MOTT MACDONALD

Bulls Lodge Substation Extension

Drainage Strategy

November 2021
Revision 1
EN010118/APP/6.2
Longfield Solar Energy Farm Ltd.

Contents

1 Introduction

National Grid has commissioned Mott MacDonald to develop a drainage strategy to support the development of the proposed expansion of the Bulls Lodge Substation site near Boreham, Essex.

This document aims to summarise the proposed drainage strategy for the development outlining the measures taken to reduce the impact of the development on both the flow rates and water quality from the site by utilising sustainable drainage systems (SuDS).

2 Site Overview

2.1 Site Location

The proposed development site is located is located approximately 6.0 km north east of Chelmsford town centre and 0.4 km north of the mainline railway and A12 road, directly north of the village of Boreham in Essex.

The approximate National Grid Reference (NGR) is 575121, 210543, this coordinate is to the approximate centre of the proposed development site.

2.2 Site Description

The proposed Bulls Lodge Substation expansion is located on agricultural land directly to the west of the existing Bulls Lodge 400kV Substation. The proposed development site covers an area of approximately 1.525ha.

Directly to the north of the site is agricultural land and approximately 500m northwest of the site is the Bulls Lodge Sand and Gravel Quarry and associated manmade ponds. The existing substation and all of its infrastructure forms the eastern boundary of the site and beyond that is Brick House Farm. Directly to the south of the site is Brick House Farm access track, more agricultural land and beyond that the A12 road. The Grove woodland is present along the western boundary of the site.

2.3 Topography

A LIDAR survey was undertaken in 2021.

The survey indicates that there is an overall fall across the site from north to south with ground levels ranging from approximately 36.00mAOD to the north of the site to approximately 30.00mAOD to the south of the site.

The finished site level of the existing Bulls Lodge Substation site adjacent to the proposed development site is set at approximately 31.50mAOD.

2.4 Geology

The British Geological Survey's (BGS) on-line 1:50,000 Geological Maps show the site to be underlain by diamicton within the Lowestoft Formation. A band of Head deposits runs from east to west along the southern boundary of the field with a band of Alluvium further to the south. Bedrock is the London Clay Formation.

An intrusive ground investigation was undertaken prior to the construction of the adjacent existing Bulls Lodge Substation site in 2015 and 2016 by ESG. Some of the boreholes were within the proposed development site.

The ground profile is summarised in Table 2.1 below.

Table 2.1: Summary of Strata Beneath the Site

Strata	General Description	Thickness (m)	Depth (mBGL)
Topsoil	Crop stubble/grass over soft brown slightly sandy slightly gravelly clay	0.20 – 0.70	0.00
Made Ground	Brown slightly sandy slightly gravelly clay/sandy clayey gravel. Gravel is angular to subangular fine to coarse flint and occasional brick and concrete (not all boreholes). Orange-brown gravelly clay over brown mottled white slightly sandy slightly gravelly clay	0.50 – 1.50	0.00
Alluvium	Very soft grey slightly sandy slightly gravelly clay. Frequent rootlets and black plant matter.	> 0.40	1.10 – 1.20
Head Deposits	Friable yellow/orange-brown slightly gravelly sandy clay, sand fine to coarse, gravel sub angular to sub rounded fine to coarse of flint.	0.10 – 1.60	0.20 – 0.70
Glacial Till	Firm to stiff yellow/brown/grey slightly sandy slightly gravelly clay, sand fine to coarse, gravel sub angular to sub rounded fine to coarse of flint, chalk, and quartzite.	1.30 – 7.30	0.30 – 1.80
Glaciofluvial Deposits	Medium dense to dense light brown slightly gravelly sand/slightly sandy to sandy gravel/ sand and gravel. Sand fine to coarse, gravel sub angular to rounded fine to coarse of flint and quartzite.	0.80 – 6.70	2.30 – 9.20
London Clay Formation	Firm to stiff fissured brownish grey fissured clay. Fissures extremely to very closely spaced, planed and smooth.	> 13.8	1.90 – 15.50

Source: Bulls Lodge Phase 2 Ground Investigation Report (Table 4.1)

2.5 Groundwater

Groundwater monitoring was carried out on four boreholes across the site. Groundwater was found between 1.7m - 8m below existing ground level.

2.6 Hydrology

The nearest Main River to the site is Boreham Brook which flows in a westerly direction approximately 50m south of the site.

There is an unnamed watercourse which flows in a southerly direction within the Grove woodland to the west of the site.

2.7 Existing Drainage

2.7.1 Public Sewers

There are no known public sewers within the vicinity of the site.

2.7.2 Private Drainage

2.7.2.1 Surface Water

As the proposed development site is undeveloped it is not currently served by a surface water drainage system. It is understood that there was a historical land drainage system which crossed through the site draining the fields to the north, however this system was severed during the construction of the Bulls Lodge Substation.

The existing Bulls Lodge Substation site is served by a surface water drainage system, an as-built drainage layout drawing is included in Appendix A. The building and transformers are shown to drain to an attenuation pond prior to discharging at a restricted rate into Boreham Brook to the south of the site. The majority of the

stie is gravel surfacing which drains to ground, all access roads and parking areas drain into the gravel surfacing.

2.7.2.2 Foul Water

There are no foul drainage provisions within the proposed development site.

The adjacent existing Bulls Lodge Substation site is served by a 9000-litre cesspool which is located within the substation site boundary, see Appendix A.

2.8 Development Proposal

The proposed development aims to provide facilities to service the proposed Longfield Solar project currently being developed by EDF Renewables.

The main features of the proposed scheme are:

- construction of a GIS Building
- construction of 5 No. small buildings and containers
- construction of an access road connecting to the existing substation road and with a new access road onto the existing public road to the south of the site. 5 No. parking spaces will also be provided
- construction of equipment foundations, including GIS and AIS equipment and 2 No. landing gantries
- construction of a new drainage outfall to Boreham Brook to the south of the proposed site

General Arrangement Drainage Plan PDD-100504-LAY-104 shows the proposed drainage works and overall site layout.

3 Drainage Strategy

3.1 Design Guidance and Policy

The drainage strategy for the proposed development has been developed based on the following guidance:

- Essex County Council (ECC), The Sustainable Drainage Systems Design Guide for Essex[1];
- ECC, Sustainable Drainage Systems Design Guide[2] (SuDS Guide);
- ECC, SuDS Standing Advice Note[3];
- Generic Electricity Substation Design Manual for Civil, Structural and Building Engineering
  - Section 01 Oil Containment (TS 2.10.01);
  - Section 09 Site Drainage (TS 2.10.09);
- Flood and Water Management Act 2010[4];
- National Planning Policy Framework (NPPF)[5]; and
- The SuDS Manual (C753)[6].

3.2 Control of Surface Water Run-off

It should be acknowledged that the satisfactory collection, control, and discharge of surface water is now a principal planning and design consideration. This is reflected in the non-statutory National Sustainable Drainage System (SuDS) Standards.

In accordance with the drainage hierarchy contained within Part H of the Building Regulations 2015, surface water run-off from developments shall discharge to one of the following, listed in order of priority:

- Rainwater re-use (rainwater harvesting /greywater recycling), or where that is not reasonably practicable;
- An adequate soakaway or other adequate infiltration system, or where that is not reasonably practicable;
- A hybrid solution of infiltration and discharging to a water body, or where that is not reasonably practicable;
- A watercourse, or where that is not reasonably practicable;
- A surface water sewer or drain, or where that is not reasonably practicable;
- A combined water sewer.

It is necessary to identify the appropriate methods of controlling and discharging surface water from the site. Where possible, surface water run-off from the developed site will be drained in such a way as to mimic the natural drainage system and thereby implement a SuDS approach. The design should seek to improve the local run-off profile using systems that can either attenuate run-off and reduce peak flow rates or positively impact on the existing flood profile.

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[1] Essex County Council, The Sustainable Drainage Systems Design Guide for Essex. [Online]. Available at: https://www.essexdesignguide.co.uk/suds [Date Accessed: 29/07/2021].

[2] Essex County Council, Sustainable Drainage Systems Design Guide (2020). [Online]. Available at: https://www.essexdesignguide.co.uk/media/2404/suds_design_guide_2020.pdf [Date Accessed: 29/07/2021] .

[3] Essex County Council, SuDS Standing Advice Note. [Online]. Available at: http://planpub.eppingforestdc.gov.uk/NorthgatePublicDocs/00495215.pdf [Date Accessed: 29/07/2021].

[4] Flood and Water Management Act 2010 (2010). [Online]. https://www.legislation.gov.uk/ukpga/2010/29/introduction [Date Accessed: 29/07/2021].

[5] 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].

[6] CIRIA, The SuDS Manual (2015). [Online]. Available at: https://www.susdrain.org/resources/SuDS_Manual.html [Date Accessed: 29/07/2021].

3.2.1 Rainwater Re-use

As the site will not be manned, there will be a very limited and infrequent use of potable water on the site, therefore the use of a rainwater harvesting system is not deemed appropriate for the site.

3.2.2 Infiltration Based System

As outlined in Section 2.4, the ground conditions on site have been proven to be Alluvium and Glacial Deposits overlain London Boulder Clay. Given these observations of the known geology there is a possibility that an infiltration-based system may potentially be viable on the site.

During the ground investigations for the existing Bulls Lodge Substation site two rising head permeability tests were undertaken within the standpipe installations during the post fieldwork monitoring period within the Head Deposits/ Glacial Till and Glaciofluvial Deposits respectively. A permeability of $1.3x10^{-5}$m/s was recorded within the Head Deposits/ Glacial Till and $1.6x10^{-5}$m/s within the Glaciofluvial Deposits. It is noted that these results should be considered as indicative only due to the limited extent of testing and the variable nature of the materials.

However, three soakaway tests were also carried out at the location of the Bulls Lodge Substation, these tests were not completed due to 25% of the effective depth not being achieved.

Based on the current information and the variable results from infiltration tests it is considered that discharge via infiltration as the only form of surface water discharge does not have potential to be a viable method of surface water disposal on this site.

However, further intrusive investigations and site-specific testing to BRE365 is required to confirm the ground conditions and infiltration rates within the development site.

3.2.3 Hybrid System

Where a site has some infiltration capacity, but the infiltration rates are too low to meet formal infiltration requirements for the site ($1x10^{-6}$m/s), ECC in their role as LLFA may accept a well-designed hybrid solution, which uses low level infiltration for smaller rainfall events and a piped outfall for larger events.

Therefore, if an infiltration rate of $1x10^{-6}$m/s is confirmed for the proposed site then infiltration could be utilised for events up to the 1 in 5-year event, assuming 50% of the attenuation capacity of storage feature is available within 24 hours after a storm. Any event larger than the 1 in 5-year event would then discharge via a piped network at the 1 in 1-year greenfield runoff rate into the nearby Boreham Brook.

A hybrid drainage system is considered to be a viable solution for the site, depending on the results of infiltration tests.

3.2.4 Watercourses

Boreham Brook is located approximately 50m to the south of the site across agricultural land. Therefore, if an infiltration-based system or hybrid system is not deemed a viable method of discharging surface water from the site then discharging all the surface water runoff directly to a watercourse by gravity is considered to be a viable solution.

3.2.5 Surface Water Drain

There is no known existing drainage system within the development site. The surface water runoff from the existing Bulls Lodge Substation site discharges into Boreham Brook via a 150mm diameter pipe which was installed for that development.

The existing drainage system for the Bulls Lodge Substation is shallow and it is not viable to discharge from the proposed site into the existing drainage system via gravity, therefore the option of connecting into the existing network has not been considered further.

3.3 Climate Change

The Environment Agency requires, in accordance with the Government's PPG-TG document, that there should be no increase in the rate of surface water emanating from a newly developed site above that of any previous development. Furthermore, it is the joint aim of the Environment Agency and Local Planning Authorities, to actively encourage a reduction in the discharge of storm water as a condition of Approval for new developments. In addition, all drainage systems should be sized to accommodate the runoff arising from a 1 in 100-year rainfall event and should include a further allowance to account for the further effects of climate change.

Table 3.1 below, shows the anticipated increases in rainfall intensities with time, and has been reproduced in part from Table 4 of PPG-TG.

Table 3.1: Peak Rainfall Intensity Allowance

Parameter	Allowance Category	2015 to 2039	2040 to 2069	2070 to 2115
Peak Rainfall Intensity	Central	5%	10%	20%
Peak Rainfall Intensity	Upper	10%	20%	40%

Source: PPG-TG

The development has a proposed design life of 40-years, which if constructed this year will be until 2061.

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).

3.4 Proposed Surface Water Drainage Strategy

3.4.1 Contributing Areas

The proposed site for the Bulls Lodge Substation expansion covers an area of 1.525ha.

The site will consist of a GIS building, access roads and associated car parking facilities. The remainder of the site will be covered in a permeable stone surfacing. Table 3.2 below provides an overview of the contributing areas.

Table 3.2: Substation Areas

Parameter	Area (m^2)	Area (Ha)	Percentage Area (%)
Impermeable surfaces	**3,600**	**0.360**	**23.6**
- Building roofs	1,600	0.160	10.5
- Access roads and parking areas	2,000	0.200	13.1
Permeable surfaces	**11,650**	**1.165**	**76.4**
Total site	**15,250**	**1.525**	**100**

Source: Mott Macdonald

The stone surfacing will be laid in accordance with National Grid Design Standards and will be constructed of a minimum 300mm deep unbound free draining subbase and a minimum 75mm top layer of stone chippings which will allow storage of storm water until it can infiltrate into the surrounding soil. The sides of the soakaway basin have not been taken into account when calculation the surface area for soil infiltration.

As per the National Grid guidance TS 2.10.09 all access roads and car parking areas will have sufficient cross fall to drain into the adjacent stone surfacing.

Therefore, the only area of the site which will need to be 'positively' drained is the roof area.

3.4.2 Proposed Surface Water Discharge Rate

As noted previously, the site is currently undeveloped and does not benefit from a positive drainage system so should be considered as a greenfield site.

The ground investigations including infiltration tests which were undertaken prior to construction of the existing Bulls Lodge Substation site were inconclusive with regards to determining an infiltration rate.

A conservative infiltration rate of $1x10^{-7}$m/s has been assumed for the ground on the site, which is too slow to meet formal infiltration requirements but could be used as part of a hybrid system which incorporates low level infiltration for smaller rainfall events and a piped outfall for larger events.

In line with ECC guidance the surface water discharge rate from the site for rainfall events larger than the 1 in 5-year event should be limited to the 1 in 1-year greenfield runoff rate for all events up to and including the 1 in 100-year rainfall event with an allowance for climate change.

Based on the proposed site boundary the total area of the site is 1.525ha. The site will either be covered in impermeable surfacing (roof areas or access roads/car parking) or gravel, it is proposed that the gravel area will be utilised as the attenuation volume for the site so the overall contributing area will be the entire site. Therefore, assuming a contributing area of 1.525ha and using ICOP SuDS method, using an estimated SOIL coefficient of 0.3 the 1 in 1-year greenfield runoff rate for the developed site is estimated to be 1.9l/s.

Outputs from these calculations are included in Appendix B.

It is proposed that a hybrid system is provided on site, where any rainfall for events up to and including the 1 in 5-year return period discharge via infiltration, the piped outfall will be set to a level above this to discharge the surface water runoff for events up to and including the 1 in 100 year plus 20% for climate change events and the discharge rate limited to 1.9l/s.

3.4.3 Proposed Attenuation Volume

The proposed attenuation volume will be provided on site within the unbound free draining subbase beneath the stone chippings, the areas beneath the buildings and access roads have been discounted as providing attenuation volume. To allow for future expansion of the site and foundations the plan area of the available subbase which can be utilised on site has been determined by calculating the proposed impermeable area (0.36ha) and multiplying by 20% to allow for creep, therefore the effective plan area of the attenuation has been calculated as 1.09ha.

For the attenuation calculations it has been assumed that a hybrid system is installed as per Section 3.4.2 with an infiltration rate of $1x10^{-7}$m/s through the base area and a piped outlet system limited to 1.9l/s above the 1 in 5-year water level. Based on the entire site (1.525ha) draining into the system and an effective attenuation area of 1.09ha it has been calculated that an approximate attenuation volume of 1160m^3 will be required to attenuate the surface water runoff for events up to and including the 1 in 100 year plus 20% for climate change event.

Based on a 30% void ratio within the subbase it has been calculated that the 1160m^3 storage requirement can be this provided within a subbase of 360mm depth. However, to be conservative it has been assumed that the depth of the subbase will be 600mm at this design stage, this will be reviewed at the next design stage and on completion of infiltration testing.

It has been calculated that for the 1 in 5-year return period (plus a 20% allowance for climate change) an attenuation volume of approximately 580m^3 would be required, which would be accommodated within a subbase depth of 177mm. Therefore, it is proposed that the piped outlet would be set at 180mm above the invert level of the subbase.

To ensure that all attenuation areas are hydraulically linked and not isolated by the proposed substation road it is proposed that pipework is installed across the road at 180mm above the invert level of the subbase to enable the free flow of water between attenuation areas. The number and location of crossings and diameter of pipework will be confirmed at the detailed design stage.

The LLFA require that 50% of the storage is available within 24 hours of a 1 in 30-year storm event plus climate change. If it is not possible to have a half drain time of less than 24 hours the LLFA expects that the feature is capable of storing a 1 in 30-year storm event plus climate change and subsequent 1 in 10-year event. The proposed system is capable of storing a 1 in 30-year storm event plus climate change and subsequent 1 in 10-year event.

Outputs from these calculations are included in Appendix C.

3.4.4 Land Drainage

Due to the proposed changes in ground level across the site and the natural drainage of the area, it is assessed that land drainage will be required along the north and western boundary of the proposed substation site. The land drains will be located outside of the operational perimeter of the substation to facilitate access for maintenance. The land drainage will be lined with an impermeable membrane to ensure that only Greenfield runoff is captured from the areas outside of the proposed substation.

The land drains, along with the controlled runoff from the site will discharge via gravity pipework to Boreham Brook to the south of the site via a new headwall structure.

The rate or volume of flow from the land drainage has not been estimated at this stage. For that, confirmation of the catchment and relative Greenfield runoff flows will be determined during detailed hydraulic modelling.

3.5 Water Quality

The proposed development will not be a manned facility, with only occasional maintenance visits and, as such will not, be heavily trafficked. As such there will be no significant discharge of contaminants emanating from the development site apart from the standby generator with associated fuel tank.

The fuel tank will be double skinned and therefore incorporates its own oil containment bund. The bund will have sufficient capacity to contain the full capacity of the fuel tank itself pus an extra 50%, as per National Grid Specification TS 2.10.01 Appendix B.

The only risk of pollution will therefore be during the occasional delivery of fuel to refill the generator fuel tank. During the delivery an inflatable storage bund with a minimum storage capacity of 7500L will be laid out for the fuel tanker to be stationed on before being inflated prior to the fuel delivery, enabling spill capture. All fuel deliveries will be supervised, however, should there be a pollution incident during the fuel delivery, there is a stop valve on the tanker to stop the flow of fuel. Any spilled fuel will be contained within the temporary inflatable bund and the procedure for use of the spill kit will be followed. The delivery tankers carry spill kits,

and the substation will have a permanent spill kit on site. Spill kits will absorb the fuel so that is can be safely disposed offsite by a licensed Contractor.

3.6 Exceedance Events

The proposed development will not significantly 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 to the south of the site towards Boreham Brook.

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

3.7 Proposed Foul Water Drainage Strategy

The proposed development will not include welfare facilities. Welfare facilities within the existing Bulls Lodge substation will be used when personnel are on site and therefore no foul water drainage is proposed as part of the proposed development.

4 Conclusion

The proposed expansion of the Bulls Lodge Substation is to be constructed on a currently undeveloped greenfield site. The site covers an area of 1.525ha.

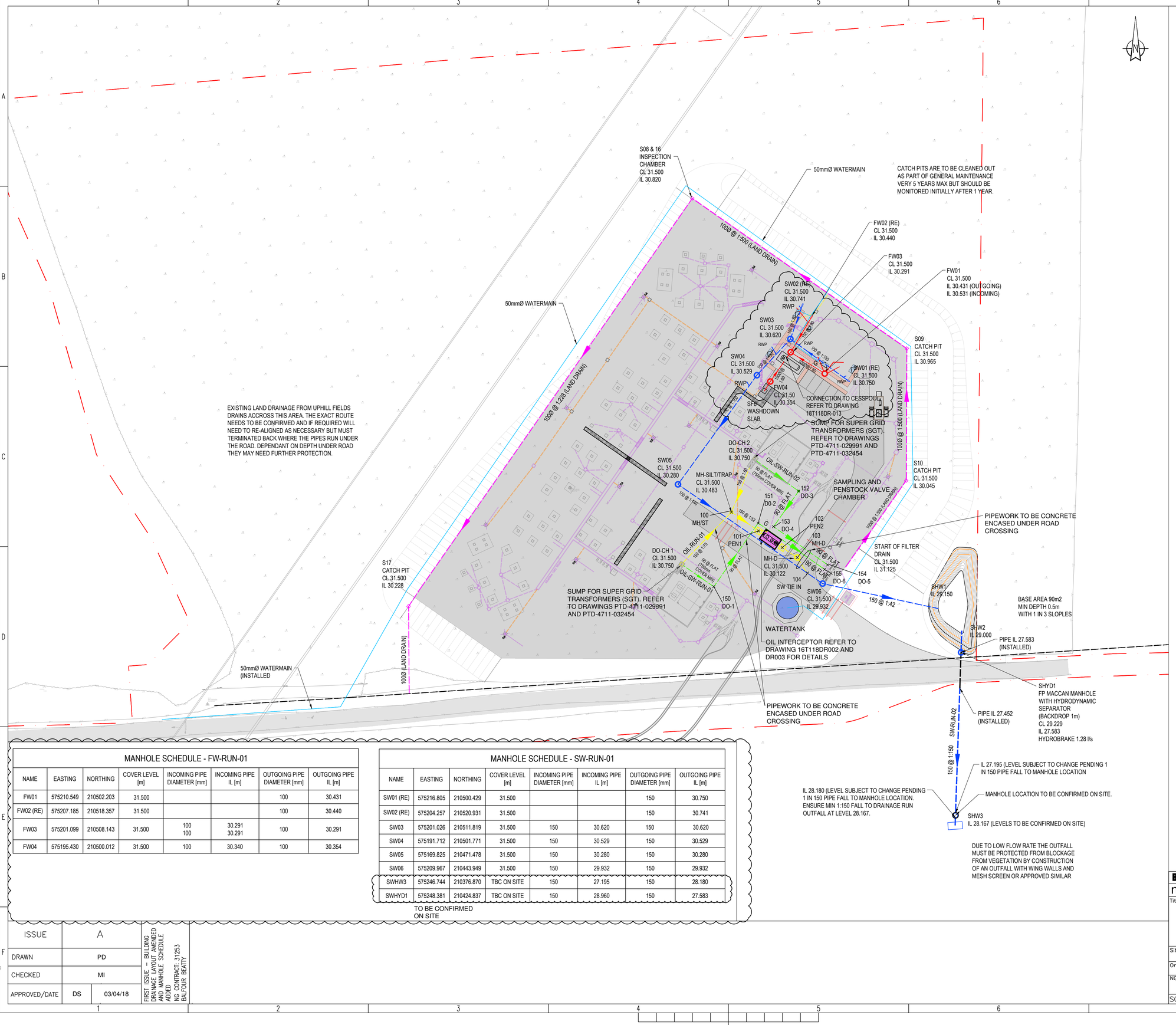
As the ground conditions are not favourable for a complete infiltration system and in line with the ECC guidance it is proposed that a hybrid system is provided on site. Any rainfall for events up to and including the 1 in 5-year return period will discharge via infiltration, and there will be a piped outfall set to a level above this to discharge the surface water runoff for events up to and including the 1 in 100 year plus 20% for climate change events with the discharge rate limited to 1.9l/s (the 1 in 1-year greenfield runoff rate).

The proposed attenuation volume (1160m^3) will be provided on site within the unbound free draining subbase beneath the stone chippings, the areas beneath the buildings and access roads have been discounted from providing attenuation volume. This SuDS system provides attenuation and water quality benefits and is also utilising the subbase for the site which is required anyway so does not require additional materials to be excavated on site or brought onto site.

It is proposed that a land drain is installed around the perimeter of the site to intercept any surface water runoff from adjacent land. It is proposed that this will discharge into the new surface water system downstream of the flow control device and attenuation.

The provisions for surface water proposals for the site will need to be agreed with the local authority.

A. Existing Drainage Layout



MANHOLE SCHEDULE - FW-RUN-01

NAME	EASTING	NORTHING	COVER LEVEL [m]	INCOMING PIPE DIAMETER [mm]	INCOMING PIPE IL [m]	OUTGOING PIPE DIAMETER [mm]	OUTGOING PIPE IL [m]
FW01	575210.549	210502.203	31.500			100	30.431
FW02 (RE)	575207.185	210518.357	31.500			100	30.440
FW03	575201.099	210508.143	31.500	100 100	30.291 30.291	100	30.291
FW04	575195.430	210500.012	31.500	100	30.340	100	30.354

MANHOLE SCHEDULE - SW-RUN-01

NAME	EASTING	NORTHING	COVER LEVEL [m]	INCOMING PIPE DIAMETER [mm]	INCOMING PIPE IL [m]	OUTGOING PIPE DIAMETER [mm]	OUTGOING PIPE IL [m]
SW01 (RE)	575216.805	210500.429	31.500			150	30.750
SW02 (RE)	575204.257	210520.931	31.500			150	30.741
SW03	575201.026	210511.819	31.500	150	30.620	150	30.620
SW04	575191.712	210501.771	31.500	150	30.529	150	30.529
SW05	575169.825	210471.478	31.500	150	30.280	150	30.280
SW06	575209.967	210443.949	31.500	150	29.932	150	29.932
SWHW3	575246.744	210376.870	TBC ON SITE	150	27.195	150	28.180
SWHYD1	575248.381	210424.837	TBC ON SITE	150	28.960	150	27.583

TO BE CONFIRMED ON SITE

ISSUE	A	
DRAWN	PD	
CHECKED	MI	
APPROVED/DATE	DS	03/04/18

FIRST ISSUE - BUILDING DRAINAGE LAYOUT AMENDED AND MANHOLE SCHEDULE ADDED. NG CONTRACT: 31253 BALFOUR BEATTY

16T118DR129

Designer's Site Specific Risk Assessment

By: RB | Date: 21/03/2018

☐ No works associated with this drawing

HAZARDS

☐ Working at height ☐ Unusual Access ☐ Site fabrication/drilling ☒ Excavation

Interfaces: ☐ Public ☒ Operatives ☒ Vehicle/Plant

WHO COULD BE HARMED?	CONTROL MEASURES
☒ Construction operatives	☐ Existing work instruction
☐ Dismantling crew	☐ Method detailed on drawing
☐ Future maintenance crew	☒ Method detailed on separate document
☐ Public	

TEMPORARY WORKS

☒ No temporary works required
☐ Temporary works required and documented separately
☐ Drawing contains temporary works:

0	Generic or proprietary solution
1	Specific basic design
2	Specific design
3	High risk or specialist design

} Complete temporary works design check certificate: DE-SF-081

Red — OK to proceed providing specific design hazards and risks have been recognised, acknowledged and understood by the operation team. Site operatives may require additional instruction/training

Amber — OK to proceed as detailed in existing work instruction or procedure detailed on drawing or separate document.

Green — OK to proceed, no significant design hazards and risks, standard control measures apply.

CDM REGULATIONS RESIDUAL RISKS

Design based hazards are actively eliminated where possible. Where hazards cannot be eliminated, this symbol along with an attached note will identify the hazard and indicate that an action is required by the person supervising the works to manage the design hazard during construction.

Other than those noted, we are not aware of any further residual design risks apart from those that a competent contractor would ordinarily consider.

Notes

1. ALL DIMENSION IN METERS UNLESS SPECIFIED OTHERWISE.
2. THIS DRAWING IS TO BE READ AND PRINTED IN COLOUR
3. COVERS ASSOCIATED WITH DRAINAGE BE PAINTED IN THE FOLLOWING COLOURS:
   SURFACE WATER BLUE (RAL 5015 TO BS 4800)
   FOUL WATER RED (RAL 3000 TO BS 4800)
   OIL CONTAINMENT BLUE (RAL 5015 TO BS 4800)
   POTABLE WATER BLUE (RAL 5015 TO BS 4800)
4. THIS DRAWING IS TO READ IN CONJUNCTION WITH 16T118DR002 AND DR003.
5. FOR CESSPOOL INVERT LEVELS REFER TO DRAWING 18T118DR-013.
6. FOR DRAINAGE DETAILS REFER TO DRAWING 16T118DR125.
7. FOR SGT BUND DETAILS REFER TO DRAWINGS PTD-4711-029991 AND PTD-4711-032454.
8. FOR DETAILS OF OILY WATER AND INTERCEPTOR REFER TO DRAWING 16T118DR003.
9. ALL PIPES CROSSING UNDER ROADS TO BE CONCRETE ENCASED. REFER TO DRAINAGE DETAILS DRAWING 16T118DR125.

LEGEND

- SURFACE WATER PIPEWORK
- SURFACE WATER PIPEWORK (INSTALLED)
- LAND DRAINAGE
- FOUL SEWER
- SGT DRAW OFF PIPEWORK (PIPE WORK TO MAINTAIN MINIMUM OF 750mm COVER FROM PLATFORM LEVEL)
- OIL PIPEWORK
- WATERMAIN
- DUCTS AND CABLES
- EARTHING

Point Table

Point #	Raw Description	Easting	Northing
100	MH/ST	575184.6716	210463.7863
101	PEN1	575192.173	210458.556
102	PEN2	575198.777	210453.952
103	MH-D	575202.9358	210451.1887
104	SW TIE IN	575205.7849	210446.8716
150	DO-1	575179.772	210443.084
151	DO-2	575192.087	210460.749
152	DO-3	575203.3117	210469.6108
153	DO-4	575196.3661	210459.7496
154	DO-5	575211.3647	21449.1376
155	DO-6	575210.5069	210447.9072

Balfour Beatty

nationalgrid National Grid plc, Warwick Technology Park, Gallows Hill, Warwick, CV34 6DA

Title

BULLS LODGE SUBSTATION DRAINAGE LAYOUT

Site	BULLS LODGE	A1
Originator Drawing Number	16T118DR129	CAD
NG Drawing Number	18/BB/0214	Sheet No. 1 / No. of Sheets 1 / ISSUE A

SCALE:– 1:500

B. Greenfield Runoff Calculation

ICP SUDS Mean Annual Flood

Input

Return Period (years) 1 SAAR (mm) 592 Urban 0.000
Area (ha) 1.525 Soil 0.300 Region Number Region 6

Results l/s

QBAR Rural 2.3
QBAR Urban 2.3

Q1 year 1.9

Q1 year 1.9
Q30 years 5.2
Q100 years 7.3

C. Attenuation Volume Calculation

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

Half Drain Time : 2179 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.129	0.129	3.6	0.0	3.6	422.2	Flood Risk
30 min Summer	0.170	0.170	3.6	0.0	3.6	554.5	Flood Risk
60 min Summer	0.212	0.212	3.6	0.3	3.9	692.5	Flood Risk
120 min Summer	0.254	0.254	3.6	1.0	4.6	831.2	Flood Risk
180 min Summer	0.278	0.278	3.6	1.2	4.8	908.9	Flood Risk
240 min Summer	0.294	0.294	3.6	1.3	4.9	960.1	Flood Risk
360 min Summer	0.313	0.313	3.6	1.4	5.0	1024.4	Flood Risk
480 min Summer	0.326	0.326	3.6	1.5	5.1	1067.6	Flood Risk
600 min Summer	0.335	0.335	3.6	1.5	5.2	1096.8	Flood Risk
720 min Summer	0.342	0.342	3.6	1.6	5.2	1117.0	Flood Risk
960 min Summer	0.349	0.349	3.6	1.6	5.2	1139.9	Flood Risk
1440 min Summer	0.351	0.351	3.6	1.6	5.3	1146.1	Flood Risk
2160 min Summer	0.344	0.344	3.6	1.6	5.2	1124.3	Flood Risk
2880 min Summer	0.336	0.336	3.6	1.5	5.2	1099.1	Flood Risk
4320 min Summer	0.319	0.319	3.6	1.4	5.1	1043.8	Flood Risk
5760 min Summer	0.302	0.302	3.6	1.3	5.0	986.9	Flood Risk
7200 min Summer	0.285	0.285	3.6	1.2	4.8	933.0	Flood Risk
8640 min Summer	0.270	0.270	3.6	1.1	4.7	882.4	Flood Risk
10080 min Summer	0.256	0.256	3.6	1.0	4.6	835.7	Flood Risk
15 min Winter	0.129	0.129	3.6	0.0	3.6	422.2	Flood Risk
30 min Winter	0.170	0.170	3.6	0.0	3.6	554.4	Flood Risk
60 min Winter	0.212	0.212	3.6	0.3	3.9	692.4	Flood Risk
120 min Winter	0.254	0.254	3.6	1.0	4.6	831.5	Flood Risk
180 min Winter	0.278	0.278	3.6	1.2	4.8	909.5	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	111.449	0.0	305.4	19
30 min Summer	73.399	0.0	311.8	34
60 min Summer	46.096	0.0	607.5	64
120 min Summer	27.998	0.0	647.3	124
180 min Summer	20.648	0.0	664.8	184
240 min Summer	16.541	0.0	677.8	244
360 min Summer	12.020	0.0	695.6	362
480 min Summer	9.590	0.0	708.8	482
600 min Summer	8.043	0.0	718.7	602
720 min Summer	6.963	0.0	726.0	722
960 min Summer	5.542	0.0	735.8	962
1440 min Summer	4.011	0.0	736.2	1440
2160 min Summer	2.898	0.0	1363.4	1796
2880 min Summer	2.299	0.0	1342.9	2160
4320 min Summer	1.656	0.0	1277.0	2944
5760 min Summer	1.311	0.0	1917.3	3800
7200 min Summer	1.093	0.0	1992.9	4608
8640 min Summer	0.942	0.0	2043.1	5448
10080 min Summer	0.831	0.0	2046.6	6248
15 min Winter	111.449	0.0	305.4	19
30 min Winter	73.399	0.0	311.8	34
60 min Winter	46.096	0.0	607.5	64
120 min Winter	27.998	0.0	647.4	122
180 min Winter	20.648	0.0	664.8	182

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
240 min Winter	0.294	0.294	3.6	1.3	4.9	961.1	Flood Risk
360 min Winter	0.314	0.314	3.6	1.4	5.0	1026.0	Flood Risk
480 min Winter	0.327	0.327	3.6	1.5	5.1	1069.7	Flood Risk
600 min Winter	0.336	0.336	3.6	1.5	5.2	1099.7	Flood Risk
720 min Winter	0.343	0.343	3.6	1.6	5.2	1120.8	Flood Risk
960 min Winter	0.350	0.350	3.6	1.6	5.3	1145.7	Flood Risk
1440 min Winter	0.354	0.354	3.6	1.6	5.3	1157.1	Flood Risk
2160 min Winter	0.346	0.346	3.6	1.6	5.2	1130.9	Flood Risk
2880 min Winter	0.336	0.336	3.6	1.5	5.2	1100.2	Flood Risk
4320 min Winter	0.315	0.315	3.6	1.4	5.0	1029.9	Flood Risk
5760 min Winter	0.292	0.292	3.6	1.3	4.9	954.4	Flood Risk
7200 min Winter	0.270	0.270	3.6	1.1	4.7	882.2	Flood Risk
8640 min Winter	0.250	0.250	3.6	0.9	4.6	816.0	Flood Risk
10080 min Winter	0.232	0.232	3.6	0.6	4.3	757.4	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
240 min Winter	16.541	0.0	677.6	240
360 min Winter	12.020	0.0	695.3	358
480 min Winter	9.590	0.0	708.3	474
600 min Winter	8.043	0.0	718.0	590
720 min Winter	6.963	0.0	725.2	708
960 min Winter	5.542	0.0	734.7	934
1440 min Winter	4.011	0.0	734.6	1384
2160 min Winter	2.898	0.0	1361.6	1988
2880 min Winter	2.299	0.0	1341.2	2244
4320 min Winter	1.656	0.0	1276.3	3156
5760 min Winter	1.311	0.0	1917.4	4040
7200 min Winter	1.093	0.0	1993.1	4968
8640 min Winter	0.942	0.0	2043.5	5792
10080 min Winter	0.831	0.0	2046.5	6664

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	1.000
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	19.000	Shortest Storm (mins)	15
Ratio R	0.395	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 1.525

Time (mins) From:	To:	Area (ha)
0	4	1.525

Model Details

Storage is Online Cover Level (m) 0.400

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.00180 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	10900.0	10900.0	0.400	10900.0	10900.0

Orifice Outflow Control

Diameter (m) 0.045 Discharge Coefficient 0.600 Invert Level (m) 0.180

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