ARCUS

CROSSAIG SUBSTATION

DRAINAGE IMPACT ASSESSMENT

FEBRUARY 2023

Prepared by
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1 INTRODUCTION

1.1 Background

This Drainage Impact Assessment ('DIA') has been prepared in support of a planning application for the construction of the proposed Crossaig North substation and an extension to the platform at the existing Crossaig substation ('the Development') on greenfield land located west of the existing Crossaig substation/at the existing Crossaig substation ('the Site'). The overhead line (OHL) works (the Associated Development) are not included in the scope of the DIA given the absence of impermeable surface associated with it, therefore this DIA assesses only the Proposed Development.

The DIA has been prepared by Arcus Consultancy Services Ltd ('Arcus'), on behalf of Scottish & Southern Electricity Networks ('the Applicant') to satisfy the following requirements:

- Scottish Government, Planning Advice Note 61: Planning and Sustainable Urban Drainage Systems[1];
- Scottish Government, Planning Advice Note 79: Planning Advice Note 79: Water and Drainage[2];
- Scottish Environmental Protection Agency (SEPA), Technical Flood Risk Guidance for Stakeholders[3];
- Scottish Water, Sewers for Scotland 4th Edition[4];
- CIRIA, The SuDS Manual (C753)[5];
- Argyll and Bute (AB), Sustainable Design Guide[6];
- Argyll and Bute, Flood Risk Management Policy and Strategy[7];
- Working Party SuDS, Water Assessment and Drainage Guide[8];
- SEPA, Regulatory Method 8 (WAT-RM-08) SuDS[9]; and
- Argyll and Bute Council Proposed Local Development Plan Supplementary Guidance[10].

The Site Layout Plan can be found in **Appendix A** of this report.

1.2 Site Context

The Site comprises an area of approximately 18 hectares (ha) and is located at the existing Crossaig Substation, PA29 6YQ.

The Development is located approximately 10 km south west of Skipness and 8 km south west of the village of Claonaig, at National Grid Reference (NGR) E 182773, N 650238.

[1] Scottish Government, Planning Advice Note 61: Planning and Sustainable Urban Drainage Systems (2001). [Online]. Available at: https://www.gov.scot/publications/pan-61-sustainable-urban-drainage-systems/

[2] Scottish Government, Planning Advice note 79: Water and Drainage (2006). [Online]. Available at: https://www.gov.scot/publications/planning-advice-note-pan-79-water-drainage/

[3] SEPA, Technical Flood Risk Guidance for Stakeholders (2019). [Online]. Available at: https://www.sepa.org.uk/environment/land/planning/guidance-and-advice-notes/

[4] Scottish Water, Sewers for Scotland (2018). [Online]. Available at: https://www.scottishwater.co.uk/-/media/ScottishWater/Document-Hub/Business-and-Developers/Connecting-to-our-network/All-connections-information/SewersForScotlandv4.pdf (Accessed 30/09/2021)

[5] CIRIA, The SuDS Manual (C753) (2015). [Online]. Available at: https://www.ciria.org/AsiCommon/Controls/BSA/Downloader.aspx

[6] Argyll and Bute Council Sustainable Design Guide (2011). [Online]. Available at: Design Guides (argyll-bute.gov.uk)

[7] Argyll and Bute Council Flood Risk Management Policy and Strategy (2015). [Online]. Available at: Flood_Risk_Management_Policy_and_Strategy%20-%20Final%20draft%20110315.pdf (argyll-bute.gov.uk)

[8] SEPA, Working Party SuDS, Water Assessment and Drainage Guide. [Online]. Available at: Water drainage assessment guide (sepa.org.uk)

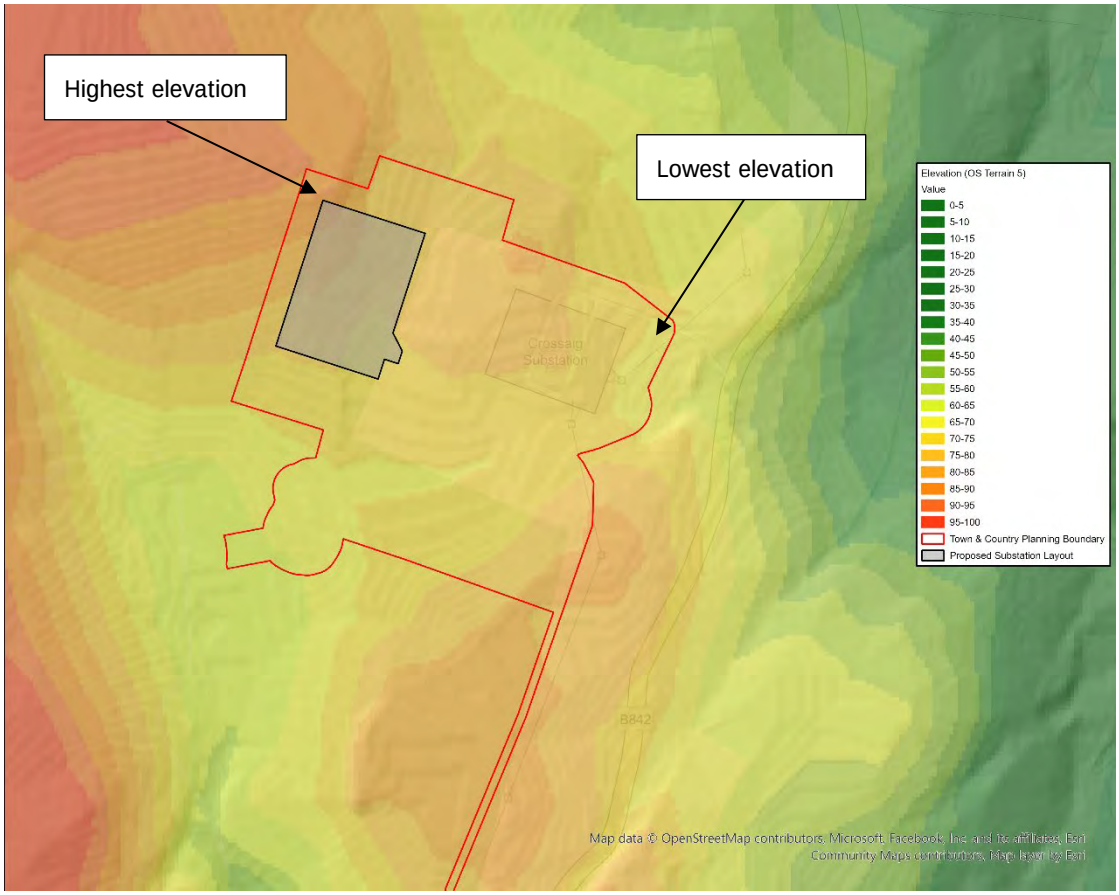
[9] SEPA, Regulatory Method (WAT-RM-08) SuDS (2019). [Online]. Available at: Regulatory Method (WAT-RM-08) (sepa.org.uk)

[10] Argyll and Bute, Proposed Local Development Plan Supplementary Guidance (2012). [Online]. Available at: FINALSGdocument1.pdf (argyll-bute.gov.uk)

The Development is in an area currently of commercial forestry approximately 1 km west of the Firth of Clyde, and approximately 500 m east of the B842.

Ordnance Survey (OS) Terrain 5 data indicates Site elevations are in the range of 74 to 89 m Above Ordnance Datum (AOD) with topography falling from a high point in the South to the lower elevations in the North of the Site, as shown by Plate 1.

Plate 1: Site Location and Elevations



There were no British Geological Survey (BGS) borehole scans[11] located within close vicinity of the Site. However, the BGS Geology of Britain Viewer[12] indicates that the bedrock of the associated area is predominantly formed of gritty Psammite and Pelite strata, with no recorded superficial deposits.

1.3 The Development Infrastructure

The Development will be constructed atop of a substation platform comprised of a subbase of 1 m thickness, covering an area of approximately 24,000 m^2 (2.4 ha). As a representation of the worst case runoff scenario, the substation platform is to be classified as impermeable area.

Impermeable areas associated with the Development are therefore limited to the buildings storing the diesel generator, feeder building, telecoms, mess and store room, LVAC room, battery room, switch room, the substation electrical infrastructure, access tracks and the area associated with a septic tank. The impermeable elements will create a total impermeable area of approximately 2.4 ha. The areas of hardstanding are detailed in **Table 1**.

[11] British Geological Survey, Borehole Scans. [Online]. Available at: GeoIndex - British Geological Survey (bgs.ac.uk)
[12] British Geological Survey, Geology of Britain Viewer. [Online]. Available at: Geology of Britain viewer | British Geological Survey (BGS)

Table 1: Proposed Impermeable Areas

Hardstanding Infrastructure	Total Area of Hardstanding (m^2)
Substation Platform	24,000
Total Impermeable (m^2):	**24,000**
Total Hardstanding (ha):	**2.4**

2 SURFACE WATER DESIGN CONDITIONS

2.1 Surface Water Discharge Options

The Development will not be permanently manned with infrequent maintenance visits. However, the Development will require welfare when manned and therefore there will be no demand for water re-use.

Consultations[13] with Argyll and Bute Council have confirmed that infiltration testing is not required at the Planning Application submission stage and that the potential for infiltration drainage will be assessed through an estimated infiltration rate sought via the SuDS Manual. This is shown in **Appendix B**.

2.2 Estimated Infiltration Rate

An estimated infiltration rate has been calculated based on the subsoils from the BGS Bedrock geology data which outlines the underlying strata comprises Psammite and Pelite bedrock.

Table 25.1 of the SuDS Manual outlines estimated infiltration rates based on the Infiltration Drainage – Manual of Good Practice[14]. Table 25.1 indicates that bedrock media has a typical infiltration rate ranging between 0.108 metres per hour (m/h) and 0.0000108 m/h dependent on the type of rock and the extent and nature of discontinuities and any infill.

The SuDS Manual outlines that where rates are less than 0.000001 m/h infiltration as a means of disposal of significant volumes of run-off may not be appropriate.

Acknowledging the limited information available as to the nature of the underlying bedrock on Site, infiltration as a means of drainage is considered unfeasible and surface water will be disposed of by controlled discharge to a nearby watercourse.

2.3 Greenfield Run-off rates

Greenfield runoff rates for the 2.4 ha of impermeable area, outlined in Table 1, have been calculated using the ICP SuDS method[15] via Micro Drainage Software with rates shown in **Table 2** and **Appendix C**.

The 1 in 1 Greenfield runoff rate (Q_1) will be utilised as the outflow rate.

The application of this approach leads to the runoff from the Site to be attenuated and discharged to the Q_1 rate of 18.8 l/s in up to the 200-year return period, with appropriate climate change allowances.

Table 2: Site Runoff Flow Rates (taken from Micro Drainage)

Return Period	Q (l/s)
Q_{BAR}	22.2

[13] Email and telephone communications between D. Moore (ABC) and R. Duff (Arcus) January 2022.
[14] R, Bettess. Infiltration Drainage – Manual of Good Practice (1996). CIRIA R156.
[15] National SuDS Working Group, Interim Code of Practice for Sustainable Drainage Systems (2004). [Online]. Available at: https://www.susdrain.org/files/resources/other-guidance/nswg_icop_for_suds_0704.pdf

1	18.8
30	41.9
100	55.0
200	62.3

2.4 Return Period and Climate Change Allowance

In accordance with Map 1 of SEPA's climate change (+CC) allowances[16], a 46 % allowance has been incorporated into the drainage design (+46 % CC).

Attenuation is required in up to and including the 1:30-year (+CC) event with exceedance events up to the 1:200-year (+CC) event to be considered for offsite flooding.

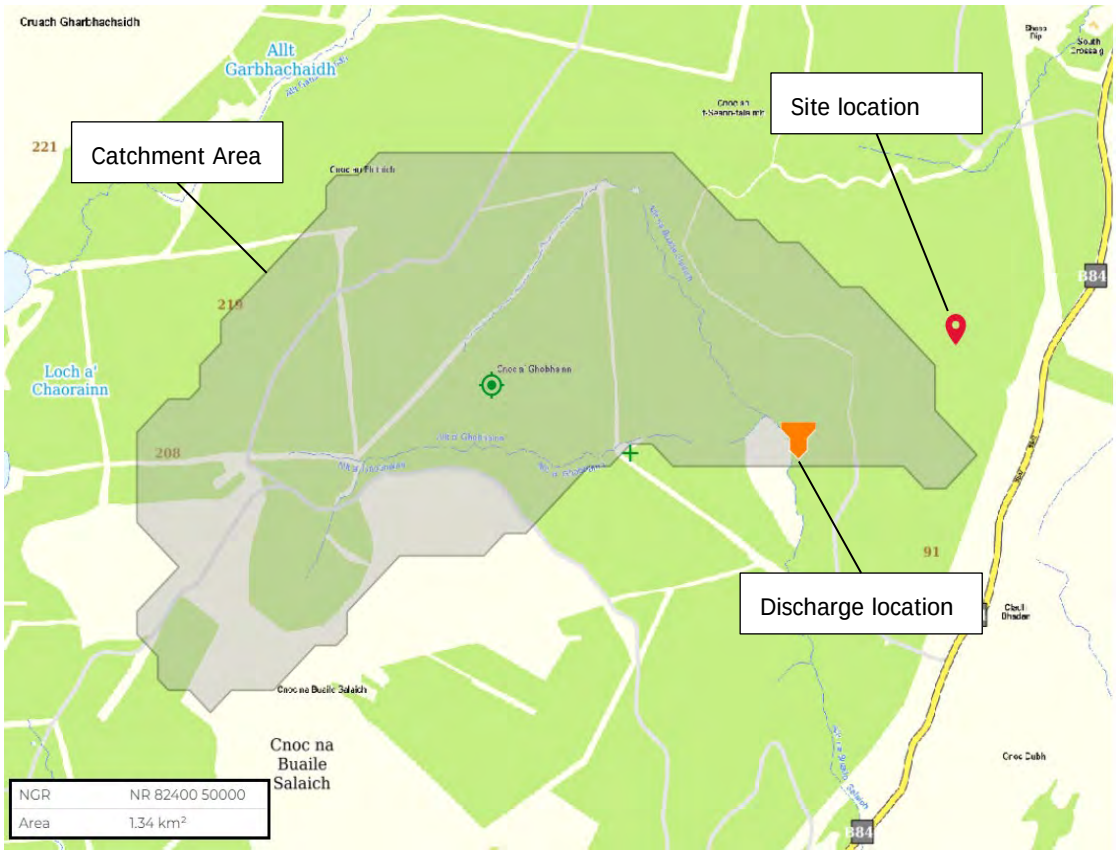
2.5 Discharge to Watercourse

As detailed in Section 2.1, the SuDS hierarchy has been consulted, with discharge to an unnamed watercourse located approximately 260 m south west of the Site deemed the practicable form of drainage at the Site.

The UK CEH (FEH) web map[17] indicates that the watercourse serves a catchment of 1.34 km² as shown in **Plate 2**.

[16] SEPA, Climate Change Allowances for Flood Risk Assessment in Land Use Planning (2019). [Online]. Available at: https://www.sepa.org.uk/media/426913/lups_cc1.pdf
[17] UK Centre for Ecology and Hydrology, Flood Estimation Handbook. [Online]. Available at: https://fehweb.ceh.ac.uk/GB/map

Plate 2: Receiving Watercourse Catchment Extents



3 SURFACE WATER DRAINAGE DESIGN

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 Development.

3.1 Should the drainage measures or final locations of infrastructure differ to what is outlined within this document, then the final detailed drainage design will be provided to Argyll and Bute Council under an agreed pre-construction condition. Hierarchical Drainage Options

In accordance with the SuDS Manual (C753)[18],the information within **Table 3** outlines the most appropriate option to dispose of surface water from the Development along with the rationale.

Table 3: Surface Water Discharge Methods

Disposal route	Feasible?	Rationale
Re-use onsite	✘	Site will be unmanned with infrequent maintenance visits, therefore no demand for water reuse.
Infiltration to ground	✘	British Geological Survey mapping indicate infiltration is unlikely to be feasible. Consultation with the Arygll and Bute Council agreed that infiltration testing was not required.
Discharge to watercourse	✓	The nearest watercourse has been determined to be a feasible discharge location and therefore will be utilised within the strategy.

[18] CIRIA, The SuDS Manual (2015). [Online]. Available at: https://www.susdrain.org/resources/SuDS_Manual.html

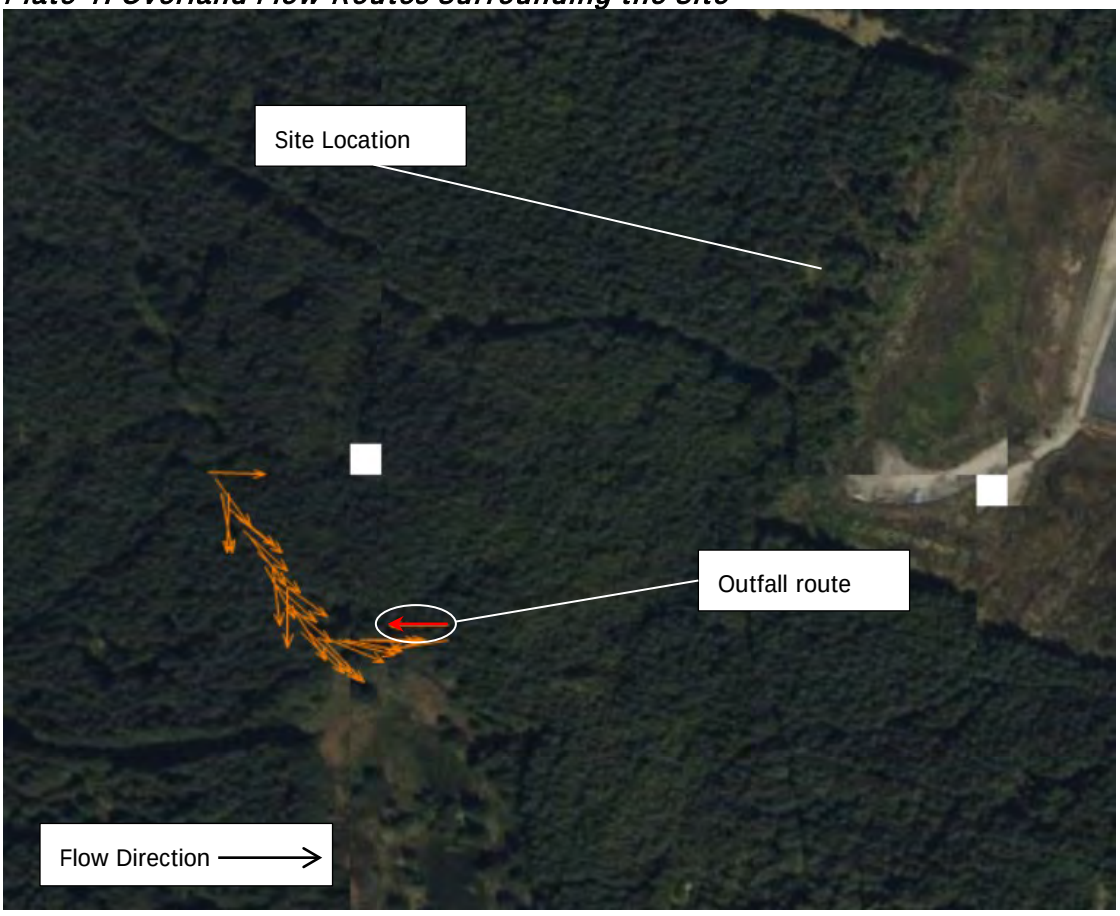
Discharge to surface water	✘	Discharge to the nearest watercourse has been deemed practicable.
Discharge to combined sewer	✘	Discharge to the nearest watercourse has been deemed practicable.

3.2 Proposed Surface Water Drainage Scheme

It is proposed that the impermeable areas within the Development will be connected to an attenuation basin to the west of the Site via a piped filter drain system. Due to the volume of attenuation required, swales have been discounted as a viable storage option as the structure length would be prohibitive and exceed the boundaries of the Site.

The attenuation basin will enable surface water to be intercepted in accordance with existing topography and overland flow routes. The outfall from the attenuation basin will fall in accordance with existing flow routes as shown by **Plate 4.**

Plate 4: Overland Flow Routes Surrounding the Site



The substation will comprise a total impermeable area of 2.4 ha. It is proposed that surface water runoff will drain into an attenuation basin, prior to discharge into a nearby watercourse to the south.

Based upon FEH rainfall data, an impermeable area of 2.4 ha and a maximum allowable discharge of 18.8 l/s, an attenuation storage volume of approximately 2700 m^3 is required for a 1:200 year return period plus 46 % for climate change.

Sewers for Scotland and SEPA guidance recommend that the SuDS structures should be designed to be free from surcharge during the 1:30 year rainfall event and that the 1:200 year event is kept onsite. The outline drainage design has been calculated to accommodate the 1:200 year event plus a 46 % allowance for climate change.

The outflow from the attenuation basin to the unnamed watercourse will be controlled by an orifice and a Hydro-Brake system at a maximum discharge rate of 18.8 l/s, and is not shown to overtop or flood in the worst-case scenario with a maximum volume of 2436.2 m^3.

In order to provide the Site with suitable attenuation of surface water in relation to the storage structure requirements (see Section 2.3) and acknowledging the nature of the Development, the attenuation basin will comprise of the approximate dimensions in accordance with the SuDS Manual, the final detailed design will be proposed prior to construction:

- Depth: 1.5 m;
- Slope: 1 in 4;
- Total area: 2247.6 m^2; and
- Maximum water depth: 1.39 m.

The gradients of the SuDS attenuation basin bank slope between any access track/path and the permanent water level should be varied along their length to reflect the naturally occurring topography of the immediate surroundings.

The basin should include a forebay to trap sediment immediately beneath the inlet occupying an area of approximately 10 % of the permanent basin surface area.

Outline design parameters have been validated for a number of storm durations during the 1:200 year return period. Details of critical events for the 1:200-year (+46 % CC) event can be found in **Appendix D**.

The proposed extension to the existing Crossaig substation platform will lead to a negligible increase in runoff rates and will feed into the existing surface water drainage system.

The critical storm event in up to a 1:200-year (+46 % CC) event is shown in **Plate 5** with the designed feature able to attenuate surface water flows without overtopping.

Plate 5: Network 1:200-Year (+CC) Critical Storm Event (Taken from Micro Drainage)

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m^3)	Max Control (l/s)	Discharge Volume (m^3)	Σ Max Outflow (l/s)	Maximum Volume (m^3)	Status
1440 min Winter	7.580	1326	78.894	1.394	0.0	18.7	2738.4	18.7	2436.2	Flood Risk

3.3 Water Quality

The Development will involve the construction and operation of a substation involving less than 300 traffic movements per day. Table 26.2 *Pollution hazard indices for different land use classifications* of the SuDS Manual identifies that the Development has a Pollution Hazard Level of Low, taken from the 'Low Traffic Roads e.g. residential roads and general access roads, < 300 traffic movements/day' scenario.

Table 4 outlines that the Development includes land uses which have the following Simple Index Approach (SIA) indices.

Table 4: Pollution Hazard Indices for Land Use Classifications

Land Use	Pollution Level Hazard	Total Suspended Soils	Metal	Hydrocarbons
Commercial/Industrial Roofing: Low Potential for Metal Leaching	Low	0.3	0.4	0.4

A SIA has been developed on behalf of the Construction Industry Research and Information Association (CIRIA) to support the implementation of the water quality management design

methods set out in the SuDS Manual, with appropriate cross referencing to the relevant 'Design Conditions' in the tool.

The Development has been categorised as 'Commercial/Industrial roofing: Low potential for metal leaching' within the SIA tool.

All internal roads will be impermeable. Gullies and channel drains will be required to capture surface water leading to a filter drain system. The substation platform will be permeable to effectively mitigate any suspended solids, metals and hydrocarbons held within surface water at the Development prior to discharging into the receiving watercourse under expected conditions i.e., in the absence of large hydrocarbon spills.

The SIA outputs as shown in **Table 5**, demonstrate that the combined Pollution Mitigation Indices for the run-off area are met by the installation of an attenuation basin.

Table 5: SIA outputs for Low Pollution Hazard Level scenario

	Total Suspended Solids	Metals	Hydrocarbons
Pollution Hazard Indices	0.5	0.4	0.5
Pond	0.7	0.7	0.5

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 Development in the absence of significant spillages of hydrocarbons or other pollutants.

3.4 Construction Phase

The drainage measures implemented within the Temporary Works Area (TWA) will be the responsibility of the appointed Contractor. This area will comprise aggregate underlain by a permeable membrane. The Contractor will implement temporary construction drainage measures in accordance with best practice guidance which will prevent any significant run-off in relation to the compaction of soils during construction (e.g., spill kits, drip trays, plant nappies, designated refuelling points, emergency response plans). Following the construction of the Development, the TWA will be decommissioned, with underlying ground reinstated to its original condition.

Therefore, the TWA will not contribute to a significant increase in surface water run-off rates and does need not be served by a formal drainage network.

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)[19].

To prevent any sediment increase in associated run-off during the construction phase mitigation measures (e.g., spill kits, bunds, drip trays, plant nappies, designated refuelling points and emergency response plans) will effectively prevent sediment entering surrounding watercourses.

4 FOUL WATER DRAINAGE

During the construction phase a temporary a 'porta-loo' facility will be onsite, with waste being stored, managed and carried offsite by a licensed waste management courier.

A septic tank will be installed to provide foul sewage management throughout the operational phase of the Development. The septic tank will be managed, inspected and

[19] The Construction Industry Research and information Association (CIRIA), (2015), Environmental Good Practice on Site Guide (C741), CIRIA: London.

drained by a licensed courier who will then dispose of the waste offsite. The septic tank will be registered with SEPA through the private sewage registration system.

5 LONG TERM MANAGEMENT AND TIMESCALES

5.1 Long Term Management

It will be the responsibility of the site operator 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 lifetime of the Development, 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 a local Contractor engaged by the Development operator.

It is not anticipated that the Council or Scottish Water will adopt the new drainage network. Therefore, it will be the responsibility of the Development operator to maintain effective drainage measures and rectify drainage measures that are not functioning adequately. A nominated person from a management company will also have responsibility for reporting on the functionality of drainage measures.

An outline management / maintenance plan is provided in **Table 6.** The table shows the management of a pond as that closely matches the characteristics of the proposed attenuation basin.

Table 6: Long-term Maintenance schedule for the Attenuation Pond[20]

Maintenance schedule	Required action	Typical frequency
Regular Maintenance	Remove litter and debris	Monthly (or as required)
	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
	Check 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

[20] Based on Table 23.1 - Operation and maintenance requirements for attenuation ponds and wetlands of the SuDS Manual.

	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 Remedial actions	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
	Repair erosion or other damage	As required
	Replate where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required

An outline management / maintenance plan for any filter drains is provided in **Table 7**.

Table 7: Outline Long-term Maintenance schedule for Filter Drains[21]

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

5.2 Timescales

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

[21] Based on Table 16.1 - Operation and maintenance requirements for filter drains of the SuDS Manual.

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

6 CONCLUSION

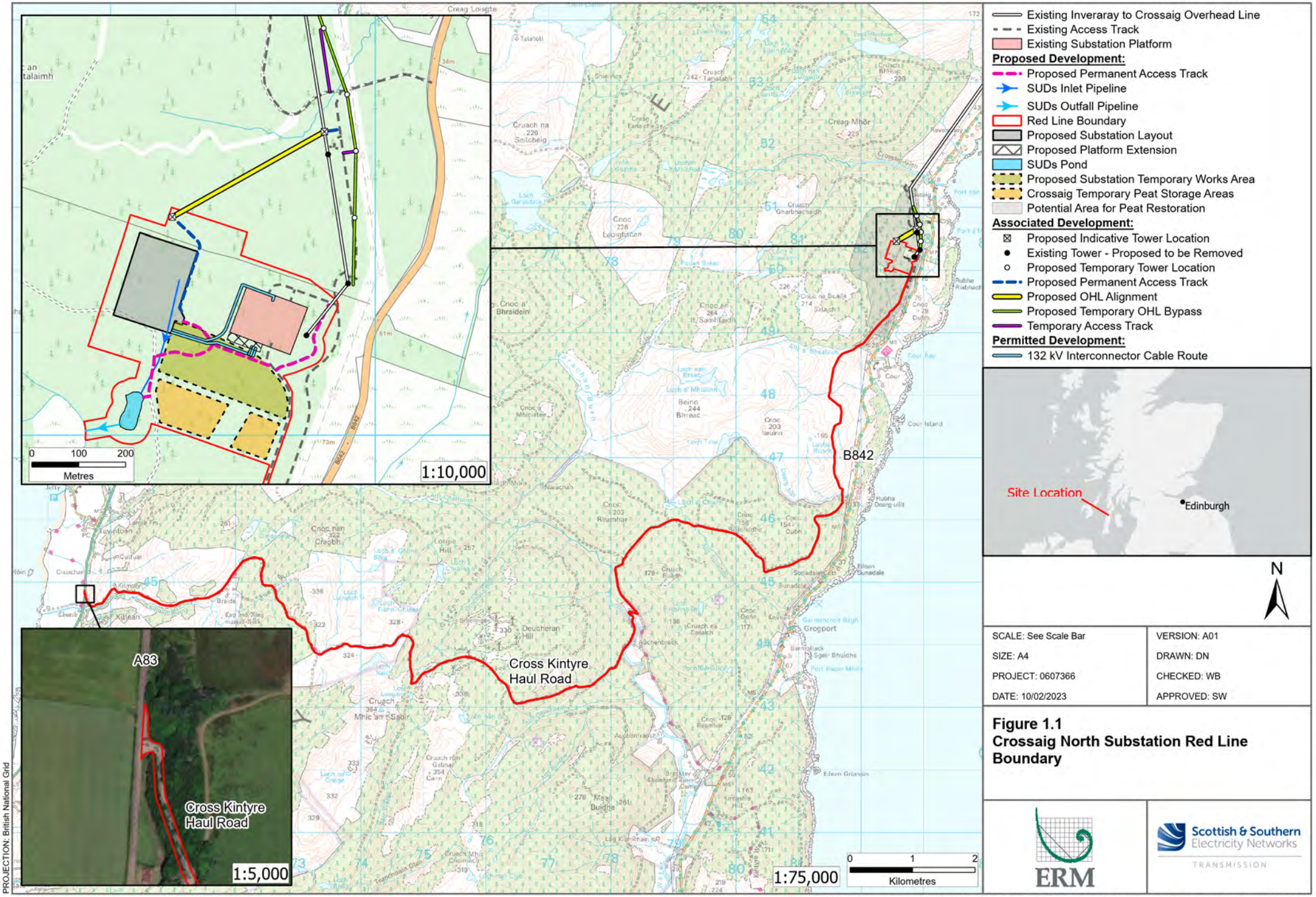
This DIA provides details on the volume of storage required to attenuate surface water run-off from the construction of the Development. The Associated Development has not been assessed in this DIA.

The Proposed Development will involve the installation of approximately 2.4 ha of impermeable elements.

The Development will utilise an attenuation basin with a volumetric capacity of 2700 m^3 as a minimum.

The proposed attenuation capacity of the platform detailed within this DIA is shown to store surface water without surcharge during a 1:200-year (+46 % CC) event and discharge to the nearest watercourse at a rate not exceeding the greenfield runoff rate of 18.8 l/s.

APPENDIX A – SITE LAYOUT



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SIZE: A4	DRAWN: DN
PROJECT: 0607366	CHECKED: WB
DATE: 10/02/2023	APPROVED: SW

Figure 1.1
Crossaig North Substation Red Line Boundary

ERM

Scottish & Southern Electricity Networks
TRANSMISSION

PROJECTION: British National Grid

Path: \\uksprdgisfs01\Data\London\0607366 - SSE Argyll Substations\MAPS\0607366 - SSE Argyll Substation.aprx\0607366_DesignFreeze_RedLineBoundary_CrossaigNorth_A01

APPENDIX B – ARGYLL AND BUTE COUNCIL CONSULTATIONS

Reagan Duff

From: Moore, David <David.Moore@argyll-bute.gov.uk>
Sent: 27 January 2022 08:29
To: Reagan Duff
Subject: RE: Argyll Substation Drainage Arrangement [OFFICIAL]

Classification: OFFICIAL

Morning Reagan,

I am in general agreement with your summary. I do recall stating that it was important any land needed for any offsite suds were in the redline boundary and also that my preference would be for the details to be submitted with the application if the work is being done now anyway.

I also referenced the need to ensure any peat matters are addressed.

Regards David

From: Reagan Duff <reagand@arcusconsulting.co.uk>
Sent: 26 January 2022 17:37
To: Moore, David <David.Moore@argyll-bute.gov.uk>
Subject: RE: Argyll Substation Drainage Arrangement

Hi David,

Thanks for your time on the phone earlier. I have summarised the outcomes of our discussion regarding the SuDS at the 4 substations in Argyll below:

- The developments located within the SEPA flood maps are those where SuDS should be focused upon, but it is preferable that SuDS at an outline level is provided for each;
- SuDS for each application will comprise a solution using infiltration utilising an assumed infiltration rate (without testing) and a solution not utilising infiltration;
- The wider details of the SuDS will be conditioned; and
- JBA will provide technical advice to the council and are likely to agree to the approach discussed.

I assume this is a true representation of the outcomes of our call and no response is required unless this is not the case.

Kind regards,

Reagan Duff
Senior Hydrologist
Arcus Consultancy Services Ltd

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Email: ReaganD@arcusconsulting.co.uk
Web: www.arcusconsulting.co.uk

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From: Reagan Duff
Sent: 26 January 2022 12:01
To: david.moore@argyll-bute.gov.uk
Subject: Argyll Substation Drainage Arrangement

Hi David,

My colleague Sophie Williams passed on your details so that we can discuss the SuDS agreements/plans for the Argyll substation development which I believe you are the planning officer for.

Please could we arrange a brief call this week to discuss? If you provide me with a time that suits I can circulate a teams invite.

Kind regards,

Reagan Duff
Senior Hydrologist
Arcus Consultancy Services Ltd

Tel: 01904 715470
Mobile: 07435911606
Email: ReaganD@arcusconsulting.co.uk
Web: www.arcusconsulting.co.uk

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conclusions and other information in this message that do not relate to the official business of Argyll and Bute Council shall be understood as neither given nor endorsed by it.

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APPENDIX C – ICP SUDS OUTPUTS

ICP SUDS Mean Annual Flood

Input

Return Period (years)	200	Soil	0.400
Area (ha)	2.400	Urban	0.000
SAAR (mm)	1644	Region Number	Region 1

Results l/s

QBAR Rural	22.2
QBAR Urban	22.2
Q200 years	62.3
Q1 year	18.8
Q30 years	41.9
Q100 years	55.0

APPENDIX D – MICRODRAINAGE OUTPUTS

Summary of Results for 200 year Return Period (+46%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	77.912	0.412	18.7	603.3	O K
30 min Summer	78.020	0.520	18.7	776.3	O K
60 min Summer	78.149	0.649	18.7	992.2	O K
120 min Summer	78.298	0.798	18.7	1253.8	O K
180 min Summer	78.393	0.893	18.7	1428.2	O K
240 min Summer	78.464	0.964	18.7	1561.5	O K
360 min Summer	78.564	1.064	18.7	1753.6	O K
480 min Summer	78.629	1.129	18.7	1883.1	O K
600 min Summer	78.675	1.175	18.7	1976.0	O K
720 min Summer	78.708	1.208	18.7	2044.4	Flood Risk
960 min Summer	78.728	1.228	18.7	2084.1	Flood Risk
1440 min Summer	78.740	1.240	18.7	2110.3	Flood Risk
2160 min Summer	78.735	1.235	18.7	2099.6	Flood Risk
2880 min Summer	78.717	1.217	18.7	2062.5	Flood Risk
4320 min Summer	78.634	1.134	18.7	1893.8	O K
5760 min Summer	78.544	1.044	18.7	1716.0	O K
7200 min Summer	78.436	0.936	18.7	1508.7	O K
8640 min Summer	78.326	0.826	18.7	1304.3	O K
10080 min Summer	78.228	0.728	18.7	1128.6	O K
15 min Winter	77.959	0.459	18.7	677.5	O K
30 min Winter	78.078	0.578	18.7	872.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	138.028	0.0	586.4	26
30 min Summer	89.444	0.0	764.3	41
60 min Summer	57.960	0.0	1025.3	70
120 min Summer	37.559	0.0	1331.2	128
180 min Summer	29.140	0.0	1549.7	188
240 min Summer	24.338	0.0	1725.2	248
360 min Summer	18.883	0.0	2004.5	366
480 min Summer	15.771	0.0	2226.4	484
600 min Summer	13.716	0.0	2410.6	602
720 min Summer	12.236	0.0	2564.5	722
960 min Summer	10.031	0.0	2738.4	922
1440 min Summer	7.580	0.0	2694.5	1160
2160 min Summer	5.728	0.0	3692.5	1560
2880 min Summer	4.695	0.0	4031.0	1972
4320 min Summer	3.476	0.0	4444.5	2816
5760 min Summer	2.808	0.0	4844.7	3640
7200 min Summer	2.379	0.0	5130.8	4464
8640 min Summer	2.078	0.0	5374.8	5184
10080 min Summer	1.854	0.0	5584.1	5856
15 min Winter	138.028	0.0	658.8	26
30 min Winter	89.444	0.0	857.1	40

Summary of Results for 200 year Return Period (+46%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	78.221	0.721	18.7	1116.4	O K
120 min Winter	78.387	0.887	18.7	1415.9	O K
180 min Winter	78.494	0.994	18.7	1619.0	O K
240 min Winter	78.573	1.073	18.7	1771.3	O K
360 min Winter	78.682	1.182	18.7	1990.7	O K
480 min Winter	78.757	1.257	18.7	2144.8	Flood Risk
600 min Winter	78.811	1.311	18.7	2259.1	Flood Risk
720 min Winter	78.852	1.352	18.7	2346.4	Flood Risk
960 min Winter	78.882	1.382	18.7	2411.5	Flood Risk
1440 min Winter	78.894	1.394	18.7	2436.2	Flood Risk
2160 min Winter	78.882	1.382	18.7	2411.6	Flood Risk
2880 min Winter	78.851	1.351	18.7	2344.7	Flood Risk
4320 min Winter	78.726	1.226	18.7	2080.6	Flood Risk
5760 min Winter	78.587	1.087	18.7	1799.3	O K
7200 min Winter	78.410	0.910	18.7	1459.6	O K
8640 min Winter	78.236	0.736	18.7	1143.3	O K
10080 min Winter	78.088	0.588	18.7	889.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	57.960	0.0	1149.5	68
120 min Winter	37.559	0.0	1491.5	126
180 min Winter	29.140	0.0	1735.3	184
240 min Winter	24.338	0.0	1930.7	242
360 min Winter	18.883	0.0	2240.2	358
480 min Winter	15.771	0.0	2482.0	474
600 min Winter	13.716	0.0	2673.6	588
720 min Winter	12.236	0.0	2809.8	702
960 min Winter	10.031	0.0	2839.3	922
1440 min Winter	7.580	0.0	2738.4	1326
2160 min Winter	5.728	0.0	4134.2	1664
2880 min Winter	4.695	0.0	4510.7	2136
4320 min Winter	3.476	0.0	4932.2	3068
5760 min Winter	2.808	0.0	5426.5	3968
7200 min Winter	2.379	0.0	5747.5	4760
8640 min Winter	2.078	0.0	6021.6	5448
10080 min Winter	1.854	0.0	6258.2	6064

Rainfall Details

Rainfall Model	FEH
Return Period (years)	200
FEH Rainfall Version	1999
Site Location	GB 182850 650650 NR 82850 50650
C (1km)	-0.020
D1 (1km)	0.480
D2 (1km)	0.415
D3 (1km)	0.364
E (1km)	0.258
F (1km)	2.315
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+46

Time Area Diagram

Total Area (ha) 2.400

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.800	4	8	0.800	8	12	0.800

Model Details

Storage is Online Cover Level (m) 79.000

Tank or Pond Structure

Invert Level (m) 77.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1352.3	1.500	2247.6

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0186-1880-1500-1880
Design Head (m)	1.500
Design Flow (l/s)	18.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	186
Invert Level (m)	77.500
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	18.8
Flush-Flo™	0.447	18.7
Kick-Flo®	0.972	15.3
Mean Flow over Head Range	-	16.2

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	6.5	1.200	16.9	3.000	26.2	7.000	39.4
0.200	16.9	1.400	18.2	3.500	28.2	7.500	40.7
0.300	18.2	1.600	19.4	4.000	30.1	8.000	42.0
0.400	18.7	1.800	20.5	4.500	31.8	8.500	43.3
0.500	18.7	2.000	21.6	5.000	33.5	9.000	44.5
0.600	18.5	2.200	22.6	5.500	35.0	9.500	45.7
0.800	17.6	2.400	23.5	6.000	36.6		
1.000	15.5	2.600	24.4	6.500	38.0		