Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Outline Operational Drainage Strategy (Revision B) (Clean Version)

Revision B
March 2023
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Title: **Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects** **DCO Application** **Outline Operational Drainage Strategy (onshore substation) (Revision B) (Clean Version)**		
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Prepared by:		
J. Murphy & Sons Limited		
Approved by:	Date:	
Sheery Atkins, Equinor	March 2023	

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Glossary of Acronyms

AOD	Above Ordnance Datum
BS	British Standard
DCO	Development Consent Order
DEL	Dudgeon Extension Limited
DEP	Dudgeon Offshore Wind Farm Extension Project
EIA	Environmental Impact Assessment
ES	Environmental Statement
HDD	Horizontal Directional Drill
HVAC	High-Voltage Alternating Current
Km	Kilometre
NG	National Grid
ODS	Outline Drainage Strategy
SEL	Scira Extension Limited
SEP	Sheringham Shoal Offshore Wind Farm Extension Project

Glossary of Terms

Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
Onshore export cables	The cables which would bring electricity from the landfall to the onshore substation. 220 – 230kV.
Onshore Substation	Compound containing electrical equipment to enable connection to the National Grid.
Outline ODP	Outline Operational Drainage Plan
Order limits	The area subject to the application for development consent, including all permanent and temporary works for SEP and DEP.
Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
The Applicant	Equinor New Energy Limited

1 OUTLINE OPERATIONAL DRAINANGE STRATEGY (ONSHORE SUBSTATION)

1.1 Background

1. Equinor New Energy Limited ('the Applicant') is seeking a Development Consent Order (DCO) for the Sheringham Shoal Offshore Wind Farm Extension Project (SEP) and Dudgeon Offshore Wind Farm Extension Project (DEP) (hereafter collectively referred to as 'the Project' or 'SEP and DEP').
2. As the owners of SEP and DEP, Scira Extension Limited (SEL) and Dudgeon Extension Limited (DEL) are the named undertakers that have the benefit of the DCO. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of SEL and DEL as the undertakers of SEP and DEP.
3. The SEP and DEP wind farm sites are located in the southern North Sea, 15.8 kilometres (km) and 26.5km from the coast respectively at their closest point. SEP and DEP will be connected to the shore by offshore export cables to a landfall point at Weybourne, on the North Norfolk coast. From there onshore export cables will transport power over approximately 60km to a new high voltage alternating current (HVAC) onshore substation near the existing Norwich Main substation. The onshore substation will be constructed to accommodate the connection of both SEP and DEP to the transmission grid. A full project description is given in the Environmental Statement (ES), **Chapter 4 Project Description** (document reference 6.4).

1.2 Introduction

4. This Outline Operational Drainage Strategy (ODS) forms part of a set of documents that support the DCO application submitted by the Applicant to the Planning Inspectorate for consent to construct and operate the Project.
5. This Outline ODS is provided as part of the DCO application to define the basis of design for the operational drainage required at the onshore substation site associated with SEP and DEP.
6. A final ODS will be produced prior to construction of SEP and DEP and will be in accordance with the content of this Outline ODS and the final design of the Project. The ODS is secured by Requirement 17 of the **Draft DCO** (document reference 3.1), which states:

> *"In the event of scenario 1 or scenario 2, each of Work Nos. [15A and 15B] must not commence until a written plan for drainage during operation of the relevant work, has been submitted to and approved by the relevant planning authority, following consultation with the relevant sewerage and drainage authorities, lead local flood authority and the Environment Agency.*
>
> *In the event of scenario 3 or scenario 4, Work No. [15C] must not commence until a written plan for drainage during operation of the relevant work, has been submitted to and approved by the relevant planning authority, following consultation with the relevant sewerage and drainage authorities, lead local flood authority and the Environment Agency.*

Each operational drainage plan must accord with the principles for the relevant work set out in the outline operational drainage plan, and must include a timetable for implementation.

Each operational drainage plan must be implemented as approved"

7. This Outline ODS should be read in conjunction with the other following documents:

- Flood Risk Assessment (Appendix 18.2 to **ES Chapter 18 Water Resources and Flood Risk** (document reference 6.18)); and
- Onshore Substation Drainage Strategy (Annex 1 to the Flood Risk Assessment described above).

8. The Onshore Substation Drainage Strategy (Rev B) concluded that drainage at the onshore substation site would be managed with attenuation combined with infiltration.

9. It has been conservatively assumed that half of the total substation platform will be impermeable. An area of 30,500m^2 has therefore been adopted. Preliminary substation layouts indicate the actual impermeable area will be less than 50%.

10. To provide a worst-case the longest potential access road that could be accommodated at the site has been adopted. The impermeable surface has been taken as the 6.0m wide bitumen bound running surface over the full length of the road from where it ties into the existing National Grid (NG) access road, an area of 4,500m^2 has been adopted.

11. The bridleway midway along the access road is the highest elevation. It is anticipated water from the access road south of the bridleway will be collected in a filter drain running south along the road verge and tie into a catch pit immediately upstream of the oil separator.

12. North of the bridleway two options are possible. Option 1 collects water from the access road in a filter drain, running north along the road verge, connecting into an oil separator before passing under the existing NG access road and connecting into the existing NG substation site drainage for discharge through their outfall. Alternatively, Option 1 could have an independent outfall, which discharges into the same location as NG's existing outfall but does not require any connection into NG's existing drainage system.

13. NG's drainage system (or outfall location) would need to accommodate water drained from approximately 2,340m^2 of access road that runs north of the bridleway. As a worst-case scenario, if a 1 in 5 year storm is considered for a 5 minute period then the NG system would need to accommodate an additional 78.6 l/s and 23.5m^3 over a 5 minute period. Paved areas under 4,000m^2 can be designed using a flat rate of rainfall method to BS EN 16933-2. Refer to **Appendix B** for calculations associated with anticipated surface water run off flows/volumes for the section of access road north of the bridleway.

14. Option 2 collects water from the access road in a filter drain which runs to the south towards to the new substation drainage system; to accommodate the changes in elevation the drain will need to be laid at a deeper elevation.

1.3 Infiltration

1.3.1 Basis of outline design

15. Soakaway testing undertaken in trial pits during the Phase 1 ground investigations reported very low permeability rates which suggested an infiltration solution may not be possible.

16. To explore the full potential of a drainage solution by infiltration a Geophysical survey was undertaken in the substation field and in surrounding fields as shown in Figure 1:

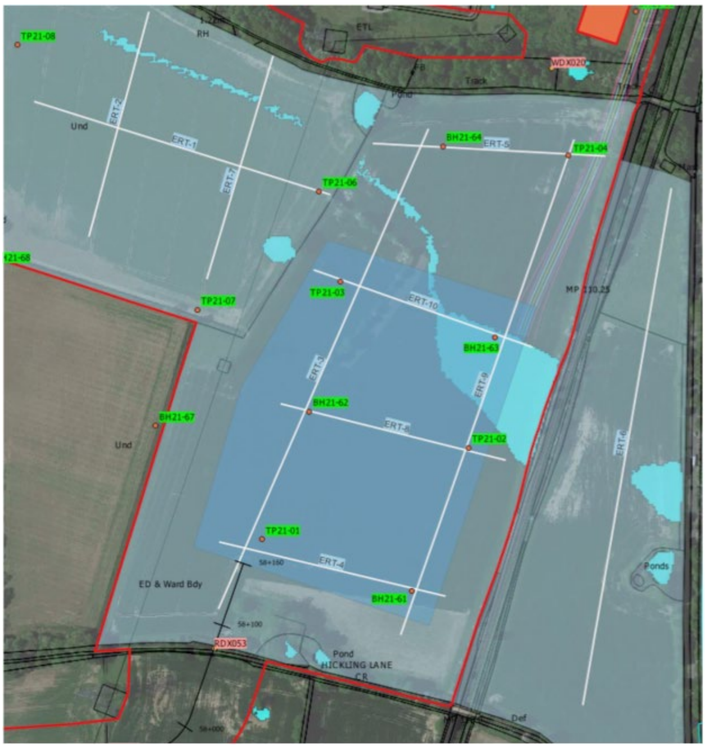

Figure 1 – Extent of Geophysical Survey

Key to Figure 1: Transparent Light Blue Shade = Electromagnetic Survey Area

White Lines = Electrical Resistivity Survey

17. The results of the survey identified a historic river channel that had been infilled with granular deposits to a depth of approximately 10m as shown by the brown polygon in Figure 2 below:

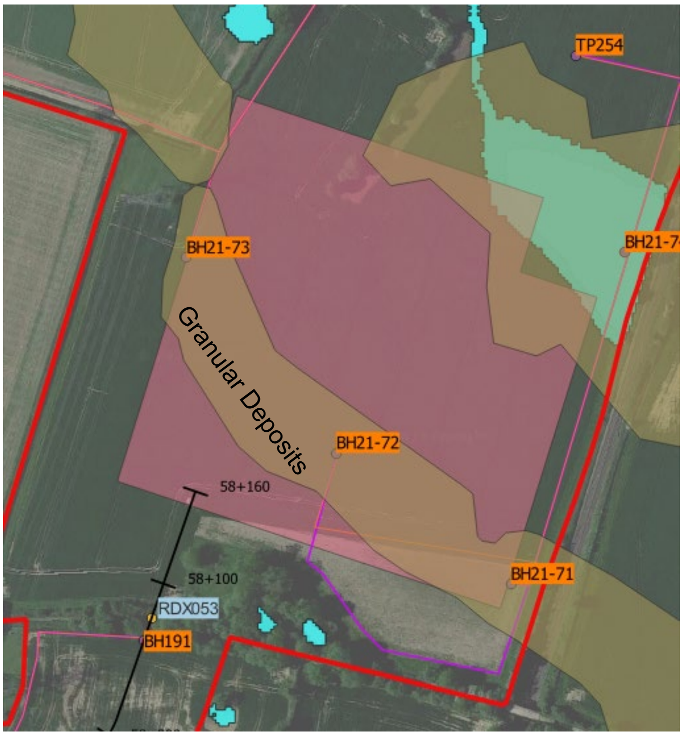

Figure 2 – Area Indicating Granular Deposits (Brown)

18. As part of Phase 2 ground investigation, three boreholes BH21-71, BH21-72 & BH21-73 shown in Figure 2 were bored to ground truth the geophysical surveys. Each borehole had a groundwater monitoring installation which monitors the granular horizon. In each borehole falling head permeability tests along with borehole soakaway tests in groundwater monitoring installations were undertaken to determine ground permeability and infiltration rates. The results from these tests will be used to calculate the soakaway storage volumes for the substation platform.

19. The footprint of the substation will be approximately 6.1Ha. Figure 3 below shows the footprint. This footprint accommodates a substation orientated either north-south or east-west.

Figure 3 – Substation Footprint

20. The anticipated volume of water to be managed during 1 in 100 year flood event over the substation and access road surface area has been calculated using Tekla® Tedds software which is based on the methods outlined in BRE Digest 365 and the Wallingford Procedure (Volume 4). Rainfall parameters in Tedds are based on those stated in the Wallingford Procedure.

21. A 45% allowance for climate change has been allowed and a conservative soil infiltration rate of $1x10^{-4}$ m/s has been used. Actual permeability rates recorded during soakaway tests ranged from $4.84x10^{-4}$ m/s to $5.4x10^{-4}$m/s.

22. It has been assumed 50% of the substation access road and platform surface area is impermeable and will accumulate water during the storm event.

23. A soakaway design has been developed and a required storage volume calculated to manage surface water from the substation and access road. Please refer to **Appendix A** for the soakaway volume calculation and drawing C282-MU-Z-XD-00118-01_F03 for the soakaway layout and cross section included in **Appendix C**.

24. Secondary verification of the calculations undertaken in Tekla® Tedds has been undertaken by RHDHV using MicroDrainage. Two verification scenarios have been analysed as follows:

25. Option 1 is in accordance with BRE 365 and NCC LLFA Statutory Consultee for Planning Guidance Document, Version 6.1. The results from this option are in general agreement with the Tekla® Tedds output with slight differences in the rainfall parameters. An additional total storage volume of 320m^3 above the total volume indicated by Tekla® Tedds is indicated to be required. This larger volume has been included in the design and is shown on drawing C282-MU-Z-XD-00118-01_F03.

26. Option 2 is not in compliance with BRE365 and proposes a 50% reduction in the base infiltration coefficient and a global factor of safety of 2, the results of this analysis indicate that the storage volume could be reduced to 1073m^{3}, an overall reduction of 352.5m^{3}. Following development of the substation layout and drainage maintenance plan this option will be given greater consideration at detailed design.

27. The results of the RHDHV analysis are included as **Appendix C.**

1.3.2 Description of solution

28. The soakaway solution works by collecting the surface water drainage in a modular crate system, buried under the platform. The outfall drainage pipe is connected to the inlet of the soakaway crates and water is allowed to accumulate in the voids that exist within the crates. At the same time as water accumulates, it is also infiltrated into the surrounding ground as all sides of the crates are open. The crates are sized to ensure the open voids that exist within them have sufficient volume to accommodate the water that will accumulate during a 1 in 100 year storm event whilst taking consideration of infiltration rates.

29. Initial sizing of the soakaway volume is based on an assumed soil infiltration rate of $1x10^{-4}$ m/s however initial results from the site tests indicate the expected infiltration rate will be higher at a value closer to $5x10^{-4}$ m/s, which means the soakaway crate volume will be on the conservative side.

30. Soakaway testing to BRE Digest 365 will be required once the substation platform is constructed to confirm the initial results and assumptions used in the design are acceptable.

31. Pollution control will be managed by incorporating a class 1 oil separator upstream of the soakaway crate inlet. Class one separators are designed to achieve a concentration of less than 5mg/l of oil under standard test conditions and are suitable for discharging to the environment. Any water collected from car parks, access roads and hard standing areas with potential for oil contamination will be required to connect into the oil separator before flowing into the soakaway.

32. In a storm event, water collected from roof tops may bypass the oil separator and connect downstream into the next catch pit before flowing into the soakaway.

33. The platform level is 28.23m Above Ordnance Datum (AOD). The finished ground level (formation level) following any earthworks is 475mm lower at 27.775m AOD. It is anticipated that the soakaway crates will be buried with a minimum cover of 1.2m to platform level to ensure any vehicles/equipment located above do not adversely impact the structure.

34. To ensure heavy loads (from transformers etc) are not directly located above the soakaway units, they will be positioned adjacent to (and within) the site boundary limits where there is higher potential for an access road to be located once the final site layout is confirmed. To maintain the required soakaway volume and keep to the site boundary limits, the soakaway crates have been positioned on the east and west sides of the site. The drainage design within the substation will ensure 50% of water collected is routed to the east soakaway and 50% to the west. A single soakaway may be possible once substation layouts have been confirmed later in the Project.

35. Access will be maintained to all catch pits located upstream of the soakaway to ensure any silt/deposits can be removed as part of a maintenance programme. Access will be maintained to the oil separator unit so routine maintenance can be performed. A detailed maintenance plan will be developed during detailed design once the drainage design is finalised.

36. An indicative layout of the soakaway design and upstream treatment is indicated on drawing C282-MU-Z-XD-00118-01_F03. Included in **Appendix D.**

Appendix A – Soakaway Volume Calculations

SOAKAWAY DESIGN

In accordance with BRE Digest 365 - Soakaway design

Tedds calculation version 2.0.04

Design rainfall intensity

Location of catchment area — Norwich

Impermeable area drained to the system — A = **35000.0** m^2

Return period — Period = **100** yr

Ratio 60 min to 2 day rainfall of 5 yr return period — r = **0.410**

5-year return period rainfall of 60 minutes duration — M5_60min = **20.0** mm

Increase of rainfall intensity due to global warming — $p_{climate}$ = **45** %

Soakaway / infiltration trench details

Soakaway type — Rectangular

Minimum depth of pit (below incoming invert) — d = **1614** mm

Width of pit — w = **15000** mm

Length of pit — l = **110000** mm

Percentage free volume — V_{free} = **95** %

Soil infiltration rate — f = **$100.\times10^{-6}$** m/s

Wetted area of pit 50% full — $a_{s50} = l \times d + w \times d$ = **201789647** mm^2

Table equations

Inflow (cl.3.3.1) — $I = M100 \times A$

Outflow (cl.3.3.2) — $O = a_{s50} \times f \times D$

Storage (cl.3.3.3) — $S = I - O$

Duration, D (min)	Growth factor Z1	M5 rainfalls (mm)	Growth factor Z2	100 year rainfall, M100 (mm)	Inflow (m^3)	Outflow (m^3)	Storage required (m^3)
5	0.38;	10.9;	1.92;	21.0;	735.87;	6.05;	729.82
10	0.53;	15.3;	1.99;	30.4;	1064.96;	12.11;	1052.85
15	0.64;	18.5;	2.02;	37.3;	1303.88;	18.16;	1285.71
30	0.81;	23.4;	2.02;	47.2;	1650.98;	36.32;	1614.66
60	1.00;	29.0;	1.98;	57.4;	2007.67;	72.64;	1935.03
120	1.20;	34.9;	1.93;	67.4;	2358.28;	145.29;	2212.99
240	1.43;	41.6;	1.88;	78.0;	2731.40;	290.58;	2440.82
360	1.59;	46.0;	1.84;	84.8;	2966.31;	435.87;	2530.44
600	1.77;	51.2;	1.80;	92.3;	3230.59;	726.44;	2504.15
1440	2.20;	63.8;	1.72;	109.5;	3832.19;	1743.46;	2088.72

Required storage volume — S_{req} = **2530.44** m^3

Soakaway storage volume — $S_{act} = l \times d \times w \times V_{free}$ = **2530.44** m^3

PASS - Soakaway storage volume

Time for emptying soakaway to half volume — $t_{s50} = S_{req} \times 0.5 / (a_{s50} \times f)$ = 17hr 25min

PASS - Soakaway discharge time less than or equal to 24 hours

Appendix B – Discharge Calculations for North Section of Access Road

MURPHY
WORLD-CLASS INFRASTRUCTURE

Calculation sheet

Project: EQUINOR		Project/ contract reference	
Section/ design		Design reference	Revision
By [redacted]	Date 28/7/22	Checked	Date	Page of

EQUINOR SITE RUN-OFF.

REQUEST TO DETERMINE RUN-OFF VOLUME FOR SITE ROAD TO NG SITE TOTALLING 2340 m^2

PAVED AREAS UNDER 4000 m^2 CAN BE DESIGNED USING FLAT RATE OF RAINFALL METHOD TO BS EN 16933 - 2 - DRAIN AND SEWER SYSTEMS OUTSIDE BUILDINGS - DESIGN. (CLAUSE NA. 4.2.2)

IF A SMALL AMOUNT OF PONDING ON THE HARDSTANDING CAN BE TOLERATED DURING HEAVY RAINFALL AND FOR A FEW MINUTES AFTERWARDS

A FLAT RATE OF 0.014 L/s/m^2 (APPROXIMATELY 50mm/hr) MULTIPLIED BY CCA (CLIMATE CHANGE ALLOWANCE) THIS IS BASED UPON A 1 IN 1 YEAR 5 MINUTE STORM. (CLAUSE NA 4.2.2) - NOTE FOR SITE LOCATION USE 0.016 L/s/m^2 (FIGURE NA.3)
IF PONDING CANNOT BE TOLERATED, A 1 IN 5 YEAR 5 MINUTE STORM IS USED, RATE = 0.024 L/s/m^2. (FIGURE NA.3)

1 IN 1 YEAR - FLOW RATE = $2340 \times 0.016 \times 1.4 = 52.4$ L/s

(WATER VOLUME = $\frac{52.4 \times 60 \times 5}{1000} = 15.7 m^3$.)

1 IN 5 YEAR - FLOW RATE = $2340 \times 0.024 \times 1.4 = 78.6$ L/s

(WATER VOLUME = $\frac{78.6 \times 60 \times 5}{1000} = 23.5 m^3$)

Appendix C – MicroDrainage Soakaway Volume Validation Calculations

REPORT

Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Onshore Substation Drainage Solution - Hydraulic Verification Calculations

Client: Equinor New Energy Limited

Reference: PC4239-ZZ-XX-RP-D-0001

Status: S0/P03.01

Date: 21 February 2023

HASKONINGDHV UK LTD.

2 Abbey Gardens
Great College Street
London
SW1P 3NL
United Kingdom
Mobility & Infrastructure
VAT registration number: 792428892

+44 207 2222115 **T**
info.london@uk.rhdhv.com **E**
[redacted] **W**

Document title:	Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects
Document short title:	OnSS Hydraulic Verification Calculations
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Status:	P03.01/S0
Date:	21 February 2023
Project name:	Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects
Project number:	PC4239
Author(s):	Iyiola Ojo

Drafted by:	Iyiola Ojo
Checked by:	Benga Ajayi
Date / initials:	21/02/2023
Approved by:	Dean Johnson
Date / initials:	21/02/2023

Classification
Project related

Royal HaskoningDHV has undertaken a hydraulic design verification of the proposed Onshore Substation (OnSS) surface water drainage design calculations in support of Equinor New Energy Limited who are seeking a Development Consent Order (DCO) for the Sheringham Shoal (SEP) and Dudgeon (DEP) Offshore Wind Farm Extension Projects.

The design verification sought to carry out a review of the third party (Murphy Infrastructure Ltd) proposed surface water drainage strategy, specifically by checking the adequacy of the proposed geocellular soakaway (infiltration) units intended for infiltrating the site surface water runoff into the underlying ground strata.

The proposed surface water drainage strategy as contained on **Drawing No. C282-MU-Z-XD-00118-01- Substation Outline Drainage Plan Infiltration Method** [APP-307] consists of a soakaway solution which involves collecting the surface water drainage in a modular crate system, to be located under the proposed OnSS platform.

The TEDDs calculation presented in **Document No C282-RH-Z-GA-00128 Outline Operational Drainage Plan (onshore substation)** [APP-307] combined the geometry of the two geocellular tanks and applied the overall effective impermeable catchment area on the combined tank. To reflect the proposed drainage design, Royal HaskoningDHV, took the approach of applying 50% of the effective catchment area to the proposed geometry of each of the geocellular tanks. This provides a more accurate means of determining the actual wetted area (internal area) of the soakaway.

The proposed surface water drainage design indicates that the outfall drainage pipe connects into the inlet of the soakaway crates and water is allowed to accumulate in the voids that exist within the crates. As water accumulates, it is infiltrated into the surrounding ground as all sides of the crates are open.

The proposed volume of each geocellular crates as proposed by **Drawing No. C282-MU-Z-XD-00118-01- Substation Outline Drainage Plan Infiltration Method** [APP-307] is approximately 1,254m^3 (i.e. total storage volume of approximately 2,508m^2). This represents the actual geometry of the crates factoring in a porosity ratio of 95%.

Norfolk County Council (NCC) LLFA Statutory Consultee for Planning Guidance Document Version 6.1, dated October 2022 has been consulted in the preparation of the design verification exercise. Section 13 Infiltration Constraints states:

'*One uncertainty for the design of infiltration systems is the infiltration rate, which may reduce over time, particularly if there is no pre-treatment or there is poor maintenance. To account for this, we expect a safety factor to be incorporated into the design, where the factor used is a judgement based on the consequence of failure of the drainage system. Table 25.2 of CIRIA SuDS Manual (C753) should be consulted and used. If the drainage system within a new development is to be offered to NCC Highways Authority to be considered for adoption, the calculations should use at least the middle column of Table 25.2. The safety factors can only be discounted if the infiltration feature is designed in accordance with BRE365 design procedure. For the avoidance of doubt, BRE365 design does not allow infiltration through the base, only the sides of the feature. This must be demonstrated in the supporting information submitted. Design of infiltration features via the SuDS Manual does allow infiltration through the base and sides of the feature and hence the extra factor of safety must be incorporated into the designs*.'

Royal HaskoningDHV

Table 25.2 of CIRIA SuDS Manual 2015 (C753) is captured below for reference:

TABLE 25.2 Suggested factors of safety, F, for use in hydraulic design of infiltration systems (designed using Bettess (1996). Note: not relevant for BRE method)

Size of area to be drained	Consequences of failure		
	No damage or inconvenience	Minor damage to external areas or inconvenience (eg surface water on car parking)	Damage to buildings or structures, or major inconvenience (eg flooding of roads)
< 100 m^2	1.5	2	10
100–1000 m^2	1.5	3	10
> 1000 m^2	1.5	5	10

The design check was carried out by hydraulic modelling of the proposed surface water drainage strategy using both the MicroDrainage Network Module and Source Control Module. Two options of hydraulic model were undertaken:

Option 01 is a departure from the default MicroDrainage safety factor of 2 when modelling geocellular infiltration structure. A unit factor of safety was adopted, which presumes that the infiltration potential of the crates is available along the full depth of the geocellular storage structure. This option sets the base infiltration coefficient to 0 in compliance with the requirement of BRE 365 guidelines for designs of infiltration structures (which does not allow infiltration through the base, only the sides). This also complies with the NCC LLFA Statutory Consultee for Planning Guidance Document, Version 6.1 which allows a discount in the factor of safety if the design is in accordance with BRE365.

The 1 in 100-year storm event (plus climate change allowance) for this option, utilising the FEH13 rainfall data simulation, resulted in flooding and indicated that an additional volume of 160m^3 is required for each of the geocellular crates (i.e. total additional volume required is 320m^3). The peak volumetric rate of infiltration is approximately 22.4l/s.

Option 02 proposes a 50% reduction in the base infiltration coefficient of the geocellular storage structure. i.e. 0.5 x 10^{-4}m/s. As detailed in the **Document No C282-RH-Z-GA-00128 Outline Operational Drainage Plan (onshore substation)** [APP-307], the average infiltration of the soil is approximately 5 x 10^{-4} m/s, therefore the original infiltration coefficient of 1 x 10^{-4} m/s is always a conservative estimate. The 1 in 100-year storm event (plus climate change allowance) for this option utilising the FEH13 rainfall indicates that the current storage volume of 1,254m^3 (as shown on **Drawing No. C282-MU-Z-XD-00118-01**) is sufficient. This analysis does not comply with the BRE365 design guidelines since it considers the infiltration potential of the base of the geocellular storage system. However, the factor of safety in MicroDrainage has been set at the default value of 2 and assumes 'No damage or inconvenience' using Table 25.2 of CIRIA SuDS Manual 2015 (C753). The maximum volume of storage required is approximately 1,073m^3. The peak volumetric rate of infiltration is approximately 30.2l/s.

Design Parameters:

- Total impermeable catchment area = 3.5Ha, it is assumed that each of the geocellular units receives a contribution of 50% of this total impermeable area
- Climate change allowance – 45%
- Rainfall data – Utilises FEH13 (2013) from the FEH Web Service
- Porosity ratio = 95% free volume assumed in crates
- Soil Infiltration Rate = $1x10^{-4}$m/s
- Plan area of both soakaways = 15m x 55m = 825m^2
- Depth of the soakaway = 1.6m
- Minimum depth of embedment (cover) = 1.2m
- Finished ground (cover level) = 27.775mAOD
- Side infiltration Coefficient = 1 x 10^{-4} m/s (0.36m/hr)
- Base infiltration Coefficient = 0.000m/hr (Option 01); 0.18m/hr(Option 02)
- Factor of Safety = 1 (Option 01 Full depth of the geocellular storage unit contributing to infiltration area)
- Factor of Safety = 2 (Option 02 Full depth and 50% of the base of the geocellular storage unit contributing to infiltration area)

The results of the hydraulic verification analysis, using the parameters highlighted above, have been provided in **Appendix 1**.

Option 01 is compliant with BRE365 design procedures (i.e using the sides only) although it models a departure from the default MicroDrainage safety factor of 2 required when modelling the infiltration structure in MicroDrainage simulations. Applying the safety factor of 1.0, the proposed geometry of the geocellular soakaways is inadequate for the 1 in 100-year rainfall event plus climate change and requires an additional 160m^3 per storage structure.

Option 02 suggests that the volume of geocellular storage unit proposed is adequate, however this model is not in accordance with BRE365 design procedures, in that it utilises the sides and base of the units. However, it does apply the default MicroDrainage safety factor of 2 within the model. The acceptability of this option to the LLFA may require maintenance management proposals to be agreed with regulators at a detailed design state.

The Applicant notes that the above hydraulic verification analysis has been undertaken based on the information presented in **Document No C282-RH-Z-GA-00128 Outline Operational Drainage Plan (onshore substation)** [APP-307].

The above document is to be resubmitted to the Examining Authority with a number of revisions, reflecting the Applicant's confirmation that a single preferred solution for surface water drainage from the Onshore Substation has been selected, comprising a shallow infiltration solution. The document will be resubmitted as **Outline Operational Drainage Strategy (onshore substation) (Revision B)** [document reference 9.20] and this Technical Note will be included as an appendix to it.

APPENDIX 1

Summary of Results for 100 year Return Period (+45%)

Half Drain Time : 683 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	25.610	0.635	8.9	497.6	O K
30 min Summer	25.805	0.830	11.6	650.8	O K
60 min Summer	25.996	1.021	14.3	800.3	O K
120 min Summer	26.164	1.189	16.6	932.0	O K
180 min Summer	26.273	1.298	18.2	1017.4	O K
240 min Summer	26.352	1.377	19.3	1079.0	O K
360 min Summer	26.455	1.480	20.7	1160.3	O K
480 min Summer	26.517	1.542	21.6	1208.3	O K
600 min Summer	26.560	1.585	22.2	1242.0	O K
720 min Summer	26.592	1.617	22.4	1265.0	O K
960 min Summer	27.781	2.806	22.4	1287.0	FLOOD
1440 min Summer	26.608	1.633	22.4	1272.1	O K
2160 min Summer	26.509	1.534	21.5	1202.2	O K
2880 min Summer	26.407	1.432	20.0	1122.1	O K
4320 min Summer	26.220	1.245	17.4	975.7	O K
5760 min Summer	26.074	1.099	15.4	861.3	O K
7200 min Summer	25.958	0.983	13.8	770.8	O K
8640 min Summer	25.866	0.891	12.5	698.4	O K
10080 min Summer	25.792	0.817	11.4	640.3	O K
15 min Winter	25.686	0.711	10.0	557.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	153.845	0.0	26
30 min Summer	101.355	0.0	41
60 min Summer	63.293	0.0	70
120 min Summer	38.008	0.0	128
180 min Summer	28.521	0.0	186
240 min Summer	23.390	0.0	244
360 min Summer	17.823	0.0	360
480 min Summer	14.689	0.0	414
600 min Summer	12.600	0.0	474
720 min Summer	11.083	0.0	536
960 min Summer	8.983	6.9	672
1440 min Summer	6.564	0.0	944
2160 min Summer	4.705	0.0	1348
2880 min Summer	3.677	0.0	1760
4320 min Summer	2.565	0.0	2548
5760 min Summer	1.978	0.0	3296
7200 min Summer	1.612	0.0	4040
8640 min Summer	1.364	0.0	4768
10080 min Summer	1.185	0.0	5552
15 min Winter	153.845	0.0	26

Summary of Results for 100 year Return Period (+45%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	25.905	0.930	13.0	729.2	O K
60 min Winter	26.120	1.145	16.0	897.2	O K
120 min Winter	26.310	1.335	18.7	1046.2	O K
180 min Winter	26.434	1.459	20.4	1143.5	O K
240 min Winter	26.524	1.549	21.7	1214.1	O K
360 min Winter	27.806	2.831	22.4	1312.6	FLOOD
480 min Winter	27.867	2.892	22.4	1373.5	FLOOD
600 min Winter	27.900	2.925	22.4	1406.3	FLOOD
720 min Winter	27.924	2.949	22.4	1429.8	FLOOD
960 min Winter	27.940	2.965	22.4	1445.8	FLOOD
1440 min Winter	27.896	2.921	22.4	1402.2	FLOOD
2160 min Winter	26.633	1.658	22.4	1278.2	O K
2880 min Winter	26.461	1.486	20.8	1164.6	O K
4320 min Winter	26.220	1.245	17.4	975.5	O K
5760 min Winter	26.040	1.065	14.9	835.0	O K
7200 min Winter	25.904	0.929	13.0	727.8	O K
8640 min Winter	25.798	0.823	11.5	645.2	O K
10080 min Winter	25.715	0.740	10.4	579.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	101.355	0.0	40
60 min Winter	63.293	0.0	68
120 min Winter	38.008	0.0	126
180 min Winter	28.521	0.0	182
240 min Winter	23.390	0.0	238
360 min Winter	17.823	32.5	350
480 min Winter	14.689	93.3	458
600 min Winter	12.600	126.2	550
720 min Winter	11.083	149.7	576
960 min Winter	8.983	165.7	730
1440 min Winter	6.564	122.1	1030
2160 min Winter	4.705	0.0	1452
2880 min Winter	3.677	0.0	1872
4320 min Winter	2.565	0.0	2680
5760 min Winter	1.978	0.0	3456
7200 min Winter	1.612	0.0	4192
8640 min Winter	1.364	0.0	4944
10080 min Winter	1.185	0.0	5744

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 652500 307500 TG 52500 07500
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+45

Time Area Diagram

Total Area (ha) 1.750

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.583	4	8	0.583	8	12	0.583

Model Details

Storage is Online Cover Level (m) 27.775

Cellular Storage Structure

Invert Level (m) 24.975 Safety Factor 1.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.36000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	825.0	825.0	1.700	0.0	1049.0
1.600	825.0	1049.0			

Summary of Results for 100 year Return Period (+45%)

Half Drain Time : 326 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	25.582	0.607	24.9	475.7	O K
30 min Summer	25.762	0.787	26.1	617.2	O K
60 min Summer	25.923	0.948	27.3	742.7	O K
120 min Summer	26.031	1.056	28.0	827.5	O K
180 min Summer	26.084	1.109	28.4	869.2	O K
240 min Summer	26.111	1.136	28.6	890.0	O K
360 min Summer	26.140	1.165	28.8	913.0	O K
480 min Summer	26.149	1.174	28.8	920.1	O K
600 min Summer	26.144	1.169	28.8	916.4	O K
720 min Summer	26.131	1.156	28.7	906.2	O K
960 min Summer	26.088	1.113	28.4	872.4	O K
1440 min Summer	25.969	0.994	27.6	779.4	O K
2160 min Summer	25.778	0.803	26.2	629.0	O K
2880 min Summer	25.602	0.627	25.0	491.3	O K
4320 min Summer	25.324	0.349	23.1	273.8	O K
5760 min Summer	25.145	0.170	21.8	133.0	O K
7200 min Summer	25.047	0.072	21.1	56.0	O K
8640 min Summer	25.022	0.047	19.6	36.5	O K
10080 min Summer	25.015	0.040	16.9	31.7	O K
15 min Winter	25.658	0.683	25.4	535.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	153.845	0.0	25
30 min Summer	101.355	0.0	40
60 min Summer	63.293	0.0	68
120 min Summer	38.008	0.0	124
180 min Summer	28.521	0.0	182
240 min Summer	23.390	0.0	238
360 min Summer	17.823	0.0	298
480 min Summer	14.689	0.0	364
600 min Summer	12.600	0.0	432
720 min Summer	11.083	0.0	500
960 min Summer	8.983	0.0	640
1440 min Summer	6.564	0.0	914
2160 min Summer	4.705	0.0	1308
2880 min Summer	3.677	0.0	1700
4320 min Summer	2.565	0.0	2420
5760 min Summer	1.978	0.0	3072
7200 min Summer	1.612	0.0	3688
8640 min Summer	1.364	0.0	4376
10080 min Summer	1.185	0.0	5136
15 min Winter	153.845	0.0	25

Summary of Results for 100 year Return Period (+45%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	25.864	0.889	26.8	696.6	O K
60 min Winter	26.049	1.074	28.1	841.9	O K
120 min Winter	26.184	1.209	29.1	947.3	O K
180 min Winter	26.256	1.281	29.6	1004.0	O K
240 min Winter	26.298	1.323	29.9	1037.0	O K
360 min Winter	26.336	1.361	30.2	1066.7	O K
480 min Winter	26.344	1.369	30.2	1072.9	O K
600 min Winter	26.334	1.359	30.1	1064.9	O K
720 min Winter	26.311	1.336	30.0	1046.8	O K
960 min Winter	26.242	1.267	29.5	992.8	O K
1440 min Winter	26.061	1.086	28.2	851.4	O K
2160 min Winter	25.782	0.807	26.3	632.7	O K
2880 min Winter	25.538	0.563	24.6	440.9	O K
4320 min Winter	25.177	0.202	22.0	158.3	O K
5760 min Winter	25.024	0.049	20.5	38.1	O K
7200 min Winter	25.015	0.040	16.7	31.0	O K
8640 min Winter	25.009	0.034	14.2	26.3	O K
10080 min Winter	25.004	0.029	12.3	22.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	101.355	0.0	39
60 min Winter	63.293	0.0	68
120 min Winter	38.008	0.0	124
180 min Winter	28.521	0.0	180
240 min Winter	23.390	0.0	234
360 min Winter	17.823	0.0	338
480 min Winter	14.689	0.0	384
600 min Winter	12.600	0.0	462
720 min Winter	11.083	0.0	540
960 min Winter	8.983	0.0	694
1440 min Winter	6.564	0.0	988
2160 min Winter	4.705	0.0	1408
2880 min Winter	3.677	0.0	1792
4320 min Winter	2.565	0.0	2468
5760 min Winter	1.978	0.0	2912
7200 min Winter	1.612	0.0	3632
8640 min Winter	1.364	0.0	4344
10080 min Winter	1.185	0.0	5128

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 652500 307500 TG 52500 07500
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+45

Time Area Diagram

Total Area (ha) 1.750

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.583	4	8	0.583	8	12	0.583

Model Details

Storage is Online Cover Level (m) 27.775

Cellular Storage Structure

Invert Level (m) 24.975 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.18000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.36000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	825.0	825.0	1.601	0.0	1049.0
1.600	825.0	1049.0			

Royal HaskoningDHV is an independent, international engineering and project management consultancy with over 138 years of experience. Our professionals deliver services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural development and water.

Backed by expertise and experience of 6,000 colleagues across the world, we work for public and private clients in over 140 countries. We understand the local context and deliver appropriate local solutions.

We focus on delivering added value for our clients while at the same time addressing the challenges that societies are facing. These include the growing world population and the consequences for towns and cities; the demand for clean drinking water, water security and water safety; pressures on traffic and transport; resource availability and demand for energy and waste issues facing industry.

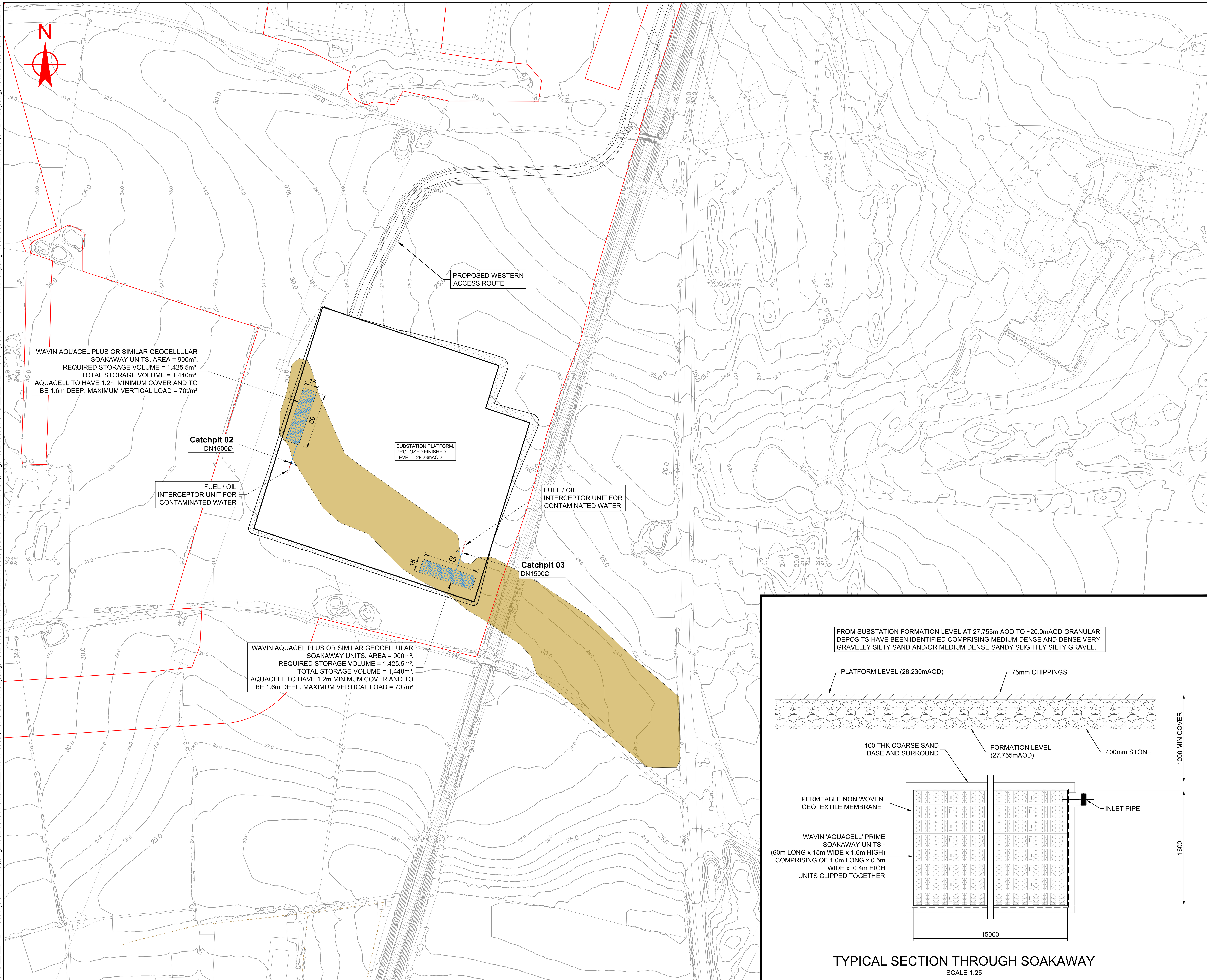
We aim to minimise our impact on the environment by leading by example in our projects, our own business operations and by the role we see in “giving back” to society. By showing leadership in sustainable development and innovation, together with our clients, we are working to become part of the solution to a more sustainable society now and into the future.

Our head office is in the Netherlands, other principal offices are in the United Kingdom, South Africa and Indonesia. We also have established offices in Thailand, India and the Americas; and we have a long standing presence in Africa and the Middle East.

[redacted]

Appendix D – Drawings

- C282-MU-Z-XD-00118-01_F03 – Substation Outline Drainage Strategy – Infiltration Method



TYPICAL SECTION THROUGH SOAKAWAY
SCALE 1:25

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM.
3. EXISTING GROUND LEVELS ARE TAKEN FROM 2014 LiDAR SURVEY DATA.
4. RECESSED STEEL MANHOLE COVERS TO COMPLY WITH BS EN1449:1991 AND GALVANISED TO COMPLY WITH BS EN ISO 1461.
5. ALL BELOW GROUND PIPEWORK TO BE Ø225 NOMINAL SIZE POLYPIPE 'POLYSEWER' TO WIS 4-35-01. TO BE INSTALLED IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.
6. FUEL / OIL INTERCEPTOR TO BE OPERATED AND MAINTAINED IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.
7. SOAKAWAY UNIT LOCATIONS ARE INDICATIVE AND WILL BE CONFIRMED IN CONJUNCTION WITH THE FINAL SUBSTATION LAYOUTS AT DETAILED DESIGN.

LEGEND:

- PROPOSED SURFACE WATER PIPEWORK
- PROPOSED SURFACE WATER MANHOLE
- PROPOSED FUEL / OIL PIPEWORK
- PROPOSED FUEL / OIL INTERCEPTOR
- PROPOSED GEOCELLULAR SOAKAWAY UNIT
- EXISTING GRANULAR SOILS
- PROPOSED CUT
- PROPOSED FILL
- DCO BOUNDARY

Plotted: 28/02/2023 2:21 PM
Attached Xrefs: 1002-000591-JMS-ZZ-M2-W-0001 (OS MAPPING).dwg; 1002-000591-JMS-ZZ-M3-W-0003 (TOPO SURFACE).dwg; 1002-000591-JMS-ZZ-M2-W-0033 (SUBSTATION LAYOUT).dwg; 1002-000591-JMS-ZZ-M2-W-0034 (SUBSTATION DRAINAGE).dwg; 1002-000591-JMS-ZZ-M2-W-0005 (UTILITIES).dwg; 1002-000591-JMS-ZZ-M3-W-000

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J. MURPHY & SONS LTD
Hiview House, Highgate Road, London NW5 1TN

equinor

0 50 100 1:2000 200m

REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS
F03	S.LYONS	M.PERKINS	J.CURRAN	28/02/23	SOAKAWAY AREA INCREASED IN LINE WITH MICRODRAINAGE VALIDATION
F02	L.EDGE	M.PERKINS	J.CURRAN	27/07/22	SOAKAWAY DETAILS ADDED
F01	S.LYONS	M.PERKINS	J.CURRAN	01/07/22	ISSUED FOR INFORMATION

Project:	SHERINGHAM SHOAL & DUDGEON WINDFARM ONSHORE CABLE FEED
Revision: F03	Dwg Title: SUBSTATION OUTLINE DRAINAGE STRATEGY INFILTRATION METHOD
Suitability: -	
Scale @ A1: 1:2000	Dwg No: C282-MU-Z-XD-00118-01
Sheets: 1 OF 1	Purpose of Issue: FOR INFORMATION
Internal Proj.Ref: 1002-000591	Client Ref Number: -