MOTT MACDONALD

Loch na Cathrach Knocknagael Substation Extension

Drainage Strategy Report

August 2024

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SSEN Transmission

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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:

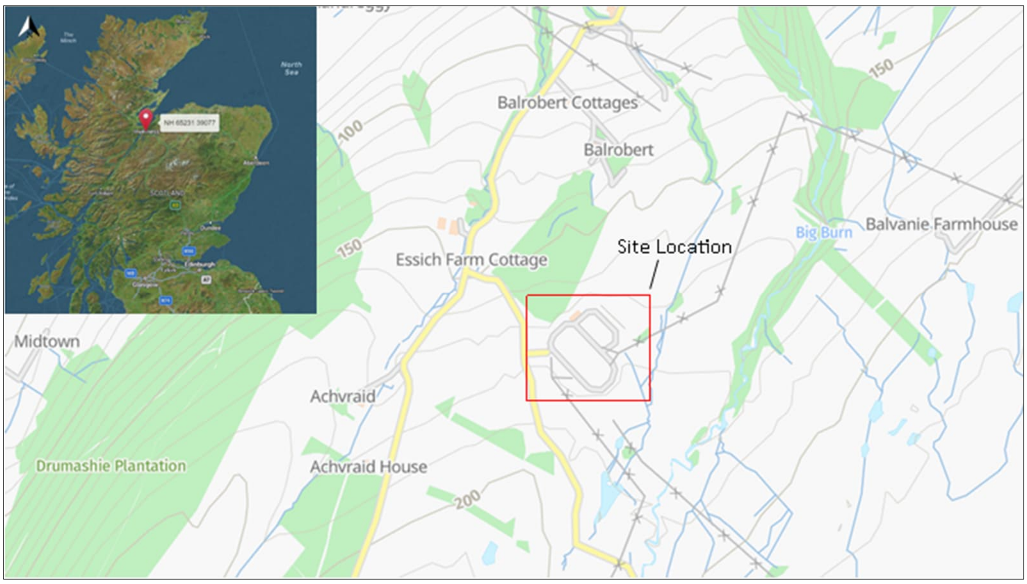
1. Knocknagael Extension Works Geotechnical and Geo-environmental Desk Study, Mott MacDonald, November 2022
2. SP-NET-CIV-501 Earthworks, Specification, SSEN, July 2023.
3. SP-NET-CIV-502 Drainage Specification, SSEN, July 2020.
4. SP-NET-CIV-503 Pavements and Roadways Specification, SSEN, July 2019.
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.

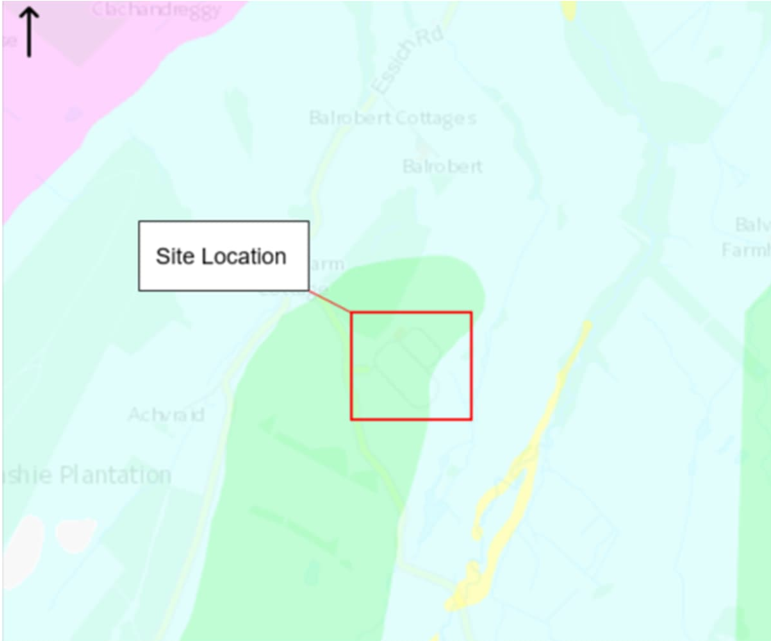
Figure 2.1: Exploratory hole locations by BAM

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



Hummocky (moundy) Glacial Deposits - Diamicton, sand and gravel.
Till, Devensian - Diamicton

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 (185mm^2 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.”

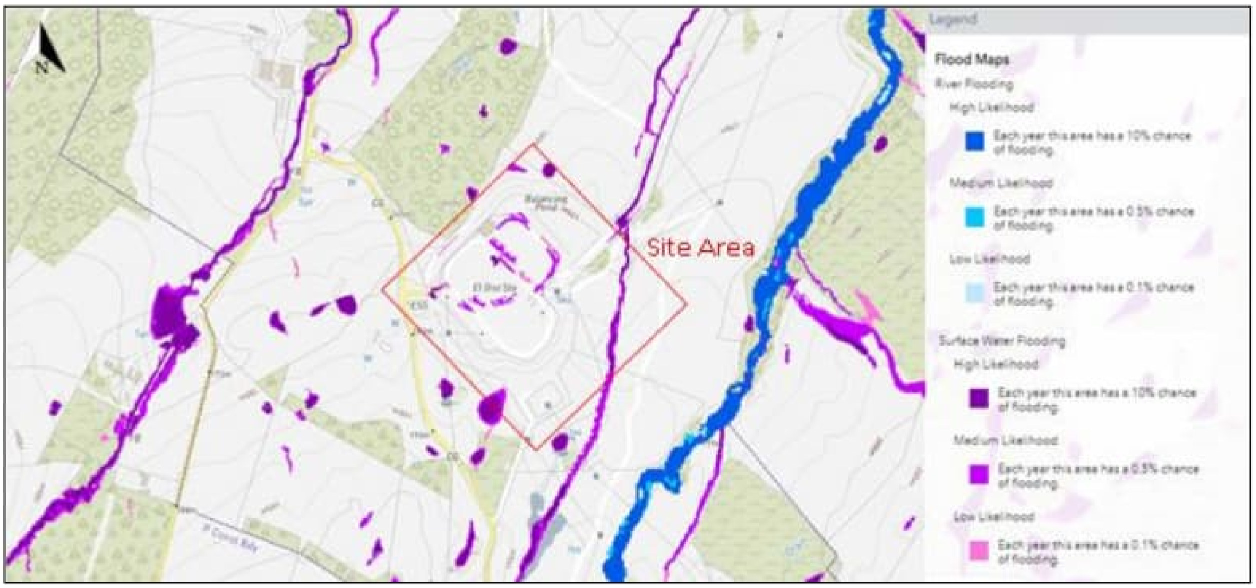
Historical maps, and SEPA records of the site show the presence of surface water bodies within close vicinity of the site. Their presence is subject to seasonal changes. These water features drain into a pond approximately 250m south-east of the site.

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	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. 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
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	For the south-eastern section of extension bay: 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 : • The extension bay shall provide storage of approx. 350m^3. 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:

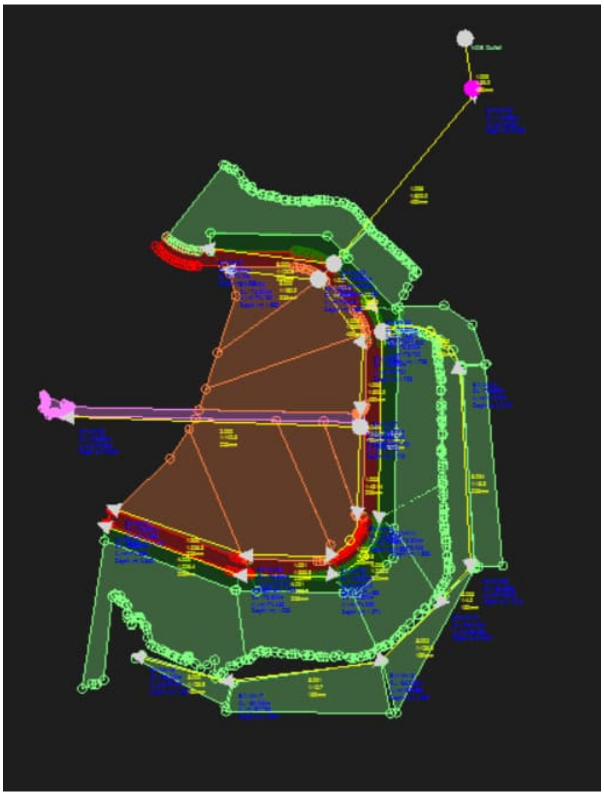
- Permeable platform.
- Internal access surfaced road and gravel road.
- New fill embankments.
- Existing overland flows from the adjacent sites.

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. <u>Proposed land drains within the new platform extension bay – South-eastern platform:</u>

   Filter drains within the permeable platform to assume permeability into the 6F2 capping material of the platform to a conservative value of 1x10-6m/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. <u>Proposed land drains used on the temporary gravel roads:</u>

   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/second[3]. 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 (Qbar) 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 +171.820mAOD, 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 proposeed 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. 350m^3 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 (m^3)
Extension Bay	1.62	0.393	4.9	5.1	5.2	• Basin: 350m^3 • Network of filter drains: 170 m^3

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:

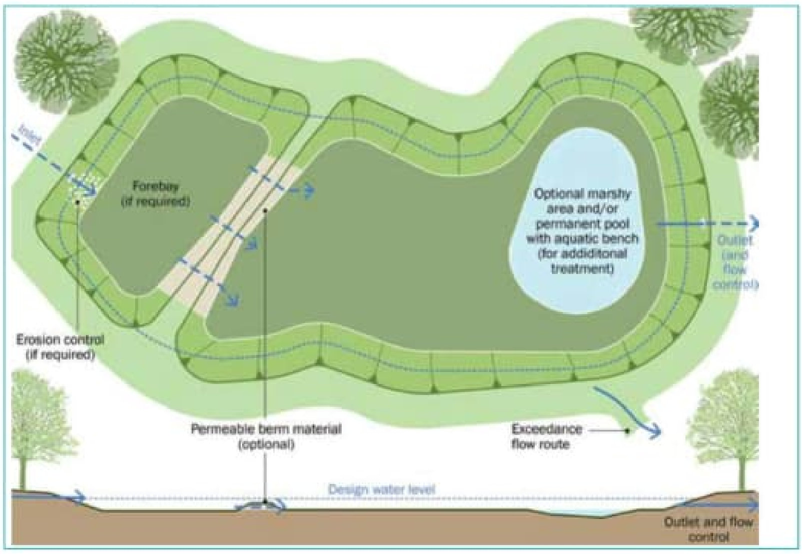
- Groundwater level for the area of the site.
- Level difference required to achieve a fall to allow discharge from the basin to the outfall.
- Spatial constraints of the site. These areas require a deeper basin to reduce the overall plan area.

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 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: 1x10-6m/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

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Ethan Hunt
Site name:	Knocknagael South
Site location:	Inverness

Site Details

Latitude:	57.42078° N
Longitude:	4.24316° W
Reference:	1955416962
Date:	Sep 21 2022 09:04

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 2.9

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	2	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.3	0.47

Hydrological characteristics	Default	Edited
SAAR (mm):	828	828
Hydrological region:	1	1
Growth curve factor 1 year:	0.85	0.85
Growth curve factor 30 years:	1.95	1.95
Growth curve factor 100 years:	2.48	2.48
Growth curve factor 200 years:	2.84	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 ≤ 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):	6.43	17.04
1 in 1 year (l/s):	5.47	14.48
1 in 30 years (l/s):	12.54	33.23
1 in 100 year (l/s):	15.95	42.26
1 in 200 years (l/s):	18.27	48.4

B. Simple Index Method (pollution prevention)

SIMPLE INDEX APPROACH: TOOL

1. 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).

2. The supporting 'Design Conditions' stated by the tool must be fully considered and implemented in all cases.

3. Relevant design examples are included in the SuDS Manual Appendix C.

4. Each of the steps below are part of the process set out in the flowchart on Sheet 3.

5. 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	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**	**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	Pollution Mitigation Indices: Total Suspended	Metals	Hydrocarbons	DESIGN CONDITIONS 1	2	3
Select SuDS Component 1 (i.e. the upstream SuDS component) from the drop down list: →	Detention basin	0.5	0.5	0.6	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		
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	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		
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	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 component(s) that trap(s) silt, 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	
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 these rows:							
	Aggregated Surface Water Pollution Mitigation Index	**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).

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

		Pollution Mitigation Indices: Total Suspended Solids	Metals	Hydrocarbons	DESIGN CONDITIONS 1	2	3	4
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**				

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: Total Suspended	Metals	Hydrocarbons
Combined Pollution Mitigation Indices for the Runoff Area	**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.

Sufficiency of Pollution Mitigation Indices: Total Suspended	Metals	Hydrocarbons	DESIGN CONDITIONS 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

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

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)	Pipe Out Diameter (mm)	PN	Pipes In Invert Level (m)	Pipes In 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	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
SWMH01	265315.564	838945.705	265315.564	838945.705	Required	
SWMH02	265360.151	838929.883	265360.151	838929.883	Required	
SWMH03	265387.850	838929.310	265387.850	838929.310	Required	
SWMH04	265397.520	838943.585	265397.520	838943.585	Required	
SWMH05	265300.290	838976.083	265300.290	838976.083	Required	

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., L*W (mm)
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., L*W (mm)
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

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

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 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	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

Trench Soakaway Manhole: SWMH09, DS/PN: 3.000

Invert Level (m)	174.150	Slope (1:X)	289.0
Trench Width (m)	1.0	Cap Volume Depth (m)	1.350
Trench Length (m)	30.0	Cap Infiltration Depth (m)	1.350

Trench Soakaway Manhole: SWMH11, DS/PN: 4.000

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	48.0
Safety Factor	2.0	Slope (1:X)	225.0
Porosity	0.30	Cap Volume Depth (m)	0.750
Invert Level (m)	174.679	Cap Infiltration Depth (m)	0.750

Trench Soakaway Manhole: SWMH12, DS/PN: 4.001

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	30.0
Safety Factor	2.0	Slope (1:X)	225.0
Porosity	0.30	Cap Volume Depth (m)	0.750
Invert Level (m)	174.464	Cap Infiltration Depth (m)	0.750

Trench Soakaway Manhole: SWMH13, DS/PN: 4.002

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)	225.0
Porosity	0.30	Cap Volume Depth (m)	0.750
Invert Level (m)	174.330	Cap Infiltration Depth (m)	0.750

Trench Soakaway Manhole: SWMH14, DS/PN: 4.003

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	62.0
Safety Factor	2.0	Slope (1:X)	225.0
Porosity	0.30	Cap Volume Depth (m)	0.750
Invert Level (m)	173.209	Cap Infiltration Depth (m)	0.750

Trench Soakaway Manhole: SWMH16, DS/PN: 5.000

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	1.0
Infiltration Coefficient Side (m/hr)	0.00360	Trench Length (m)	30.0
Safety Factor	2.0	Slope (1:X)	128.0
Porosity	0.30	Cap Volume Depth (m)	1.350
Invert Level (m)	187.970	Cap Infiltration Depth (m)	1.350

Trench Soakaway Manhole: SWMH17, DS/PN: 5.001

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)	187.730	Cap Infiltration Depth (m)	1.350

Trench Soakaway Manhole: SWMH18, DS/PN: 5.002

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 Volume (m³)	Total 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

2 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

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	SWMH01	30 minute 2 year Winter I+37%	175.500	174.414	-0.196	0.000	0.04		1.2	OK
1.001	SWMH02	480 minute 2 year Winter I+37%	175.500	174.130	-0.195	0.000	0.04		1.0	OK
1.002	SWMH03	30 minute 2 year Winter I+37%	175.500	174.072	-0.170	0.000	0.11		2.1	OK
1.003	SWMH04	30 minute 2 year Winter I+37%	175.500	174.042	-0.158	0.000	0.19		3.9	OK
2.000	SWMH05	15 minute 2 year Summer I+37%	175.500	174.675	-0.225	0.000	0.00		0.0	OK
1.004	SWMH06	30 minute 2 year Winter I+37%	175.500	173.941	-0.194	0.000	0.22		9.9	OK
1.005	SWMH07	30 minute 2 year Winter I+37%	175.500	173.928	-0.196	0.000	0.26		9.8	OK
1.006	SWMH08	30 minute 2 year Winter I+37%	175.500	173.862	-0.218	0.000	0.17		12.1	OK
3.000	SWMH09	30 minute 2 year Winter I+37%	175.500	174.198	-0.102	0.000	0.22		3.7	OK
1.007	SWMH10	30 minute 2 year Winter I+37%	175.500	173.745	-0.170	0.000	0.39		15.7	OK
4.000	SWMH11	30 minute 2 year Winter I+37%	175.500	174.714	-0.161	0.000	0.18		5.2	OK
4.001	SWMH12	30 minute 2 year Winter I+37%	175.500	174.510	-0.150	0.000	0.24		7.0	OK
4.002	SWMH13	30 minute 2 year Winter I+37%	175.500	174.299	-0.227	0.000	0.14		8.1	OK
4.003	SWMH14	120 minute 2 year Winter I+37%	175.500	174.166	-0.239	0.000	0.09		6.1	OK
5.000	SWMH16	30 minute 2 year Winter I+37%	189.320	187.983	-0.137	0.000	0.02		0.3	OK
5.001	SWMH17	30 minute 2 year Winter I+37%	189.260	187.734	-0.146	0.000	0.01		0.3	OK
5.002	SWMH18	15 minute 2 year Winter I+37%	185.030	183.717	-0.113	0.000	0.13		1.8	OK
5.003	SWMH19	15 minute 2 year Winter I+37%	184.410	183.478	-0.132	0.000	0.04		2.6	OK
5.004	SWMH20	15 minute 2 year Winter I+37%	180.400	179.412	-0.198	0.000	0.03		3.8	OK
5.005	SWMH21	720 minute 2 year Winter I+37%	175.560	175.141	-0.217	0.000	0.01		0.5	OK
4.004	SWMH22	120 minute 2 year Winter I+37%	175.500	173.779	-0.273	0.000	0.10		6.2	OK
4.005	SWMH23	120 minute 2 year Winter I+37%	175.500	173.751	-0.276	0.000	0.10		6.6	OK
6.000	SWMH24	30 minute 2 year Winter I+37%	175.500	174.281	-0.194	0.000	0.05		1.9	OK
1.008	SWMH25	30 minute 2 year Winter I+37%	175.500	173.660	-0.230	0.000	0.25		17.7	OK
1.009	SWHW27	240 minute 2 year Winter I+37%	174.300	173.551	-0.192	0.000	0.02		4.9	OK

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

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
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

200 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 Coeffecient 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

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	SWMH01	30 minute 200 year Winter I+37%	175.500	174.442	-0.168	0.000	0.14		4.2	OK
1.001	SWMH02	60 minute 200 year Winter I+37%	175.500	174.241	-0.084	0.000	0.54		12.6	OK
1.002	SWMH03	60 minute 200 year Winter I+37%	175.500	174.210	-0.032	0.000	0.87		16.4	OK
1.003	SWMH04	60 minute 200 year Winter I+37%	175.500	174.178	-0.022	0.000	1.00		20.2	OK
2.000	SWMH05	15 minute 200 year Summer I+37%	175.500	174.675	-0.225	0.000	0.00		0.0	OK
1.004	SWMH06	15 minute 200 year Winter I+37%	175.500	174.134	-0.001	0.000	0.94		42.2	OK
1.005	SWMH07	15 minute 200 year Winter I+37%	175.500	174.117	-0.007	0.000	1.00		37.1	OK
1.006	SWMH08	60 minute 200 year Winter I+37%	175.500	174.065	-0.015	0.000	0.49		35.3	OK
3.000	SWMH09	30 minute 200 year Winter I+37%	175.500	174.250	-0.050	0.000	0.78		13.1	OK
1.007	SWMH10	60 minute 200 year Winter I+37%	175.500	174.020	0.106	0.000	1.16		46.2	SURCHARGED
4.000	SWMH11	30 minute 200 year Winter I+37%	175.500	174.781	-0.094	0.000	0.63		18.6	OK
4.001	SWMH12	30 minute 200 year Winter I+37%	175.500	174.590	-0.070	0.000	0.81		23.4	OK
4.002	SWMH13	30 minute 200 year Winter I+37%	175.500	174.368	-0.158	0.000	0.45		27.1	OK
4.003	SWMH14	30 minute 200 year Winter I+37%	175.500	174.275	-0.130	0.000	0.58		40.8	OK
5.000	SWMH16	30 minute 200 year Winter I+37%	189.320	187.995	-0.125	0.000	0.07		0.9	OK
5.001	SWMH17	30 minute 200 year Winter I+37%	189.260	187.745	-0.135	0.000	0.02		0.9	OK
5.002	SWMH18	15 minute 200 year Winter I+37%	185.030	183.762	-0.068	0.000	0.56		7.4	OK
5.003	SWMH19	15 minute 200 year Winter I+37%	184.410	183.499	-0.111	0.000	0.15		10.9	OK
5.004	SWMH20	15 minute 200 year Winter I+37%	180.400	179.443	-0.167	0.000	0.14		16.4	OK
5.005	SWMH21	60 minute 200 year Winter I+37%	175.560	175.191	-0.167	0.000	0.14		9.9	OK
4.004	SWMH22	30 minute 200 year Winter I+37%	175.500	174.038	-0.014	0.000	0.71		42.1	OK
4.005	SWMH23	30 minute 200 year Winter I+37%	175.500	174.021	-0.007	0.000	0.61		42.1	OK
6.000	SWMH24	30 minute 200 year Winter I+37%	175.500	174.312	-0.163	0.000	0.17		6.8	OK
1.008	SWMH25	30 minute 200 year Winter I+37%	175.500	173.988	0.098	0.000	1.31		92.4	SURCHARGED
1.009	SWHW27	360 minute 200 year Winter I+37%	174.300	173.929	0.186	0.000	0.03		5.1	SURCHARGED

1000 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

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	SWMH01	30 minute 1000 year Winter I+0%	175.500	174.442	-0.168	0.000	0.15		4.3	OK
1.001	SWMH02	60 minute 1000 year Winter I+0%	175.500	174.246	-0.079	0.000	0.54		12.7	OK
1.002	SWMH03	60 minute 1000 year Winter I+0%	175.500	174.217	-0.025	0.000	0.88		16.7	OK
1.003	SWMH04	60 minute 1000 year Winter I+0%	175.500	174.184	-0.016	0.000	1.00		20.2	OK
2.000	SWMH05	15 minute 1000 year Summer I+0%	175.500	174.675	-0.225	0.000	0.00		0.0	OK
1.004	SWMH06	30 minute 1000 year Summer I+0%	175.500	174.139	0.004	0.000	0.92		41.4	SURCHARGED
1.005	SWMH07	30 minute 1000 year Summer I+0%	175.500	174.122	-0.001	0.000	1.00		37.1	OK
1.006	SWMH08	60 minute 1000 year Winter I+0%	175.500	174.072	-0.008	0.000	0.50		35.8	OK
3.000	SWMH09	30 minute 1000 year Winter I+0%	175.500	174.256	-0.044	0.000	0.78		13.2	OK
1.007	SWMH10	30 minute 1000 year Winter I+0%	175.500	174.029	0.114	0.000	1.41		56.3	SURCHARGED
4.000	SWMH11	30 minute 1000 year Winter I+0%	175.500	174.783	-0.092	0.000	0.65		18.9	OK
4.001	SWMH12	30 minute 1000 year Winter I+0%	175.500	174.592	-0.068	0.000	0.83		23.9	OK
4.002	SWMH13	30 minute 1000 year Winter I+0%	175.500	174.370	-0.157	0.000	0.46		27.6	OK
4.003	SWMH14	30 minute 1000 year Winter I+0%	175.500	174.277	-0.128	0.000	0.59		41.7	OK
5.000	SWMH16	30 minute 1000 year Winter I+0%	189.320	187.996	-0.124	0.000	0.07		0.9	OK
5.001	SWMH17	30 minute 1000 year Winter I+0%	189.260	187.745	-0.135	0.000	0.02		0.9	OK
5.002	SWMH18	15 minute 1000 year Winter I+0%	185.030	183.763	-0.067	0.000	0.56		7.4	OK
5.003	SWMH19	15 minute 1000 year Winter I+0%	184.410	183.499	-0.111	0.000	0.15		11.0	OK
5.004	SWMH20	15 minute 1000 year Winter I+0%	180.400	179.443	-0.167	0.000	0.15		16.5	OK
5.005	SWMH21	60 minute 1000 year Winter I+0%	175.560	175.192	-0.167	0.000	0.15		10.0	OK
4.004	SWMH22	30 minute 1000 year Winter I+0%	175.500	174.048	-0.004	0.000	0.73		43.3	OK
4.005	SWMH23	30 minute 1000 year Winter I+0%	175.500	174.031	0.003	0.000	0.63		43.2	SURCHARGED
6.000	SWMH24	30 minute 1000 year Winter I+0%	175.500	174.313	-0.162	0.000	0.17		6.9	OK
1.008	SWMH25	30 minute 1000 year Winter I+0%	175.500	173.997	0.107	0.000	1.34		94.0	SURCHARGED
1.009	SWHW27	240 minute 1000 year Winter I+0%	174.300	173.897	0.153	0.000	0.03		5.1	SURCHARGED

D. Soakaway Tests at Basin Location

Soil Infiltration Rate (Soakaway) Test

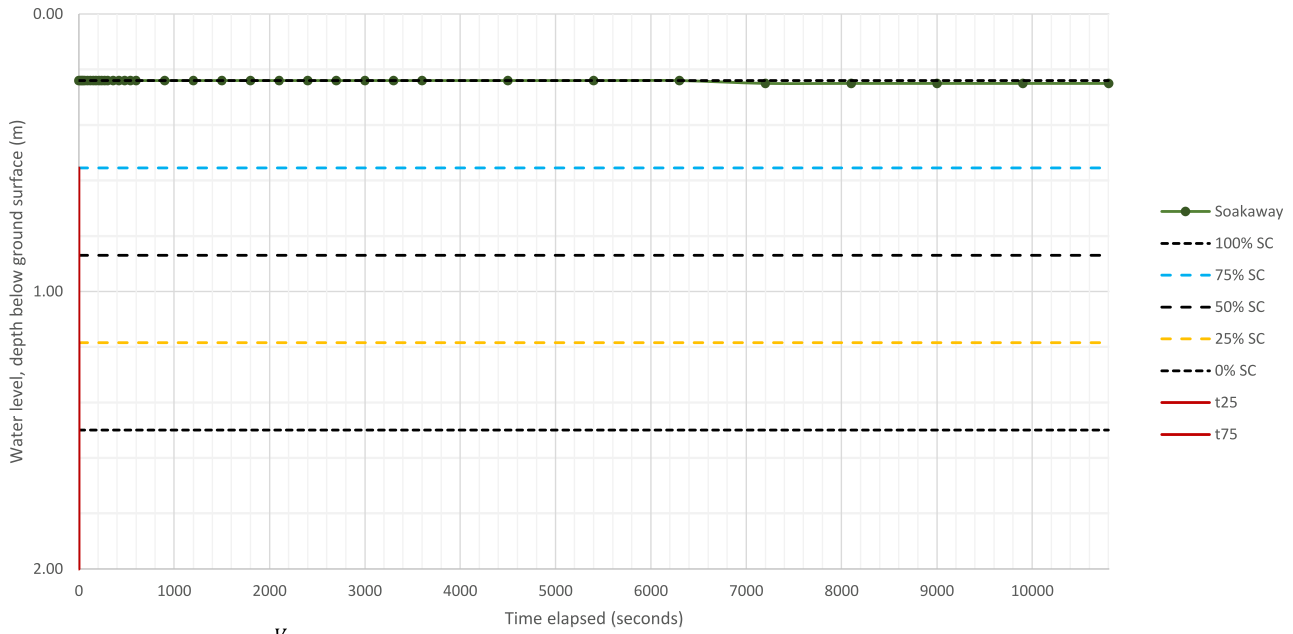
Soil Infiltration Test carried out in accordance with BRE Digest 365:2016.

Borehole number: **MMTP11**

Project name:	Red John	Survey grid system:	OSGB	Hole type:	TP
Project number:	331K	Co-ordinates:	265425.81 mE	Checked by:	JD
Client:	SSEN-T		839059.44 mN	Approved by:	
Operative:	Scott Campbell	Ground level:	178.03 mOD		
Start of test:	16/04/2024 09:20:00				
End of test:	45398.51389	Test reference:	1	Weather:	Overcast

Test type:	Soil Infiltration Test		Shape of test section:	Trial Pit (Cuboid)		Groundwater before:	Dry
Response zone top:	0.10	m bgl	Test section dimensions:	0.70m x 1.50m		Water added:	1000 l
Reponse zone base:	1.50	m bgl				Water level start of test:	0.24 m bgl
Test section diameter:	0	mm	Type of filter used:	None		Water level end of test:	0.25 m bgl
			(Assumed porosity)	100	%	Hole depth after test:	1.50 m bgl

Time, t (seconds)	Water Depth (m)	Time, t (seconds)	Water Depth (m)	Time, t (seconds)	Water Depth (m)
0	0.24	600	0.24	9900	0.25
15	0.24	900	0.24	10800	0.25
30	0.24	1200	0.24		
45	0.24	1500	0.24		
60	0.24	1800	0.24		
90	0.24	2100	0.24		
120	0.24	2400	0.24		
150	0.24	2700	0.24		
180	0.24	3000	0.24		
210	0.24	3300	0.24		
240	0.24	3600	0.24		
270	0.24	4500	0.24		
300	0.24	5400	0.24		
360	0.24	6300	0.24		
420	0.24	7200	0.25		
480	0.24	8100	0.25		
540	0.24	9000	0.25		



$$Soil\ infiltration\ rate, f = \frac{V_{p\ 75-25}}{a_{s\ 50} \times t_{p\ 75-25}}$$

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:

Soil Infiltration Rate (Soakaway) Test

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

Borehole number: **MMTP12**

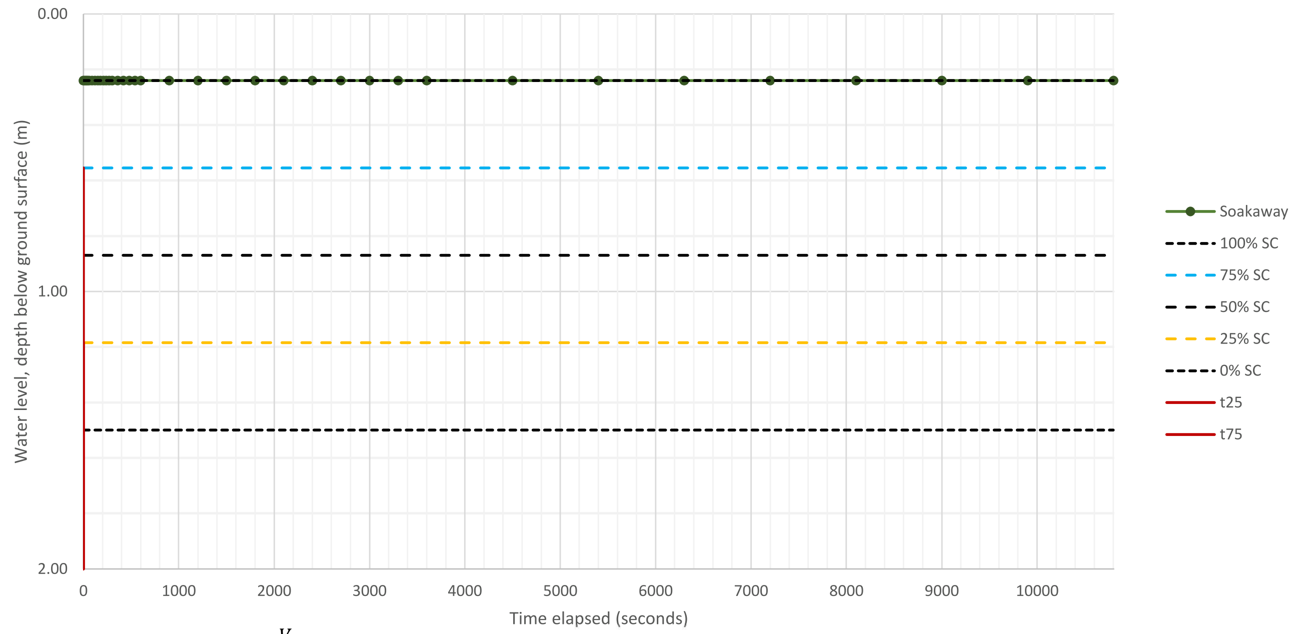
Project name:	Red John	Survey grid system:	OSGB	Hole type:	TP
Project number:	331K	Co-ordinates:	265473.46 mE	Checked by:	JD
Client:	SSEN-T		839104.98 mN	Approved by:	
Operative:	Scott Campbell	Ground level:	175.90 mOD		
Start of test:	16/04/2024 08:30:00				
End of test:	45398.47917	Test reference:	1	Weather:	Overcast

Test type:	Soil Infiltration Test		Shape of test section:	Trial Pit (Cuboid)		Groundwater before:	Dry
Response zone top:	0.00	m bgl	Test section dimensions:	0.30m x 1.50m		Water added:	850 l
Reponse zone base:	1.50	m bgl				Water level start of test:	0.24 m bgl
Test section diameter:	0	mm	Type of filter used:	None		Water level end of test:	0.24 m bgl
			(Assumed porosity)	100	%	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	0.24
8100	0.24
9000	0.24

Time, t (seconds)	Water Depth (m)
9900	0.24
10800	0.24



$$Soil\ infiltration\ rate, f = \frac{V_{p\ 75-25}}{a_{s\ 50} \times t_{p\ 75-25}}$$

Where

$V_{p\ 75-25}$	*Effective storage volume of water in borehole between 75% and 25% effective storage capacity (SC) depth.*	0.2835 m^3
$a_{s\ 50}$	*Internal surface area of borehole up to 50% effective storage capacity (SC) depth, including the base area*	2.7180 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:

Test completed in material below topsoil.

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 Manual[4] 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

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