Scottish & Southern Electricity Networks

TRANSMISSION

Annex K - Drainage Impact Assessment

August 2022

CRARAE SUBSTATION

ANNEX K
DRAINAGE IMPACT ASSESSMENT

NOVEMBER 2022

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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 Crarae substation.

The Proposed Development is accompanied by the Associated Development, a permanent overhead line (OHL) Tie in comprising of 3 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 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];
- Construction Industry Research and Information Association (CIRIA), The Sustainable Urban Drainage Systems (SuDS) Manual (C753)[5]; and
- Argyll and Bute Council (ABC), Flood Risk Management Policy and Strategy[6].

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

1.2 Site Context

The Site comprises an area of maximum 18.8 hectares (ha) and is located approximately 1.2 kilometres (km) south west of the existing Crarae Substation, 1.6 km north west of Minard and 1.7 km west of Crarae at National Grid Reference (NGR) E 196149, N 697487. The Site is approximately 220 m south east of Abhainn Bheag an Tunns.

The Proposed Development is in an area of commercial forestry with low conservation value as well as an area of semi-natural broadleaved woodland with higher ecological importance. A short section of new access track and existing access tracks would be utilised to access the Proposed Development from the existing road to ensure operational access is maintained.

Ordnance Survey (OS) Terrain 5 data indicates Site elevations are in the approximate range of 150 to 175 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**.

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[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/

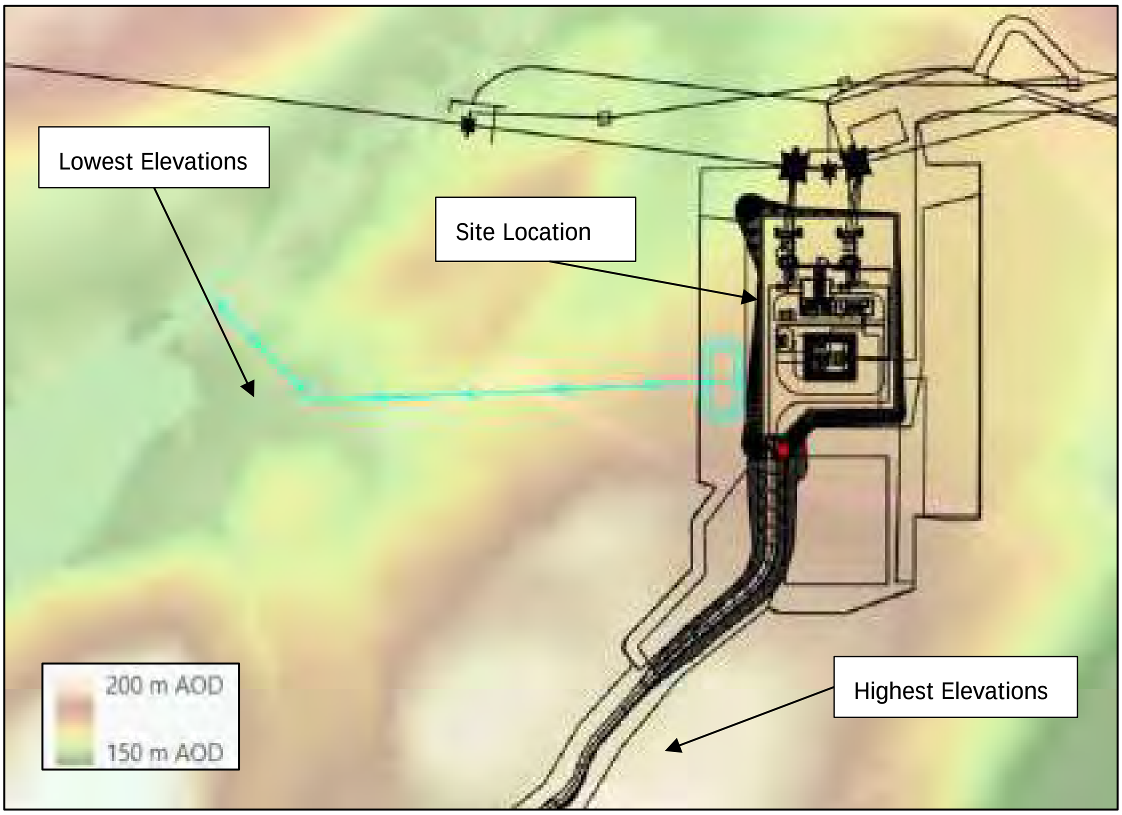
[3] SEPA, Technical Flood Risk Guidance for Stakeholders (2019). [Online]. Available at: https://www.sepa.org.uk/environment/land/planning/guidance-and-advice-notes/

[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 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)

Plate 1: Site Location and Elevations



There were no British Geological Survey (BGS) borehole scans located close to the Site, with the closest record being located >5 km away from the Site. However, The BGS Geology of Britain Viewer[7] shows that most of the area is underlain by bedrock geology consisting of Ardishaig Phyllite Formation, and has superficial deposits consisting mainly of Till.

Peat depths ranged from 0.0 m to 6.0 m thickness across the Project and were shown as localised or isolated zones, with 98 (41 %) probes confirming peat in excess of 2 m. These deeper areas of peat are located across the central to north-eastern areas of the study area. Further details on the associated peat depths are available in **Annex N: Peat Management Plan** of the Crarae 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. The impermeable elements will create a total impermeable area of approximately 1.44 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.

[7] British Geological Viewer. [Online]. Available at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html

2.1 Surface Water Discharge Options

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

Consultations[8] 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.

2.2 Estimated Infiltration Rate

An assumed infiltration rate has been calculated based on the subsoils from the BGS Bedrock geology data which outlines the underlying strata comprises till (boulder clay).

Table 25.1 of the SuDS Manual outlines estimated infiltration rates based on the Infiltration Drainage – Manual of Good Practice[9]. 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 1.44 ha of impermeable area, have been calculated using the ICP SuDS method[10] via Micro Drainage Software with rates shown in **Table 1** and **Appendix B** 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 26.9 l/s in up to the 1:200-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}	26.9
1	22.9
30	50.9
100	66.8
200	75.7

2.4 Return Period and Climate Change Allowance

In accordance with Map 1 of SEPA's climate change (+CC) allowances[11] a 46 % allowance has been incorporated into the drainage design (+46 % CC).

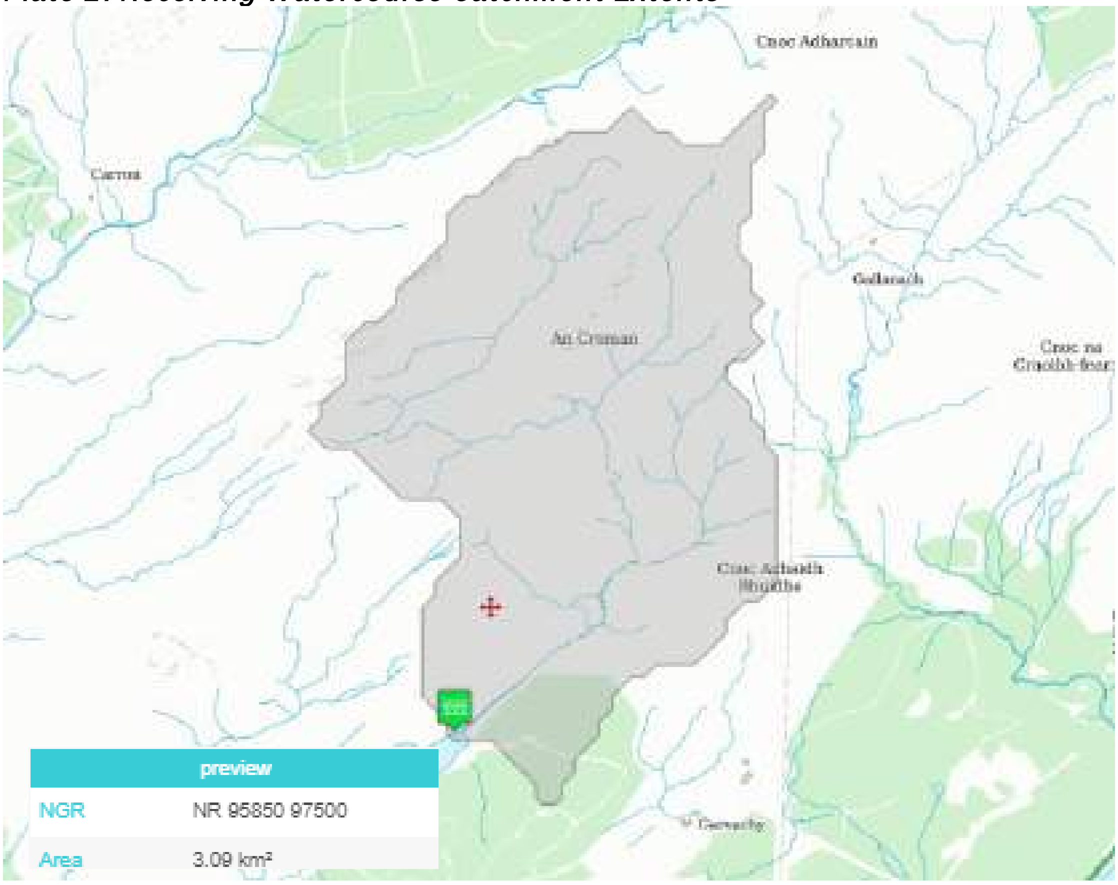
[8] Email and telephone communications between D. Moore (ABC) and R. Duff (Arcus) January 2022.
[9] R, Bettess. Infiltration Drainage – Manual of Good Practice (1996). CIRIA R156.
[10] National SuDS Working Group, Interim Code of Practice for Sustainable Drainage Systems (2004). [Online]. Available at: https://www.susdrain.org/files/resources/other-guidance/nswg_icop_for_suds_0704.pdf
[11] 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

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 map[12] indicates that the Abhainn Bheag an Tunns watercourse is served by a catchment of 3.09 km² as shown in **Plate 2**. This watercourse is located approximately 220 m north west of the Site. The watercourse flows in a south westerly direction until it joins Feorlin approximately 300 m west 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.

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.

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

3.1 Hierarchical Drainage Options

In accordance with the SuDS Manual (C753)[13] 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. 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.
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.

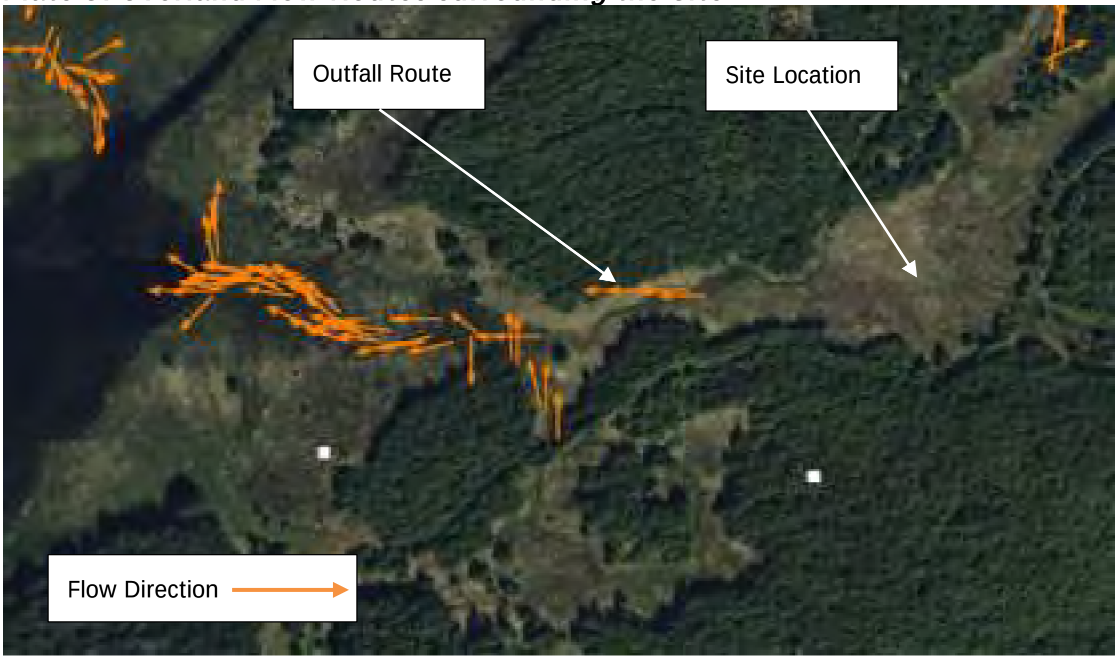
3.2 Proposed Surface Water Drainage Scheme

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 from east to west at the location of the Project. The outfall from the attenuation basin will fall in accordance with existing flow routes as shown by **Plate 3.**

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

Plate 3: 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 220 m 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 pond to the Abhainn Bheag an Tunns will be controlled by a Hydro-Brake (or other flow control device) and discharge to the watercourse to the west at 26.9 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: 0.9 m;
- Slope: 1 in 4;
- Base area: 1,250 m^2;
- Total area: 1,741.9 m^2; and
- Maximum water depth: 0.856 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.

The critical storm event in up to a 1:200-year (+46 % CC) event is shown in **Plate 4** 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 C.

Plate 4: 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	14.406	560	169.956	0.856	0.0	26.8	2013.9	26.8	1264.4	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 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 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 attenuation basin 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)[14].

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.

[14] 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 Pond[15]

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

[15] 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 Drains[16]

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

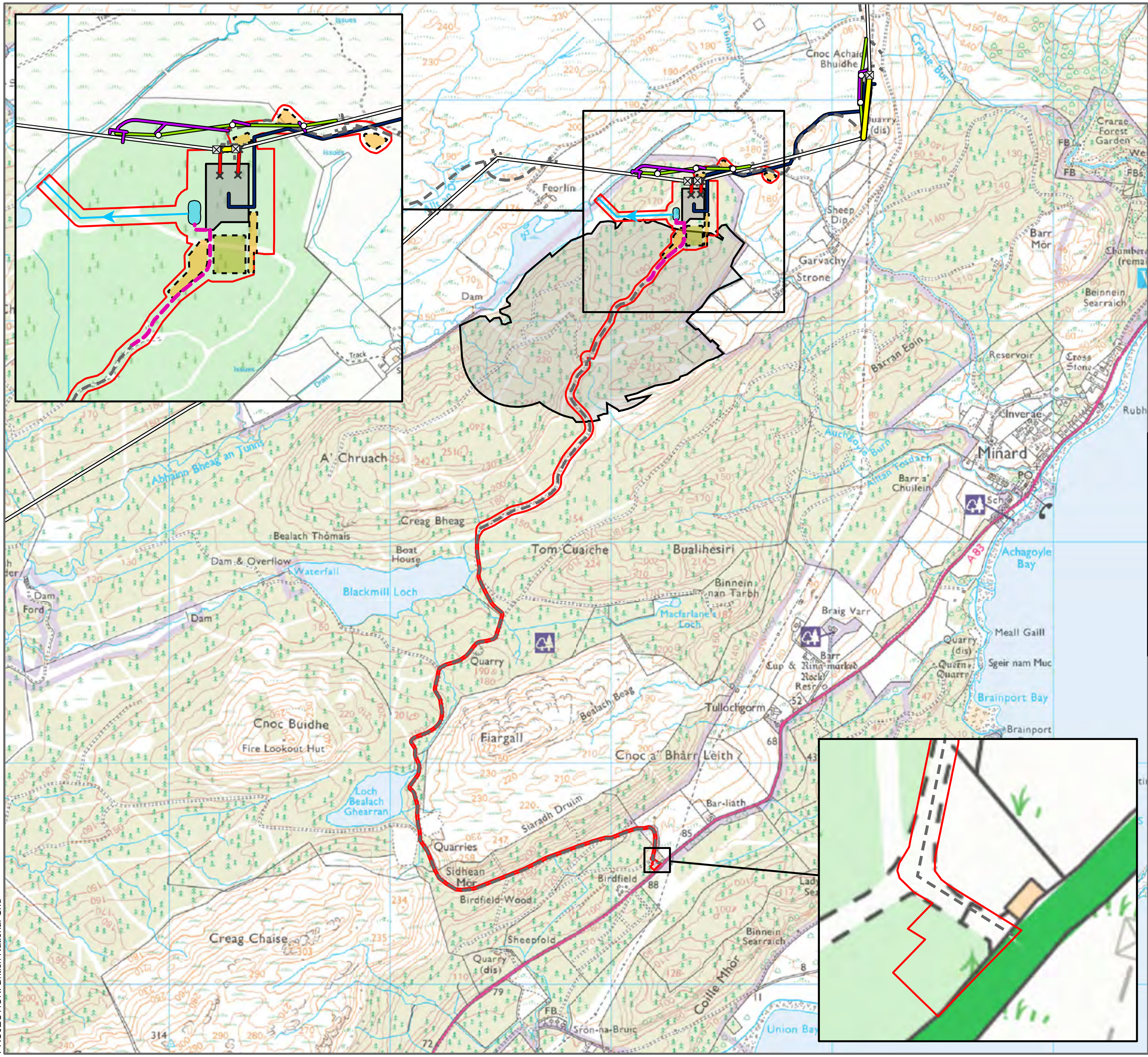
This DIA provides details on the volume of storage required to attenuate surface water run-off from the construction of the Proposed Development. The Associated Development has not been assessed in this DIA.

The Proposed Development will involve the installation of approximately 1.44 ha of impermeable elements.

[16] 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 26.9 l/s.

APPENDIX A – SITE LAYOUT



Existing Inveraray to Crossaig Overhead Line
Existing Access Track
Proposed Development:
Proposed Permanent Access Track
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 Temporary Tower Location
Proposed OHL Alignment
OHL Downleads
Proposed Temporary OHL Bypass
Temporary Access Track

0 1
Kilometres
N

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0607366
DATE: 18/11/2022
VERSION: A03
DRAWN: DN
CHECKED: WB
APPROVED: SW

Figure K.1
Crarae Substation Red Line Boundary

ERM
Scottish & Southern Electricity Networks
TRANSMISSION

PROJECTION: British National Grid

Path: \\UKSSMBNAF-a383.ops.erm55.com\UKSGISData01\London\0607366 - SSE Argyll Substations\MAPS\0607366 - SSE Argyll Substation.aprx\0607366_DesignFreeze_RedLineBoundary_Crarae_A03

APPENDIX B – ICP SUDS OUTPUTS

ICP SUDS Mean Annual Flood

Input

Return Period (years)	200	Soil	0.500
Area (ha)	1.440	Urban	0.000
SAAR (mm)	1986	Region Number	Region 1

Results	**l/s**
QBAR Rural	26.9
QBAR Urban	26.9
Q200 years	75.7
Q1 year	22.9
Q30 years	50.9
Q100 years	66.8

APPENDIX C – 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	169.421	0.321	26.7	427.4	O K
30 min Summer	169.500	0.400	26.8	540.6	O K
60 min Summer	169.590	0.490	26.8	675.0	O K
120 min Summer	169.688	0.588	26.8	824.8	O K
180 min Summer	169.744	0.644	26.8	913.2	Flood Risk
240 min Summer	169.781	0.681	26.8	973.3	Flood Risk
360 min Summer	169.822	0.722	26.8	1039.1	Flood Risk
480 min Summer	169.845	0.745	26.8	1077.2	Flood Risk
600 min Summer	169.860	0.760	26.8	1101.5	Flood Risk
720 min Summer	169.869	0.769	26.8	1116.9	Flood Risk
960 min Summer	169.858	0.758	26.8	1098.8	Flood Risk
1440 min Summer	169.821	0.721	26.8	1038.1	Flood Risk
2160 min Summer	169.746	0.646	26.8	917.3	Flood Risk
2880 min Summer	169.668	0.568	26.8	794.4	O K
4320 min Summer	169.558	0.458	26.8	626.9	O K
5760 min Summer	169.467	0.367	26.8	493.6	O K
7200 min Summer	169.400	0.300	26.6	398.0	O K
8640 min Summer	169.354	0.254	26.2	333.6	O K
10080 min Summer	169.326	0.226	25.8	295.5	O K
15 min Winter	169.458	0.358	26.8	480.5	O K
30 min Winter	169.546	0.446	26.8	609.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	166.596	0.0	427.3	25
30 min Summer	106.935	0.0	553.4	39
60 min Summer	68.640	0.0	729.7	68
120 min Summer	44.058	0.0	939.3	126
180 min Summer	33.994	0.0	1088.4	184
240 min Summer	28.280	0.0	1208.1	242
360 min Summer	21.820	0.0	1399.2	332
480 min Summer	18.153	0.0	1552.7	392
600 min Summer	15.738	0.0	1683.0	458
720 min Summer	14.006	0.0	1797.3	526
960 min Summer	11.400	0.0	1950.0	664
1440 min Summer	8.529	0.0	2185.8	944
2160 min Summer	6.381	0.0	2472.7	1348
2880 min Summer	5.194	0.0	2682.7	1732
4320 min Summer	4.004	0.0	3096.1	2468
5760 min Summer	3.329	0.0	3446.6	3168
7200 min Summer	2.885	0.0	3732.5	3824
8640 min Summer	2.566	0.0	3982.2	4504
10080 min Summer	2.325	0.0	4201.9	5152
15 min Winter	166.596	0.0	480.7	25
30 min Winter	106.935	0.0	621.9	39

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	169.648	0.548	26.8	762.6	O K
120 min Winter	169.759	0.659	26.8	937.6	Flood Risk
180 min Winter	169.824	0.724	26.8	1043.2	Flood Risk
240 min Winter	169.866	0.766	26.8	1111.3	Flood Risk
360 min Winter	169.912	0.812	26.8	1189.9	Flood Risk
480 min Winter	169.934	0.834	26.8	1226.8	Flood Risk
600 min Winter	169.948	0.848	26.8	1250.0	Flood Risk
720 min Winter	169.956	0.856	26.8	1264.4	Flood Risk
960 min Winter	169.937	0.837	26.8	1232.5	Flood Risk
1440 min Winter	169.879	0.779	26.8	1133.1	Flood Risk
2160 min Winter	169.761	0.661	26.8	940.7	Flood Risk
2880 min Winter	169.631	0.531	26.8	736.9	O K
4320 min Winter	169.456	0.356	26.8	478.0	O K
5760 min Winter	169.348	0.248	26.1	326.3	O K
7200 min Winter	169.311	0.211	23.9	275.0	O K
8640 min Winter	169.292	0.192	21.5	249.4	O K
10080 min Winter	169.279	0.179	19.6	231.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	68.640	0.0	818.4	68
120 min Winter	44.058	0.0	1053.1	124
180 min Winter	33.994	0.0	1220.0	180
240 min Winter	28.280	0.0	1354.1	238
360 min Winter	21.820	0.0	1568.2	348
480 min Winter	18.153	0.0	1740.0	446
600 min Winter	15.738	0.0	1885.9	482
720 min Winter	14.006	0.0	2013.9	560
960 min Winter	11.400	0.0	2184.9	716
1440 min Winter	8.529	0.0	2448.4	1024
2160 min Winter	6.381	0.0	2770.2	1460
2880 min Winter	5.194	0.0	3005.8	1828
4320 min Winter	4.004	0.0	3470.1	2516
5760 min Winter	3.329	0.0	3860.9	3120
7200 min Winter	2.885	0.0	4181.3	3752
8640 min Winter	2.566	0.0	4461.5	4488
10080 min Winter	2.325	0.0	4709.2	5152

Rainfall Details

Rainfall Model	FEH
Return Period (years)	200
Site Location	GB 195850 697500 NR 95850 97500
C (1km)	-0.019
D1 (1km)	0.461
D2 (1km)	0.385
D3 (1km)	0.459
E (1km)	0.255
F (1km)	2.500
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) 1.440

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.480	4	8	0.480	8	12	0.480

Model Details

Storage is Online Cover Level (m) 170.000

Tank or Pond Structure

Invert Level (m) 169.100

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1250.0	0.900	1741.9

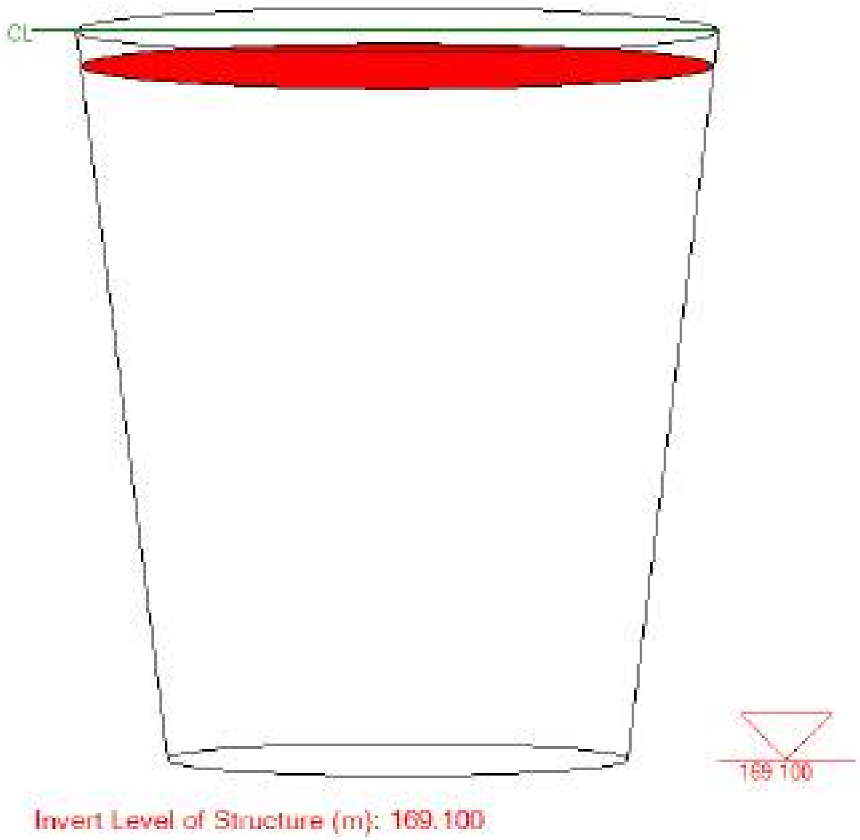
Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0226-2690-0900-2690
Design Head (m)	0.900
Design Flow (l/s)	26.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	226
Invert Level (m)	169.100
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.900	26.8
Flush-Flo™	0.357	26.8
Kick-Flo®	0.682	23.5
Mean Flow over Head Range	-	22.0

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.6	1.200	30.7	3.000	47.8	7.000	72.1
0.200	22.6	1.400	33.1	3.500	51.5	7.500	74.5
0.300	26.6	1.600	35.3	4.000	54.9	8.000	76.9
0.400	26.7	1.800	37.3	4.500	58.1	8.500	79.2
0.500	26.2	2.000	39.3	5.000	61.2	9.000	81.5
0.600	25.2	2.200	41.1	5.500	64.1	9.500	83.2
0.800	25.3	2.400	42.9	6.000	66.9		
1.000	28.2	2.600	44.6	6.500	69.5		



CL
169.100
Invert Level of Structure (m): 169.100