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Appendix A13.3: SuDS and Water Quality

1 Introduction

Scope

1.1 This appendix provides the following additional information on the operational Sustainable Drainage Systems (from herein referred to as SuDS) associated with the proposed scheme:

- description of existing drainage conditions;
- A9/A96 Inshes to Smithton SuDS design principles, and project specific departures from these principles;
- proposed SuDS components and management trains, and justification for their adoption;
- proposed SuDS outfall locations and discharge rates, and justification for their adoption;
- indicative SuDS maintenance requirements;
- proposed attenuation and restricted discharge rates; and
- water quality assessments in accordance with the Design Manual for Roads and Bridges (DMRB) HD45/09 (Highways Agency, Scottish Government, Welsh Assembly Government and The Department for Regional Development Northern Ireland 2009) and SEPA Regulatory Method (WAT-RM-08) Sustainable Urban Drainage Systems (SUDS or SUD Systems) (SEPA 2019).

1.2 Temporary SuDS measures to be adopted during the construction of the proposed scheme are discussed within Appendix A4.1 (Construction Information).

Background

1.3 The primary purpose of SuDS is to provide a drainage solution which mimics the way that the natural hydrological cycle manages precipitation from interception, attenuation and transportation prior to eventual discharge into the ground or to a surface watercourse. SuDS are a legal requirement for discharges from road schemes under the Water Environment Water Services (Scotland) Act 2003 (WEWS Act) and the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR), so are therefore integral to the design of the proposed scheme.

1.4 The four overarching pillars of SuDS design, of which any proposed SuDS scheme should aim to provide benefits to, are:

- water quality;
- water quantity;
- biodiversity; and
- amenity.

1.5 This appendix specifically considers the water quality and water quantity aspects embedded within the proposed SuDS design. Further information on SuDS in relation to water quantity and flood risk is provided in Appendix A13.1 (Flood Risk Assessment).

2 Existing Conditions

Site Description

2.1 The study area for the proposed scheme is characterised by gently sloping agricultural land, with drainage generally occurring to the north towards the Inner Moray Firth estuary. The study area mainly consists of agricultural land surrounded by urban settlements, commercial properties, A9 and A96 trunk roads and local access roads. The study area is within The Highland Council's Inverness East Development Brief (The Highland Council 2018) area and therefore is subject to future urbanisation.

2.2 All watercourses within the study area are direct or indirect tributaries of the Inner Moray Firth estuary. The proposed scheme is located exclusively in the catchments of the Scretan Burn (SWF04) and Cairnlaw Burn (SWF08), with urban land uses influencing hydrology and water quality in the lower reaches of these catchments.

2.3 The bedrock geology within the catchment of the proposed scheme is dominated by sedimentary sandstone (Hillhead Sandstone Formation). Superficial deposits are predominately glacial till within the upper reaches of the study area and progressively become more characterised by raised tidal flat and beach sedimentary deposits in the lower reaches. Ground Investigation (GI) data, including groundwater monitoring, indicates that groundwater levels are typically near the surface (<5m below ground level) across the study area.

2.4 Further information on the hydrology and hydrogeology of the study area is provided within Appendix A13.2 (Surface Water Hydrology) and Chapter 12 (Geology, Soils, Contaminated Land and Groundwater), respectively.

Existing Drainage

2.5 The proposed scheme is predominantly located on greenfield land and therefore existing drainage is limited to open field drains associated with agricultural land uses.

2.6 The drainage on the existing trunk roads (A9 Perth – Inverness and A96 Aberdeen – Inverness (hereafter referred to as the A96, which incorporates the A96 Inverness to Nairn (including Nairn Bypass) scheme proposals) and local access roads (e.g., B9006 Culloden Road) surrounding the proposed scheme consist mainly of kerb and gully arrangements with some limited areas of filter drains adjacent to parts of the A9 and A96.

3 Proposed Scheme

3.1 The mainline carriageway and associated side roads of the proposed scheme would incorporate eight drainage catchments and outfalls (labelled A to H). Due to the nature of the drainage proposals and assessment methods adopted, both mainline and side road drainage catchments are discussed collectively.

3.2 The SuDS management trains and outfall locations for the proposed scheme are detailed in Table 1. The locations of the proposed mainline SuDS components and drainage catchments are shown on Figure 13.4.

SuDS Design Standards

3.3 The following specific SuDS design standards, relevant to water quality and water quantity aspects, have been adopted for the proposed scheme:

- SuDS will not be developed within the 0.5% Annual Exceedance Probability (AEP) (200-year) plus 20% allowance for climate change (herein referred to as '0.5% AEP (200-year) plus CC event') floodplain extent.
- Two levels of conventional SuDS treatment will be provided for all drainage catchments.
- SuDS will attenuate the surface runoff generated from the overall development footprint from all storm events up to the 0.5% AEP (200-year) plus CC event, with controlled outflow at the greenfield discharge rate of QMED. QMED is defined as the Median Annual Maximum Flood, further detail on the derivation of QMED is provided in Appendix A13.2 (Surface Water Hydrology).

Proposed SuDS

3.4 The SuDS management trains for all drainage of the proposed scheme, outfall locations and estimated traffic flows (measured in Average Annual Daily Traffic (AADT) vehicles per day (vpd)) are provided within Table 1 below. Justification for specific SuDS management trains are presented in Section 3.5.

Table 1: Proposed Scheme SuDS

Drainage Catchment ID	Location	Coordinates of Outfall Location		Receiving Water Feature	Estimated Traffic Flows (AADT vpd)	Proposed Management Train (MT)
		Easting	Northing			
A	Link 4: Eastfield Way Roundabout to Smithton Junction	270736	846591	SWF08 (Cairnlaw Burn)	13,136	Swale and Retention Pond
B	Link 4: Eastfield Way Roundabout to Smithton Junction	270267	845950	SWF08 (Cairnlaw Burn)	13,136	Swale and Wetland
C	Link 4: Eastfield Way Roundabout to Smithton Junction	270155	845232	SWF08 (Cairnlaw Burn)	12,824	Swale and Wetland
D	Link 2: Cradlehall Roundabout to Eastfield Way Roundabout	269743	844944	SWF04 (Scretan Burn)	20,970	Swale and Filter Drain (Enhanced Swale)
E	Link 1: Culloden Road to Cradlehall Roundabout	269716	844806	SWF04 (Scretan Burn)	20,970	Wetland and Filter Drain
F	Link 3: Eastfield Way Roundabout to Inverness Retail and Business Park	269503	845388	SWF03 (Beechwood Burn)	6,186	Swale and Wetland
G	Link 5: Cradlehall Roundabout to Inverness Campus	269082	844773	SWF03 (Beechwood Burn)	5,150	Swale and Filter Drain (Enhanced Swale)
H	A9 southbound lane gain/lane drop	268698	845800	Inner Moray Firth Estuary	20,606	Filter Drain and Swale

Justification for Proposed SuDS

3.5 In Scotland, it is a legal requirement to provide SuDS (refer to paragraph 1.3) to treat and attenuate runoff from new developments. The location, design and type of SuDS has been informed by best practice guidance (CIRIA 2015) and local authority planning guidance (The Highland Council 2013).

3.6 In addition, SEPA stated in their response dated 25 July 2018 (PCS/160003) to the A9/A96 Inshes to Smithton DMRB Stage 3 Scoping Report (Jacobs 2018) that they would expect to see a minimum of two levels of surface water treatment (refer to Appendix A6.1: Summary of Consultation Responses). Additional levels of treatment have not been considered unless indicated as a requirement from the water quality assessments.

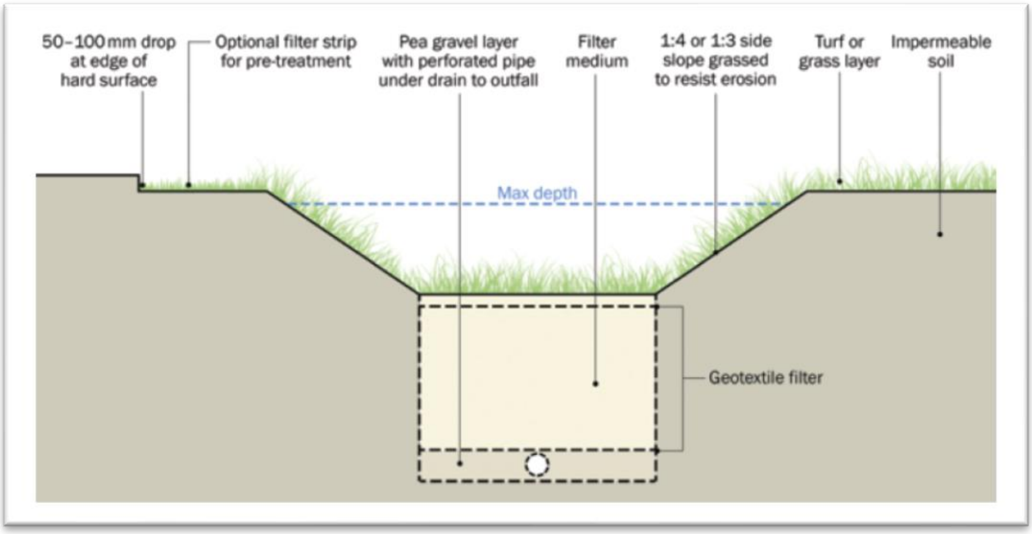
Specific SuDS Components

<u>Swales and Enhanced Swales</u>

3.7 Swales are shallow, flat bottomed, vegetated channels designed to convey runoff and provide attenuation and treatment (see Diagram 1 for schematic of a typical swale). Berms or check dams can be installed perpendicular to the flow path to allow runoff to a temporarily pond, thus increasing pollutant retention and infiltration, as well as further reducing flow velocity.

3.8 Enhanced swales which incorporate an underlying filter drain have been adopted on several constrained catchments. The design of these features has been undertaken in accordance with good practice guidance (SCOTS 2010) so that they provide two levels of treatment. The first level of treatment is provided by the grassed channel, e.g. infiltration, sediment settling and nutrient uptake. The second level is provided by the underlying filter drain at the base of the swale which facilitates the removal of pollutants through sediment filtering and adsorption of heavy metals onto filter material.

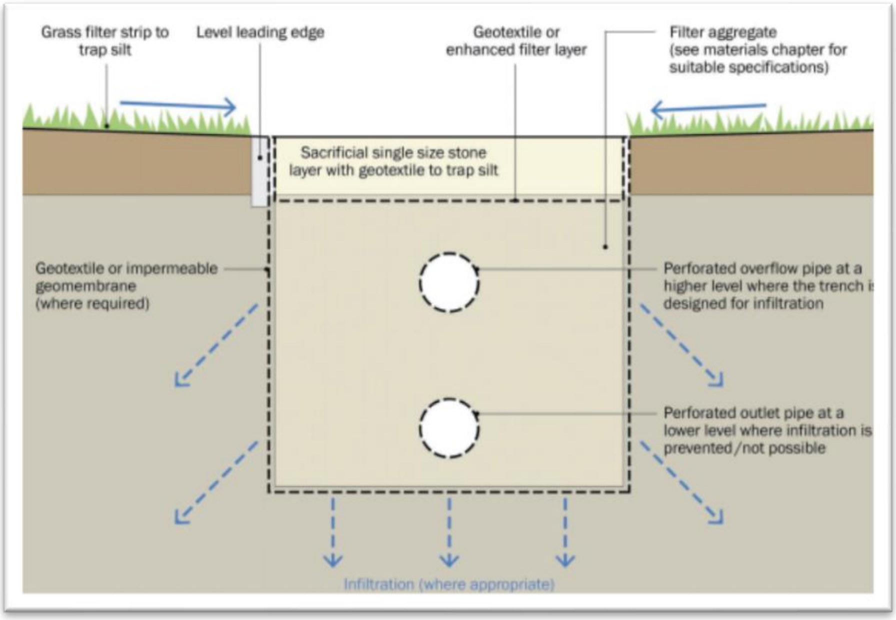
Diagram 1: Typical Schematic of a Dry Swale (CIRIA 2015)



<u>Filter Drains</u>

3.9 Filter drains are trenches filled with a permeable material or media designed to filter, temporarily detain and then convey runoff (see Diagram 2 for a schematic of a filter drain). At the base of the trench there is a perforated pipe, which conveys runoff downstream. Typically filter drains are positioned alongside carriageways but can be designed to be incorporated in the bottom of swales. An assessment of the suitability of the ground conditions to facilitate infiltration will be assessed during the Specimen design phase.

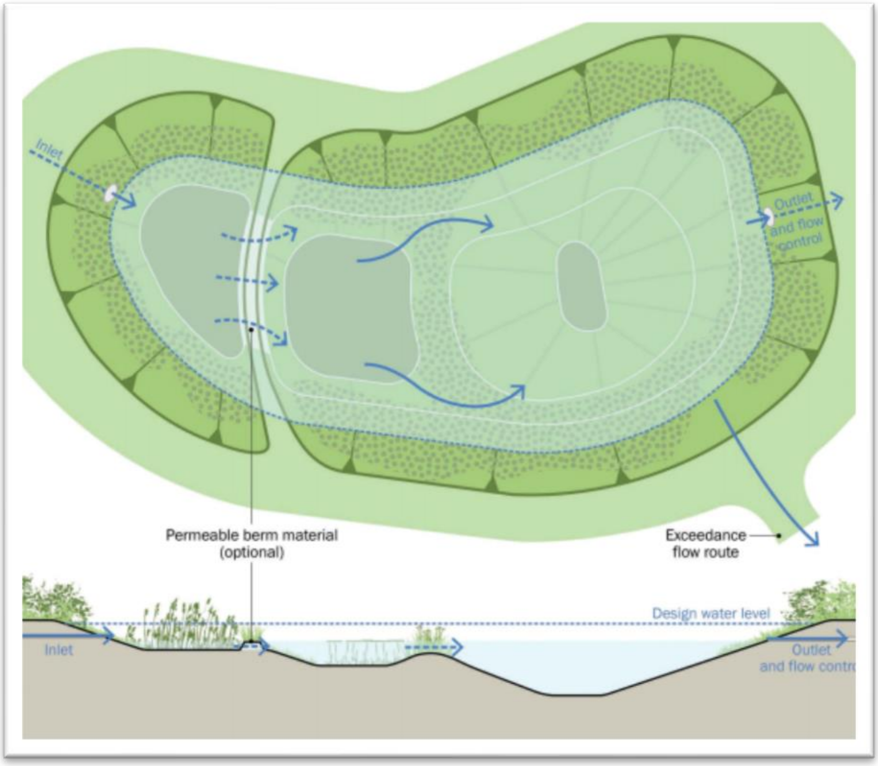
Diagram 2: Typical Schematic of a Filter Drain (CIRIA 2015)



Wetlands

3.10 Wetlands are basin features that include a permanent volume of water and are designed to temporarily detain and treat runoff (see Diagram 3 for a schematic of a typical wetland). They are largely similar to retention ponds, but a larger area is apportioned to aquatic vegetation, with shallow zones that promote the growth of bottom rooted plants, a more varied depth profile and optional inclusion of islands (CIRIA 2015). This increased biological and morphological diversity can increase pollutant removal efficiency compared to retention ponds.

Diagram 3: Typical Schematic of a Wetland (CIRIA 2015)



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Indicative SuDS Maintenance

3.11 An indicative SuDS maintenance regime, as taken from the SuDS Manual (CIRIA 2015) for each proposed SuDS component, is detailed in Table 2 below.

Table 2: Indicative SuDS Maintenance Schedule

Maintenance Schedule	Required Action	Typical / Recommended Frequency
Swales/Enhanced Swales		
Regular Maintenance	Remove litter and debris	Monthly or as required
	Cut grass to retain height in line with specified design range	Monthly during growing season or as required
	Manage other vegetation and remove nuisance plants	Monthly (at start) then as required
	Inspect inlets, outlets and overflows for blockages and clear as necessary	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation and record areas where ponding for >48 hours	Monthly or as required
	Inspect inlets and surface for silt accumulation and establish appropriate silt removal frequency	Every 6 months
Occasional Maintenance	Reseed areas with poor vegetation growth and alter plant composition to better suit conditions if needed	As required if exposed bare soil is >10% of swale treatment area
	In high pollution load areas, remove and replace surface geotextile and wash or replace filter media in underlying filter drain	Every 5 years or as required
Remedial Actions	Repair erosion or other damage by re-turfing or reseeding	As required
	Re-level uneven surfaces and reinstate design levels	As required
	Remove build-up of sediment on upstream gravel trench, flow separator or at top of filter strip	As required
	Remove oils or petrol residues	As required
Filter Drains		
Regular Maintenance	Remove litter and debris from drain surface, access chambers and pre-treatment devices	Monthly or as required
	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly
	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation	Every 6 months
	Remove sediment from pre-treatment devices	Every 6 months or as required
Occasional Maintenance	In high pollution load areas, remove and replace surface geotextile and wash or replace overlying filter media	Every 5 years or as required
Remedial Actions	Clear perforated pipework of blockages	As required
Wetland		
Regular Maintenance	Remove litter and debris	Monthly or as required
	Inspect marginal and bankside vegetation and remove nuisance plants	Monthly at start then as required; nuisance plants should be removed for first 3 years
	Inspect feature including inlet, outlet and pipework for evidence of blockage or physical damage	Monthly
	Inspect water body for signs of poor water quality	Monthly (May to October)
	Inspect silt accumulation rates and establish removal frequencies	Every 6 months
	Check any mechanical devices	Every 6 months

Maintenance Schedule	Required Action	Typical / Recommended Frequency
	Management of submerged, emergent and bank vegetation	Annually
	Remove sediment from any forebay	Every 1 to 5 years or as required
	Remove sediment and planting from one quadrat of the main body of ponds without sediment forebays	Every 5 years or as required
Occasional Maintenance	Remove sediment from main body of big ponds when pool volume is reduced by 20%	Approximately every 25 to 50 years' subject to pre-treatment effectiveness
Remedial Actions	Repair erosion or other damage, replant where necessary	As required
	Aerate pond if signs of eutrophication are present	As required
	Realign rip-rap or repair other damage	As required

Attenuation and Restricted Discharge Rates

3.12 The drainage strategy for surface water (quantity) is to ensure that the post development flows within the receiving watercourses do not increase with respect to the pre-development conditions for all return period events up to the 0.5% AEP (200-year) plus CC event.

3.13 This has generally been achieved by attenuating the surface runoff generated from the overall development footprint from all storms up to the 0.5% AEP (200-year) plus CC event, with controlled outflow at the greenfield discharge rate of QMED (50% AEP (2-year) event).

3.14 On the A9 southbound lane gain/lane drop where SuDS are being retrofitted into the existing drainage network, attenuation has been provided up to the 3.33% AEP (30-year) plus CC event, with controlled outflow set at a rate to ensure no increase in downstream surface water flood risk. Existing impermeable areas to inform the existing QMED runoff rates were estimated using as-built drainage drawings.

3.15 Drainage design software (MicroDrainage) has been used to estimate the required size for SuDS attenuation components (swales and wetlands). The models have simulated the required rainfall event based on the contributing permeable and impermeable surface areas and subsequent flow mechanisms within the pipe network. Where achievable, a freeboard of 300mm has been adopted for the SuDS attenuation components.

3.16 Greenfield and existing runoff rates have been estimated using the methods outlined in the guidance document 'Preliminary Rainfall Runoff Management for Developments' (Environmental Agency 2012). Table 3 below provides the:

- proposed impermeable surface areas within each drainage catchment;
- greenfield runoff rates (QMED) for each drainage catchment (excluding any existing impermeable areas);
- proposed restricted discharge rates and standards; and
- proposed attenuation volumes and the subsequent rainfall return period attenuated.

Table 3: Pre- and Post-development Discharge Rates and Attenuation

Drainage Catchment	Receiving Watercourse	Proposed Impermeable Area (Ha)	Proposed Permeable Area (Ha)	Existing Runoff Rates (QMED) (l/s)	Proposed Discharge Rate (l/s)	Rainfall Return Period Event Attenuated
A	SWF08	1.688	0.892	10.3	10.3	0.5% AEP (200-year) plus CC event
B	SWF08	1.179	0.253	5.7	5.7	0.5% AEP (200-year) plus CC event
C	SWF08	0.962	0.221	5.3	5.3	0.5% AEP (200-year) plus CC event
D	SWF04	0.305	0.219	2.6	5.0	0.5% AEP (200-year) plus CC event

Drainage Catchment	Receiving Watercourse	Proposed Impermeable Area (Ha)	Proposed Permeable Area (Ha)	Existing Runoff Rates (QMED) (l/s)	Proposed Discharge Rate (l/s)	Rainfall Return Period Event Attenuated
E	SWF04	1.290	0.195	7.3	7.3	0.5% AEP (200-year) plus CC event
F	SWF03	0.871	0.040	4.1	5.0	0.5% AEP (200-year) plus CC event
G	SWF03	0.290	0.072	1.5	5.0	0.5% AEP (200-year) plus CC event
H	Inner Moray Firth estuary	1.593	0.394	373.6*	311.3**	3.33% AEP (30-year plus CC event)

*Drainage catchment H (associated with widening of existing southbound carriageway of A9 between the Raigmore Interchange and the Inshes Overbridge) is the only catchment with an existing runoff rate as all other drainage catchments are greenfield.

**Drainage catchment H is proposed to discharge at a lower rate than existing.

4 Water Quality Assessment

Methodology

4.1 Water quality assessments for the proposed mainline carriageway have been undertaken in accordance with DMRB HD45/09 (Highways Agency et al. 2009) using the Highways England (formally Highways Agency) Water Risk Assessment Tool (HAWRAT). The assessments undertaken include Method A, which assesses the impacts on receiving watercourses from routine runoff, and Method D, which assess the risk from the accidental spillage of pollutants.

4.2 HAWRAT is designed to be used for assessing the impacts of road runoff where Annual Average Daily Traffic (AADT) volumes are >10,000 vehicles. For the proposed scheme, where side roads have AADT volumes of <10,000, the suitability of SuDS have been assessed using the Simple Index Approach, in-line with SEPA's Regulatory Guidance (WAT-RM-08) Sustainable Urban Drainage Systems (SUDS or SUD Systems) (SEPA 2019) and as detailed within CIRIA (2015).

4.3 Neither HAWRAT nor Simple Index Approach are considered appropriate for catchment H, which largely involves the retrofitting of SuDS into a developed catchment, and where the discharge will ultimately outfall to an estuary via the existing drainage network.

4.4 Water quality assessment methodologies adopted for each individual drainage catchment for the proposed scheme are provided in Table 4.

Table 4: Water Quality Assessment Methodologies for each Drainage Catchment

Drainage Catchment	Receiving Water Body	Water Quality Assessment Methodology	Justification for Methodology
A	SWF08 (Cairnlaw Burn)	HAWRAT Method A and D	Estimated AADT >10,000
B	SWF08 (Cairnlaw Burn)	HAWRAT Method A and D	Estimated AADT >10,000
C	SWF08 (Cairnlaw Burn)	HAWRAT Method A and D	Estimated AADT >10,000
D	SWF04 (Scretan Burn)	HAWRAT Method A and D	Estimated AADT >10,000
E	SWF04 (Scretan Burn)	HAWRAT Method A and D	Estimated AADT >10,000
F	SWF03 (Beechwood Burn)	Simple Index Approach	AADT <10,000 so HAWRAT not applicable
G	SWF03 (Beechwood Burn)	Simple Index Approach	AADT <10,000 so HAWRAT not applicable
H	Inner Moray Firth estuary	None other than the qualitative assessment reported within Chapter 13.	Retrofitting of SuDS in a constrained location with discharge to an estuary.

HAWRAT Method A: Routine Runoff Assessment

4.5 The HAWRAT assessment uses statistically based models for predicting the quality of road runoff in terms of specific soluble and sediment-bound pollutants. The models use traffic density, climatic region and event rainfall characteristics to predict runoff quality in terms of Event Mean Concentrations (EMCs) and Event Mean Sediment Concentrations (EMSCs).

4.6 The tool then predicts the impact of the road runoff on receiving watercourses. For soluble pollutants, the assessment comprises a simple mass balance calculation accounting for river flows and hence dilution of pollutants. For sediment-bound pollutants, the model considers both the likelihood and extent of sediment accumulation.

4.7 Dissolved copper (Cu) and dissolved zinc (Zn) are used as indicators of the level of impact from soluble pollutants, as they are known to result in acute toxic effects to aquatic ecology at certain threshold concentrations. The assessment results detail whether the SuDS discharge would ‘pass’ or ‘fail’ in terms of the frequency that pollutant thresholds are exceeded. For sensitive sites (defined as outfalls with 1km of a protected site, e.g. a Special Area of Conservation (SAC)), the toxicity thresholds may only be exceeded once per year in any given 24-hour period (reported as ‘RST24’) or 0.5 times per year in any given 6-hour period (reported as ‘RST6’). For non-sensitive sites (i.e. >1km from a protected site), the toxicity threshold exceedances for RST24 and RST6 increase to twice per year and once per year respectively. The proposed scheme has both sensitive and non-sensitive sites which means applicable thresholds vary between certain locations.

4.8 HAWRAT also estimates in-river annual average concentrations for dissolved Cu and dissolved Zn that can be compared to adopted Environmental Quality Standards (EQS) as detailed in The Scotland River Basin District (Standards) Directions 2014 (Scottish Government 2014) which are 1µg/l and 10.9µg/l for dissolved copper (bioavailable) and dissolved zinc (bioavailable) respectively.

4.9 Chronic impacts associated with sediment-bound pollutants are also identified by assessing concentrations of total copper, zinc, cadmium, pyrene, fluoranthene, anthracene, phenanthrene and total Polycyclic Aromatic Hydrocarbons (PAH). These concentrations are similarly assessed against ecological-based thresholds to determine the toxicity risk. The assessment determines whether polluted sediment will accumulate on the river bed or disperse in the river downstream (based on the stream velocity under low flow conditions). If accumulation occurs, it is then determined whether the resulting deposition is high or low in extent.

4.10 A ‘pass’ or ‘fail’ result is also given, however an ‘alert’ is given for outfalls that would otherwise pass the assessment for sediment-bound pollutants, were it not for the following features being present downstream:

- a protected site within 1km of the point of discharge; and
- a structure, lake or pond within 100m of the point of discharge.

4.11 The efficiency of the proposed SuDS components in treating pollutants (treatment efficiencies) has been obtained using data provided in Table 26.13 of the SuDS Manual (CIRIA 2015) and Table 8.1 of DMRB Volume 4, Section 2, Part 3, HD 33/16: Design of Highway Drainage Systems (Highways England, Transport Scotland, Welsh Government and Department for Infrastructure 2016). Further details of the treatment efficiencies used in both single and cumulative assessments are provided in Annex 1: SuDS Management Train Treatment Efficiencies.

4.12 The HAWRAT routine runoff assessment uses a three-step approach to assess the impacts of both soluble and sediment-bound pollutants. The three-step approach is as follows:

- Step 1: estimates pollutant concentrations in the undiluted road runoff;
- Step 2: estimates pollutant concentrations after dilution within the receiving watercourse; and
- Step 3: estimates pollutant concentrations after mitigation (i.e. the treatment provided by the proposed SuDS) and dilution within the receiving watercourse.

4.13 Only Step 2 and Step 3 results are presented within this appendix. These results subsequently translate into the pre-mitigation (Step 2) and post-mitigation (Step 3) impacts reported within Chapter 13 (Road Drainage and Water Environment).

4.14 A cumulative assessment has been undertaken which has also considered drainage catchments D and E associated with the proposed A96 Dualling Inverness to Nairn (including Nairn Bypass) scheme, which both discharge into the Cairnlaw Burn (SWF08) downstream of the proposed scheme.

4.15 The input data and associated sources used within the routine runoff assessments are presented in Table 5 (collated data for all parameters presented in Annex 2: Water Quality Assessment Input Data, specific to each drainage catchment). The methodology used to calculate treatment efficiencies for each drainage catchment is detailed within Annex 1: SuDS Management Train Treatment Efficiencies.

Table 5: Method A - Standard Input Data and Data Sources

Parameter	Value Used	Notes / Data Sources
Annual Average Daily Traffic (AADT)	>10,000 and <50,000	Design year 2037 Source: Moray Firth Transport Model (MFTM) (refer to Chapter 2: Need for the Scheme).
Climatic Region	Colder Wet	Source: HAWRAT Help v1.0
Rainfall Site	Ardtalnaig (SAAR 1343.9mm)	Source: HAWRAT Help v1.0
Hardness	Low = <50mg $CaCO_3$/l	Scottish Water's hardness calculations using the average results for 2017 for calcium and magnesium from regulation zones
95%ile River Flow (m^3/s)	Specific to each outfall location	Source: Low Flow Enterprise (LFE) data purchase (see Appendix A13.2: Surface Water Hydrology for further details)
Baseflow Index (BFI)	Specific to each outfall location	Source: FEH CD - ROM (2009)
Impermeable and permeable area draining to outfall (ha)	Specific to each drainage catchment	Source: Scheme information
Receiving watercourse dimensions (estimated river width at Q95, bed width, side slope and long slope)	Specific to each outfall location	Source: Site survey and desk study using LiDAR data
Receiving watercourse Manning's n	Specific to each outfall location	Source: Site survey and with reference to Chow (1959)
Proposed treatment of solubles and sediments (%)	Specific to each drainage catchment	Sources: SuDS Manual (C753) (CIRIA 2015) Table 26.13 – Performance of SuDS components in reducing urban runoff contamination and DMRB HD33/16 (Highways England et al, 2016) Table 8.1 – Indicative Treatment Efficiencies of Drainage Systems
Proposed attenuation – restricted discharge rate (l/s) to Q_{BAR}	Specific to each drainage catchment	Source: FEH Statistical Method (see Appendix A13.2: Surface Water Hydrology for further details)

<u>HAWRAT Method D: Spillage Risk Assessment</u>

4.16 Method D of DMRB HD45/09 (Highways Agency et al. 2009) has been designed to calculate spillage risk during the operation of the proposed scheme and the associated probability of a serious pollution incident. The risk is calculated assuming that an accident involving spillage of pollutants onto the carriageway would occur at an assumed frequency (expressed as annual probabilities) based on calculated traffic volumes; the percentage of that traffic volume that is considered a Heavy Goods Vehicle (HGV); and the type of road/junction within each drainage catchment.

4.17 The probability that a spillage will cause a pollution incident is calculated as:

$P_{INC} = P_{SPL} \times P_{POL}$; where:

- P_{SPL} = probability of a serious accidental spillage in one year over a given road length, which is calculated using the road length, risk factors associated with the specific road type, and AADT and % HGV in the design year. The design year is defined as 15 years after the road is due to open, for the proposed scheme the opening year is 2022, therefore the traffic model predicts traffic values for year 2037; and

- P_{POL} = the risk reduction factor, dependent upon emergency services response times, which determines the probability of a serious spillage leading to a serious pollution incident of surface waters (factor of 0.45 is applied for the proposed scheme as it is classed as being in an 'Urban' environment with a response time of <20minutes).

4.18 In line with DMRB HD45/09 (Highways Agency et al. 2009), where spillage risk is calculated as less than the 0.5% AEP (200-year), the spillage risk falls within acceptable limits even when road runoff discharges within close proximity (i.e. within 1km) to a designated conservation site (i.e. the Inner Moray Firth Special Protection Area (SPA)).

Simple Index Approach for Side Roads

4.19 The Simple Index Approach has been used to determine the suitability of the SuDS proposed for road drainage catchment areas with AADT volumes of <10,000 vpd (i.e. predominately side roads off a main trunk road drainage in-line with SEPA's Regulatory Guidance (WAT-RM-08) Sustainable Urban Drainage Systems (SUDS or SUD Systems) (SEPA 2019). The Simple Index Approach, as detailed within 'The SuDS Manual' (CIRIA 2015), was developed from a study by Ellis et al. (2012) and comprises two key components:

- pollution Hazard Indices (PHI) of between 0 and 1, based on the pollutant levels likely for different land-use types, where higher values indicate higher pollutant levels; and
- pollution Mitigation Indices (PMI) of between 0 and 1, based on the ability of SuDS components or groundwater protection measures to treat pollutants, where higher values indicate higher treatment efficiency.

4.20 PHI and PMI values are given for three broad pollutant categories: Total suspended solids (TSS), Metals, and Hydrocarbons. Where PHI is assessed to be less than PMI, mitigation or proposed SuDS is considered sufficient to treat runoff from the pollution source.

4.21 A number of road drainage catchment areas associated with the proposed scheme (drainage catchments F and G) have calculated AADT volumes of <10,000 vpd. The Simple Index Approach was therefore applicable and the land use type 'Roads (excluding low traffic roads, highly frequented lorry approaches to industrial estates, trunk roads/motorways)' was considered most appropriate to represent these catchments and hence was adopted within the assessment.

Limitations of Assessments

4.22 The following key limitations to the water quality assessments undertaken are detailed below. Despite these limitations, the results of the assessments are considered to be valid, and justification is provided below where appropriate:

- The research data that has informed the HAWRAT tool is derived from studies of motorways and trunk roads in England, which is noted as causing some differences when applied in Scotland. For example, on the A96 Inverness to Nairn (including Nairn bypass) scheme (Jacobs 2016), the accidental spillage risk assessment results have been observed to be far below the acceptable limits stated in DMRB HD45/09 (Highways Agency et al. 2009) even without mitigation. This is likely due to the comparatively low traffic and HGV volumes experienced on trunk roads in many parts of Scotland. Therefore, the risk factors used in the determination of spillage risk as derived from roads with higher traffic volumes may provide results that are more conservative when applied to roads with lower traffic volumes. However, the results are considered to remain valid and in keeping with the 'precautionary principle'.
- The HAWRAT tool contains a fixed number of rainfall sites categorised by generalised climatic conditions (e.g. Cold and Dry, Warm and Wet, Cold and Wet, etc.). The user can select a rainfall site which best matches the climatic conditions at their specific site and this tends to be the rainfall station which is geographically closest to the specific study area. For this project, the rainfall data is taken from the nearest rainfall station (Ardtalnaig) for which data is available. This station is approximately 155km south from the proposed scheme, therefore there may be some differences in the rainfall

events that occur within the study area. During a sensitivity analysis it was found that in almost all instances, the use of sites with a lower average annual (AA) rainfall resulted in reduced Average Annual Environmental Quality Standard (AA-EQS) concentrations and the same or improved results in terms of passing or failing dissolved Copper (Cu), dissolved Zine (Zn) and sediment impacts. Therefore, in line with the precautionary principle, it is considered that the adoption of the Ardtalnaig rainfall site is appropriate for use in routine run-off assessments and results generated demonstrating the suitability of proposed levels of SuDS treatment are valid.

- The quoted SuDS treatment efficiencies taken from CIRIA (2015) and Highways England et al. (2016) are derived from limited studies, and do not account for the length or size of certain SuDS components. However, this is currently the best data available to be used in the assessment.
- Existing water quality within receiving watercourses is not directly taken into consideration in the HAWRAT routine runoff model, though it is considered within the impact assessment in Chapter 13 (Road Drainage and Water Environment).
- All SuDS features are currently proposed to be lined to prevent infiltration therefore groundwater risk (quantitative) assessments related to SuDS features have not been undertaken (please also refer to Mitigation Item G-12 in Chapter 12: Geology, Soils, Contaminated Land and Groundwater). During further refinements of the design, if infiltration is to be permitted a risk assessment may be undertaken.

Results

4.23 The results from the HAWRAT Method A and D, are provided in Table 6. The results of cumulative assessments using HAWRAT Method A and D are provided in Table 7.

<u>HAWRAT Method A: Routine Runoff Assessment</u>

4.24 The results from the single outfall assessments (Table 6) include:

- A 'Fail' related to exceedance of the RST24 thresholds for soluble zinc (Zn) for drainage catchments A, B and C pre-mitigation (Step 2);
- An 'Alert' for sediment-bound pollutants, for drainage catchment A pre and post mitigation (Step 2 and 3) due to the presence of a protected site (i.e. Inner Moray Firth SPA) <1km downstream; and
- A 'Pass' for all aspects of the HAWRAT assessment (RST24, RST6, EQSs for Copper (Cu) and Zinc (Zn) and sediment-bound pollutants) and all drainage catchments post mitigation (Step 3).

4.25 The results from the cumulative outfall assessments (please refer to Table 7 for further details where reference is made to 'cumulative drainage catchments') include:

- A 'Fail' related to exceedance of the RST24 thresholds for soluble copper (Cu) pre-mitigation (Step 2) on cumulative drainage catchments discharging to Carinlaw Burn (SWF08);
- A 'Fail' related to exceedance of the RST24 thresholds for soluble zinc pre-mitigation (Step 2) on cumulative drainage catchments discharging to Cairnlaw Burn (SWF08) and Scretan Burn (SWF04);
- A 'Fail' related to exceedance of the RST6 thresholds for soluble zinc pre-mitigation (Step 2) on cumulative drainage catchments discharging to Cairnlaw Burn (SWF08);
- A 'Fail' against AA-EQS for soluble copper pre-mitigation (Step 2) on cumulative drainage catchments B and C discharging to Cairnlaw Burn (SWF08);
- An 'Alert' for sediment-bound pollutants, for cumulative drainage catchments of A9/A96 (A and B) and A96 (D and E) for pre and post mitigation (Step 2 and 3) due to the presence of a protected site (e.g. Inner Moray Firth SPA) <1km downstream; and
- A 'Pass' for all aspects of the HAWRAT assessment, for all cumulative drainage catchments including the proposed A96 Inverness to Nairn (including Nairn Bypass) scheme, post-mitigation (Step 3).

HAWRAT Method D: Spillage Risk Assessment

4.26 The annual probability of a serious pollution incident occurring within each highway catchment draining to an individual outfall has been estimated to be below the 0.5% AEP (200-year) event guidance quoted in DMRB HD45/09 (Highways Agency et al. 2009) for sensitive areas. For the results presented in Table 6, the green coloured boxes indicate a ‘Pass’ and red coloured boxes indicate ‘Fail’ for specific and respective parameters. The amber coloured boxes indicate an ‘Alert’ indicating a pass, but the outfall is discharging within 1km of a protected site. Likewise, the summed annual probability of a serious pollution incident occurring across all the cumulative drainage catchments, including the relevant A96 catchments, is observed to be below the 0.5% AEP (200-year) event threshold. For the A9/A96 cumulative catchments the return periods (years) for spillage risk were as follows: A and B = 11,839, B and C = 9,597 and D and E = 11,484. The return period (years) calculated for cumulative catchments for both the proposed scheme and the A96 Inverness to Nairn (including Nairn Bypass) scheme in combination was 4,005.

Table 6: Mainline Water Quality Assessment Results

Drainage Catchment	Receiving Watercourse	HAWRAT Routine Runoff Assessment (Method A)											HAWRAT Spillage Risk Assessment (Method D)	
		Soluble Cu		Soluble Zn		AA-EQS Compliance (Cu)	AA-EQS Compliance (Zn)	Sediment-bound Pollutants	Velocity	DI	Settlement needed (%)	Tier 1 or Tier 2 Assessment	Return Period (Years)	Acceptable Limits, i.e. <200 years?
		RST24	RST6	RST24	RST6									
Pre- Mitigation (Step 2)														
A	SWF08	0.40	0.00	1.60	0.20	0.45	1.39	Alert	0.25	-	-	Tier 2	26,343	**Yes**
B	SWF08	1.40	0.20	2.50	0.60	0.75	2.30	Pass	0.17	-	-	Tier 2	21,503	**Yes**
C	SWF08	1.20	0.10	2.40	0.60	0.72	2.20	Pass	0.15	-	-	Tier 2	17,334	**Yes**
D	SWF04	0.00	0.00	0.30	0.00	0.17	0.53	Pass	0.17	-	-	Tier 2	251,898	**Yes**
E	SWF04	1.00	0.00	1.80	0.30	0.58	1.77	Pass	0.20	-	-	Tier 2	12,032	**Yes**
F	SWF03	Method A not applicable as AADT <10,000 vpd therefore Simple Index Approach used (see Table 8)											77,450	**Yes**
G	SWF03	Method A not applicable as AADT <10,000 vpd therefore Simple Index Approach used (see Table 8)											25,531	**Yes**
H	Inner Moray Firth estuary	Method A not applicable as discharge is into an estuary / coastal environment. Simple Index Approach not applicable for trunk road.											12,619	**Yes**
Post-Mitigation (Step 3)														
A	SWF08	0.00	0.00	0.10	0.00	0.26	0.66	Alert		-	-	Tier 2		
B	SWF08	0.00	0.00	0.20	0.00	0.33	0.89	Pass		-	-	Tier 2		
C	SWF08	0.00	0.00	0.20	0.00	0.31	0.85	Pass		-	-	Tier 2		
D	SWF04	0.00	0.00	0.00	0.00	0.08	0.21	Pass		-	-	Tier 2		
E	SWF04	0.20	0.00	0.10	0.00	0.41	0.70	Pass		-	-	Tier 2		

Table 7: Cumulative Mainline Water Quality Assessment Results

Cumulative Catchments	Receiving Watercourse	HAWRAT Routine Runoff Assessment (Cumulative Assessments)						
		Soluble Cu		Soluble Zn		AA-EQS (Cu)	AA-EQS (Zn)	Sediment-bound Pollutants
		RST24	RST6	RST24	RST6			
Pre-Mitigation (Step 2)								
A and B	SWF 08	1.10	0.00	2.20	0.60	0.68	2.10	n/a
B and C	SWF 08	3.40	0.40	3.80	1.60	1.13	3.49	n/a
D and E (A9/A96)	SWF 04	1.2.0	0.10	2.30	0.60	0.67	2.06	n/a
A and B (A9/A96) and D and E (A9 Inverness to Nairn (including Nairn Bypass) scheme)	SWF08	2.00	0.30	2.90	0.90	0.89	2.74	Alert
Post-Mitigation (Step 3)								
A and B	SWF 08	0.10	0.00	0.30	0.00	0.36	0.94	n/a
B and C	SWF 08	0.30	0.00	0.30	0.00	0.49	1.35	n/a
D and E (A9/A96)	SWF 04	0.20	0.00	0.20	0.00	0.44	0.81	n/a
A and B (A9/A96) and D and E (A96 Inverness to Nairn (including Nairn Bypass scheme))	SWF08	0.30	0.00	0.30	0.00	0.50	1.26	Alert

Simple Index Approach for road drainage catchments <10,000 vpd

4.27 The results from the Simple Index Approach for side road drainage are presented in Table 8 below. The results indicate that implementing a Swale to Wetland SuDS treatment train in catchment F, and Enhanced Swale (Swale to Filter Drain) in drainage catchment G, will be sufficient for treating road runoff from these catchments.

Table 8: Side Road Water Quality Assessment Results

Parameter	Category	TSS	Metals	Hydrocarbons
PHI	Roads (excluding low traffic roads, highly frequented lorry approaches to industrial estates, trunk roads/motorways)	0.7	0.6	0.7
Drainage catchment F: Proposed SuDS management train – Swale to Wetland				
PMI SuDs	Swale	0.5	0.6	0.6
PMI SuDs	Wetland	0.7	0.7	0.5
Combined Pollution Mitigation Indices for Runoff Area		0.85	0.95	0.85
Sufficiency of Pollutant Mitigation Indices (PHI≤PMI)		Sufficient	Sufficient	Sufficient
Drainage catchment G: Proposed SuDS management train – Enhanced Swale (Swale to Filter Drain)				
PMI SuDs	Swale	0.5	0.6	0.6
PMI SuDs	Filter Drain	0.4	0.4	0.4
Combined Pollution Mitigation Indices for Runoff Area		0.7	0.8	0.8
Sufficiency of Pollutant Mitigation Indices (PHI≤PMI)		Sufficient	Sufficient	Sufficient

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5 Summary

5.1 SuDS have been embedded within the design of the proposed scheme, and filter drains, swales and wetlands have been adopted in order to treat and attenuate runoff from the proposed scheme.

5.2 The SuDS design provides two levels of treatment, attenuation up to the 0.5% AEP (200-year) plus CC rainfall event and a restricted discharge rate to mimic pre-development runoff conditions (greenfield QMED). No SuDS have been located within the 0.5% AEP (200-year) plus CC flood extent.

5.3 Water quality assessments have been undertaken in line with DMRB HD45/09 (Highways Agency et al., 2009). These assessments indicate that no residual significant impacts on water quality are anticipated to occur as a result of routine runoff and accidental spillage risk associated with the proposed scheme. The water quality assessments have included a consideration of the cumulative impacts associated with the proposed A96 Inverness to Nairn (including Nairn Bypass) scheme.

5.4 A reduced standard of attenuation (3.33% AEP or 1 in 30 year) and increased restricted discharge rate has been adopted on drainage catchment H, due to the constrained nature of the catchment, and the works largely involving retrofitting SuDS into an existing drainage network which discharges directly into an estuary.

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Annex 1: SuDS Management Train Treatment Efficiencies

The treatment efficiency calculation and overall treatment efficiencies of the five different management train component combinations used across the proposed scheme, and additional management train used in catchments D and E of A96 Inverness to Nairn (including Nairn Bypass) scheme, are shown in Table A1.1. 'The SuDS Manual' (CIRIA 2015) guidance advises, if a management train contains more than one SuDS component, all treatment efficiencies following the first SuDS component should be multiplied by a factor of 0.5. The treatment performance of secondary, third (etc.) or tertiary levels of treatment is reduced due to already reduced pollutant concentrations in the inflow and this is reflected in the calculations where required. % of Pollutant Remaining = *100% x (1 – SC1) x (1 – SC2) x (1-SC3) etc., etc.*

Where:

- SC1 = Treatment efficiency of SuDS Component 1
- SC2 = 0.5 x treatment efficiency of SuDS Component 2
- SC3 = 0.5 x treatment efficiency of SuDS Component 3, etc., etc.
- Total System Treatment Efficiency (%) = 100 - % of Pollutant Remaining

Table A1.1: Management Train 1 to 6 - Summary of Pollutant Removal Efficiencies

Drainage System	Treatment Efficiencies (%)		
	Dissolved Cu	Dissolved Zn	TSS
MT1			
SC1: Swale	50*	50*	60**
SC2: Retention Pond	40*	30*	76**
Total system	*60*	*57*	*75*
MT2			
SC1: Swale	50*	50*	60**
SC2: Wetland	30*	50*	81**
Total system	*57*	*62*	*76*
MT3			
SC1: Swale	50*	50*	60**
SC2: Filter Drain	0***	45*	60*
Total system	*50*	*61*	*72*
MT4			
SC1: Wetland	30*	50*	81**
SC2: Filter Drain	0***	45*	60**
Total system	*30*	*61*	*86*
MT5 (used in Catchment H but not quantitative assessment undertaken for this catchment)			
SC1: Filter Drain	0*	45*	60**
SC2: Swale	50***	50*	60**
Total system	*50*	*58*	*72*
MT6 (A96 Inverness to Nairn (including Nairn Bypass) catchments)			
SC1: Filter Drain	0*	45*	60*
SC2: Retention Pond	40***	30*	76**
Total system	*40*	*53*	*75*

** Derived from Table 8.1 of DMRB HD33/16 (Highways England et al., 2016)*

***Derived from Table 26.13 of The SuDS Manual C753 (CIRIA, 2015)*

****Neither SC1 or SC2 provide treatment, therefore treatment efficiency of SC1/SC2 is not multiplied by 0.5.*

For cumulative assessments, where two catchments have different SuDS treatment management trains, treatment efficiencies of the SuDS proposed were calculated by weighting catchment areas. Firstly, the percentage of any individual catchment in the cumulative assessment is calculated when divided by the total catchment area for all catchments in the assessment. Each individual catchment percentage is then multiplied by the relevant treatment efficiency for each unique management train in the cumulative assessment. Finally, the individual catchment weighted treatment efficiencies are added together to produce a final treatment efficiency for the cumulative catchment. The calculated overall efficiency should always be between the values of the lowest and highest treatment efficiencies of any individual catchment.

The treatment efficiencies calculated for all cumulative assessments (both A9/A96 only and A9/A96 and A96) are presented in Table A1.2. It is noted that the proposed SuDS treatment train for the two drainage catchments from the A96 Inverness to Nairn (including Nairn bypass) scheme, associated with cumulative assessment alongside the proposed scheme, consist of Filter Drains and a Retention Pond.

Table A1.2: Cumulative Assessment - Pollutant Removal Efficiencies

Drainage System	Treatment Efficiencies (%)		
	Dissolved Cu	Dissolved Zn	TSS
A9/A96: Catchment A and B			
A: Swale to Retention Pond (MT1)	60	57	75
B: Swale to Wetland (MT2)	57	62	76
A96 inputs: Filter Drain to Retention Pond	40	53	75
Total system	*48*	*56*	*75*
A9/A96: Catchments B and C			
B: Swale to Wetland (MT2)	57	62	76
C: Swale to Wetland (MT2)	57	62	76
Total system	*57*	*62*	*76*
A9/A96: Catchments D and E			
D: Swale to Filter Drain (MT3)	50	61	72
E: Wetland to Filter Drain (MT4)	30	61	86
Total system	*35*	*61*	*82*
A9/A96 and A96 Inverness to Nairn (including Nairn Bypass): Catchment A and A96 Inverness to Nairn (including Nairn Bypass) Inputs			
A – A9/A96: Swale to Retention Pond (MT1)	60	57	75
A96 Inverness to Nairn (including Nairn Bypass) inputs: Filter Drain to Retention Pond (MT6)	40	53	75
Total system	*43*	*53*	*75*
A9/A96 and A96 Inverness to Nairn (including Nairn Bypass) - Catchments A and B and A96 Inverness to Nairn (including Nairn Bypass) Inputs			
A – A9/A96: Swale to Retention Pond (MT1)	60	57	75
B – A9/A96: Swale to Wetland (MT2)	57	62	76
A96 Inverness to Nairn (including Nairn Bypass) inputs: Filter Drain to Retention Pond (MT6)	40	53	75
A96 Inverness to Nairn (including Nairn Bypass) inputs: Filter Drain to Retention Pond (MT6)	40	53	75
Total system	*45*	*55*	*75*

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Annex 2: Water Quality Assessment Input Data

Table A2.1 and Table A2.2 summarise the input data used in HAWRAT Routine Runoff and Spillage Risk calculations. Certain parameters selected as part of the HAWRAT Routine Runoff (Method A) assessments were the same across all drainage catchments. To avoid repetition in the tables below these parameters are noted as:

- Climatic Region / Rainfall Site = Cold Wet / Ardtalnaig
- AADT = >10,000 and <50,000
- Water Hardness = Low <50mg $CaCO_3$/l

Table A2.1: HAWRAT and Spillage Risk Input Data (1)

Outfall Location	Drainage Catchment	Q95 Flow (m^3/s)	Proposed Impermeable Area (ha)	Proposed Permeable Area (ha)	BFI Index	Is the Discharge within 1km of a Protected Site?	Downstream Structure Reducing Velocity?	Estimated River Width (m)	Manning's n value	Side Slope (m/m)	Long Slope (m/m)	Proposed SuDS Treatment Train
SWF08	A	0.00589	1.688	0.892	0.626	Yes	No	1.5	0.04	0.171	0.018	Swale and Retention Pond
SWF08	B	0.00215	1.179	0.253	0.584	No	No	1	0.04	0.194	0.011	Swale and Wetland
SWF08	C	0.00186	0.962	0.221	0.566	No	No	1.3	0.04	0.147	0.014	Swale and Wetland
SWF04	D	0.00323	0.305	0.219	0.529	No	No	1	0.05	0.122	0.013	Enhanced Swale (Swale and Filter Drain)
SWF04	E	0.00320	1.29	0.195	0.529	No	No	1	0.05	0.095	0.022	Wetland and Filter Drain
SWF03	F	0.00111	0.871	0.04	0.58	No	No	1	0.06	0.200	0.006	Swale and Wetland
SWF03	G	0.00078	0.290	0.072	0.712	No	No	1	0.07	0.185	0.032	Enhanced Swale (Swale and Filter Drain)
Inner Moray Firth estuary	H	n/a	1.593	0.394	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Filter Drain to Swale

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Table A2.2: HAWRAT and Spillage Risk Input Data (2)

Drainage Catchment	Proposed SuDS Treatment Train	Proposed treatment of Cu (%)	Proposed treatment of Zn (%)	Proposed settlement of sediments (%)	Restricted Discharge Rate from SuDS Outfall (l/s)	Modelled Traffic Data (AADT)	Assessment Type Comment
A	Swale and Retention Pond and A96 treatment (Filter Drain and Retention Pond)	43	53	75	10.3	13,136	>10,000 AADT so HAWRAT needed
B	Swale and Wetland	57	62	76	5.7	13,136	>10,000 AADT so HAWRAT needed
C	Swale and Wetland	57	62	76	5.3	13,136	>10,000 AADT so HAWRAT needed
D	Enhanced Swale (Swale and Filter Drain)	50	61	72	5.0	20,970	>10,000 AADT so HAWRAT needed
E	Wetland and Filter Drain	30	61	86	7.3	20,970	>10,000 AADT so HAWRAT needed
F	Swale and Wetland	57	62	76	5.0	6,186	<10,000 AADT so Simple Index Approach and NO HAWRAT
G	Enhanced Swale (Swale and Filter Drain)	50	61	72	5.0	5,150	<10,000 AADT so Simple Index Approach and NO HAWRAT
H	Filter Drain and Swale	50	58	72	311.3	20,606	Discharging to the Inner Moray Firth so no specific method adopted
Cumulative catchment A and B	Swale and Retention Pond and A96 treatment (Filter Drain and Retention Pond) (A) and Swale and Wetland (B)	48	56	75	16.0	13,136	Outfalls >100m apart therefore HAWRAT soluble component assessment only
Cumulative catchment B and C	Swale and Wetland (B) and Swale and Wetland (C)	57	62	76	11.0	13,136	Outfalls >100m apart therefore HAWRAT soluble component assessment only
Cumulative catchment D and E	Enhanced Swale (Swale and Filter Drain) (D) and Wetland and Filter Drain (E)	35	61	82	12.3	20,970	Outfalls >100m apart therefore HAWRAT soluble component assessment only
Cumulative catchment A9/A96 and A96 schemes	Swale and Retention Pond and A96 treatment (Filter Drain and Retention Pond) (A) and Swale and Wetland (B) and Filter Drain and Retention Pond (A96).	45	55	75	21.0	35,084	Outfalls <100m apart therefore HAWRAT soluble and sediment component assessments – Tier 2 assessment