



ARCUS

AN SUIDHE SUBSTATION

**ANNEX K
DRAINAGE IMPACT ASSESSMENT**

DECEMBER 2022



Prepared by
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1 INTRODUCTION

1.1 Background

This Drainage Impact Assessment (DIA) has been produced in support of a planning application for the construction of a 275 kV substation (the Proposed Development) on greenfield land south west of Inveraray (the Site) in the vicinity of the existing An Suidhe substation.

The Proposed Development is accompanied by Associated Development, a permanent overhead line (OHL) Tie in comprising of 6 no. towers and access tracks. This is not included within this DIA given the absence of impermeable surfaces associated with it, therefore this DIA assesses only the Proposed Development.

This DIA has been prepared by Arcus Consultancy Services Ltd (Arcus), on behalf of SSEN Transmission (the Applicant) to satisfy the following requirements:

- Scottish Government, Planning Advice Note 61: Planning and Sustainable Urban Drainage Systems¹;
- Scottish Government, Planning Advice Note 79: Planning Advice Note 79: Water and Drainage²;
- Scottish Environmental Protection Agency (SEPA), Technical Flood Risk Guidance for Stakeholders³;
- Scottish Water, Sewers for Scotland 4th Edition⁴;
- CIRIA, The SuDS Manual (C753)⁵;
- Argyll and Bute (AB), Sustainable Design Guide⁶;
- Argyll and Bute, Flood Risk Management Policy and Strategy⁷;
- Working Party SuDS, Water Assessment and Drainage Guide⁸;
- SEPA, Regulatory Method 8 (WAT-RM-08) SuDS⁹; and
- Argyll and Bute Council Proposed Local Development Plan Supplementary Guidance¹⁰.

The Proposed Development Layout Plan can be found in **Appendix A** of this DIA.

1.2 Site Context

The Site comprises an area of approximately 8 hectares (ha) and is located approximately 500 metres (m) north of the existing An Suidhe Substation and approximately 4 kilometres (km) south west of Inveraray at National Grid Reference (NGR) 204861, 705524. The Site is approximately 300 m west of Douglas Water and upslope of the Douglas Water river valley and the existing substation.

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 \(argyll-bute.gov.uk\)](https://www.argyll-bute.gov.uk/design-guides/)

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 \(argyll-bute.gov.uk\)](https://www.argyll-bute.gov.uk/flood-risk-management-policy-and-strategy%20-%20Final%20draft%20110315.pdf)

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

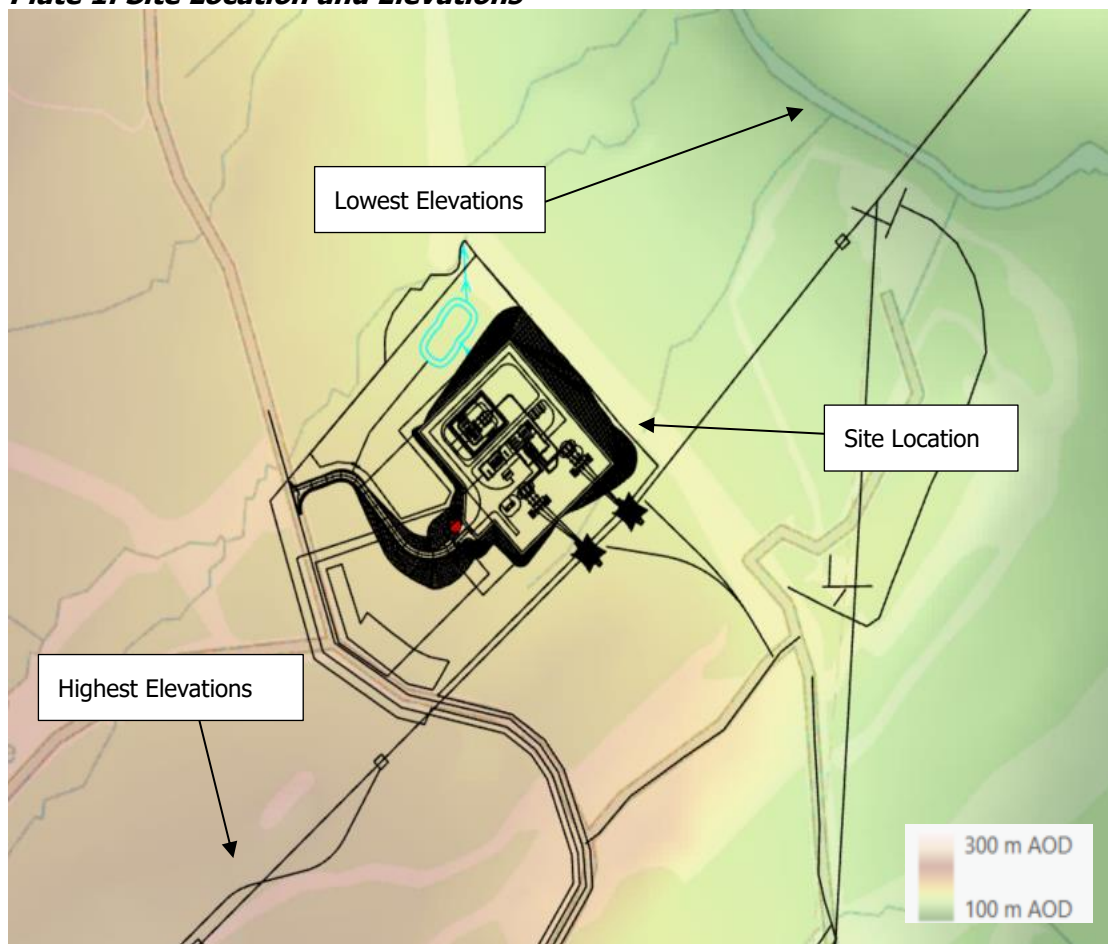
⁹ SEPA, Regulatory Method (WAT-RM-08) SuDS (2019). [Online]. Available at: [Regulatory Method \(WAT-RM-08\) \(sepa.org.uk\)](https://www.sepa.org.uk/regulatory-method-wat-rm-08/)

¹⁰ Argyll and Bute, Proposed Local Development Plan Supplementary Guidance (2012). [Online]. Available at: [FINALSGdocument1.pdf \(argyll-bute.gov.uk\)](https://www.argyll-bute.gov.uk/finalsgdocument1.pdf)

The Proposed Development is in an area of commercial forestry as well as an area of semi-natural broadleaved woodland with higher ecological importance. The Proposed Development is accessed from the A83, utilising existing forestry tracks.

Ordnance Survey (OS) Terrain 5 data indicates Site elevations are in the approximate range of 165 to 190 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



A British Geological Survey (BGS) borehole scan¹¹ located approximately 130 m north west of the Site indicates there is peat located at depths of 0.3 m before transitioning to sandy and gravelly clay strata to depths of 2.9 m below ground level (bgl). Further details on peat depths associated are available in **Annex O: Peat Management Plan** of the An Suidhe Substation Environmental Appraisal.

1.3 The Proposed Development Infrastructure

The Associated Development is not considered to have any significant impermeable materials and therefore has not been considered within this appraisal. Impermeable areas associated with the Proposed 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 packaged sewage treatment tank.

¹¹ British Geological Survey, Borehole Scans, BGS ID 694940. [Online]. Available at: http://scans.bgs.ac.uk/sobi_scans/boreholes/694940/images/16697028.html

The impermeable elements will create a total impermeable area of approximately 0.68 ha. The total contributing area including the substation platform to be attenuated and discharged is approximately 1.43 ha.

2 SURFACE WATER DESIGN CONDITIONS

In accordance with the SuDS Manual, an evaluation has been undertaken to determine the most appropriate option to dispose of surface water from the Proposed Development.

2.1 Surface Water Discharge Options

The Proposed Development will require a welfare facility; however, it will not be permanently manned, with infrequent maintenance visits. Therefore, there will be no demand for water re-use. Consultations¹² with ABC 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. The conversations are shown in **Appendix B**.

2.2 Estimated Infiltration Rate

An assumed infiltration rate has been calculated based on the subsoils from the BGS borehole records located approximately 130 m south west of the Site. The borehole record shows sandy and gravelly clay strata to depths of 2.9 m bgl.

Table 25.1 of the SuDS Manual outlines estimated infiltration rates based on the Infiltration Drainage – Manual of Good Practice¹³. Table 25.1 indicates clay media has a typical maximum infiltration rate of an infiltration rate of 0.0000018 metres per hour (m/h).

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 infiltration capacity of the underlying soils infiltration as a means of drainage is assessed as unfeasible and surface water will be disposed of by controlled discharge to a nearby watercourse.

2.3 Greenfield Run-off rates

Greenfield run-off rates for the 1.43 ha of impermeable area, have been calculated using the ICP SuDS method¹⁴ via Micro Drainage Software with rates shown in **Table 1** below and **Appendix C** of this DIA.

Q_{BAR} will be utilised as the outflow rate.

The application of this approach leads to the run-off from the Site to be attenuated and discharged to the greenfield run-off rate of 33.4 l/s in up to the 200-year return period, with appropriate climate change allowances.

Table 1: Site Run-off Flow Rates (taken from Micro Drainage)

Return Period	Q (l/s)
Q_{BAR}	33.4
1	28.4
30	63.1
100	82.8

¹² Email and telephone communications between D. Moore (ABC) and R. Duff (Arcus) January 2022.

¹³ R, Bettess. Infiltration Drainage – Manual of Good Practice (1996). CIRIA R156.

¹⁴ 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

200	93.8
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2.4 Return Period and Climate Change Allowance

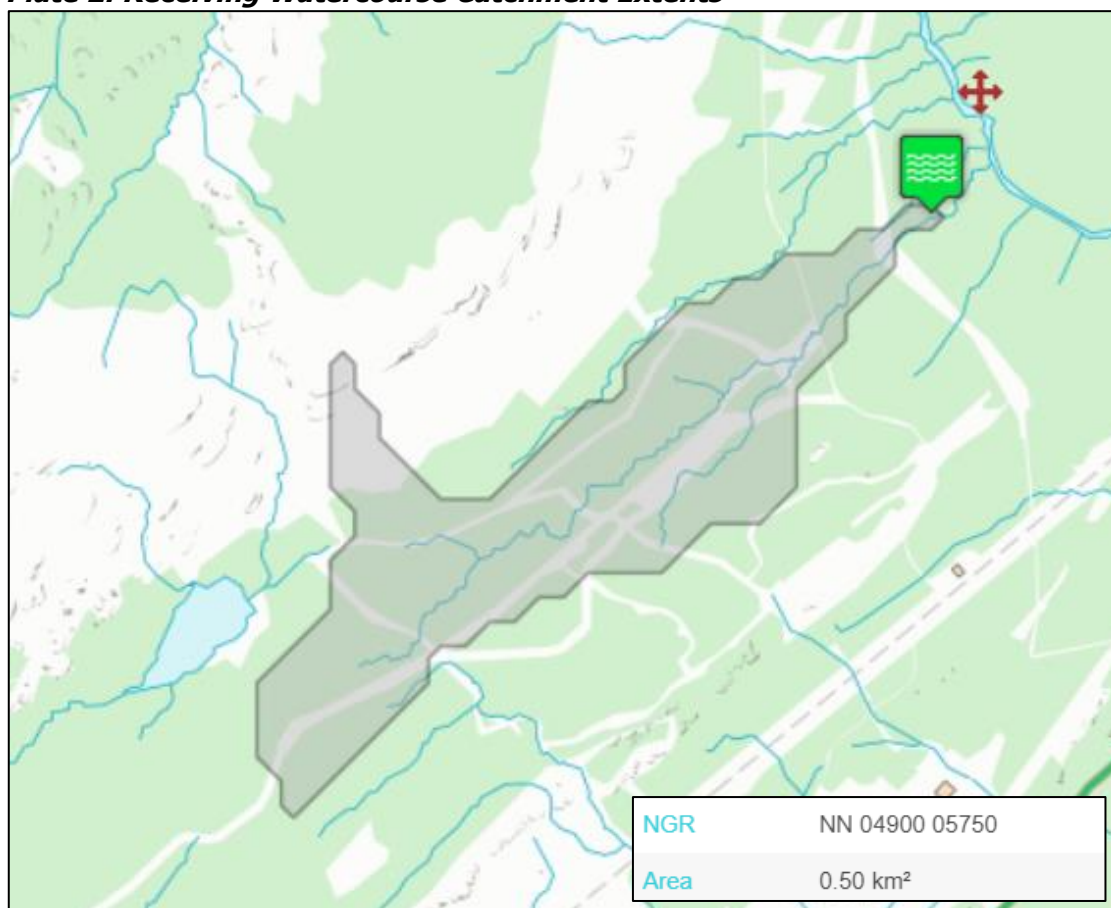
In accordance with Map 1 of SEPA’s climate change (+CC) allowances¹⁵ a 46% allowance has been incorporated into the drainage design (+46% CC).

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

The UK CEH (FEH) web map¹⁶ indicates that the Tom an Buachaillean watercourse is served by a catchment of 0.5 km² as shown in **Plate 2**. This watercourse is located approximately 120 m north west of the Site. The watercourse flows in a northerly direction until it joins the Douglas Water approximately 300 m north east of the Site. The proposed drainage design will utilise a piped system to the watercourse.

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 chosen Contractor to ensure that greenfield run-off rates are maintained during the construction and operational phases of the Proposed Development.

¹⁵ 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

¹⁶ UK Centre for Ecology and Hydrology, Flood Estimation Handbook. [Online]. Available at: <https://fehweb.ceh.ac.uk/GB/map>

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 ABC under an agreed pre-construction condition.

3.1 Hierarchical Drainage Options

In accordance with the SuDS Manual (C753)¹⁷ the information within **Table 2** outlines the most appropriate option to dispose of surface water from the Development along with the rationale.

Table 2: 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.
Discharge to watercourse	✔	The nearest watercourse has been determined to be a feasible discharge location and therefore will be utilised within the strategy..
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.

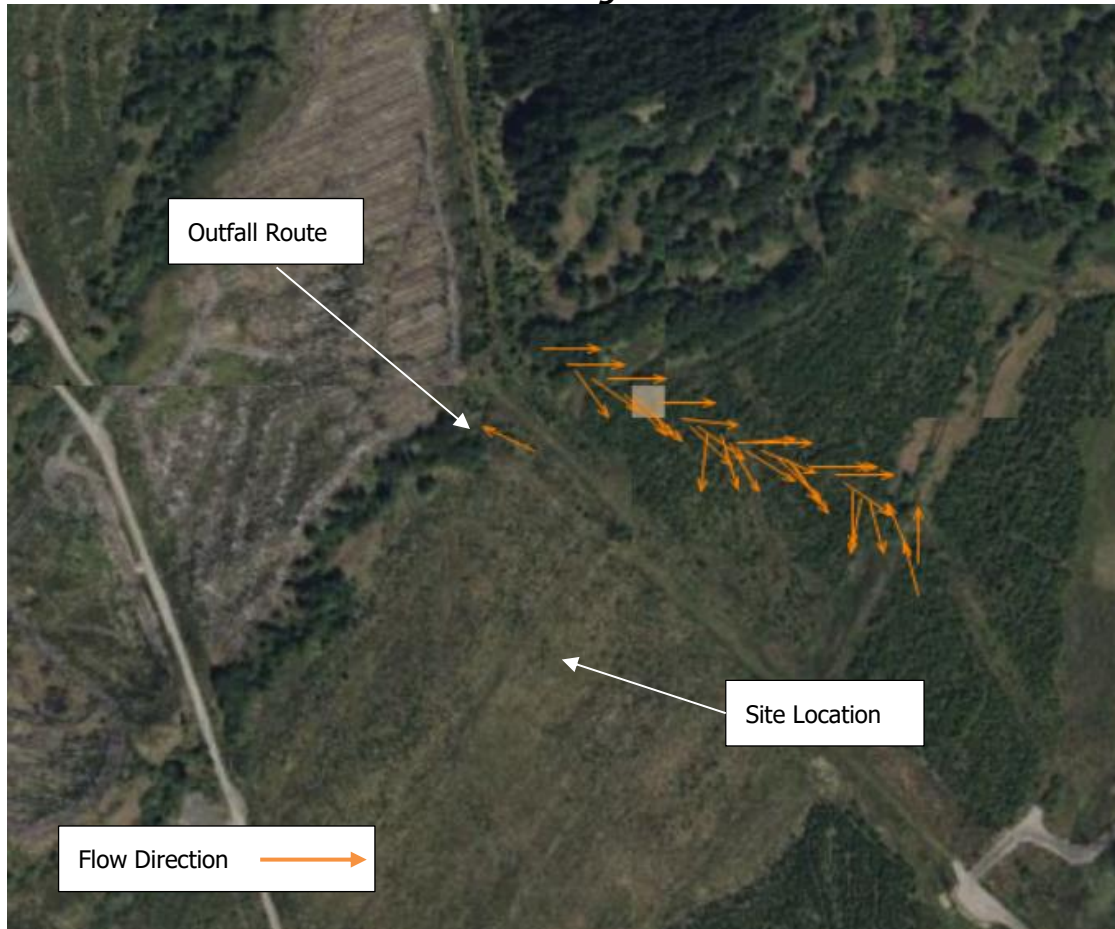
3.2 Proposed Surface Water Drainage Scheme

It is currently 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.

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**. Although sparse, **Plate 4** shows that the flow routes will connect the Site to the nearest watercourse, as represented by the outfall route.

¹⁷ CIRIA, The SuDS Manual (2015). [Online]. Available at: https://www.susdrain.org/resources/SuDS_Manual.html

Plate 4: Overland Flow Routes Surrounding the Site



An attenuation basin was selected as the most viable SuDS option due to the outfall location to the nearest watercourse being located approximately 120 m north west of the Site, as such both swales and filter drains were considered not to be feasible due to these distances. The outfall to the open land drain is located within the extents of the existing land ownership and no third-party access agreements are required for the route to the discharge point.

The outflow of the basin to the Tom an Buachaillean will be controlled by a Hydro-Brake (or other flow control device) and discharge to the watercourse to the west at 33.4 l/s.

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: 0.85 m;
- Slope: 1 in 4;
- Base area: 1,375 m²;
- Total area: 1,858.2 m²; and
- Maximum water depth: 0.842 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 attenuation basin should include a forebay to trap sediment immediately beneath the inlet occupying an area of approximately 10 % of the permanent basin surface area.

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 surcharge.

Details of critical events for the 1:200-year (+46 % CC) event and a cross-section of the attenuation basin design output can be found in **Appendix D**.

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

Storm Event	Rain (mm/hr)	Time to Vol Peak	Max Water Level	Max Depth (m)	Flooded Volume	Max Control (l/s)	Discharge Volume	Σ Max Outflow (l/s)	Maximum Volume	Status
720 min Winter	15.783	546	169.992	0.842	0.0	33.2	2254.7	33.2	1353.9	Flood Risk

3.3 Water Quality

The Proposed 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 Proposed 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 3 outlines that the Proposed Development includes land uses which have the following Simple Index Approach (SIA) indices.

Table 3: Pollution Hazard Indices for Land Use Classifications

Land Use	Pollution Level Hazard	Total Suspended Solids	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 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 Proposed 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 Proposed 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 4**, demonstrate that the combined Pollution Mitigation Indices for the run-off area are met by the utilisation of the substation platform as a surface water attenuation structure.

Table 4: 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 Proposed 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 not contribute to a significant increase in surface water run-off rates and 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)¹⁸.

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 Proposed Development. The septic tank will be managed, inspected and 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 SSEN Transmission 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 Proposed 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 SSEN Transmission

It is not anticipated that ABC or Scottish Water will adopt the new drainage network. Therefore, it will be the responsibility of SSEN Transmission to maintain effective drainage measures and rectify drainage measures that are not functioning adequately.

An outline management / maintenance plan is provided in **Table 5**. The table shows the management of a pond as that closely matches the characteristics of the proposed attenuation basin.

¹⁸ The Construction Industry Research and information Association (CIRIA), (2015), Environmental Good Practice on Site Guide (C741), CIRIA: London.

Table 5: Outline Long-term Maintenance schedule for the Pond¹⁹

Maintenance schedule	Required action	Typical frequency
Regular Maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass – public areas	Monthly (during growing season)
	Cut meadow grass	Half yearly (spring, before nesting season and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Inspect inlets, outlets, banksides, 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 once some build-up has occurred, to inform management and disposal options	Half yearly
	Check any mechanical devices, eg penstocks	Half yearly
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1m above water level	Annually
	Tidy all dead growth (scrub clearance) before start of growing season (Note: tree maintenance is usually part of overall landscape management contract)	Annually
	Remove sediment from any forebay.	Every 1-5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays.	Every 5 years, or as required
Occasional Maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25–50 years
Remedial actions	Repair erosion or other damage	As required
	Replant, where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required

¹⁹ Based on Table 23.1 - Operation and maintenance requirements for ponds and wetlands of the SuDS Manual.

	Realign rip-rap or repair other damages	As required
	Repair/rehabilitate inlets. Outlets and overflows	As required

An outline management / maintenance plan for any filter drains is provided in **Table 6**.

Table 6: Outline Long-term Maintenance schedule for Filter Drains²⁰

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 DIA 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.

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

6 CONCLUSION

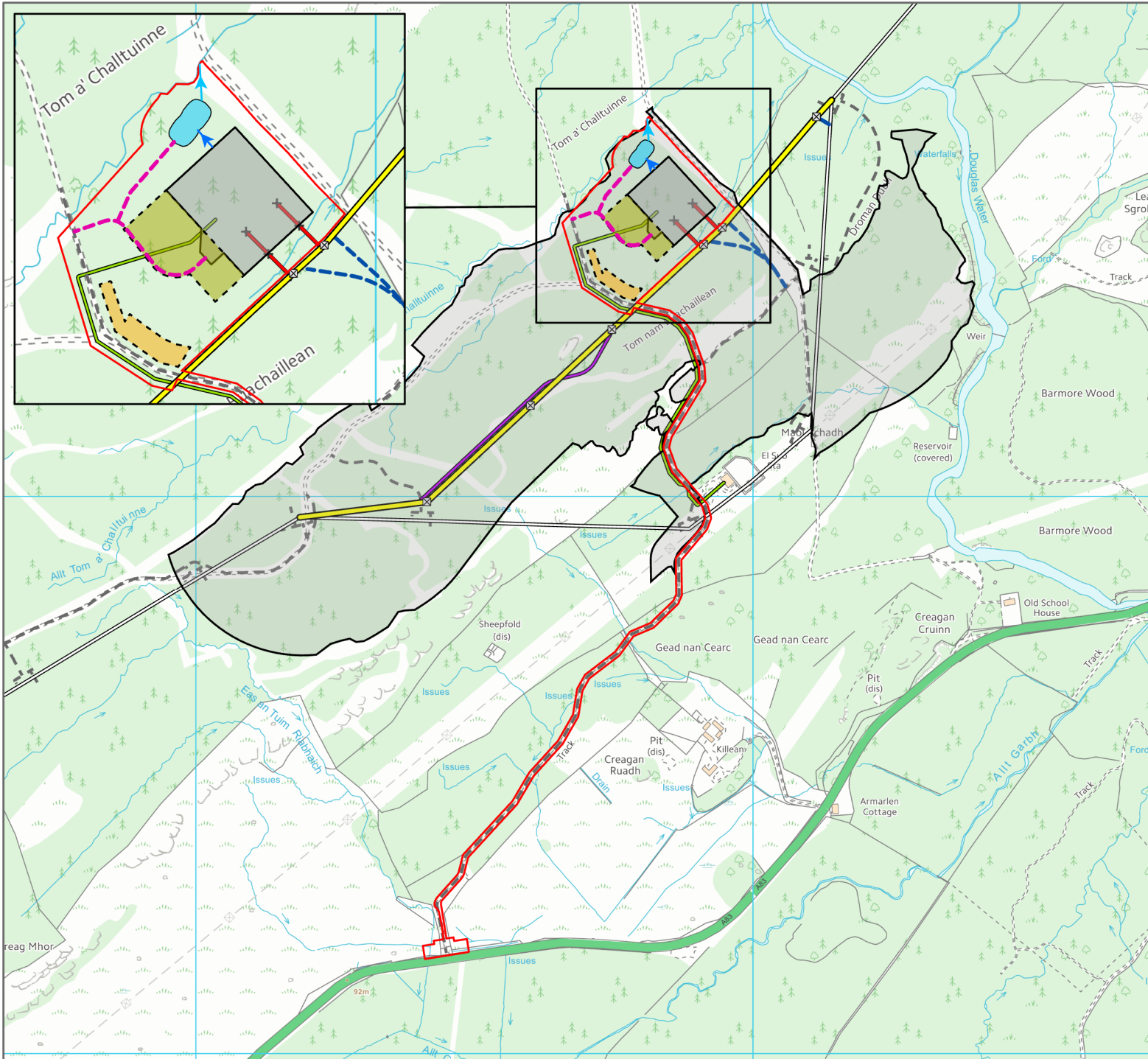
This DIA provides details on the volume of storage required to attenuate surface water run-off from the construction of the Proposed Development. The proposed OHL works have not been assessed in this DIA.

The Proposed Development will involve the installation of approximately 1.43 ha of impermeable elements.

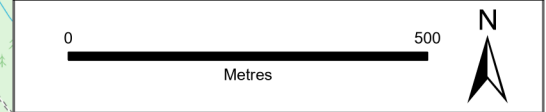
²⁰ Based on Table 16.1 - Operation and maintenance requirements for filter drains of the SuDS Manual.

The proposed attenuation basin and associated piped network detailed within this report are shown to not surcharge during a 1:200-year (+46 % CC) event and discharge to the nearest watercourse at a 33.4 l/s.

APPENDIX A – SITE LAYOUT



- Existing Inveraray to Crossaig Overhead Line
- - - Existing Access Track
- Proposed Development:**
- Proposed Permanent Access Track
- SUDs Inlet Pipeline
- SUDs Outfall Pipeline
- Town & Country Planning Boundary
- Proposed Substation Layout
- SUDs Pond
- Proposed Substation Temporary Works Area
- Temporary Peat Storage Area
- Potential Area for Peat Restoration
- Permitted Development:**
- 33kV Interconnector Cable Route
- Associated Development:**
- ⊗ Proposed Tower Location
- Proposed OHL Alignment
- OHL Downloads
- Proposed Permanent Access Track
- Temporary Access Track



SCALE: See Scale Bar	VERSION: A02
SIZE: A4	DRAWN: DN
PROJECT: 0607366	CHECKED: WB
DATE: 05/12/2022	APPROVED: SW

Figure 1.1
An Suidhe Substation Red Line
Boundary



PROJECTION: British National Grid

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

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





Consultancy of the Year 2022

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



Consultancy of the Year 2022

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APPENDIX C – ICP SUDS OUTPUTS

Suite 1C, Swinegate Court East
No3 Swingegate
York, YO1 8AJ



Date 01/12/2022 15:52
File

Designed by Tom.Cusworth
Checked by

Innovyze Source Control 2015.1

ICP SUDS Mean Annual Flood

Input

Return Period (years)	200	Soil	0.500
Area (ha)	1.430	Urban	0.000
SAAR (mm)	2400	Region Number	Region 1

Results 1/s

QBAR Rural 33.4
QBAR Urban 33.4

Q200 years 93.8

Q1 year 28.4
Q30 years 63.1
Q100 years 82.8

APPENDIX D – MICRODRAINAGE OUTPUTS

Suite 1C, Swinegate Court East
 No3 Swingegate
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Date 01/12/2022 16:23

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Innovyze

Source Control 2015.1

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m ³)	Status
15 min Summer	169.429	0.279	32.6	404.1	O K
30 min Summer	169.506	0.356	33.2	523.6	O K
60 min Summer	169.598	0.448	33.2	669.6	O K
120 min Summer	169.699	0.549	33.2	836.1	O K
180 min Summer	169.757	0.607	33.2	935.8	Flood Risk
240 min Summer	169.797	0.647	33.2	1003.8	Flood Risk
360 min Summer	169.847	0.697	33.2	1091.2	Flood Risk
480 min Summer	169.877	0.727	33.2	1144.7	Flood Risk
600 min Summer	169.897	0.747	33.2	1180.6	Flood Risk
720 min Summer	169.910	0.760	33.2	1204.5	Flood Risk
960 min Summer	169.901	0.751	33.2	1188.6	Flood Risk
1440 min Summer	169.867	0.717	33.2	1126.3	Flood Risk
2160 min Summer	169.794	0.644	33.2	998.2	Flood Risk
2880 min Summer	169.714	0.564	33.2	861.3	Flood Risk
4320 min Summer	169.598	0.448	33.2	669.5	O K
5760 min Summer	169.507	0.357	33.2	525.5	O K
7200 min Summer	169.444	0.294	32.8	426.7	O K
8640 min Summer	169.402	0.252	32.2	364.0	O K
10080 min Summer	169.383	0.233	30.5	334.9	O K
15 min Winter	169.461	0.311	33.0	454.1	O K
30 min Winter	169.548	0.398	33.2	590.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Discharge Volume (m ³)	Time-Peak (mins)
15 min Summer	159.816	0.0	403.7	25
30 min Summer	105.584	0.0	540.0	38
60 min Summer	69.754	0.0	735.1	66
120 min Summer	46.084	0.0	974.8	124
180 min Summer	36.161	0.0	1149.1	182
240 min Summer	30.445	0.0	1291.1	240
360 min Summer	23.890	0.0	1521.2	304
480 min Summer	20.114	0.0	1708.6	370
600 min Summer	17.601	0.0	1869.5	438
720 min Summer	15.783	0.0	2012.0	508
960 min Summer	12.941	0.0	2199.4	648
1440 min Summer	9.783	0.0	2491.8	926
2160 min Summer	7.395	0.0	2846.2	1328
2880 min Summer	6.064	0.0	3110.6	1708
4320 min Summer	4.695	0.0	3605.5	2428
5760 min Summer	3.916	0.0	4025.8	3120
7200 min Summer	3.401	0.0	4370.1	3816
8640 min Summer	3.032	0.0	4671.5	4488
10080 min Summer	2.751	0.0	4937.5	5152
15 min Winter	159.816	0.0	454.6	25
30 min Winter	105.584	0.0	607.2	38

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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	169.651	0.501	33.2	757.5	O K
120 min Winter	169.767	0.617	33.2	951.9	Flood Risk
180 min Winter	169.836	0.686	33.2	1072.9	Flood Risk
240 min Winter	169.881	0.731	33.2	1151.4	Flood Risk
360 min Winter	169.931	0.781	33.2	1242.8	Flood Risk
480 min Winter	169.960	0.810	33.2	1295.5	Flood Risk
600 min Winter	169.980	0.830	33.2	1332.4	Flood Risk
720 min Winter	169.992	0.842	33.2	1353.9	Flood Risk
960 min Winter	169.973	0.823	33.2	1319.1	Flood Risk
1440 min Winter	169.912	0.762	33.2	1208.5	Flood Risk
2160 min Winter	169.791	0.641	33.2	993.4	Flood Risk
2880 min Winter	169.658	0.508	33.2	768.1	O K
4320 min Winter	169.484	0.334	33.1	488.8	O K
5760 min Winter	169.393	0.243	32.0	350.0	O K
7200 min Winter	169.367	0.217	28.2	310.6	O K
8640 min Winter	169.349	0.199	25.2	284.1	O K
10080 min Winter	169.336	0.186	23.0	265.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	69.754	0.0	824.7	66
120 min Winter	46.084	0.0	1093.0	122
180 min Winter	36.161	0.0	1288.3	180
240 min Winter	30.445	0.0	1447.3	236
360 min Winter	23.890	0.0	1705.1	340
480 min Winter	20.114	0.0	1915.0	388
600 min Winter	17.601	0.0	2095.2	466
720 min Winter	15.783	0.0	2254.7	546
960 min Winter	12.941	0.0	2464.6	702
1440 min Winter	9.783	0.0	2791.8	1004
2160 min Winter	7.395	0.0	3188.7	1432
2880 min Winter	6.064	0.0	3485.3	1796
4320 min Winter	4.695	0.0	4041.1	2468
5760 min Winter	3.916	0.0	4509.7	3016
7200 min Winter	3.401	0.0	4895.5	3744
8640 min Winter	3.032	0.0	5233.7	4424
10080 min Winter	2.751	0.0	5533.5	5152

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	200
Site Location	GB 204900 705750 NN 04900 05750
C (1km)	-0.017
D1 (1km)	0.492
D2 (1km)	0.400
D3 (1km)	0.459
E (1km)	0.252
F (1km)	2.532
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) 1.430

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From:	To:	From:	To:	From:	To:
	(ha)		(ha)		(ha)
0	4 0.477	4	8 0.477	8	12 0.477

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Model Details

Storage is Online Cover Level (m) 170.000

Tank or Pond Structure

Invert Level (m) 169.150

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	1375.0	0.850	1858.2


Hydro-Brake Optimum® Outflow Control

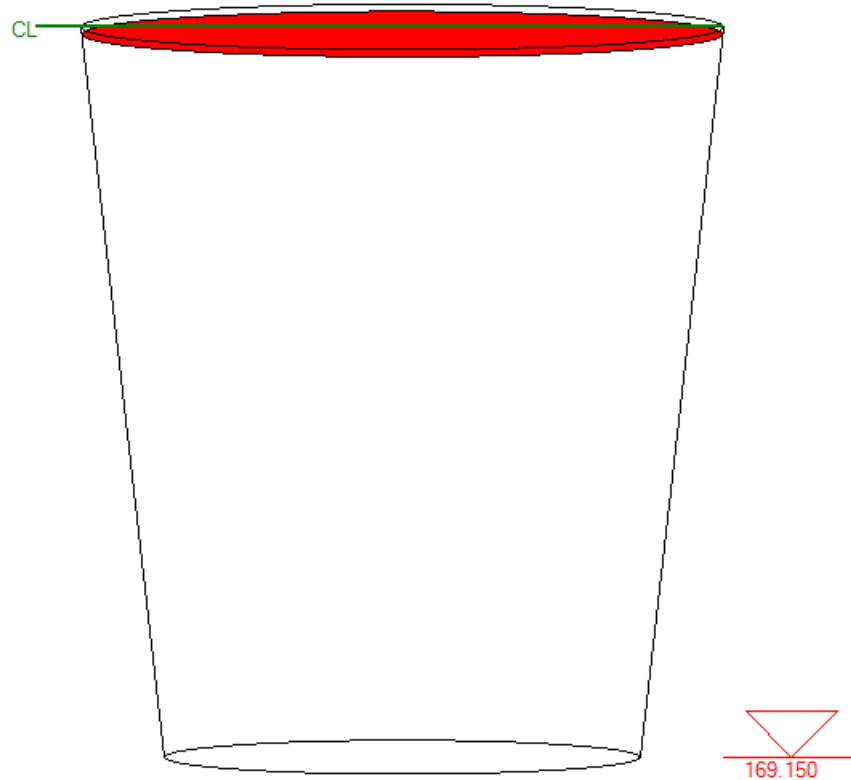
Unit Reference	MD-SHE-0249-3340-0850-3340
Design Head (m)	0.850
Design Flow (l/s)	33.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	249
Invert Level (m)	169.150
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.850	33.3
Flush-Flo™	0.377	33.2
Kick-Flo®	0.664	29.6
Mean Flow over Head Range	-	26.7

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	8.1	1.200	39.3	3.000	61.2	7.000	92.4
0.200	25.5	1.400	42.3	3.500	65.9	7.500	95.5
0.300	32.9	1.600	45.1	4.000	70.3	8.000	98.6
0.400	33.2	1.800	47.8	4.500	74.5	8.500	101.5
0.500	32.6	2.000	50.3	5.000	78.4	9.000	103.8
0.600	31.3	2.200	52.6	5.500	82.1	9.500	106.7
0.800	32.3	2.400	54.9	6.000	85.7		
1.000	36.0	2.600	57.1	6.500	89.1		

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Invert Level of Structure (m): 169.150