63.4	0.2	0.3
100 + 40%*	93.7	93.9	0.2	0.2

* Calculated by multiplying Standard Annual Average Rainfall (SAAR) by 1.4 to simulate a 40% climate change uplift on rainfall intensity

3.24 As shown within Table 3.1, the post-development runoff rate, when factoring in the increased impermeable area from the ancillary equipment is anticipated to increase the QBAR rate by 0.1l/s (0.4%), the 1 in 100-year runoff rate by 0.2l/s (0.3%) and the 1 in 100-year plus 40% climate change by 0.2l/s (0.2%). Therefore, the impact of developing the Site is considered to have a negligible impact on the existing runoff rate.

3.25 An assessment of the impacts the proposed ancillary equipment will have on the 1 in 100-year 6-hour runoff volume post-development has been undertaken. The pre- and post-development runoff volumes are compared in Table 3.2, with the supporting calculations provided within Appendix 6.

3.26 As the proposed development area is currently entirely greenfield, the existing runoff volume has been calculated using MicroDrainage to be 12,907m^3.

3.27 The runoff volume from the new impermeable area (i.e., 0.04ha associated with the ancillary equipment has been calculated using an average rainfall intensity of 10.7mm/hr as calculated using FEH rainfall data within Micro Drainage, and multiplied by the impermeable area, as described within Figure 3.1. The 100-year, 6-hour rainfall profile is presented within Appendix 7.

Av. Rainfall (m/hr) x 6 (hours) x Impermeable Area (m^2) = Runoff Volume (m^3)

0.0107 x 6 x 362 = 23m^3

Figure 3.1: 1 in 100-Year, 6 Hour Runoff Volume

3.28 As shown in Figure 3.1, the runoff volume from the newly introduced impermeable area is 25m^3. The runoff volume from the remaining permeable portion of the proposed development area (62.16ha) has been calculated using MicroDrainage to be 12,899m^3. As a result, the total post-development runoff volume is calculated to be 12,922m^3.

Table 3.2: Runoff Volume Comparison

Existing Volume (m^3)	Proposed Volume (m^3)		Difference (m^3)
	Permeable	Impermeable	
12,907	12,899	23	15

3.29 As shown within Table 3.2, the proposed introduction of the ancillary equipment will result in an increase of surface water runoff volume during the 1 in 100-year 6-hour event by 15m^3. This an increase of approximately 0.1% of the existing conditions within the Site.

3.30 It is anticipated that any increase in surface water runoff volume leaving the site will be intercepted within the interception swales located across the site.

Interception Swales

3.31 It is proposed that the interception swales will have 1:4 internal side slopes with a maximum design water depth of 300mm. The material excavated to install the swales will be applied to the downstream edge of the features to create an earth bund. A typical cross section of the proposed interception swales is provided within Appendix 4.

3.32 The proposed swales have been positioned outside of Flood Zone 3 and are also not anticipated to adversely displace any existing floodplains within the Site as no level raising will be associated with the construction of the swales.

3.33 Based on the proposed dimensions of the interception swales, it is anticipated that the maximum storage capacity of the swales is approximately 0.4m^3/m.

3.34 The interception storage capacity of the swales is such that in increase in runoff volume associated with the ancillary equipment will be intercepted by the proposed swales. Additionally, the inclusion of the swales within the development will act to provide a betterment to the existing surface water runoff rate and volume that will leave the Site onto surrounding land and Bourne Brook and the UOW post-development.

3.35 The inclusion of the interception swales across the development will also function as a mitigation measure to reduce the likelihood of any pollution incidents leaving the Site. As the risk of pollution incidents is more likely to occur during the construction phase as opposed to the operation of the Site, it is recommended that the swales are constructed early on during the construction phase and silt fences are utilised on the swales during the entire construction phase.

3.36 The proposed swales should be maintained throughout the lifetime of the development to reduce the risk of the features becoming less effective due to silt accumulation, litter accumulation or vegetation issues.

3.37 The final operations and maintenance plan should be developed during the construction design stage prior to the development becoming live; however, a basic maintenance schedule based off guidance provided within the CIRIA SuDS Manual[6] is provided within Section 4.

Infiltration Trenches

3.38 Gravel infiltration trenches can be installed alongside ancillary equipment in order to provide residual attenuation and land drainage, as well as intercepting exceedance flows. Illustrative locations of where the trenches are proposed to be installed are shown within Appendix 4.

3.39 The infiltration trench dimensions can vary; however, a 300mm wide and 300mm deep trench with a 30% void aggregate ratio would provide approximately $0.03m^3/m$ of attenuation.

3.40 An indicative cross section of an arrangement of utilising infiltration trenches surrounding the ancillary equipment is presented as Figure 3.2.

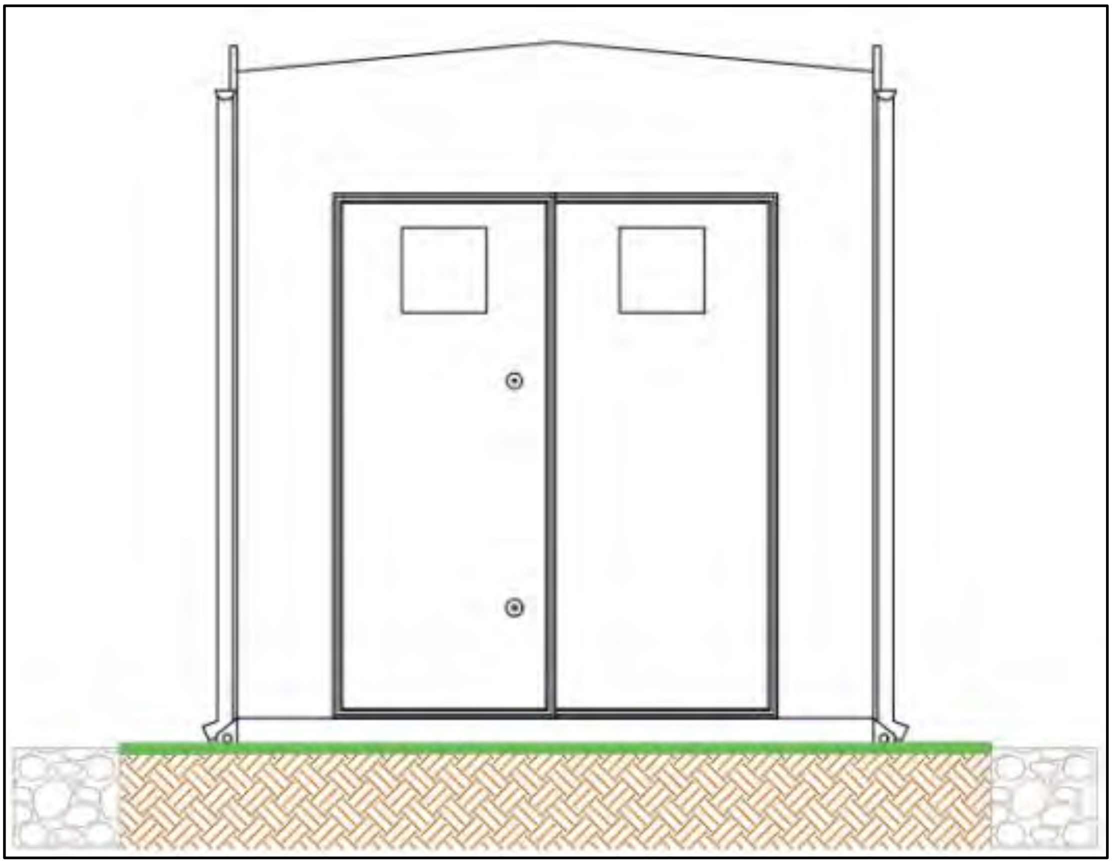


Figure 3.2: Indicative Filter Drain and Ancillary Equipment Arrangement

[6] The SuDS Manual C753 -Version 6 (CIRIA, 2019)

Detention Basins

3.41 A total of three detention basins have been added to the proposed drainage strategy, the locations of which are shown on the Conceptual Drainage Strategy within Appendix 4.

3.42 The surveyed water level on the topographical survey (Appendix 2) was approximately 200mm above the watercourse bed level. Therefore, the detention basins are proposed to have an inlet pipe set approximately 250mm above the surveyed bed level of the nearest watercourse.

3.43 Setting the pipe inlet above the water level during normal conditions will mean that the detention basins will only engage once the water levels within the watercourses rises during a potential flood event. As the water levels rise, water will enter the detention basins and be temporarily attenuated within the basin, before draining back into the watercourse, via an outlet pipe, once water levels in the watercourse drop.

3.44 The degree of betterment that the basins will provide has not been assessed; however, the potential maximum temporary attenuation potential of the basins is outlined within Table 3.3. Additionally, the incorporation of the basins within the development will act to slow the peak flow of water passing through the site, towards Fillongley Village.

Table 3.3: Detention Basin potential maximum temporary attenuation volumes

Basin	Potential Attenuation Volume (m^3)
South-west	1,055
North-west	325
North-east	1,350
Total	2,730

3.45 It should be noted that Fillongley village is part of a significantly larger catchment area than the application site. As such, although the inclusion of the detention basins may provide a degree of betterment to the flooding situation in the village, the impact of the basins may be limited in the context of the total natural drainage catchment draining through the village.

3.46 An Illustrative section of the detention basins and engineering sections of the proposed basins are included within Appendix 4. The exact details of the basins, including location and size, is to be confirmed through detailed design.

Foul Water Drainage

3.47 No foul water flows will be produced as a result of the proposed development. Therefore, no foul water drainage provision is required.

4. MAINTENANCE

4.1 The SuDS Manual maintenance schedule for swales, is shown in Table 4.1.

Table 4.1: The SuDS Manual Typical Maintenance Schedule for Swales

Maintenance Schedule	Typical Frequency	Required Action
Regular Maintenance	Monthly	Inspect inlets, outlets, and overflows for blockages, and clear if required.
	Monthly (or as required)	Remove litter and debris; and Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours.
	Monthly (during growing season), or as required	Cut grass – to retain grass height within specified design range.
	Monthly for first year then as required	Manage other vegetation and remove nuisance plants.
	Monthly for 6 months, quarterly for 2 years, then half yearly	Inspect vegetation coverage.
	Half yearly	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies.
Occasional Maintenance	As required or if bare soil is exposed over > 10% of the swale treatment area	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required.
Remedial Action	As required	Repair erosion or other damage by re-turfing or reseeding; Relevel uneven surfaces and reinstate design levels; Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface; Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip; and Remove and dispose of oils or petrol residues using safe standard practices.

4.2 The SuDS Manual maintenance schedule for filter drains, is shown in Table 4.2.

Table 4.2: The SuDS Manual Typical Maintenance Schedule for Filter Drains

Maintenance Schedule	Typical Frequency	Required Action
Regular Maintenance	Monthly (or as required)	Remove litter (including leaf litter) and debris from filter drain surface, access chambers and pre-treatment devices.
	Monthly	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage.
	Six monthly (or as required)	Remove sediment from pre-treatment devices.
	Six monthly	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation, and establish appropriate silt removal frequencies.
Occasional Maintenance	Five yearly, or as required	At locations with high pollution loads, remove surface geotextiles and replace, and wash or replace overlying filter medium.
	As required	Remove or control tree roots where they are encroaching the sides of the filter drain, using recommended methods (e.g., NJUG, 2007 or BS 3998:2010); and Clear perforated pipework of blockages.

Detention Basins

4.3 The SuDS Manual maintenance schedule for detention basins, is shown in Table 4.3.

Table 4.3: The SuDS Manual Typical Maintenance Schedule for Detention Basins

Maintenance Schedule	Typical Frequency	Required Action
Regular Maintenance	Monthly	Remove litter and debris; Inspect inlets, outlets and overflows for blockages, and clear if required; and Inspect banksides, structures, pipework etc for evidence of physical damage.
	Monthly (during growing season, or as required	Cut grass – for spillways and access routes.
	Monthly for first year, then annually or as required	Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies.
	Monthly at start, then as required	Manage other vegetation and remove nuisance plants.
	Half yearly (spring – before nesting season, and autumn	Cut grass – meadow grass in and around basin.
	Annually	Check any penstocks and other mechanical devices; Tidy all dead growth before start of growing season; and Manage wetland plants in outlet pool – where provided.
	Annually or as required	Remove sediment from inlets, outlet and forebay.
Occasional Maintenance	As required	Reseed areas of poor vegetation growth.
	Every 2 years, or as required	Prune and trim any trees and remove cuttings.
	Every 5 years, or as required	Remove sediment from inlets, outlets, forebay and main basin when required.
Remedial Action	As required	Repair/rehabilitation of inlets, outlets and overflows; and Relevel uneven surfaces and reinstate design levels.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 This DS has been written in accordance with the latest relevant local and national guidance and the latest accepted research on solar farm developments at the time of initial validation of planning application "PAP/2023/0071".

5.2 This DS is intended to be read in conjunction with the accompanying FRA (reference: NFW-BWB-ZZ-XX-RP-YE-0001_FRA).

5.3 The findings of this DS are that the proposed solar development will have negligible impact on the post-development surface water runoff rates and volumes.

5.4 Whilst the proposed development will have negligible impact on the surface water runoff regime, in accordance with the LLFA requirements it is proposed that interception swales are used within the development to mitigate against the potential risk of surface water runoff rates and volumes increasing as a result of the development.

5.5 Detention basins have been incorporated into the development as a form a natural flood management, with the aim being to provide a degree of betterment to the village of Fillongley, during potential periods when there are high flows than normal, within the surrounding watercourses. .

5.6 A suitably qualified maintenance company should be appointed to undertake the required maintenance of the proposed interception swales for the proposed lifespan of the development. General best practice maintenance activities and schedules are provided within this report.

APPENDICES

Appendix 1: Letter to LLFA to Address their Comments (Reference:NFW-BWB-ZZ-XX-RP-CD-0002_LLFA Letter_S2-P01)

Warwickshire Count Council,
Flood Risk Management Team,
Planning Delivery,
Environmental Services.

Our Ref: NFW-BWB-ZZ-XX-RP-CD-0002_LLFA Letter_S2-P01
Contact: Matthew Bailey
Direct Dial: 07436 031863

Date: 26th October 2023

Dear Scarlett

SUBMISSION OF ADDITIONAL INFORMATION FOLLOWING LEAD LOCAL FLOOD AUTHROITY OBJECTION TO PLANNING APPLICATION PAP/2023/0071

I am writing to formally summarise consultation that has taken place with Warwickshire County Council Flood Risk Management Team and to submit new information following these discussions, in response to the Lead Local Flood Authority's (LLFA) objection to the proposed solar development at Fillongley (planning application reference: PAP/2023/0071). The LLFA's objection is dated 29th March 2023 and has been attached to this letter as Appendix 1 for reference.

Following receipt of the objection, consultation has taken place both via email and a teleconference meeting on the 15th June 2023. The email correspondence undertaken with the LLFA has been attached to this letter as Appendix 2.

Although the objection states that BRE365 infiltration testing should be undertaken within the site, it was agreed with the LLFA that falling head tests would be acceptable (Appendix 2).

Falling head permeability testing was undertaken by BWB Consulting between 13th and 18th September 2023. The ground investigation findings (reference: NFW-BWB-ZZ-XX-RP-YE-0003) are presented as Appendix 3 to this letter. A summary of the testing findings and their implications for the proposed development is provided below.

11 Portland Street
(Aytoun St Side)
Manchester
M1 3HU

Tel: 0161 233 4260

manchester@bwbconsulting.com
www.bwbconsulting.com

Summary of falling head test results and implications for the proposed development

Falling head tests were undertaken at seven Test locations across the site.

The testing demonstrated that the site has good drainage characteristics in the granular strata and poor drainage characteristics in the cohesive strata within the site. Although the drainage characteristics were poor in the cohesive strata, there was evidence of infiltration in these locations and we have calculated a rate for each test location. The infiltration rates calculated across the site range between 3.09×10^{-6} m/s to 2.58×10^{-9} m/s and generally the western region of the site showed better infiltration potential than the eastern portion.

Based on the findings of the infiltration testing, it is considered that surface water naturally drains from the site via infiltration at varying rates.

On the eastern region of the development, the only impermeable area proposed is associated with three transformer units, totalling $75m^2$ of impermeable area across approximately 24.7ha (or, $247{,}000m^2$) of land, which is the natural drainage catchment area within the east of the site. Therefore, although the infiltration rates are poor in the east of the site, the low rate and minimal impermeable area associated with the transformer units will have a negligible impact on the rate and volume of surface water leaving the site.

The use of any sort of restriction device to enable a restriction to greenfield rates from this area, would not be practical and/or feasible, based upon the significantly low calculated runoff rate. It would not be possible to physically restrict to such a low rate, whilst ensuring that any orifice/restriction device, does not become blocked with sediment etc.

Additionally, the runoff from these impermeable areas will be captured by the proposed cut off swales located upstream from any offsite receptors of surface water runoff. Surface water captured by runoff swales can slowly infiltrate into the ground.

Based on the above summary and attached ground investigation findings, it is considered that the proposed drainage strategy submitted in support of planning application PAP/2023/0071 (reference: NFW-BWB-ZZ-XX-RP-CD-0001_S2-P04) is suitable to ensure that there is no downstream detriment, based upon the surface water runoff rates and runoff volume, associated with the proposals.

In addition to the above, it is proposed that additional residual mitigation will be proposed for the isolated transformer units across the site, to reduce the likelihood of ground surrounding this infrastructure becoming ‘boggy’ following rainfall. This additional resilience is outlined below and will provide further attenuation to surface water running off the impermeable surfaces.

Additional Mitigation for Transformer Units

As a general resilience measure to reduce the ground becoming ‘boggy’ around the transformer units, we are proposing that the units will be raised 150mm above the external ground level.

Additionally, it is proposed that each transformer unit will be surrounded by infiltration trenches to capture, attenuate and discharge surface water runoff from the transformers.

The infiltration trench for each individual transformer can be sized up ahead of construction using the nearest infiltration test location for the relevant transformer. However, for the planning stage a Quick Storage Estimate (QSE) has been undertaken in MicroDrainage using the upper and lower infiltration range found during the permeability testing.

Based on the QSE outputs, the required attenuation volume for the infiltration trenches to manage the 1 in 100-year plus climate change return period ranged between 1.2m^3 – 4.3m^3 per transformer. It is expected that the volume required at detailed design will be in the middle of this range. The QSE outputs are provided as Appendix 4.

<u>Maintenance Contact Details</u>
Within their objection the LLFA ask for details of the party responsible for undertaking the future operations and maintenance of the Sustainable Drainage Systems within the proposed development.

It is understood that the ongoing maintenance of the proposed development will be undertaken by the developer of the site, as per the approach they have taken for their other operational solar sites. Their details are provided below:

> O&M provider - Enviromena Asset Manager UK Ltd
> Contact number – 03301071415
> Adress – 15 Diddenham Court, Grazeley, Reading, RG7 1JQ

<u>Next Steps</u>
I trust the above summary and information attached is suitable to allow the LLFA to reassess the proposed development and provide new comments on planning application PAP/2023/0071.

Yours sincerely,

Matthew Bailey
Environmental Engineer

Enc:

> Appendix 1 – LLFA Objection (reference: WCC002749/FRM/SR/001)
> Appendix 2 – LLFA Email Correspondence
> Appendix 3 – Ground Investigation Findings (reference: NFW-BWB-ZZ-XX-RP-YE-0003)
> Appendix 4 – MicroDrainage Quick Storage Estimate Outputs

Appendix 1 – LLFA Objection (reference: WCC002749/FRM/SR/001)

Warwickshire County Council

Flood Risk & Sustainable Drainage Local guidance for developers[iii]

Scarlett Robertson

Appendix 2 - LLFA Email Correspondence

Matthew Bailey

From: FRM Planning <frmplanning@warwickshire.gov.uk>
Sent: 04 July 2023 10:49
To: Matthew Bailey
Subject: Re: 221748_Nailcote Farm, Fillongley, Warwickshire (Planning ref: PAP/2023/0071)

Please send responses to FRMplanning@warwickshire.gov.uk

[redacted]

Emails sent to individual FRM officers may not be logged or processed promptly.

From:
Sent:
To:
Cc:
Subject:

Hi Scarlett,

Thank you for your time last week to discuss this site / application.

Following our discussion we have put together an indicative test location plan for falling head tests across the site (see attached markup plan).

We are looking at seven total falling head tests across the site. Would this be acceptable to confirm there is infiltration within the site and address your concerns about the runoff from the ancillary equipment?

Thanks,

Matt

Matthew Bailey
Engineer | Environmental Engineering | BWB Consulting Limited

[redacted]

From:
Sent:
To:
Subject:

Please send responses to FRMplanning@warwickshire.gov.uk

[redacted]

Emails sent to individual FRM officers may not be logged or processed promptly.

From:
Sent:
To:
Cc:
Subject:

F.A.O Scarlett Robertson

Hi Scarlett,

I am writing in respect of your consultee comments (dated 29/03/2023) relating to the proposed Solar Farm development at Fillongley (Planning ref: PAP/2023/0071). I have attached your comments for ease of reference.

We are in the process of preparing a response to your objection with the additional information requested. As part of this we are looking into getting soakaway testing commissioned within the site.

Please can you confirm if falling head infiltration testing would be sufficient to inform the infiltration potential of the proposed interception swales? Given the size of the development and potential logistical difficulties associated with transporting a water bowser across the site, BRE365 Digest testing may be difficult to undertake across the whole site.

The size of the site at approximately 61.5 hectares is such that we would look to have 4 test locations spread across the site. **Would you deem this sufficient?**

As the swales are only intended to be utilised as a buffer to reduce soil erosion from runoff from the solar panels and there only being approximately 2,000m^2 of impermeable area associated with the ancillary equipment, the swales provided across the site will likely be sufficient to manage any additional runoff post-development even if the infiltration rate is extremely low, which we do not expect to be the case given the Sandstone bedrock indicated on British Geological Survey mapping.

I am awaiting confirmation on the exact details on the approach to maintenance, but am expecting a detailed maintenance scope from the client, based upon other sites they operate. We will send this over to you in due course, as part of our formal response.

Your input would be appreciated as it will reduce the likelihood of undertaking abortive work and/or submit insufficient information again, in turn leading to a delay in the application process.

Many thanks,

Matt

Matthew Bailey
Engineer | Environmental Engineering | BWB Consulting Limited

[redacted]

To help protect your privacy, Microsoft Office prevented automatic download of this picture from the Internet.
BWB Consulting

Appendix 3 - Ground Investigation Findings (reference: NFW-BWB-ZZ-XX-RP-YE-0003)

Nailcote Farm, September 2023

Project Name:	Land at Nailcote Farm, Warwickshire
Project No:	221748
Revision:	P02
Reference:	NFW-BWB-ZZ-XX-RP-YE-0003
Author:	Thomas Flame
Approver:	Chris Rhodes

BWB Consulting Ltd (BWB) was instructed by Environmena Project Management UK Ltd (the Client) to carry out a ground investigation and permeability testing at the above site. The testing was required to obtain information regarding the suitability of the underlying geology at the site to support soakaway drainage for a proposed solar farm development.

The site currently comprises a series of large fields adjacent to Meriden Lane, near Filongley, Coventry.

Scope of Works

BWB undertook permeability testing at the site between 13th and 18th September 2023 which comprised the drilling of seven boreholes across the site and infiltration testing to assess the permeability characteristics of the underlying soils . Investigation locations are presented on Drawing 1, labelled FH01 – FH07.

Published geology indicates ground conditions to comprise superficial Thrussington Member deposits in the east and west of the site overlying Bedrock of the Keresley Member (sandstone). Superficial deposits are absent in the central areas of the site.

Ground Conditions

Ground conditions encountered during this investigation comprised Topsoil across the entire site comprising dark brown clayey sand with rootlets and occasional sandstone gravel.

The Thrussington Member was identified below the topsoil in FH03, FH04 and FH05 and typically comprised slightly clayey or slightly gravelly sand. Gravels consisted of sandstone and quartzite.

The Keresley Member bedrock was encountered as reddish brown clayey sand in FH01, FH03 and FH05. Cohesive strata, inferred to be weathered mudstone units of the Keresley member, or cohesive Glacial Till deposits of the Thrussington member, was encountered as a red sandy clay in FH02, FH04 and FH07. Exploratory hole logs are presented in Appendix 1.

Groundwater was not encountered during the drilling, however it was observed in FH06 prior to the commencement of the permeability testing. The level was recorded at 1.20m bgl on the first day of testing, and 0.90m bgl on the second day.

Soakaway Test Results

Results of the infiltration tests are presented within Appendix 2 and a summary of the results are presented below in Table 1.

In FH01, FH05 and FH06, 3 full test runs were completed, wherein the water level was raised and allowed to drain at least 75% before refilling. FH02, FH03, FH04 and FH07 were filled and monitored for 24 hours without draining 75% of the way back to their original level.

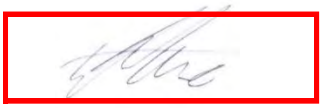
Table 1: Summary of Soakaway Test Results

Location	Test No.	Permeability Rate (m/s) – Basic Time Lag Method	Permeability Rate (m/s) – General Method
FH01	A	$2.57x10^{-06}$	$3.89x10^{-07}$
	B	$2.44x10^{-06}$	$3.13x10^{-07}$
	C	$3.09x10^{-06}$	$2.03x10^{-06}$
FH02	A	N/A	$7.46x10^{-08}$
FH03	A	$2.97x10^{-07}$	$3.14x10^{-08}$
FH04	A	N/A	$2.58x10^{-09}$
FH05	A	$8.73x10^{-08}$	$1.08x10^{-07}$
	B	$1.45x10^{-07}$	$2.15x10^{-07}$
	C	$1.78x10^{-07}$	$2.69x10^{-07}$
FH06	A	$1.16x10^{-07}$	$1.37x10^{-07}$
	B	$1.25x10^{-07}$	$1.14x10^{-07}$
	C	$1.54x10^{-07}$	$4.10x10^{-07}$
FH07	A	N/A	$1.01x10^{-08}$

Conclusions

Falling head permeability testing has been conducted at the site, which has demonstrated good drainage characteristics in granular strata, and poor drainage characteristics in cohesive strata.

Yours Sincerely



Thomas Flame
Geo-Environmental Consultant
M.Sci (Hons), FGS

DRAWING 1: EXPLORATORY HOLE LOCATION PLAN

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APPENDIX 1: EXPLORATORY HOLE LOGS

BOREHOLE LOG

Scale 1:50 | Sheet 1 of 1

LOCATION ID				
FH01	**Project Name:** Nailcote Farm, Warwickshire		**Ground Level (m AOD):**	134.48
	Project Number: 221748		**Eastings:**	427294.27
	Client: Environmena Project Management UK Ltd		**Northings:**	285815.87
Hole Type: WLS	**Rig:** Premier 110	**Start & End Date:** 13/09/2023	**Engineer:** TF	**Checker:** CR

Strike	Well	Level (m AOD) & [Thickness (m)]	Description	Legend	Depth (m bgl)	Samples Type (Ublows)	Samples From (m)	Samples To (m)	In-Situ Type	In-Situ Depth (m)	Result	Casing Depth & (Water Level)
		[0.10] 134.38	Dark brown clayey SAND.()		0.10							
		[2.40] 131.98	Weathered SANDSTONE recovered as reddish brown clayey SAND.()		2.50							
			Hole Terminated at 2.50m bgl.									

Chiseling			Water Added		
From (m bgl)	To (m bgl)	Time (hh:mm)	From (m bgl)	To (m bgl)	Volume (l)

Remarks

Reason for Termination:

Target depth reached.

Groundwater Remarks:

No groundwater encountered.

Other Remarks:

Location cleared of buried services. Borehole advanced to enable installation of standpipe for falling head infiltration test.

BOREHOLE LOG

Scale 1:50 | Sheet 1 of 1

LOCATION ID	Project Name:	Nailcote Farm, Warwickshire	Ground Level (m AOD):	132.98
FH02	Project Number:	221748	Eastings:	427939.06
	Client:	Environmena Project Management UK Ltd	Northings:	285857.47

Hole Type: WLS	Rig: Premier 110	Start & End Date: 14/09/2023	Engineer: TF	Checker: CR

Boring		Strata				Samples			In-Situ Tests			
Strike	Well	Level (m AOD) & [Thickness (m)]	Description	Legend	Depth (m bgl)	Type (Ublows)	From (m)	To (m)	Type	Depth (m)	Result	Casing Depth & (Water Level)
		[1.00]	Grass over dark brown clayey SAND with moderate rootlet content.()									
		131.98 [1.00]	Soft reddish brown sandy CLAY.()		1.00							
		130.98	Hole Terminated at 2.00m bgl.		2.00							

Chiseling		
From (m bgl)	To (m bgl)	Time (hh:mm)

Water Added		
From (m bgl)	To (m bgl)	Volume (l)

Remarks

Reason for Termination:

Target depth reached.

Groundwater Remarks:

No groundwater encountered.

Other Remarks:

Location cleared of buried services. Borehole advanced to enable installation of standpipe for falling head infiltration test.

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BOREHOLE LOG

Scale 1:50 | Sheet 1 of 1

LOCATION ID **FH03**	**Project Name:** Nailcote Farm, Warwickshire	**Ground Level (m AOD):**	126.52
	Project Number: 221748	**Eastings:**	427336.36
	Client: Environmena Project Management UK Ltd	**Northings:**	286126.41
Hole Type: WLS	**Rig:** Premier 110 · **Start & End Date:** 13/09/2023	**Engineer:** TF	**Checker:** CR

Strike	Well	Level (m AOD) & [Thickness (m)]	Description	Legend	Depth (m bgl)	Samples Type (Ublows)	From (m)	To (m)	In-Situ Tests Type	Depth (m)	Result	Casing Depth & (Water Level)
		[1.50]	Crops over light brown clayey SAND.()									
		125.02 [0.50]	Reddish brown very clayey SAND.()		1.50							
		124.52	Hole Terminated at 2.00m bgl.		2.00							

Chiseling		
From (m bgl)	To (m bgl)	Time (hh:mm)

Water Added		
From (m bgl)	To (m bgl)	Volume (l)

Remarks

Reason for Termination:

Target depth reached.

Groundwater Remarks:

No groundwater encountered.

Other Remarks:

Location cleared of buried services. Borehole advanced to enable installation of standpipe for falling head infiltration test.

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BOREHOLE LOG

Scale 1:50 | Sheet 1 of 1

LOCATION ID	Project Name:	Nailcote Farm, Warwickshire	Ground Level (m AOD):	123.99
FH04	Project Number:	221748	Eastings:	428061.88
	Client:	Environmena Project Management UK Ltd	Northings:	286341.30

Hole Type: WLS	Rig: Premier 110	Start & End Date: 14/09/2023	Engineer: TF	Checker: CR

Strike	Well	Level (m AOD) & [Thickness (m)]	Description	Legend	Depth (m bgl)	Type (Ublows)	From (m)	To (m)	Type	Depth (m)	Result	Casing Depth & (Water Level)
		[0.40]	Dark brown very clayey SAND with moderate rootlet content.()									
		123.59 [0.20]	Light brown gravelly SAND. Gravel is subangular to rounded, fine to coarse of sandstone and quartzite.()		0.40							
		123.39 [1.40]	Firm red sandy CLAY()		0.60							
		121.99	Hole Terminated at 2.00m bgl.		2.00							

Chiseling		
From (m bgl)	To (m bgl)	Time (hh:mm)

Water Added		
From (m bgl)	To (m bgl)	Volume (l)

Remarks

Reason for Termination:

Target depth reached.

Groundwater Remarks:

No groundwater encountered.

Other Remarks:

Location cleared of buried services. Borehole advanced to enable installation of standpipe for falling head infiltration test.

BOREHOLE LOG

Scale 1:50 | Sheet 1 of 1

LOCATION ID **FH05**	**Project Name:** Nailcote Farm, Warwickshire	**Ground Level (m AOD):**	125.08
	Project Number: 221748	**Eastings:**	427468.06
	Client: Environmena Project Management UK Ltd	**Northings:**	286304.46
Hole Type: WLS	**Rig:** Premier 110 — **Start & End Date:** 13/09/2023	**Engineer:** TF	**Checker:** CR

Strike	Well	Level (m AOD) & [Thickness (m)]	Description	Legend	Depth (m bgl)	Type (Ublows)	From (m)	To (m)	Type	Depth (m)	Result	Casing Depth & (Water Level)
		[0.40]	Brown clayey SAND.()									
		124.68 [0.20]	Orangish brown clayey SAND.()		0.40							
		124.48 [1.40]	Weathered SANDSTONE recovered as redish brown clayey SAND.()		0.60							
		123.08	Hole Terminated at 2.00m bgl.		2.00							

Chiseling

From (m bgl)	To (m bgl)	Time (hh:mm)

Water Added

From (m bgl)	To (m bgl)	Volume (l)

Remarks

Reason for Termination:

Target depth reached.

Groundwater Remarks:

No groundwater encountered.

Other Remarks:

Location cleared of buried services. Borehole advanced to enable installation of standpipe for falling head infiltration test.

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BOREHOLE LOG

Scale 1:50 | Sheet 1 of 1

LOCATION ID **FH06**	**Project Name:**	Nailcote Farm, Warwickshire	**Ground Level (m AOD):**	134.85
	Project Number:	221748	**Eastings:**	427525.77
	Client:	Environmena Project Management UK Ltd	**Northings:**	285978.70

Hole Type: WLS	**Rig:** Premier 110	**Start & End Date:** 13/09/2023	**Engineer:** TF	**Checker:** CR

Boring: Strike	Well	Strata: Level (m AOD) & [Thickness (m)]	Description	Legend	Depth (m bgl)	Samples: Type (Ublows)	From (m)	To (m)	In-Situ Tests: Type	Depth (m)	Result	Casing Depth & (Water Level)
		[0.10]	Brown slightly clayey slightly gravelly SAND. Gravel is subangular to subrounded, fine to coarse fo sandstone.()		0.10							
		134.75 [1.90]	Firm red slightly sandy slightly gravelly CLAY. Gravel is subangular to subrounded, fine to coarse of quartzite.()									
		132.85			2.00							
			Hole Terminated at 2.00m bgl.									

Chiseling: From (m bgl)	To (m bgl)	Time (hh:mm)

Water Added: From (m bgl)	To (m bgl)	Volume (l)

Remarks

Reason for Termination:

Target depth reached.

Groundwater Remarks:

No groundwater encountered.

Other Remarks:

Location cleared of buried services. Borehole advanced to enable installation of standpipe for falling head infiltration test.

BOREHOLE LOG

LOCATION ID	**Project Name:**	Nailcote Farm, Warwickshire		**Ground Level (m AOD):**	140.99
FH07	**Project Number:**	221748		**Eastings:**	427831.03
	Client:	Environmena Project Management UK Ltd		**Northings:**	286144.97
Hole Type: WLS	**Rig:** Premier 110	**Start & End Date:**	14/09/2023	**Engineer:** TF	**Checker:** CR

Boring		Strata				Samples			In-Situ Tests			
Strike	Well	Level (m AOD) & [Thickness (m)]	Description	Legend	Depth (m bgl)	Type (Ublows)	From (m)	To (m)	Type	Depth (m)	Result	Casing Depth & (Water Level)
		140.69 [0.30]	Crops over dark brown very clayey SAND with moderate rootlet content.()		0.30							
		138.99 [1.70]	Firm reddish brown sandy CLAY.()		2.00							
			Hole Terminated at 2.00m bgl.									

Chiseling		
From (m bgl)	To (m bgl)	Time (hh:mm)

Water Added		
From (m bgl)	To (m bgl)	Volume (l)

Remarks

Reason for Termination:

Target depth reached.

Groundwater Remarks:

No groundwater encountered.

Other Remarks:

Location cleared of buried services. Borehole advanced to enable installation of standpipe for falling head infiltration test.

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APPENDIX 2: INFILTRATION TEST RESULTS

PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH01
Date:	13-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.20
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.20
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.300	1.900	1.000
0.25	0.400	1.800	0.947
0.50	0.500	1.700	0.895
0.75	0.600	1.600	0.842
1.00	0.720	1.480	0.779
2.00	0.810	1.390	0.732
4.00	1.100	1.100	0.579
6.00	1.350	0.850	0.447
8.00	1.440	0.760	0.400
10.00	1.530	0.670	0.353
12.00	1.640	0.560	0.295
15.00	1.740	0.460	0.242
20.00	1.850	0.350	0.184
25.00	1.880	0.320	0.1684
30.00	1.900	0.300	0.158
35.00	1.920	0.280	0.147
40.00	1.950	0.250	0.132

Basic Time Lag Method (after BS5930:1999)

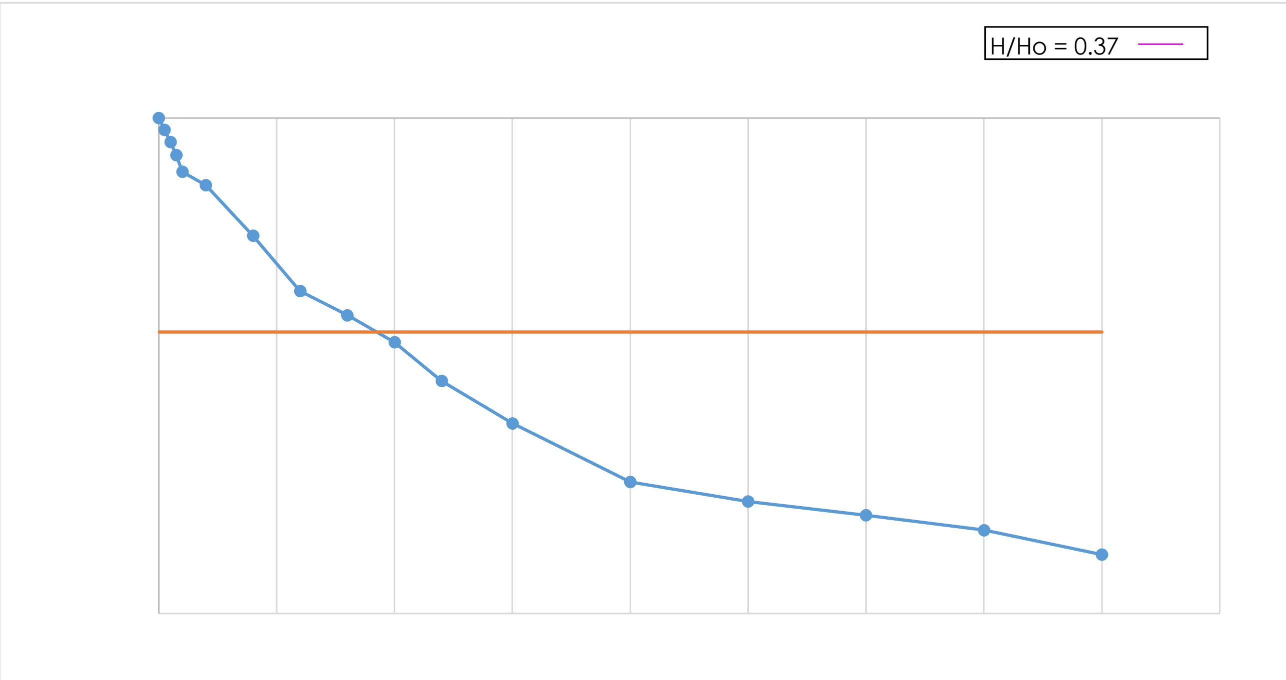
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T= 9.00 (min)
T= 540.00 (sec)
K= 2.57E-06 (m/s)
K= 0.222 (m/d)

General Method (after BS5930:1999)

$$k \quad \frac{A}{F(t_2 \quad t_1)} \log_e \frac{H_1}{H_2}$$

t1= 20.00 (min)
t2= 40.00 (min)
H(head)1= 0.35 (m)
H(head)2= 0.25 (m)
K= 3.89E-07 (m/s)
K= 0.034 (m/d)



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH01
Date:	13-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.20
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.300	1.900	1.000
0.25	0.410	1.790	0.942
0.50	0.520	1.680	0.884
0.75	0.550	1.650	0.868
1.00	0.570	1.630	0.858
2.00	0.720	1.480	0.779
4.00	1.060	1.140	0.600
6.00	1.210	0.990	0.521
8.00	1.400	0.800	0.421
10.00	1.530	0.670	0.353
12.00	1.620	0.580	0.305
15.00	1.740	0.460	0.242
20.00	1.840	0.360	0.189
25.00	1.860	0.340	0.1789
30.00	1.880	0.320	0.168
35.00	1.890	0.310	0.163
40.00	1.910	0.290	0.153
45.00	1.930	0.270	0.142
50.00	1.960	0.240	0.126

Basic Time Lag Method (after BS5930:1999)

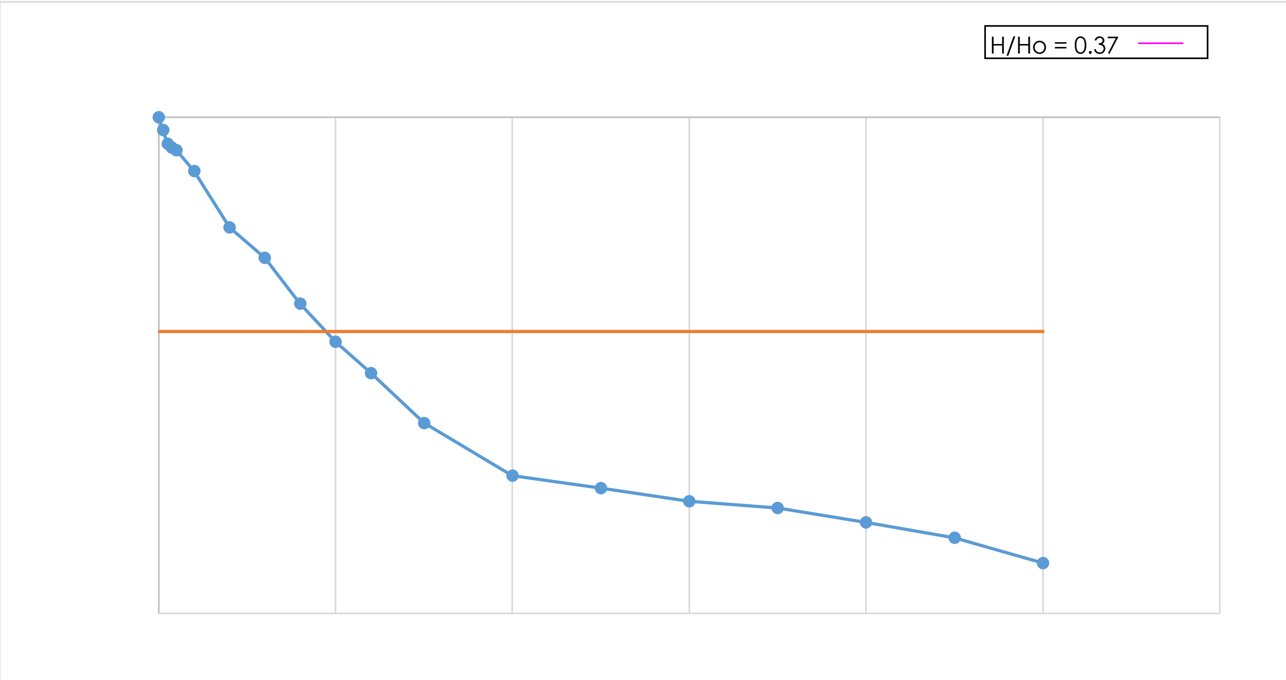
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T= 9.50 (min)
T= 570.00 (sec)
K= 2.44E-06 (m/s)
K= 0.210 (m/d)

General Method (after BS5930:1999)

$$k \quad \frac{A}{F(t_2 \quad t_1)} \log_e \frac{H_1}{H_2}$$

t1= 20.00 (min)
t2= 50.00 (min)
H(head)1= 0.36 (m)
H(head)2= 0.24 (m)
K= 3.13E-07 (m/s)
K= 0.027 (m/d)



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH01-C
Date:	13-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.20
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.20
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.300	1.900	1.000
0.25	0.320	1.880	0.989
0.50	0.450	1.750	0.921
0.75	0.500	1.700	0.895
1.00	0.650	1.550	0.816
2.00	0.820	1.380	0.726
4.00	1.100	1.100	0.579
6.00	1.400	0.800	0.421
8.00	1.540	0.660	0.347
10.00	1.680	0.520	0.274
12.00	1.750	0.450	0.237
15.00	1.820	0.380	0.200
20.00	1.850	0.350	0.184
25.00	1.900	0.300	0.1579
30.00	1.910	0.290	0.153
35.00	1.980	0.220	0.116
40.00	2.050	0.150	0.079
45.00	2.090	0.110	0.058
50.00	2.150	0.050	0.026

Basic Time Lag Method (after BS5930:1999)

K= A/(F*T)

T= TIME FOR H/Ho:0.37

T= 7.50 (min)

T= 450.00 (sec)

K= 3.09E-06 (m/s)

K= 0.267 (m/d)

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1= 30.00 (min)

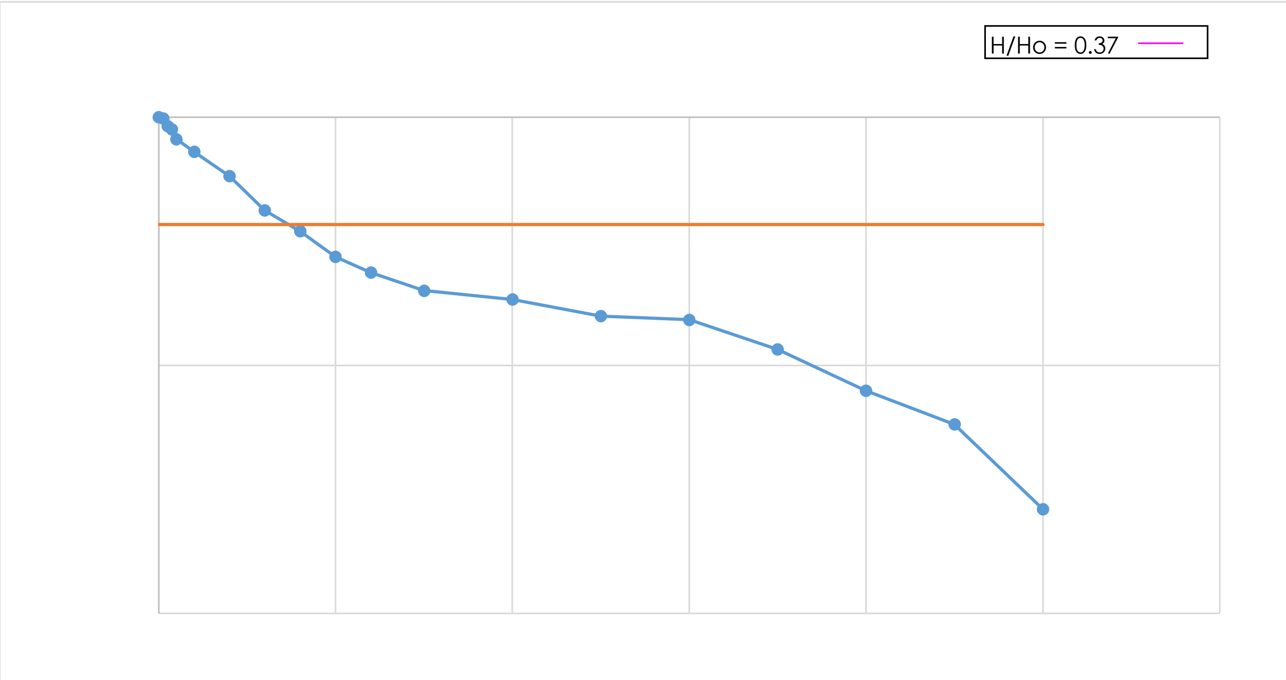
t2= 50.00 (min)

H(head)1= 0.29 (m)

H(head)2= 0.05 (m)

K= 2.03E-06 (m/s)

K= 0.176 (m/d)



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

BWB
CONSULTANCY | ENVIRONMENT
INFRASTRUCTURE | BUILDINGS

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH02
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.00
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Mudstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	b
F Value	1.65E-01
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	2.000	1.000
0.25	0.200	1.800	0.900
0.50	0.230	1.770	0.885
0.75	0.270	1.730	0.865
1.00	0.320	1.680	0.840
2.00	0.450	1.550	0.775
4.00	0.500	1.500	0.750
6.00	0.570	1.430	0.715
8.00	0.600	1.400	0.700
12.00	0.690	1.310	0.655
16.00	0.710	1.290	0.645
60.00	0.750	1.250	0.625
120.00	0.800	1.200	0.600
240.00	0.880	1.120	0.5600
1440.00	1.150	0.850	0.425
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000

Basic Time Lag Method (after BS5930:1999)

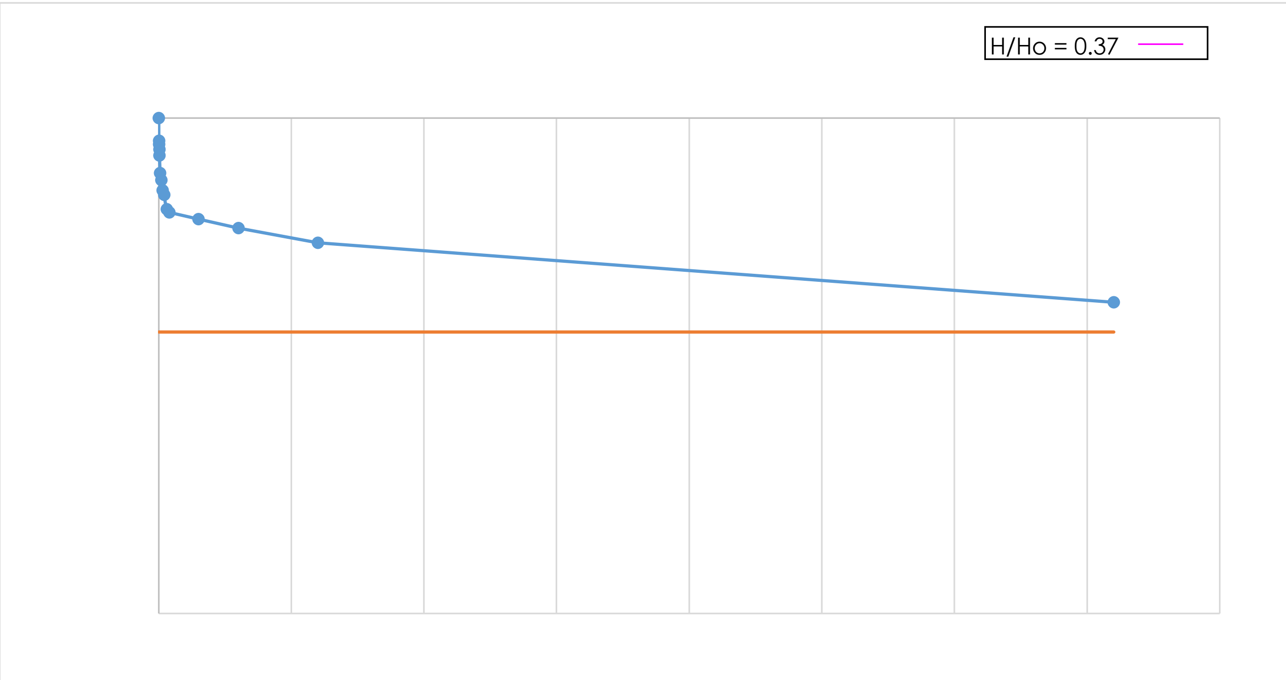
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T=		(min)
T=	0.00	(sec)
K=	**#DIV/0!**	**(m/s)**
K=	**#DIV/0!**	**(m/d)**

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1=	120.00	(min)
t2=	1440.00	(min)
H(head)1=	1.20	(m)
H(head)2=	0.85	(m)
K=	**7.46E-08**	**(m/s)**
K=	**0.006**	**(m/d)**



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH03
Date:	13-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.00
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Mudstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	2.000	1.000
0.25	0.010	1.990	0.995
0.50	0.010	1.990	0.995
0.75	0.010	1.990	0.995
1.00	0.010	1.990	0.995
2.00	0.010	1.990	0.995
10.00	0.020	1.980	0.990
20.00	0.050	1.950	0.975
60.00	0.100	1.900	0.950
120.00	0.200	1.800	0.900
240.00	0.450	1.550	0.775
1440.00	1.700	0.300	0.150
		2.000	1.000
		2.000	1.0000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000

Basic Time Lag Method (after BS5930:1999)

K= A/(F*T)

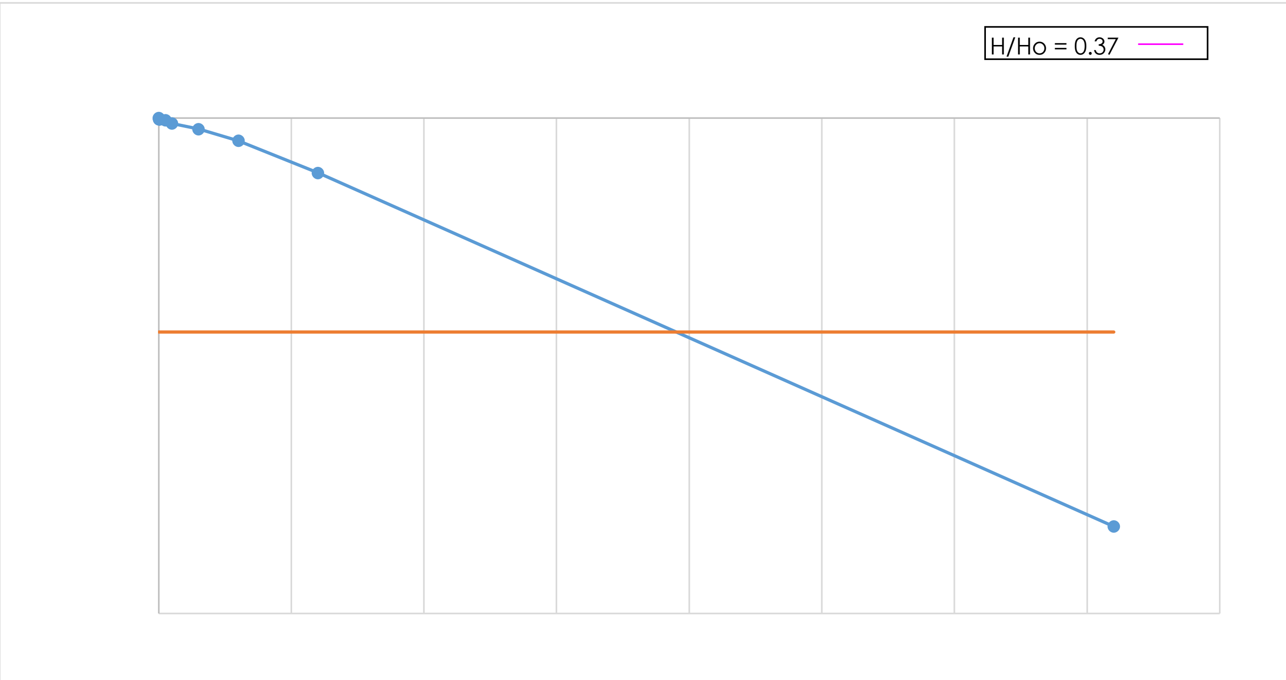
T= TIME FOR H/Ho:0.37

T=	78.00	(min)
T=	4680.00	(sec)
K=	**2.97E-07**	**(m/s)**
K=	**0.026**	**(m/d)**

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1=	120.00	(min)
t2=	1440.00	(min)
H(head)1=	1.80	(m)
H(head)2=	0.30	(m)
K=	**3.14E-08**	**(m/s)**
K=	**0.003**	**(m/d)**



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

BWB
CONSULTANCY | ENVIRONMENT
INFRASTRUCTURE | BUILDINGS

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH04
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.00
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Mudstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	2.000	1.000
0.25	0.000	2.000	1.000
0.50	0.000	2.000	1.000
0.75	0.000	2.000	1.000
1.00	0.000	2.000	1.000
2.00	0.000	2.000	1.000
4.00	0.000	2.000	1.000
6.00	0.000	2.000	1.000
8.00	0.000	2.000	1.000
12.00	0.000	2.000	1.000
16.00	0.000	2.000	1.000
60.00	0.000	2.000	1.000
120.00	0.000	2.000	1.000
240.00	0.000	2.000	1.0000
1440.00	0.250	1.750	0.875
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000

Basic Time Lag Method (after BS5930:1999)

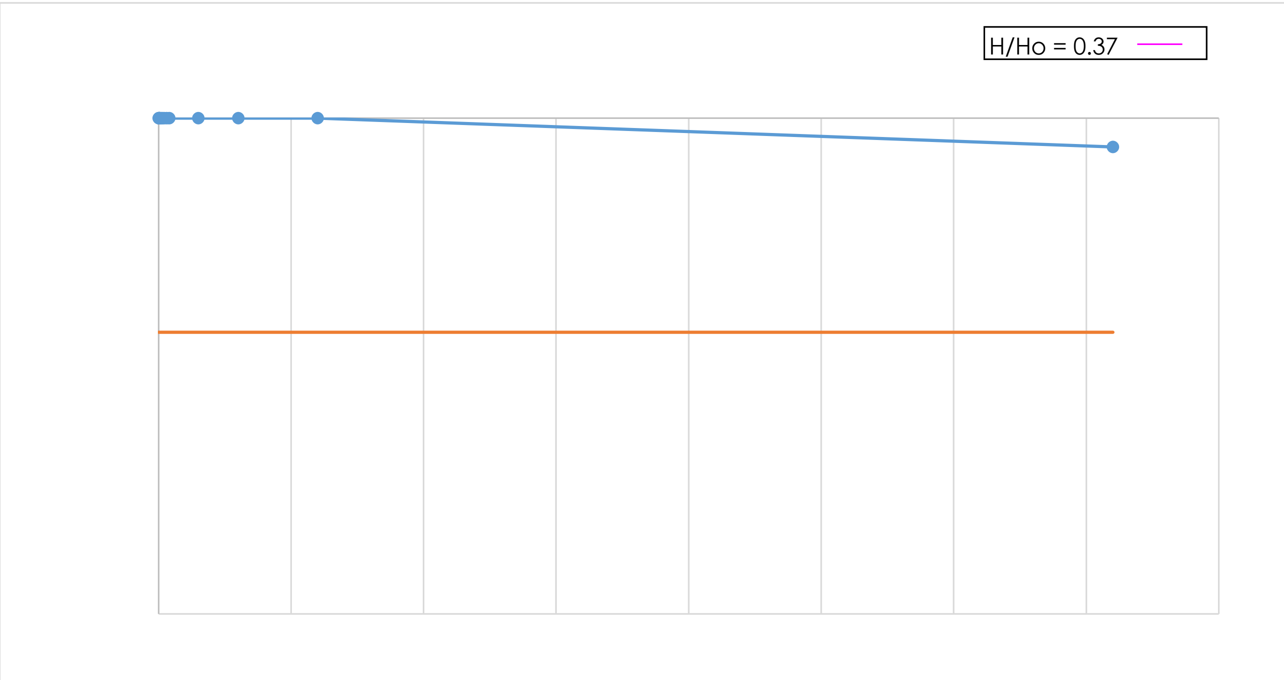
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T=		(min)
T=	0.00	(sec)
K=	**#DIV/0!**	**(m/s)**
K=	**#DIV/0!**	**(m/d)**

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1=	240.00	(min)
t2=	1440.00	(min)
H(head)1=	2.00	(m)
H(head)2=	1.75	(m)
K=	**2.58E-09**	**(m/s)**
K=	**0.000**	**(m/d)**



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH05
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.00
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	2.000	1.000
0.25	0.150	1.850	0.925
0.50	0.170	1.830	0.915
0.75	0.180	1.820	0.910
1.00	0.210	1.790	0.895
2.00	0.220	1.780	0.890
4.00	0.270	1.730	0.865
6.00	0.310	1.690	0.845
8.00	0.360	1.640	0.820
20.00	0.580	1.420	0.710
30.00	0.660	1.340	0.670
90.00	1.000	1.000	0.500
240.00	1.200	0.800	0.400
1080.00	1.990	0.010	0.0050

Basic Time Lag Method (after BS5930:1999)

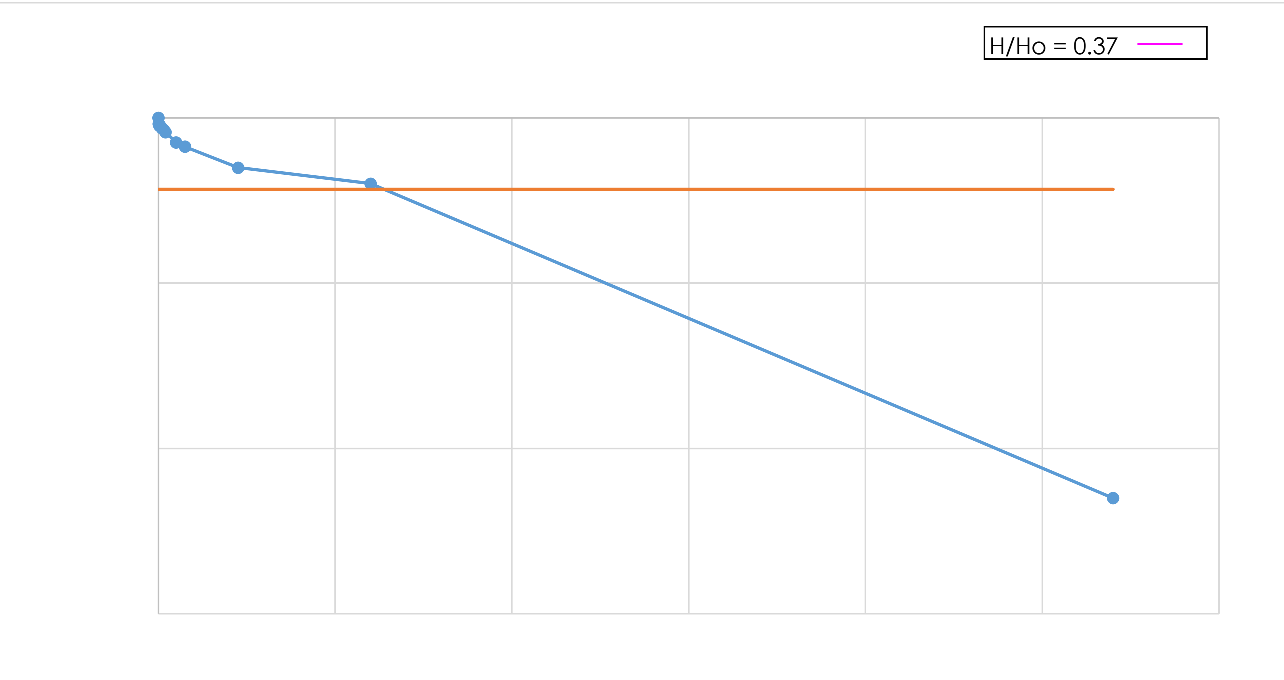
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T=	265.00	(min)
T=	15900.00	(sec)
K=	**8.73E-08**	**(m/s)**
K=	**0.008**	**(m/d)**

General Method (after BS5930:1999)

$$k \quad \frac{A}{F(t_2 \quad t_1)} \log_e \frac{H_1}{H_2}$$

t1=	90.00	(min)
t2=	1080.00	(min)
H(head)1=	1.00	(m)
H(head)2=	0.01	(m)
K=	**1.08E-07**	**(m/s)**
K=	**0.009**	**(m/d)**



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH05 B
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.00
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	2.000	1.000
0.25	0.170	1.830	0.915
0.50	0.180	1.820	0.910
0.75	0.180	1.820	0.910
1.00	0.190	1.810	0.905
2.00	0.210	1.790	0.895
4.00	0.240	1.760	0.880
6.00	0.280	1.720	0.860
8.00	0.280	1.720	0.860
10.00	0.300	1.700	0.850
20.00	0.400	1.600	0.800
90.00	0.930	1.070	0.535
240.00	1.510	0.490	0.245
420.00	1.950	0.050	0.0250
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000

Basic Time Lag Method (after BS5930:1999)

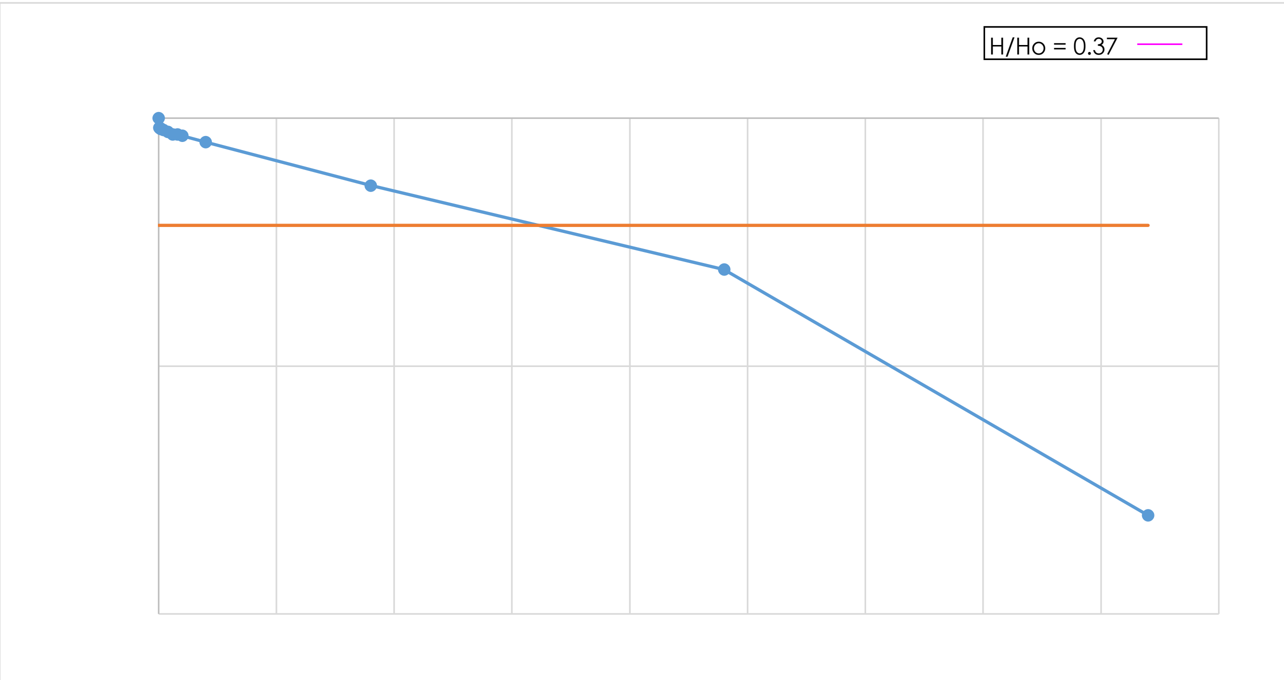
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T=	160.00	(min)
T=	9600.00	(sec)
K=	**1.45E-07**	**(m/s)**
K=	**0.012**	**(m/d)**

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1=	90.00	(min)
t2=	420.00	(min)
H(head)1=	1.07	(m)
H(head)2=	0.05	(m)
K=	**2.15E-07**	**(m/s)**
K=	**0.019**	**(m/d)**



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

BWB
CONSULTANCY | ENVIRONMENT
INFRASTRUCTURE | BUILDINGS

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH05 C
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.00
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins)	Hi(mbd)	H(head)	H/Ho
0.00	0.000	2.000	1.000
0.25	0.020	1.980	0.990
0.50	0.030	1.970	0.985
0.75	0.040	1.960	0.980
1.00	0.050	1.950	0.975
2.00	0.100	1.900	0.950
4.00	0.150	1.850	0.925
6.00	0.180	1.820	0.910
8.00	0.220	1.780	0.890
10.00	0.260	1.740	0.870
20.00	0.370	1.630	0.815
60.00	0.680	1.320	0.660
180.00	1.510	0.490	0.245
420.00	1.980	0.020	0.0100

Basic Time Lag Method (after BS5930:1999)

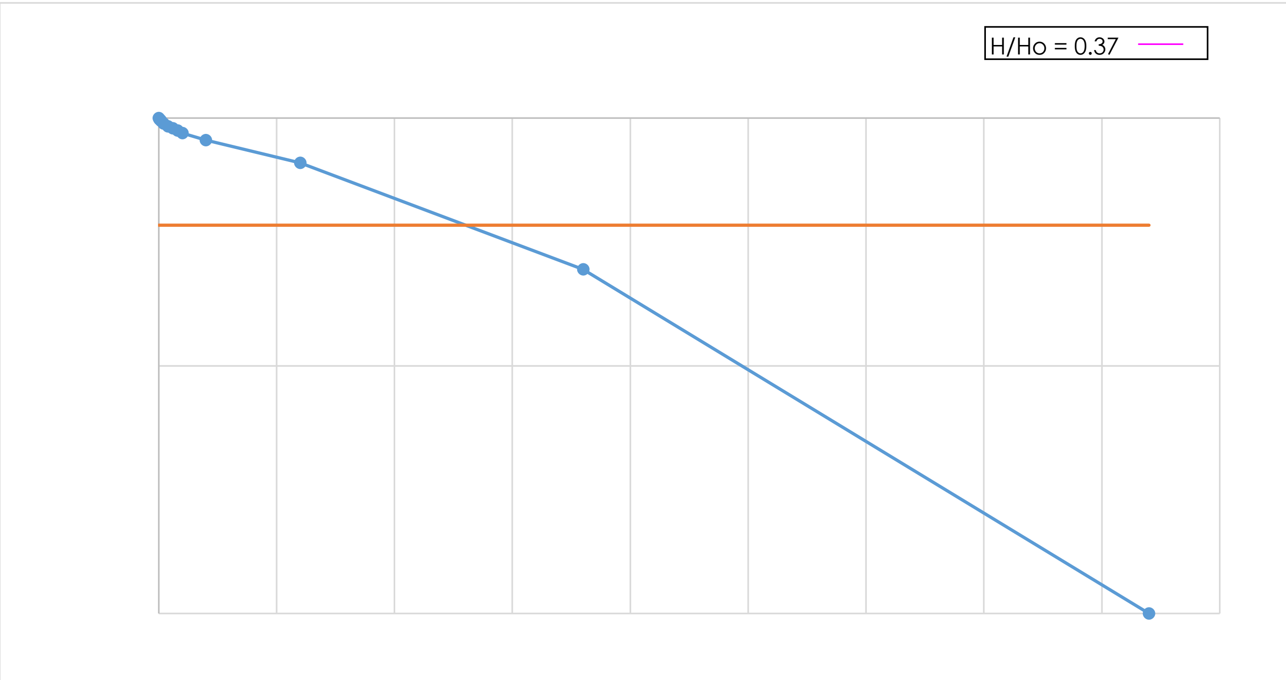
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T=	130.00	(min)
T=	7800.00	(sec)
K=	**1.78E-07**	**(m/s)**
K=	**0.015**	**(m/d)**

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1=	60.00	(min)
t2=	420.00	(min)
H(head)1=	1.32	(m)
H(head)2=	0.02	(m)
K=	**2.69E-07**	**(m/s)**
K=	**0.023**	**(m/d)**



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

BWB
CONSULTANCY | ENVIRONMENT
INFRASTRUCTURE | BUILDINGS

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH06
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	1.20
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	1.200	1.000
0.25	0.000	1.200	1.000
0.50	0.000	1.200	1.000
0.75	0.010	1.190	0.992
1.00	0.020	1.180	0.983
2.00	0.040	1.160	0.967
4.00	0.060	1.140	0.950
10.00	0.120	1.080	0.900
15.00	0.170	1.030	0.858
20.00	0.230	0.970	0.808
25.00	0.250	0.950	0.792
30.00	0.290	0.910	0.758
60.00	0.460	0.740	0.617
120.00	0.650	0.550	0.4583
150.00	0.700	0.500	0.417
300.00	0.860	0.340	0.283
360.00	1.010	0.190	0.158
		1.200	1.000
		1.200	1.000
		1.200	1.000

Basic Time Lag Method (after BS5930:1999)

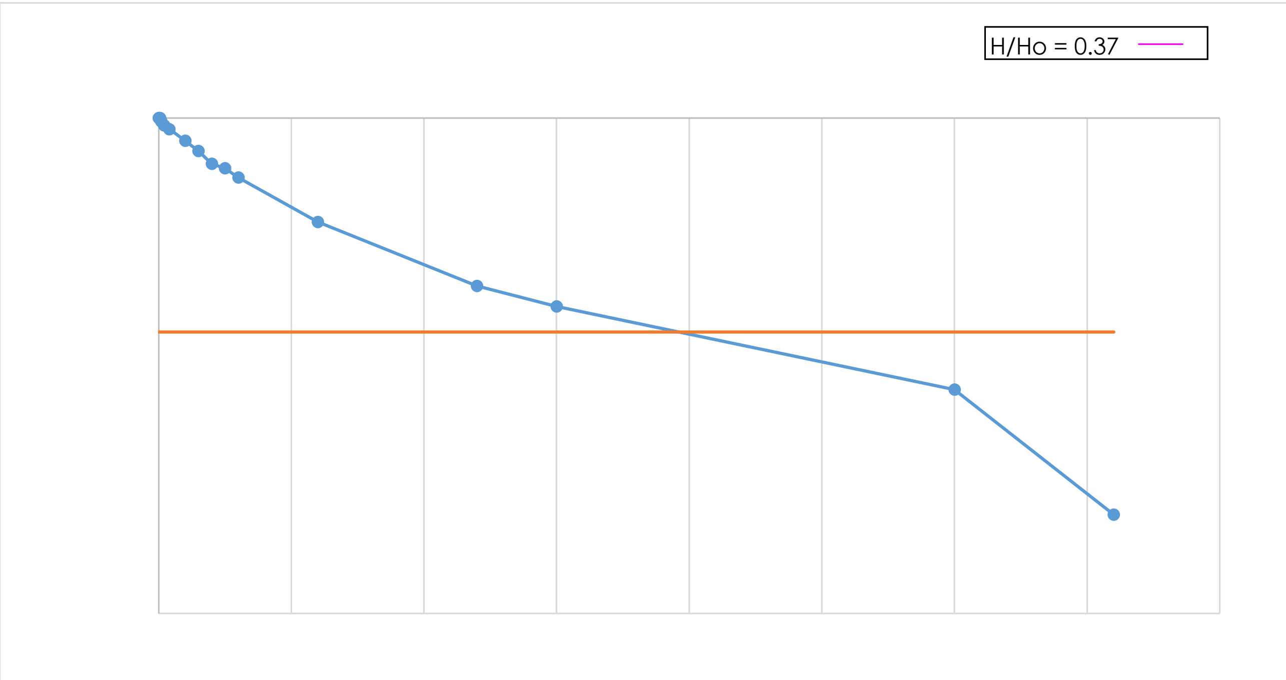
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T= 200.00 (min)
T= 12000.00 (sec)
K= 1.16E-07 (m/s)
K= 0.010 (m/d)

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1= 120.00 (min)
t2= 300.00 (min)
H(head)1= 0.55 (m)
H(head)2= 0.19 (m)
K= 1.37E-07 (m/s)
K= 0.012 (m/d)



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH06
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	1.20
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	1.200	1.000
0.25	0.000	1.200	1.000
0.50	0.000	1.200	1.000
0.75	0.010	1.190	0.992
1.00	0.030	1.170	0.975
2.00	0.050	1.150	0.958
4.00	0.070	1.130	0.942
10.00	0.090	1.110	0.925
15.00	0.120	1.080	0.900
20.00	0.140	1.060	0.883
25.00	0.170	1.030	0.858
30.00	0.270	0.930	0.775
60.00	0.410	0.790	0.658
120.00	0.620	0.580	0.4833
150.00	0.650	0.550	0.458
360.00	1.020	0.180	0.150

Basic Time Lag Method (after BS5930:1999)

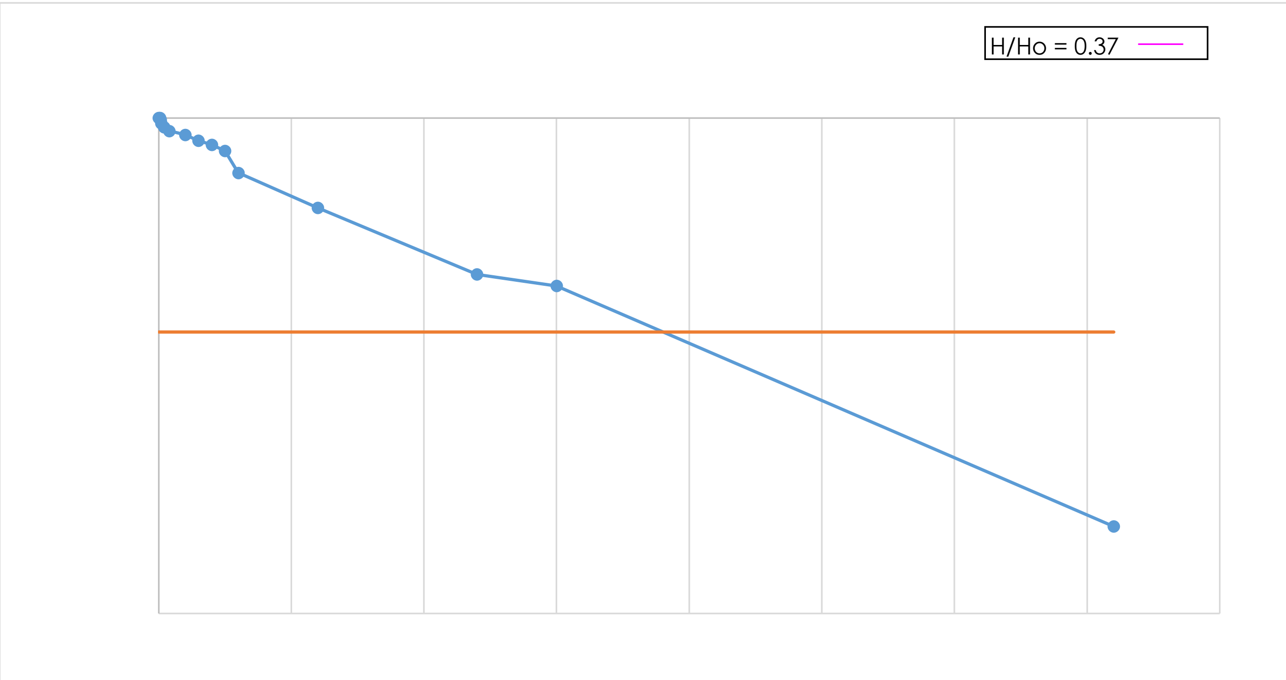
K= A/(F*T)
T= TIME FOR H/Ho:0.37

T= 185.00 (min)
T= 11100.00 (sec)
K= 1.25E-07 (m/s)
K= 0.011 (m/d)

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1= 60.00 (min)
t2= 360.00 (min)
H(head)1= 0.79 (m)
H(head)2= 0.18 (m)
K= 1.14E-07 (m/s)
K= 0.010 (m/d)



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH06
Date:	18-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	0.90
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Sandstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	0.900	1.000
0.25	0.000	0.900	1.000
0.50	0.000	0.900	1.000
0.75	0.000	0.900	1.000
1.00	0.010	0.890	0.989
2.00	0.020	0.880	0.978
4.00	0.030	0.870	0.967
6.00	0.050	0.850	0.944
8.00	0.050	0.850	0.944
10.00	0.060	0.840	0.933
15.00	0.090	0.810	0.900
20.00	0.120	0.780	0.867
25.00	0.140	0.760	0.844
30.00	0.180	0.720	0.8000
60.00	0.260	0.640	0.711
150.00	0.530	0.370	0.411
1000.00	0.899	0.001	0.001

Basic Time Lag Method (after BS5930:1999)

K= A/(F*T)

T= TIME FOR H/Ho:0.37

T= 150.00 (min)

T= 9000.00 (sec)

K= 1.54E-07 (m/s)

K= 0.013 (m/d)

General Method (after BS5930:1999)

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

t1= 1.00 (min)

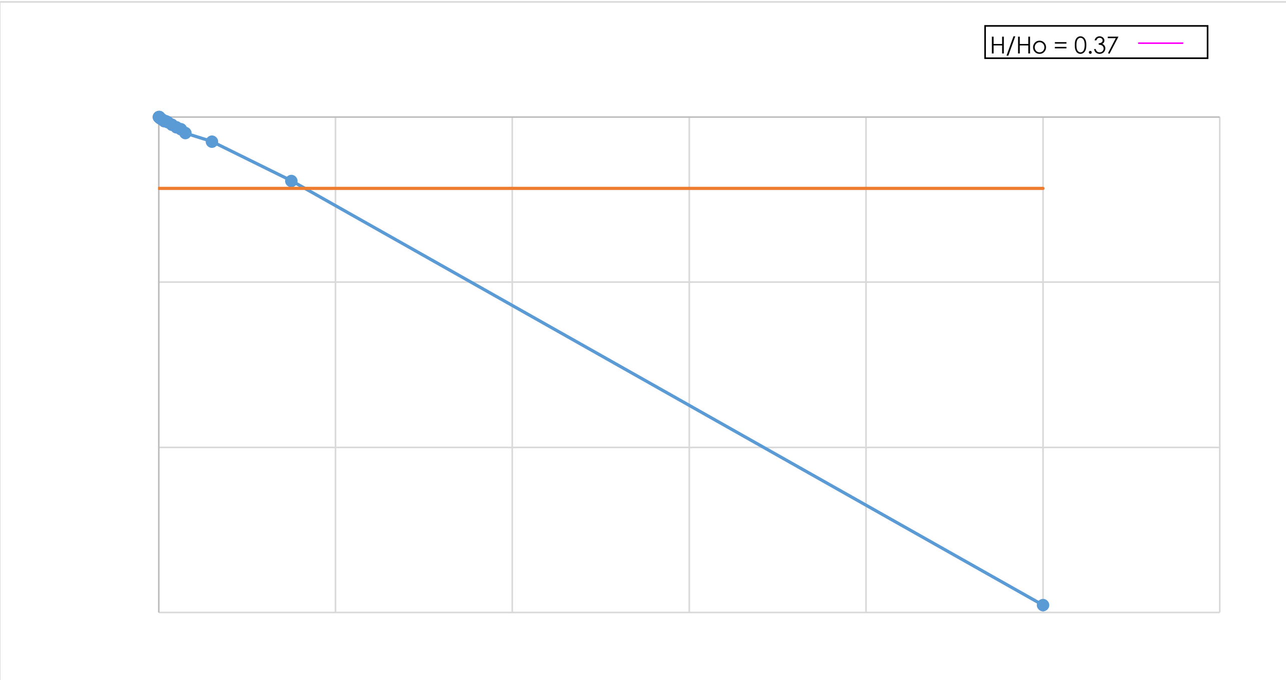
t2= 300.00 (min)

H(head)1= 1.99 (m)

H(head)2= 0.01 (m)

K= 4.10E-07 (m/s)

K= 0.035 (m/d)



PIEZOMETER VARIABLE HEAD PERMEABILITY TEST

Project Name:	Nailcote Farm
Project Number:	221748
Borehole Ref:	FH07
Date:	14-Sep-23
Borehole Diameter (mm):	60
Resting Water Level (m bd):	2.00
Length (L) of Response Zone (m):	1.00

Base of Standpipe (m):	2.00
Geology:	Mudstone
Borehole Diameter (D) (m):	6.00E-02
Scenario (F):	d2
F Value	2.04E+00
Area (A) of Borehole (m^2)	2.83E-03

Time (mins	Hi(mbd)	H(head)	H/Ho
0.00	0.000	2.000	1.000
0.25	0.150	1.850	0.925
0.50	0.200	1.800	0.900
0.75	0.200	1.800	0.900
1.00	0.200	1.800	0.900
2.00	0.200	1.800	0.900
4.00	0.200	1.800	0.900
6.00	0.200	1.800	0.900
8.00	0.200	1.800	0.900
12.00	0.200	1.800	0.900
16.00	0.200	1.800	0.900
60.00	0.200	1.800	0.900
120.00	0.220	1.780	0.890
240.00	0.250	1.750	0.8750
1440.00	1.000	1.000	0.500
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000
		2.000	1.000

Basic Time Lag Method (after BS5930:1999)

K= A/(F*T)

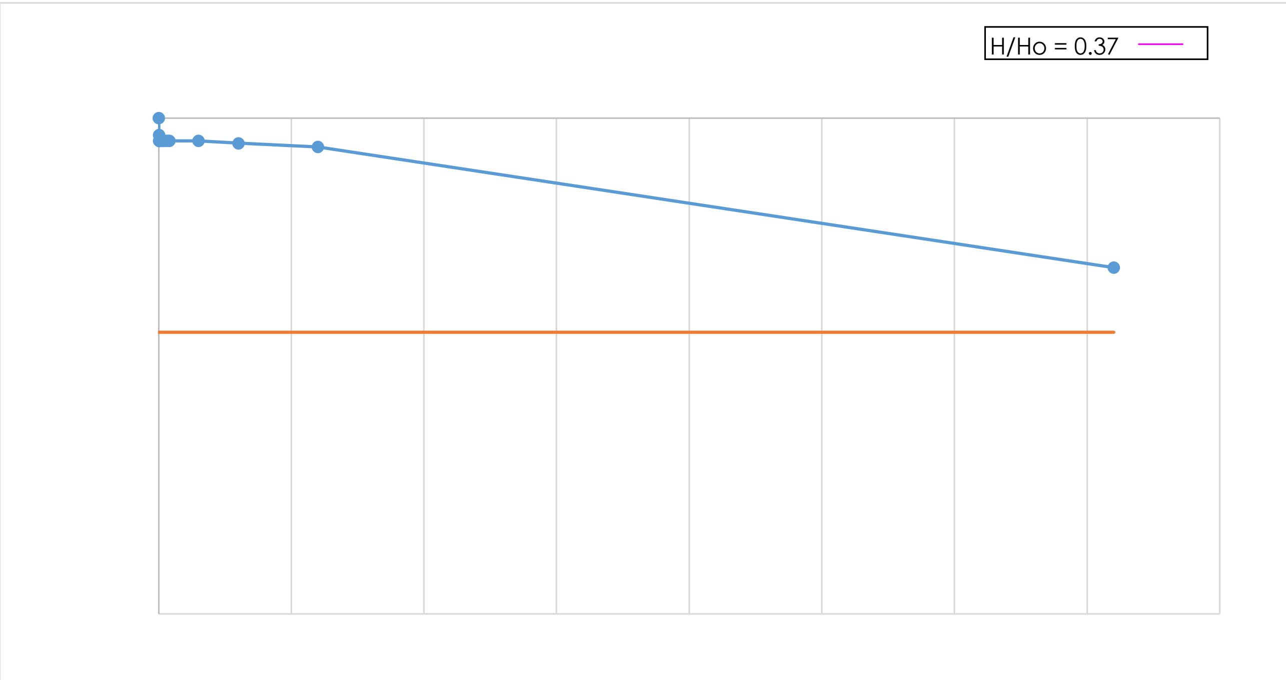
T= TIME FOR H/Ho:0.37

T=		(min)
T=	0.00	(sec)
K=	**#DIV/0!**	**(m/s)**
K=	**#DIV/0!**	**(m/d)**

General Method (after BS5930:1999)

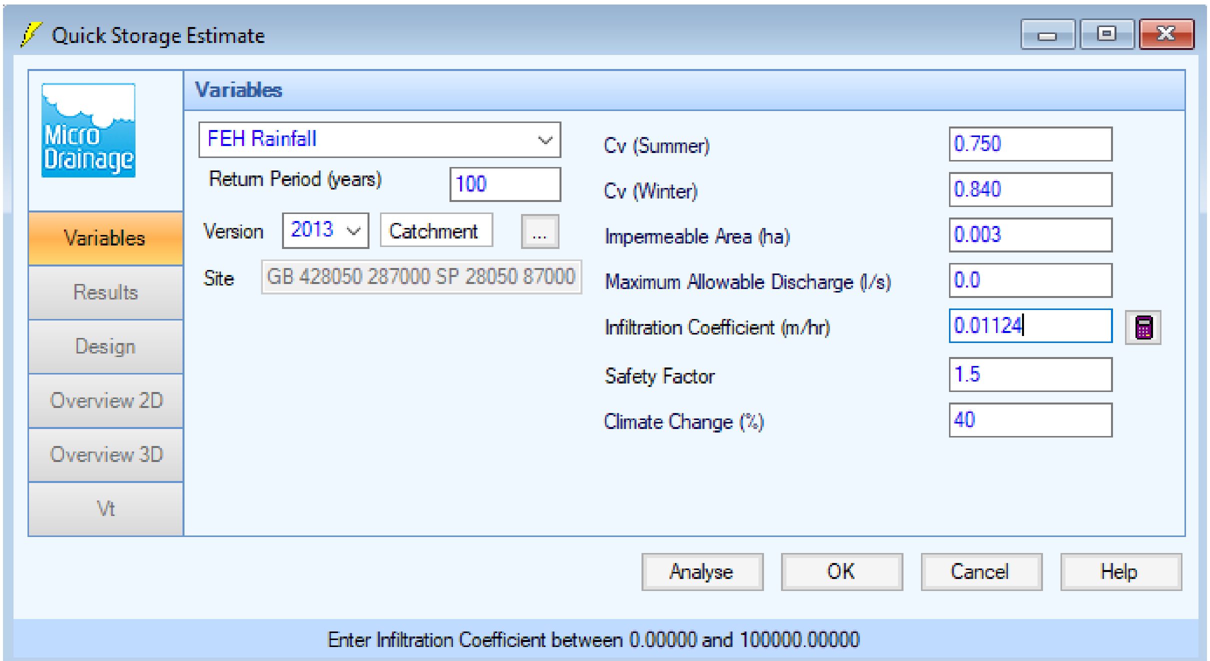
$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$$

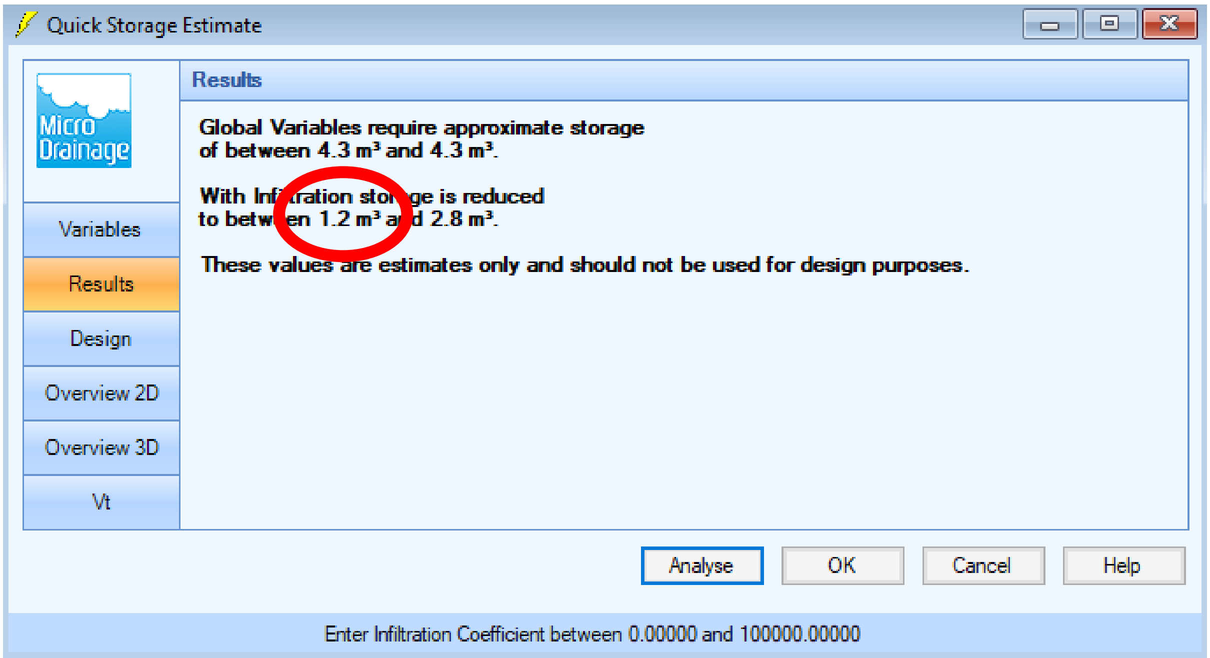
t1=	120.00	(min)
t2=	1440.00	(min)
H(head)1=	1.78	(m)
H(head)2=	1.00	(m)
K=	**1.01E-08**	**(m/s)**
K=	**0.001**	**(m/d)**

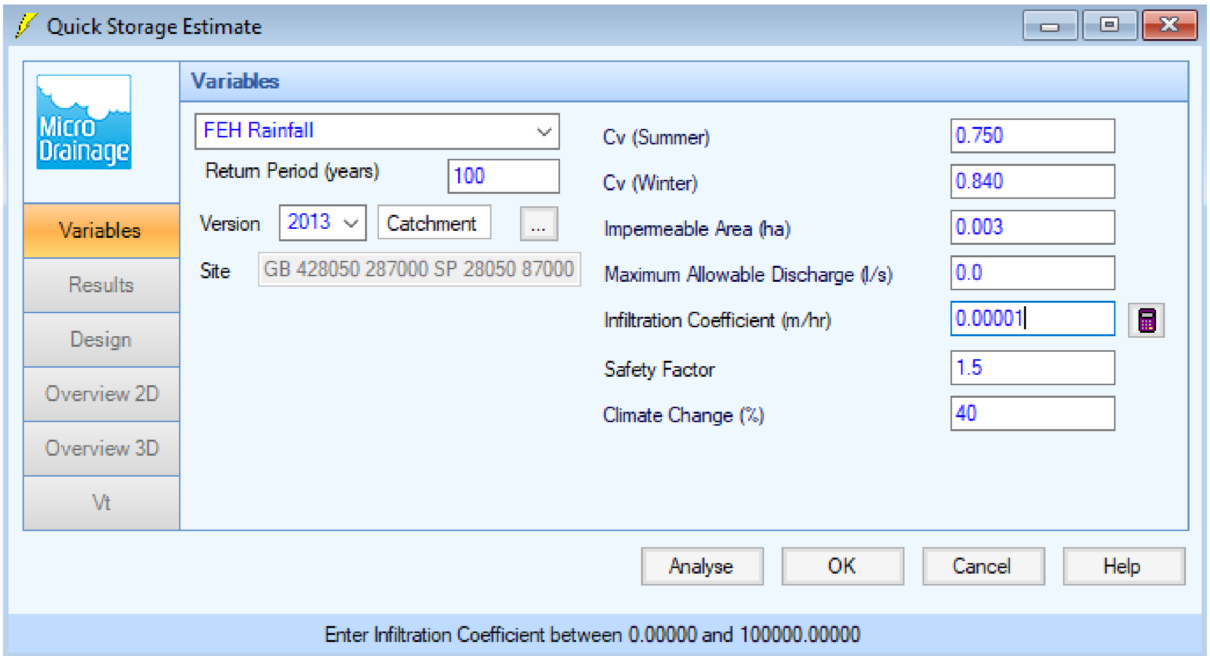


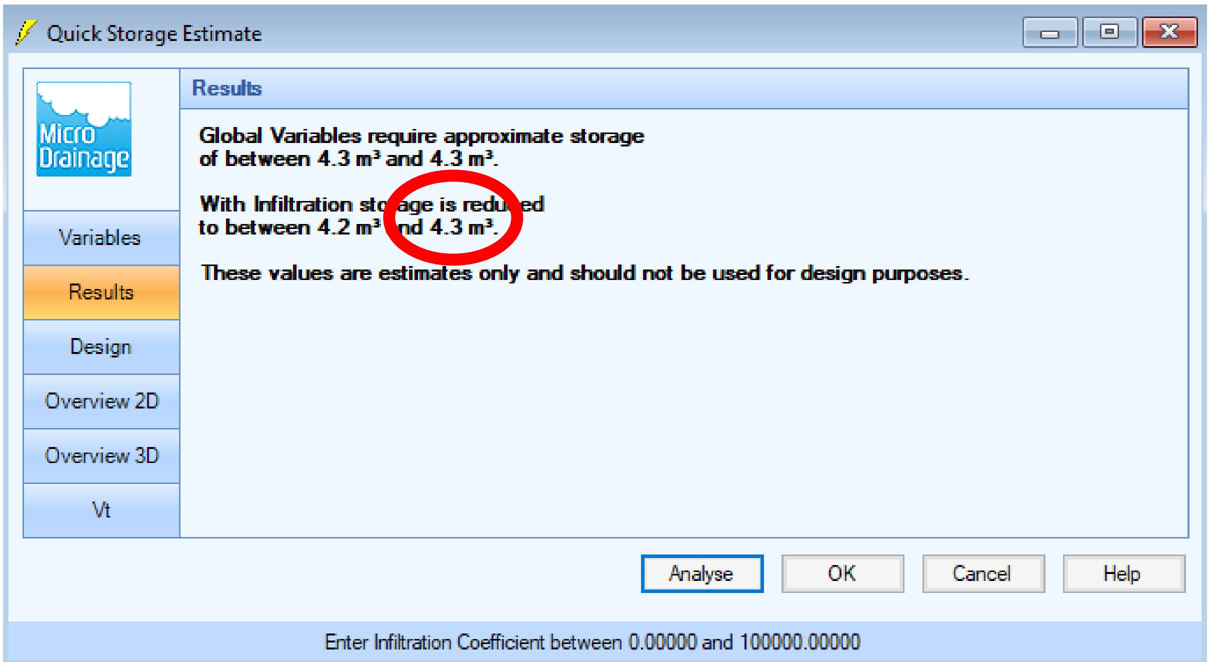
Appendix 4 - MicroDrainage Quick Storage Estimate Outputs

Quick Storage Estimate Outputs



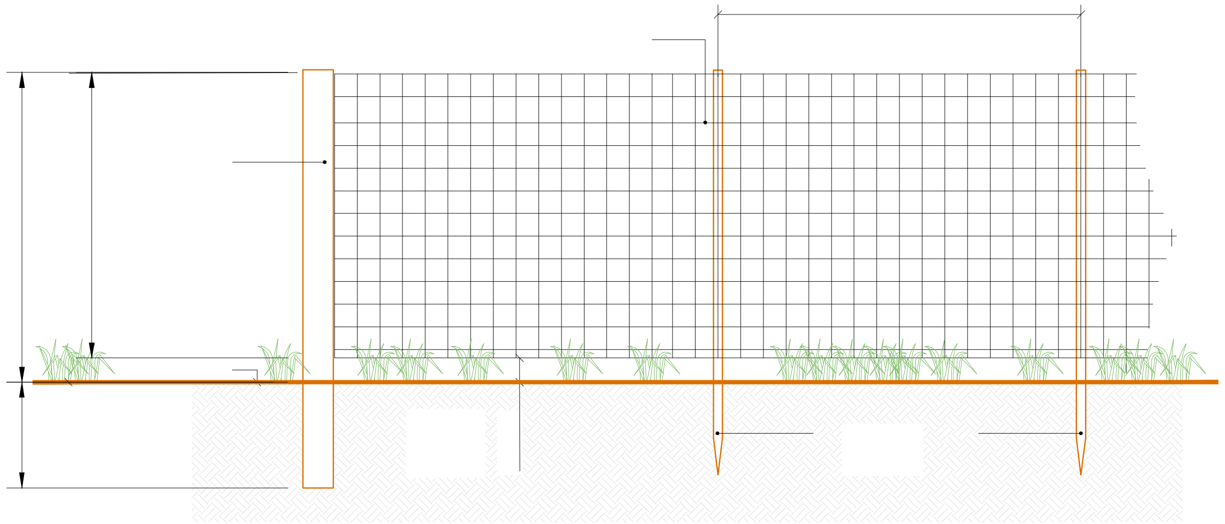


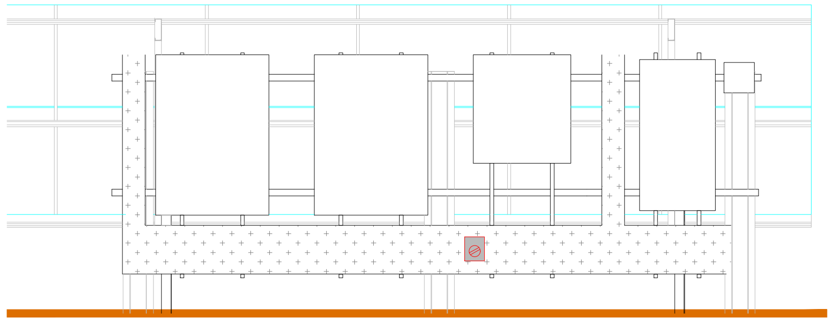

Quick Storage Estimate
Micro Drainage
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Variables
FEH Rainfall
Return Period (years) 100
Version 2013 Catchment ...
Site GB 428050 287000 SP 28050 87000
Cv (Summer) 0.750
Cv (Winter) 0.840
Impermeable Area (ha) 0.003
Maximum Allowable Discharge (l/s) 0.0
Infiltration Coefficient (m/hr) 0.00001
Safety Factor 1.5
Climate Change (%) 40
Analyse OK Cancel Help
Enter Infiltration Coefficient between 0.00000 and 100000.00000

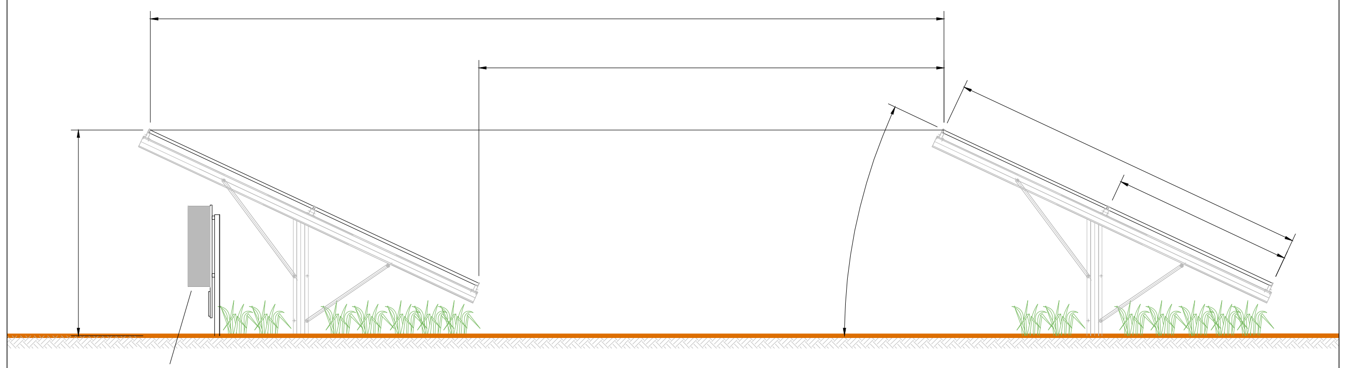

Quick Storage Estimate
Micro Drainage
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Results
Global Variables require approximate storage of between 4.3 m³ and 4.3 m³.
These values are estimates only and should not be used for design purposes.
Analyse OK Cancel Help
Enter Infiltration Coefficient between 0.00000 and 100000.00000

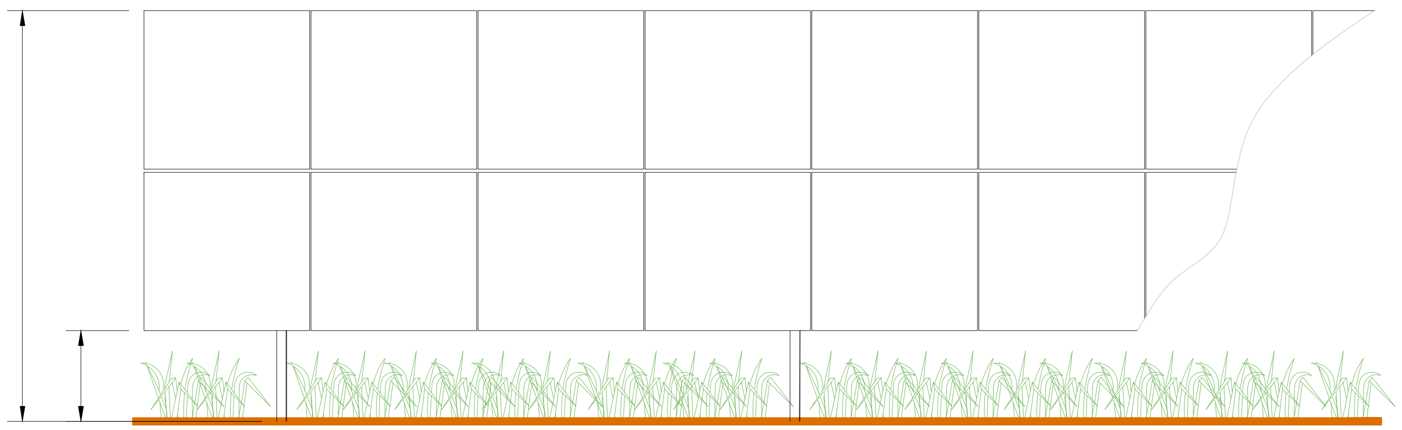
Appendix 2: Proposed Development Layout and Sections


N
MERIDEN ROAD
B 4102
Track
Pond
M 6
Path (um)
ENVIROMENA

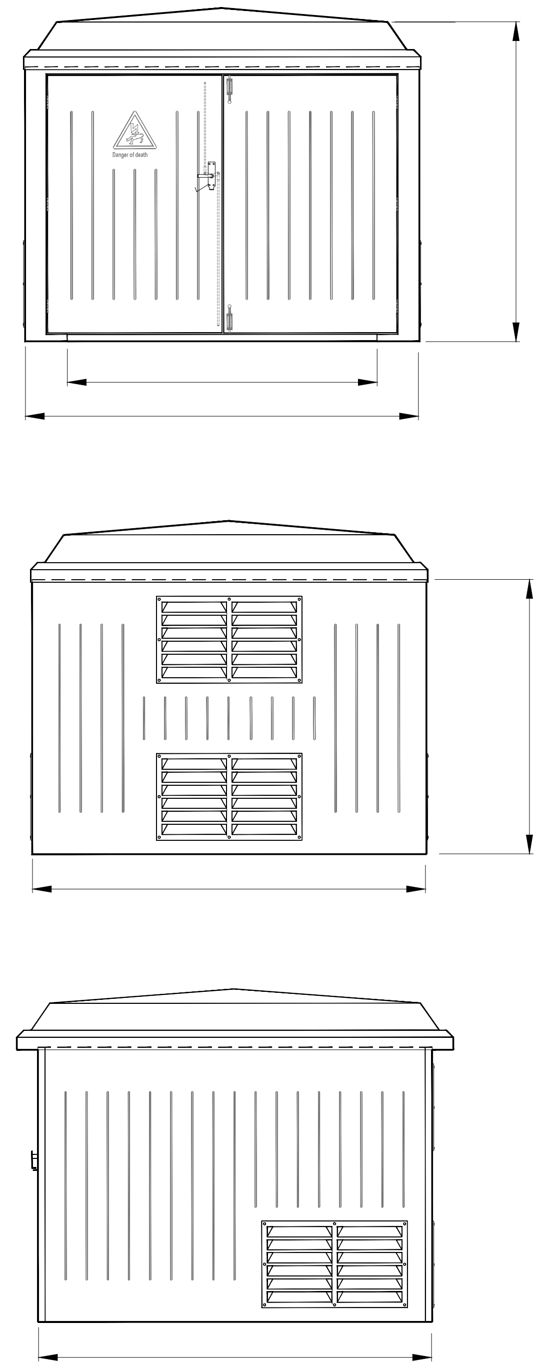


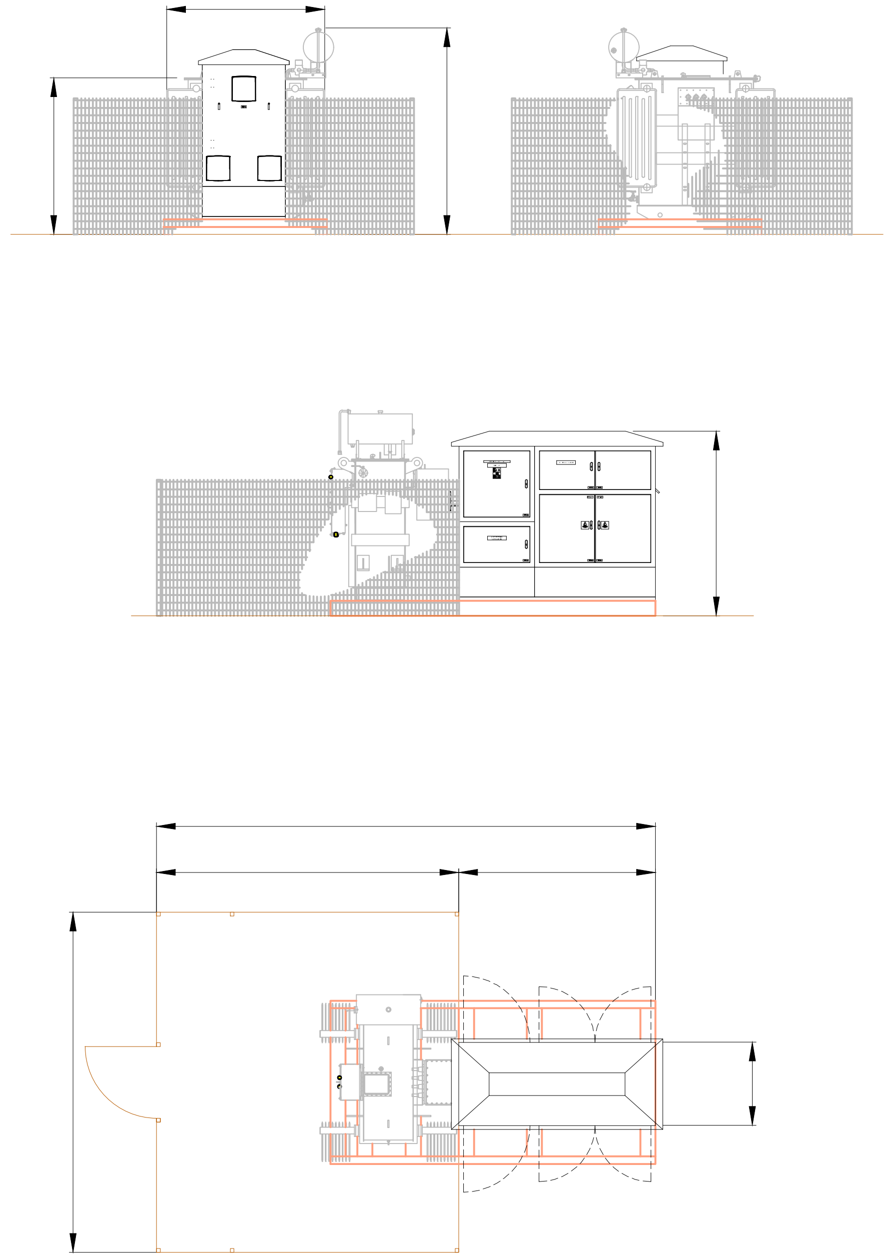


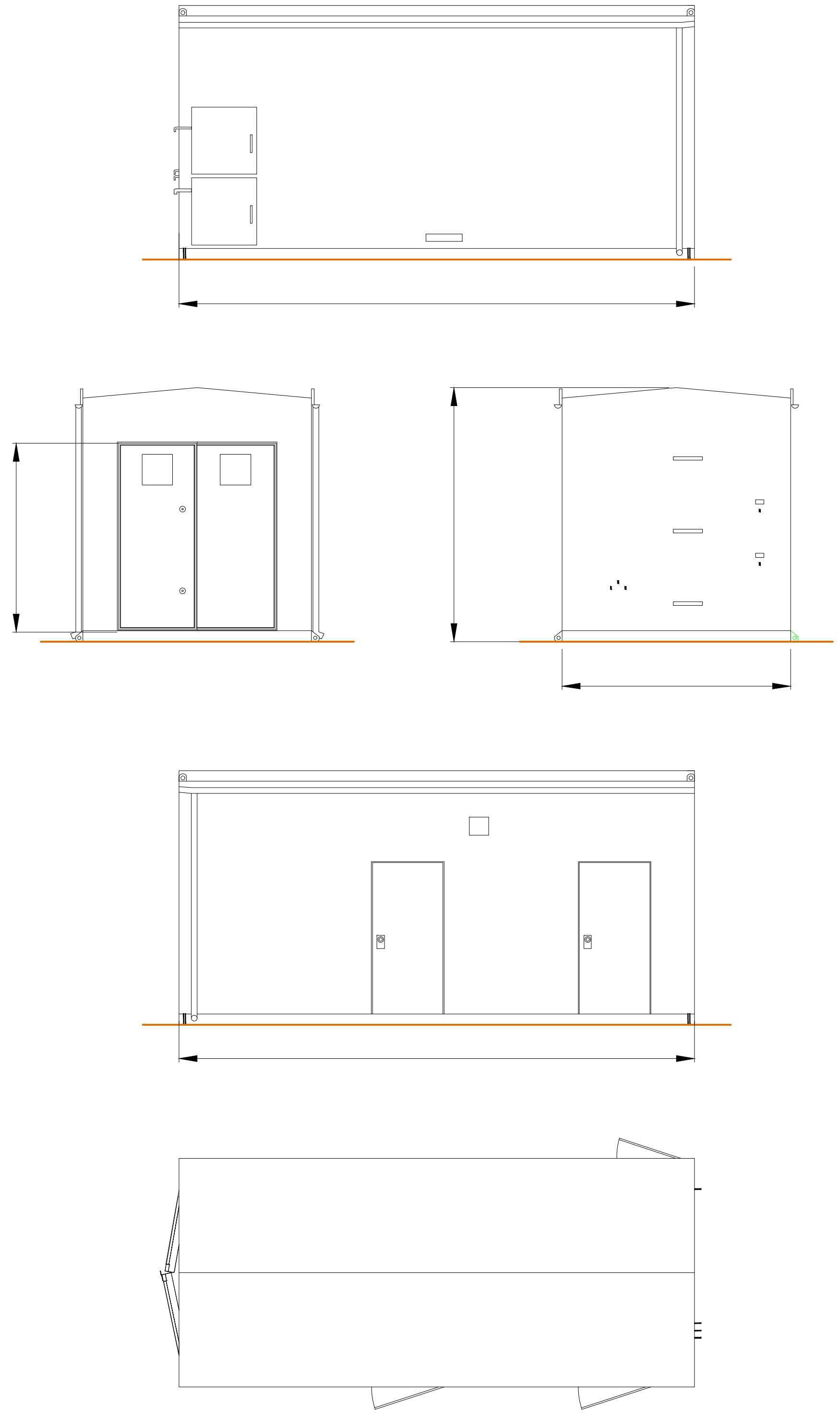




ENVIROMENA



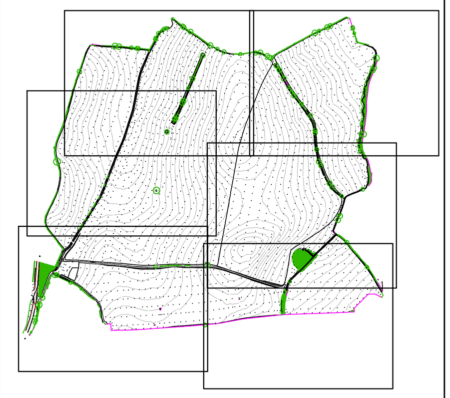


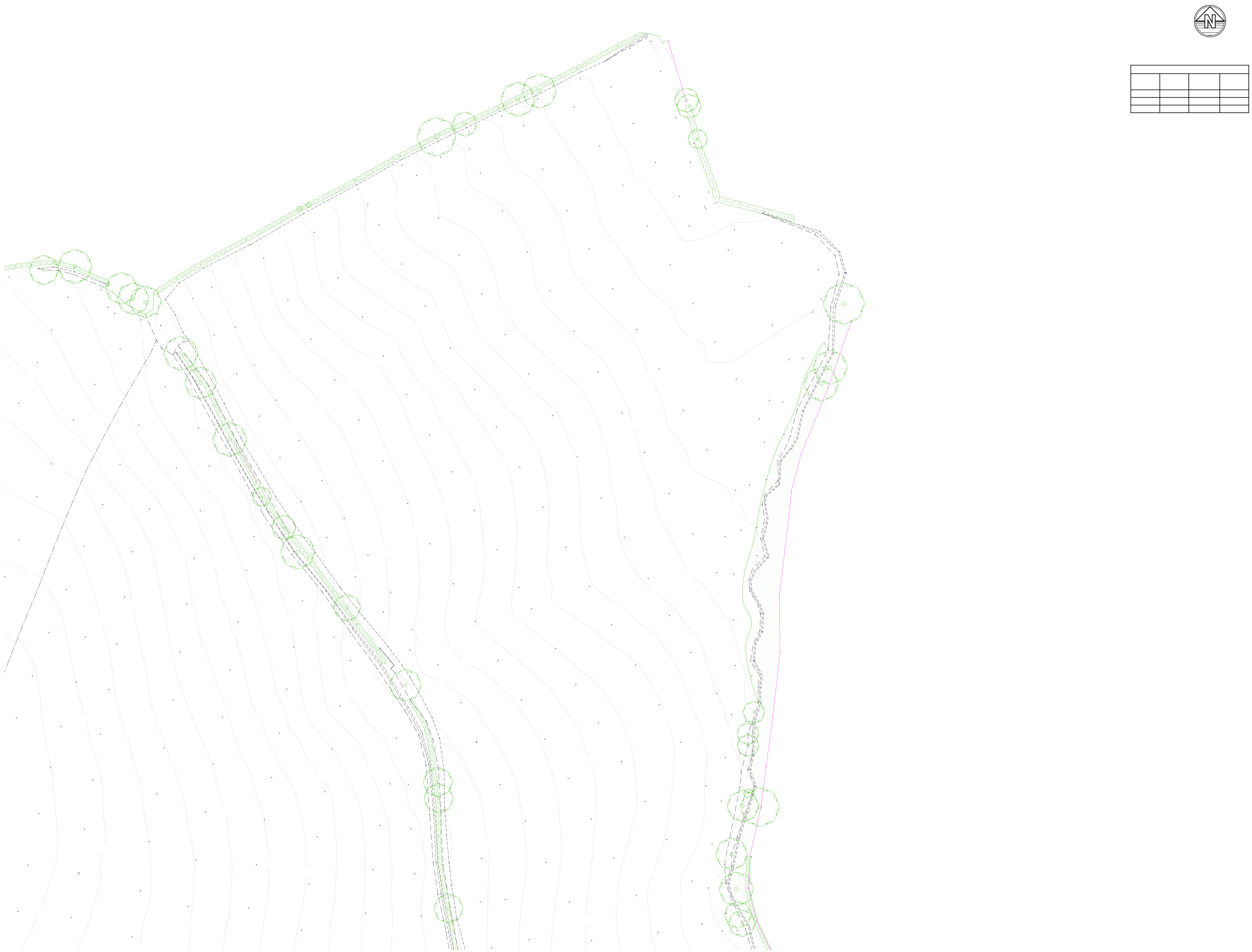


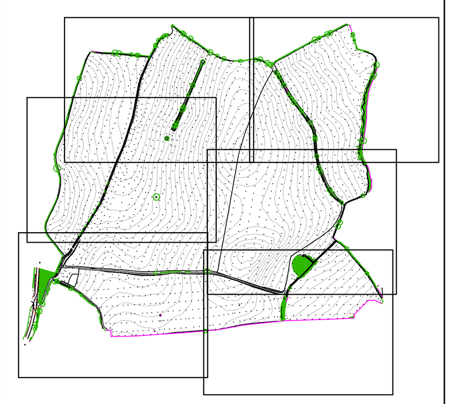
ENVIROMENA

Appendix 3: Topographical Survey

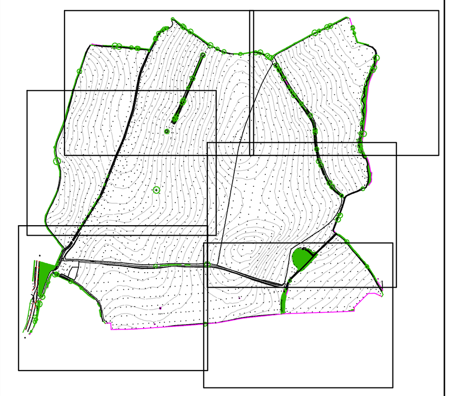

N

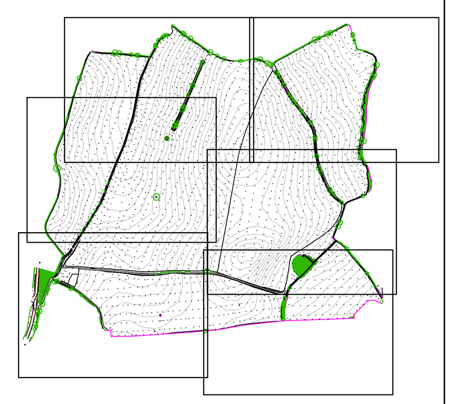


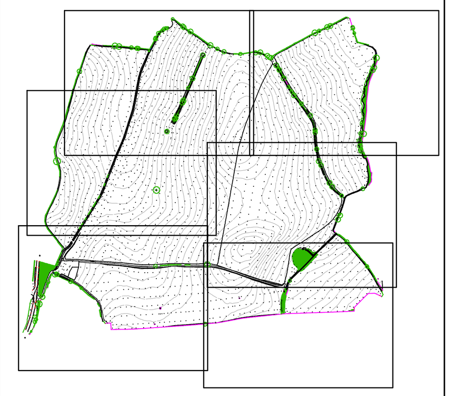




BWB
A CAF GROUP COMPANY







Appendix 4: Conceptual Drainage Strategy and Basin Sections


White House Farm
A CAF GROUP COMPANY

BWB
A CAF GROUP COMPANY

Appendix 5: Pre and Post Development Runoff Calculations

IH 124 Mean Annual Flood

Input

Return Period (years)	100	Soil	0.150
Area (ha)	62.200	Urban	0.000
SAAR (mm)	700	Region Number	Region 4

Results	**l/s**
QBAR Rural	24.6
QBAR Urban	24.6
Q100 years	63.2
Q1 year	20.4
Q2 years	22.0
Q5 years	30.2
Q10 years	36.6
Q20 years	43.7
Q25 years	46.2
Q30 years	48.2
Q50 years	54.1
Q100 years	63.2
Q200 years	74.3
Q250 years	78.0
Q1000 years	102.3

IH 124 Mean Annual Flood

Input

Return Period (years)	100	Soil	0.150
Area (ha)	62.200	Urban	0.000
SAAR (mm)	980	Region Number	Region 4

Results	**l/s**
QBAR Rural	36.5
QBAR Urban	36.5
Q100 years	93.7
Q1 year	30.3
Q2 years	32.7
Q5 years	44.8
Q10 years	54.3
Q20 years	64.8
Q25 years	68.5
Q30 years	71.4
Q50 years	80.3
Q100 years	93.7
Q200 years	110.1
Q250 years	115.6
Q1000 years	151.7

IH 124 Mean Annual Flood

Input

Return Period (years)	100	Soil	0.150
Area (ha)	62.200	Urban	0.001
SAAR (mm)	700	Region Number	Region 4

Results	**l/s**
QBAR Rural	24.6
QBAR Urban	24.7
Q100 years	63.4
Q1 year	20.5
Q2 years	22.1
Q5 years	30.4
Q10 years	36.8
Q20 years	43.8
Q25 years	46.3
Q30 years	48.3
Q50 years	54.3
Q100 years	63.4
Q200 years	74.5
Q250 years	78.2
Q1000 years	102.5

IH 124 Mean Annual Flood

Input

Return Period (years)	100	Soil	0.150
Area (ha)	62.200	Urban	0.001
SAAR (mm)	980	Region Number	Region 4

Results	**l/s**
QBAR Rural	36.5
QBAR Urban	36.5
Q100 years	93.9
Q1 year	30.3
Q2 years	32.8
Q5 years	45.0
Q10 years	54.4
Q20 years	64.9
Q25 years	68.6
Q30 years	71.6
Q50 years	80.4
Q100 years	93.9
Q200 years	110.3
Q250 years	115.8
Q1000 years	151.9

Appendix 6: Pre and Post Development Runoff Volumes

Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	2013
Site Location	GB 428050 287000 SP 28050 87000
Data Type	Catchment
Areal Reduction Factor	1.00
Area (ha)	62.200
SAAR (mm)	709
CWI	106.161
SPR Host	32.470
URBEXT (1990)	0.0107

Results

Percentage Runoff (%)	32.22
Greenfield Runoff Volume (m^3)	12906.902

Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	2013
Site Location	GB 428050 287000 SP 28050 87000
Data Type	Catchment
Areal Reduction Factor	1.00
Area (ha)	62.160
SAAR (mm)	709
CWI	106.161
SPR Host	32.470
URBEXT (1990)	0.0107

Results

Percentage Runoff (%)	32.22
Greenfield Runoff Volume (m^3)	12898.601

Appendix 7: Rainfall Profile

Rainfall profile

Storm duration (mins) 360

FEH Data

FEH Rainfall Version	2013
Site Location	GB 428050 287000 SP 28050 87000
Data Type	Catchment
Peak Intensity (mm/hr)	27.146
Ave. Intensity (mm/hr)	10.733
Return Period (years)	100.0