



Loch na Cathrach Knocknagael Substation Extension

Flood Risk Assessment

August 2024

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Networks

Loch na Cathrach Knocknagael Substation Extension

Flood Risk Assessment

August 2024

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The report is a factual assessment of flood risk based on the existing available statistical information. The flood risk assessment has been based on the information available at the time of study, to be used to inform relevant parties, and to assist in the planning process. Mott MacDonald is not liable for, and will not give a warranty against, actual flooding of the site, or damage as a result of said flooding

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Glossary

AEP	Annual Exceedance Probability. A flood with a 1% AEP has a statistical probability of being reached or exceeded in each year of 1%. This is often referred to as the “once in 100 year flood”. It should be noted however, that the occurrence of a flood event does not change the statistical probability of another flood occurring.
Design Flood	A simplified flood used in the numerical modelling
FEH	The Flood Estimation Handbook is a Centre for Ecology and Hydrology publication, giving guidance on rainfall and river flood frequency estimation in the UK.
Functional Floodplain	The functional floodplain is defined in SPP7 (para 16) as generally having greater than 0.5% probability of flooding in any year (less than a 1 in 200 year return period)
Estry	One-dimensional hydraulic modelling software produced by BMT WBM
mAOD	Levels in meters above Ordnance Datum (Newlyn)
One-dimensional hydraulic model.	A numerical model in which water levels only change along the river, i.e. water levels across the channel are assumed to be the same.
FFL	Finished Floor Level. The proposed lowest ground floor level of the proposed buildings. The level at which statistically the flood level will not exceed for the proposed AEP, meeting current Scottish Planning Policy requirements. Basements and parts of the property below this level statistically shall be flooded more frequently.
SEPA	Scottish Environment Protection Agency
THC	The Highland Council
TUFLOW	Two-dimensional hydraulic modelling software produced by BMT WBM
Two-dimensional hydraulic model	A numerical model in which water is not constrained within a defined channel, and can spread out across a floodplain or storage area

1 Introduction

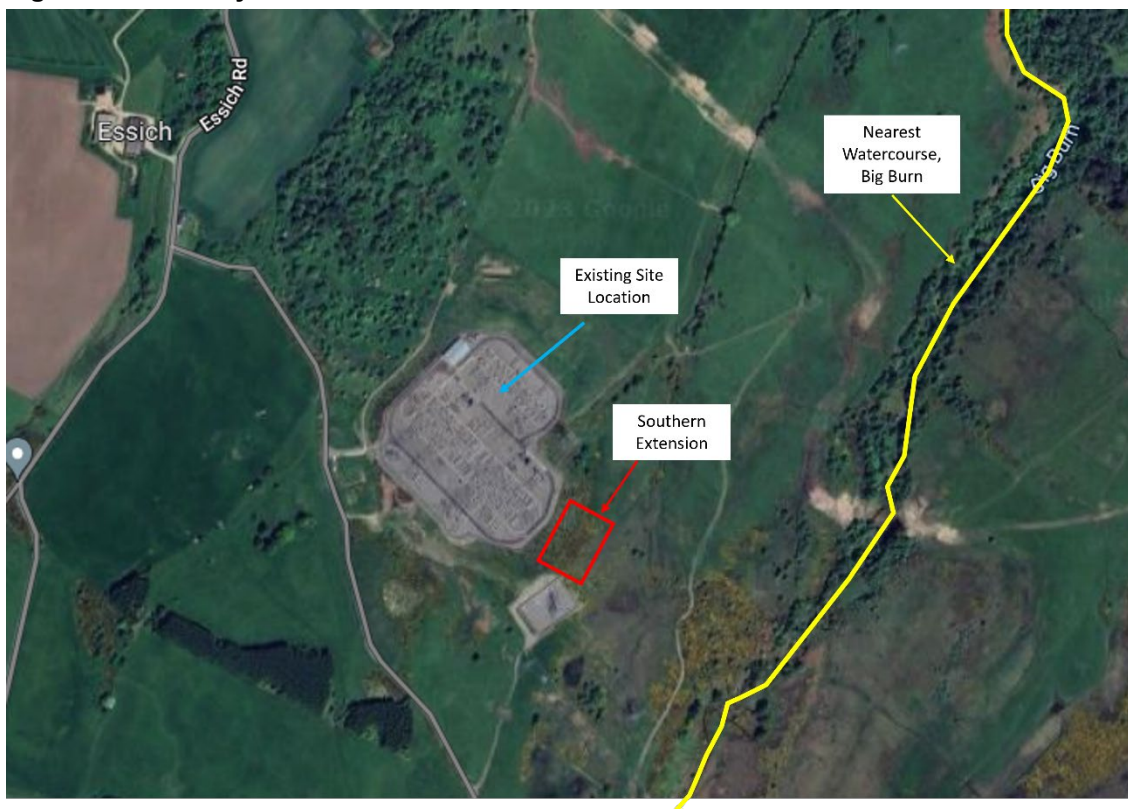
1.1 Study Area Description

The site lies south east of Essich, Inverness which is situated 8km south of the city of Inverness. The site is 400m from Essich Road, and 15m away from a minor road. The approximate grid reference for the site is 265682, 840002, and the nearest postcode is IV2 6AJ. The existing site is previously a greenfield.

The site location plan and site plan are illustrated in **Error! Reference source not found..** A proposed development of a southern extension is to be added to the existing substation.

The existing site covers an area of approximately 5.1 ha, with new proposed site being 1.3 ha. The existing site slopes downwards from the south west to the north east, where a detention basin is located. The detention pond is an existing drainage system fed by French drains located around the perimeter of the platform.

Figure 1.1: Site Layout



Source: Google Maps (2023), Essich

1.2 Development Proposal

The Knocknagael substation extension is to accommodate a new firm connection for the 450MW Red John pumped storage hydro project at 275kV. The extension is essential to create an additional bay as a minimum as the existing 275kV bays within the Knocknagael site are in use.

- Extension of existing 275kV AIS double busbar substation platform (on the south side of the substation) to accommodate a new bus-coupler, a cable bays for new Red John cable and associated busbar and HV plant equipment.
- Earthworks involving cut and fill embankments to tie into existing slope angles. These will likely involve the excavation and re-use of on-site material
- The removal and subsequent replacement of the existing 275kV bus coupler (on the south side) required for the connection.
- Rerouting of existing drainage around extension platform extents.
- Creation of a retention basin out with site fence line.
- Creation of temporary construction access tracks

The proposed new development will be aligned with the existing platform level of 175.5mAOD and will be constructed using 20mm crushed gravel.

1.3 Scope and Purpose of Study

Mott MacDonald have been commissioned by Scottish & Southern Energy Network (SSEN) Transmission to undertake a flood risk assessment for the proposed extensions of the Knocknagael 275/132kV substation.

The purpose of this report is to determine the flood risk in association to the proposed new substation and the access road. The nearest watercourse to the site is Big Burn located approximately 300m away from the proposed southern extension.

1.4 Flood Risk Policy and Guidance

Scottish Planning Policy (SPP) provides a statement of the Scottish Government's policy on flood risk as a material planning consideration and states that "Development which would have a significant probability of being affected by flooding or would increase the probability of flooding elsewhere should not be permitted"¹. This policy document characterises areas in terms of flood risk as follows in its 'Risk Framework':

- Little or no risk area (annual probability of flooding of less than 0.1% (1:1000)) – no general constraints;
- Low to medium risk area (0.1% to 0.5% (1:1000 – 1:200)) – suitable for most development but not essential civil infrastructure;
- Medium to high risk area (0.5% (1:200)) or greater – In built up areas, may be suitable provided flood prevention measures to the appropriate standard exist, are currently under construction or are planned as part of a long term strategy. If built development is permitted, appropriate measures to manage flood risk will be required and the loss of flood storage capacity mitigated.

In SPP the functional floodplain is described as having a "greater than 0.5% (1:200) probability of flooding in any year".

SPP notes that "development should...normally be avoided in areas with increased vulnerability to the effects of climate change, particularly areas at significant risk of flooding"².

⁴ SPP, Section 197: Flooding and Drainage.

⁴ SPP, Section 197: Flooding and Drainage.

An allowance for 'freeboard' to account for uncertainties in the modelling results, wave action etc. is generally added on to the indicative flood levels. SEPA recommend a minimum freeboard of 500mm to 600mm³.

The proposed development is essential civil infrastructure, therefore the development should not be at risk in the 0.1%AEP flood event including an allowance for climate change. The change in flood risk elsewhere has been reviewed based on the 0.5% Annual Exceedance Probability (AEP) flood event including an allowance for climate change.

SPP is complemented by the following policy and guidance documents, which have been considered in the preparation of this Flood Risk Assessment:

- Planning Advice Note (PAN) 69: 'Planning and Building Standards Advice on Flooding';
- SEPA Policy No. 41: 'Development at Risk of Flooding: Advice and Consultation';
- SEPA Guidance Note: 'Technical Flood Risk Guidance for Stakeholders, V12';
- CIRIA guidance document C624: 'Development and Flood Risk';
- SEPA Flood Modelling Guidance for Responsible Authorities, Version 1.1;
- SEPA: Climate change allowances for flood risk assessment in land use planning.

⁴ SPP, Section 197: Flooding and Drainage.

2 Background

2.1 Flood Risk Policy and Guidance

Scottish Planning Policy (SPP) provides a statement of the Scottish Government's policy on flood risk as a material planning consideration and states that "Development which would have a significant probability of being affected by flooding or would increase the probability of flooding elsewhere should not be permitted"⁴. This policy document characterises areas in terms of flood risk as follows in its 'Risk Framework':

- Little or no risk area (annual probability of flooding of less than 0.1% (1:1000)) – no general constraints;
- Low to medium risk area (0.1% to 0.5% (1:1000 – 1:200)) – suitable for most development but not essential civil infrastructure;
- Medium to high risk area (0.5% (1:200)) or greater – In built up areas, may be suitable provided flood prevention measures to the appropriate standard exist, are currently under construction or are planned as part of a long term strategy. If built development is permitted, appropriate measures to manage flood risk will be required and the loss of flood storage capacity mitigated.

In SPP the functional floodplain is described as having a "greater than 0.5% (1:200) probability of flooding in any year".

SPP notes that "development should...normally be avoided in areas with increased vulnerability to the effects of climate change, particularly areas at significant risk of flooding"⁵.

An allowance for 'freeboard' to account for uncertainties in the modelling results, wave action etc. is generally added on to the indicative flood levels. SEPA recommend a minimum freeboard of 500mm to 600mm⁶.

The proposed development is essential civil infrastructure, therefore the development should not be at risk in the 0.1%AEP flood event including an allowance for climate change. The change in flood risk elsewhere has been reviewed based on the 0.5% Annual Exceedance Probability (AEP) flood event including an allowance for climate change.

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- SEPA Guidance Note: 'Technical Flood Risk Guidance for Stakeholders, V12';
- CIRIA guidance document C624: 'Development and Flood Risk';
- SEPA Flood Modelling Guidance for Responsible Authorities, Version 1.1;
- SEPA: Climate change allowances for flood risk assessment in land use planning.

⁴ SPP, Section 197: Flooding and Drainage.

⁵ SPP, Section 42: Climate Change.

⁶ SEPA Guidance Note entitled: 'Technical Flood Risk Guidance for Stakeholders, V12'.

2.2 Consultation

Pre-application consultation responses received from SEPA and The Highland Council (THC) on 15th February 2022, conducted by SSEN directly without the involvement of Mott MacDonald Ltd, is summarised below.

SEPA

SEPA provides planning advice on their website and should be reviewed and implemented as part of the design.

The Highland Council (THC)

Flood risks from all sources of flooding including lesser known watercourses that may not be present on SEPA flood maps should be considered. The FRA should consider the impact of a 1 in 200 years plus climate change return period and discharge should be limited to pre-development greenfield rate. A minimum buffer strip of 6m should be kept free from development, measured from top of bank(s) of any watercourse or waterbody. Storage of materials within this area during the construction is not permitted.

The Drainage Impact Assessment (DIA) written in accordance with our supplementary guidance: Flood Risk and Drainage Impact Assessment, is required to be submitted with the planning application. The DIA will need to detail the proposed surface water drainage and include appropriate drawings and calculations.

See Appendix C for full response from SEPA and THC.

2.3 Site Visit

A site visit was undertaken by the Mott MacDonald staff on the 15th September 2022, during which the site, detention basin and surrounding land were inspected. A sample from the photographic record of the site walkover is contained in Appendix A.

2.4 Local flood risk planning

The site is in the Highland & Argyll Local District Plan Flood Risk Management Plan. The site is not within a Potentially Vulnerable Area.

2.5 Historic flooding

There has been no known reported incidents of flooding at the site.

2.6 Data Sources

To undertake this study the following data and information were collated and analysed:

- Site Visual Survey;
- Ordnance Survey Maps;
- SEPA Flood Maps;
- LiDAR Remote Sensing Scotland.

3 Flood Risk Assessment

3.1 Potential flood sources

Category	Mechanism
Fluvial flooding	Exceedance of the flow capacity of the channel of a river, stream or other natural watercourse (which may be culverted). Fluvial flooding is typically associated with heavy rainfall events, and excess water spills onto the river floodplain.
Coastal and tidal flooding	Caused by high astronomical tide, storm surge, wave action, and local bathymetric effects, often in combination. In estuaries and watercourses affected by tide locking, flooding can occur as a result of high tidal levels and high fluvial flows in combination
Pluvial flooding (overland flow)	Water flowing over the ground surface that has not reached a natural or artificial drainage channel. This can occur when intense rainfall exceeds the infiltration capacity of the ground, or when the ground is so highly saturated that it cannot accept any more water.
Groundwater flooding	Raised groundwater levels, typically following prolonged rain (that may be slow to recede). High groundwater levels may result in increased overland flow flooding. Normally associated with catchments where porous substrate and/or aquifers exist.
Flooding from artificial drainage systems	Blockage or overloading of pipes, sewers, canals, and drainage channels or failure of pumping systems. Typically occurs following heavy rainfall or as a result of high water levels in a receiving watercourse
Flooding from infrastructure failure	Structural, hydraulic or geotechnical failure of infrastructure that retains, transmits, or controls the flow of water. Examples include hydro-power dams, water supply reservoirs, canals, flood defence structures, underground conduits (e.g. sewers), and water treatment tanks.

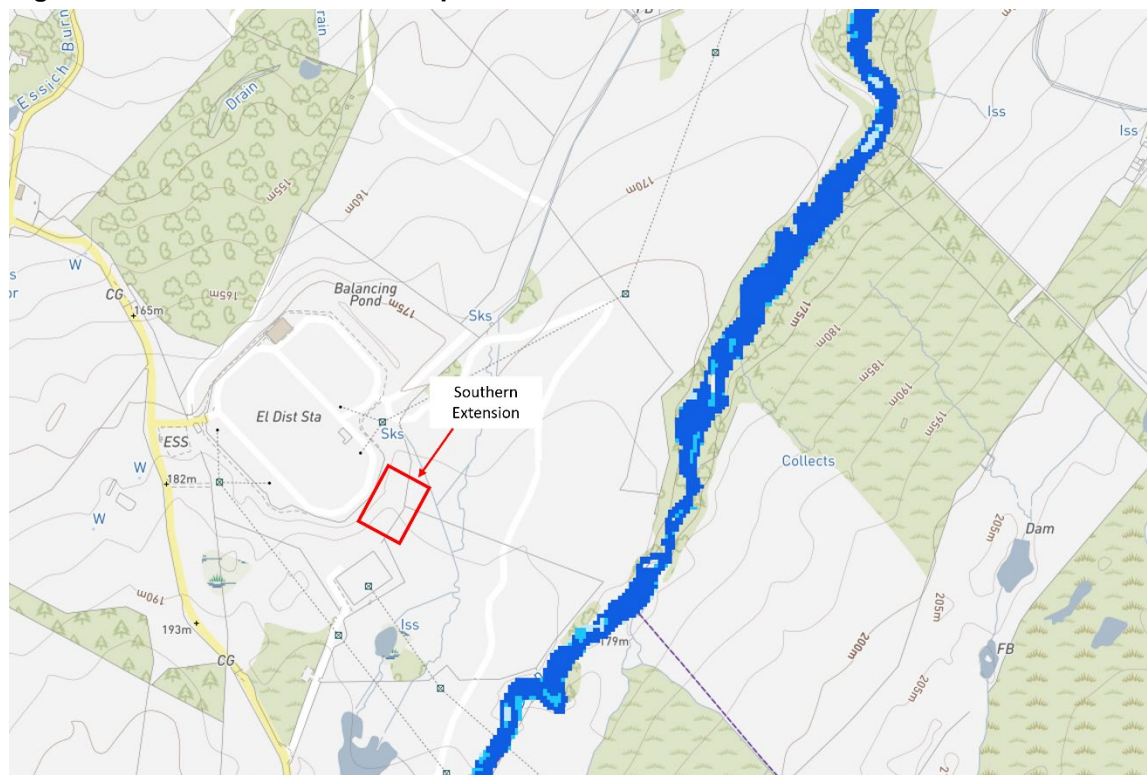
3.2 Discussion on sources of risk

3.2.1 Fluvial flooding

The SEPA fluvial flood maps, shown in Figure 3.1 show no impact of flooding at the site location from fluvial sources. The nearest major watercourse is Big Burn located approximately 300m away from the southern extension proposed site with no obvious flood risk.

The southern extension is in close proximity to minor watercourses marked on OS Mapping, it is expected during a flood event that the water will stay within the channel, this assumption is based on site visit photographs of the area, but can be seen in the SEPA pluvial flood risk maps in Figure 3.2. As these minor watercourses are shown on the pluvial SEPA flood risk maps and not fluvial, these have been discussed in the pluvial section on flood risk.

Figure 3.1: SEPA Fluvial Flood Map



Source: SEPA Flood Map (2022)

3.2.2 Coastal and Tidal Flooding

The asset is not at risk of coastal flooding as the site is located significantly inland with site levels above tidal levels.

3.2.3 Pluvial Flooding

The SEPA pluvial flood map, shown in Figure 3.2 shows no pluvial flooding of the southern extension. The drainage strategy includes localised site drainage as shown in Figure 3.4, which in general will cater for pluvial runoff local to the site and will be designed so as not to increase flood risk elsewhere from run off.

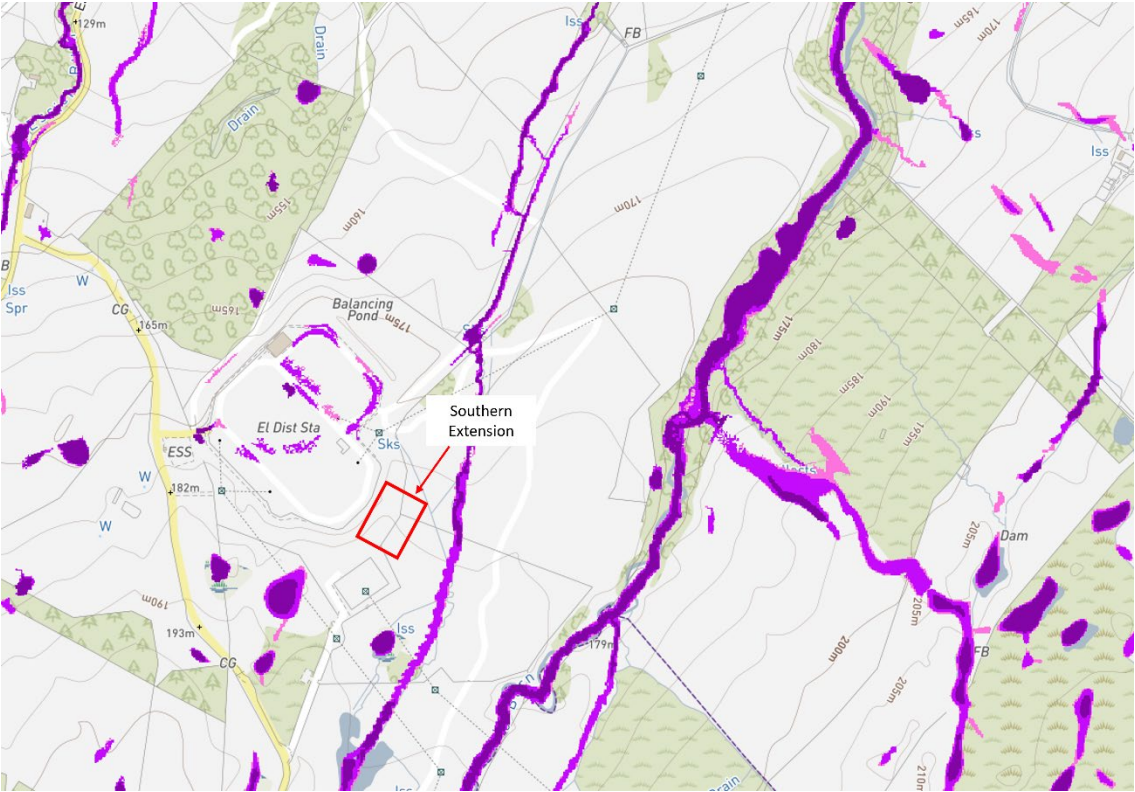
LiDAR sourced from Remote Sensing Scotland covers the northern part of the site and was used to understand the ground profile of the nearby watercourses in relation to the site, as shown in Figure 3.3. It is noted from the LiDAR that the minor watercourses in closest proximity to the site are at a greater level than the level of the site platform, which may pose a flood risk, but there is high ground between the minor watercourse and the site, which is confirmed from the detailed topographic survey.

SEPA pluvial flood maps indicate pluvial flooding is localised to the channel and local low topography in this area. A review of detailed topographic survey suggests the SEPA pluvial maps are correct and the pluvial flooding would be conveyed via the drainage ditches and the low ground to the east, within the site boundary.

A temporary haul road is located in close proximity to the watercourse. Whilst it is expected that the overland flow will bypass the works there is a potential flood risk to the site. To minimise the flood risk to the site, the haul road will be graded to drain towards the eastern side and will be slightly raised prior to entering the cutting, to reduce the risk of flood flows into the cutting. In

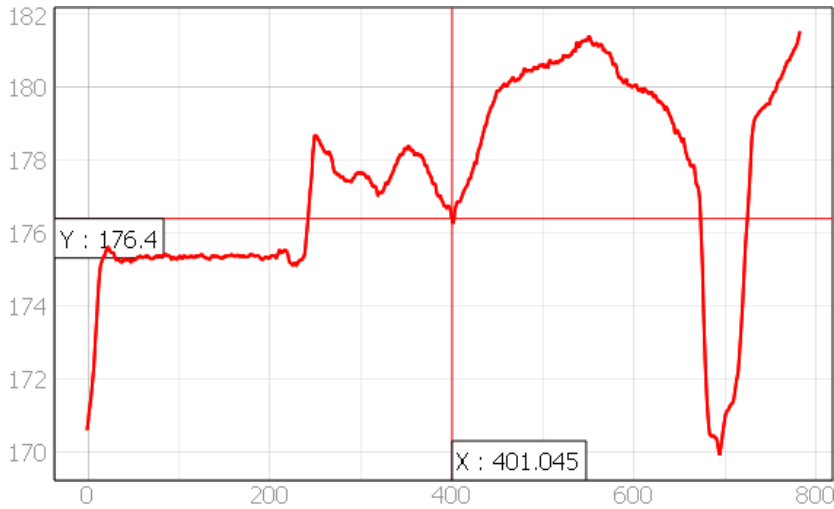
addition, a new ditch is proposed to the east side of the cutting crest defending against overland flow. The temporary haul road is to be removed after construction with ground levels reinstated. These reinstated ground levels are higher than the exiting ditches and pluvial flow paths, and thereby will minimise the risk of flooding.

Figure 3.2: SEPA Pluvial Flood Map



Source: SEPA Flood Map (2022)

Figure 3.3: Ground Profile



Source: QGIS and LiDAR sourced from Remote Sensing Scotland

Section (m)	Feature
0-250	Existing site
250-255	Embankment
280	Drainage Ditch
320	Drainage Ditch
400	Minor Watercourse
700	Major Watercourse

3.2.4 Groundwater Flooding

The topography of the platform is at a consistent level, with clear drainage paths away from the site. In addition, drainage surrounds the site to manage water levels and encourage water away from the site. Therefore it is considered that the site is not at groundwater flood risk.

3.2.5 Flooding from Artificial drainage systems

French drains are located around the perimeter of the site which lead to detention basins. Should the capacity of these be exceeded, the designed topography is such that flow would be away from the site. Therefore it is considered the site is not at risk from artificial drainage systems.

3.3 Principle sources of flood risk identified at Knocknagael

Based on the assessment of the sources of flood risk, the site is not at risk of coastal, fluvial or groundwater flooding.

SEPA flood maps shows pluvial flooding is limited to the existing drainage ditch locations and low ground within the east area of the site. In the permanent case pluvial flood water will be separated from the site via reinstated high ground. During construction the drainage around the temporary haul road will be designed so as not to introduce a pluvial flood risk to the site. Therefore, the site is not considered at risk of pluvial flooding assuming the site drainage is designed appropriately.

4 Conclusions

The purpose of this report is to determine the flood risk in association with a southern extension to the Knocknagael substation. Through the assessment of existing flood risk maps, local topographic information and proposed drawings, the flood risk to the proposed development has been assessed.

An assessment of coastal, pluvial, fluvial and groundwater flood sources was carried out, concluding that the site is not at risk of coastal, fluvial or groundwater flooding.

SEPA flood maps shows pluvial flooding is limited to the existing drainage ditch locations and low ground within the east area of the site. In the permanent case pluvial flood water will be separated from the site via reinstated high ground. During construction the drainage around the temporary haul road will be designed so as not to introduce a pluvial flood risk to the site. Therefore, the site is not considered at risk of pluvial flooding assuming the site drainage is designed appropriately.

Appendices

A.	Site Photographs	13
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A. Site Photographs

Figure 4.1: Southern Extension Site, Cut Earthworks Location



Source: Mott Macdonald Site Visit

Figure 4.2: Manhole Location, French Drains around perimeter



Source: Mott Macdonald Site Visit

Figure 4.3: Existing Drainage Pond with Headwall



Source: Mott Macdonald Site Visit

Figure 4.4: Existing Detention Basin



Source: Mott Macdonald Site Visit

Figure 4.5: Existing Detention Basin Headwall



Source: Mott Macdonald Site Visit

B. SEPA Flood Risk Assessment Checklist

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 16 - Last updated 27/08/2019)

This document must be attached within the front cover of any Flood Risk Assessments issued to Local Planning Authorities (LPA) in support of a development proposal which may be at risk of flooding. The document will take only a few minutes to complete and will assist SEPA in reviewing FRAs, when consulted by LPAs. This document should not be a substitute for a FRA.

Development Proposal Summary

Site Name:	Knocknagael		
Grid Reference:	Easting: 265682	Northing: 840002	
Local Authority:	Highland Council		
Planning Reference number (if known):			
Nature of the development:	Utility Infrastructure	If residential, state type:	
Size of the development site:	0.25 Ha		
Identified Flood Risk:	Source: Pluvial	Source name: Rainfall	

Land Use Planning

Is any of the site within the functional floodplain? (refer to SPP para 255)	No	If yes, what is the net loss of storage?		m ³
Is the site identified within the local development plan?	No	Local Development Plan Name:	Year of Publication:	
If yes, what is the proposed use for the site as identified in the local plan?	Select from List	Allocation Number / Reference:		
Does the local development plan and/or any pre-application advice, identify any flood risk issues with or requirements for the site.	No	If Other please specify:		
What is the proposed land use vulnerability?	Essential Infrastructure	If so, please specify:		
		Do the proposals represent an increase in land use vulnerability?	Yes	

Supporting Information

Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)?	Yes	
Has sufficient supporting information, in line with our Technical Guidance, been provided? For example: site plans, photos, topographic information, structure information and other site specific information.	Yes	
Has a historic flood search been undertaken?	No	If flood records in vicinity of the site please provide details:
Is a formal flood prevention scheme present?	No	If known, state the standard of protection offered:
Current / historical site use:	Existing site is a substation, proposed site is an extension of the substation but currently is a greenfield	
Is the site considered vacant or derelict?	Yes	

Development Requirements

Freeboard on design water level:		m
Is safe / dry access and egress available?	Vehicular and Pedestrian	Min access/egress level: 173 m AOD
Design levels:	Ground level: 175.5 m AOD	Min FFL: 175.5 m AOD

Mitigation

Can development be designed to avoid all areas at risk of flooding?	Yes
Is mitigation proposed?	Yes
If yes, is compensatory storage necessary?	No
Demonstration of compensatory storage on a "like for like" basis?	No
Should water resistant materials and forms of construction be used?	No

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 16 - Last updated 27/08/2019)

Hydrology	
Is there a requirement to consider fluvial flooding?	<div>No</div>
Area of catchment:	<div>km²</div>
Estimation method(s) used (please select all that apply):	<div> <div>Pooled Analysis</div> <div>Single Site Analysis</div> <div>Enhanced Single Site</div> <div>ReFH2</div> <div>FEH RRM</div> <div>Other</div> </div>
Estimate of 200 year design flood flow:	<div>m³/s</div>
Qmed estimate:	<div>m³/s</div>
Statistical Distribution Selected:	<div>Select from List</div>
<div>Is a map of catchment area included in FRA?</div> <div>Select from List</div>	
<div>If Pooled analysis have group details been included?</div> <div>Select from List</div>	
<div>If other (please specify methodology used):</div> <div></div>	
<div>Method:</div> <div>Select from List</div>	
<div>Reasons for selection:</div> <div></div>	
Hydraulics	
Hydraulic modelling method:	<div>Select from List</div>
Number of cross sections:	
Source of data (i.e. topographic survey, LiDAR etc):	
Modelled reach length:	<div>m</div>
Any changes to default simulation parameters?	
Model timestep:	
Model grid size:	
Any structures within the modelled length?	<div>Select from List</div>
Maximum observed velocity:	<div>m/s</div>
Brief summary of sensitivity tests, and range:	
variation on flow (%)	<div>%</div>
variation on channel roughness (%)	<div>%</div>
blockage of structure (range of % blocked)	<div>%</div>
boundary conditions:	
(1) type	<div>Upstream</div> <div>Flow</div> <div>Specify if other</div> <div></div>
(2) does it influence water levels at the site?	<div>Downstream</div> <div>Select from List</div> <div>Specify if other:</div> <div></div>
Has model been calibrated (gauge data / flood records)?	
Is the hydraulic model available to SEPA?	
Design flood levels:	
Cross section results provided?	
Long section results provided?	
Cross section ratings provided?	
Tabular output provided (i.e. levels, velocities)?	
Mass balance error:	<div>%</div>
200 year	<div>m AOD</div>
200 year plus climate change	<div>m AOD</div>
Coastal	
Is there a requirement to consider coastal / tidal flooding?	<div>No</div>
Estimate of 200 year design flood level:	<div>m AOD</div>
Estimation method(s) used:	<div>Select from List</div>
Allowance for climate change (m):	<div>m</div>
Allowance for wave action etc (m):	<div>m</div>
Overall design flood level:	<div>m AOD</div>
<div>If other please specify methodology used:</div> <div></div>	
Comments	
Any additional comments:	
Approved by:	
Organisation:	
Date:	

Note: Further details and guidance is provided in 'Technical Flood Risk Guidance for Stakeholders' which can be accessed here:-

[CLICK HERE](#)

C. Consultation Response

Full consultation response from SEPA and The Highland Council (THC), conducted by SSEN directly without the involvement of Mott MacDonald Ltd, are presented below.

SEPA

SEPA's standing advice on planning should be considered which could be found on their website at: www.sepa.org.uk/environment/land/planning/

The Highland Council

Under SEPA's 'Flood Risk and Land Use Vulnerability Guidance', this type of infrastructure is classed as 'Essential Infrastructure'. The infrastructure can therefore be located in areas of medium to high risk of flooding if 'designed and constructed to remain operational during floods (i.e. 0.5% AP), and not impede water flow'.

OS mapping shows small watercourses to the east of site (not included in SEPA's online Flood maps due to their catchment size) which may present a flood risk to the development. As the site covers a large area, it may be possible to locate the infrastructure a suitable distance from, and/or elevation above, the waterbodies. If any infrastructure is located at a position potentially at risk of flooding a Flood Risk Assessment (FRA) should be submitted to demonstrate that the infrastructure will not be at risk (or will remain operational during a flood) and that the development will not increase risk elsewhere. The FRA shall consider the impact of a 1 in 200 years plus climate change return period flood event.

If any new or upgraded watercourses crossings are required, small watercourses crossings should be oversized and larger scale watercourses crossings should be demonstrated to be adequately designed to accommodate the 1 in 200 year flow (including an allowance for climate change and freeboard) to avoid increasing the risk of flooding.

A minimum buffer strip of 6m should be kept free from development, measured from top of bank(s) of any watercourse or waterbody. Storage of materials within this area during the construction is not permitted.

Further advice and SEPA's best practice guidance is available within the water engineering section of SEPA's website: <https://www.sepa.org.uk/regulations/water/engineering/>

Guidance on the design of water crossings can be found in construction of River Crossings Good Practice Guide: <http://www.sepa.org.uk/media/151036/wat-sg-25.pdf>

The Drainage Impact Assessment (DIA) written in accordance with our supplementary guidance: Flood Risk and Drainage Impact Assessment, is required to be submitted with the planning application.

The DIA will need to detail the proposed surface water drainage and include appropriate drawings and calculations. An allowance for climate change should be included in the calculations and runoff from storms up to and including the 1 in 200 year plus climate change event should be managed within the site boundary without flooding to essential infrastructure, buildings or critical infrastructure. Clear exceedance routing plans should be provided with the planning application.

Surface water discharge from the site to any receiving watercourse should be limited to the equivalent pre-development greenfield rate for a range of storms up to and including the 1 in 200 year plus climate change event.

Supporting evidence in the DIA should include (but not limited to) calculations showing drainage network details, contributing area summary, control/storage structure details and simulation results table for any new network. A site plan showing the type of treatment and location on site, where this will be discharge to, and proposed maintenance arrangements should be submitted in support of the application. The drainage should be designed in line with Sustainable Drainage Systems (SUDs) principles. The applicant should demonstrate, within the proposals submitted, any mitigation measures to manage the residual risk of overland flow/pluvial flooding.

Refer to the council's *Flood Risk and Drainage Impact: Supplementary Guidance* for further detailed requirements.



A large teal graphic element on the left side of the page. It consists of a large triangle pointing upwards, with a smaller triangle pointing downwards from its base, creating a shape that resembles a stylized 'M' or a mountain peak. The right side of this shape is a vertical rectangle.

Loch na Cathrach Knocknagael Substation Extension

Drainage Strategy Report

August 2024

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SSEN Transmission

Loch na Cathrach Knocknagael Substation Extension

Drainage Strategy Report

August 2024

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1 Introduction

1.1 Project Background

Mott MacDonald have been commissioned by Scottish & Southern Energy Networks (SSEN) Transmission to produce a drainage strategy for the proposed extension of the Knocknagael 275/132kV substation.

The site is located 8km south of Inverness city centre in the Highlands of Scotland. It is centred roughly at grid reference NH 65231 39077.

1.2 Relevant Previous Reports

This Report should be read in conjunction with the following documents:

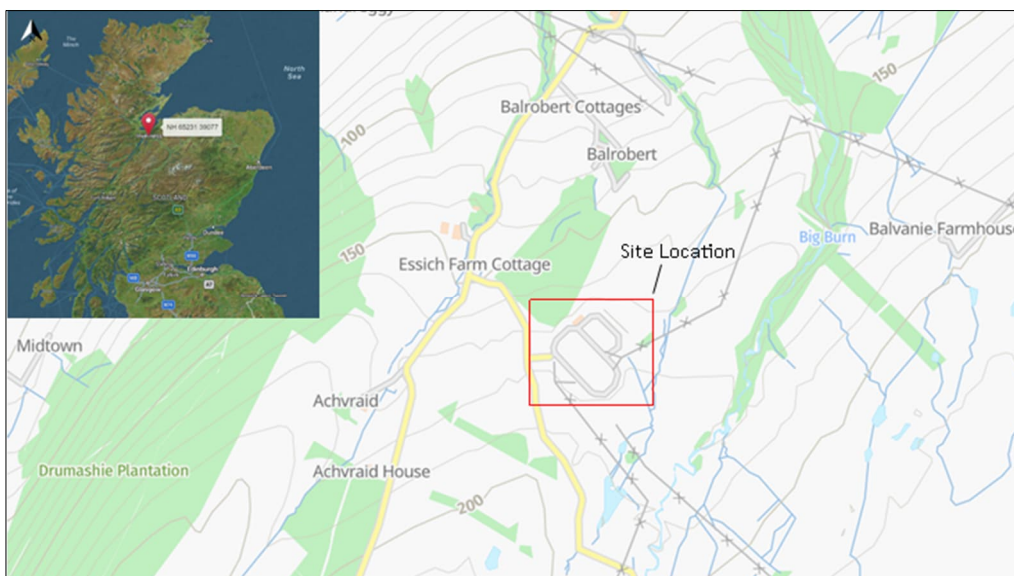
1. Knocknagael Extension Works Geotechnical and Geo-environmental Desk Study, Mott MacDonald, November 2022
2. SP-NET-CIV-501 Earthworks, Specification, SSEN, July 2023.
3. SP-NET-CIV-502 Drainage Specification, SSEN, July 2020.
4. SP-NET-CIV-503 Pavements and Roadways Specification, SSEN, July 2019.
5. SP-NET-CIV-504 Ducting, Trenching and Trench Covers Specification, SSEN, June 2016.
6. SP-NET-CIV-509 Substation Bunds Specification, SSEN, July 2020.

1.3 Site Information

The site lies south of Essich, Inverness which is situated 8km south of the city of Inverness. The site location plan in Figure 1.1. The site has existing infrastructure which will have to be considered to accommodate the Knocknagael extension works. A single bay is to be added to the existing substation, located at the south-eastern corner of the substation.

LiDAR Survey data provided by CainTech identifies the finished platform level at 175.5m AOD (Drawing Reference: CTCH-5118-01). Within the extension works footprints, the existing ground level is 188.5m AOD. Therefore, approximately 4.5m of cut will be required to form the platform.

Figure 1.1: Site Location Plan



Source: Mott MacDonald, 2023.

1.4 Description of the Works

The Knocknagael substation extension is to accommodate a new firm connection for the 450MW Red John pumped storage hydro project at 275kV. The extension is essential to create an additional bay as the existing 275kV bays within the Knocknagael site are in use. The envisaged scope:

- Extension of existing 275kV AIS double busbar substation platform (on the south side of the substation) to accommodate a new bus-coupler, a cable bays for new Red John cable and associated busbar and HV plant equipment.
- Earthworks involving cut and fill embankments to tie into existing slope angles. These will likely involve the excavation and re-use of on-site material.
- The removal and subsequent replacement of the existing 275kV bus coupler (on the south side) required for the connection.
- Rerouting of existing drainage around extension platform extents.
- Creation of a retention basin out with site fence line and access track for basin maintenance.
- Creation of temporary construction access tracks

The proposed development areas at the site are summarised as follows:

- Eastern-South Side: Extension Bay platform which includes the internal road and carpark, roof buildings and external to the new platform, the new cut embankment.
- A temporary construction compound and a temporary access road to the substation extension.
- A single detention basin.
- A permanent bund formed with the excess of cut from the extension.

2 Site Description

2.1 Existing Geology

Recent ground investigation dated 22 July 2024 'Red John 275kV Cable Connection GI' Ground Investigation Report by BAM Ritchies No. RGN.331K is referenced in this drainage strategy.

Figure 2.1: Exploratory hole locations by BAM

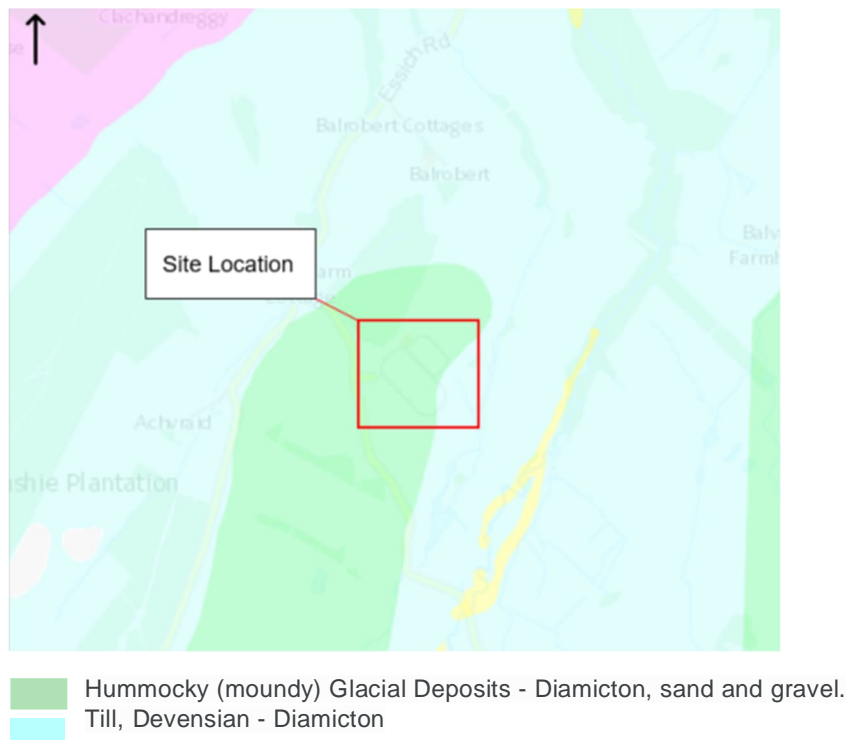


Sources: Ground Investigation Report by BAM Ritchies No. RGN.331K

A summary of the ground conditions is presented on this section based on Geotechnical and Geo-environmental Desk Study MMD-106510-DOC-10003 (Mott MacDonald, 2022), the following geology and ground conditions are anticipated to be encountered on site and have been inferred from available published maps and historical boreholes:

- Topsoil – composition unknown
- Localised Made Ground – composition unknown. Anticipated to comprise concrete and engineered fill.
- Hummocky (moundy) glacial deposits – anticipated to comprise diamicton, sand and gravel.
- Devensian Till – anticipated to comprise silty clay sometimes containing layers of silt, sand, peat and basal gravel.
- Inishes Flagstone Formation – anticipated to comprise red, green and grey flaggy sandstone with rare grey calcareous mudstones and limestones.

Figure 2.2: British Geological Viewer Map



The BGS GeoIndex, superficial deposits at a scale of 1:50,000 indicates that most of the site on the western extents is underlain by hummocky (moundy) glacial deposits consisting of diamicton, sand and gravel. The BGS Lexicon described the glacial deposit to be composed of “rock debris, clayey till and poorly- to well-stratified sand and gravel.”

South-east of the site where the proposed extension bay is located, is underlain by Devensian Till as shown in Figure 2.2: British Geological Viewer Map.

Recent site-specific ground investigation includes four boreholes with depths ranging from 16m bgl to 17.25m below ground level. Preliminary borehole descriptions are available indicating superficial deposits down to the bottom of the boreholes.

2.2 Contaminated Land

A review of the site history through available historical mapping and current land use has not highlighted any obvious and significant geo-environmental risks. However, according to previous, similar projects, the limited previous GI, the potential presence of Made Ground, and historical and current identified land uses, geo-environmental risks may be present.

2.3 Utilities and Services

There are 275kV underground cables running north to south through the proposed extension bay and a 15m long concrete plinth over the cables. There is an underground live cable (185mm² 4 core XLPE) under the site entrance path encircling the existing platform located at the top of the slope connecting the mini substation to the Knocknagael substation control building.

There is existing ‘herringbone’ drainage is located where the bay extension is proposed. Under the slopes surrounding the existing platform on the southeast side. In addition to this there are 225mm diameter perforated pipes at the bottom of the embankment to collect the flows from the ‘herringbone’ drainage; and 150mm diameter perforated pipes at the top of the embankment to collect the overland flows.

There are Overhead Electrical Powerlines within the surrounding area and an associated tower located immediately south of the site.

2.4 Woodlands

Woodland borders the north-west of the site. Most of the area (7.6 ha) is classified as native woodland with a canopy percentage of 70%, and it is not designated as planted on ancient woodland sites. The area is also identified as a pinewood zone and a target for grey squirrel control as part of species conservation.

2.5 Protected Areas

The Scotland's Environment Online Viewer identifies a scheduled monument located approximately 0.69km southwest of the site. This monument is categorised as a prehistoric ritual and funerary: chambered cairn called Carn Glas. The cairns date back to the fourth millennium BC.

2.6 Permeability and Groundwater

Groundwater conditions were investigated in the GI report by BAM. Groundwater monitoring of the borehole installations was carried out at different locations. It should be appreciated that seasonal fluctuations in groundwater level occur. Other effects such as investigation and constructional excavation may also change groundwater levels.

Soil infiltration tests were carried out at TP 11 and TP12, indicating no permeability in the superficial deposits and no groundwater at the location of the new permanent basin. Soakaway results are included in Appendix D.

Seasonal springs could be encountered onsite due to the nature of the superficial deposits.

2.7 Existing Hydrology

Geotechnical and Geo-environmental Desk Study MMD-106510-DOC-10003 Rev A (Mott MacDonald, 2022) is being used as a reference for this section.

Figure 2.3: Existing hydrology



Source: SEPA

The nearest Scottish Environmental Protection Agency (SEPA) classified surface water feature is the Big Burn (SEPA ID:20260) which is located approximately 0.35km southeast of the site and runs in the north to south direction. The surface water body is the Ness confluence to Loch Ashie. Under the SEPA water classifications, following the last available assessment in 2020, Big Burn is classified as having “bad” ecological potential and “fail” for ecological indicators. According to SEPA, “The water body has been designated as a heavily modified water body on account of physical alterations that cannot be addressed without a significant impact on water storage for public drinking water.”

The site is not shown to be at risk of flooding associated with rivers or coastal waters. However, the ‘Big Burn’ which is in proximity of the site has a high likelihood of river flooding with a 10% chance with Future Flood Maps showing that “by the 2080s, each year this area might have a 0.5% chance of flooding.”

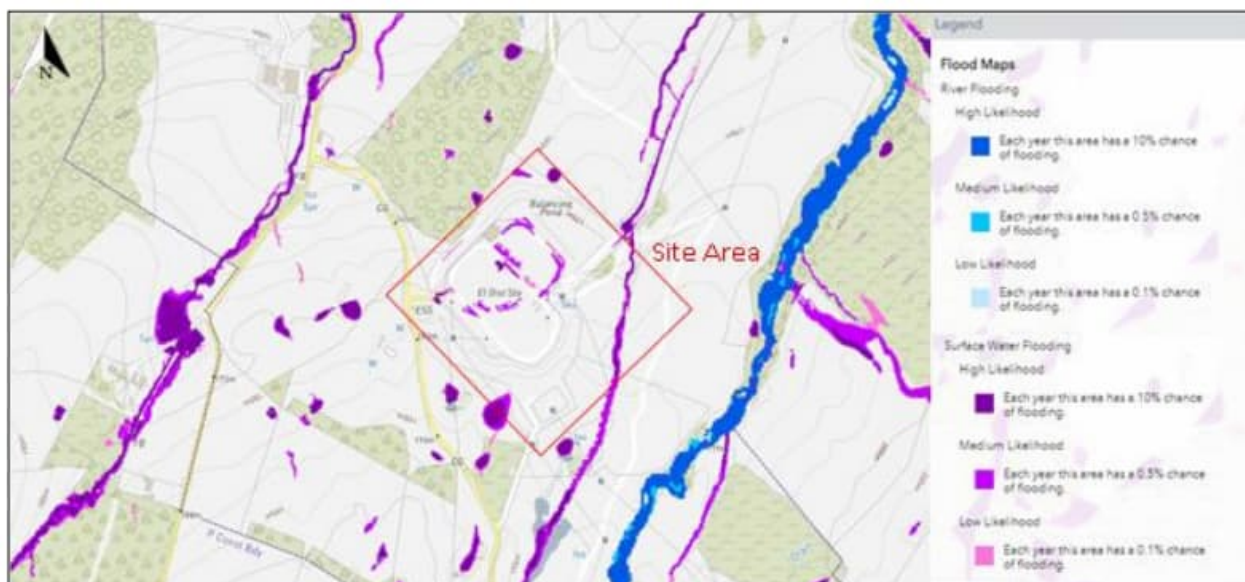
Historical maps, and SEPA records of the site show the presence of surface water bodies within close vicinity of the site. Their presence is subject to seasonal changes. These water features drain into a pond approximately 250m south-east of the site.

The BGS GeoIndex indicates the rock unit underlying the site consists of middle old red sandstone (undifferentiated) and is considered as a moderately productive aquifer. Small amounts of groundwater can yield locally with the sandstone being flaggy in places with siltstones, mudstones, conglomerates, and interbedded lavas. Using the Scotland’s Environment Online Map Viewer and SEPA water classification hub, the groundwater classification of the area is good (SEPA ID:150670).

2.8 Flooding

Areas of the site are known to be affected by surface water flooding with a 10% chance of flooding. The ‘Big Burn’ located 0.35km southeast of the site has a high likelihood of river flooding with a 10% chance. Flooding may pose a risk to future site investigations or construction at the site.

Figure 2.4: River and Surface Water Flooding Map



Source: SEPA (2023)

3 Proposed Surface Water Drainage Strategy

A drainage strategy is required for the extension bay added to the existing substation, located at the south-eastern corner of the substation as summarised below:

- New extension bay: platform, internal roads and embankments.
- New temporary access road (track road) for the construction phase only. Ground will be reinstated when the construction phase is completed.

The proposed drainage strategy is indicated in the following drawings:

- 109116-MMD-KNOC-XX-DR-CE-0005 – Drainage Layout
- 109116-MMD-KNOC-XX-DR-CE-0006 – Drainage Details

The new substation site comprises the following elements:

New Platform

The platform will be finished with a 75mm layer of 'chippings' with 200mm Type 3 permeable granular material in accordance with Drainage Specification SP-NET-CIV-502. The platform construction and material specification shall be in accordance with SP-NET-CIV-501.

To build the new substation extensions an uplift layer of 725mm minimum 6F2 material will be utilised. The extension bay is formed with approximately 4.5m of cut material.

New Internal Roads

Internal roads within the new bay are surfaced roads on the perimeter of the platform, for the delivery of the transformers, and the rest of the internal roads are unbound. Internal access roads shall discharge through to adjacent filter drains. These filter drains will connect to the new detention basin.

Earthworks associated with the Platform

The runoff from extension bay platform embankments will discharge into filter drains on edges of the site. The extension bay is formed with cut material, consequently, there will be a filter drain at the edge of the new platform to collect the runoff from the new cut slope, and a filter drain at the top of the cut slope to collect any overland flows entering the site. These filter drains will discharge into the new detention basin.

Due to the considerable size of the cut and fill earthworks slopes associated with the construction of the extension bay, cut off drains will be installed at intervals of the slopes.

Cut off drains

Seasonal springs could be encountered during the excavation works of the substation extension. Cut off drains will be installed across the slope to intercept surface runoff and any springs affected by the excavation works and discharge into the filter drain installed at the bottom of the embankment.

New External Access Roads for the Construction Phase only

There is one external access road for the new substation extension. The new access road has a gravel surface. The minimum longitudinal gradient for an unbound pavement shall be 5% as per the Pavements and Roadways Specification SP-NET-CIV-503.

The Drainage Layout drawing 109116-MMD-KNOC-XX-DR-CE-0005 shows an eastern access road is only for access to extension bay during construction. The land for the eastern access road shall be reinstated to its original condition once work is complete. Runoff from the external access road, where in 'fill', shall soak into the ground and any exceedance will discharge into the low ground nearby. Where the road is in 'cut', a new

land drain will be installed on one/both edges of the access road to drain the runoff from the road and embankments into the new detention basin or the low ground nearby.

New Permanent Bund

A new permanent bund is proposed with the excess of excavated material from the substation extension. This permanent bund's maximum elevation is +195.25mAOD and is formed south of the existing cable sealing end compound. A new ditch along the bottom of the bund is proposed to capture any runoff from the bund.

3.1 Proposed Systems, Design Criteria and Key Assumptions

The design parameters for the design of the newly extended substation platform drainage systems are those listed in the scheme specific design strategy report. Generic design parameters applied for this scheme and details are listed in tables in this section.

Table 3.1 – Pipe & Slot Drain Design Parameters

Criteria	Parameter
Rainfall	FEH / Modified Rational Method
Volumetric run off Coefficient	Cv – 0.75
Simulation Criteria	Cv (Summer) – 0.75 Cv (Winter) – 0.84
Design Rainfall	FEH 2013-point rainfall ²
Min Velocity	0.75 m/s for pipes
Velocity calculation formula for pipes	Colebrook-White – (k)
Velocity calculation formula for ditches	Mannings n Value of n to be used is 0.045 for a grassed channel drain.
Maximum bend of carrier pipes	11¼ ° , pipes are designed as straight pipes, in case required then can be allowed to go with bend.
Climate change allowance	37% (SEPA guidance)
Catchment types	Roads and footpaths Impermeable PIMP 80% Substation Platform Permeable PIMP 10% Landscape Earthworks Semi permeable PIMP 21% Verges Semi permeable PIMP 16%
Cut slope and verge runoff from natural ground	Runoff calculated using CD 521 Appendix A based on urban catchment wetness index and permeability.
Design criteria	<ol style="list-style-type: none"> 1. Longitudinal carrier Drains and filter drains in the platform: 2 year + 37% climate change - no surcharge in drainage systems. 2. 25 year + 37% climate change – No flooding on the platform. 3. 200 year + 37% climate change - no surcharge above manhole cover level or top of slot. No flooding on the platform. 4. 1000 year rainfall - the maximum depth of water in during the 1 in 1000 year event shall not exceed 100 mm in the new extended platform. <p>There is no standing water that could impact on the operation, inspection and maintenance of the substation during the 1:1000 year return period event</p>
Time of Entry	Global Time of Entry = 15 min
Pipe Cover	Min. 1.2m pipe cover within carriageways and other trafficable locations, with normal bedding. This includes verges and pipe crossings.

² Modelling work was started before FEH22 was issued and consideration should be given to using the latest FEH rainfall for future design stages.

Criteria	Parameter
	Desirable min. 0.9m pipe cover within natural ground and other non-trafficable locations.

Table 3.2 – Attenuation Design

Criteria	Parameter
Return Period	200 years + 37%CC
Discharge Rates	<u>For the south-eastern section of extension bay:</u> Peak outflows from the proposed catchment will be controlled to 5.2l/s.
Discharge velocity into watercourses	Maximum Velocity of discharges from an outfall to watercourse shall be 1.2 m/sec. Adequate erosion control measures are provided to ensure that receiving watercourses are protected from potential high velocity or turbulence damage as indicated in the drawings.
Storage design. See Section 3.6.	Storage is provided in the form of a single detention basin at the north east location at the site – denoted extension bay : <ul style="list-style-type: none"> The extension bay shall provide storage of approx. 350m³. Storage within the platform is provided via a network of filter drains: Total filter drains attenuation volume extension bay =170m ³ approx.

Table 3.3 – Pipe Design Parameters

Pipe Material	Pipe Roughness, Ks (mm)	Pipe Diameters used in design (mm)
Plastic (carrier)	0.6 (surface water)	150
		225
		300
		350
Filter Drain (perforated pipe)	0.6 (surface water)	225
		300
		350

3.2 Proposed Development Areas

The breakdown of the contributing areas of the extension bay is as follows:

Proposed permanent development areas as per Figure 3.1:

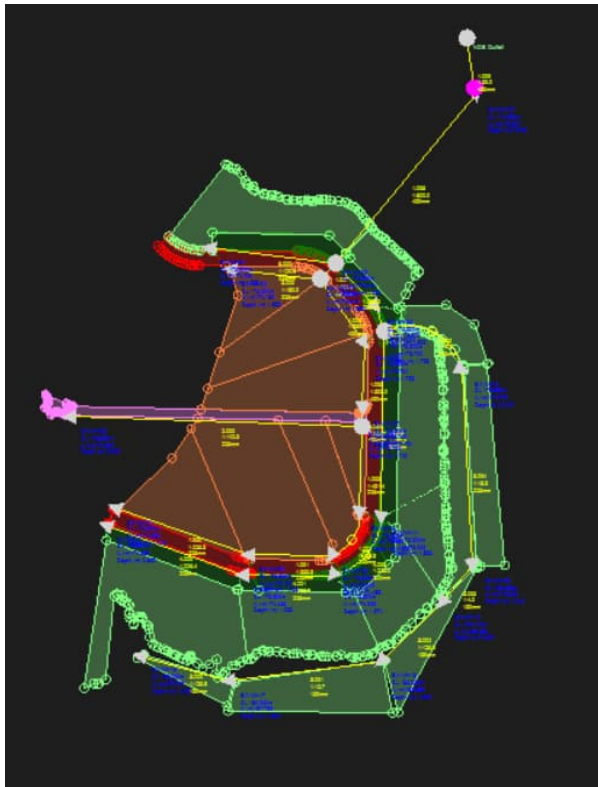
- Permeable platform.
- Internal access surfaced road and gravel road.
- New fill embankments.
- Existing overland flows from the adjacent sites.

The access road to the extension bay is not being considered in the drainage calculations of the proposed detention basin, due to its temporary condition. The access road will only serve the platform extension bay during construction, ground will be reinstated to its normal condition after the construction phase is completed.

The Figure 3.1 shows the percentage of impervious surface per catchment used in MicroDrainage as described below:

- Red: 100% of the gross area is impermeable (the surfaced road).
- Light green: 21% of the gross area is impermeable (grassed areas).
- Dark Green: 16% of the gross area is impermeable (verge areas)
- Pink: 80% of the gross area is impermeable (gravel access road).
- Orange colour: 10% of the gross area is impermeable (permeable platform).

Figure 3.1: Catchment areas for Extension Bay



Source: MicroDrainage (2023)

3.3 Infiltration Based Systems

The existing ground conditions of the site indicates the superficial deposits are glacial deposits consisting of diamicton, sand and gravel. The proposed platforms will be formed with 6F2 capping material up via an uplift material of 0.725m minimum thickness above the existing ground. The 6F2 is an aggregate which is composed of crushed concrete, brick and mortar produced as a by-product of demolition projects.

The permeability of the capping material of the platform has been considered for the design of the network of filter drains within the platform. In the absence of ground investigation data, infiltration rates have been assumed based on the CIRIA C753 SuDS Manual Table 25.1 which states that loamy sand deposits typically have a lower end infiltration rate of 10-5 m/s, as shown in the Table 3.1.

The proposed infiltration strategy has been applied:

1. Proposed land drains within the new platform extension bay – South-eastern platform:

Filter drains within the permeable platform to assume permeability into the 6F2 capping material of the platform to a conservative value of $1 \times 10^{-6} \text{ m/s}$, due to the north-western platform is formed by cut of existing ground and a minimum 0.725mm depth of 6F2 material will be used to form the platform.

2. Proposed land drains used on the temporary gravel roads:

No permeability into the existing ground assumed.

3.4 Pre-Development Runoff Rates

The proposed discharge rate was previously suggested in SLR Drainage Strategy (2022) as being limited to the Q_{BAR} of 1.6 litres/second³. This was incorporated into the planning submission. A discharge rate of 5litres/second is recommended to allow for more reasonable orifice control from the site which will be less prone to blockage, present less risk of site flooding and require less maintenance.

The contributing area of each site considers the gross area of all catchments of the new development: new embankments, platform and access roads; all works affected by the new substations.

Refer to Appendix A for the greenfield runoff calculation.

Table 3.1: Pre-development greenfield run-off rates

Pre-Development Runoff Rates					
Catchment	Contributing Area (ha)	Q(bar) (l/s)	1:2-year (l/s)	1:30-year (l/s)	1:100-year (l/s)
Extension Bay	2.9	6.43	5.47	12.54	15.95

Source: "Greenfield runoff rate estimation for sites" from HR Wallingford, www.uksuds.com

3.5 Post-Development Discharge Rate

Surface water run-off discharging from the development site into the existing watercourses nearby is to be restricted to an appropriate discharge rate that will not increase the risk of flooding downstream. As noted previously, the site is currently undeveloped, therefore, in line with local and national guidelines the flow restriction from the developed site shall be based on the estimated 'greenfield' run-off rate (Q_{bar}) for the undeveloped site.

SuDS should mimic natural drainage and reduce the amount and rate of water flow by:

- Infiltration into the ground,
- Holding water in storage areas, and
- Slowing the flow of water.

The design will meet the following discharge hierarchy (with acceptable justification for moving between levels) by the CIRIA C753 SuDS manual:

1. infiltration to the maximum extent that is practical – where it is safe and acceptable to do so
2. discharge to surface waters
3. discharge to surface water sewer
4. discharge to combined sewer (last resort)

The proposed discharge rate shall be controlled by an Hydrobrake manhole or an orifice control approximately 75mm in diameter equating to a control rate of 5l/sec. The advisable minimum Hydrobrake control rate is 5l/sec to avoid blockages. If an orifice control is used, it would be installed in a catchpit with an overflow to reduce the risk of blockages.

The post-development discharge rate of extension bay: 5 l/s using either a vortex control device or an orifice control.

3.5.1 Outfalls for proposed detention basin

The outfall from the extension bay is to discharge into an existing ditch via a 5l/sec flow control device as shown in the Drainage Layout 109116-MMD-KNOC-XX-DR-CE-0005.

A topographical survey provides the base of the ditch elevation and top of the embankment where the outfall is proposed. The ditch is the receptor of the substation extension flows and it is connected to a downstream watercourse. The top of the ditch is at +172.441m AOD and the bottom of the ditch is +171.820m AOD, which shows a continuous ditch height of 0.62m approximately.

In order to set up the Invert Level (IL) of the outfall a permanent water level is assumed on the ditch. Therefore, the outfall has a minimum vertical distance of 200mm from the (assumed) permanent water level to avoid outfalls being permanently submerged. The proposed outfall IL=+172.00m AOD in the existing ditch, this provides a 200mm clearance from the bottom of the ditch.

Upstream of the outfall a proposed penstock valve with sampling chamber is installed to control any pollution from the substation site.

Headwalls shall be provided at all positions where a drainage system discharges into open water. The outfall to the proposed detention basin is to be a headwall with a flap valve and the outlet from proposed detention basin is to be a headwall with a sluice gate. Scour protection should be provided for the permanent outfall into the ditch.

Outfalls should be angled at 45° to the water flow; small pipes (less than 300 mm diameter) can be at a maximum of 90° to the flow. The proposed outfall is 150mm diameter, with a proposed discharge rate of 5litres/second as indicated in Section 3.4.

The proposed scour protection details are included in the Drainage Details drawing 109116-MMD-KNOC-XX-DR-CE-0006.

3.6 Proposed Attenuation Volume

Proposed attenuation for the site has been estimated based on accommodating 1 in 200-year storm event with a 37% climate change factor, as per SEPA guidance for Northern Scotland. It will be provided through one detention basin at the south of the site.

The South-eastern extension bay is to have a 1 in 200-year plus climate change attenuation storage of approx. 350m³ storage. This is an upper estimate based on 1.62ha impermeable platform area. The extension bay discharges to an existing ditch northeast of the site. The proposed detention basin is constrained due to the topography in the area, by an existing access road, an existing overhead line on its western side and by an existing ditch on its eastern side.

The proposed detention basin is formed by cut material, hence the risk of groundwater entering the basin is high. In order to prevent groundwater ingress, the proposed detention basin will be lined with impermeable membrane. Also, the design depth of the detention basin will be 0.5m with an additional 300mm of freeboard to limit the amount of cut and interference with groundwater table.

Table 3.2: Post-Development Runoff Rates

Post-Development Runoff Rates (+37%CC)						
Catchment	Total gross area (ha) [Without pond]	Contributing Area Impermeable (ha)	1 in 2-year (l/s)	1:30-year (l/s)	1:200-year (l/s)	Proposed Attenuation Volume (m³)
Extension Bay	1.62	0.393	4.9	5.1	5.2	<ul style="list-style-type: none">Basin: 350m³Network of filter drains: 170 m³

Source: MicroDrainage (2023)

3.6.1 Exceedance Events

It is acknowledged that critical infrastructure must be protected against flooding in the event of a 1 in 1000-year rainfall. A previous Flood Risk Assessment found that the new platform is not at risk of fluvial or pluvial flooding. In case of a 1 in 1000-year rainfall event on site, the detention basin would overflow to the surrounding land. The platform, at a finished level of 175.5 m AOD, is approximately 1m higher than the proposed detention basin (173.5m AOD base level + 0.8m crest level).

4 Proposed SuDS Design

The drainage strategy for the proposed development has been developed based on the SuDS Manual (C753) guidance. The proposed surface water drainage strategy is to replicate as closely as possible the natural runoff characteristics of the existing site, intercepting all flows from the permanent works into an attenuation basin prior to discharging into the nearest watercourse.

4.1 Proposed Detention Basin

A detention basin is a vegetated depression designed to store runoff on the surface with an outflow to the nearest available watercourse. They are typically dry except during periods of heavy rainfall. The depth of a typical basin varies from 0.5-1.0m and is defined by the:

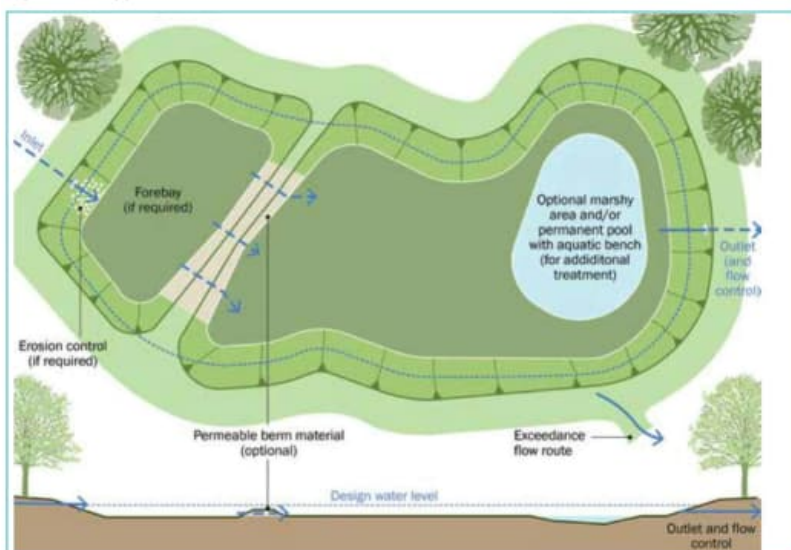
- Groundwater level for the area of the site.
- Level difference required to achieve a fall to allow discharge from the basin to the outfall.
- Spatial constraints of the site. These areas require a deeper basin to reduce the overall plan area.

In low-lying areas where the elevation is flat and there is proximity to a watercourse, currently available topographic levels may not allow for gravity-fed drainage to the outfall location. In these cases, the basin water depth has been limited to 0.5m, which also reduces the risk of groundwater ingress.

The detention basin will be designed where possible with 1:3 slopes, lined with an impermeable geo-textile where necessary due to the groundwater ingress and include an inlet forebay. The inlet forebay will provide treatment of the surface water runoff by allowing for settlement of silts, heavy metals and the removal of oxygen demanding material.

When the proposed attenuation / infiltration basin is used for temporary sediment control during construction, an additional settling pond or vegetated forebay within the main pond should be included to trap sediments and prevent clogging of the main infiltration pond. The sediment trap should be approximately 20% of the pool volume. Where a pond with a forebay element is retained for the permanent phase, the forebay will be removed at the end of the construction phase. The general arrangement of the construction pond is shown in Figure 4.1 extracted from CIRIA SuDS Manual C753.

Figure 4.1: Typical Plan View of Detention / Basin Pond



Source: CIRIA 653 SuDS Manual C753

4.2 Header and Filter Drains

Header drains are used along the platform perimeter to intercept 'clean' overland flows. These drains prevent overland flows from discharging into the new substation platforms or embankments and reduce the risk of flooding and erosion.

Filter drains or swales are used on either side of the temporary and permanent roads. The effective storage volume provided within the filter drain is based on the 30% void ratio of the permeable gravel material. Filter drains are used to collect runoff from the platform, earthworks, overland flows and new access road (internal and external). Filter drains will be provided with a minimum 225mm diameter perforated pipe for maintenance and inspection.

5 Pollution Prevention

The proposed surface water drainage system will reduce the risk of pollution entering the local watercourse from the development proposals. This will be achieved by using a treatment chain where each subsequent system within the proposed drainage network is treated to improve water quality. The extended new substation platform area will act as an infiltration system and will act as an infiltration system with the overflow collecting into the filter drains. The surface water treatment stage is dependent on the potential hazards on the site and the sensitivity of the receiving water body to pollution. The general site is considered a low risk of pollution. Access roads will drain into a filter drain system or the permeable platform; this will provide an adequate level of water quality treatment.

The treatment for the site was determined in accordance with the SUDS manual CIRIA 753 and followed the procedure outline by the Wallingford 'simple index approach' tool. See Appendix B for further details.

1. **Catchment: new substation platform;** Hazard Level: Low level.
2. **Catchment: Proposed access road;** Hazard Level: Low level.

The drainage systems on site will be designed to meet the water quality design criteria and good practice pollution control measures as outlined in the CIRIA SuDS manual. The different areas of the site will be categorised by the appropriate pollution hazard level from Table 26.2 of The SuDS Manual.

When considering the site characteristics, proposed use, and site constraints, SuDS are likely to be incorporated via a combination of the following components:

1. The access road and parking areas will be drained via filter drains. The filter drains will clean any possible pollutants from the vehicle traffic when the water passes through them. They are particularly effective at removing the main pollutants: suspended solids, hydrocarbons and metals. As indicated in Table 26.15 from the SuDS Manual.
2. It is proposed that all the manholes on the surface water network are catchpit chambers which will collect the silt and gravel from the runoff.

With this additional mitigation measure and the fact that the site is going to be lightly trafficked, it is believed that there are sufficient measures in place to ensure the water quality discharged from the site is to a satisfactory level.

As an initial check, the Simple Index Approach has been applied to confirm the pollution risks are mitigated sufficiently as recommended in Section 26.7.1 "Water quality management: design methods" of The SuDS Manual. For the operational phase, the SuDS components (gravel platform and filter drains) are proposed to provide sufficient pollution mitigation.

6 Conclusion

The proposed Knocknagael substation extension bay is to be constructed in currently undeveloped greenfield site. The extension bay covers 1.62ha with 0.382ha of impermeable area.

The proposed drainage is being designed on the basis that the platform ground conditions are favourable for an infiltration system through the permeable platform with assumed infiltration rate: 1×10^{-6} m/s for extension bay due to the platform being formed with a minimum of 725mm of imported fill material 6F2.

A network of filter drains (24m^3) in combination with a permeable platform within the platform and an external detention basin outside will accommodate the rainfall event of 1 in 200-year plus 37% climate change allowance limiting the discharge rate to the existing greenfield rate of the site, approximately 5l/sec for extension.

The SuDS system including a permeable platform, filter drain and detention basin, reduces the discharge flows of the proposed site and provides mitigation against pollution.

New header drains are proposed along the perimeter of the proposed permeable platform to absorb any water avoiding water seepage into the proposed substation platform.

The extension bay discharges into an existing road ditch that feeds into a network of small ditches and watercourses.

Discharge consents affecting the existing watercourses shall be agreed with SEPA.

A. Greenfield Runoff Rate Estimation

Calculated by:

Site name:

Site location:

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:

Longitude:

Reference:

Date:

Runoff estimation approach

Site characteristics

Total site area (ha):

Methodology

Q_{BAR} estimation method:

SPR estimation method:

Soil characteristics	Default	Edited
SOIL type:	<input type="text" value="2"/>	<input type="text" value="4"/>
HOST class:	<input type="text" value="N/A"/>	<input type="text" value="N/A"/>
SPR/SPRHOST:	<input type="text" value="0.3"/>	<input type="text" value="0.47"/>

Hydrological characteristics

	Default	Edited
SAAR (mm):	<input type="text" value="828"/>	<input type="text" value="828"/>
Hydrological region:	<input type="text" value="1"/>	<input type="text" value="1"/>
Growth curve factor 1 year:	<input type="text" value="0.85"/>	<input type="text" value="0.85"/>
Growth curve factor 30 years:	<input type="text" value="1.95"/>	<input type="text" value="1.95"/>
Growth curve factor 100 years:	<input type="text" value="2.48"/>	<input type="text" value="2.48"/>
Growth curve factor 200 years:	<input type="text" value="2.84"/>	<input type="text" value="2.84"/>

Notes

(1) Is $Q_{BAR} < 2.0$ l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is $SPR/SPRHOST \leq 0.3$?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates	Default	Edited
Q_{BAR} (l/s):	<input type="text" value="6.43"/>	<input type="text" value="17.04"/>
1 in 1 year (l/s):	<input type="text" value="5.47"/>	<input type="text" value="14.48"/>
1 in 30 years (l/s):	<input type="text" value="12.54"/>	<input type="text" value="33.23"/>
1 in 100 year (l/s):	<input type="text" value="15.95"/>	<input type="text" value="42.26"/>
1 in 200 years (l/s):	<input type="text" value="18.27"/>	<input type="text" value="48.4"/>

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at www.uksuds.com/terms-and-conditions.htm. The outputs from this tool are estimates of greenfield runoff rates. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of this data in the design or operational characteristics of any drainage scheme.

B. Simple Index Method (pollution prevention)

SIMPLE INDEX APPROACH: TOOL



HRW shall not be liable for any direct or indirect damage claim, loss, cost, expense or liability howsoever arising out of the use or impossibility to use the tools, even when HRW has been informed of the possibility of the same. The user hereby indemnifies HRW from and against any damage claim, loss, expense or liability resulting from any action taken against HRW that is related in any way to the use of the tool or any reliance made in respect of the output of such use by any person whatsoever. HRW does not guarantee that the tool's functions meet the requirements of any person, nor that the tool is free from errors.

- The steps set out in the tool should be applied for each inflow or 'runoff area' (ie each impermeable surface area separately discharging to a SuDS component).
 - The supporting 'Design Conditions' stated by the tool must be fully considered and implemented in all cases.
 - Relevant design examples are included in the SuDS Manual Appendix C.
 - Each of the steps below are part of the process set out in the flowchart on Sheet 3.
 - Sheet 4 summarises the selections made below and indicates the acceptability of the proposed SuDS components.
- DROP DOWN LIST** RELEVANT INPUTS NEED TO BE SELECTED FROM THESE LISTS, FOR EACH STEP
- USER ENTRY** USER ENTRY CELLS ARE ONLY REQUIRED WHERE INDICATED BY THE TOOL

STEP 1: Determine the Pollution Hazard index for the runoff area discharging to the proposed SuDS scheme

This step requires the user to select the appropriate land use type for the area from which the runoff is occurring

If the land use varies across the 'runoff area', either:

- use the land use type with the highest Pollution Hazard Index
- apply the approach for each of the land use types to determine whether the proposed SuDS design is sufficient for all. If it is not, consider collecting more hazardous runoff separately and providing additional treatment.

If the generic land use types suggested are not applicable, select 'Other' and enter a description of the land use of the runoff area and agreed user defined indices in the row below the drop down lists.

Runoff Area Land Use Description	Pollution Hazard	Pollution Hazard Indices		
		total Suspended Solids	Metals	Hydrocarbons
Select land use type from the drop down list (or 'Other' if none applicable) → Low traffic roads (e.g. residential roads and general access roads, <300 traffic movements/day)	Low	0.5	0.4	0.4
If the generic land use types in the drop down list above are not applicable, select 'Other' and enter a description of the land use of the runoff area and agreed user defined indices in this row:				
Landuse Pollution Hazard Index		Low	0.5	0.4

DESIGN CONDITIONS	
1	2

STEP 2A: Determine the Pollution Mitigation Index for the proposed SuDS components

This step requires the user to select the proposed SuDS components that will be used to treat runoff - before it is discharged to a receiving surface waterbody or downstream infiltration component

If the runoff is discharged directly to an infiltration component, without upstream treatment, select 'None' for each of the 3 SuDS components and move to Step 2B

This step should be applied to evaluate the water quality protection provided by proposed SuDS components for discharges to receiving surface waters or downstream infiltration components (note: in England and Wales this will include components that allow any amount of infiltration, however small, even where infiltration is not specifically accounted for in the design).

If you have fewer than 3 components, select 'None' for the components that are not required

If the proposed component is bespoke and/or a proprietary treatment product and not generically described by the suggested components, then 'Proprietary treatment system' or 'User defined indices' should be selected and a description of the component and agreed user defined indices should be entered in the rows below the drop down lists.

SuDS Component Description	Total Suspended Solids	Pollution Mitigation Indices		
		Metals	Hydrocarbons	
Select SuDS Component 1 (i.e. the upstream SuDS component) from the drop down list: → Detention basin	0.5	0.5	0.6	
Select SuDS Component 2 (i.e. the second SuDS component in a series) from the drop down list: → Filter strip	0.4	0.4	0.5	
Select SuDS Component 3 (i.e. the third SuDS component in a series) from the drop down list: → Filter drain (where the trench is not designed as an infiltration component)	0.4	0.4	0.4	
If the proposed SuDS components are bespoke/proprietary and/or the generic indices above are not considered appropriate, select 'Proprietary treatment system' or 'User defined indices' and enter component descriptions and agreed user defined indices in this row:				
Aggregated Surface Water Pollution Mitigation Index		0.9	0.9	>0.95

DESIGN CONDITIONS		
1	2	3
SuDS components can only be assumed to deliver these indices if they follow design guidance with respect to hydraulics and treatment set out in the relevant technical component chapters of the SuDS Manual. See also checklists in Appendix B		
SuDS components can only be assumed to deliver these indices if they follow design guidance with respect to hydraulics and treatment set out in the relevant technical component chapters of the SuDS Manual. See also checklists in Appendix B		
SuDS components can only be assumed to deliver these indices if they follow design guidance with respect to hydraulics and treatment set out in the relevant technical component chapters of the SuDS Manual. See also checklists in Appendix B		
Filter drains should be preceded by upstream components that trap/sift, or designed specifically to retain sediment in a separate zone, easily accessible for maintenance, such that the sediment will not be re-suspended in subsequent events		

Note: If the total aggregated mitigation index is > 1 (which is not a realistic outcome), then the outcome is fixed at ">0.95". In this scenario, the proposed components are likely to have a very high mitigation potential for reducing pollutant levels in the runoff and should be sufficient for any proposed land use (note: where risk assessment is required, this outcome would need more detailed verification).

Is the runoff now discharged to an infiltration component?

Yes ? Go to Step 2B

No ? Go to Step 2C

STEP 2B: Determine the Pollution Mitigation Index for the proposed Groundwater Protection

This step requires the user to select the type of groundwater protection that is either part of the SuDS component or that lies between the component and the groundwater

This step should be applied where a SuDS component is specifically designed to infiltrate runoff (note: in England and Wales this will include components that allow any amount of infiltration, however small, even where infiltration is not specifically accounted for in the design).

'Groundwater protection' describes the proposed depth of soil or other material through which runoff will flow between the runoff surface and the underlying groundwater.

Where the discharge is to surface waters and risks to groundwater need not be considered, select 'None'

If the proposed groundwater protection is bespoke and/or a proprietary product and not generically described by the suggested measures, then a description of the protection and agreed user defined indices should be entered in the row below the drop down list

Groundwater Protection Description	total Suspended Solids	Pollution Mitigation Indices		
		Metals	Hydrocarbons	
Select type of groundwater protection from the drop down list: → None				
If the proposed groundwater protection is bespoke/proprietary and/or the generic indices above are not considered appropriate, select 'Proprietary product' or 'User defined indices' and enter a description of the protection and agreed user defined indices in this row:				
Groundwater Protection Pollution Mitigation Index		0	0	0

DESIGN CONDITIONS			
1	2	3	4

STEP 2C: Determine the Combined Pollution Mitigation Indices for the Runoff Area

This is an automatic step which combines the proposed SuDS Pollution Mitigation Indices with any Groundwater Protection Pollution Mitigation Indices

Combined Pollution Mitigation Indices for the Runoff Area	Combined Pollution Mitigation Indices		
	total Suspended Solids	Metals	Hydrocarbons
	0.9	0.9	>0.95

Note: If the total aggregated mitigation index is > 1 (which is not a realistic outcome), then the outcome is fixed at ">0.95". In this scenario, the proposed components are likely to have a very high mitigation potential for reducing pollutant levels in the runoff and should be sufficient for any proposed land use (note: where risk assessment is required, this outcome would need more detailed verification).

STEP 2D: Determine Sufficiency of Pollution Mitigation Indices for Selected SuDS Components

This is an automatic step which compares the Combined Pollution Mitigation Indices with the Land Use Hazard Indices, to determine whether the proposed components are sufficient to manage each pollutant category type

When the combined mitigation index exceeds the land use pollution hazard index, then the proposed components are considered sufficient in providing pollution risk mitigation.


In England and Wales, where the discharge is to protected surface waters or groundwater, an additional treatment component (ie over and above that required for standard discharges), or other equivalent protection, is required that provides environmental protection in the event of an unexpected pollution event or poor system performance. Protected surface waters are those designated for drinking water abstraction. In England and Wales, protected groundwater resources are defined as Source Protection Zone 1. In Northern Ireland, a more precautionary approach may be required and this should be checked with the environmental regulator on a site by site basis.

DESIGN CONDITIONS

Sufficiency of Pollution Mitigation Indices		
total Suspended Solids	Metals	Hydrocarbons
1		
Sufficient	Sufficient	Sufficient





















Reference to local planning documents should also be made to identify any additional protection required for sites due to habitat conservation (see Chapter 7: The SuDS design process). The implications of developments on or within close proximity to an area with an environmental designation, such as a Site of Special Scientific Interest (SSSI), should be considered via consultation with relevant conservation bodies such as Natural England.

C. Hydraulic Results

Mott MacDonald		Page 1
Mott MacDonald House 8-10 Sydenham Road Croydon CR0 2EE	Knocknagael SubStation Proposed Site Bay 2 Basin 2	
Date 28/06/2023 18:17	Designed by Arya Joshi	
File SOUTH EASTERN BASIN 2 NO TRACK R...	Checked by Ana Isabel Ruiz-Diaz	
Innovyze	Network 2020.1.3	


STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for NDB

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.000	47.311	0.210	225.3	0.012	15.00	0.0	1.500	o	225	Pipe/Conduit	
1.001	27.705	0.083	333.8	0.032	0.00	0.0	1.500	o	225	Pipe/Conduit	
1.002	18.428	0.042	438.8	0.019	0.00	0.0	1.500	o	225	Pipe/Conduit	
1.003	29.342	0.065	451.4	0.020	0.00	0.0	1.500	o	225	Pipe/Conduit	
2.000	98.163	0.690	142.3	0.000	15.00	0.0	1.500	o	225	Pipe/Conduit	
1.004	5.740	0.011	500.0	0.056	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.005	22.034	0.044	500.0	0.000	0.00	0.0	1.500	o	300	Pipe/Conduit	
1.006	26.057	0.165	158.0	0.023	0.00	0.0	1.500	o	300	Pipe/Conduit	
3.000	30.555	0.385	79.3	0.038	15.00	0.0	1.500	o	150	Pipe/Conduit	
1.007	7.391	0.025	300.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
4.000	48.666	0.215	226.4	0.054	15.00	0.0	1.500	o	225	Pipe/Conduit	
4.001	30.120	0.134	225.0	0.019	0.00	0.0	1.500	o	225	Pipe/Conduit	
4.002	27.263	0.121	225.0	0.011	0.00	0.0	1.500	o	300	Pipe/Conduit	
4.003	62.637	0.353	177.5	0.038	0.00	0.0	1.500	o	300	Pipe/Conduit	
5.000	30.911	0.240	128.8	0.003	15.00	0.0	1.500	o	150	Pipe/Conduit	
5.001	51.386	4.050	12.7	0.000	0.00	0.0	1.500	o	150	Pipe/Conduit	
5.002	28.358	0.220	128.9	0.011	0.00	0.0	1.500	o	150	Pipe/Conduit	
5.003	16.043	4.000	4.0	0.006	0.00	0.0	1.500	o	150	Pipe/Conduit	
5.004	65.905	4.252	15.5	0.009	0.00	0.0	1.500	o	225	Pipe/Conduit	
5.005	33.343	0.821	40.6	0.005	0.00	0.0	1.500	o	225	Pipe/Conduit	






Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	50.00	16.03	174.385	0.012	0.0	0.0	0.0	0.76	30.3	1.7
1.001	50.00	16.77	174.100	0.044	0.0	0.0	0.0	0.63	24.9	6.0
1.002	50.00	17.33	174.017	0.063	0.0	0.0	0.0	0.55	21.7	8.6
1.003	50.00	18.24	173.975	0.083	0.0	0.0	0.0	0.54	21.4	11.3
2.000	50.00	16.70	174.675	0.000	0.0	0.0	0.0	0.96	38.2	0.0
1.004	50.00	18.38	173.835	0.140	0.0	0.0	0.0	0.70	49.2	18.9
1.005	50.00	18.98	173.824	0.140	0.0	0.0	0.0	0.62	43.6	18.9
1.006	50.00	19.37	173.779	0.163	0.0	0.0	0.0	1.10	77.9	22.0
3.000	50.00	15.52	174.150	0.038	0.0	0.0	0.0	0.98	17.4	5.2
1.007	50.00	19.51	173.615	0.201	0.0	0.0	0.0	0.90	63.8	27.2
4.000	50.00	16.07	174.650	0.054	0.0	0.0	0.0	0.76	30.3	7.3
4.001	50.00	16.72	174.435	0.073	0.0	0.0	0.0	0.76	30.4	9.8
4.002	50.00	17.22	174.226	0.084	0.0	0.0	0.0	0.92	65.2	11.3
4.003	50.00	18.22	174.105	0.122	0.0	0.0	0.0	1.04	73.5	16.5
5.000	50.00	15.67	187.970	0.003	0.0	0.0	0.0	0.77	13.6	0.4
5.001	50.00	16.02	187.730	0.003	0.0	0.0	0.0	2.47	43.6	0.4
5.002	50.00	16.63	183.680	0.014	0.0	0.0	0.0	0.77	13.6	1.9
5.003	50.00	16.69	183.460	0.020	0.0	0.0	0.0	4.39	77.7	2.7
5.004	50.00	17.06	179.385	0.029	0.0	0.0	0.0	2.92	116.3	3.9
5.005	50.00	17.37	175.133	0.033	0.0	0.0	0.0	1.80	71.7	4.5

Mott MacDonald		Page 2
Mott MacDonald House 8-10 Sydenham Road Croydon CR0 2EE	Knocknagael SubStation Proposed Site Bay 2 Basin 2	
Date 28/06/2023 18:17 File SOUTH EASTERN BASIN 2 NO TRACK R...	Designed by Arya Joshi Checked by Ana Isabel Ruiz-Diaz	
Innovyze	Network 2020.1.3	

STORM SEWER DESIGN by the Modified Rational Method

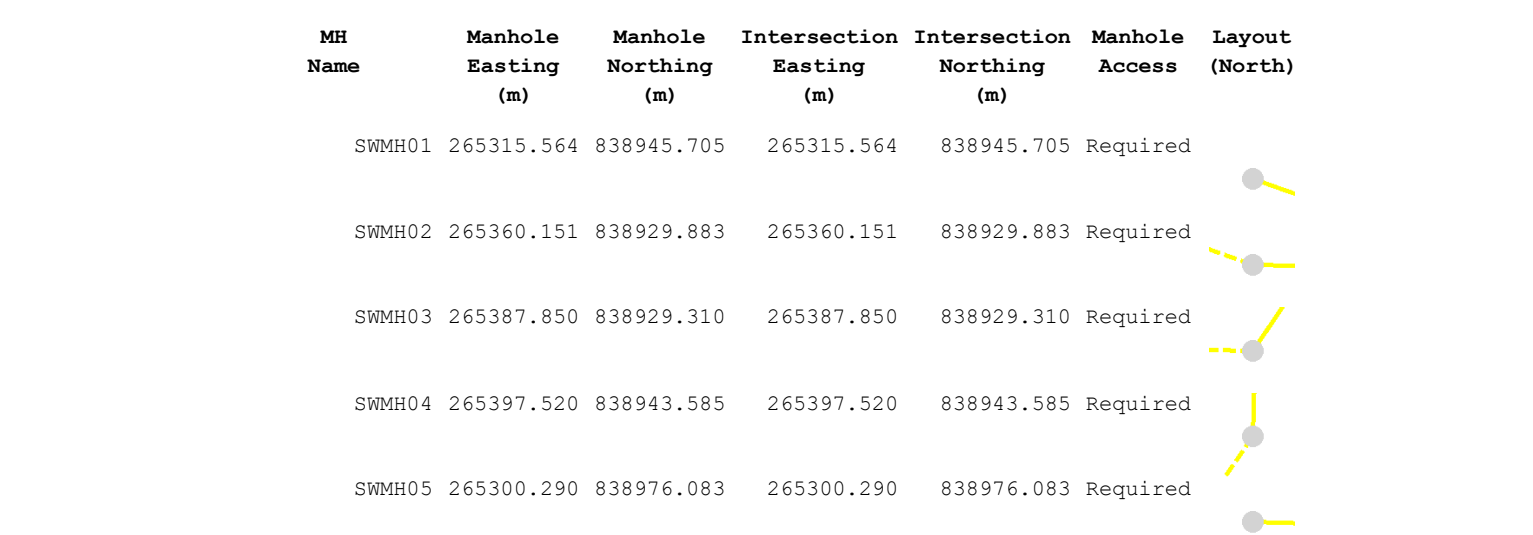
Network Design Table for NDB

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
4.004	8.477	0.024	350.0	0.000	0.00	0.0	0.600	o	350	Pipe/Conduit	
4.005	19.961	0.057	350.0	0.006	0.00	0.0	1.500	o	350	Pipe/Conduit	
6.000	42.942	0.356	120.6	0.020	15.00	0.0	1.500	o	225	Pipe/Conduit	
1.008	73.113	0.146	500.0	0.000	0.00	0.0	0.600	o	350	Pipe/Conduit	
1.009	19.460	0.389	50.0	0.000	0.00	0.0	0.600	o	350	Pipe/Conduit	




















Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
4.004	50.00	18.37	173.702	0.155	0.0	0.0	0.0	0.92	88.6	21.0
4.005	50.00	18.78	173.678	0.162	0.0	0.0	0.0	0.82	78.6	21.9
6.000	50.00	15.69	174.250	0.020	0.0	0.0	0.0	1.04	41.5	2.6
1.008	50.00	21.09	173.540	0.382	0.0	0.0	0.0	0.77	74.0	51.7
1.009	50.00	21.22	173.394	0.382	0.0	0.0	0.0	2.46	236.5	51.7

Manhole Schedules for NDB											
MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam., L*W (mm)	PN	Pipe Out Invert Level (m)	Diameter (mm)	PN	Pipes In Invert Level (m)	Diameter (mm)	Backdrop (mm)
SWMH01	175.500	1.115	Open Manhole	1200	1.000	174.385	225				
SWMH02	175.500	1.400	Open Manhole	1200	1.001	174.100	225	1.000	174.175	225	75
SWMH03	175.500	1.483	Open Manhole	1200	1.002	174.017	225	1.001	174.017	225	
SWMH04	175.500	1.525	Open Manhole	1200	1.003	173.975	225	1.002	173.975	225	
SWMH05	175.500	0.825	Open Manhole	1200	2.000	174.675	225				
SWMH06	175.500	1.665	Open Manhole	1200	1.004	173.835	300	1.003	173.910	225	
								2.000	173.985	225	75
SWMH07	175.500	1.676	Open Manhole	1200	1.005	173.824	300	1.004	173.824	300	
SWMH08	175.500	1.721	Open Manhole	1200	1.006	173.779	300	1.005	173.779	300	
SWMH09	175.500	1.350	Open Manhole	1200	3.000	174.150	150				
SWMH10	175.500	1.885	Open Manhole	1500	1.007	173.615	300	1.006	173.615	300	
								3.000	173.765	150	
SWMH11	175.500	0.850	Open Manhole	1200	4.000	174.650	225				
SWMH12	175.500	1.065	Open Manhole	1200	4.001	174.435	225	4.000	174.435	225	
SWMH13	175.500	1.274	Open Manhole	1200	4.002	174.226	300	4.001	174.301	225	
SWMH14	175.500	1.395	Open Manhole	1200	4.003	174.105	300	4.002	174.105	300	
SWMH16	189.320	1.350	Open Manhole	1200	5.000	187.970	150				
SWMH17	189.260	1.530	Open Manhole	1200	5.001	187.730	150	5.000	187.730	150	
SWMH18	185.030	1.350	Open Manhole	1200	5.002	183.680	150	5.001	183.680	150	
SWMH19	184.410	0.950	Open Manhole	1200	5.003	183.460	150	5.002	183.460	150	
SWMH20	180.400	1.015	Open Manhole	1200	5.004	179.385	225	5.003	179.460	150	
SWMH21	175.560	0.427	Open Manhole	1200	5.005	175.133	225	5.004	175.133	225	
SWMH22	175.500	1.798	Open Manhole	1200	4.004	173.702	350	4.003	173.752	300	
								5.005	174.312	225	485
SWMH23	175.500	1.822	Open Manhole	1200	4.005	173.678	350	4.004	173.678	350	
SWMH24	175.500	1.250	Open Manhole	1200	6.000	174.250	225				
SWMH25	175.500	1.960	Open Manhole	1500	1.008	173.540	350	1.007	173.590	300	
								4.005	173.621	350	81
								6.000	173.894	225	229
SWHW27	174.300	0.906	Open Manhole	2000	1.009	173.394	350	1.008	173.394	350	
Basin 2 Outfall	174.000	0.996	Open Manhole	0		OUTFALL		1.009	173.004	350	




Manhole Schedules for NDB

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
SWMH06	265398.401	838972.914	265398.401	838972.914	Required	
SWMH07	265398.561	838978.651	265398.561	838978.651	Required	
SWMH08	265399.135	839000.678	265399.135	839000.678	Required	
SWMH09	265354.093	839025.399	265354.093	839025.399	Required	
SWMH10	265384.484	839022.226	265384.484	839022.226	Required	
SWMH11	265312.463	838939.810	265312.463	838939.810	Required	
SWMH12	265358.149	838923.042	265358.149	838923.042	Required	
SWMH13	265388.269	838922.889	265388.269	838922.889	Required	
SWMH14	265404.788	838942.102	265404.788	838942.102	Required	
SWMH16	265323.757	838896.108	265323.757	838896.108	Required	
SWMH17	265353.501	838887.695	265353.501	838887.695	Required	
SWMH18	265404.475	838894.190	265404.475	838894.190	Required	
SWMH19	265424.991	838913.768	265424.991	838913.768	Required	
SWMH20	265435.216	838926.130	265435.216	838926.130	Required	
SWMH21	265431.986	838991.956	265431.986	838991.956	Required	
SWMH22	265405.866	839004.730	265405.866	839004.730	Required	
SWMH23	265403.067	839012.731	265403.067	839012.731	Required	
SWMH24	265347.024	839032.710	265347.024	839032.710	Required	
SWMH25	265389.651	839027.510	265389.651	839027.510	Required	

Manhole Schedules for NDB						
MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
SWHW27	265436.442	839083.690	265436.442	839083.690	Required	
Basin 2 Outfall	265433.485	839102.923			No Entry	

PIPELINE SCHEDULES for NDB									
Upstream Manhole									
PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., (mm)	L*W
1.000	o	225	SWMH01	175.500	174.385	0.890	Open Manhole		1200
1.001	o	225	SWMH02	175.500	174.100	1.175	Open Manhole		1200
1.002	o	225	SWMH03	175.500	174.017	1.258	Open Manhole		1200
1.003	o	225	SWMH04	175.500	173.975	1.300	Open Manhole		1200
2.000	o	225	SWMH05	175.500	174.675	0.600	Open Manhole		1200
1.004	o	300	SWMH06	175.500	173.835	1.365	Open Manhole		1200
1.005	o	300	SWMH07	175.500	173.824	1.376	Open Manhole		1200
1.006	o	300	SWMH08	175.500	173.779	1.421	Open Manhole		1200
3.000	o	150	SWMH09	175.500	174.150	1.200	Open Manhole		1200
1.007	o	300	SWMH10	175.500	173.615	1.585	Open Manhole		1500
4.000	o	225	SWMH11	175.500	174.650	0.625	Open Manhole		1200
4.001	o	225	SWMH12	175.500	174.435	0.840	Open Manhole		1200
4.002	o	300	SWMH13	175.500	174.226	0.974	Open Manhole		1200
4.003	o	300	SWMH14	175.500	174.105	1.095	Open Manhole		1200
5.000	o	150	SWMH16	189.320	187.970	1.200	Open Manhole		1200
5.001	o	150	SWMH17	189.260	187.730	1.380	Open Manhole		1200
5.002	o	150	SWMH18	185.030	183.680	1.200	Open Manhole		1200
5.003	o	150	SWMH19	184.410	183.460	0.800	Open Manhole		1200
5.004	o	225	SWMH20	180.400	179.385	0.790	Open Manhole		1200
5.005	o	225	SWMH21	175.560	175.133	0.202	Open Manhole		1200
Downstream Manhole									
PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., (mm)	L*W
1.000	47.311	225.3	SWMH02	175.500	174.175	1.100	Open Manhole		1200
1.001	27.705	333.8	SWMH03	175.500	174.017	1.258	Open Manhole		1200
1.002	18.428	438.8	SWMH04	175.500	173.975	1.300	Open Manhole		1200
1.003	29.342	451.4	SWMH06	175.500	173.910	1.365	Open Manhole		1200
2.000	98.163	142.3	SWMH06	175.500	173.985	1.290	Open Manhole		1200
1.004	5.740	500.0	SWMH07	175.500	173.824	1.376	Open Manhole		1200
1.005	22.034	500.0	SWMH08	175.500	173.779	1.421	Open Manhole		1200
1.006	26.057	158.0	SWMH10	175.500	173.615	1.585	Open Manhole		1500
3.000	30.555	79.3	SWMH10	175.500	173.765	1.585	Open Manhole		1500
1.007	7.391	300.0	SWMH25	175.500	173.590	1.610	Open Manhole		1500
4.000	48.666	226.4	SWMH12	175.500	174.435	0.840	Open Manhole		1200
4.001	30.120	225.0	SWMH13	175.500	174.301	0.974	Open Manhole		1200
4.002	27.263	225.0	SWMH14	175.500	174.105	1.095	Open Manhole		1200
4.003	62.637	177.5	SWMH22	175.500	173.752	1.448	Open Manhole		1200
5.000	30.911	128.8	SWMH17	189.260	187.730	1.380	Open Manhole		1200
5.001	51.386	12.7	SWMH18	185.030	183.680	1.200	Open Manhole		1200
5.002	28.358	128.9	SWMH19	184.410	183.460	0.800	Open Manhole		1200
5.003	16.043	4.0	SWMH20	180.400	179.460	0.790	Open Manhole		1200
5.004	65.905	15.5	SWMH21	175.560	175.133	0.202	Open Manhole		1200
5.005	33.343	40.6	SWMH22	175.500	174.312	0.963	Open Manhole		1200

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Innovyze	Network 2020.1.3	


PIPELINE SCHEDULES for NDB

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
4.004	o	350	SWMH22	175.500	173.702	1.448	Open Manhole	1200
4.005	o	350	SWMH23	175.500	173.678	1.472	Open Manhole	1200
6.000	o	225	SWMH24	175.500	174.250	1.025	Open Manhole	1200
1.008	o	350	SWMH25	175.500	173.540	1.610	Open Manhole	1500
1.009	o	350	SWHW27	174.300	173.394	0.556	Open Manhole	2000

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
4.004	8.477	350.0	SWMH23	175.500	173.678	1.472	Open Manhole	1200
4.005	19.961	350.0	SWMH25	175.500	173.621	1.529	Open Manhole	1500
6.000	42.942	120.6	SWMH25	175.500	173.894	1.381	Open Manhole	1500
1.008	73.113	500.0	SWHW27	174.300	173.394	0.556	Open Manhole	2000
1.009	19.460	50.0	Basin 2 Outfall	174.000	173.004	0.646	Open Manhole	0

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Mott MacDonald House 8-10 Sydenham Road Croydon CR0 2EE	Knocknagael SubStation Proposed Site Bay 2 Basin 2	
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Innovyze	Network 2020.1.3	

Area Summary for NDB						
Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	Classification	PermeABLE pLOTFORM	10	0.076	0.008	0.008
	Classification	Verge	16	0.029	0.005	0.012
1.001	Classification	Paved	100	0.015	0.015	0.015
	Classification	PermeABLE pLOTFORM	10	0.144	0.014	0.029
	Classification	Verge	16	0.016	0.003	0.032
1.002	Classification	Paved	100	0.002	0.002	0.002
	Classification	PermeABLE pLOTFORM	10	0.059	0.006	0.008
	Classification	Verge	16	0.007	0.001	0.009
	Classification	Paved	100	0.008	0.008	0.017
	Classification	Verge	16	0.013	0.002	0.019
1.003	Classification	Paved	100	0.015	0.015	0.015
	Classification	PermeABLE pLOTFORM	10	0.025	0.002	0.017
	Classification	Verge	16	0.017	0.003	0.020
2.000	-	-	100	0.000	0.000	0.000
1.004	Classification	Paved	100	0.017	0.017	0.017
	Classification	Unbound	80	0.033	0.027	0.044
	Classification	PermeABLE pLOTFORM	10	0.092	0.009	0.053
	Classification	Verge	16	0.020	0.003	0.056
1.005	-	-	100	0.000	0.000	0.000
1.006	Classification	Paved	100	0.012	0.012	0.012
	Classification	PermeABLE pLOTFORM	10	0.082	0.008	0.021
	Classification	Verge	16	0.016	0.002	0.023
3.000	Classification	Paved	100	0.029	0.029	0.029
	Classification	PermeABLE pLOTFORM	10	0.045	0.005	0.034
	Classification	Verge	16	0.027	0.004	0.038
1.007	-	-	100	0.000	0.000	0.000
4.000	Classification	Access Earthwork	21	0.140	0.029	0.029
	Classification	Paved	100	0.025	0.025	0.054
4.001	Classification	Access Earthwork	21	0.088	0.019	0.019
4.002	Classification	Access Earthwork	21	0.053	0.011	0.011
4.003	Classification	Access Earthwork	21	0.121	0.025	0.025
	Classification	Access Earthwork	21	0.060	0.013	0.038
5.000	Classification	Verge	16	0.016	0.003	0.003
5.001	-	-	100	0.000	0.000	0.000
5.002	Classification	Verge	16	0.070	0.011	0.011
5.003	Classification	Verge	16	0.036	0.006	0.006
5.004	Classification	Verge	16	0.058	0.009	0.009
5.005	Classification	Verge	16	0.029	0.005	0.005
4.004	-	-	100	0.000	0.000	0.000
4.005	Classification	Access Earthwork	21	0.031	0.006	0.006
6.000	Classification	Access Earthwork	21	0.093	0.020	0.020
1.008	-	-	100	0.000	0.000	0.000
1.009	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				1.620	0.382	0.382

Network Classifications for NDB

PN	USMH Name	Pipe Dia (mm)	Min Cover Depth (m)	Max Cover Depth (m)	Pipe Type	MH Dia (mm)	MH Width (mm)	MH Ring Depth (m)	MH Type
1.000	SWMH01	225	0.890	1.100	Unclassified	1200	0	0.890	Unclassified
1.001	SWMH02	225	1.175	1.258	Unclassified	1200	0	1.175	Unclassified
1.002	SWMH03	225	1.258	1.300	Unclassified	1200	0	1.258	Unclassified
1.003	SWMH04	225	1.300	1.365	Unclassified	1200	0	1.300	Unclassified
2.000	SWMH05	225	0.600	1.290	Unclassified	1200	0	0.600	Unclassified
1.004	SWMH06	300	1.365	1.376	Unclassified	1200	0	1.365	Unclassified
1.005	SWMH07	300	1.376	1.421	Unclassified	1200	0	1.376	Unclassified
1.006	SWMH08	300	1.421	1.585	Unclassified	1200	0	1.421	Unclassified
3.000	SWMH09	150	1.200	1.585	Unclassified	1200	0	1.200	Unclassified
1.007	SWMH10	300	1.585	1.610	Unclassified	1500	0	1.585	Unclassified
4.000	SWMH11	225	0.625	0.840	Unclassified	1200	0	0.625	Unclassified
4.001	SWMH12	225	0.840	0.974	Unclassified	1200	0	0.840	Unclassified
4.002	SWMH13	300	0.974	1.095	Unclassified	1200	0	0.974	Unclassified
4.003	SWMH14	300	1.095	1.448	Unclassified	1200	0	1.095	Unclassified
5.000	SWMH16	150	1.200	1.380	Unclassified	1200	0	1.200	Unclassified
5.001	SWMH17	150	1.200	1.380	Unclassified	1200	0	1.380	Unclassified
5.002	SWMH18	150	0.800	1.200	Unclassified	1200	0	1.200	Unclassified
5.003	SWMH19	150	0.790	0.800	Unclassified	1200	0	0.800	Unclassified
5.004	SWMH20	225	0.202	0.790	Unclassified	1200	0	0.790	Unclassified
5.005	SWMH21	225	0.202	0.963	Unclassified	1200	0	0.202	Unclassified
4.004	SWMH22	350	1.448	1.472	Unclassified	1200	0	1.448	Unclassified
4.005	SWMH23	350	1.472	1.529	Unclassified	1200	0	1.472	Unclassified
6.000	SWMH24	225	1.025	1.381	Unclassified	1200	0	1.025	Unclassified
1.008	SWMH25	350	0.556	1.610	Unclassified	1500	0	1.610	Unclassified
1.009	SWHW27	350	0.556	0.646	Unclassified	2000	0	0.556	Unclassified

Free Flowing Outfall Details for NDB

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.009	Basin 2 Outfall	174.000	173.004	0.000	0	0

Simulation Criteria for NDB

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1
Number of Input Hydrographs	0	Number of Offline Controls	0
Number of Online Controls	1	Number of Time/Area Diagrams	0
		Number of Storage Structures	21
		Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FEH	Summer Storms	Yes
Return Period (years)	25	Winter Storms	No
FEH Rainfall Version	2013	Cv (Summer)	0.750
Site Location	GB 377178 814306 NJ 77178 14306	Cv (Winter)	0.840
Data Type		Point Storm Duration (mins)	30

Online Controls for NDB

Hydro-Brake® Optimum Manhole: SWHW27, DS/PN: 1.009, Volume (m³): 9.7

Unit Reference	MD-SHE-0110-5200-0800-5200
Design Head (m)	0.800
Design Flow (l/s)	5.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	110
Invert Level (m)	173.394
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	5.2	Kick-Flo®	0.537	4.3
Flush-Flo™	0.241	5.2	Mean Flow over Head Range	-	4.5

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)	Depth (m)	Flow (l/s)
0.100	3.8	0.800	5.2	2.000	8.0	4.000	11.1	7.000	14.5
0.200	5.2	1.000	5.8	2.200	8.3	4.500	11.7	7.500	14.9
0.300	5.2	1.200	6.3	2.400	8.7	5.000	12.3	8.000	15.4
0.400	5.0	1.400	6.7	2.600	9.0	5.500	12.9	8.500	15.8
0.500	4.6	1.600	7.2	3.000	9.7	6.000	13.4	9.000	16.3
0.600	4.6	1.800	7.6	3.500	10.4	6.500	14.0	9.500	16.8

Storage Structures for NDB

Trench Soakaway Manhole: SWMH01, DS/PN: 1.000

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	47.0
Safety Factor	2.0	Slope (1:X)	225.0
Porosity	0.30	Cap Volume Depth (m)	1.200
Invert Level (m)	174.385	Cap Infiltration Depth (m)	1.200

Trench Soakaway Manhole: SWMH02, DS/PN: 1.001

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	27.0
Safety Factor	2.0	Slope (1:X)	330.0
Porosity	0.30	Cap Volume Depth (m)	1.200
Invert Level (m)	173.100	Cap Infiltration Depth (m)	1.200

Trench Soakaway Manhole: SWMH03, DS/PN: 1.002

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	18.0
Safety Factor	2.0	Slope (1:X)	400.0
Porosity	0.30	Cap Volume Depth (m)	1.200
Invert Level (m)	173.942	Cap Infiltration Depth (m)	1.115

Trench Soakaway Manhole: SWMH04, DS/PN: 1.003

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	29.0
Safety Factor	2.0	Slope (1:X)	450.0
Porosity	0.30	Cap Volume Depth (m)	1.200
Invert Level (m)	173.900	Cap Infiltration Depth (m)	1.200

Trench Soakaway Manhole: SWMH05, DS/PN: 2.000

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	98.0
Safety Factor	2.0	Slope (1:X)	142.0
Porosity	0.30	Cap Volume Depth (m)	1.200
Invert Level (m)	174.675	Cap Infiltration Depth (m)	0.825

Trench Soakaway Manhole: SWMH07, DS/PN: 1.005

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	22.0
Safety Factor	2.0	Slope (1:X)	500.0
Porosity	0.30	Cap Volume Depth (m)	1.115
Invert Level (m)	173.749	Cap Infiltration Depth (m)	1.115

Trench Soakaway Manhole: SWMH08, DS/PN: 1.006

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	22.0
Safety Factor	2.0	Slope (1:X)	289.0
Porosity	0.30	Cap Volume Depth (m)	1.115
Invert Level (m)	173.704	Cap Infiltration Depth (m)	1.115

Trench Soakaway Manhole: SWMH09, DS/PN: 3.000

Infiltration Coefficient Base (m/hr)	0.00000	Safety Factor	2.0
Infiltration Coefficient Side (m/hr)	0.00360	Porosity	0.30



Micro
Drainage

Checked by Ana Isabel Ruiz-Diaz

Network 2020.1.3

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	51.0
Safety Factor	2.0	Slope (1:X)	12.0
Porosity	0.30	Cap Volume Depth (m)	1.350
Invert Level (m)	183.680	Cap Infiltration Depth (m)	1.350

Trench Soakaway Manhole: SWMH19, DS/PN: 5.003

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	16.0
Safety Factor	2.0	Slope (1:X)	4.0
Porosity	0.30	Cap Volume Depth (m)	1.350
Invert Level (m)	183.460	Cap Infiltration Depth (m)	1.350

Trench Soakaway Manhole: SWMH20, DS/PN: 5.004

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	65.0
Safety Factor	2.0	Slope (1:X)	14.0
Porosity	0.30	Cap Volume Depth (m)	1.350
Invert Level (m)	179.050	Cap Infiltration Depth (m)	1.350

Trench Soakaway Manhole: SWMH21, DS/PN: 5.005

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	33.0
Safety Factor	2.0	Slope (1:X)	130.0
Porosity	0.30	Cap Volume Depth (m)	1.350
Invert Level (m)	174.273	Cap Infiltration Depth (m)	1.350

Trench Soakaway Manhole: SWMH23, DS/PN: 4.005

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	19.0
Safety Factor	2.0	Slope (1:X)	237.0
Porosity	0.30	Cap Volume Depth (m)	0.750
Invert Level (m)	173.830	Cap Infiltration Depth (m)	0.750

Trench Soakaway Manhole: SWMH24, DS/PN: 6.000

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	42.0
Safety Factor	2.0	Slope (1:X)	121.0
Porosity	0.30	Cap Volume Depth (m)	1.250
Invert Level (m)	174.250	Cap Infiltration Depth (m)	1.250

Tank or Pond Manhole: SWHW27, DS/PN: 1.009

Invert Level (m) 173.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	350.9	0.500	457.6	0.800	528.4

Volume Summary (Static)

Length Calculations based on Centre-Centre

Pipe Number	USMH Name	Pipe Volume (m³)	Storage Structure	Total Volume (m³)
			Volume (m³)	
1.000	SWMH01	1.881	14.249	16.130
1.001	SWMH02	1.102	9.720	10.822
1.002	SWMH03	0.733	6.480	7.213
1.003	SWMH04	1.167	10.440	11.607
2.000	SWMH05	3.903	14.110	18.013
1.004	SWMH06	0.406	0.000	0.406
1.005	SWMH07	1.557	7.359	8.916
1.006	SWMH08	1.842	7.359	9.201
3.000	SWMH09	0.540	11.683	12.223
1.007	SWMH10	0.522	0.000	0.522
4.000	SWMH11	1.935	10.116	12.051
4.001	SWMH12	1.198	6.750	7.948
4.002	SWMH13	1.927	6.075	8.002
4.003	SWMH14	4.428	13.950	18.378
5.000	SWMH16	0.546	11.095	11.642
5.001	SWMH17	0.908	4.155	5.063
5.002	SWMH18	0.501	3.280	3.782
5.003	SWMH19	0.284	0.541	0.825
5.004	SWMH20	2.620	3.827	6.448
5.005	SWMH21	1.326	11.485	12.811
4.004	SWMH22	0.816	0.000	0.816
4.005	SWMH23	1.920	4.275	6.195
6.000	SWMH24	1.707	13.563	15.271
1.008	SWMH25	7.034	0.000	7.034
1.009	SWHW27	1.872	349.283	351.155
Total		42.675	519.796	562.471



Micro
Drainage

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for NDB

Simulation Criteria

Areal Reduction Factor 1.000	Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0	MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0	Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500	Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000	

Number of Input Hydrographs 0	Number of Offline Controls 0	Number of Time/Area Diagrams 0
Number of Online Controls 1	Number of Storage Structures 21	Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FEH	Data Type Point	
FEH Rainfall Version	2013 Cv	(Summer)	0.750
Site Location GB 377178 814306 NJ 77178 14306	Cv	(Winter)	0.840

Margin for Flood Risk Warning (mm) 300.0	DVD Status OFF
Analysis Timestep	Fine Inertia Status OFF
DTS Status	ON

Profile(s)	Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440	
Return Period(s) (years)	2, 30, 200, 1000
Climate Change (%)	37, 37, 37, 0

US/MH						Water	Surcharged	Flooded			Pipe	Status
PN	Name	Event		US/CL	(m)	Level	Depth	Volume	Flow /	Overflow	Flow	
					(m)	(m)	(m)	(m³)	Cap.	(l/s)	(l/s)	
1.000	SWMH01	30 minute	30 year Winter I+37%	175.500	174.431		-0.179	0.000	0.09		2.7	OK
1.001	SWMH02	60 minute	30 year Winter I+37%	175.500	174.177		-0.148	0.000	0.25		5.9	OK
1.002	SWMH03	15 minute	30 year Winter I+37%	175.500	174.122		-0.120	0.000	0.31		5.9	OK
1.003	SWMH04	15 minute	30 year Winter I+37%	175.500	174.098		-0.102	0.000	0.56		11.2	OK
2.000	SWMH05	15 minute	30 year Summer I+37%	175.500	174.675		-0.225	0.000	0.00		0.0	OK
1.004	SWMH06	15 minute	30 year Winter I+37%	175.500	174.034		-0.101	0.000	0.64		28.8	OK
1.005	SWMH07	15 minute	30 year Winter I+37%	175.500	174.020		-0.103	0.000	0.75		27.8	OK
1.006	SWMH08	30 minute	30 year Summer I+37%	175.500	173.926		-0.154	0.000	0.47		33.7	OK
3.000	SWMH09	30 minute	30 year Winter I+37%	175.500	174.225		-0.075	0.000	0.50		8.4	OK
1.007	SWMH10	30 minute	30 year Summer I+37%	175.500	173.859		-0.056	0.000	1.00		39.9	OK
4.000	SWMH11	30 minute	30 year Winter I+37%	175.500	174.750		-0.125	0.000	0.40		11.8	OK
4.001	SWMH12	30 minute	30 year Winter I+37%	175.500	174.551		-0.109	0.000	0.52		15.0	OK
4.002	SWMH13	30 minute	30 year Winter I+37%	175.500	174.337		-0.189	0.000	0.29		17.5	OK
4.003	SWMH14	60 minute	30 year Summer I+37%	175.500	174.227		-0.178	0.000	0.31		22.0	OK
5.000	SWMH16	30 minute	30 year Winter I+37%	189.320	187.990		-0.130	0.000	0.04		0.6	OK
5.001	SWMH17	30 minute	30 year Winter I+37%	189.260	187.739		-0.141	0.000	0.01		0.6	OK
5.002	SWMH18	15 minute	30 year Winter I+37%	185.030	183.743		-0.087	0.000	0.36		4.7	OK
5.003	SWMH19	15 minute	30 year Winter I+37%	184.410	183.491		-0.119	0.000	0.10		7.0	OK
5.004	SWMH20	15 minute	30 year Winter I+37%	180.400	179.432		-0.178	0.000	0.09		10.5	OK
5.005	SWMH21	120 minute	30 year Winter I+37%	175.560	175.164		-0.194	0.000	0.04		2.9	OK
4.004	SWMH22	60 minute	30 year Winter I+37%	175.500	173.858		-0.194	0.000	0.38		22.6	OK
4.005	SWMH23	60 minute	30 year Winter I+37%	175.500	173.833		-0.195	0.000	0.34		23.7	OK
6.000	SWMH24	30 minute	30 year Winter I+37%	175.500	174.299		-0.176	0.000	0.11		4.3	OK
1.008	SWMH25	30 minute	30 year Winter I+37%	175.500	173.791		-0.099	0.000	0.81		56.8	OK
1.009	SWHW27	480 minute	30 year Winter I+37%	174.300	173.739		-0.005	0.000	0.03		5.1	OK



Micro
Drainage

Simulation Criteria

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	1	Number of Storage Structures	21	Number of Real Time Controls	0

Rainfall Model	FEH	Data Type	Point
FEH Rainfall Version	2013	Cv (Summer)	0.750
Site Location	GB 377178 814306 NJ 77178 14306	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years)	2, 30, 200, 1000
Climate Change (%)	37, 37, 37, 0

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Simulation Criteria

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	1	Number of Storage Structures	21	Number of Real Time Controls	0

Rainfall Model	FEH	Data Type	Point
FEH Rainfall Version	2013	Cv (Summer)	0.750
Site Location	GB 377178 814306 NJ 77178 14306	Cv (Winter)	0.840

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years)	2, 30, 200, 1000
Climate Change (%)	37, 37, 37, 0

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D. Soakaway Tests at Basin Location

Soil Infiltration Rate (Soakaway) Test

Soil Infiltration Test carried out in accordance with BRE Digest 365:2016.

Borehole number:

MMTP11

Page 1 of 1

Project name: Red John
Project number: 331K
Client: SSEN-T
Operative: Scott Campbell
Start of test: 16/04/2024 09:20:00
End of test: 45398.51389

Survey grid system: OSGB
Co-ordinates: 265425.81 mE
839059.44 mN
Ground level: 178.03 mOD

Hole type: TP
Checked by: JD
Approved by:

Test reference: 1

Weather: Overcast

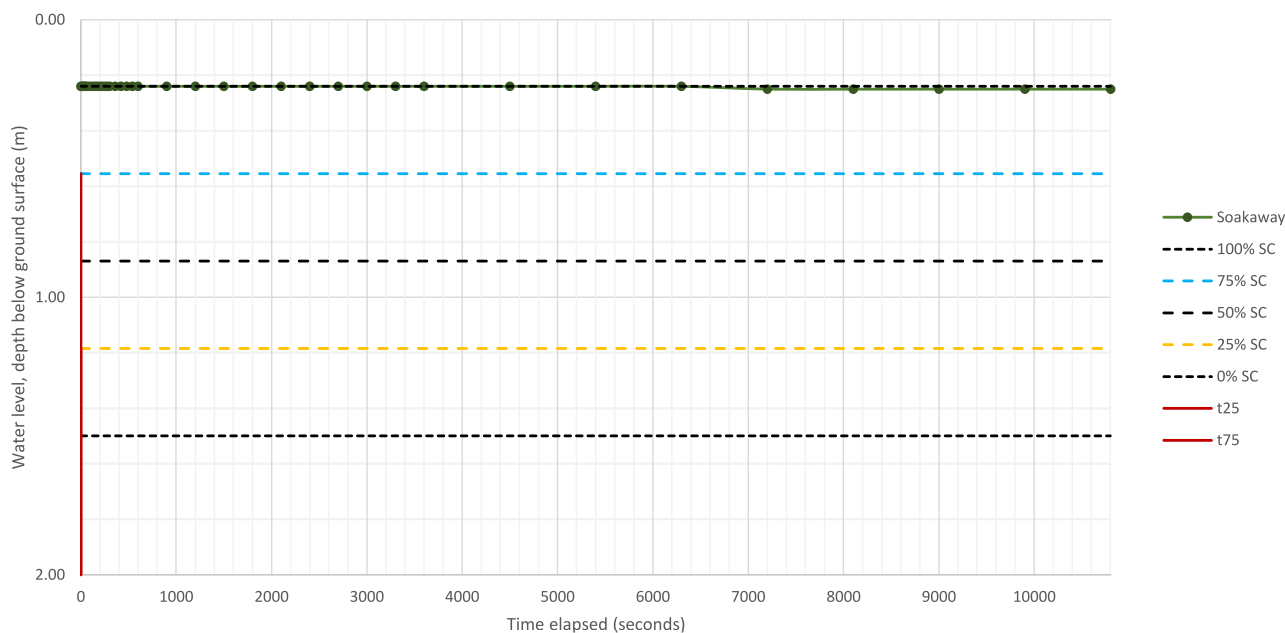
Test type:	Soil Infiltration Test	
Response zone top:	0.10	m bgl
Reponse zone base:	1.50	m bgl
Test section diameter:	0	mm

Shape of test section:	Trial Pit (Cuboid)
Test section dimensions:	0.70m x 1.50m
Type of filter used:	None
(Assumed porosity)	100 %

Groundwater before:	Dry
Water added:	1000 l
Water level start of test:	0.24 m bgl
Water level end of test:	0.25 m bgl
Hole depth after test:	1.50 m bgl

Time, t (seconds)	Water Depth (m)
0	0.24
15	0.24
30	0.24
45	0.24
60	0.24
90	0.24
120	0.24
150	0.24
180	0.24
210	0.24
240	0.24
270	0.24
300	0.24
360	0.24
420	0.24
480	0.24
540	0.24

Time, t (seconds)	Water Depth (m)
600	0.24
900	0.24
1200	0.24
1500	0.24
1800	0.24
2100	0.24
2400	0.24
2700	0.24
3000	0.24
3300	0.24
3600	0.24
4500	0.24
5400	0.24
6300	0.24
7200	0.25
8100	0.25
9000	0.25

[illegible]

$$\text{Soil infiltration rate, } f = \frac{V_{p75-25}}{a_{s50} \times t_{p75-25}}$$

Where	$V_{p\ 75-25}$	Effective storage volume of water in borehole between 75% and 25% effective storage capacity (SC) depth.	0.6615	m ³
	$a_{s\ 50}$	Internal surface area of borehole up to 50% effective storage capacity (SC) depth, including the base area	3.8220	m ²
	$t_{p\ 75-25}$	Time for water level to fall from 75% to 25% effective storage capacity (SC) depth.		seconds

f = - m/s

Comments:

E. Drainage Maintenance Schedule

Maintenance Schedule

This document aims to identify the planned maintenance needs to reduce reactive maintenance, asset failure or pollution of the environment. The CIRIA SuDS Manual⁴ has been used to recommend required actions and frequency for key assets across the site. Refer to the CIRIA SuDS Manual for basic maintenance procedures in addition to asset-specific manuals as provided by manufacturers. SSEN is ultimately responsible for the maintenance of all drainage assets at the Knocknagael substation site.

Table 6.1: Knocknagael Substation - Drainage Maintenance Schedule

Maintenance Schedule	Required Action	Recommended Frequency	Possible Plant Required/Method
Attenuation Basin			
Regular maintenance	Removal of litter and debris.	Monthly and after heavy rainfall events.	Manual litter picking Waste Removal Van
Regular maintenance	Inspect inlet and outlet headwalls for blockages and clear if needed.	Monthly Visual inspection	CCTV / Jetting crew as required
Regular maintenance	Inspect bankside, manholes and pipework for evidence of physical damage.	Monthly (for the first year), then annually or as required.	Visual inspection
Regular Maintenance	Inspect headwalls and associated pipe network for silt accumulation. Establish appropriate silt removal frequencies based on accumulation levels and clear if needed.	Monthly (for the first year), then annually or as required.	Visual inspection CCTV / Jetting crew (assumed yearly)
Monitoring	Inspect lifebuoy/water safety devices for tampering and vandalism. Check device is fit for purpose.	Monthly	Visual inspection
Occasional Maintenance	Repair any damage to lifebuoy/water safety devices.	As needed	To be assessed on defect
Remedial Actions	Repair / rehabilitation of inlets, outlets, and overflows.	As required	To be assessed based on defect
Remedial actions	Reprofile uneven surfaces and reinstate design levels.	Annually or as required	To be assessed based on defect.
Open drainage ditches			
Regular maintenance	Removal of litter and debris.	Monthly	Manual litter picking Waste removal van
Regular maintenance	Inspect inlet headwall for blockages and clear if needed.	Monthly or as needed	Visual inspection CCTV / Jetting crew as required
Occasional Maintenance	Check for sediment/ plant build-up along the ditch and remove as needed.	Spring and summer, or as needed. After heavy rainfall events.	Visual inspection Removal vehicle

⁴ The SuDS Manual (C753F)

Maintenance Schedule	Required Action	Recommended Frequency	Possible Plant Required/Method
			Maintenance team
Filter Drains			
Regular maintenance	Removal of litter and debris.	Monthly (or as required)	Manual litter picking Waste removal van
Regular maintenance	Inspect filter drain surface, inlet/outlet pipework and control system for blockages and clear if needed.	Monthly	Visual inspection CCTV team Jetting team
Occasional Maintenance	Remove/control tree roots and plant growth where they encroach the filter drain.	As required	To be assessed based on the severity
Occasional Maintenance	Removed surface geotextile and replaced in areas of high pollution. Wash the overlying filter medium.	Five yearly or as required.	Jetting team Manual or plant removal based on the amount of surface needing to be replaced.
Occasional Maintenance	Clear perforated pipework of blockages.	As required.	Jetting team
Drainage Pipework and Manholes			
Monitoring	Check operations of pipework by inspection of flows after rainfall events.	Monthly or after heavy rainfall	Visual inspection
Regular maintenance	Inspection for sediment, accumulation and removal as needed.	Six monthly or as required	CCTV team for inspection Jetting team for removal if necessary.
Regular maintenance	Removal of sediment from manhole/catch pit sump.	Six monthly or as required	Visual inspection Jetting team.
Flow control Device			
Regular maintenance	Remove sediment from pump.	As necessary – indicated by monthly system inspection or immediately following significant rainfall.	Visual inspection Removal vehicle Maintenance team
Remedial actions	Replace malfunctioning parts.	As required	As recommended by the manufacturer
Monitoring	Inspect sediment accumulation rates to determine correct operation of upstream components.	Monthly for 6 months, then every 6 months	Visual inspection
Penstock Valve and Sampling Point			
Regular maintenance	Check operations of penstock by fully opening and closing penstock.	Annually	Visual inspection Maintenance team

Maintenance Schedule	Required Action	Recommended Frequency	Possible Plant Required/Method
Regular maintenance	Clean equipment with clean water and stiff brush to prevent build-up that cause obstruction.	As required	Visual inspection Maintenance team
Regular maintenance	Treated with grease or oil on the hoist, bearing, nits and screens.	Quarterly	Maintenance team
Monitoring	Check for damage and obstructions.	Monthly or after heavy rainfall	Visual
Basin Inlet / Outlet and Headwall			
Regular maintenance	Remove sediment from pipe.	As necessary – indicated by monthly system inspection or immediately following significant rainfall.	Visual inspection Removal vehicle Maintenance team
Monitoring	Inspect sediment accumulation rates to determine correct operation of upstream components.	Monthly for 6 months, then every 6 months	Visual inspection

