Longfield Solar Farm

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Appendix 9C: Longfield Solar Farm SuDS Strategy

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SUDS STRATEGY

LONGFIELD SOLAR FARM

LONGFIELD SOLAR ENERGY FARM LTD

FEBRUARY 2022

Prepared By:

Arcus Consultancy Services

Suite 1C
Swinegate Court East
York
North Yorkshire
YO1 8AJ

[redacted]

Registered in England & Wales No. 5644976

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1 INTRODUCTION

1.1 Background

Arcus Consultancy Services Limited (Arcus) has been instructed by Longfield Solar Energy Farm Ltd (the Applicant) to produce a Sustainable Drainage System (SuDS) Strategy for the Longfield Solar Farm (the Scheme) located north of Boreham village, Chelmsford at National Grid Reference E 576667, N 212069 (the DCO Site).

The Scheme is classified as a Nationally Significant Infrastructure Project (NSIP) under the Planning Act 2008[1] and therefore an application for a Development Consent Order (DCO) will be submitted to the Planning Inspectorate for the Order Limits of the Scheme, with the approval of the DCO decided by the Secretary of State for Business, Energy and Industrial Strategy.

This SuDS Strategy is part of the application process for the proposed application for a DCO to be submitted by the Applicant in relation to the Scheme.

The Scheme comprises the construction, operation, maintenance and decommissioning of solar photovoltaic (PV) arrays, a Battery Energy Storage System (BESS) facility with a total capacity exceeding 50 megawatts (MW), a grid connection route from the west of the DCO Site and the extension of the existing Bull's Lodge Substation to enable export to the National Grid.

The Order Limits is separated into three components:

- Solar Farm Site;
- Grid Connection Route; and
- Bulls Lodge Substation Extension.

The PV arrays, Balance of Solar System (BoSS) Plant, solar stations, secondary access tracks and distribution cables will be located within the Solar PV Array Works Area.

The BESS will be located within the BESS Compound which will also comprise a substation serving the Solar Farm (Longfield Substation) and is assessed as part of the BESS Compound.

The Solar PV Array Works Area and BESS Compound are located within the Solar Farm Site.

For the purposes of the SuDS Strategy, given their different functions and geographic locations, the Scheme infrastructure is assessed as four separate elements, as follows:

- The Solar PV Array Works Area;
- BESS Compound including Longfield Substation;
- Grid Connection Route; and
- Bulls Lodge Substation Extension.

An ancillary plant building (Ancillary Building) will be constructed in the Solar Farm Site between Potential Development Areas (PDA) 15, 22 and 27 as shown in Appendix A (drawing 4007_DR_PRE_0001). The Ancillary Building will comprise a warehouse, office, kitchen and toilet facilities.

The SuDS associated with the Bulls Lodge Substation Extension is being designed as a separate component to this SuDS Strategy and is detailed in a standalone document, the Bulls Lodge Substation Extension: Drainage Strategy [Mott MacDonald, Bulls Lodge Substation Extension Drainage Strategy 2021]. Section 4 of this document and section 3

[1] The Planning Act 2008 (2008). [Online]. Available at: https://www.legislation.gov.uk/ukpga/2008/29/pdfs/ukpga_20080029_en.pdf [Date Accessed: 29/07/2021].

of the Bulls Lodge Substation Extension: Drainage Strategy form the 'outline drainage strategy' for the Scheme, which forms part of a Requirement under the DCO.

The Solar Farm Site and Bulls Lodge Substation Extension are within the Boreham Tributary, with the Scheme also partly located within the Ter tributary catchment as per Environment Agency (EA) catchment data[2]. The purpose of the drainage strategy for both developments is to manage surface water to prevent an increase in surface water runoff into the surrounding catchment. The responsibility and maintenance of the Bulls Lodge Substation Extension Drainage Strategy will be separate to that of the Scheme and will be delegated to the appropriate operator and/or contractor.

A layout of the Scheme and the three elements discussed above are shown in Appendix A.

1.2 Guidance and Policy

This SuDS Strategy has been produced in accordance with the following guidance:

- Essex County Council (ECC), The Sustainable Drainage Systems Design Guide for Essex[3];
- ECC, Sustainable Drainage Systems Design Guide[4] (SuDS Guide);
- ECC, SuDS Standing Advice Note[5];
- Department for Environment, Food and Rural Affairs (DEFRA), Sustainable Drainage Systems: Non-Statutory Technical Standards[6];
- Flood and Water Management Act 2010[7];
- National Planning Policy Framework (NPPF)[8]; and
- The SuDS Manual (C753)[9].

2 THE DCO SITE

2.1 DCO Site Characteristics

The Order Limits is approximately 459 hectares (ha) in area and spans immediately north of the A12 to the River Ter approximately 300 metres (m) south of Fuller Street village.

The BESS Compound is located within PDA 31 of the DCO Site, as shown in Appendix A. The field referenced as PDA 31 is approximately 33 ha in area.

The Bull's Lodge Substation is located within the south west extremity of the DCO Site as shown in Appendix A.

[2] Environment Agency, Catchment Data Explorer. [Online]. Available at: https://environment.data.gov.uk/catchment-planning
[3] Essex County Council, The Sustainable Drainage Systems Design Guide for Essex. [Online]. Available at: [redacted] [Date Accessed: 29/07/2021].
[4] Essex County Council, Sustainable Drainage Systems Design Guide (2020). [Online]. Available at: Sustainable Drainage Systems Design Guide [Date Accessed: 29/07/2021].
[5] Essex County Council, SuDS Standing Advice Note. [Online]. Available at: [redacted] [Date Accessed: 29/07/2021].
[6] Department for Environment, Food and Rural Affairs, Sustainable Drainage Systems: Non-Statutory Technical Standards (2015). [Online]. Available at: https://www.gov.uk/government/publications/sustainable-drainage-systems-non-statutory-technical-standards [Date Accessed: 29/07/2021].
[7] Flood and Water Management Act 2010 (2010). [Online]. https://www.legislation.gov.uk/ukpga/2010/29/introduction [Date Accessed: 29/07/2021].
[8] Ministry of Housing, Communities and Local Government (2021). [Online]. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 [Date Accessed: 29/07/2021].
[9] CIRIA, The SuDS Manual (2015). [Online]. Available at: [redacted] [Date Accessed: 29/07/2021].

2.2 Surrounding Hydrological Network

The DCO Site is within the Anglian River Basin District[10], Essex Combined Management Catchment[11] and the Chelmer Operational Catchment[12] and within the Boreham and Ter tributaries.

The DCO Site is not shown to be located within the operational boundary of an Internal Drainage Board (IDB)[13].

2.2.1 River Ter

The River Ter flows through the north of the DCO Site with an approximate length of 120 m between NGR TL 74677 15439 and TL 74762 15477 from south of Fuller Street Village and west of Sandy Wood as shown in Appendix B.

The River Ter is a Main River[14] with a total length of 31.3 km and drains a catchment area of 79.5 km².

The River Ter flows east from the north of the DCO Site towards Terling and then south to Hatfield Peveral approximately 1.2 km east of the DCO Site along this stretch of the watercourse.

A stretch of the River Ter immediately upstream and downstream of the DCO Site was assessed during the Arcus Site walkover[15] from public footpaths at NGR E 574846, N 215545 and E 574949, N 215641 respectively, as shown in Plate 1. The watercourse has a channel of approximately 3 m in width with various road crossings and bridges along the route, outside of the DCO Order Limits Boundary (OLB).

The land located between the DCO Site and the River Ter in the areas assessed comprises dense vegetation with a tree planting scheme, as shown in Plate 2.

[10] Environment Agency, Anglian River Basin District River Basin Management Plan (2015). [Online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718327/Anglian_RBD_Part_1_river_basin_management_plan.pdf [Date Accessed: 30/07/2021].
[11] DEFRA, Essex Combined Management Plan (2020). [Online]. Available at: [redacted] [Date Accessed: 30/07/2021].
[12] DEFRA, Chelmer Operational Catchment (2020). [Online]. Available at: [redacted] Date Accessed: 30/07/2021].
[13] Association of Drainage authorities, IDB Map. [Online]. Available at [redacted] [Accessed: 03/08/2021].
[14] Environment Agency, Main River Map. [Online]. Available at: [redacted] Date Accessed: 30/07/2021].
[15] Conducted July 2021.

Plate 1: River Ter to the North of the DCO Site (NGR E 574851, N 215547) (Facing North)

Plate 2: Vegetation and Planting Intercepting the DCO Site and River Ter (NGR E 574994, N 215585) (Facing East)

2.2.2 Boreham Tributary

The Boreham Tributary flows in a south easterly direction to the west of Waltham Road partly flowing through the DCO Site at Porters Grove to the south of the quarry ponds for a stretch of approximately 400 m.

The watercourse is culverted beneath the A12 and Roman Road approximately 600 m south of the DCO Site.

The watercourse discharges at a confluence with the River Chelmer north of Little Baddow village approximately 2 km south and 4 km downstream of the DCO Site.

2.2.3 Other Surface Water Bodies

There are various undesignated waterbodies within the DCO Site which comprise drainage channels and ponds, some of which are connected to the wider hydrological network associated with the River Ter and Boreham Tributary. These watercourses are identified in Appendix B.

There are various ponds across the DCO Site located within low lying areas and these are assessed to provide storage capacity through the flow of surface water flow towards low lying areas.

There is a collection of former gravel quarry pits approximately 250 m immediately west of the DCO Site adjacent to Witham Road.

An irrigation reservoir is located approximately 650 m north east of the DCO Site north of the River Ter.

2.3 Site Geology and Soils

Infiltration Testing has been carried out at the BESS Compound area by Rogers Geotechnical Services (RGS) in July 2021 to inform the design and layout of the solar farm, with the test pits logs indicating underlying geology comprises slightly sandy gravelly clay with some clay based gravel. The locations of the conducted test pits are shown in Table 1. Further detail on the ground investigation is detailed within Section 3.

Table 1: Infiltration Testing Summary (Taken from RGS Soakaway Letter Report)

Location	Soakage Area Dimensions (average (m)	Depths of Soaked Strata (m)	Soil Description	Infiltration Rate (m/sec)	Drainage Characteristics
TP01	2.1 x 0.35	0.5 – 1.6	Slightly sandy gravelly clay.	N/A.	Practically Impermeable
TP02	2.0 x 0.35	0.6 – 1.5	Slightly sandy gravelly clay.	N/A.	Practically Impermeable
TP03	1.9 x 0.35	0.9 – 1.5	Slightly sandy gravelly clay.	N/A.	Practically Impermeable
TP04	1.9 x 0.35	0.97 – 1.7	Slightly clayey slightly cobbly sandy gravel. Very sandy clay at base.	N/A.	Practically Impermeable
TP05	2.1 x 0.35	1 – 1.2	Slightly clayey slightly cobbly sandy gravel.	3.5×10^{-5}	Good
TP06	2.2 x 0.35	0.88 – 1.55	Slightly clayey slightly cobbly sandy gravel. Silty clay at base.	N/A.	Practically Impermeable
TP07	2.1 x 0.35	1.75 – 2.2	Slightly sandy slightly gravelly clayey silt.	N/A.	Practically Impermeable

British Geological Society (BGS) borehole records (TL71SE14[16], TL71SE130[17] and TL71SW3[18]) located throughout the DCO Site indicate that Boulder Clay, London Clay and Gravel Clay stratum is present to maximum depths of approximately 18 m below ground level (m bgl) with no groundwater identified within such records.

The Cranfield Soil and Agrifood Institute Soilscapes map[19] indicates soils at the DCO Site are categorised as 'freely draining slightly acid sandy soils', 'Slightly acid loamy and clayey soils with impeded drainage' and 'Lime-rich loamy and clayey soils with impeded drainage'.

[16] British Geological Survey, Borehole Records. [Online]. Available at: http://scans.bgs.ac.uk/sobi_scans/boreholes/549108/images/12156234.html [Accessed 30/07/2021].
[17] British Geological Survey, Borehole Records. [Online]. Available at: http://scans.bgs.ac.uk/sobi_scans/boreholes/549227/images/12156333.html [Accessed 30/07/2021].
[18] British Geological Survey, Borehole Records. [Online]. Available at: [redacted] [Accessed 30/07/2021].
[19] Cranfield Soil and Agrifood Institute, Soilscapes. [Online]. Available at [redacted] (Accessed 30/07/21)

2.4 Development Infrastructure

2.4.1 Solar PV Array Works Area

The Solar PV Array Works Area will consist of rows of solar panels composed of photovoltaic (PV) modules mounted on a metal frame and pile driven into the ground to limit the footprint of PV array units.

The panels would be mounted at approximately 0.6 m from the ground at the lowest point rising to up to no more than 3 m at the highest point.

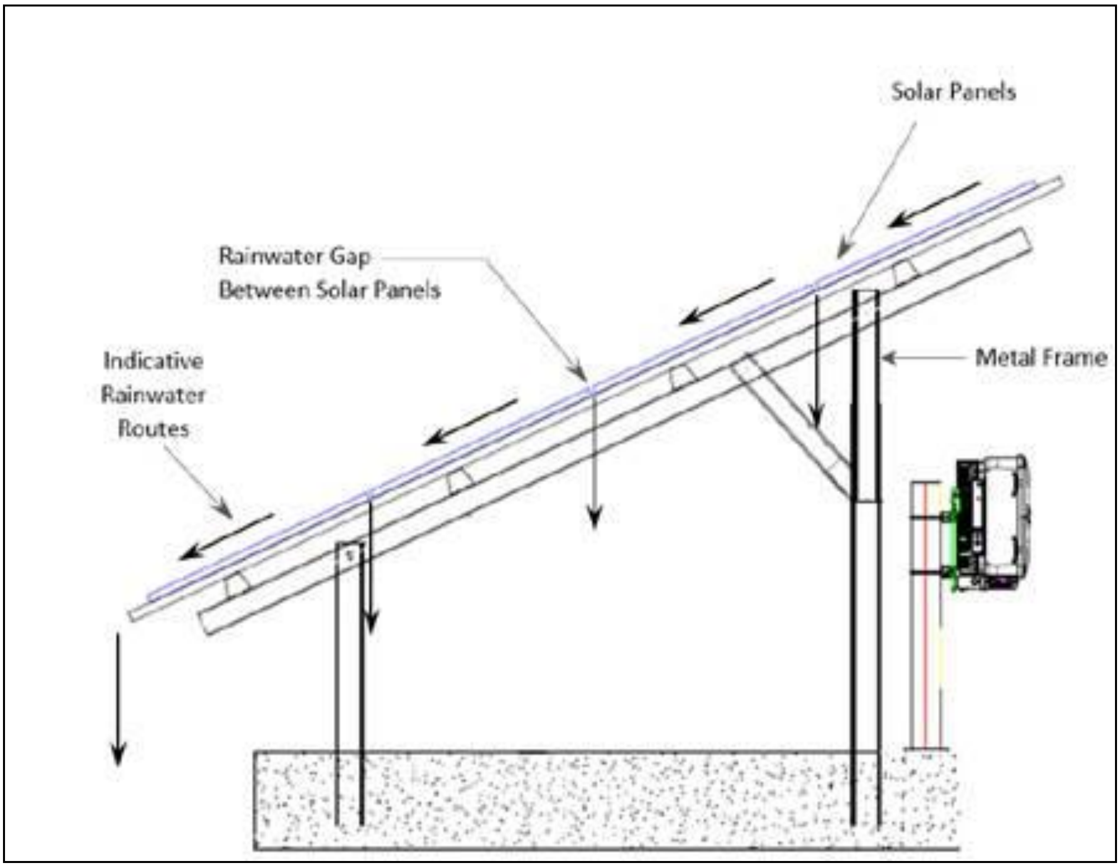
Installation of the PV arrays does not involve the introduction of hardstanding at ground level meaning the superficial cover for the Solar PV Array Works Area will remain the same as the baseline. Additionally, the PV array tables will have regular rainwater gaps to prevent water being concentrated along a single drip line, as shown in Plate 3.

As such, rainfall landing on the solar panels will drain through rainwater gaps and infiltrate into the ground beneath and between each row of panels, as shown in Plate 4.

Plate 3: Typical PV Drip Line / Rainwater Gap[20]

[20] Arkwright Solar Farm, Chesterfield - Arcus As-built drainage review

Plate 4: Typical PV racking system



The Longfield Solar Farm Transport Assessment [AECOM, Longfield Solar Farm Transport Assessment 2022] outlines that the existing hard-surfaced tracks which run throughout the Solar Farm Site will be utilised as the primary route where possible and additional secondary access tracks will be constructed where connectivity is required. Permeable crushed aggregate (e.g., Type 2 aggregate) will be used for any new access tracks, as shown in Plate 5.

The Site entrance will be surfaced with asphalt over a 20 m distance from the road. To minimise the runoff from the implemented surfacing a permeable asphalt surface is to be implemented with a suitable surface course, binder course, granular reservoir and a geotextile or geomembrane. Surface water within the asphalt extent will therefore percolate within the asphalt surface.

Plate 5: Typical Type 2 Aggregate Solar Farm Track[18]

The elements within the Solar PV Array Works Area which make up the impermeable footprint are therefore limited to the inverter, transformer and switchgear (Solar Station) units. Given the limited extent of the Solar Station units relative to the DCO Site any runoff from such units will percolate naturally within the surrounding grounds.

Further details of the measures to be implemented to manage surface water runoff in relation to the Solar PV Array Works Area are provided in Section 4 of this report.

2.4.2 BESS Compound Infrastructure

The proposed access track within the BESS Compound will comprise of permeable materials (e.g., Type 2 aggregate) and is therefore excluded from the total impermeable areas.

The BESS containers and transformers will be underlain by concrete bases, with design areas detailed in Table 2.

The total impermeable areas are shown for the BESS Compound in Table 2 with total impermeable areas of approximately 1.94 ha.

Table 2: BESS Compound Impermeable Areas

Hardstanding Infrastructure	Per Unit Area (m²)	Number of Units	Area of Hardstanding (m²)
BESS Concrete Bases	90	160	14,400
Units adjacent to BESS	30	22	660
BESS transformers concrete base	26.25	80	2100
BESS Substation Transformer Buildings	257	3	771
Office and welfare building	378	1	378
Square connection units to the west of substation	12	12	144

area			
400kv filter compound	901	1	901
Total Hardstanding (m²):			19,354
Total Hardstanding (ha):			1.94

2.4.3 Grid Connection Route

The Grid Connection Route comprises cabling spanning approximately 3 km from the west of PDA 19 along Cranham Road and Wheeler's Hill to connect the Solar Farm Site to the Bulls Lodge Substation.

Jointing pits will be installed at regular intervals along the Grid Connection Route to facilitate the installation and connection of cables beneath the existing roads within the route.

There is no identified highway drainage system along Cranham Road nor Wheeler's Hill, with surface water emanating from both roads assessed to release into the vegetated verges adjacent to the road. An unnamed watercourse flows adjacent to and beneath a section of Cranham Road, ultimately flowing to a small lake south of Waltham Road adjacent to Brent Hall. Along the section of the road where the watercourse flows there is the potential for runoff associated with Cranham Road to partly flow towards this watercourse via the adjacent vegetated verge.

2.5 Consultations

Arcus attended a design consultation meeting with ECC and Chelmsford City Council (CCC) dated 1st July 2021 to detail the proposed surface water management methodology for the Scheme.

As the Lead Local Flood Authority (LLFA) for the surrounding area, ECC responded to the proposed methodology during the consultation meeting.

ECC confirmed during such consultation that they agreed with the rationale provided by Arcus, as shown in Appendix D. The key points which Arcus detailed within such consultations which ECC agreed with are:

- Infiltration testing will be conducted at the BESS Compound to confirm whether the underlying strata is suitable for surface water disposal via infiltration;
- Attenuated discharge to on-site watercourses is the most feasible outlet solution and surface water will be discharged at the 1:1-year rate to the 1:100-year (+climate change) event;
- Installation of the PV arrays does not involve the introduction of hardstanding at ground level meaning the superficial cover in relation to the Solar PV Array Works Area will remain the same as the baseline; and
- Rural Sustainable Drainage Systems (RSuDS)[21] will be utilised to manage surface water runoff in relation to the Solar PV Array Works Area.

[21] Environment Agency, Rural Sustainable Drainage Systems (RSuDS) (2012). [Online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291508/scho0612buwh-e-e.pdf [Accessed 02/08/2021].

3 DRAINAGE DESIGN PARAMETERS

3.1 Greenfield Runoff Rates

Greenfield runoff rates have been calculated for the DCO Site using the Institute of Hydrology 124 (IH124) method[22] via Micro Drainage software with rates shown in Table 3 and Appendix E.

Greenfield runoff rates for the 1.94 ha of impermeable area have been calculated using the Interim Code of Practice for SuDS (ICP SuDS) method[23] via Micro Drainage Software with rates shown in Table 4 and Appendix F.

The DCO Site lies within Hydrological Region 6 of the UK.

Table 3: DCO Site Greenfield Runoff Flow Rates (taken from Micro Drainage)

Return Period	Q (l/s)
Q_{BAR}	516.7
1	439.2
30	1171
100	1648.3

Table 4: BESS Compound Area Greenfield Runoff Flow Rates (taken from Micro Drainage)

Return Period	Q (l/s)
Q_{BAR}	2.8
1	2.4
30	6.3
100	8.9

3.2 Development Runoff Rates

Following consultations with ECC any attenuated discharge rate will limit discharge to the 1:1-year rate in up the and including the 1:100-year (+climate change allowance) event in accordance with the ECC SuDS Guide.

3.3 Climate Change Allowances

The proposed drainage network will make allowances for climate change relative to Table 4 from DEFRA guidance on climate change[24] which has been recreated in Table 5.

Table 5: Climate Change Allowances

	Design Life 2015 - 2039	Design Life 2040-2069	Design Life 2070-2115
Upper End Projection	10 %	20 %	40 %
Central Projection	5 %	10 %	20 %

[22] Institute of Hydrology, Report No. 124 Flood Estimation for Small Catchments (1994). [Online]. Available at: [redacted] [Accessed 02/08/2021].
[23] National SuDS Working Group, Interim Code of Practice for Sustainable Drainage Systems (2004). [Online]. Available at: [redacted] [Accessed 02/08/2021].
[24] DEFRA, Climate Change Allowances (2020). [Online] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Accessed 02/08/2021].

The construction of the Scheme is anticipated to commence not earlier than 2024-2026 and will be operational not earlier than 2026, subject to gaining the required consents, and is anticipated to have a design life of 40 years, with decommissioning not earlier than 2066.

In accordance with the ECC SuDS Design Guide the Upper End Projection will be applied. Acknowledging the anticipated design life of 40 years a climate change allowance of 20% will be incorporated into drainage calculations (+20% CC).

Consultations with ECC[25] confirmed that as the design life will be less than 50 years the 20% climate change allowance is applicable.

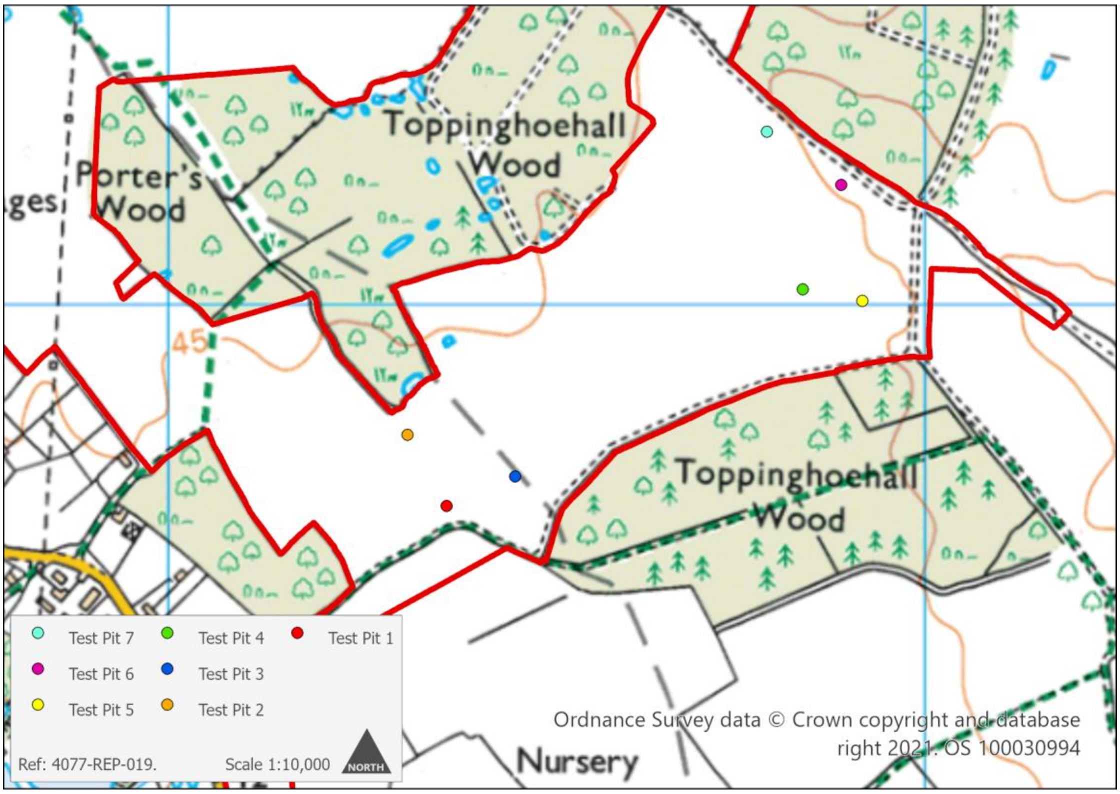
3.4 Infiltration Testing

Following consultation with ECC, infiltration testing to Building Research Establishment (BRE) Digest 365 standard[26] was carried out at the BESS Compound by RGS in July 2021.

To enable any potential soakaway to utilise the existing topography the surface water flow routing at the BESS Compound was derived from a 2D pluvial hydraulic model developed within Flood Modeller software. The 2D model utilises LiDAR data to 1 m resolution to confirm the low lying areas of the DCO Site, with the flow routes demonstrated in Appendix H.

To confirm the infiltration potential across the BESS Compound seven test pits were excavated in relation to the varying geological settings and topography. The locations of the test pits (TPs) are shown in Plate 6.

Plate 6: Infiltration Test Pit Locations



The soakaway tests within test pits TP01 to TP04, TP06 and TP07 the water level did not achieve a fall from 75% to 25% and a negligible water movement was observed. Due to

[25] Email communications between R. Duff (Arcus) to Z. Yousaf (ECC) dated July- August 2021.
[26] BRE, DG 365, Soakaway Design (20616). [Online]. Available at [redacted] [Accessed 02/08/2021].

the limited soakage rate the tests within such pits could not be conducted to BRE 365 standard and no soakage rate was calculated.

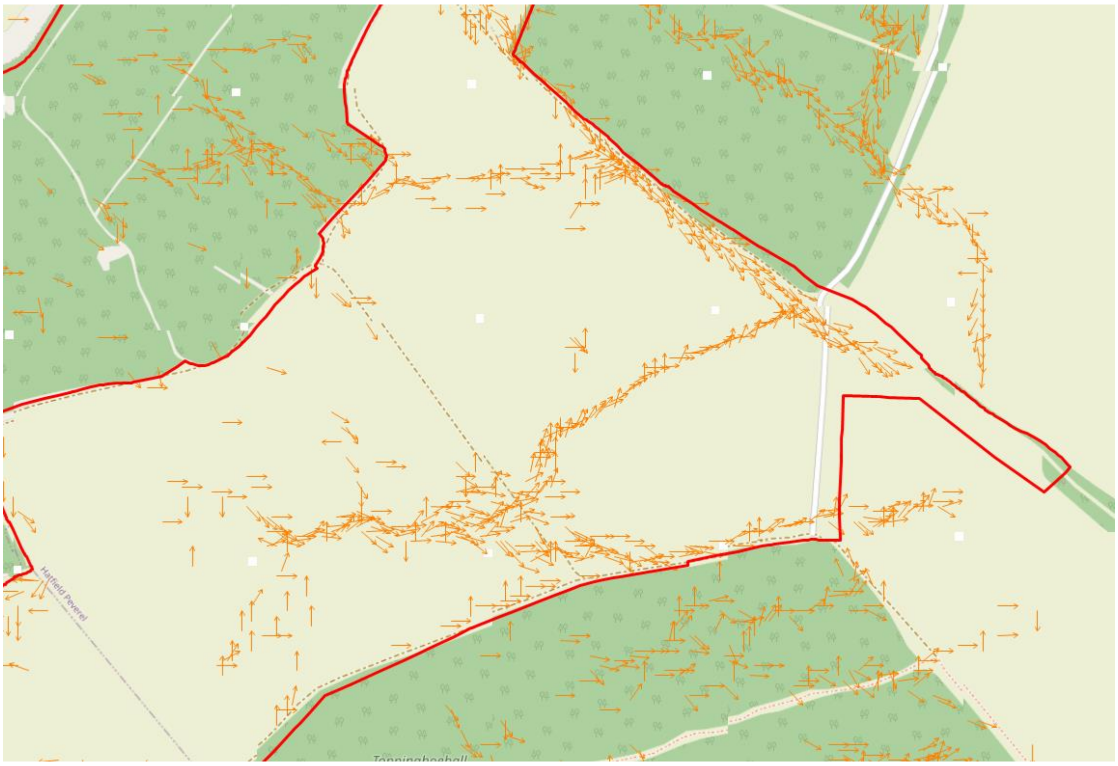
Water movement was observed within 2 of the 3 tests undertaken within TP05 in the south east of the BESS Compound area, with a calculated rate of 3.5 x 10^{-5} metres per second (m/s).

As only one test pit provided an active infiltration rate and only 2 out of the 3 tests within TP05 resulted in significant movement in water levels the infiltration capacity of the underlying strata is assessed to be poor.

The ECC SuDS Guide requires a minimum infiltration rate of less than $1x10^{-6}$ m/s should not be utilised in soakaway SuDS design. Whilst the rate obtained from TP05 was greater than the ECC required rate the remaining test pits failed and only 2 out of the 3 tests at TP05 provided an active infiltration rate. Furthermore, the RGS report states that the underlying strata is not suitable for soakaways.

The implementation of a hybrid infiltration and discharge solution utilising the strata at TP05 would be further limited by the existing topography and surface water flow routes. A 2D surface water model produced by Arcus demonstrates that surface water at the DCO Site flows east in accordance with topography and away from TP5 as shown in Plate 7. As such to utilise the underlying strata at TP05 a gravity based system would not be feasible and surface water would need to be pumped to and from the point of TP05 prior to release into the gravity system. As such the use of TP05 as part of a wider hybrid solution is deemed unfeasible.

Plate 7: Surface Water Flow Routes (Taken From Flood Modeller)



The ECC SuDS Guide states that rates lower than the $1x10^{-6}$ m/s can be utilised within a hybrid soakaway and discharge network. Given the majority of test pits did not provide a positive drainage rate and not all tests within TP05 resulted in substantial falls in water levels it is assessed that a hybrid solution is not feasible.

Therefore, no infiltration rate will be incorporated into the SuDS design. To maximise infiltration capacity throughout the DCO Site and BESS Compound any SuDS attenuation features will be unlined or utilise permeable lining wherever possible.

A summary of the infiltration testing results is shown in Table 1, with the infiltration testing report provided in Appendix G.

3.5 Hierarchical Drainage Options

In accordance with the SuDS Manual, the information within Table 6 outlines the most appropriate option to dispose of surface water from the BESS Compound along with the rationale.

Table 6: Disposal of Surface Water based on the SuDS Hierarchy

Disposal Route	Feasibility	Reason
Re-use on-site	×	Site will be unmanned with infrequent maintenance visits, therefore no demand for water re-use.
Infiltrate to ground	×	Infiltration testing at the BESS Compound indicates the underlying strata does not provide a significant infiltration rate.
Discharge to watercourse	✓	The network of open land drains is assessed as being appropriate outlet for surface water flows.
Discharge to surface water sewer	×	Surface water will be discharged to a nearby watercourse and therefore discharge to a surface water sewer is not required.
Discharge to combined sewer	×	Surface water will be discharged to a nearby watercourse and therefore discharge to a combined water sewer is not required.

As the BESS Compound cannot utilise infiltration, the proposed SuDS network will attenuate and discharge surface water runoff to a nearby watercourse as per the above drainage hierarchy.

Further details of the proposed drainage scheme are detailed in Section 3 of this DIA.

3.6 Proposed Drainage Network

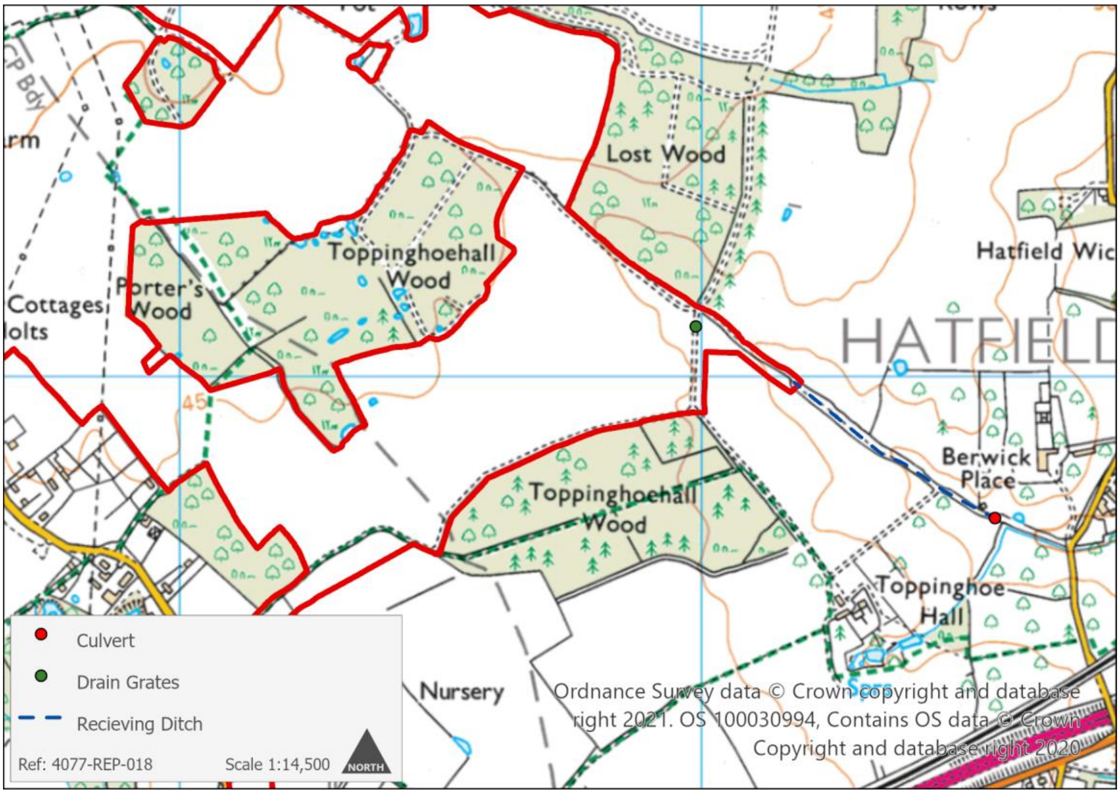
The BESS Compound will discharge surface water to the open land drain to the east, with the 2D pluvial hydraulic model indicating surface water currently flows towards the land drain as shown in Plate 7 and Appendix H. Therefore the discharge of surface water at the 1:1-year rate will discharge surface water to the land drain to the east as per the existing flow routes, with a reduction in discharge rates into the watercourse during events greater than the 1:1-year.

The designed SuDS network will therefore discharge surface water into the open land drain to the east. ECC have been consulted[27] to provide any comment on the proposed network, they outlined that the current grounds may discharge to multiple outfalls and this should be confirmed. As demonstrated in Plate 7 and Appendix H surface water currently flows to the drain to the east and therefore the proposed SuDS system will utilise existing flow routes, with no additional flow into the drain to the east.

The location of the receiving open land drain is shown in Plate 8.

[27] Email communications between R. Duff (Arcus) to Z. Yousaf (ECC) dated July- August 2021.

Plate 8: Open Land Drain Location and Characteristics



A 150 mm diameter clay pipe flows from the west of the BESS Compound towards the open land drain to the east. The exact location of the clay pipe is not confirmed; anecdotal evidence from the current landowner indicates the clay pipe from the location of the drain grates towards the receiving open land drain to the east.

During the Arcus Site walkover two cast iron storm drain grates were identified adjacent to the access track to the east of the BESS Compound location and are associated with the drain currently discharging into the open land drain to the east.

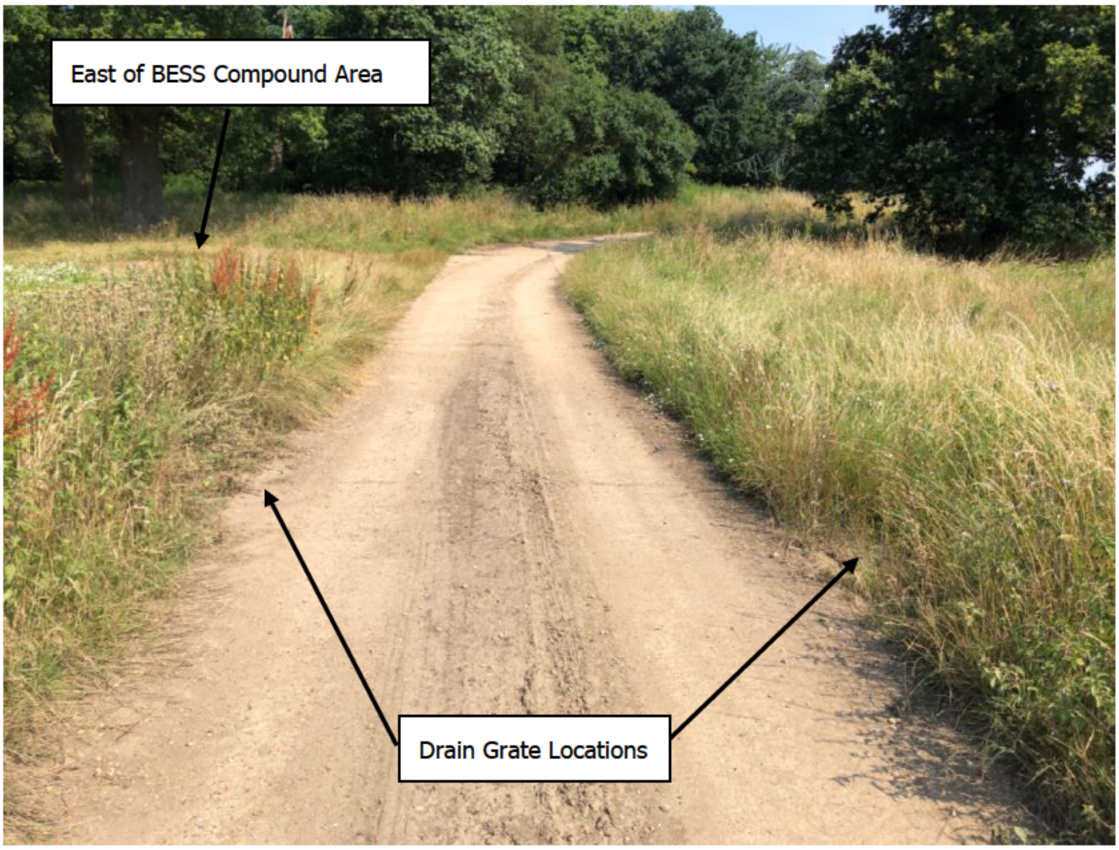
The two drain grates are located at a low point and anecdotal evidence from the farm operator at the DCO Site indicates that water does not collect in the area, indicating the existing system effectively discharges into the open land drain. The location of the grates is shown in Plate 8.

There is an existing c. 150 mm clay land drain which drains the field from the west and discharges into the receiving ditch to the east. If the existing drain has the appropriate capacity and design, it will either be utilised as it is, to discharge surface water, or replaced with a suitable pipe. Consultations with ECC[28] have confirmed that ECC Watercourse Consent[29] approval will not be required for any replacement of the field drain.

Images of the drain grates are shown in Plate 9.

[28] Email communications between R. Duff (Arcus) to Z. Yousaf (ECC) dated July- August 2021.
[29] Essex County Council, Watercourse Consent. [Online]. Available at: https://flood.essex.gov.uk/maintaining-or-changing-a-watercourse/apply-for-a-watercourse-consent/

Plate 9: Cast Iron Storm Drain Grates at the BESS Compound (NGR E 577001, N 212073) (Facing North)



The open land drain is not shown on OS mapping until a downstream culvert approximately 500 m south east of the BESS Development. The open land drain is then culverted further downstream beneath Terling Hall Road approximately 750 m south east from the BESS Development before ultimately discharging into the River Ter approximately 1.1 km south east from the BESS Development. The location of the culvert and surrounding hydrological network is shown in Plate 7.

During the Arcus Site walkover outlets from surrounding agricultural field drains were identified across the route of the open land drain as shown in Plate 10.

Plate 10: Outfall into Receiving Open Land Drain

Maximum water levels within the open land drain were approximately 100 mm during the Arcus Site walkover, with limited rainfall in the weeks prior to the assessment, as shown in Plate 11.

Plate 11: Surface Water Within the Open Land Drain

Along the route of the open land drain there are areas of in channel vegetation which may limit the flows along the route and a fallen tree was also found within the open land drain. Images of vegetation and the fallen tree along the route of the open land drain are shown in Plates 12 and 13 respectively.

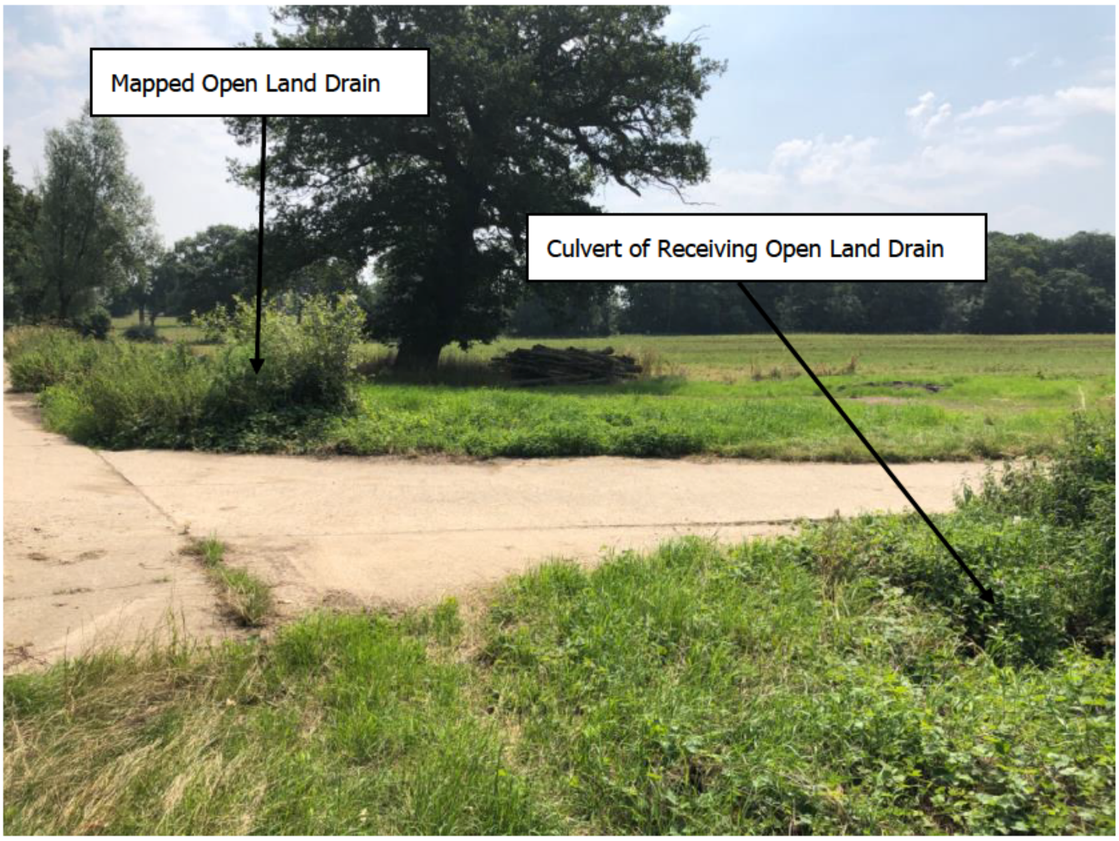
Plate 12: Vegetation within the Open Land Drain

Plate 13: Fallen Tree Within the Open Land Drain (Taken from bank)

The mapped open land drain downstream of the culvert was assessed during the Arcus Site walkover, with water levels of approximately 120 mm. Images of the culvert and downstream mapped open land drain are shown in Plates 14 and 15.

Plate 14: Culvert at Receiving Open Land Drain

Plate 15: Downstream Mapped Open Land Drain



The receiving ditch will be subject to a maintenance schedule up to the downstream culverting of the watercourse, with the culvert location outlined in Plate 6. The maintenance schedule will ensure that the ditch has the suitable conditions for surface water to flow within the ditch into the receiving hydrological network throughout the lifetime of the Scheme.

Consultations with ECC have indicated that the location of discharge from the system to the drain to the east may require Ordinary Watercourse Consent from ECC as the LLFA if there are alterations to the watercourse bank or a restriction is created. The outfall into the drain to the east will comprise a sub-surface pipe network which will discharge into the watercourse from within the confines of the existing bank. Therefore bank profiles and flows will not be altered or restricted. Should the design of the outfall change whereby the bank profile or flows within the watercourse are altered ECC will be consulted.

Surface water will be attenuated within a SuDS Pond to the east of the BESS Development and discharged to the identified open land drain at the 1:1-year rate. The pond will attenuate surface water without overtopping in up to and including the 1:100-year (+20%) event.

The outline surface water drainage schematic is shown in Appendix C and further details of the designed SuDS Network are provided in Section 4 of this report.

4 OUTLINE DRAINAGE STRATEGY

4.1 SuDS Measures

The measures outlined in the following Sections will be implemented by the Applicant's Contractor to ensure that greenfield runoff rates are maintained during the construction and operational phases of the Scheme. This section, combined with section 3 of the Bulls Lodge Extension: Drainage Strategy (AECOM, Bulls Lodge Extension Drainage Strategy 2021), is the 'outline drainage strategy' which forms part of a Requirement under the draft DCO. The Applicant's Contractor will adhere to the following guidance:

- DEFRA: Sustainable Drainage Systems - Non-statutory technical standards for sustainable drainage systems;
- The Construction Industry Research and Information Association (CIRIA), Environmental Good Practice on Site (C741)[30];
- CIRIA, The SuDS Manual; and
- CIRIA, Control of Water Pollution from Linear Construction Sites (C649)[31].

4.1.1 Solar PV Array Works Area PV Array Runoff

As detailed in Section 2.4 of this report, the installation of PV arrays will not lead to an increase in hardstanding and surface water runoff rates will remain the same as the baseline, with rainwater gaps within PV arrays limiting the potential of channelisation at the base of PV arrays.

Acknowledging the limited impermeable areas to be constructed, the Solar PV Array Works Area will comprise surface water management techniques to control runoff based on RSuDS. Such measures will manage surface water within the DCO Site through interception and absorption via natural mechanisms in order to drain the DCO Site as per the existing scenario.

4.1.2 Proposed RSuDS Measures

To limit possible channelisation from surface water from PV arrays and promote interception and infiltration potential throughout the Solar PV Array Works Area, the grounds surrounding and between the PV Arrays will be planted with native species rich grassland and wildflower mix which will act as dripline planting. This will allow surface water which falls from the drip line across the face of PV arrays to be intercepted by the vegetation and limit the potential of surface water to concentrate and run across the surface and into the surrounding hydrological network.

Examples of typical vegetated driplines are shown in Plate 16.

[30] CIRIA, Environmental Good Practice on Site C741 (2015). [Online]. Available at: [redacted] [Accessed 02/08/2021].
[31] CIRIA, Control of Water Pollution from Linear Construction Sites C649 (2006). [Online]. Available at: [redacted] [Accessed 02/08/2021].

***Plate 16: Managed Grassland and Native Seed Mix Surrounding PV Arrays*[32]**

Existing ground conditions at the DCO Site varies with areas identified to comprise bare ground associated with agricultural use during the Arcus Site walkover in July 2021, as shown in Plate 17.

Planting the ground with native species rich grassland and wildflower mix will provide additional friction relative to the existing conditions at the DCO Site, which currently have potential for surface water to flow with limited interception.

[32] Malmaynes Solar Farm – Arcus As-built drainage review

Plate 17: Existing Ground at the DCO Site (First Image NGR E 576371, N 211657 Looking North) (Second Image NGR E 575216, N 213350 Looking West)

To intercept extreme surface water runoff, which may already run offsite from the Solar PV Array Works Area perimeters, swales are proposed within low lying areas and parallel to the DCO Site's contours, with example perimeter swales shown in Plate 18. With the negligible increase in surface water runoff associated with the Solar PV Array Works Area, the proposed swales will provide additional surface water storage capacity relative to the baseline scenario and do not form part of the formal SuDS network.

To limit the potential flows of surface water within the proposed swales check dams will be implemented within the swales throughout the operational phase of the Scheme, limiting the potential of surface water to settle in low lying extents of the swales.

Plate 18: Example Perimeter Swale at a Solar Farm Site[33]

4.2 BESS Development

The surface water runoff associated with the BESS will be attenuated within the unbound free-draining subbase beneath the aggregate chippings and an attenuation pond which will discharge to the existing open land drain to the east through an excavated surface water pipe.

The unbound free drainage subbase implemented beneath the aggregate chippings will be utilised to attenuate surface water runoff associated with the BESS Development. The areas beneath the infrastructure and access roads have been discounted as providing attenuation volume.

Stone surfacing will comprise a minimum 300 mm deep unbound free-draining aggregate subbase and a minimum 75 mm top layer of stone chippings, which will allow storage of storm water prior to discharge to the attenuation pond. Areas of the subbase are detailed in Table 7.

[33] Bent Spur Solar Farm

Table 7: BESS Development Areas

Infrastructure	Area (ha)
BESS Development Area	6.86
Impermeable Areas	1.94
Access Tracks	1.27
Subbase Available for Attenuation	3.65

The subbase will be served by a network of drains which will migrate surface water to two outfalls located at topographic low points within the BESS area. The two outfalls are located at the location of existing surface water flow routes which will lead to the attenuation pond to the east, as shown in Appendix C. To account for the two main flow routes within the BESS Development the subbase area of 3.65 ha has been split into two areas of 1.825 ha within the drainage calculations.

Surface water flows will be limited to the 1:1-year rate of 2.4 l/s up to and including the 1:100-year (+20% CC) event in accordance with ECC consultations. In order to restrict surface water flows, a Hydro-Brake (or other flow restricting device) will be placed on the outfall of the pipes from the subbase and the attenuation pond to the receiving land drain. The design of the Hydro Brake has been conducted in Micro Drainage software and can be found in Appendix I.

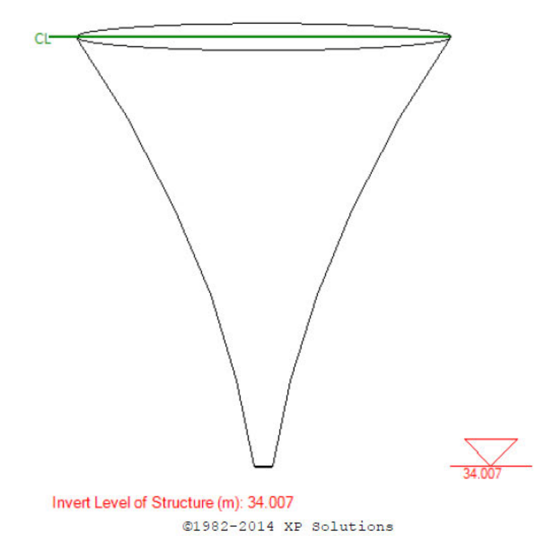
The attenuation pond has been designed in accordance with the SuDS Manual, with the design parameters as follows:

- Cover level: 35.007 m;
- Inlet pipe invert level: 34.157 m;
- Outlet pipe invert level: 34.007 m;
- Pond invert level: 34.007 m;
- Depth: 1 m;
- Slope: 1 in 4;
- Base area: 4 m^2; and
- Total area: 82.1 m^2.

To provide additional ecological benefits the attenuation pond will incorporate embankments of approximately 0.5 m in width at 0.2 m increments, with native planting to be implemented on the wider banks of the pond. A cross section of the pond is shown in Plate 19.

Plate 19: Attenuation Pond (Taken from Micro Drainage)

Arcus Consulting		Page 1
1C Swinegate Ct East 3 Swinegate York YO1 8AJ		Micro Drainage
Date 25/11/2021 11:37 File	Designed by reagand Checked by	
XP Solutions	Source Control 2014.1.1	



The impermeable areas served by the SuDS system have been attributed to the two pipes which the subbase is attributed to (1.001 and 2.001) with a total attributed impermeable area of 1.94 ha. The attributed impermeable areas are detailed in Plate 20.

The SuDS attenuation pond has been designed in the Source Control feature of Micro Drainage software, which has then been incorporated into a SuDS network within the Network feature of Micro Drainage.

The SuDS pond and pipe network have been designed with no additional storage capacity calculated within the pipe network in accordance with the ECC SuDS Guide.

Plate 20: Attributed Impermeable Areas (Taken from Micro Drainage)

Pipe Number	Rain (mm/hr)	TC (mins)	DS/IL (m)	Σ Imp. Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Pro. Vel (m/s)	Pro. Depth (mm)	Velocity (m/s)	Cap (l/s)	Flow (l/s)	Rain No.
1.000	50.00	5.02	36.543	0.000	0.0	0.0	0.0	0.00	0	1.01	7.9	0.0	1
1.001	50.00	5.18	34.307	0.970	0.0	0.0	0.0	3.71	150	3.70	261.6	131.4	1
2.000	50.00	5.02	38.633	0.000	0.0	0.0	0.0	0.00	0	1.01	7.9	0.0	1
2.001	50.00	5.32	37.690	0.970	0.0	0.0	0.0	2.41	216	2.16	152.4	131.4	1
2.002	50.00	6.38	37.380	0.970	0.0	0.0	0.0	1.12	311	1.01	160.4	131.4	1
2.003	50.00	6.72	34.157	0.970	0.0	0.0	0.0	3.21	137	4.05	643.5	131.4	1
1.002	50.00	7.64	33.887	1.940	0.0	0.0	0.0	1.21	430	1.08	306.3	262.7	1
1.003	50.00	8.12	33.825	1.940	0.0	0.0	0.0	1.21	431	1.08	306.0	262.7	1
1.004	50.00	8.79	33.360	1.940	0.0	0.0	0.0	1.89	296	1.90	536.6	262.7	1
1.005	50.00	8.97	32.110	1.940	0.0	0.0	0.0	3.33	194	4.06	1148.9	262.7	1
1.006	50.00	9.45	32.048	1.940	0.0	0.0	0.0	1.21	431	1.08	306.0	262.7	1

The Seasonal Return Period tool has been utilised within Micro Drainage software in order to define the 'worst-case' scenario event in up to a 1:100-year (+20% CC) event.

This indicates that during the critical event there is no surcharging within the proposed SuDS network in up to and including the 1:100-year (+20% CC) event, as shown in Appendix I.

The designed SuDS Network accommodates surface water flows with no out of system flooding in up to and including the 1:100-year (+20% CC) event, as shown in Appendix I.

A schematic drawing of the proposed BESS Development surface water layout and manhole scheduling is provided in Appendix C of this report.

4.2.1 Exceedance Events

The BESS Development will not alter existing ground levels and therefore, overland flow routes will not significantly vary from the baseline scenario.

During an exceedance event which exceeds the 1:100-year (+20% CC) event surface water flow routes will disperse as per the current scenario within the DCO Site.

The BESS Development will be unmanned and the DCO Site is located within an agricultural catchment with no residential or manned property on-site. Therefore, any exceedance will disperse within the DCO Site and catchment, with no risk to people or property.

4.2.2 Water Quality

The Scheme will not be occupied to a significant extent on a regular basis, with an anticipated maximum of 16 permeant onsite staff as such will not be heavily trafficked. As such there will be no significant discharge of contaminants emanating from the Development.

The Pollution Train tool within Micro Drainage software has been used to detail the potential treatment attributes of the proposed SuDS pond, with outputs shown in Plate 21. This indicates that the proposed SuDS pond has pollution removal capacity of 30 to 90 % for associated pollutants.

In accordance with the ECC SuDS Guide the Simple Index Approach (SIA) tool has been utilised to establish whether the proposed SuDS system provides suitable treatment potential. The outputs of the SIA tool indicate that the SuDS network has the required treatment potential in relation to the potential pollution hazard of the BESS Development. The outputs of the SIA tool are shown in Appendix J.

Plate 21: Pollution Treatment Potential Tool (Taken from Micro Drainage)

	% Pollution Removal											
	Total Suspended Solids		Hydrocarbons		Total Phosphorous		Total Nitrogen		Faecal Coli Forms		Heavy Metals	
Season	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Summer/Winter	75.0	90.0	30.0	60.0	30.0	50.0	30.0	50.0	50.0	70.0	50.0	80.0

4.2.3 Firewater Storage

Consultations with ECC Fire and Rescue (F&R) department have outlined that the BESS Development has a fire risk which must be assessed in relation to the potential contaminants within any fire suppressing water runoff.

Acknowledging the nature of the Scheme there will be an intent to contain any fire and allow it to burn out whilst keeping people at a safe distance, with fire water limited to cool surroundings to prevent spread.

The BESS units will be underlain by a concrete base and any immediate runoff from the infrastructure during a fire event which would require direct firefighting would then runoff the concrete base and be intercepted by the drainage system. The limited infiltration capacity of the underlying grounds confirmed via localised infiltration testing would prevent any potentially contaminated water from percolating into the underlying grounds.

Whilst the DCO Site is split across two hydrological catchments the BESS Development is limited to the River Ter catchment and therefore any runoff would be limited to a single catchment.

In the instance there is a small fire which can be directly contained there may be potential for contaminated runoff into the SuDS system. The suppressant of firewater by applying firewater to cool surrounding areas will be the intent of firefighting operations, with any direct firefighting to occur during small events requiring limited firewater.

During fire events whereby fires are to be managed onsite approximately 4,000 kilolitres of suppressant water will be released as per agreement with ECC F&R. Due to the potential contaminants within any firewater runoff a separation and storage mechanism will be required within the drainage system.

To enable any contaminants to be extracted from the system it is proposed that the drains will have the ability to be bunged and a penstock to be implemented at the downstream extremity of pipe 1.013 to isolate the network. The penstock will then enable potential contaminated suppression waters to be isolated and stored within a sub-surface attenuation tank prior to extraction in order to be suitably tested and disposed of offsite without entering the surrounding hydrological network.

The bung and penstock system is designed to intercept and isolate potentially contaminated runoff from the wider SuDS system for all fire events and thus prevent contaminated runoff entering the wider hydrological network.

To attenuate 4,000 kilolitres of firewater a sub-surface attenuation tank storage volume of 4,000 m³ will be required, with an outline design calculation for the storage tank shown in Plate 22.

Plate 22: Firewater Tank Volume Calculation

Estimation Pond Area / Volume Calculation (based on rectangular pond)

Base width	80	m	
Base length	50	m	
Ratio (L to W)	1		SuDS for Road 1.5:1 to 4:1, Sewers for Scotland Minimum 3:5
Side slope (1 in)	0		
Increment	0.1	m	

Depth	Area	Volume	Length	Width	
0	4000	0	50	80	Invert Level of Oriface In Outlet Chamber
0.1	4000	400	50	80	
0.2	4000	800	50	80	
0.3	4000	1200	50	80	
0.4	4000	1600	50	80	
0.5	4000	2000	50	80	
0.6	4000	2400	50	80	
0.7	4000	2800	50	80	
0.8	4000	3200	50	80	
0.9	4000	3600	50	80	
1	4000	4000	50	80	Permanent Water Level / IL of Outfall Pipe
1.1	4000	4400	50	80	
1.2	4000	4800	50	80	
1.3	4000	5200	50	80	
1.4	4000	5600	50	80	
1.5	4000	6000	50	80	
1.6	4000	6400	50	80	
1.7	4000	6800	50	80	
1.8	4000	7200	50	80	
1.9	4000	7600	50	80	
2	4000	8000	50	80	

The bung equipment required to manage suppression waters is to be covered further in the Emergency Response Plan and ancillary emergency equipment will be kept onsite (e.g., drain bungs, extra fire hose). The Emergency Response Plan will outline the emergency measures in place and the procedures implemented to mitigate potential impacts of the infrastructure on surrounding receptors during emergency situations. The Emergency Response Plan will be produced in accordance with principles agreed with ECC F&R with engagement and communication ongoing from an early stage in the concept stage and through to the design and construction phase.

Following a fire event, the drainage network will require an assessment to confirm the absence of any contaminants prior to the penstock being released. The designated Development operator will be responsible for conducting a controlled flushing of the drainage network prior to the release of the penstock and bung tools.

4.3 Ancillary Building

An Ancillary Building is located within the DCO Site which measures 540 m² and will comprise a warehouse building, office, kitchen and toilets. Runoff rates for the Ancillary Building are detailed in Table 8 as per the ICP SuDS method, with a Qbar rate of 0.1 l/s.

Table 8: Plant Building Greenfield Runoff Flow Rates (taken from Micro Drainage)

Return Period	Q (l/s)
Q_{BAR}	0.1
1	0.1
30	0.2
100	0.3

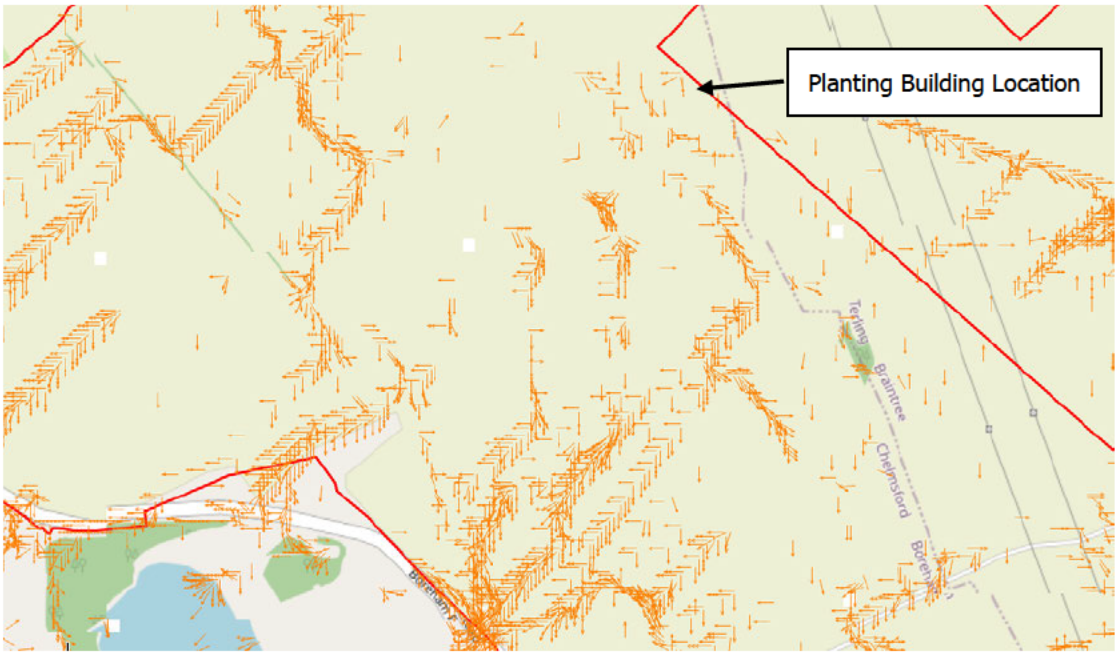
Infiltration testing indicates soils at the Site are not suitable for infiltration for all test pits, with only TP05 providing a calculated infiltration rate during 2 of the 3 tests at TP05. BGS geology mapping indicates superficial deposits at the location of the Ancillary Building is of the same formation as the test pits which provided no calculated infiltration rate (Brickearth – clay, silt and sand). The nearest BGS borehole scan[34] to the location of the Ancillary building indicates underlying strata comprises boulder clays and London clays to depths of approximately 13.7 m bgl; similar underlying strata to the failed test pit locations. As such it is assessed no infiltration rate would be obtained at the location of the Ancillary Building.

The Ancillary Building is not located with proximity of any watercourses identified through the Site walkover, OS mapping, aerial imagery or from the 2D surface water model produced by Arcus. Furthermore given the negligible runoff rates any attenuated discharge method would be restricted due to the likely blockage of flow control devices.

The 2D surface water model produced by Arcus indicates that surface water flows in a southerly direction from the location of the Ancillary Building and disperses within the wider DCO Site's surface water flows as shown in Plate 23.

[34] British Geological Survey Borehole Scans, BGS ID 549256. [Online]. Available at: [redacted]cessed 27/10/2021].

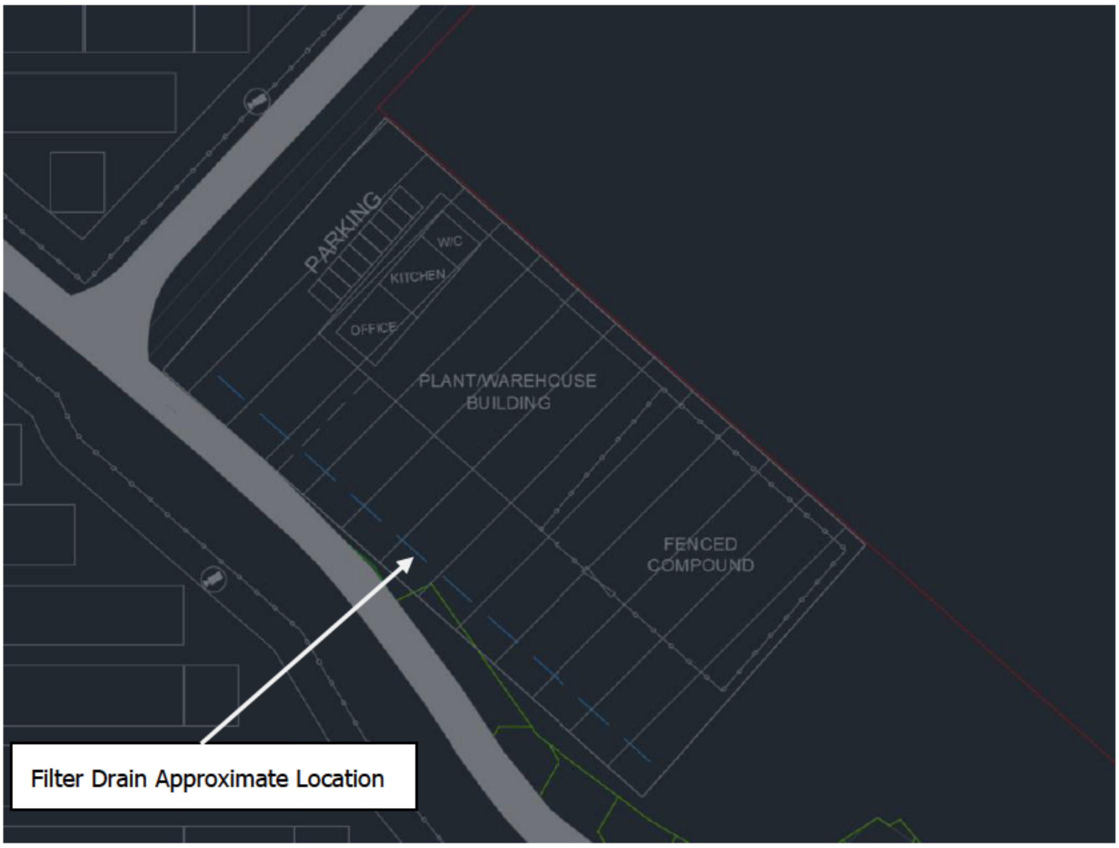
Plate 23: Surface Water Flow Routes



Given the limited footprint of the Ancillary Building and lack of surrounding hydrological network surface water runoff from the plant building will be intercepted by a shallow filter drain located between the building and the proposed access track, with an approximate location shown in Plate 24.

The filter drain will not utilise an active outfall and instead will intercept and store onsite surface water flows with no overtopping, preventing any increase in surface water runoff.

Plate 24: Outline Filter Drain Location



Due to the limited percolation capacity at the Site surface water will not disperse into soils to a significant rate. As such the implemented feature will be designed with no calculated outflow or discharge and will slowly percolate to the underlying strata as per the natural percolation of the soils. Acknowledging the lack of identified infiltration rate the proposed attenuation features have been designed with excess capacity in order to enable surface water to percolate without overtopping. The designed structure does not account for the potential percolation capacity and is therefore a conservative attenuation volume.

The filter drain unit has been designed to the following extents:

- Depth: 1 m;
- Width: 0.5 m; and
- Length: 90 m.

The filter drain unit has been designed to attenuate surface water flows for the 504 m² of impermeable areas associated with the Ancillary Building in up to and including the 1:100-year (+20% CC) climate change event, as shown in Plate 25 and Appendix I.

Plate 25: Filter Drain Source Critical Storm Outputs (Taken from Micro Drainage)

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m³)	Max Filtration (l/s)	Σ Max Outflow (l/s)	Maximum Volume (m³)	Status
10080 min Winter	0.827	10096	55.258	0.958	0.0	0.0	0.0	63.0	Flood Risk

The intercepting filter drain unit will not overtop during a 1:100-year (+20%) event but due to having no design outfall or infiltration rate there will be the potential for overtopping during successive extreme events. In such an eventuality there would be significant surface water depths at the surrounding Site and catchment. Surface water emanating from the filter drain would disperse as per existing flow routes within the wider Site and would flow away from the Ancillary Building.

4.4 Bull's Lodge Sub Station Development

The Bull's Lodge Substation comprises a hybrid soakaway and discharge system with surface water released into the Boreham Tributary to the south east of the Bull's Lodge substation.

The SuDS associated with the Bulls Lodge Substation Extension is being designed as a separate component to this SuDS Strategy and is detailed in a standalone document. This section 4 of this document and section 3 of the Bulls Lodge Substation Extension: Drainage Strategy form the 'outline drainage strategy' for the Scheme, which forms part of a Requirement under the DCO.

4.5 Grid Connection Route

Jointing pits will be installed at regular intervals along the Grid Connection Route to facilitate the installation and connection of cables beneath the existing roads within the route. As such the Grid Connection Route will not lead to an increase in hardstanding areas and surface water runoff rates for associated with the Grid Connection Route will not increase relative to the existing scenario.

Given there will be no increase in surface water runoff into the surrounding hydrological network associated with the Grid Connection Route no drainage based upon SuDS principles are deemed appropriate.

The excavation works associated with the Grid Connection Route works may result in sediment transfer during extreme rainfall events through surface water passing through excavated grounds. The implementation of construction phase drainage measures, as detailed in Section 4.7, will prevent the transfer of sediment into the surrounding hydrological network.

4.6 Construction Phase

The nature of hydrological incidents that could result from construction activities will be mitigated through the implementation of construction phase SuDS and the application of industry good practice as per CIRIA Guidance (C741)[35].

To prevent sediment increase in associated runoff during the construction of the Scheme, construction measures will effectively prevent sediment entering surrounding watercourses.

The implementation of such construction phase drainage is to be confirmed prior to the construction phase within the Construction Environmental Management Plan[36] and the Framework Construction Environmental Management Plan[37] and will be confirmed through the discharge of requirements submitted to the appropriate consenting authority.

4.7 Operation and Management of Drainage Infrastructure

It will be the responsibility of the Applicant to maintain effective drainage measures and rectify drainage measures that are not functioning adequately. A nominated person will also have responsibility for reporting on the functionality of drainage measures.

Where impermeable areas remain through the operational phase of the Scheme, the SuDS measures serving these areas will be checked on a regular basis. Should drainage measures require dredging or unblocking, this will be undertaken as soon as practicable by the Development operator or nominated personnel.

A maintenance schedule will be undertaken by the Applicant for the pond structures as outlined in Appendix K.

4.8 Timescales

Drainage measures outlined within this SuDS Strategy should be implemented as soon as practical by the Applicant's Contractor but in any event before the construction of any impermeable surfaces which are proposed to drain into the approved drainage system.

Measures such as drainage pipes should be installed at the same time as the excavations, or as soon as practicable thereafter.

4.9 Foul Water Drainage

During construction of the Scheme foul water will be disposed of via 'Port-a-loo' type facilities and disposed of via a licenced waste carrier.

During the operational phase there is capacity for permanent staff members to be located at the Site with office and welfare facilities within the Ancillary Building and Longfield substation. The welfare facilities at the plant building and BESS will comprise toilets and a kitchen with foul waters emanating from both facilities.

The Ancillary Building and Longfield substation are located approximately 550 m and 750 m from the nearest potential foul sewer, assumed to be on Waltham Road. Therefore connection to a foul sewer will not be feasible.

[35] The Construction Industry Research and Information Association (CIRIA), (2015), Environmental Good Practice on Site Guide (C741), CIRIA: London. [Accessed 02/08/2021].

[36] AECOM, Construction Environment Management Plan, Longfield Solar Farm (2022).

[37] AECOM, Framework Construction Environment Management Plan, Longfield Solar Farm (2021).

Foul water associated with the Ancillary Building and Longfield substation will therefore be stored via cesspits within the confines of the plant building and Longfield Substation welfare facility areas. The cesspits will be managed, inspected and drained by a licensed courier who will then dispose of the waste offsite. The cesspits will either meet the general binding rules for the operation of a cesspit[38] or the EA will be consulted to obtain a permit[39] for the operation of the cesspits.

[38] DEFRA, General Binding Rules for Small Sewage Discharges. [Online]. Available at: https://www.gov.uk/government/publications/small-sewage-discharges-in-england-general-binding-rules/general-binding-rules-for-small-sewage-discharges-in-england [Accessed 27/10/2021]
[39] Environment Agency, Septic Tanks and Treatment Plants: Apply for a Permit. [Online]. Available at: https://www.gov.uk/permits-you-need-for-septic-tanks/apply-for-a-permit [Accessed 27/10/2021]

5 CONCLUSION

This report demonstrates that the utilisation of the unbound free-draining subbase beneath the aggregate chippings and an attenuation pond with a flow restriction device will attenuate surface water associated with the BESS Development without surcharge and out of system flooding during the 1:30 (+20% CC) and 1:100 (+20% CC) year events respectively, as demonstrated by outputs from Micro Drainage.

Surface water runoff associated with the Ancillary Building will be intercepted by a filter drain which will attenuate and store flows in up to and including the 1:100-year (+20% CC) event without overtopping.

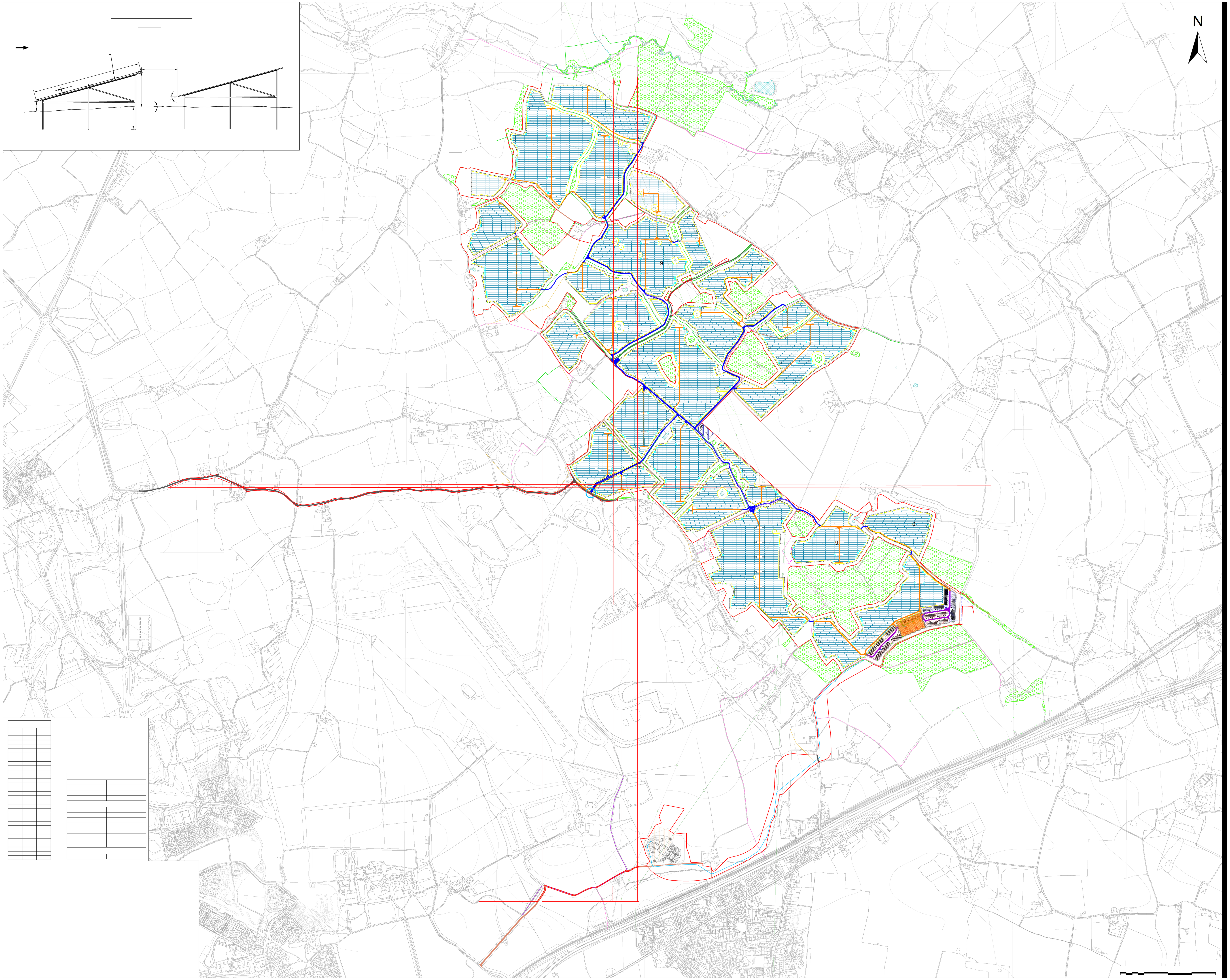
The surface water runoff associated with the Solar PV Array Works Area will be managed by RSuDS measures, including vegetation to limit channelisation and the implementation of perimeter swales across the DCO Site.

Following implementation of the proposed mitigation measures, the limited introduction of hard-standing associated with the Scheme will not lead to an increase in surface water runoff from the DCO Site above greenfield levels in up to and including the 1:100-year (+20 % CC) return period. The design of the Scheme has ensured that impermeable surfaces and hardstanding has been kept to a minimum.

For lower return periods, the implemented mitigation measures will act to reduce any effects of runoff from the DCO Site in the wider catchment relative to the greenfield levels and therefore provide a beneficial effect.

The ECC SuDS Water Quantity and Quality LLFA Technical Assessment Proforma has been completed and is in Appendix L of this report.

APPENDIX A – DCO SITE LAYOUT PLAN



AECOM

Longfield Solar Farm

ARCUS
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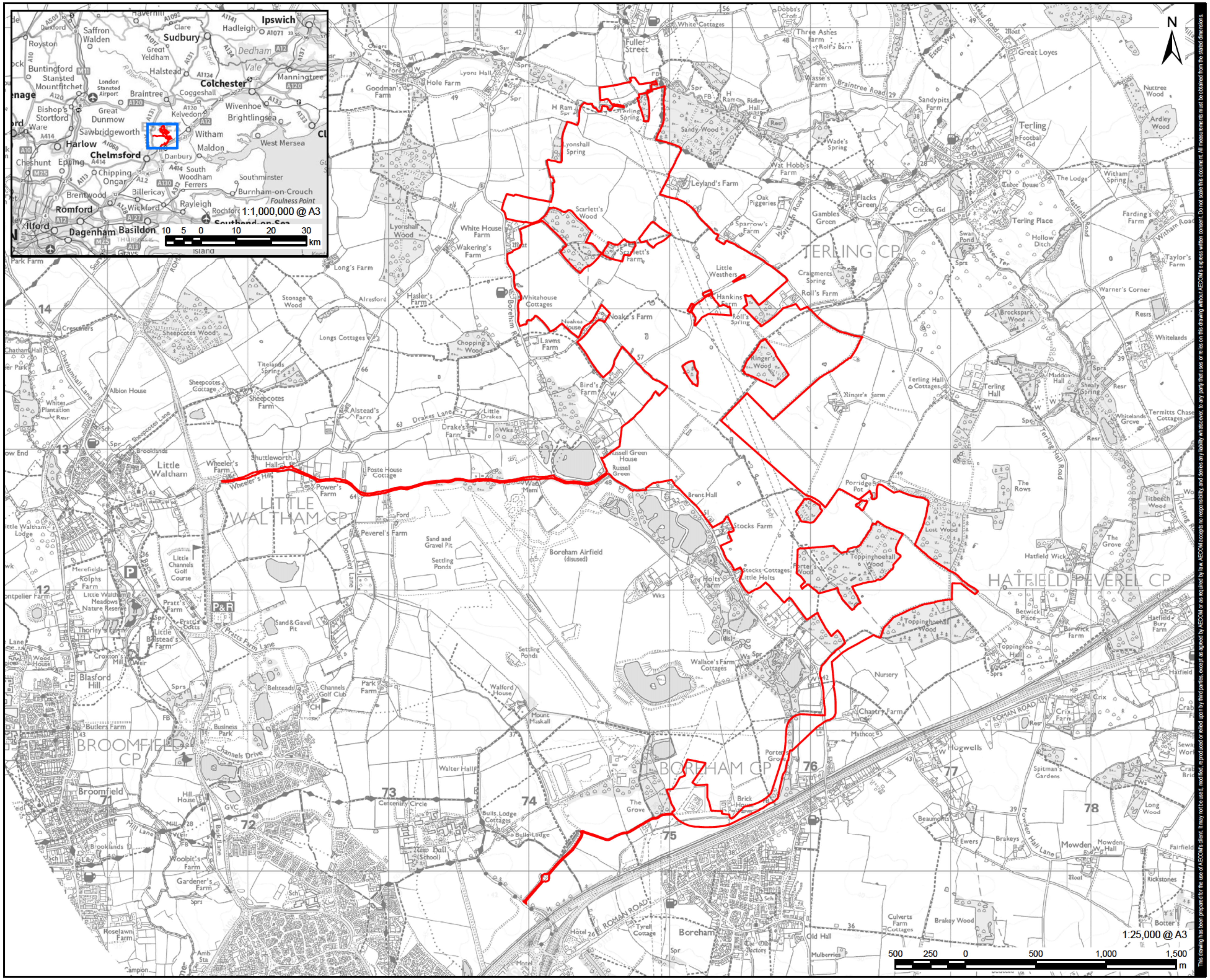
APPENDIX B – DCO SITE LOCATION PLAN



AECOM

PROJECT

60640215 - LONGFIELD SOLAR FARM

CLIENT

Longfield Solar Farm

CONSULTANT

AECOM Limited
3rd Floor Portwall Place,
Portwall Lane,
Bristol, BS1 6NA
www.aecom.com

LEGEND

Order Limits

NOTES

ISSUE PURPOSE

Environmental Statement
APFP Regulation: 5(2)(a)

PINS REFERENCE NUMBER

EN010118

FIGURE TITLE

Scheme Location

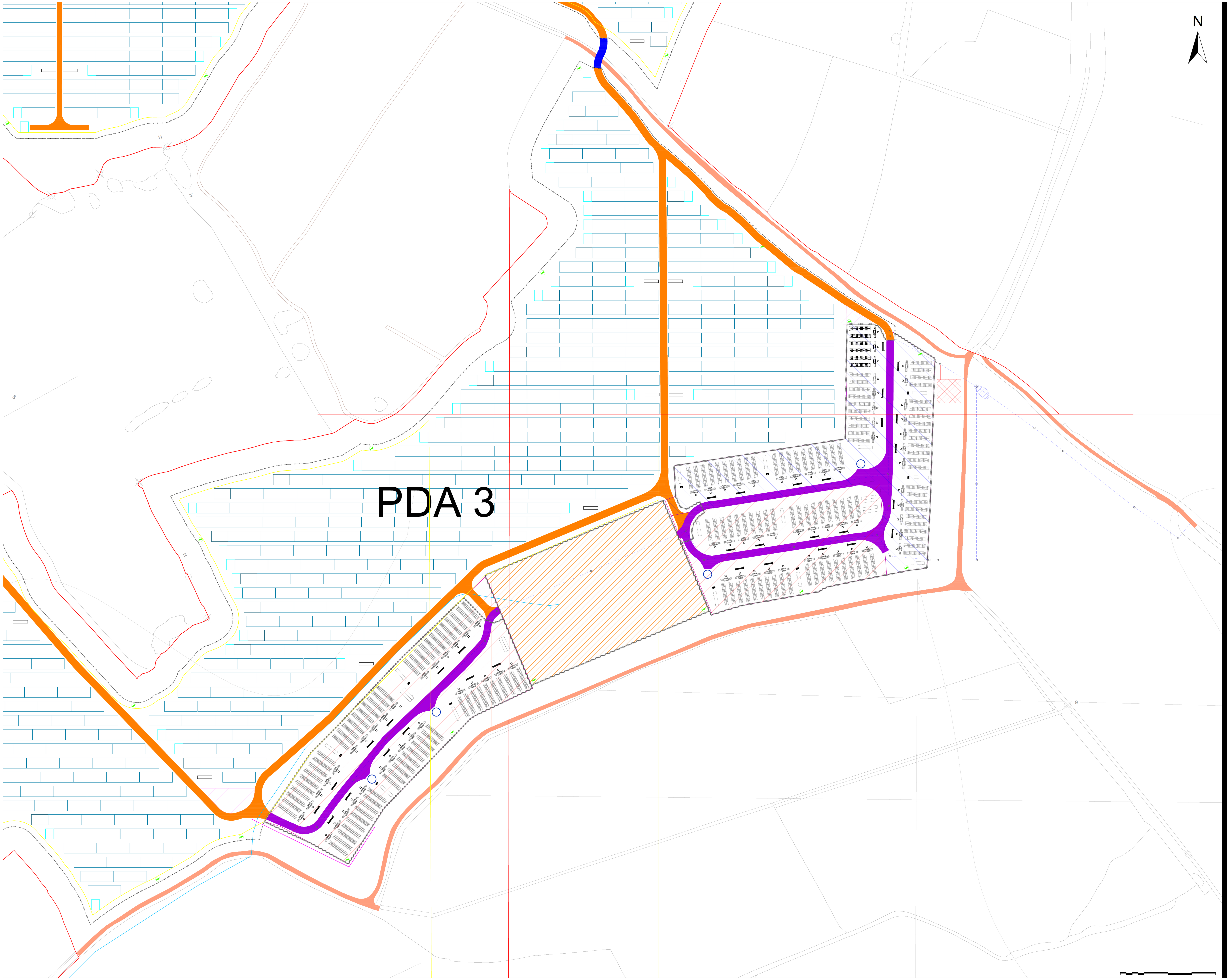
FIGURE NUMBER

Figure 1-1

Revision: 0 Drawn: DD Checked: BM Approved: PD Date: 2022-01-31

Filename: \\na.aecomnet.com\lfs\EMEA\Bristol-UKBRI\Legacy\UKBRI2FP001\VOL1BE\Projects\Environmental\General\GIS\Projects\Chelmsford\02_Maps\ES\GEN_ES_1_1_Scheme_Location.mxd

APPENDIX C – OUTLINE SURFACE WATER DRAINAGE LAYOUT



AECOM

Longfield Solar Farm

ARCUS
An ERM Group Company

APPENDIX D – ESSEX COUNTY COUNCIL CONSULTATION MEETING

DRAFT

Meeting name
Water and Drainage Meeting

Time
15:00

Project name
Longfield Solar Farm

Meeting date
01/07/21

Location
Microsoft Teams

Prepared by
Peta Donkin

Attendees
Rachel O'Donovan, Lead Planning Officer (RD)
Nicholas French, ECC, Project Manager (NF)
Zahida Yousaf, Senior Development and Flood Risk Officer ECC, (ZY)
Laura Percy, CCC, Lead Planning Officer (LP)
Gloria Osai, ECC Green Infrastructure Delivery Officer (GO)
Timothy Jones, AECOM, Water Lead (TJ)
Christopher Brandon, AECOM, Drainage Lead (CB)
Bill Gregory, AECOM, Longfield Planning Lead (BG)
Peta Donkin, AECOM, Longfield EIA Lead (PD)
Charlie Hadden, Arcus, Longfield Environmental Team (CH)
Liam Nevins, Arcus, Longfield Environmental Team (LN)
Reagan Duff, Arcus, Longfield Environmental Team (RDu)
James Pateman, Pershing Consultants, Longfield Project Manager, (JP)

Apologies
Tim Havers, BDC, Planning Lead

Circulation list
As per attendees and apologies

Ref	Note	Action
01	Welcome and introductions All attendees introduced themselves and their roles	
02	Safety Moment TJ ran through a safety moment regarding Japanese Knotweed on site, and the importance of recognising species such as this which are very invasive, but also species which can be harmful including Giant Hogweed, and Wild Parsnip. Good app called Picture This which helps identify what vegetation is. Some vegetation can cause skin irritation or burns.	
03	BG Introduced the Scheme design and boundary and provided overview of proposals and the DCO Scheme, plus programme to submission. BG identified that the Statutory Consultation phase is slightly removed from the ongoing meetings, and minutes will be taken and agreed. RD – areas that are work in progress from the Longfield side, when can the host authorities make comment on those issues that they can't comment on now? BG – we will take account of stat con comments, and once application submitted, there is a formal opportunity to respond further to the Local Impact Report. However keen to keep engagement going as we develop the final proposals. RD – Glint and Glare, Cumulative Impact – matters not included in the PEIR. BG, can we pick those up in another meeting and concentrate on Water and Drainage. RD agreed.	
04	Intro to the PEIR (TJ) • PEIR submitted. Water chapter and FRA was an appendix. • Tabled water features as a figure: River Ter (main River), WFD watercourse Boreham Tributary (ordinary WC and then Main River) requires two crossing points for cable route. • Within fields there are field drains, land drains and small tributaries of the Ter and Boreham Brook. • Numerous ponds across the site (one with GCN), and larger waterbodies to the west at the quarrying area. Essex Gravels waterbody.	

Ref	Note	Action

- WFD – sets out no deterioration or prevention of future improvement of these elements.
- Flood risk – gen in Flood Zone 1, low risk, small areas in 2 and 3 along riparian areas along River Ter and Boreham Brook.
- Surface water flooding very low risk, while small patches of low, medium and higher risk are mainly around ponds or topographic depressions.
- Sewer flood risk very low, no sewers found in proximity to compound areas.
- Groundwater risk is generally low across site, except for small section in east of site towards River Ter, south of Terling.
- Water Env baseline: River Ter very high importance for water quality, WFD designated, SSSI upstream, protected species in the watercourse (e.g. bullhead) and evidence of otter. Watercourse shows evidence of disconnection from the floodplain in places and is considered medium importance in terms of morphology.
- Boreham Trib – high importance for water quality, WFD designated, no evidence of protected species, agricultural pollution in water quality. Low importance for morphology as a straightened watercourse with an artificial planform in places.
- Tributaries show no protected species, and low importance
- One pond with GCN (Pond 5) and diversity of uncommon aquatic plants (pond 7) but generally in EIA terms have low importance.
- Groundwater, secondary B aquifers – medium importance but investigation data from EA of abstraction records to be confirmed.
- Construction impacts:

  Pollution of surface or groundwater due to deposition or spillage of soils, sediment, oils, fuels, or other construction chemicals, or through uncontrolled site run-off;

  Temporary impacts on sediment dynamics and hydromorphology within watercourses and waterbodies, where new crossings are required due to construction works to lay cables, or where culverting is required for new access tracks;

  Temporary changes in flood risk from changes in surface water runoff and exacerbation of localised flooding, due to deposition of silt, sediment in drains and ditches;

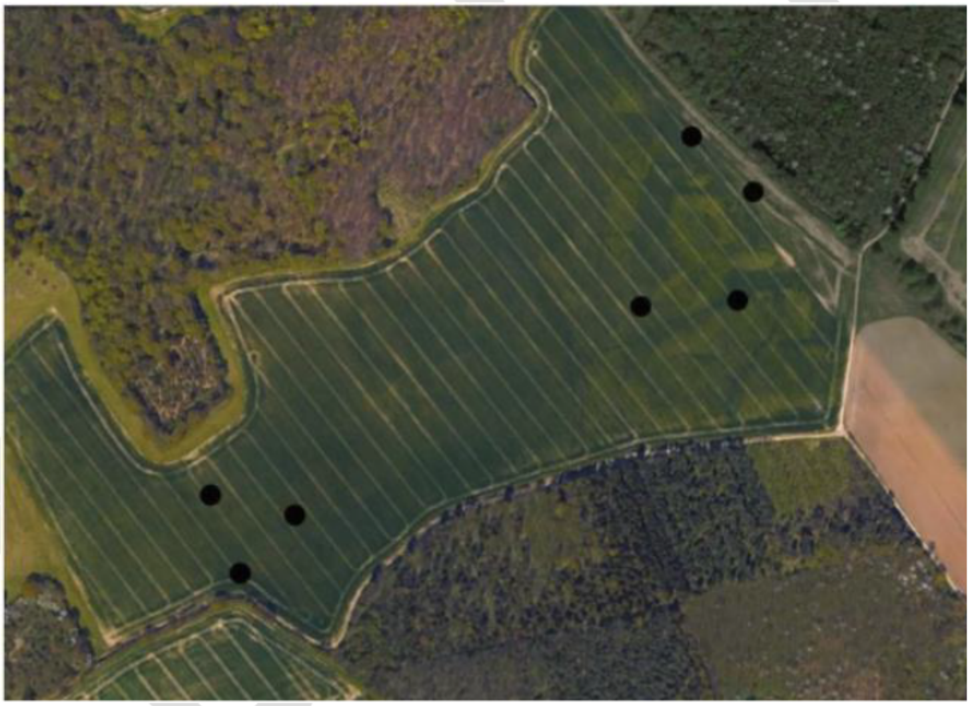
  Temporary changes in flood risk due to the construction of solar PV panels, site compound and storage facilities, which alter the surface water runoff from the DCO Site; and

- Potential impacts on local water supplies.

Ref	Note	Action
	Construction Stage Mitigation • Construction Environmental Management Plan – manage risk of pollution to surface water and groundwater, plus management of activities in floodplain areas. Framework CEMP provided within PEIR. • CEMP supported by Water Management Plan – greater detail on protection of water environment, including emergency response plan. • 132kV cable watercourse crossings (Boreham Tributary and unnamed ditches) to be minimum 1.5m below bed. Trenchless where possible. • Where open-cut required, water flow to be maintained by over-pumping, watercourses to be reinstated as found (with reference to pre-works morphological survey), water quality monitoring undertaken (pre, during and post). Once complete, initially use silt fences, geotextile matting or straw bales to capture mobilised sediment until settled. Monitoring post-works to check vegetation re-establishment. • Minimum buffer of 8m around watercourses and 5m around ponds is proposed. • For LLFA confirmation – land drainage consent requirements, e.g. for culverts, outfalls, open-cut trenching.	**ZY**
	• TJ asked if mitigation for cable crossings of ordinary watercourses was considered sufficient. ZY responded – would like to see land management strategy for the post construction phase, to ensure no land compaction which can lead to increased run off rates. PD noted that the Landscape and Ecological Management Plan should include this.	
	• TJ can we agree 8m around watercourses – ZY more than enough. ZY Will check 5m around ponds is sufficient.	**ZY**
	• TJ asked "where do we measure the buffer from? Top of bank? Waters edge? Would prefer to use the 'typical waters edge for normal flows, which should align with OS watercourse extents" – ZY to confirm	**ZY**
	• ZY – website link for watercourse consent for culverts etc for pre-application advice service (https://flood.essex.gov.uk/maintaining-or-changing-a-watercourse/guidance-on-applying-for-watercourse-consent/). BG will investigate whether this could be incorporated within the DCO itself.	**ZY / BG**
	Operational Stage • Impacts on water quality in affected waterbodies that may receive surface water runoff or be at risk of chemical spillages from supporting infrastructure for the Scheme (e.g. substations, battery stores, solar stations, local site offices and car parking etc.) and maintenance activities; • Potential for reduced chemical loading of watercourses associated with cessation of nitrate, pesticide, herbicide and insecticide applications on arable fields, or reduction in fine sediment/soil erosion, which would be beneficial • Impacts on flood risk from increased runoff from new impervious areas across the site; • Potential impacts on hydrology as a result of the Scheme by changing the way water infiltrates into the ground; and • Potential beneficial impacts on local waterbodies if it is confirmed that local abstractions are made (e.g. crop irrigation) and therefore need will reduce.	
	• Key operational stage mitigation:	
	• Drainage Strategy- further discussion from Arcus later in the meeting.	

Ref	Note	Action
	• Foul Drainage – low volume, and expected to be self-contained in independent non-mains domestic storage and/or treatment system. Unlikely to present any issues.	
	• Culvert Design ongoing, locations TBC but look to minimise river alignment changes and have sunken bed to allow natural substrate to develop. Explore opportunities for length-for-length watercourse enhancement where culverts are proposed – ZY will consult a colleague for feedback	**ZY**
	• Explore WC enhancements to provide benefits	
	• GO asked about soil cover – what species will protect against run off? PD responded with comment that mixes will be chosen to best respond to the soil types across the site. GO wanted reassurance that no herbicides or pesticides would be used.	
05	Drainage Strategy	

- RDu shared summary.
- BESS infiltration test pits location in low lying areas:



- Rolling ball analysis to confirm flow routes and inform location.
- Accordance with BRE Digest 365 Infiltration testing.
- PV arrays:

  - The PV arrays will be fitted with rainwater gaps along the face of panels to allow surface water to disperse evenly and prevent a concentration of surface water beneath the base of P\ arrays.
  - RSuDS measures will be utilised to manage surface water runoff associated with PV array units.

- Swales with check dams to be utilised for catchments/fields where required and dripline planting to be implemented to limit channelization. RSuDS measures to be applied for solar development rather than 'formal' SuDS. ZY in agreement with methodology for PV arrays.

Ref	Note	Action

	• BESS Infrastructure:
	  • Swales, ponds or soakaways will be utilised to manage surface water associated with the BESS development, with discharge via infiltration, attenuated discharge to a nearby watercourse/sewer or a hybrid of infiltration and attenuated discharge.
	• Bull's Lodge Substation Extension:
	  • Permeable material will be designed to the required capacity to provide storage and infiltratior for the substation infrastructure, utilising a similar approach to the existing substation (assuming a feasible infiltration rate is confirmed).
	  • Greenfield runoff rates to be calculated for each appropriate catchment throughout the site and SuDS measures to be designed in relation to the extent of the associated catchment.
	• ZY stated that more testing on site might be required at the Bull's Lodge extension for infiltration in a couple of places to confirm rates from earlier investigations – should be with reference to the greenfield runoff rate. Hybrid solution to be utilised if a lower infiltration rate is obtained.
	• Recommend calc discharge rate for whole site boundary, and ensure combined catchment runoff rates should not increase overall discharge rates relative to whole site boundary rate
	• RDu – Either 1:1-year rate used for all return periods up to the 1:100-year with climate change or a representative runoff rate for each relative return period to be used with long term storage.
	• ZY - Could use representative run off rate with long term storage to be applied – 1 in 1 yr run off accepted, and also accept long terms storage rate too. Proper calculations required for long term storage.
	• PV panels will not increase surface water runoff, as above. ZY had a concern over channelized flow, but this helps to allay those concerns. Would like to see veg between solar arrays to prevent erosion. Slow down surface run off and prevent soil erosions, check damns, suds etc. PD confirmed site to be left to vegetate between PV arrays.
	• RDu - Water quality – contaminants to be treated via SuDS (e.g. swales) and soakaways act as a treatment themselves. ZY stated that treatment efficiency should be determined against the SuDS Manual Simple Index Approach.However, soakways to be appropriately sized to handle the expected volumes of water, and several may be required across the site.
	• Firewater – if incident at BESS there will be cut off valves within isolated storage before entering SuDS systems and soakaways, enabling contaminated firewater to be isolated from the surface water drainage system. ZY confirmed the approach was acceptable.
	• ZY – Questioned whether a layout of the drainage system will be provided.
	• RDu - a schematic layout of the drainage system will be provided with the drainage report.
	• LN – The exact layout cannot be provided at this moment in time as infiltration testing will confirm the approach and thus drainage network designed.	

06	FRA (CB) • CB: Low risk of fluvial flooding and very low risk of surface water flooding. Wants to focus on fluvial risk areas, and groundwater risk. • Groundwater risk very low. Small area in east near to River Ter	**LP**

Ref	Note	Action
	• Summary of FRA: LP why are most recent maps not being used? Andy Bestrick (sp?) could make these available as they do exist	
	• Flood Zone 2 extent used as proxy for Flood Zone 3a including Climate Change. Confirmation required if this is sufficient to use as Flood Zone 3a extent including climate change, as recommended in SFRA? No development and all compatible with sequential and exception tests. Is the EA mapping acceptable? This extent includes both Main River and Ordinary watercourse.	**CB / ZY**
	• ZY what is extent of flooding, any in the flood compensation zone? Cables, substation etc all outside the flood zones. Not with current ,aping but will update with Chelmsford City Council flood mapping and reconfirm.	**CB / ZY**
	• ZY defer to EA on acceptability of the FRA for River Ter. On the Boreham Trib, would like agreement from EA and host Authorities as this is ordinary watercourse and also Main River	
07	AOB / questions	
	• Liam Nevins – applied for consent prior to determination for watercourse consent on other solar DCO which was acceptable.	**BG NOTE**

APPENDIX E – DCO SITE RURAL RUNOFF RATES

IH 124 Mean Annual Flood

Input

Return Period (years)	100	Soil	0.300
Area (ha)	454.000	Urban	0.000
SAAR (mm)	576	Region Number	Region 6

Results	**l/s**
QBAR Rural	516.7
QBAR Urban	516.7
Q100 years	1648.3
Q1 year	439.2
Q2 years	455.2
Q5 years	661.4
Q10 years	837.1
Q20 years	1035.1
Q25 years	1109.9
Q30 years	1171.0
Q50 years	1353.8
Q100 years	1648.3
Q200 years	1937.7
Q250 years	2030.7
Q1000 years	2666.2

APPENDIX F – BESS DEVELOPMENT AREA RURAL RUNOFF RATES

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.300
Area (ha)	1.940	Urban	0.000
SAAR (mm)	571	Region Number	Region 6

Results l/s

QBAR Rural	2.8
QBAR Urban	2.8
Q100 years	8.9
Q1 year	2.4
Q30 years	6.3
Q100 years	8.9

APPENDIX G – INFILTRATION TESTING REPORT

Environmental
Geotechnical
Specialists

RGS

SOAKAWAY LETTER REPORT

job number C1873/21/E/2900	date 28.07.2021

site address
Land Near Longfield
Boreham,
Chelmsford,
Cambridgeshire

written by C. Mason	checked by R. A. Palmer

issued by C. Mason

Rogers Geotechnical Services Ltd
Telephone 0843 50 666 87 Fax 0843 51 599 30
Email enquiries@rogersgeotech.co.uk
www.rogersgeotech.co.uk
Offices 1 & 2, Barncliffe Business Park, Near Bank, Shelley,
Huddersfield, West Yorkshire HD8 8LU.

GEOTECHNICAL
ENVIRONMENTAL

Environmental Geotechnical Specialists

Contents

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Environmental
Geotechnical
Specialists

Report on Soakaway Testing

Location:	**Land Near Longfield** Boreham, Chelmsford, Cambridgeshire		
For:	Arcus Consulting Engineers		
Consultants:	-		
Report No.	C1873/21/E/2900	Report Date:	July 2021

For and on behalf of **Rogers Geotechnical Services Ltd**

[redacted]

Geo-environmental Engineer	Senior Geo-environmental Engineer

Report Summary[1]

Item	Comments	Section
Geology	Superficial Geology – Lowestoft Formation (Glaciofluvial). Solid Geology – London Clay.	4.
Strata Conditions	TP01 – TP03: Slightly gravelly very sandy CLAY. TP04 – TP07: Clayey sandy GRAVEL with occasional cobbles. Both stratum types are anticipated to represent glaciofluvial superficial deposits.	5.
Groundwater	Not recorded.	5.
Suitability of Soakaways	Not recommended.	7.

[1] This summary should not be relied upon to provide a comprehensive review. All of the information contained in this document should be considered.

1. Introduction

We thank you for your request to undertake percolation testing at the above mentioned site and take pleasure in enclosing the results of this work. The investigation was undertaken on the 21st and 22nd July 2021 in accordance with your instruction to proceed. This reports describes the work undertaken, presents the data obtained and discusses the results of the tests

2. Limitations

The recommendations made and opinions expressed in this report are based on the ground conditions revealed by the site works, together with an assessment of the site. Whilst opinions may be expressed relating to sub-soil conditions in parts of the site not investigated, for example between trialpit positions, these are for guidance only and no liability can be accepted for their accuracy.

This report has been prepared in accordance with our understanding of current best practice. However, new information or legislation, or changes to best practice may necessitate revision of the report after the date of issue.

3. Fieldworks

A total of 7 trialpits were excavated in order to undertake soakaway testing, the positions of which are shown in Appendix 1 (as specified by the client). The soakaway tests were undertaken at the base of the pit at depths rational to the construction of soakaways. The soils exposed in the trialpits were logged on site in general accordance with BS5930: 2015 +A1: 2020, and full descriptions are given on the trialpit records which are presented in Appendix 2.

Once excavations were completed, the trialpits were carefully re-instated with the arisings. Whilst every care was taken during the infilling process, including compacting of the infill at regular intervals with the back acting arm of the excavator, it should be appreciated that some mounding of the surface may have resulted. Moreover, the infilled soils may be subjected to settlement over time, such that a depression in the surface may also occur. Therefore, the locations of any pits undertaken in this investigation should be conveyed to the current site user, as the mounds or depressions associated with the pits may present a risk to current site operations. Furthermore, it must be realised that the infilled pits represent an area of disturbance within the site soils, thus the soils at the pit locations may vary characteristically compared to the undisturbed ground. As such, this disturbed material may not perform as anticipated for any future development.

4. Geology

The available published geological data for the site has been examined and the following table presents the anticipated geology.

Table 1: Geological Data for the Site

Strata Type	Strata Name[2]	Previous Name[3]	Description[3]
Superficial Geology	Lowestoft Formation	-	The Lowestoft Formation forms an extensive sheet of chalky till, together with outwash sands and gravels, silts and clays. The till is characterised by its chalk and flint content. The carbonate content of the till matrix is about 30%, and tills within the underlying Happisburgh Formation have less than 20%
Solid Geology	London Clay Formation	-	The London Clay mainly comprises bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. It commonly contains thin courses of carbonate concretions ('cementstone nodules') and disseminated pyrite. It also includes a few thin beds of shells and fine sand partings or pockets of sand, which commonly increase towards the base and towards the top of the formation.

5. Strata Conditions

In accordance with the geology of the area, the succession has been shown to include the following:

Table 2: Generalised Strata Profile

Depth m below ground level to underside of layer	Strata Type	Positions Layer Revealed	Groundwater Strikes m below ground level
0.3 – 0.4	TOPSOIL	All	None
+1.5 - +1.7	Slightly gravelly very sandy CLAY.	TP01 – TP03	None
+1.4 - +2.2	Clayey slightly cobbly sandy GRAVEL	TP04 – TP07	None
+1.55 – +1.7	Stiff grey slightly gravelly very sandy CLAY.	TP04 & TP06	None

'+' denotes that the strata extended below the termination depth of the investigated positions, thus the extent of the deposit is only proven to the depths indicated.

This investigation has revealed that the site is capped with topsoil, ranging in thickness between 0.3m and 0.4m. Beneath the topsoil within the south-western quadrant of the site (TP01 – TP03), superficial soils predominantly comprising slightly gravelly silty clay were recorded to the base of all pits. Within the north-eastern quadrant of the site (TP04 – TP07) granular soils predominantly comprising clayey

[2] Sources: British Geological Survey (NERC) Map Sheets 241; Chelmsford; Solid and Drift Edition, and Geology of Britain Viewer [*online resource from www.bgs.ac.uk*]
[3] Sources: British Geological Survey (NERC) Lexicon of Named Rock Units [*online resource from www.bgs.ac.uk*]

slightly cobbly sandy gravel were encountered. At the base of TP04 and TP06 a clay horizon was recorded. These deposits are anticipated to represent superficial soils.

It should be be noted that clay pipes, anticipated to be associated with land drainage were encountered at ~0.8m depth within TP02 and TP07.

6. Insitu Testing

6.1 Soakaway Test

On reaching the elected soakaway test depth, the pit was trimmed and squared as much as practicable. Water was then introduced into the pit at a controlled rate to prevent collapse of the sides and the level monitored at time intervals relative to a reference bar at ground level. The results obtained from the soakaway tests are presented at Appendix 3 and are summarised below:

Table 3: Soakaway Test Results

Location	Soakage Area Dimensions (average) (m)	Depths of soaked strata (m)	Soil Description (of soaked strata)	Infiltration Rate (m/sec)	*Drainage Characteristics
TP01	2.1 x 0.35	0.50 – 1.60	Slightly sandy gravelly CLAY	-	Practically impermeable
TP02	2.0 x 0.35	0.60 – 1.50	Slightly sandy gravelly CLAY	-	Practically impermeable
TP03	1.9 x 0.35	0.90 – 1.50	Slightly sandy gravelly CLAY	-	Practically impermeable
TP04	1.9 x 0.35	0.97 – 1.70	Slightly clayey slightly cobbly sandy GRAVEL Very sandy CLAY at base.	-	Practically impermeable
TP05	2.1 x 0.35	1.00 – 1.20	Slightly clayey slightly cobbly sandy GRAVEL	3.5×10^{-5}	Good
TP06	2.2 x 0.35	0.88 – 1.55	Slightly clayey slightly cobbly sandy GRAVEL silty CLAY at base	-	Practically impermeable
TP07	2.1 x 0.35	1.75 – 2.20	Slightly sandy slightly gravelly clayey SILT	-	Practically impermeable

*Based on the most onerous results for each test.

During the soakaway tests within pits TP01 to TP04, TP06 and TP7, the water level did not achieve a fall from 75% to 25% of the effective depth of the storage volume in both trialpits. In all tests (with the expection of TP05) negligible water movement was observed. On this basis, the tests could not be completed within the scope of the method provided in BRE Digest 365 due to the poor soakage rate of the exposed soils. Due to the negligible water movement it was not possbile to extrapolate the results obtained in order to obtain a soil infiltration rate.

It should be noted, however, that water movement was observed within 2 of the 3 tests undertaken within TP05, such that an infiltration rate could be obtained. It is not clear the reasonaning as to why water infiltration was good at this location as the ground conditions appeared to be relatively comparable to those elsewhere on site.

7. Discussion

The soils encountered beneath the made ground were found to be typical of superficial glaciofluvial soils. The strata conditions and subsequent drainage characteristics appear to largely be comparable in each quadrant of the site. In this instance, the infiltration testing has revealed that the soils generally have poor drainage characteristics. Therefore, soakaways cannot be recommended at this site and an alternative form of drainage should be adopted.

8. References

- Building Research Establishment (BRE) Digest 365, *Soakaway Design*, September 1991.
- British Standards Institution (2015 +A1: 2020) BS 5930: *Code of practice for ground investigations*, B.S.I., London.
- Barnes, G. (2000). *Soil Mechanics Principle and Practice.* 2nd ed. London: Macmillan Press Ltd, p.47.

Appendix 1

Site Plan

Appendix 2

Trialpit Records

Appendix 3

Soakaway Results

ARCUS

- Test Pit 7
- Test Pit 6
- Test Pit 5
- Test Pit 4
- Test Pit 3
- Test Pit 2
- Test Pit 1
- Site Boundary

1:4,000 Scale @ A3

0 0.07 0.15 km

NORTH

Produced By: RD	Ref: 4077-PUB-022.
Checked By:	Date: 06/07/2021

Infiltration Test Pits

Longfield Solar

Appendix 2

Trialpit Records

Trial Pit Log

Trialpit No	**TP01**	Sheet 1 of 1

Project Name: Longfield, Chelmsford.	Project No. C1873/21/E/2900	Co-ords: 576375.95 - 211734.37 Level:	Date 21/07/2021
Location: Longfield, Boreham, Chelmsford, Cambridgeshire		Dimensions (m): 2.1 x 0.35 Depth 1.60	Scale 1:50
Client: Arcus Consultancy Services Ltd			Logged CRC

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			TOPSOIL (dark brown slightly sandy slightly gravelly silty CLAY with frequent rootlets).
				1.60			Very stiff orangish brown mottled dark grey slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular to subrounded of chert, quartzite and chalk.

End of pit at 1.60 m

Depth scale: 1 2 3 4 5 6 7 8 9 10

Remarks: No groundwater encountered. Grid references are approximate only.

Stability: Stable.

Trial Pit Log

Trialpit No	TP02
Sheet	1 of 1
Project Name:	Longfield, Chelmsford.
Project No.	C1873/21/E/2900
Co-ords:	576307.06 - 211839.56
Level:	
Date	21/07/2021
Location:	Longfield, Boreham, Chelmsford, Cambridgeshire
Dimensions (m):	2 x 0.35
Depth	1.50
Scale	1:50
Client:	Arcus Consultancy Services Ltd
Logged	CRC

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			TOPSOIL (dark brown slightly sandy slightly gravelly silty CLAY with frequent rootlets).
				1.50			Stiff orangish brown mottled dark grey slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular to subrounded of chert, quartzite and chalk. Locally sandy. Noted to be friable.
							End of pit at 1.50 m

Depth scale: 1 2 3 4 5 6 7 8 9 10

Remarks: No groundwater encountered. Grid references are approximate only.

Stability: Stable.

Trial Pit Log

Trialpit No	TP03
Sheet	1 of 1
Project Name:	Longfield, Chelmsford.
Project No.	C1873/21/E/2900
Co-ords:	576462.74 - 211761.07
Level:	
Date	21/07/2021
Location:	Longfield, Boreham, Chelmsford, Cambridgeshire
Dimensions (m):	1.9 x 0.35
Depth	1.50
Scale	1:50
Client:	Arcus Consultancy Services Ltd
Logged	CRC

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			TOPSOIL (dark brown slightly sandy slightly gravelly silty CLAY with frequent rootlets).
				1.40			Firm orangish brown slightly sandy silty CLAY. Sand is fine. Noted to be friable.
				1.50			Stiff dark grey mottled orangish brown slightly sandy gravelly CLAY. Sand is fine. Gravel is fine to coarse rounded to subangular of chalk, chert and quartzite.

End of pit at 1.50 m

Remarks: No groundwater encountered. Clay pipe land drain encountered at 0.8m depth. Grid references are approximate only.

Stability: Stable.

Trial Pit Log

Project Name: Longfield, Chelmsford.	Project No. C1873/21/E/2900	Co-ords: 576837.99 - 212013.39 Level:	Trialpit No **TP04** Sheet 1 of 1 Date 21/07/2021
Location: Longfield, Boreham, Chelmsford, Cambridgeshire		Dimensions (m): 1.9 × 0.35 Depth 1.70	Scale 1:50
Client: Arcus Consultancy Services Ltd			Logged CRC

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			TOPSOIL (dark brown slightly sandy gravelly CLAY with frequent rootlets. Sand is fine. Gravel is fine to coarse rounded quartzite).
				1.60			Brown slightly clayey slightly cobbly sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse rounded to subangular of quartzite and chert. Cobbles are subangular of chert.
				1.70			Stiff grey slightly gravelly very sandy CLAY. Sand is fine to coarse. Gravel is fine rounded of chalk.
							End of pit at 1.70 m

Depth scale (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Remarks: No groundwater encountered. Grid references are approximate only.

Stability: Stable.

Trial Pit Log

Trialpit No	**TP05**
	Sheet 1 of 1

Project Name: Longfield, Chelmsford.	Project No. C1873/21/E/2900	Co-ords: 576931.40 - 211986.53 Level:	Date 20/07/2021
Location: Longfield, Boreham, Chelmsford, Cambridgeshire		Dimensions (m): 2.1 × 0.35 Depth 1.60	Scale 1:50
Client: Arcus Consultancy Services Ltd			Logged CRC

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			TOPSOIL (dark brown slightly sandy gravelly CLAY with frequent rootlets. Sand is fine. Gravel is fine to coarse rounded quartzite. One cobble sized wood fragment observed).
				1.60			Brown slightly clayey slightly cobbly sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse rounded to subangular of quartzite and chert. Cobbles are subangular of chert. *... becomes orangish brown at 0.9m depth.* *... contains rare clay pockets below 1.4m depth.*
							End of pit at 1.60 m

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Remarks: No groundwater encountered. Grid references are approximate only.

Stability: Stable.

Trial Pit Log

Trialpit No	TP06
Sheet	1 of 1

Project Name:	Longfield, Chelmsford.	Project No. C1873/21/E/2900	Co-ords: 576894.51 - 212159.05 Level:
Date	20/07/2021		
Location:	Longfield, Boreham, Chelmsford, Cambridgeshire	Dimensions (m): 2.2 x 0.35 Depth 1.55	Scale 1:50
Client:	Arcus Consultancy Services Ltd		Logged CRC

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							TOPSOIL (brown slightly sandy silty CLAY with frequent rootlets. Sand is fine).
				0.40			Orangish brown and grey slightly sandy slightly cobbly clayey GRAVEL. Sand is fine to coarse. Gravel is fine to coarse rounded to subangular of quartzite, chert and rare chalk. Cobbles are rounded to subangular of chert and quartzite. Contains rare pockets of clay. Noted to be wet.
				1.20			Stiff grey and brown silty CLAY.
				1.55			End of pit at 1 55 m

Depth scale: 1 2 3 4 5 6 7 8 9 10

Remarks: No groundwater encountered. Grid references are approximate only.

Stability: Slightly unstable to 1.2m during excavation. Unstable on addition of water for infiltration testing.

Trial Pit Log

Trialpit No	**TP07**
Sheet	1 of 1
Project Name:	Longfield, Chelmsford.
Project No.	C1873/21/E/2900
Co-ords:	576797.12 - 212231.89
Level:	
Date	20/07/2021
Location:	Longfield, Boreham, Chelmsford, Cambridgeshire
Dimensions (m):	2.1 x 0.35
Depth	2.20
Scale	1:50
Client:	Arcus Consultancy Services Ltd
Logged	CRC

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			TOPSOIL (brown slightly sandy silty CLAY with frequent rootlets. Sand is fine).
				2.20			Soft to firm orangish brown slightly sandy slightly gravelly clayey SILT. Sand is fine. Gravel is fine to coarse rounded to subangular of chalk, chert and quartzite. Friable to 0.8m depth. ... *gravelly band between 1.7m and 2.0m.*
							End of pit at 2.20 m

Remarks: No groundwater encountered. Clay pipe land drain encountered at 0.8m depth. Grid references are approximate only.

Stability: Stable.

Appendix 3

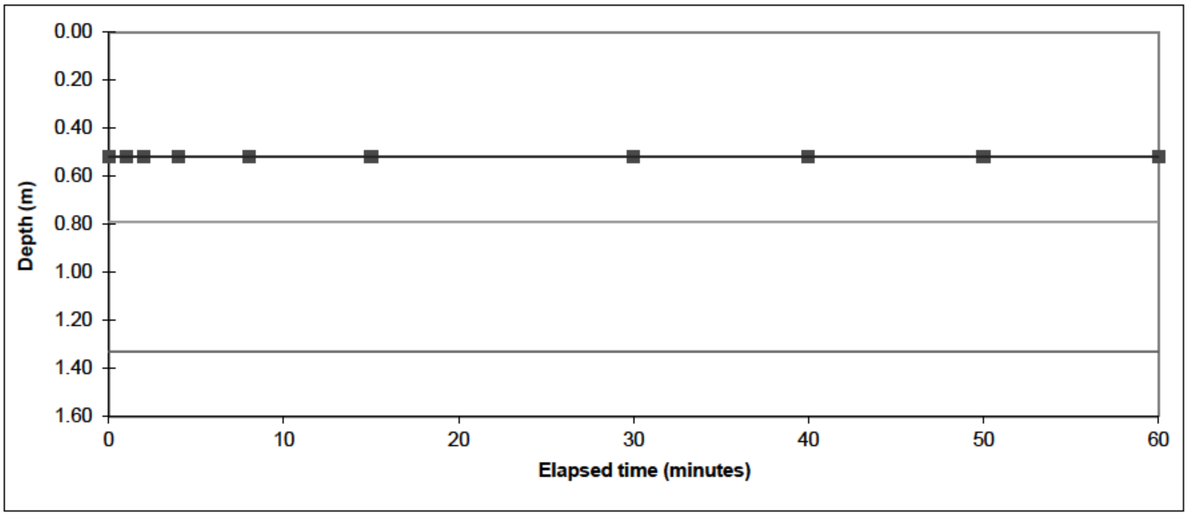
Soakaway Results

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP01	Test No: 1		Date: 21/07/2021
Length (m):	2.100	Datum Height:	0.00 m agl	
Width (m):	0.35	Granular infill: None		
Depth (m):	1.60	Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.520		
1	0.520		
2	0.520		
4	0.520		
8	0.520		
15	0.520		
30	0.520		
40	0.520		
50	0.520		
60	0.520		



Start water depth for analysis (mbgl):	0.52		
75% effective depth (mbgl):	0.79	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.06		
25% effective depth (mbgl):	1.33	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.60		

Volume outflow between 75% and 25% effective depth (m^3):

Mean surface area of outflow (m^2): 3.38
(side area at 50% effective depth + base area)

Time for outflow between 75% and 25% effective depth (mins):

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks
Results processed following BRE 365 (2007).
Negligible water movement recorded throughout the test.

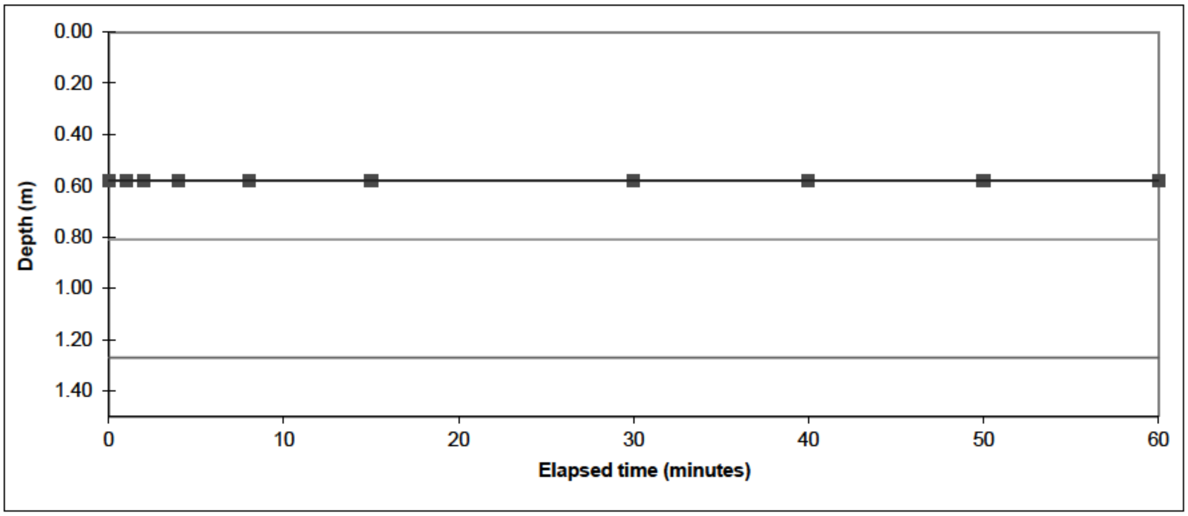
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP02	Test No:	1	Date: 21/07/2021
Length (m):	2.000	Datum Height:	0.00	m agl
Width (m):	0.35	Granular infill:	None	
Depth (m):	1.50	Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.580		
1	0.580		
2	0.580		
4	0.580		
8	0.580		
15	0.580		
30	0.580		
40	0.580		
50	0.580		
60	0.580		



Start water depth for analysis (mbgl):	0.58		
75% effective depth (mbgl):	0.81	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.04		
25% effective depth (mbgl):	1.27	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.50		

Volume outflow between 75% and 25% effective depth (m³):

Mean surface area of outflow (m^2): 2.86
(side area at 50% effective depth + base area)

Time for outflow between 75% and 25% effective depth (mins):

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).
Negligible water movement recorded throughout test.

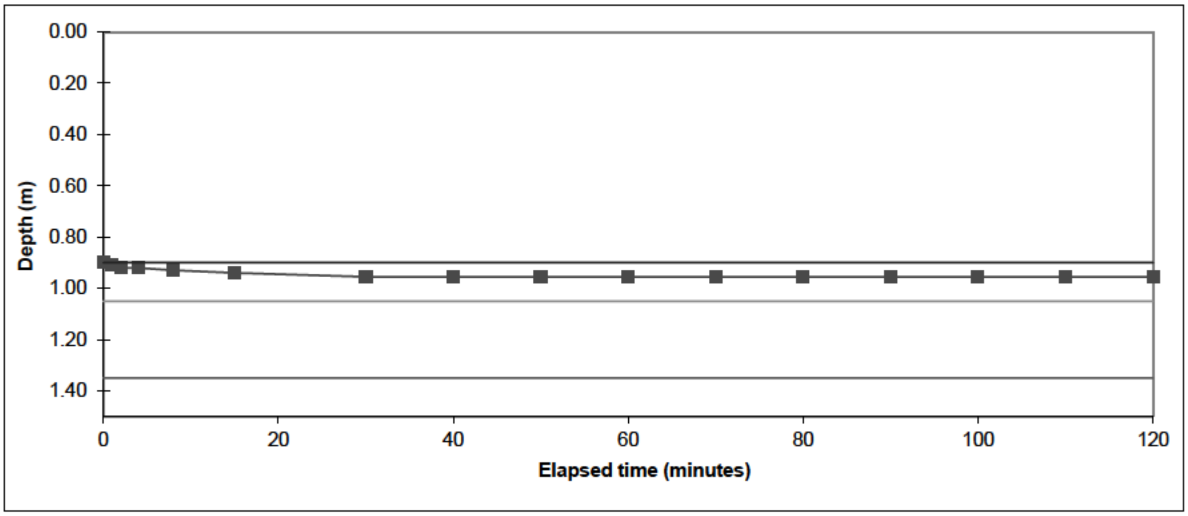
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No: TP03	Test No: 1	Date: 21/07/2021	
Length (m): 1.900	Datum Height:	0.00 m agl	
Width (m): 0.35	Granular infill: None		
Depth (m): 1.50	Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.900	110	0.955
1	0.910	120	0.955
2	0.920		
4	0.920		
8	0.930		
15	0.940		
30	0.955		
40	0.955		
50	0.955		
60	0.955		
70	0.955		
80	0.955		
90	0.955		
100	0.955		



Start water depth for analysis (mbgl):	0.90		
75% effective depth (mbgl):	1.05	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.20		
25% effective depth (mbgl):	1.35	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.50		

Volume outflow between 75% and 25% effective depth (m^3):

Mean surface area of outflow (m^2): 2.02
(side area at 50% effective depth + base area)

Time for outflow between 75% and 25% effective depth (mins):

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).
Negligible water movement recorded througout test.

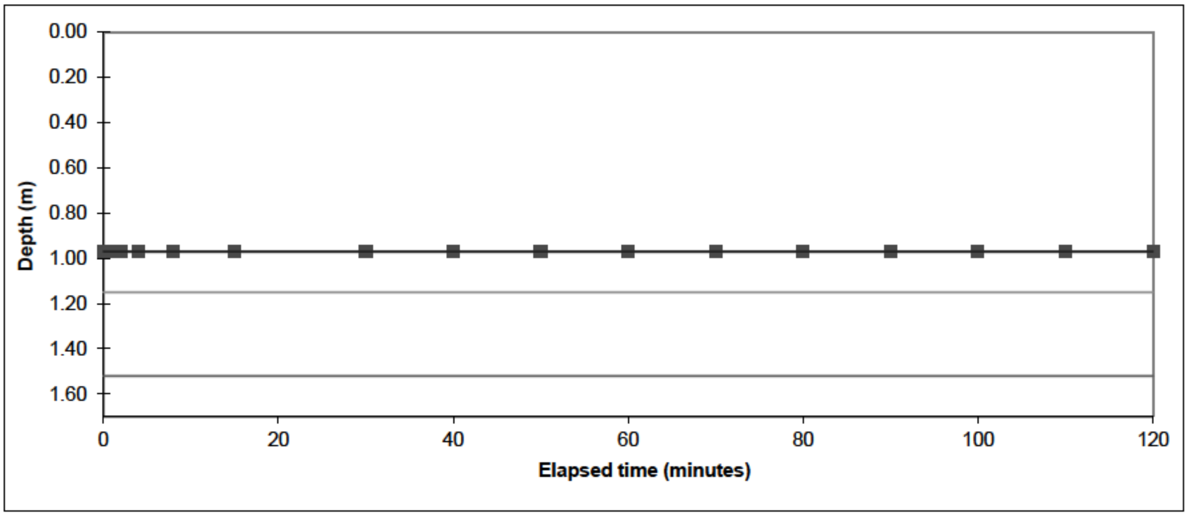
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP04	Test No: 1	Date:	21/07/2021
Length (m):	1.900	Datum Height:	0.00	m agl
Width (m):	0.35	Granular infill:	None	
Depth (m):	1.70	Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.970	110	0.972
1	0.972	120	0.972
2	0.972		
4	0.972		
8	0.972		
15	0.972		
30	0.972		
40	0.972		
50	0.972		
60	0.972		
70	0.972		
80	0.972		
90	0.972		
100	0.972		



Start water depth for analysis (mbgl):	0.97		
75% effective depth (mbgl):	1.15	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.34		
25% effective depth (mbgl):	1.52	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.70		

Volume outflow between 75% and 25% effective depth (m^3):

Mean surface area of outflow (m^2): 2.29

(side area at 50% effective depth + base area)

Time for outflow between 75% and 25% effective depth (mins):

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks

Results processed following BRE 365 (2007).
Negligible Water movement recorded throughout test

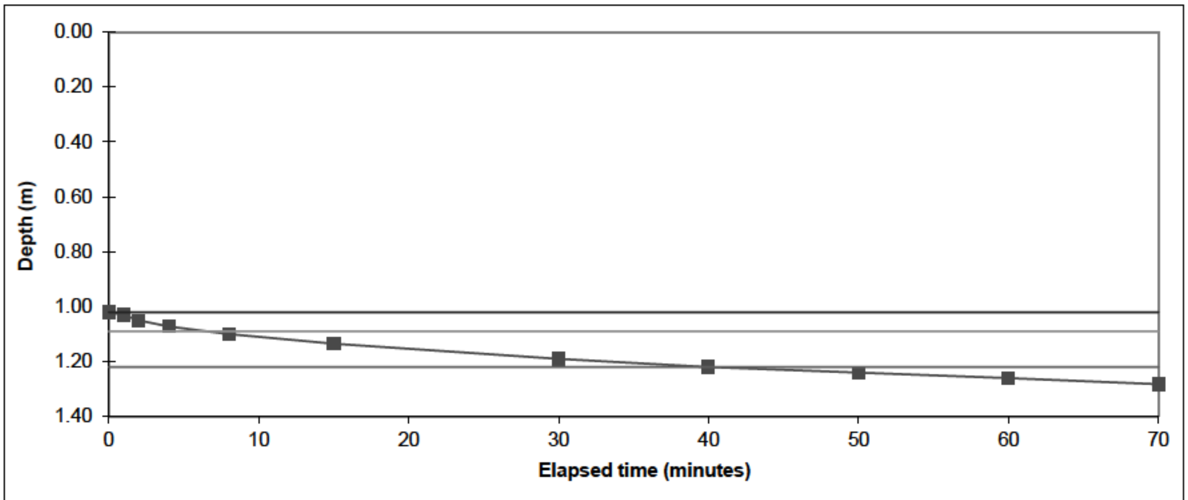
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP05	Test No: 1	Date: 20/07/2021
Length (m):	2.100	Datum Height:	0.00 m agl
Width (m):	0.35	Granular infill:	None
Depth (m):	1.28	Porosity of infill:	1 (assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	1.020		
1	1.030		
2	1.050		
4	1.072		
8	1.100		
15	1.135		
30	1.190		
40	1.220		
50	1.240		
60	1.260		
70	1.282		



Start water depth for analysis (mbgl):	1.02		
75% effective depth (mbgl):	1.09	Elapsed time (mins):	6.6
50% effective depth (mbgl):	1.15		
25% effective depth (mbgl):	1.22	Elapsed time (mins):	40.0
Base of soakage zone (mbgl):	1.28		

Volume outflow between 75% and 25% effective depth (m^3):	0.096
Mean surface area of outflow (m^2): (side area at 50% effective depth + base area)	1.38
Time for outflow between 75% and 25% effective depth (mins):	33.4

Soil infiltration rate (m/s):	**3.5E-5**

Remarks Results processed following BRE 365 (2007).

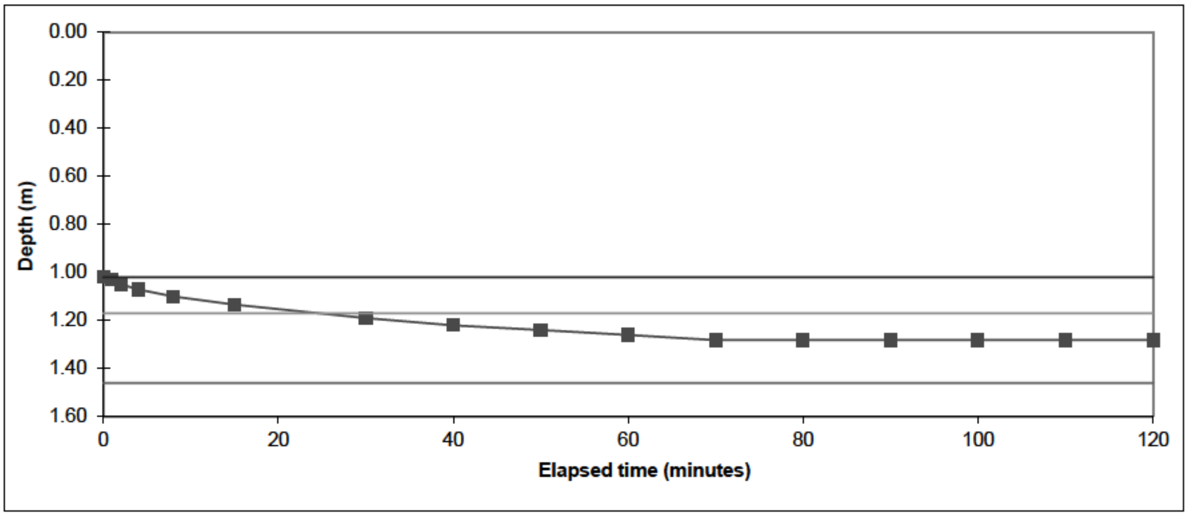
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP05	Test No:	1	Date: 20/07/2021
Length (m):	2.100	Datum Height:	0.00 m agl	
Width (m):	0.35	Granular infill:	None	
Depth (m):	1.60	Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	1.020	110	1.282
1	1.030	120	1.282
2	1.050		
4	1.072		
8	1.100		
15	1.135		
30	1.190		
40	1.220		
50	1.240		
60	1.260		
70	1.282		
80	1.282		
90	1.282		
100	1.282		



Start water depth for analysis (mbgl):	1.02		
75% effective depth (mbgl):	1.17	Elapsed time (mins):	24.5
50% effective depth (mbgl):	1.31		
25% effective depth (mbgl):	1.46	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.60		

Volume outflow between 75% and 25% effective depth (m^3):

Mean surface area of outflow (m^2): 2.16
(side area at 50% effective depth + base area)

Time for outflow between 75% and 25% effective depth (mins):

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).

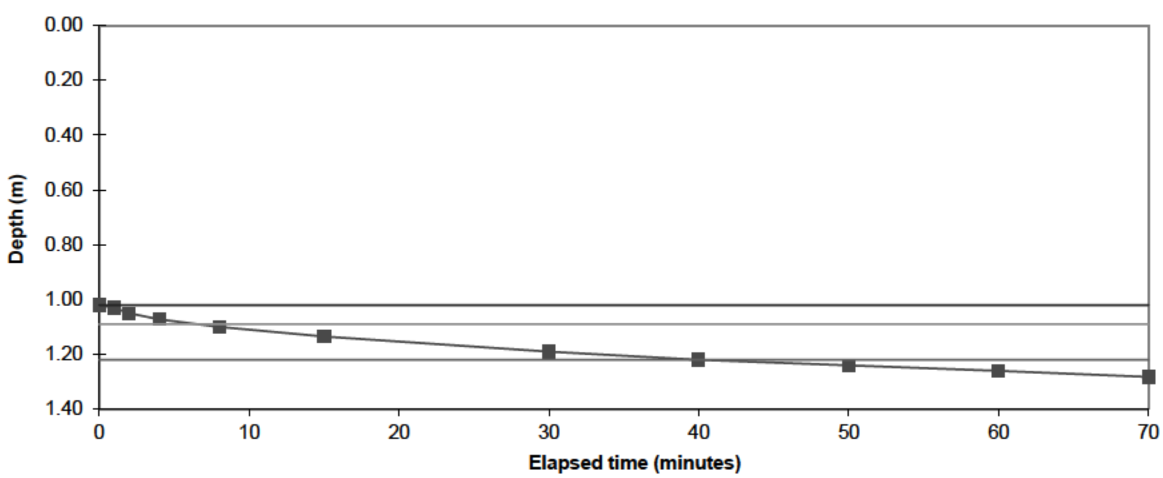
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP05	Test No:	1	Date:	20/07/2021
Length (m):	2.100		Datum Height:	0.00	m agl
Width (m):	0.35		Granular infill:	None	
Depth (m):	1.28		Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	1.020		
1	1.030		
2	1.050		
4	1.072		
8	1.100		
15	1.135		
30	1.190		
40	1.220		
50	1.240		
60	1.260		
70	1.282		



Start water depth for analysis (mbgl):	1.02		
75% effective depth (mbgl):	1.09	Elapsed time (mins):	6.6
50% effective depth (mbgl):	1.15		
25% effective depth (mbgl):	1.22	Elapsed time (mins):	40.0
Base of soakage zone (mbgl):	1.28		

Volume outflow between 75% and 25% effective depth (m^3):	0.096
Mean surface area of outflow (m^2): (side area at 50% effective depth + base area)	1.38
Time for outflow between 75% and 25% effective depth (mins):	33.4

Soil infiltration rate (m/s):	**3.5E-5**

Remarks Results processed following BRE 365 (2007).

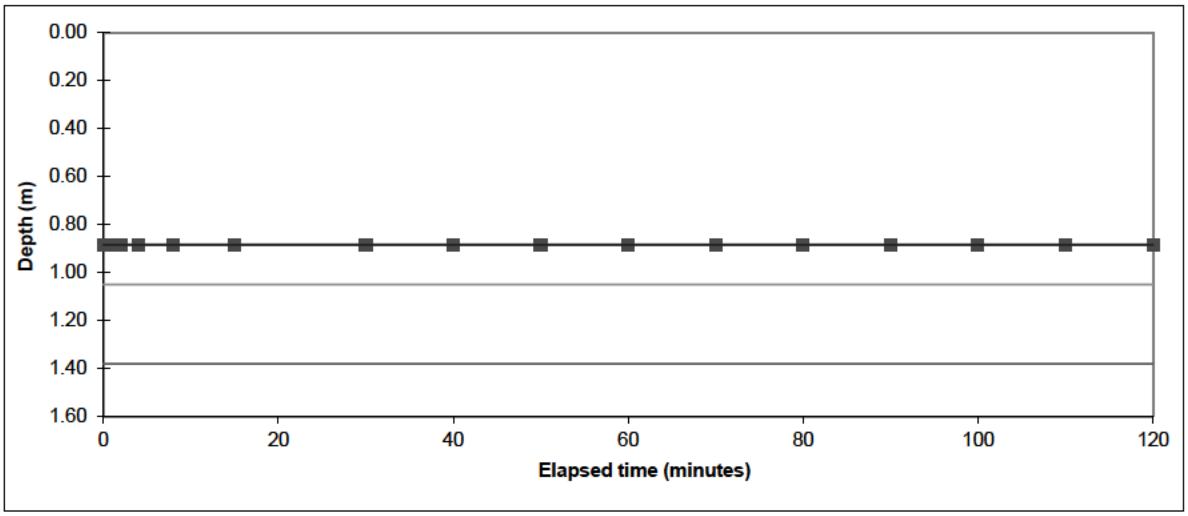
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP06	Test No:	1	Date:	20/07/2021
Length (m):	2.200	Datum Height:	0.00 m agl		
Width (m):	0.35	Granular infill:	None		
Depth (m):	1.55	Porosity of infill:	1	(assumed)	

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.884	110	0.883
1	0.883	120	0.883
2	0.883		
4	0.883		
8	0.883		
15	0.883		
30	0.883		
40	0.883		
50	0.883		
60	0.883		
70	0.883		
80	0.883		
90	0.883		
100	0.883		



Start water depth for analysis (mbgl):	0.88		
75% effective depth (mbgl):	1.05	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.22		
25% effective depth (mbgl):	1.38	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.55		

Volume outflow between 75% and 25% effective depth (m³):

Mean surface area of outflow (m^2): 2.45
(side area at 50% effective depth + base area)

Time for outflow between 75% and 25% effective depth (mins):

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).
Negligible water movement recorded

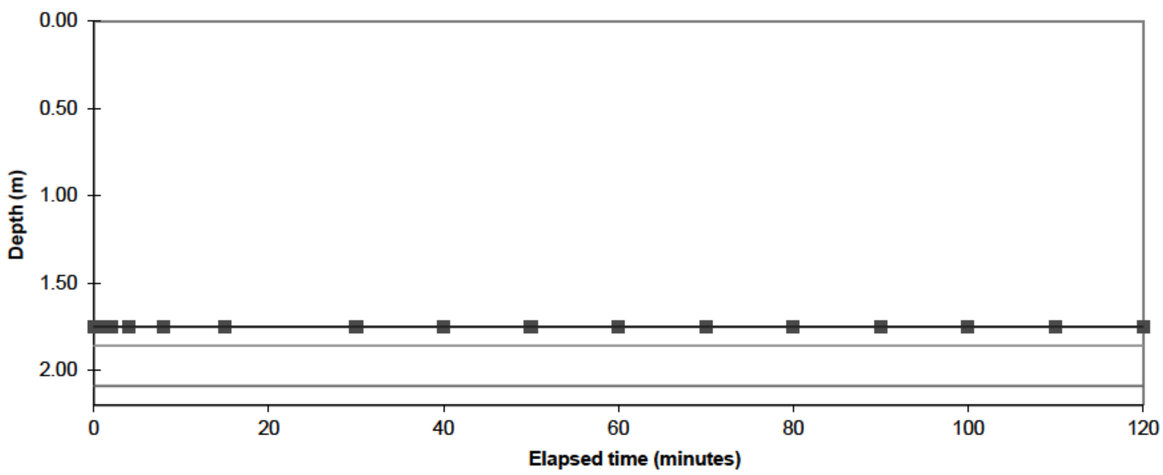
Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

Rogers Geotechnical Services Ltd

Soakaway Test

Trial Pit No:	TP07	Test No: 1	Date:	20/07/2021
Length (m):	2.100	Datum Height:	0.00	m agl
Width (m):	0.35	Granular infill:	None	
Depth (m):	2.20	Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	1.750	110	1.752
1	1.750	120	1.752
2	1.750		
4	1.750		
8	1.752		
15	1.752		
30	1.752		
40	1.752		
50	1.752		
60	1.752		
70	1.752		
80	1.752		
90	1.752		
100	1.752		



Start water depth for analysis (mbgl):	1.75		
75% effective depth (mbgl):	1.86	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.98		
25% effective depth (mbgl):	2.09	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	2.20		

Volume outflow between 75% and 25% effective depth (m^3):

Mean surface area of outflow (m^2): 1.81
(side area at 50% effective depth + base area)

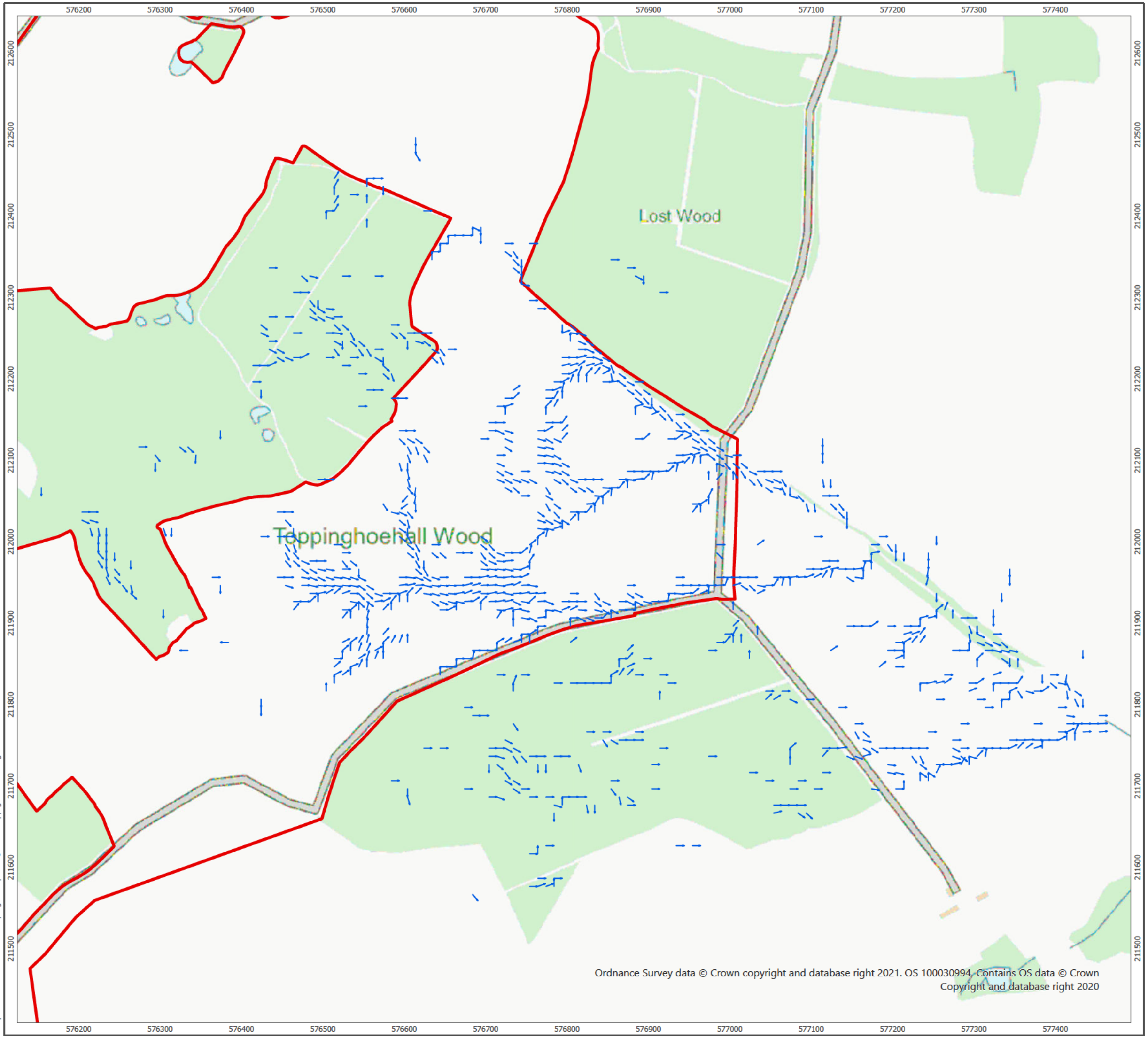
Time for outflow between 75% and 25% effective depth (mins):

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).
Negligible water movement observed.

Client:	Arcus Consultancy Services Ltd	**Job No:**
Site:	Longfield, Chelmsford	C1873/21/E/2900

APPENDIX H – 2D PLUVIAL HYDRAULIC MODEL FLOW OUTPUTS



ARCUS

2D Pluvial Model Velocity Flow Direction

Order Limits Boundary

1:4,500 Scale @ A3

0 90 180 m

NORTH

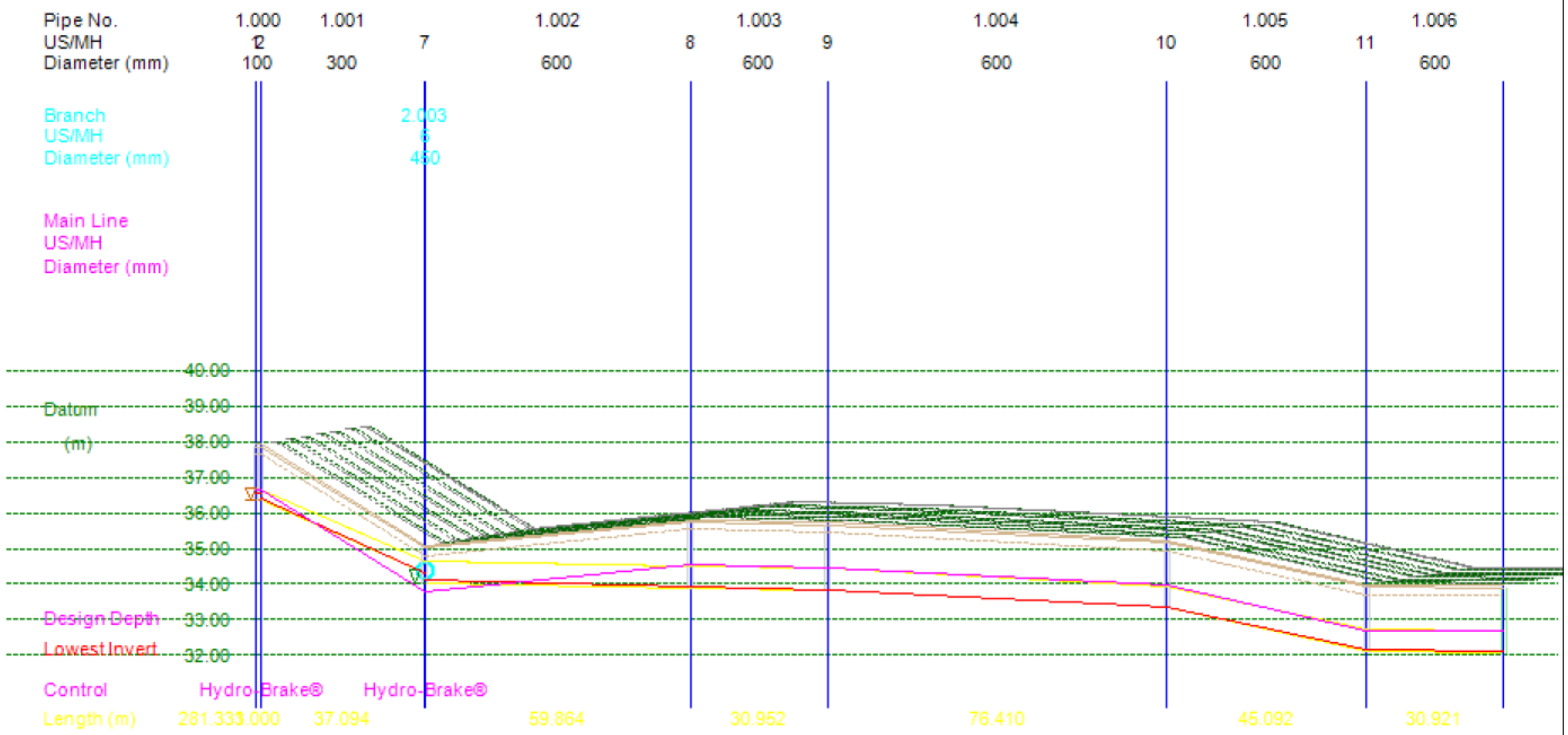
Produced By: RD	Ref: 4077-REP-020
Checked By: RS	Date: 03/08/2021

2D Pluvial Model Flows
Figure 3

Longfield Solar Farm SuDS Strategy

APPENDIX I – MICRODRAINAGE NETWORK DESIGN, SIMULATION AND RESULTS

Arcus Consulting		Page 1
1C Swinegate Ct East 3 Swinegate York YO1 8AJ		
Date 25/11/2021 14:00 File 4077_SuDS_v2-0_RD_20211124.MDX	Designed by reagand Checked by	
XP Solutions	Network 2014.1.1	



STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	100	Add Flow / Climate Change (%)	0
M5-60 (mm)	19.100	Minimum Backdrop Height (m)	0.200
Ratio R	0.400	Maximum Backdrop Height (m)	1.500
Maximum Rainfall (mm/hr)	50	Min Design Depth for Optimisation (m)	1.200
Maximum Time of Concentration (mins)	30	Min Vel for Auto Design only (m/s)	1.00
Foul Sewage (l/s/ha)	0.000	Min Slope for Optimisation (1:X)	500
Volumetric Runoff Coeff.	0.750		

Designed with Level Soffits

Network Design Table for Storm

- Indicates pipe length does not match coordinates

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Auto Design
1.000	1.000#	0.017	58.5	0.000	5.00	0.0	0.600	o	100	
1.001	37.094	2.036	18.2	0.970	0.00	0.0	0.600	o	300	
2.000	1.000#	0.017	58.5	0.000	5.00	0.0	0.600	o	100	
2.001	39.682	0.743	53.4	0.970	0.00	0.0	0.600	o	300	
2.002	64.107	0.160	401.4	0.000	0.00	0.0	0.600	o	450	
2.003	81.894	3.223	25.4	0.000	0.00	0.0	0.600	o	450	
1.002	59.864	0.120	498.9	0.000	0.00	0.0	0.600	o	600	
1.003	30.952	0.062	500.0	0.000	0.00	0.0	0.600	o	600	
1.004	76.410	0.465	164.2	0.000	0.00	0.0	0.600	o	600	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	50.00	5.02	36.560	0.000	0.0	0.0	0.0	1.01	7.9	0.0
1.001	50.00	5.18	36.343	0.970	0.0	0.0	0.0	3.70	261.6	131.4
2.000	50.00	5.02	38.650	0.000	0.0	0.0	0.0	1.01	7.9	0.0
2.001	50.00	5.32	38.433	0.970	0.0	0.0	0.0	2.16	152.4	131.4
2.002	50.00	6.38	37.540	0.970	0.0	0.0	0.0	1.01	160.4	131.4
2.003	50.00	6.72	37.380	0.970	0.0	0.0	0.0	4.05	643.5	131.4
1.002	50.00	7.64	34.007	1.940	0.0	0.0	0.0	1.08	306.3	262.7
1.003	50.00	8.12	33.887	1.940	0.0	0.0	0.0	1.08	306.0	262.7
1.004	50.00	8.79	33.825	1.940	0.0	0.0	0.0	1.90	536.6	262.7

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Auto Design
1.005	45.092	1.250	36.1	0.000	0.00	0.0	0.600	o	600	
1.006	30.921	0.062	500.0	0.000	0.00	0.0	0.600	o	600	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.005	50.00	8.97	33.360	1.940	0.0	0.0	0.0	4.06	1148.9	262.7
1.006	50.00	9.45	32.110	1.940	0.0	0.0	0.0	1.08	306.0	262.7

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	PN	Pipe Out Invert Level (m)	Diameter (mm)	PN	Pipes In Invert Level (m)	Diameter (mm)	Backdrop (mm)
1	37.860	1.300	Open Manhole	1200	1.000	36.560	100				
2	37.860	1.517	Open Manhole	1200	1.001	36.343	300	1.000	36.543	100	
3	39.950	1.300	Open Manhole	1200	2.000	38.650	100				
4	39.950	1.517	Open Manhole	1200	2.001	38.433	300	2.000	38.633	100	
5	39.190	1.650	Open Manhole	1350	2.002	37.540	450	2.001	37.690	300	
6	39.630	2.250	Open Manhole	1350	2.003	37.380	450	2.002	37.380	450	
7	35.007	1.000	Open Manhole	1500	1.002	34.007	600	1.001	34.307	300	
								2.003	34.157	450	
8	35.740	1.853	Open Manhole	1500	1.003	33.887	600	1.002	33.887	600	
9	35.650	1.825	Open Manhole	1500	1.004	33.825	600	1.003	33.825	600	
10	35.160	1.800	Open Manhole	1500	1.005	33.360	600	1.004	33.360	600	
11	33.910	1.800	Open Manhole	1500	1.006	32.110	600	1.005	32.110	600	
	33.900	1.852	Open Manhole	0		OUTFALL		1.006	32.048	600	

PIPELINE SCHEDULES for Storm

Upstream Manhole

- Indicates pipe length does not match coordinates

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	o	100	1	37.860	36.560	1.200	Open Manhole	1200
1.001	o	300	2	37.860	36.343	1.217	Open Manhole	1200
2.000	o	100	3	39.950	38.650	1.200	Open Manhole	1200
2.001	o	300	4	39.950	38.433	1.217	Open Manhole	1200
2.002	o	450	5	39.190	37.540	1.200	Open Manhole	1350
2.003	o	450	6	39.630	37.380	1.800	Open Manhole	1350
1.002	o	600	7	35.007	34.007	0.400	Open Manhole	1500
1.003	o	600	8	35.740	33.887	1.253	Open Manhole	1500
1.004	o	600	9	35.650	33.825	1.225	Open Manhole	1500
1.005	o	600	10	35.160	33.360	1.200	Open Manhole	1500
1.006	o	600	11	33.910	32.110	1.200	Open Manhole	1500

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	1.000#	58.5	2	37.860	36.543	1.217	Open Manhole	1200
1.001	37.094	18.2	7	35.007	34.307	0.400	Open Manhole	1500
2.000	1.000#	58.5	4	39.950	38.633	1.217	Open Manhole	1200
2.001	39.682	53.4	5	39.190	37.690	1.200	Open Manhole	1350
2.002	64.107	401.4	6	39.630	37.380	1.800	Open Manhole	1350
2.003	81.894	25.4	7	35.007	34.157	0.400	Open Manhole	1500
1.002	59.864	498.9	8	35.740	33.887	1.253	Open Manhole	1500
1.003	30.952	500.0	9	35.650	33.825	1.225	Open Manhole	1500
1.004	76.410	164.2	10	35.160	33.360	1.200	Open Manhole	1500
1.005	45.092	36.1	11	33.910	32.110	1.200	Open Manhole	1500
1.006	30.921	500.0		33.900	32.048	1.252	Open Manhole	0

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.006		33.900	32.048	0.000	0	0

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	20.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Storage Structures	3
Number of Online Controls	3	Number of Time/Area Diagrams	0
Number of Offline Controls	1	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Storm Duration (mins)	30
Ratio R	0.400		

Online Controls for Storm

Hydro-Brake Optimum® Manhole: 2, DS/PN: 1.001, Volume (m³): 1.7

Unit Reference	MD-SHE-0070-2400-1217-2400
Design Head (m)	1.217
Design Flow (l/s)	2.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	70
Invert Level (m)	36.343
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	1.217	2.4
Flush-Flo™	0.309	2.2
Kick-Flo®	0.627	1.8
Mean Flow over Head Range	-	2.0

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	1.8	1.200	2.4	3.000	3.6	7.000	5.4
0.200	2.1	1.400	2.6	3.500	3.9	7.500	5.6
0.300	2.2	1.600	2.7	4.000	4.2	8.000	5.8
0.400	2.2	1.800	2.9	4.500	4.4	8.500	5.9
0.500	2.1	2.000	3.0	5.000	4.6	9.000	6.1
0.600	1.9	2.200	3.1	5.500	4.8	9.500	6.2
0.800	2.0	2.400	3.3	6.000	5.0		
1.000	2.2	2.600	3.4	6.500	5.2		

Hydro-Brake Optimum® Manhole: 4, DS/PN: 2.001, Volume (m³): 1.7

Unit Reference	MD-SHE-0073-2400-1017-2400
Design Head (m)	1.017
Design Flow (l/s)	2.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	73
Invert Level (m)	38.633
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	1.017	2.4
Flush-Flo™	0.308	2.4

Hydro-Brake Optimum® Manhole: 4, DS/PN: 2.001, Volume (m³): 1.7

Control Points	Head (m)	Flow (l/s)
Kick-Flo®	0.632	1.9
Mean Flow over Head Range	-	2.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.0	1.200	2.6	3.000	3.9	7.000	5.8
0.200	2.3	1.400	2.8	3.500	4.2	7.500	6.0
0.300	2.4	1.600	2.9	4.000	4.5	8.000	6.2
0.400	2.3	1.800	3.1	4.500	4.7	8.500	6.4
0.500	2.3	2.000	3.2	5.000	5.0	9.000	6.6
0.600	2.0	2.200	3.4	5.500	5.2	9.500	6.7
0.800	2.1	2.400	3.5	6.000	5.4		
1.000	2.4	2.600	3.7	6.500	5.6		

Hydro-Brake Optimum® Manhole: 7, DS/PN: 1.002, Volume (m³): 17.1

Unit Reference	MD-SHE-0073-2400-1000-2400
Design Head (m)	1.000
Design Flow (l/s)	2.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	73
Invert Level (m)	34.007
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	2.4
Flush-Flo™	0.308	2.4
Kick-Flo®	0.629	1.9
Mean Flow over Head Range	-	2.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.0	0.800	2.2	2.000	3.3	4.000	4.5
0.200	2.3	1.000	2.4	2.200	3.4	4.500	4.8
0.300	2.4	1.200	2.6	2.400	3.6	5.000	5.0
0.400	2.4	1.400	2.8	2.600	3.7	5.500	5.3
0.500	2.3	1.600	3.0	3.000	4.0	6.000	5.5
0.600	2.0	1.800	3.1	3.500	4.3	6.500	5.7

Hydro-Brake Optimum® Manhole: 7, DS/PN: 1.002, Volume (m³): 17.1

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
7.000	5.9	8.000	6.3	9.000	6.6		
7.500	6.1	8.500	6.5	9.500	6.8		

Offline Controls for Storm

Orifice Manhole: 1, DS/PN: 1.000, Loop to PN: None

Diameter (m) 0.031 Discharge Coefficient 0.600 Invert Level (m) 36.560

Storage Structures for Storm

Cellular Storage Manhole: 2, DS/PN: 1.001

Invert Level (m) 36.343 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	18250.0	0.0	0.300	18250.0	0.0

Cellular Storage Manhole: 4, DS/PN: 2.001

Invert Level (m) 38.633 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	24600.0	0.0	0.300	24600.0	0.0

Tank or Pond Manhole: 7, DS/PN: 1.002

Invert Level (m) 34.007

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4.0	0.400	23.3	0.601	38.9	1.000	82.1
0.200	11.7	0.401	23.3	0.800	58.5		
0.201	11.7	0.600	38.9	0.801	58.5		

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	20.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Storage Structures	3
Number of Online Controls	3	Number of Time/Area Diagrams	0
Number of Offline Controls	1	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Ratio R	0.400
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	19.100	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years)	1, 30, 100, 1000
Climate Change (%)	20, 20, 20, 20

PN	Storm	Return Period	Climate Change	First X Surcharge	First Y Flood	First Z Overflow	O/F Act.	Lvl Exc.
1.000	360 Winter	100	+20%				0	
1.001	7200 Winter	100	+20%					
2.000	10080 Winter	100	+20%					
2.001	10080 Winter	100	+20%					
2.002	10080 Winter	100	+20%					
2.003	10080 Winter	100	+20%					
1.002	8640 Winter	100	+20%	1000/960 Winter	1000/1440 Winter			14
1.003	8640 Winter	100	+20%					
1.004	8640 Winter	100	+20%					
1.005	8640 Winter	100	+20%					
1.006	8640 Winter	100	+20%					

PN	US/MH Name	Water Level (m)	Surch'ed Depth (m)	Flooded Volume (m³)	Flow / Cap.	O'flow (l/s)	Pipe Flow (l/s)	Status
1.000	1	36.560	-0.100	0.000	0.00	0.0	0.0	OK
1.001	2	36.403	-0.240	0.000	0.00	0.0	1.1	OK
2.000	3	38.681	-0.069	0.000	0.00	0.0	0.0	OK
2.001	4	38.681	-0.052	0.000	0.01	0.0	0.9	OK
2.002	5	37.552	-0.438	0.000	0.01	0.0	0.9	OK

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Water Level (m)	Surch'ed Depth (m)	Flooded Volume (m³)	Flow / Cap.	O'flow (l/s)	Pipe Flow (l/s)	Status
2.003	6	37.383	-0.447	0.000	0.00	0.0	0.9	OK
1.002	7	34.112	-0.495	0.000	0.01	0.0	2.0	OK
1.003	8	33.913	-0.574	0.000	0.01	0.0	2.0	OK
1.004	9	33.837	-0.588	0.000	0.00	0.0	2.0	OK
1.005	10	33.365	-0.594	0.000	0.00	0.0	2.0	OK
1.006	11	32.147	-0.563	0.000	0.01	0.0	2.0	OK

Summary of Results for 100 year Return Period (+20%)

Half Drain Time exceeds 7 days.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	54.774	0.474	0.0	11.5	O K
30 min Summer	54.831	0.531	0.0	15.1	O K
60 min Summer	54.883	0.583	0.0	18.9	O K
120 min Summer	54.930	0.630	0.0	22.9	O K
180 min Summer	54.956	0.656	0.0	25.2	O K
240 min Summer	54.974	0.674	0.0	26.9	O K
360 min Summer	54.997	0.697	0.0	29.3	O K
480 min Summer	55.015	0.715	0.0	31.2	Flood Risk
600 min Summer	55.028	0.728	0.0	32.7	Flood Risk
720 min Summer	55.039	0.739	0.0	33.9	Flood Risk
960 min Summer	55.057	0.757	0.0	36.0	Flood Risk
1440 min Summer	55.083	0.783	0.0	39.0	Flood Risk
2160 min Summer	55.109	0.809	0.0	42.2	Flood Risk
2880 min Summer	55.128	0.828	0.0	44.6	Flood Risk
4320 min Summer	55.155	0.855	0.0	48.2	Flood Risk
5760 min Summer	55.174	0.874	0.0	50.8	Flood Risk
7200 min Summer	55.189	0.889	0.0	52.9	Flood Risk
8640 min Summer	55.202	0.902	0.0	54.7	Flood Risk
10080 min Summer	55.213	0.913	0.0	56.2	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	113.234	0.0	27
30 min Summer	74.402	0.0	42
60 min Summer	46.601	0.0	72
120 min Summer	28.225	0.0	132
180 min Summer	20.780	0.0	192
240 min Summer	16.627	0.0	252
360 min Summer	12.069	0.0	372
480 min Summer	9.621	0.0	492
600 min Summer	8.064	0.0	612
720 min Summer	6.977	0.0	732
960 min Summer	5.549	0.0	972
1440 min Summer	4.012	0.0	1452
2160 min Summer	2.895	0.0	2172
2880 min Summer	2.295	0.0	2892
4320 min Summer	1.652	0.0	4332
5760 min Summer	1.307	0.0	5776
7200 min Summer	1.089	0.0	7216
8640 min Summer	0.938	0.0	8656
10080 min Summer	0.827	0.0	10096

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Winter	54.797	0.497	0.0	12.8	O K
30 min Winter	54.857	0.557	0.0	16.9	O K
60 min Winter	54.911	0.611	0.0	21.1	O K
120 min Winter	54.960	0.660	0.0	25.6	O K
180 min Winter	54.987	0.687	0.0	28.3	O K
240 min Winter	55.005	0.705	0.0	30.2	Flood Risk
360 min Winter	55.030	0.730	0.0	32.8	Flood Risk
480 min Winter	55.048	0.748	0.0	34.9	Flood Risk
600 min Winter	55.062	0.762	0.0	36.6	Flood Risk
720 min Winter	55.074	0.774	0.0	38.0	Flood Risk
960 min Winter	55.093	0.793	0.0	40.3	Flood Risk
1440 min Winter	55.120	0.820	0.0	43.7	Flood Risk
2160 min Winter	55.148	0.848	0.0	47.3	Flood Risk
2880 min Winter	55.168	0.868	0.0	50.0	Flood Risk
4320 min Winter	55.197	0.897	0.0	54.0	Flood Risk
5760 min Winter	55.217	0.917	0.0	56.9	Flood Risk
7200 min Winter	55.233	0.933	0.0	59.3	Flood Risk
8640 min Winter	55.247	0.947	0.0	61.3	Flood Risk
10080 min Winter	55.258	0.958	0.0	63.0	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Winter	113.234	0.0	27
30 min Winter	74.402	0.0	42
60 min Winter	46.601	0.0	72
120 min Winter	28.225	0.0	132
180 min Winter	20.780	0.0	192
240 min Winter	16.627	0.0	252
360 min Winter	12.069	0.0	372
480 min Winter	9.621	0.0	492
600 min Winter	8.064	0.0	612
720 min Winter	6.977	0.0	732
960 min Winter	5.549	0.0	972
1440 min Winter	4.012	0.0	1452
2160 min Winter	2.895	0.0	2172
2880 min Winter	2.295	0.0	2892
4320 min Winter	1.652	0.0	4332
5760 min Winter	1.307	0.0	5776
7200 min Winter	1.089	0.0	7216
8640 min Winter	0.938	0.0	8656
10080 min Winter	0.827	0.0	10096

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.200	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.054

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.018	4	8	0.018	8	12	0.018

Model Details

Storage is Online Cover Level (m) 55.300

Swale Structure

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	90.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	1.0
Safety Factor	2.0	Slope (1:X)	125.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	54.300	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5		

APPENDIX J – SIMPLE INDEX APPROACH OUTPUT

SIMPLE INDEX APPROACH: SUMMARY TABLE

SUMMARY TABLE		DESIGN CONDITIONS 1	2	3	4
Land Use Type	Commercial/industrial roofing Medium potential for metal leaching	This classification should be informed by an assessment of the leachab ility of metals from the adopted roofing materials. Particular risks are likely to be posed by materials that include copper and galvanised steel			
Pollution Hazard Level	Medium				
Pollution Hazard Indices					
TSS	0.3				
Metals	0.6				
Hydrocarbons	0.05				
SuDS components proposed					
Component 1	Pond or wetland	SuDS components can only be assumed to deliver these indices if they follow design guidance with respect to hydraulics and treatment set out in the relevant technical component chapters of the SuDS Manual. See also checklists in Appendix B	Ponds/wetlands should be preceded by an upstream component(s) that trap(s) s lt, or designed specifically to retain sediment in a separate zone, easily accessible for maintenance, such that the sediment will not be re-suspended in subsequent events		
Component 2	None				
Component 3	None				
SuDS Pollution Mitigation Indices					
TSS	0.7				
Metals	0.7				
Hydrocarbons	0.5				
Groundwater protection type	None				
Groundwater protection Pollution Mitigation Indices					
TSS	0				
Metals	0				
Hydrocarbons	0				
Combined Pollution Mitigation Indices		**Note: In order to meet both Water Quality criteria set out in the SuDS Manual (Chapter 4), interception should be delivered for all impermeable areas wherever possible. Interception delivery and treatment may be met by the same components, but interception requires separate evaluation.**	Reference to local planning documents should also be made to identify any additional protection required for sites due to habitat conservation (see Chapter 7 The SuDS design process). The implications of developments on or within close proximity to an area with an environmental designation, such as a Site of Special Scientific Interest (SSSI), should be considered via consultation with relevant conservation bodies such as Natural England		
TSS	0.7				
Metals	0.7				
Hydrocarbons	0.5				
Acceptability of Pollution Mitigation					
TSS	Sufficient				
Metals	Sufficient				
Hydrocarbons	Sufficient				

APPENDIX K –LONG TERM MAINTENCE – SCHEDULE FOR PONDS[40]

Maintenance schedule	Required action	Typical frequency
Regular Maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass (in public areas)	Monthly (during growing season)
	Cut meadow grass	Half yearly (spring, before nesting season, and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants for first 3 years	Monthly (as start, then as required)
	Inspect inlets, outlets, bankside, structures, pipework etc for evidence of blockage and/or physical damage	Monthly
	Inspect water body for signs of poor water quality	(Monthly (May – October)
	Inspect silt accumulation rates in any forebay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing on some build up has occurred, to inform management and disposal options	Half yearly
	Checky any mechanical devices (e.g., penstocks)	Half yearly
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1 m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1 m above water level	Annually
	Tidy all dead growth (Scrub clearance) before start of growing season (Note: tree maintenance usually part of overall landscape management contract)	Annually
	Remove sediment from any forebay	Every 1-5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays	Every 5 years, or as required
Occasional Maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, e.g., every 25-50 years
Remedial actions	Repair erosion or other damage	As required
	Replate where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required
	Realign rip-rap or repair other damage	As required
	Repair/rehabilitate inlets, outlet, overflows and vents	As required

[40] Based on Table 21.1 - Operation and maintenance requirements for attenuation ponds and wetlands of the SuDS Manual

APPENDIX L – ESSEX COUNTY COUNCIL SUDS WATER QUANTITY AND QUALITY LLFA TECHNICAL ASSESSMENT PROFORMA

Essex County Council

SuDS Water quantity and Quality – LLFA Technical Assessment Proforma

Introduction

This proforma identifies the information required by Essex LLFA to enable technical assessment the Designers approach to water quantity and water quality as part of SuDS design approach in compliance with Essex SuDS Design Guide.

Completion of the proforma will also allow for technical assessment against Non-statutory technical standards (NSTS) for Sustainable Drainage. The proforma will accompany the site specific Flood Risk Assessment and Drainage Strategy submitted as part of the planning application.

Please complete this form in full for full applications and the coloured sections for outline appllications. This will help us identify what information has been included and will assist with a smoother and quicker application.

Instructions for use

Use the units defined for input of figures

Numbers in brackets refer to accompanying notes.

Where ………m^3 ………m^3/m^2 *are noted – both values should be filled in.*

Site details

1.1 Planning application reference (if known)

1.2 Site name Longfield Solar Farm

1.3 Total application site area (1) 459 ha

1.4 Predevelopment use (4) Greenfield

1.5 Post development use Industrial

If other, please sepcify

1.6 Urban creep applicable No if yes, factor applied:

1.7 Proposed design life / planning application life c. 40 years

1.8 Method(s) of discharge: (5)

☐ *Reuse* ☐ *Infiltration* ☐ *Hybrid* ☑ *Waterbody* ☐ *Storm sewer* ☐ *Combined sewer*

1.9 Is discharge direct to estuary / sea No

1.10 Have agreements in principle (where applicable) for discharge been provided Yes

Essex County Council

SuDS Water quantity and Quality – LLFA Technical Assessment

Calculation inputs

2.1	Area within site which is drained by SuDS (2)	6.86	m^2
2.2	Impermeable area drained pre development (3)	0	m^2
2.3	Impermeable area drained post development (3)	0.34	m^2
2.4	Additional impermeable area (2.3 minus 2.2)		m^2
2.5	Method for assessing greenfield runoff rate	ICP SuDS and IH124	
2.6	Method for assessing brownfield runoff rate	N/A	
2.7	Coefficient of runoff (Cv) (6)	Summer 0.75, Wi	
2.8	Source of rainfall data (FEH Preferred)	FSR	
2.9	Climate change factor applied	20	%

Attenuation (positive outlet)

2.10 Drainage outlet at risk of drowning (tidal locking, elevated water levels in watercourse/sewer)
Note: Vortex controls require conditions of free discharge to operate as per manufacturers specification.

2.11 Invert level at final outlet 30.822 mAOD

2.12 Design level used for surcharge water level at point of discharge (16) 30.822 mAOD

Infiltration (Discharge to Ground)

2.13 Have infiltration tests been undertaken Yes

2.14 If yes, which method has been used BRE365

2.15 Infiltration rate (where applicable) 0 m/s

2.16 Depth to highest known ground water table 4.5 (BGS data, mAOD

2.17 If there are multiple infiltration features please specify where they can be found in the FRA N/A

2.18 Depth of infiltration feature N/A mAOD

2.19 Factor of safety used for sizing infiltration storage N/A

Essex County Council

SuDS Water quantity and Quality – LLFA Technical Assessment Proforma

Calculation outputs

Sections 3 and 4 refer to site where storage is provided by full attenuation or partial infiltration. Where all flows are infiltrated to ground go straight to Section 6.

3.0	**Greenfield runoff rates (incl. Urban Creep)**				
3.1	1 in 1 year rainfall		l/s/ha,	15.7	l/s for the site
3.2	1 in 30 year rainfall		l/s/ha,	41.9	l/s for the site
3.3	1 in 100 year rainfall + CCA		l/s/ha,	59.0	l/s for the site
4.0	**Brownfield runoff rates (incl. Urban Creep)**				
4.1	1 in 1 year rainfall		l/s/ha,		l/s for the site
4.2	1 in 30 year rainfall		l/s/ha,		l/s for the site
4.3	1 in 100 year rainfall + CCA		l/s/ha,		l/s for the site
5.0	**Proposed maximum rate of runoff from site (incl. Urban Creep)** (7)				
5.1	1 in 1 year rainfall	15.7	l/s/ha,	15.7	l/s for the site
5.2	1 in 30 year rainfall	15.7	l/s/ha,	15.7	l/s for the site
5.3	1 in 100 year rainfall + CCA	15.7	l/s/ha,	15.7	l/s for the site

6.0 Attenuation storage to manage flow rates from site (incl. Climate Change Allowance (CCA) and Urban Creep)

6.1	Storage - 1 in 100 year + CCA (9)	96.5	m^3	529	m^3/m^2
6.2	50% storage drain down time 1 in 30 years	0			hours

7.0 Controlling volume of runoff from the site(10)

7.1	Pre development runoff volume(12) (development area)	m^3 for the site
7.2	Post development runoff volume (unmitigated) (12)	m^3 for the site
7.3	Volume to be controlled (5.2 - 5.1)	m^3 for the site

Essex County Council

7.4 Volume control provided by:

- Interception losses(13) m^3
- Rain harvesting (14) m^3
- Infiltration m^3
- Attenuation m^3
- Separate volume designated as long term storage(15) m^3

7.5 Total volume control (sum of inputs for 5.4) m^3 (17)

8.0 Site storage volumes (full infiltration only)

8.1 Storage - 1in 30 year + CCA (8) m^3 m^3/m^2 (of developed impermeable area)

8.2 Storage - 1 in 100 year + CCA (11) m^3 m^3/m^2

SuDS Water quantity and Quality – LLFA Technical Assessment Proforma

Design Inputs

Proposed site use Solar Farm and BESS Facility

Pollution hazard category (see C753 Table 26.2) Other Roofs (With Medium Metal

High risk area defined as area storing fuels chemicals, refuelling area, washdown area, loading bay.

Design Outputs

List order of SuDS techniques proposed for treatment Attenuation Pond

Note that gully pots, pipes and tanks are not accepted by Essex LLFA as a form of treatment (for justification see C753 Section 4.1, Table 26.15 and Box B.2)

Are very high pollution risk areas drained separate from SuDS to foul system No

Other

Please include any other information that is relevant to your application

For Section 6.2 the half drain time is not identified in Micro Drainage software unless it is more than 24 hours. The outputs from the Micro Drainage design indicate it is less than 24 hours, but no exact half drain time is provided. The half drain time is < 24 hours up to and including the 1:1000-year (CCA) event.

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SuDS Water quantity and Quality – LLFA Technical Assessment Proforma

Notes

1. All area with the proposed application site boundary to be included.
2. The site area which is positively drained includes all green areas which drain to the SuDS system and area of surface SuDS features. It excludes large open green spaces which do not drain to the SuDS system.
3. Impermeable area should be measured pre and post development. Impermeable surfaces include, roofs, pavements, driveways and paths where runoff is conveyed to the drainage system.
4. Predevelopment use may impact on the allowable discharge rate. The LLFA will seek for reduction in flow rates to GF (Essex SuDS Design Guide).
5. Runoff may be discharge via one or more methods.
6. Sewers for Adoption 6th Edition recommends a Cv of 100% when designing drainage for impermeable area (assumes no loss of runoff from impermeable surfaces) and 0% for permeable areas. Where lower Cv's are used the applicant should justify the selection of Cv.
7. It is Essex County Council's preference that discharge rates for all events up to the 1 in 100 year event plus climate change are limited to the 1 in 1 greenfield rate. This is also considered to mitigate the increased runoff volumes that occur with the introduction of impermeable surfaces. If discharge rates are limited to a range of matched greenfield flows then it is necessary to provide additional mitigation of increased runoff volumes by the provision of Long-term Storage.
8. Storage for the 1 in 30 year must be fully contained within the SuDS components. Note that standing water within SuDS components such as ponds, basins and swales is not classified as flooding. Storage should be calculated for the critical duration rainfall event.
9. Runoff generated from rainfall events up to the 1 in 100 year will not be allowed to leave the site in an uncontrolled way. Temporary flooding of designated areas to shallow depths and velocities may be acceptable.
10. The following information should only be provided if increased runoff volumes are not mitigated by limiting all discharge rates back to the greenfield 1 in 1 year rate.
11. Climate change is specified as 40% increase to rainfall intensity, unless otherwise agreed with the LLFA / EA.
12. To be determined using the 100 year return period 6 hour duration winter rainfall event.
13. Where Source Control is provided Interception losses will occur. An allowance of 5mm rainfall depth can be subtracted from the net inflow to the storage calculation where interception losses are demonstrated. The Applicant should demonstrate use of subcatchments and source control techniques. Further information is available in the SuDS Design Guide.
14. Please refer to Rain harvesting BS for guidance on available storage.
15. Flows within long term storage areas should be infiltrated to the ground or discharged at low flow rate of maximum 2 l/s/ha.
16. Careful consideration should be used for calculations where flow control / storage is likely to be influenced by surcharged sewer or peak levels within a watercourse. Outlets can be tidally locked where discharge is direct to estuary or sea. Calculations should demonstrate that risk of downed outlet has been taken into consideration. Vortex controls require conditions of free discharge to operate as per specification.
17. In controlling the volume of runoff the total volume from mitigation measures should be greater than or equal to the additional volume generated.