Appendix A11.6: Water Quality

1 Introduction

1.1.1 This appendix provides additional information on the assessment of the operational impacts of the proposed scheme on water quality within the receiving water environment, as reported in the Environmental Statement (ES) Chapter 11 (Road Drainage and the Water Environment).

1.1.2 An assessment of the effects of routine road runoff and accidental spillage risk to receiving water features (WFs) has been undertaken using the Highways England's (formally Highways Agency) Water Risk Assessment Tool (HAWRAT). These assessments are as outlined within DMRB Volume 11, Section 3, Part 10, HD 45/09 Road Drainage and the Water Environment (Highways Agency et al., 2009); hereafter referred to as DMRB HD 45/09.

1.1.3 The following procedures are discussed within this appendix:

- Method A – Effects of Routine Runoff on Surface Waters; and
- Method D – Pollution Impacts from Accidental Spillages.

1.1.4 In addition, a Salt Assessment on the mainline and junctions and a Simple Index Approach assessment (as detailed in 'The SuDS Manual (C753)' (CIRIA, 2015)) of Tier 3 accesses have been undertaken.

1.1.5 This appendix is set out as follows:

- an overview of the proposed SuDS features is provided in Section 2;
- the assessment methodologies are provided in Section 3;
- the inputs and results of the assessments are provided in Section 4; and
- discussion of the results is provided in Section 5.

2 Sustainable Drainage Systems (SuDS) for Water Quality

2.1.1 SuDS are a requirement under the Water Environment Water Services (Scotland) Act 2003 and the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) and have been included within the DMRB Stage 3 design. Four SuDS components are included as part of the proposed scheme: filter drains, detention basins, retention ponds and wetlands. These components are proposed in differing combinations, or 'treatment trains', dependent on the varying treatment efficiencies required or site constraints associated with each proposed outfall location.

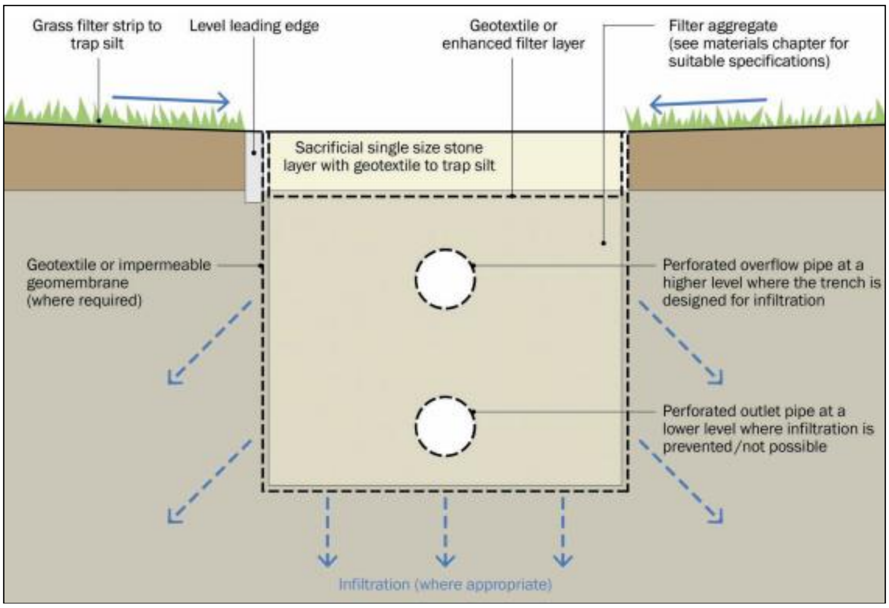
2.1.2 The treatment performances of these features, as detailed in Section 3 'Treatment Efficiency Calculations', will be dependent on their correct design and maintenance, as detailed below.

Filter Drains

2.1.3 Filter drains are trenches alongside the carriageway that are filled with a permeable material or media that is designed to filter, temporarily detain and then convey runoff. At the base of the trench there is a perforated pipe, which conveys runoff downstream. Diagram 1 shows a typical schematic of a filter drain (CIRIA, 2015). Filter drains can remove pollutants through:

- directly filtering out sediments, hydrocarbons and heavy metals;
- encouraging adsorption (adhesion of pollutants to the surface of the filter media);
- biodegradation (biological breakdown of pollutants by organisms that develop within the filter media); and
- volatilisation (conversion of pollutants to a gas (predominantly hydrocarbons)).

Diagram 1: Typical schematic of a filter drain (from CIRIA, 2015)



2.1.4 The filter drains for the proposed scheme will not generally be preceded by a grass filter strip, due to site constraints and will be designed to allow infiltration unless a requirement is identified by the Contractor during detailed design to include an impermeable liner (e.g. high water table or geotechnical constraints). The reduction in pollutant concentrations will be achieved through filtration, adsorption, biodegradation and volatilisation processes. The minimum depth of the filter media to ensure reasonable treatment is 500mm, however the minimum depth for the proposed scheme will be 900mm which will improve the treatment efficiency of the features.

2.1.5 Filter drains should not be used for drainage during the construction phase as untreated runoff is likely to contain large amounts of fine sediment, debris and other pollutants. This would cause rapid clogging and sub-optimal treatment during the operational phase.

2.1.6 The filter drains will require regular maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities. Treatment performance is detailed in Section 3: 'Treatment Efficiency Calculations' and is dependent on correct design, maintenance, and commitment to a management programme. Maintenance of filter drains includes:

- inspection of the filter drain surface, and litter and debris removal;
- inspection of inlet/outlet pipework and perforated pipework, and control systems for silt accumulation blockages, clogging, standing water and structural damage with clearance as required;
- removal of vegetation, weed control and removal or control of tree roots; and
- replacement of filter material that is clogged or has high pollutant loads typically at least once every 5 years or as required. Sediment may be considered toxic or hazardous material under the Waste (Scotland) Regulations 2012, so consideration of disposal is required.

2.1.7 Further detail on the maintenance of filter drains can be found in The SuDS Manual C753 (CIRIA, 2015).

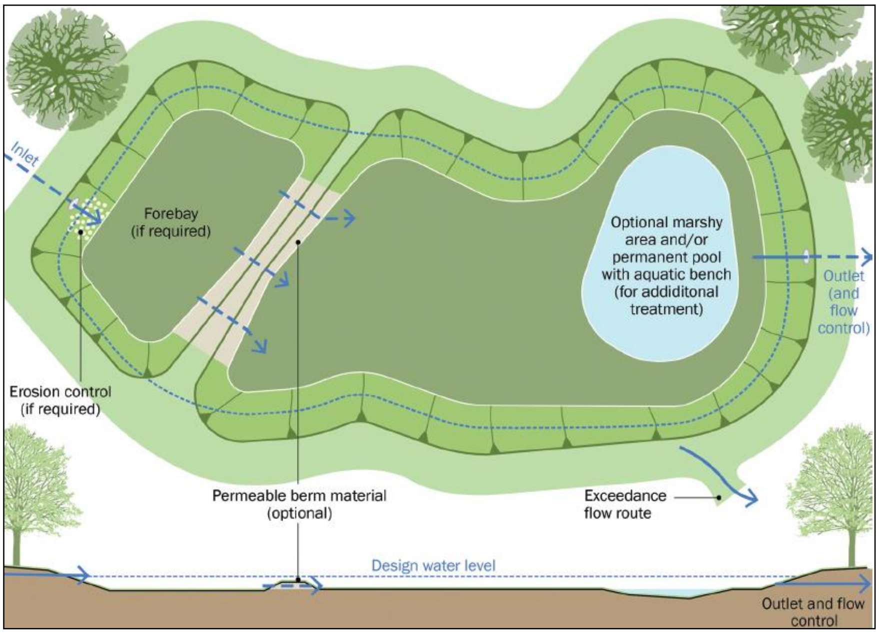
Detention Basin

2.1.8 Detention basins are depressions that are normally dry and are designed to temporarily detain and treat runoff. Diagram 3 shows a typical schematic of a detention basin (CIRIA, 2015). They only contain a volume of water during and immediately after storm events and treatment occurs via:

- settlement of suspended sediments and other pollutants;
- filtration through vegetation on the basin base;

- biodegradation (biological degradation of pollutants by organisms that develop within and around vegetation and within sediments); and
- volatilisation (conversion of pollutants to a gas (predominantly hydrocarbons)).

Diagram 3: Typical schematic of a detention basin (from CIRIA, 2015)



2.1.9 To maximise treatment efficiency, detention basins should include a forebay occupying a minimum of 10% of the total basin area, separated by a permeable berm to allow for trapping of sediment within a more manageable area and reducing the risk of remobilisation of sediment that has settled in the remainder of the basin. Providing a small ponded area prior to the outlet of the detention basin can further reduce the risk of sediment remobilisation (CIRIA, 2015).

2.1.10 Landscaping the basin to enable the distribution of inflows across its width and planting vegetation (to increase Manning's roughness coefficient) also helps to maximise treatment efficiency as this reduces flow velocity and provides a greater surface area for treatment processes to take place. Flow velocity can be further reduced by installing check dams or weirs at intervals within the basin. For a 100% Annual Exceedance Probability (AEP) (1-year) rainfall event, the recommended flow depth should be below vegetation height, velocity should be below 0.3m/s and residence time should be greater than 9 minutes (CIRIA, 2015).

2.1.11 The detention basins will require maintenance to ensure; continuing operation to design performance standards; and all designers should provide detailed specifications and frequencies for the required maintenance activities. Maintenance of detention basins should include:

- removal of litter and debris;
- management of vegetation through grass cutting around access routes, embankments and the main storage area;
- pruning of any marginal or aquatic vegetation and removal of any nuisance plants from any ponded areas, if present;
- inspect inlets, outlets, banksides, structures, pipework etc. for any blockage and/or structural damage and remediate where appropriate;
- appropriate remedial measures to rectify any blockage or other damage identified during inspections; and
- remove accumulated sediment from inlets, outlets and within basin (once depth exceeds 25mm). Sediment may be considered toxic or hazardous material under the Waste (Scotland) Regulations 2012, so consideration of disposal is required.

Retention Pond and Wetland

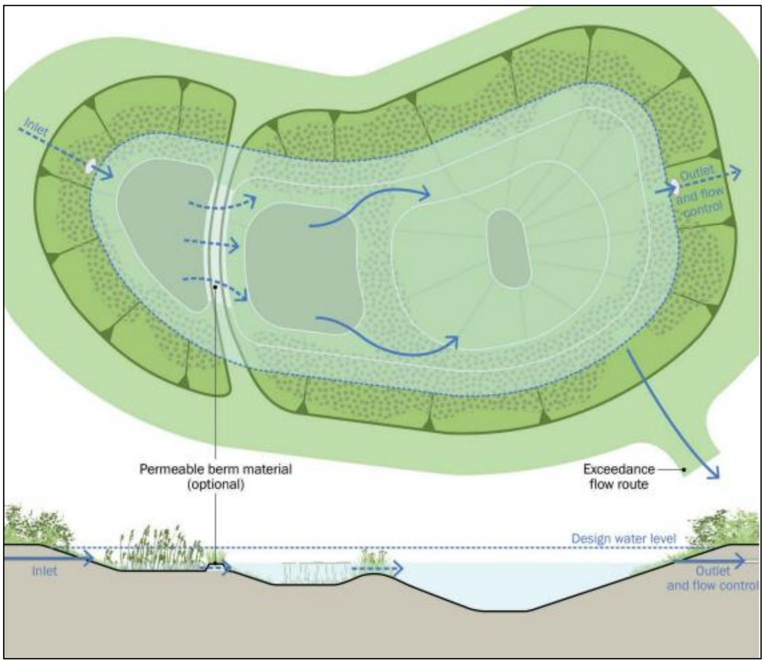
2.1.12 Retention ponds and wetlands are depressions that include a permanent volume of water (normally a maximum of 1.2m deep (CIRIA, 2015)) and are designed to temporarily detain and treat runoff.

2.1.13 Wetlands are largely similar to retention ponds but support a greater proportion of vegetation around their margins and aquatic vegetation within marshy areas around the permanent volume of water. The larger area apportioned to aquatic plants in wetlands compared to retention ponds can also include 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.

2.1.14 Diagram 4 shows a typical schematic of a retention pond/wetland (CIRIA, 2015). The permanent volume of water enables:

- the establishment of aquatic vegetation;
- settlement of suspended sediments and other pollutants;
- filtration through aquatic vegetation;
- adsorption (adhesion of pollutants to sediment within the pond);
- biodegradation (biological breakdown of pollutants by organisms that develop within the permanent pool, within and around aquatic vegetation, biofilms and within sediments).
- precipitation (condensation of dissolved pollutants into solids);
- uptake of pollutants by plants and biofilms; and
- nitrification (biological oxidation, particularly of ammonia, by bacteria).

Diagram 4: Typical schematic of a retention pond (from CIRIA, 2015).



2.1.15 To maximise treatment efficiency, retention ponds should include a forebay (as per detention basins), occupying a minimum of 10% of the total pond area, separated by a permeable berm to allow for trapping of sediment within a more manageable area and reducing sedimentation within the remainder of the retention pond or wetland.

2.1.16 Planting aquatic vegetation within and across retention ponds and wetlands (both in shallow and deep areas in wetlands) is required to enhance treatment and ensure polluted runoff does not bypass treatment areas. Planting vegetation zones increases filtration, biodegradation and uptake of pollutants by plants. Planting can also be used to create separate treatment areas and to encourage the development of biofilms (algae, bacteria and other microorganisms) that further enhance treatment.

2.1.17 Retention ponds and wetlands should be designed to enable inflows to distribute across the width of the pond, with inlets and outlets placed to maximise flow path length. Retention ponds and wetlands should also increase in depth to avoid remobilisation of sediments close to the outlet during high flow events.

2.1.18 Retention ponds and wetlands will require maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities. Maintenance requirements of retention ponds and wetlands are largely similar to those of detention basins aforementioned.

3 Methodology

HAWRAT Routine Runoff Assessment

3.1.1 Method A of DMRB HD 45/09, employed using HAWRAT, has been developed to assess the magnitude of potential short-term impacts of routine runoff on surface waters. Runoff Specific Thresholds (RSTs) have been devised by the Highways Agency and the Environment Agency (EA). Two thresholds have been developed to protect aquatic ecology in watercourses, which relate to the intermittent nature of road runoff (i.e. contaminants washed off the road surface in a rainfall event):

- a typical exposure period of six hours (RST 6 hour); and
- a worst-case scenario of 24 hours (RST 24 hour).

3.1.2 Dissolved copper (Cu) and dissolved zinc (Zn) are used as indicators of the level of impact as they can result in particularly acute toxic effects to aquatic life at certain concentrations. Table 1 summarises the RSTs for dissolved Cu and dissolved Zn used within HAWRAT.

Table 1: RSTs for short-term exposure (WRc, 2007 cited within Highways Agency et al., 2009a)

		Zn (µg/l) Hardness		
Threshold	Cu (µg/l)	Low (<50mg CaCO3/l)	Medium (50 – 200mg CaCO3/l)	High (>200mg CaCO3/l)
RST 24 hour	21	60	92	385
RST 6 hour	42	120	182	770

3.1.3 RSTs are short-term only and are designed to be used alongside Environmental Quality Standards (EQS), adopted as part of the Water Framework Directive (WFD), that represent ecological thresholds for long-term water quality. A HAWRAT 'pass' or 'fail' for RSTs is determined through a calculation of the number of exceedances per year; Table 2 shows the number of exceedances used to determine a HAWRAT 'pass'.

Table 2: Number of exceedances per year required to achieve a HAWRAT 'pass'

Metal	Not within 1km of protected site.		Within 1km of protected site.	
	RST 24	RST 6	RST 24	RST 6
Dissolved Cu	<2	<1	<1	<0.5
Dissolved Zn	<2	<1	<1	<0.5

3.1.4 HAWRAT 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 and shown in Table 3.

Table 3: EQS for Cu and Zn required to achieve 'Good' status under WFD as detailed in The Scotland River Basin District (Standards) Directions 2014

Metal	Annual mean bioavailable concentration (µg/l)
Cu	1
Zn	10.9

3.1.5 HAWRAT calculates concentrations for dissolved Cu and Zn, and in the absence of long-term water quality data, a comparison is made for exceedance against EQS for bioavailable Cu and Zn. This results in a conservative 'worst-case' assessment assuming that all dissolved Cu and Zn is bioavailable and therefore has the potential to have long-term negative environmental impacts on aquatic flora and fauna.

3.1.6 HAWRAT also assesses chronic impacts associated with sediment-bound pollutants on aquatic ecology within watercourses. Two standards are used for metal and polycyclic aromatic hydrocarbon (PAH) in sediment respectively, these are:

- Threshold Effect Level (TEL) – concentration below which toxic effects are extremely rare; and
- Probable Effect Level (PEL) – concentration above which toxic effects are observed on most occasions.

3.1.7 Table 4 details TELs and PELs for a range of sediment-bound pollutants found in highway runoff.

Table 4: TELs and PELs for highway pollutants (Gaskell et al., 2008 cited within Highways Agency et al., 2009a)

Pollutant	TEL	PEL
Cu	35.7 mg/kg	197 mg/kg
Zn	123 mg/kg	315 mg/kg
Cadmium (Cd)	0.6 mg/kg	3.5 mg/kg
Total Polyaromatic Hydrocarbons (PAH)	1,684 µg/kg	16,770 µg/kg
Pyrene	53 µg/kg	875 µg/kg
Fluoroanthene	111 µg/kg	2,355 µg/kg

3.1.8 HAWRAT uses a three step approach to assessing the impacts of both soluble and sediment-bound pollutants and determines whether the drainage system would 'pass' or 'fail' (or 'alert') in terms of water quality in the receiving water features during operation. The three step approach is as follows:

- Step 1: calculate pollutant concentrations in highway runoff (before mixing in SuDS feature);
- Step 2: calculate pollutant concentrations in SuDS feature after mixing has taken place (accounts for pollutant dilution and dispersal capacity in water feature); and
- Step 3: consider the effectiveness of the proposed treatment systems at mitigating pollutant concentrations.

3.1.9 Step 2 and 3 also contain two tiers of assessment for sediment accumulation: Tier 1 is a simple assessment requiring only an estimate of the river width, while Tier 2 is a more detailed assessment which requires further watercourse parameters including roughness, bed gradient, side slopes and channel width. Tier 2 assessments are only undertaken where outfalls fail for sediment impacts under Tier 1.

3.1.10 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.

3.1.11 In both cases, the alert indicates the need for further consideration of the proposed outfall and the agreement of appropriate settlement measures with the 'Overseeing Organisation'; in this case SEPA.

Treatment Efficiency Calculations

3.1.12 The proposed drainage strategy includes three variants of SuDS treatment train, comprising:

- Treatment Train 1: Filter Drains and a Detention Basin (**W41**);
- Treatment Train 2: Filter Drains and a Retention Pond (**W42**); and
- Treatment Train 3: Filter Drains and a Wetland (**W43**).

3.1.13 The selection of specific SuDS components has been undertaken based on the primary functions and capabilities of those components (e.g. pre-treatment, conveyance, source control, site control and regional control). The treatment efficiencies discussed below are indicative and subject to the correct design and maintenance of each component (refer to Section 2).

3.1.14 Values for the indicative treatment performance data of various SuDS components are provided in Table 26.13 of 'The SuDS Manual' (CIRIA, 2015). This table includes a range of average pollutant inflow concentrations from urban surfaces and average outflow concentrations after treatment by various SuDS components. These values are sourced from a number of studies, including those listed in the 'International Stormwater Best Management Practices (BMP) Database' (Leisenring et al., 2012).

3.1.15 The adopted pollutant removal values for the removal of total suspended solids (TSS) by detention basins and retention ponds are based on the average percentage removal derived from the inflow and outflow concentrations provided in Table 26.13 of 'The SuDS Manual'. Table 5 and the calculation below show how the treatment efficiency has been derived from Table 26.13 of 'The SuDS Manual.'

Table 5: Derivation of treatment efficiency for TSS

	Concentration range TSS (25%ile – 75%ile) as stated in CIRIA (2015) (mg/l)	Mean value TSS (mg/l)
Inflow from urban surface	20 – 114	67
Outflow from detention basin*	10 – 47	28.5
Outflow from retention pond**	4 – 28	16
Outflow from wetland***	4 – 21	12.5

* % of mean inflow concentration remaining after treatment by detention basin *= 28.5 / 67 = 43%* thus; removal efficiency = *100% - 43% = 57%*

** % of mean inflow concentration remaining after treatment by retention pond = *16 / 67 x 100 = 24%* thus; removal efficiency = *100% - 24% = 76%*

*** % of mean inflow concentration remaining after treatment by retention pond = *12.5 / 67 x 100 = 19%* thus; removal efficiency = *100% - 19% = 81%*

3.1.16 Table 26.13 of 'The SuDS Manual' also gives values for total Cu and total Zn; however, these values are not appropriate to use for soluble removal efficiencies. Instead, the removal efficiencies for dissolved Cu and Zn have been based on pre-defined removal rates quoted in the DMRB Volume 4, Section 2, Part 3 'Design of Highway Drainage Systems' HD33/16 (Highways England, Transport Scotland, Welsh Government and Department for Infrastructure, 2016).

3.1.17 The CIRIA guidance does not include performance values for filter drains; consequently, the DMRB HD 33/16 values have also been used for TSS, dissolved Cu and dissolved Zn. The subsequent removal efficiencies derived for each SuDS component are provided in Table 6.

Table 6: Treatment efficiencies of SuDS components

Drainage System	Treatment Efficiencies (%)		
	Dissolved Cu	Dissolved Zn	TSS
Filter drain	0	45	60
Detention basin	0	0	57
Retention pond	40	30	76
Wetland	30	50	81

3.1.18 The overall treatment efficiencies of the four treatment train components are described in the following section. The 'The SuDS Manual' (CIRIA, 2015) guidance advises that a factor of 0.5 is applied to the treatment efficiency of a secondary treatment component, as the treatment performance of secondary or tertiary levels of treatment is reduced due to already reduced pollutant concentrations in the inflow. This has been accounted for in all treatment efficiency calculations and is presented below.

3.1.19 Figures shown in bold text have been used in the Step 3 routine runoff assessments.

<u>Treatment of Cu:</u>

- Treatment train 1 does not include any (**0%**) treatment for dissolved Cu;
- Treatment train 2 includes **40%** treatment for dissolved Cu; and
- Treatment train 3 includes **30%** treatment for dissolved Cu.

<u>Treatment of Zn:</u>

- Treatment train 1 includes **45%** treatment for dissolved Zn;
- Treatment train 2: 100% x (1 – 0.45) x (1 – 0.15) = 47% of dissolved Zn remaining, therefore the treatment efficiency is **53%**; and
- Treatment train 3: 100% x (1 – 0.45) x (1 – 0.25) = 42% of dissolved Zn remaining, therefore the treatment efficiency is **58%**.

3.1.20 As the treatment removal rates for dissolved Cu and Zn are different, Step 3 of the HAWRAT assessment was been performed twice. Firstly, with a soluble removal rate of 0% for treatment train 1, 40% for treatment train 2 and 30% for treatment train 3, which reflect the varying removal efficiencies of dissolved Cu. Secondly, soluble removal rates were set at 45% for treatment train 1, 53% for treatment train 2 and 58% for treatment train 3 which reflect the varying removal efficiencies of dissolved Zn.

<u>Calculation for Settlement of Suspended Sediment:</u>

- Treatment train 1 100% x (1 – 0.60) x (1 – 0.285) = 29% sediment remaining after treatment, therefore the settlement efficiency (relevant to sediment chronic impacts) is **71%;**
- Treatment train 2: 100% x (1 – 0.60) x (1 – 0.38) = 25% sediment remaining after treatment, therefore the settlement efficiency (relevant to sediment chronic impacts) is **75%**; and
- Treatment train 3: 100% x (1 – 0.60) x (1 – 0.40) = 24% sediment remaining after treatment, therefore the settlement efficiency (relevant to sediment chronic impacts) is **76%**.

3.1.21 Table 7 below, shows the different pollutant removal efficiencies for TSS, dissolved Cu and dissolved Zn, for treatment trains 1 to 3.

Table 7: Treatment train 1-3 – summary of pollutant removal efficiencies

Drainage System	Treatment Efficiencies (%)		
	Dissolved Cu	Dissolved Zn	TSS
Treatment Train 1			
Filter drain	0	45	60
Detention basin	0	0	28*

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Drainage System	Treatment Efficiencies (%)		
	Dissolved Cu	Dissolved Zn	TSS
Treatment Train 1			
Total system	*0*	*45*	*71*
Treatment Train 2			
Filter drain	0	45	60
Retention pond	40	15*	38*
Total system	*40*	*53*	*75*
Treatment Train 3			
Filter drain	0	45	60
Wetland	30	25*	41*
Total system	*30*	*58*	*76*

*0.5 x treatment performance as indicated in The SuDS Manual (C753).

3.1.22 Details of the proposed outfalls, assessment point locations and proposed treatment trains used in the HAWRAT routine runoff assessment are presented in Table 8. Where outfalls are located along the same watercourse and within 1km of one another; a cumulative assessment has been undertaken. Where cumulative assessments have been undertaken, the most downstream outfall location has been selected.

Table 8: Location Details

Outfall(s)	Assessment	Receiving Watercourse	OS Grid Reference of Assessment/Outfall Location		Proposed Treatment Train
			Easting	Northing	
A	Non-cumulative	Allt Girnaig (WF89)	291582	763114	2 – Filter drains and retention pond
B	Non-cumulative	Allt Girnaig (WF89)	291479	763084	2 – Filter drains and retention pond
C	Non-cumulative	Allt Chluain (WF98)	290012	763997	3 – Filter drains and wetland
D(1)	Non-cumulative	Allt Chluain (WF98)	289892	763698	2 – Filter drains and retention pond
D(2)	Non-cumulative	WF178	289134	764396	1 – Filter drains and detention basin
E(1) + E(2)	Non-cumulative	WF99	289077	764227	2 – Filter drains and retention pond
F	Non-cumulative	River Garry (WF100)	286817	765178	3 – Filter drains and wetland
G	Non-cumulative	Allt Bhaic (WF115)	284463	765568	3 – Filter drains and wetland
H	Non-cumulative	Allt Bhaic (WF115)	284475	765575	3 – Filter drains and wetland
I	Non-cumulative	River Garry (WF100)	283227	765573	2 – Filter drains and retention pond
J(1)	Non-cumulative	River Garry (WF100)	282544	765818	2 – Filter drains and retention pond
J(2)	Non-cumulative	River Garry (WF100)	282463	765726	1 – Filter drains and detention basin
K	Non-cumulative	River Garry (WF100)	281380	765577	2 – Filter drains and retention pond
L	Non-cumulative	WF136	280270	765869	2 – Filter drains and retention pond
M	Non-cumulative	River Garry (WF100)	279082	766276	3 – Filter drains and wetland
N	Non-cumulative	River Garry (WF100)	278690	766697	3 – Filter drains and wetland
O	Non-cumulative	River Garry (WF100)	277886	767237	3 – Filter drains and wetland
P	Non-cumulative	Allt Crom Bhruthaich (WF167)	276919	768826	3 – Filter drains and wetland
Q	Non-cumulative	Allt Anndeir (WF158)	275581	769517	3 – Filter drains and wetland
R	Non-cumulative	Allt Anndeir (WF158)	275607	769499	3 – Filter drains and wetland
S	Non-cumulative	Allt Geallaidh (WF164)	273484	770201	3 – Filter drains and wetland
A + B	Cumulative	Allt Girnaig (WF89)	291479	763084	2 – Filter drains and retention pond
C + D1	Cumulative	Allt Chluain (WF98)	289892	763698	2 – Filter drains and retention pond
G + H	Cumulative	Allt Bhaic (WF115)	284475	765575	3 – Filter drains and wetland

Outfall(s)	Assessment	Receiving Watercourse	OS Grid Reference of Assessment/Outfall Location		Proposed Treatment Train
			Easting	Northing	
J(1) + J(2)	Cumulative	River Garry (WF100)	282544	765818	1 – Filter drains and detention basin
I + J(1) + J(2)	Cumulative	River Garry (WF100)	283227	765573	2 – Filter drains and retention pond
M + N + O	Cumulative	River Garry (WF100)	279082	766276	3 – Filter drains and wetland
Q + R	Cumulative	Allt Anndeir (WF 158)	275607	769499	3 – Filter drains and wetland

3.1.23 Input parameters (both generic to all outfalls and specific to individual outfalls) and data sources used within the assessments are presented in Tables 9 to 12.

Table 9: Generic User Parameters applied to all outfalls

Parameter	Units	Value Used	Notes/Sources
AADT	vpd	>10,000 and <50,000	Design year 2041 Source: Jacobs' traffic modelling team.
Climatic Region	-	Colder Wet	Source: HAWRAT Help v1.0
Rainfall Site	-	Ardtalnaig (SAAR 1343.9mm)	Source: HAWRAT Help v1.0
Hardness	$CaCO_3$ mg/l	Low = <50mg $CaCO_3$/l	Worst-case scenario. SEPA water quality monitoring data for River Tay at Pitnacree used as donor information.

Table 10: Information sources

Parameter	Notes/Sources
95%ile River Flow (m^3/s)	Source: Jacobs' hydrologists
Baseflow Index (BFI)	Source: FEH CD-ROM
Impermeable road area drained (ha)	Source: scheme information
Permeable area draining to outfall (ha)	Source: scheme information
Within 1km upstream of a protected site?	River Garry forms part of the River Tay SAC
Downstream structure that reduces the velocity <100m?	Source: scheme information
Estimated river width at Q95 (m)	Source: site information
Tier 2 Bed width (m)	Source: site information
Tier 2 Side slope (m/m)	Source: site information
Tier 2 Long slope (m/m)	Source: LiDAR
Tier 2 Manning's n	Source: site information and referring to Chow (1959)
Existing treatment of solubles (%)	Only partial treatment on the existing A9. Precautionary approach to assume no existing treatment.
Existing attenuation – restricted discharge rate (%)	
Existing settlement of sediments (%)	
Proposed treatment of solubles (%)	Two or three levels of treatment: filter drains, detention basin, retention pond or wetlands Sources: SuDS Manual (C753) Table 26.13 – Performance of SuDS components in reducing urban runoff contamination and DMRB HD 33/16 (2016) Table 8.1 – Indicative Treatment Efficiencies of Drainage Systems
Proposed attenuation – restricted discharge rate (l/s) to Q_{BAR}	Source: Jacobs' engineers
Proposed settlement of sediments (%)	Two or three levels of treatment: filter drains, detention basin, retention pond or wetlands. Source: SuDS Manual (C753) Table 26.13 – Performance of SuDS components in reducing urban runoff contamination. DMRB HD 33/16 (2016) Table 8.1 – Indicative Treatment Efficiencies of Drainage Systems

Table 11: Specific User Parameters – Outfalls A – D(2)

Parameter	Outfall(s)										
	A	B	C	D(1)	D(2)	E(1) +E(2)	F	G	H	I	J(1)
Receiving Watercourse	WF89	WF89	WF98	WF98	WF178	WF99	WF100	WF115	WF115	WF100	WF100
95%ile River Flow (m^3/s)	0.153	0.154	0.025	0.025	0.001	0.0029	1.06	0.037	0.037	0.992	0.941
Baseflow Index (BFI)	0.476	0.476	0.542	0.542	0.721	0.721	0.429	0.469	0.469	0.429	0.429
Impermeable road area drained (ha)	2.45	2.72	1.95	3.56	0.36	4.45	3.2	4.53	3.62	2.53	4.27
Permeable area draining to outfall (ha)	0.44	0.59	0.88	5.51	0.8	5.82	3.59	5.02	1.31	0.9	2.51
Within 1km upstream of a protected site?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Downstream structure that reduces the velocity <100m?	No	No	No	Yes	Yes	Yes	No	No	No	No	No
Use Tier 1	True	True	True	True	True	False	True	False	False	True	True
Use Tier 2	False	False	False	False	False	True	False	True	True	False	False
Estimated river width at Q95 (m)	4.1	4.4	4.9	4.9	1.2	0.85	27.9	6.2	6.1	14.3	20.1
Tier 2 Bed width (m)	-	-	-	-	-	0.75	-	6.2	6.1	-	-
Tier 2 Side slope (m/m)	-	-	-	-	-	10	-	1.122	1.122	-	-
Tier 2 Long slope (m/m)	-	-	-	-	-	0.008	-	0.012	0.012	-	-
Tier 2 Manning's n	-	-	-	-	-	0.03	-	0.035	0.035	-	-
Existing treatment of solubles (%)	0	0	0	0	0	0	0	0	0	0	0
Existing attenuation – restricted discharge rate (%)	U/L	U/L	U/L	U/L	U/L	U/L	U/L	U/L	U/L	U/L	U/L
Existing settlement of sediments (%)	0	0	0	0	0	0	0	0	0	0	0
Proposed treatment of solubles (%)	40 (Cu) 53 (Zn)	40 (Cu) 53 (Zn)	30 (Cu) 58 (Zn)	40 (Cu) 53 (Zn)	0 (Cu) 45 (Zn)	40 (Cu) 53 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)	40 (Cu) 53 (Zn)	40 (Cu) 53 (Zn)
Proposed attenuation – restricted discharge rate (l/s)	17	16	13	23.6	3.80	25.3	22.3	27.4	30	13	30
Proposed settlement of sediments (%)	75	75	76	75	71	75	76	76	76	75	75

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Table 12: Specific User Parameters – Outfalls J(2) – S

Parameter	Outfall(s)									
	J(2)	K	L	M	N	O	P	Q	R	S
Receiving Watercourse	WF100	WF100	WF136	WF100	WF100	WF100	WF167	WF158	WF158	WF164
95%ile River Flow (m^3/s)	0.941	0.927	0.001	0.791	0.752	0.744	0.0013	0.14	0.14	0.0159
Baseflow Index (BFI)	0.429	0.429	0.396	0.429	0.429	0.429	0.358	0.445	0.445	0.289
Impermeable road area drained (ha)	0.87	2.04	2.1	2.5	2.02	5.07	0.98	3.28	4.73	0.74
Permeable area draining to outfall (ha)	1.34	0.6	2.93	2.35	1.1	2.07	0.97	2.14	1.94	0.9
Within 1km upstream of a protected site?	Yes	Yes	Yes	No	No	No	No	No	No	No
Downstream structure that reduces the velocity <100m?	No	No	Yes	No	No	No	No	No	No	No
Use Tier 1	True	True	False	True	True	True	True	True	True	True
Use Tier 2	False	False	True	False	False	False	False	False	False	False
Estimated river width at Q95 (m)	20.1	16	1.1	6.2	11.1	8.1	2.6	10.3	10.3	4.1
Tier 2 Bed width (m)	-	-	1.1	-	-	-	-	-	-	-
Tier 2 Side slope (m/m)	-	-	1.5	-	-	-	-	-	-	-
Tier 2 Long slope (m/m)	-	-	0.1	-	-	-	-	-	-	-
Tier 2 Manning's n	-	-	0.04	-	-	-	-	-	-	-
Existing treatment of solubles (%)	0	0	0	0	0	0	0	0	0	0
Existing attenuation – restricted discharge rate (%)	U/L	U/L	U/L	U/L	U/L	U/L	U/L	U/L	U/L	U/L
Existing settlement of sediments (%)	0	0	0	0	0	0	0	0	0	0
Proposed treatment of solubles (%)	0 (Cu) 45 (Zn)	40 (Cu) 53 (Zn)	40 (Cu) 53 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)	30 (Cu) 58 (Zn)
Proposed attenuation – restricted discharge rate (l/s)	10	13	19	20	15	32	8	24.5	34	6.4
Proposed settlement of sediments (%)	71	75	75	76	76	76	76	76	76	76

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Limitations

3.1.24 HAWRAT is an indicative assessment tool only, and a HAWRAT 'pass' or 'fail' is not intended to be rigid. Further water quality assessments may be required during the CAR application process and specimen design stage in consultation with SEPA, particularly in the scenario where input data changes.

3.1.25 HAWRAT is primarily designed for the assessment of major trunk roads and motorways with relatively high traffic levels, such that the minimum traffic banding available within HAWRAT is '>10,000 and <50,000' vehicles per day (vpd). Traffic forecasts for the A9 for this project have predicted flows of <20,000vpd, which is at the lower end of the HAWRAT traffic banding. Therefore, pollution loading calculated by the HAWRAT tool is likely to be higher than the actual pollution loading generated by the proposed scheme.

Accidental Spillage Assessment

3.1.26 Method D of DMRB HD 45/09 has been designed to calculate spillage risk during operation of a road 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. The annual probability of a serious accidental spillage leading to a serious pollution incident is also dependent upon the response time of the emergency services. A risk factor is applied depending on the location and likely response time, and the type and sensitivity of the receiving water feature.

3.1.27 The risk factors applicable to the proposed scheme are provided in Table 13. As the A9 is classified as a rural trunk road with a response time of >20minutes and <1 hour, the probability factor for a serious accidental spillage leading to a serious pollution incident of surface waters was taken as 0.6 from Table D1.1 of DMRB HD 45/09.

Table 13: Risk factors for serious accidental spillages per billion HGV (km/year)

Junction Type	Rural trunk roads
No junction	0.29
Slip road	0.83
Side road	0.93
Roundabout	3.09

Source: DMRB HD 45/09

Note: Risk factor applies to all road lengths within 100m of these junction types.

3.1.28 The probability of a serious accidental spillage was calculated as follows:

$P_{SPL} = RL \times SS \times (AADT \times 365 \times 10^{-9}) \times (\%HGV \div 100)$

Where:

- P_{SPL} = probability of a serious accidental spillage in one year over a given road length;
- RL = road length in kilometres;
- SS = risk factors serious spillage rates from Table 16;
- AADT = Annual Average Daily Traffic (in design year 2041); and
- %HGV = percentage of Heavy Goods Vehicles (in design year 2041).

3.1.29 The probability that a spillage will cause a pollution incident is calculated thus:

$P_{INC} = P_{SPL} \times P_{POL}$

Where:

- 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 0.6 applied to the proposed scheme).

3.1.30 In line with DMRB HD 45/09, where spillage risk is calculated as less than the 1% Annual Exceedance Probability (AEP) (i.e. less frequent than 1 in 100 years), the spillage falls within acceptable limits and no further spillage prevention measures are required. Where assessed to be greater than the 1% AEP (i.e. more frequent than 1 in 100 years), the risk is unacceptable and mitigation will be required to reduce the risk of an impact occurring.

3.1.31 Higher levels of protection are afforded where road runoff discharges within close proximity (i.e. within 1km) to designated wetlands or designated conservation sites protected by EU or UK legislation, including Special Areas of Conservation (SACs) or Sites of Special Scientific Interest (SSSIs); or could affect public or private water supplies (or other important abstractions). In these cases, it is more appropriate to achieve a spillage risk of less than the 0.5% AEP (i.e. less frequent than 1 in 200 years). Where assessed to be greater than the 0.5% AEP (i.e. more frequent than 1 in 200 years), the risk is unacceptable and mitigation will be required to reduce the risk of an impact occurring; as all water features eventually flow into the River Tay SAC, all outfalls have been assessed to this standard.

Simple Index Approach for Tier 3 Accesses

3.1.32 Tier 3 accesses include agricultural and residential accesses that will experience low traffic volumes. These accesses are likely to have an AADT of <100vpd and in some instances <10vpd. The HAWRAT is not considered to be appropriate for these accesses as the minimum AADT range provided by the tool is >10,000 and <50,000 vpd, therefore an assessment using HAWRAT would greatly overestimate pollutant loading.

3.1.33 The ‘Simple Index Approach’ (SIA) presented in ‘The SuDS Manual’ (CIRIA, 2015) was developed from a study by Ellis et al., (2012) and comprises two components. These are:

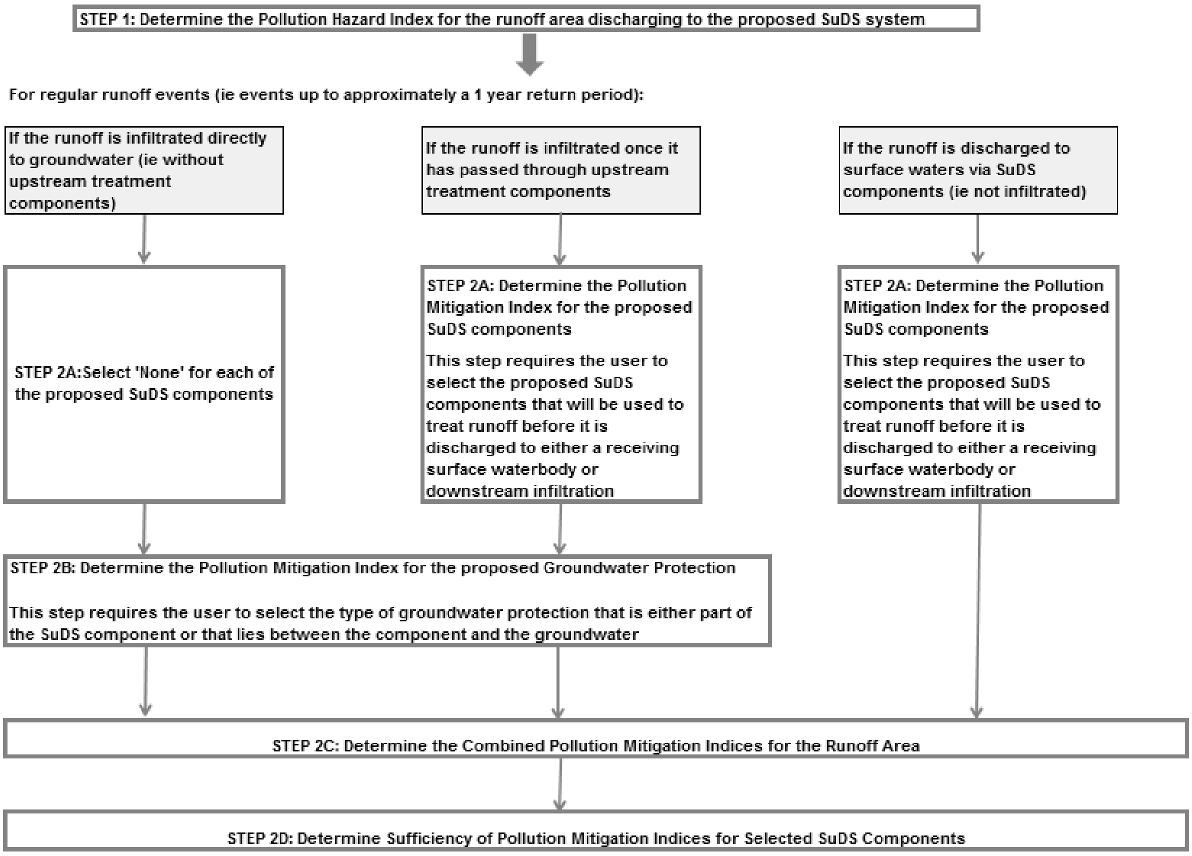
- Pollution Hazard Indices (PHI) of between 0 and 1, based on the pollutant levels likely for different land-use types where higher values indicate higher pollutant levels; and
- Pollution Mitigation Indices (PMI) of between 0 and 1, based on the ability of SuDS components or groundwater protection measures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

3.1.34 PHI and PMI values are given for three broad pollutant categories. These are:

- Total suspended solids (TSS);
- Metals; and
- Hydrocarbons.

3.1.35 A simple flow chart, containing up to five steps, is then followed as shown in Diagram 5 below:

Diagram 5: Simple Index Approach: Process Flow Chart (from the SIA tool produced on behalf of SEPA by Susdrain, 2015)



3.1.36 The Tier 3 accesses will generally be unsurfaced and constructed of compacted stone and gravel. The surface will likely be semi-pervious, allowing for some infiltration of runoff and attenuation of contaminants. There will be no formal SuDS associated with the Tier 3 accesses, however it is assumed that there will be ‘over the edge’ runoff that will be dispersed over vegetation. The protection to groundwater afforded by this drainage arrangement can be classified as a *‘dense vegetation layer underlain by 300mm minimum depth of soils with good contamination attenuation potential’* within the SIA Tool (Susdrain, 2015). The SIA Tool considers this to be one level of treatment.

3.1.37 Where drainage is required parallel to the Tier 3 accesses, runoff will be permitted to infiltrate within open ditches and residual flow will be spread diffusely over vegetated areas to allow for natural infiltration into groundwater. The protection to groundwater afforded by this drainage arrangement can be classified as a *‘Infiltration trenches with suitable depth of filtration material underlain by 300 mm minimum depth of soils with good contamination attenuation potential’ followed by ‘Dense vegetation layer underlain by 300mm minimum depth of soils with good contamination attenuation potential’* within the SIA Tool (Susdrain, 2015). The SIA Tool considers this to be greater than one level of treatment.

3.1.38 The adoption of infiltration trenches and dispersal of runoff over dense vegetation will provide attenuation and treatment of pollutants. The indices for the two treatment components is estimated as follows:

- Total mitigation index = mitigation index$_1$ + 0.5 (mitigation index$_2$); where mitigation index$_n$ = mitigation index for component n.

3.1.39 Where PHI is less than PMI, mitigation is considered sufficient to treat runoff from the pollution source.

Limitations

3.1.40 The 'Simple Index Approach' (SIA) (CIRIA, 2015) has been used with assumptions that surface runoff from these tracks would be treated within infiltration trenches (open ditches) and dispersed over vegetated areas. It is noted that a detailed design of these features has not been provided at this stage.

Salt Assessment

3.1.41 The DMRB does not provide a method for assessing the potential impacts of salt on the water environment, yet this is an area that has been identified as a concern by Scottish Natural Heritage (SNH) and the Spey Fishery Board (SFB).

3.1.42 Research by Jacobs has not identified an applicable methodology for the assessment of salt from other reference sources and specifically the concentration of chloride (Cl^-) ions on the water environment. It is known that Cl^- and the presence of salt ions (as measured by conductivity) have a negative impact on freshwater pearl mussels and fish species in the water environment. There is literature available on the application of salt for safety purposes and for the management of salt application to reduce environmental impacts (UK Roads Liaison Group, 2013).

3.1.43 The application of salt on road infrastructure is a winter activity (typically October to April) intended to prevent icing and avoid excessive build-up of snow and to promote the melting of snow. It is a widespread and existing practice that is unlikely to change significantly as a direct result of the A9 dualling programme, however the dualling of the A9 will create a larger surface area to which salt is applied and new drainage systems will alter the current pathways for salt to enter the water environment.

3.1.44 In the absence of an existing method for assessing salt concentrations in road runoff and at the point of dilution, a simple and conservative risk-based model has been developed that mirrors the approach taken by the HAWRAT routine runoff method described above. The method uses UK Roads Liaison Group, (2013) guidance on the maximum application rate of road salt, combined with information of the ratio of road salt to brine in pre-wetted salt application; to estimate the mass (kg) of salt applied per square meter of road and subsequently per section of road draining to each outlet.

3.1.45 The mass (kg) of salt is then adjusted to estimate the mass (kg) of NaCl applied given a 23% concentration of salt within the brine used and a 90% concentration of salt within the rock salt used. It is then conservatively assumed that this mass of NaCl is dissolved in the first 5mm of subsequent rainfall or snow melt and conservatively that 100% of this will runoff to the relevant drainage outlet. The result is an estimated concentration of NaCl in road runoff in kg/m^3, which can be converted to milligrams per litre (mg/l).

3.1.46 The second stage of the assessment considers the dilution available within the receiving watercourse, which because of the winter conditions at the time of application, is calculated from the estimated mean flow in each watercourse. No allowance for background salt concentrations is currently included in the assessment. The subsequent concentration of Cl^- in the receiving watercourse is calculated from the outflow concentrations of NaCl (atomic weight of 58.44 g/mol) based on the ratio of relative atomic weights of Na (atomic weight of 22.98 g/mol) and Cl^- (atomic weight of 35.45 g/mol) of 39:61.

3.1.47 There is no UK short-term EQS for Cl^- that can be used to assess the impact of the estimated outflow concentrations. For the purposes of this assessment, resultant Cl^- concentrations have been compared against the Canadian Council of Ministers of the Environment (2011) short-term exposure guideline value of 640mg/l. The Canadian guidance is based on Cl^- toxicity tests which included a mussel species with similar biology / ecology to the freshwater pearl mussel native to the UK. Freshwater mussels are noted in the Canadian guidance document as being the most sensitive taxonomic group to Cl^-.

3.1.48 Generic input parameters used within the salt assessments are provided in Table 14 below.

Table 14: Generic input parameters

Parameter	Value Used	Source
Max application of salt per m^2	$40g/m^2$	UK Roads Liaison Group (2013)
Rainfall depth	5mm	Value adopted relates to the first flush rainfall depths used in the 'The SuDS Manual' (CIRIA, 2015).
Ratio of dry salt to brine	70:30	UK Roads Liaison Group (2013).
Runoff Coefficient	1	Coefficient as used in the HAWRAT.
Canadian Water Quality Guideline for Short-term exposure (WQG-S) to Chloride	$640mgCl^-/l$	Canadian Council of Ministers to the Environment (2011)

Limitations

3.1.49 It is noted the results of the salt assessment have not been included within the overall impact assessment for the proposed scheme due to the lack of a UK short-term EQS for Cl^-, published data on SuDS treatment efficiency of Cl^-; and a defined methodology for assessing the impacts of salt within the DMRB.

4 Results

HAWRAT Routine Runoff Assessment

4.1.1 The results of the routine runoff assessments are presented in Tables 15 and 16. Within these tables, a traffic light system has been used to aid interpretation: green shading indicates a HAWRAT 'pass', orange shading indicates HAWRAT 'alert', and red shading indicates HAWRAT 'fail'. Where a 'fail' is recorded at Step 2 of the assessment, the required mitigation percentage to achieve a 'pass' is stated. It is noted that HAWRAT displays an AA-EQS of 0µg/l for pollutant concentrations <0.01µg/l. The resulting Magnitude of Impact, as used within Chapter 11 (Road Drainage and Water Environment), is also provided.

4.1.2 It is noted that an 'alert' is recorded for all outfalls due to the presence of the River Tay SAC (protected area) downstream from the proposed scheme; increased mitigation does not remove the alert.

4.1.3 At Step 2 (pre-mitigation), seven outfalls (shown in Table 15) assessed independently, fail the HAWRAT routine runoff assessment because of either short-term acute impacts (from dissolved/soluble pollutants) and/or long-term chronic impacts (from sediment-bound pollutants). Three of the seven outfalls, namely C, D1 and R fail the assessment due to the predicted impact from sediment-bound pollutants. Two of the seven outfalls (E1+E2 and L) fail the assessment as result of the predicted impact from soluble pollutants; while a further two outfalls (D2 and P) fail the assessment due to the predicted impact from both soluble pollutants and sediment-bound pollutants.

4.1.4 At Step 3 (post-mitigation), three outfalls (E1+E2, L and P) again fail the routine runoff assessment due to the predicted impact from soluble pollutants under an assumed worst case assessment scenario which considers an exposure duration of 24-hour (RST 24). No outfall fails the assessment under a typical exposure period of six hours (RST 6) and only outfall L fails the EQS criteria although, it is noted that with a predicted annual average Cu concentration of 1.01 mg/l; the EQS criteria is only marginally exceeded by 0.01mg/l.

4.1.5 Where outfalls are located along the same watercourse and within 1km of one another; a cumulative assessment has been undertaken. At Step 2 (pre-mitigation), three of the cumulative assessments (Table 16) register a fail. However, following the inclusion of mitigation at Step 3; all three cumulative assessments register a pass.

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Table 15: Results of non-cumulative Routine Runoff Assessment

Outfall	Step 2 – In-River Impacts									Step 3 – Post-mitigation								
	Soluble Pollutants						Sediment-bound pollutants		Magnitude of Impact*	Soluble Pollutants						Sediment-bound pollutants		Magnitude of Impact*
	RST 24 (exc./year)		RST6 (exc./year)		AA-EQS (µg/l)		Low-flow velocity (m/s)	DI value		RST 24 (exc./year)		RST 6 (exc./year)		AA-EQS (µg/l)		Low-flow velocity (m/s)	DI Value	
	Cu	Zn	Cu	Zn	Cu	Zn				Cu	Zn	Cu	Zn	Cu	Zn			
A	0	0	0	0	0.03	0.1	0.13	-	negligible	0	0	0	0	0.02	0.05	0.13	-	negligible
B	0	0	0	0	0.03	0.11	0.11	-	negligible	0	0	0	0	0.02	0.05	0.11	-	negligible
C	0	0.2	0	0	0.14	0.45	0.02	162 (39%)	slight	0	0	0	0	0.1	0.19	0.02	39	negligible
D(1)	0	0.7	0	0	0.24	0.75	0.02	295 (67%)	slight	0	0	0	0	0.15	0.36	0.02	74	negligible
D(2)	0.4	1.5 (25%)	0	0.2	0.46	1.43	0.01	184 (46%)	moderate	0.4	0.2	0	0	0.46	0.79	0.01	53	negligible
E(1) + E(2)	4.2 (42%)	4.8 (59%)	0.4	1.5	1.45	4.51	0.23	-	major	1	1.2	0.1	0	0.88	2.15	0.23	-	minor
F	0	0	0	0	0.01	0.02	0.04	22	negligible	0	0	0	0	0	0.01	0.01	5	negligible
G	0	0.6	0	0	0.21	0.66	0.3	-	negligible	0	0	0	0	0.15	0.28	0.3	-	negligible
H	0	0.3	0	0	0.18	0.55	0.3	-	negligible	0	0	0	0	0.12	0.23	0.3	-	negligible
I	0	0	0	0	0	0.02	0.1	-	negligible	0	0	0	0	0	0.01	0.10	-	negligible
J(1)	0	0	0	0	0.01	0.03	0.05	19	negligible	0	0	0	0	0.01	0.01	0.05	5	negligible
J(2)	0	0	0	0	0	0.01	0.05	4	negligible	0	0	0	0	0	0	0.05	1	negligible
K	0	0	0	0	0	0.01	0.08	7	negligible	0	0	0	0	0	0.01	0.08	2	negligible
L	5.3 (49%)	6 (61%)	0.70	2.1	1.68	5.19	0.24	-	major	1.5	1.4	0.2	0.1	1.01	2.45	0.24	-	major
M	0	0	0	0	0.01	0.02	0.33	-	negligible	0	0	0	0	0	0.01	0.33	-	negligible
N	0	0	0	0	0.01	0.02	0.12	-	negligible	0	0	0	0	0	0.01	0.12	-	negligible
O	0	0	0	0	0.01	0.04	0.2	-	negligible	0	0	0	0	0.01	0.02	0.2	-	negligible
P	2.1 (2%)	2.8 (25%)	0.2	0.70	0.87	2.64	0	298 (67%)	moderate	0.7	0.3	0.0	0	0.61	1.12	0	72	minor
Q	0	0	0	0	0.04	0.14	0.02	91	negligible	0	0	0	0	0.03	0.06	0.02	22	negligible
R	0	0	0	0	0.06	0.2	0.02	131 (24%)	minor	0	0	0	0	0.04	0.08	0.02	32	negligible
S	0	0.1	0	0	0.08	0.25	0.01	74	negligible	0	0	0	0	0.06	0.11	0.01	18	negligible

* Refer to Appendix A11.7 (Impact Assessment) for full operational impact assessment results.

Table 16: Results of cumulative routine runoff assessment

Outfalls	Step 2 – In-River Impacts									Step 3 – Post-mitigation								
	Soluble Pollutants						Sediment-bound pollutants		Magnitude of Impact*	Soluble Pollutants						Sediment-bound pollutants		Magnitude of Impact*
	RST 24 (exc./year)		RST6 (exc./year)		AA-EQS (µg/l)		Low-flow velocity (m/s)	DI value		RST 24 (exc./year)		RST 6 (exc./year)		AA-EQS (µg/l)		Low-flow velocity (m/s)	DI Value	
	Cu	Zn	Cu	Zn	Cu	Zn				Cu	Zn	Cu	Zn	Cu	Zn			
A + B	0	0	0	0	0.06	0.2	0.11	-	negligible	0	0	0	0	0.04	0.1	-	-	negligible
C + D(1)	0.3	1.1 (5%)	0	0.2	0.35	1.09	-	-	minor	0	0	0	0	0.21	0.51	-	-	negligible
G + H	0.3	1.1 (6%)	0	0.2	0.35	1.09	0.3	-	minor	0	0	0	0	0.25	0.46	0.3	-	negligible
J(1) + J(2)	0	0	0	0	0.01	0.03	0.05	23	negligible	0	0	0	0	0.01	0.02	0.05	6	negligible
I + J(1) + J(2)	0	0	0	0	0.01	0.05	-	-	negligible	0	0	0	0	0.01	0.03	-	-	negligible
M + N + O	0	0	0	0	0.02	0.07	-	-	negligible	0	0	0	0	0.02	0.03	-	-	negligible
Q + R	0	0.1	0	0	0.1	0.32	0.02	222 (56%)	minor	0	0	0	0	0.07	0.14	0.02	53	negligible

* Refer to Appendix A11.7 (Impact Assessment) for full operational impact assessment results.

Accidental Spillage Assessment

4.1.6 The spillage risk assessment has been undertaken for both individual outfalls and for all outfalls discharging to the same water feature (assessment of cumulative risk). The individual outfall assessment results are presented in Table 17 and the cumulative outfall assessment results are presented in Table 18.

4.1.7 The annual probability of a serious pollution incident occurring within each highway catchment draining to an individual outfall, and cumulatively draining to the Allt Girnaig (WF89), Allt Chluain (WF98), River Garry (WF100), Allt Bhaic (WF115) and Allt Anndeir (WF158) has been estimated to be far below the 0.5% AEP (1:200 year) guidance quoted in DMRB HD 45/09 for sensitive areas.

Table 17: Results of spillage risk assessment – individual outfalls pre-mitigation

Receiving water feature	Section	Risk Weighting	Length within catchment (km)	Annual Average Daily Traffic (vpd)	%HGV	Probability Score (PPOL)	Probability of Spillage (PSPL)	Probability of Incident (PINC)	Probability of Incident (PINC)%	Return Period (Years)	Within Acceptable Limits?*
Outfall A											
Allt Girnaig (WF89)	Mainline	0.29	1.09	16,430	12.7	0.6	**0.0002**	**0.0001**	**0.0144**	**6,923**	**Yes**
Outfall B											
Allt Girnaig (WF89)	Mainline	0.29	1.05	16,430	12.7	0.6	**0.0002**	**0.0001**	**0.0139**	**7,187**	**Yes**
Outfall C											
Allt Chluain (WF98)	Mainline	0.29	0.49	16,430	12.7	0.6	0.0001	0.0001	0.0065	15,400	**Yes**
		0.83	0.2	16,430	12.7	0.6	0.0001	0.0001	0.0076	13,183	
	NB Diverge	0.83	0.39	880	6.9	0.6	0.00001	0.000004	0.0004	232,317	
						Total:	**0.0002**	**0.0001**	**0.0145**	**6,892**	
Outfall D(1)											
Allt Chluain (WF98)	Mainline	0.29	0.41	16,430	12.7	0.6	0.0001	0.0001	0.0054	18,405	**Yes**
		0.83	0.44	16,430	12.7	0.6	0.0003	0.0002	0.0167	5,992	
	NB Diverge	0.83	0.36	880	6.9	0.6	0.00001	0.000004	0.0004	251,677	
	NB Merge	0.83	0.72	30	3.2	0.6	0.0000002	0.0000001	0.0000	7,959,285	
						Total:	**0.0004**	**0.0002**	**0.0225**	**4,438**	
Outfall D(2)											
WF178	SB Merge	0.83	0.34	980	8.8	0.6	0.0000	0.0000	0.0005	187,625	**Yes**
	SB Diverge	0.83	0.42	70	2.3	0.6	0.0000	0.0000	0.0000	8,135,844	
						Total:	**0.0000**	**0.0000**	**0.0005**	**183,395**	
Outfall E(1) + E(2)											
WF99	Mainline	0.29	1.62	14,680	13.3	0.6	0.0003	0.0002	0.0201	4,978	**Yes**
		0.83	0.2	14,680	13.3	0.6	0.0001	0.0001	0.0071	14,089	
	Shierglas jct.	0.83	0.21	70	2.3	0.6	0.0000	0.0000	0.0000	16,271,689	
	Glackmore farm access	0.83	0.22	70	2.3	0.6	0.0000	0.0000	0.0000	15,532,066	
						Total:	**0.0005**	**0.0003**	**0.0272**	**3,677**	
Outfall F											
River Garry (WF100)	Mainline	0.29	1.4	14,680	13.3	0.6	**0.0003**	**0.0002**	**0.0174**	**5,760**	**Yes**

Receiving water feature	Section	Risk Weighting	Length within catchment (km)	Annual Average Daily Traffic (vpd)	%HGV	Probability Score (PPOL)	Probability of Spillage (PSPL)	Probability of Incident (PINC)	Probability of Incident (PINC)%	Return Period (Years)	Within Acceptable Limits?*
Outfall G											
Allt Bhaic (WF115)	Mainline	0.29	1.78	14,680	13.3	0.6	**0.0004**	**0.0002**	**0.0221**	**4,531**	**Yes**
Outfall H											
Allt Bhaic (WF115)	Mainline	0.29	1.43	14,680	13.3	0.6	**0.0003**	**0.0002**	**0.0177**	**5,640**	**Yes**
Outfall I											
River Garry (WF100)	Mainline	0.29	0.61	14,680	13.3	0.6	0.0001	0.0001	0.0076	13,221	**Yes**
		0.83	0.2	14,680	13.3	0.6	0.0001	0.0001	0.0071	14,089	
	SB Merge	0.83	0.4	1,370	5.9	0.6	0.0000	0.0000	0.0006	170,155	
						Total:	**0.0003**	**0.0002**	**0.0152**	**6,558**	
Outfall J(1)											
River Garry (WF100)	Mainline	0.29	0.47	14,680	13.3	0.6	0.0001	0.0001	0.0058	17,159	**Yes**
		0.83	0.53	14,680	13.3	0.6	0.0003	0.0002	0.0188	5,316	
	NB Diverge	0.83	0.5	1,230	5.3	0.6	0.0000	0.0000	0.0006	168,782	
	NB Merge	0.83	0.45	510	4.7	0.6	0.0000	0.0000	0.0002	510,032	
						Total:	**0.0004**	**0.0003**	**0.0254**	**3,933**	
Outfall J(2)											
River Garry (WF100)	SB Merge	0.83	0.3	1,370	5.9	0.6	0.0000	0.0000	0.0004	226,874	**Yes**
	SB Diverge	0.83	0.6	530	4.7	0.6	0.0000	0.0000	0.0003	368,089	
						Total:	**0.0000**	**0.00001**	**0.0007**	**140,361**	
Outfall K											
River Garry (WF100)	Mainline	0.29	1.06	13,140	14.1	0.6	**0.0002**	**0.0001**	**0.0125**	**8,017**	**Yes**
Outfall L											
WF136	Mainline	0.29	0.74	13,140	14.1	0.6	**0.0001**	**0.0001**	**0.0087**	**11,484**	**Yes**
Outfall M											
River Garry (WF100)	Mainline	0.29	1.08	13,140	14.1	0.6	**0.0002**	**0.0001**	**0.0127**	**7,869**	**Yes**
Outfall N											
River Garry (WF100)	Mainline	0.29	0.94	13,140	14.1	0.6	**0.0002**	**0.0001**	**0.0111**	**9,041**	
Outfall O											

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Receiving water feature	Section	Risk Weighting	Length within catchment (km)	Annual Average Daily Traffic (vpd)	%HGV	Probability Score (PPOL)	Probability of Spillage (PSPL)	Probability of Incident (PINC)	Probability of Incident (PINC)%	Return Period (Years)	Within Acceptable Limits?*
River Garry (WF100)	Mainline	0.29	2.05	13,140	14.1	0.6	**0.0004**	**0.0002**	**0.0241**	**4,146**	**Yes**
Outfall P											
WF 167	Mainline	0.29	0.33	13,140	14.1	0.6	**0.0001**	**0.00004**	**0.0039**	**25,753**	**Yes**
Outfall Q											
WF 158	Mainline	0.29	1.29	13,140	14.1	0.6	**0.0003**	**0.0002**	**0.0152**	**6,588**	**Yes**
Outfall R											
WF 158	Mainline	0.29	2.16	13,140	14.1	0.6	**0.0004**	**0.0003**	**0.0254**	**3,935**	**Yes**
Outfall S											
WF 164	Mainline	0.29	0.32	13,140	14.1	0.6	**0.0001**	**0.00004**	**0.0038**	**26,558**	**Yes**

* Acceptable limit defined as the 0.5% AEP (1:200) flood event and magnitude of impact is 'Negligible'

Table 18: Results of spillage risk assessment – cumulative outfalls pre-mitigation

Receiving water feature	Outfall	Probability of Spillage (PSPL)	Probability of Incident (PINC)	Probability of Incident (PINC) %	Return Period (Years)	Within Acceptable Limits?*
Allt Girnaig (WF89)	A	0.00024	0.00014	0.01444	6923	**Yes**
	B	0.00023	0.00014	0.01391	7187	
	Total	**0.00047**	**0.00028**	**0.02836**	**3526**	
Allt Chluain (WF98)	C	0.00024	0.00015	0.01451	6892	**Yes**
	D(1)	0.00038	0.00023	0.02253	4438	
	Total	**0.00062**	**0.00037**	**0.03704**	**2700**	
Allt Bhaic (WF115)	G	0.00037	0.00022	0.02207	4531	**Yes**
	H	0.00030	0.00018	0.01773	5640	
	Total	**0.00066**	**0.00040**	**0.03980**	**2512**	
Allt Anndeir (WF158)	Q	0.00025	0.00015	0.01518	6588	**Yes**
	R	0.00042	0.00025	0.02542	3935	
	Total	**0.00068**	**0.00041**	**0.04060**	**2463**	

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Receiving water feature	Outfall	Probability of Spillage (PSPL)	Probability of Incident (PINC)	Probability of Incident (PINC) %	Return Period (Years)	Within Acceptable Limits?*
River Garry (WF100)	F	0.00029	0.00017	0.01736	5760	**Yes**
	I	0.00025	0.00015	0.01525	6558	
	J(1)	0.00042	0.00025	0.02543	3933	
	J(2)	0.00001	0.00001	0.00071	140361	
	K	0.00021	0.00012	0.01247	8017	
	M	0.00021	0.00013	0.01271	7869	
	N	0.00018	0.00011	0.01106	9041	
	O	0.00040	0.00024	0.02412	4146	
	Total	**0.00199**	**0.00119**	**0.11911**	**840**	

* Acceptable limit defined as the 0.5% AEP (1:200) flood event and magnitude of impact is 'Negligible'

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Simple Index Approach for Tier 3 Accesses

4.1.8 The inputs and results of the SIA are provided in Table 19. The results of the SIA assessment indicate that the proposed groundwater protection (infiltration trenches and dispersal of runoff over dense vegetation) is sufficient to mitigate pollution from the Tier 3 accesses.

Table 19: SIA inputs and results

Parameter	Category	TSS	Metals	Hydrocarbons
PHI	Low traffic roads (e.g. residential roads and general access roads, < 300 traffic movements/day)	0.5	0.4	0.4
PMI SuDS	None	0	0	0
PMI Groundwater Protection	Level 1: Infiltration trench with suitable depth of filtration material underlain by 300 mm minimum depth of soils with good contamination attenuation potential	0.4	0.4	0.4
	Level 2: Dense vegetation layer underlain by 300 mm minimum depth of soils with good contamination attenuation potential	0.3 (0.6*0.5)	0.25 (0.5*0.5)	0.3 (0.6*0.5)
Sufficiency of Pollutant Mitigation Indices (PHI≤PMI)		**Sufficient**	**Sufficient**	**Sufficient**

Salt Assessment

4.1.9 Table 20 presents the contributing catchment area, mean flow and the estimated maximum salt concentration in the receiving watercourse for each of the proposed outfalls. Rows that are coloured red indicate a 'fail', relative to the guidance concentration, while green indicates a 'pass'.

4.1.10 Assuming the maximum spreading rate of road salt application to the road surface (Table 17) and a 15mm depth rainfall event; the results show that the concentrations of Cl^- exceed the Canadian short-term exposure water quality guideline of 640mg/l at three (16.7%) of the outfall locations.

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Table 20: Specific Input Parameters and Results of Salt Assessment

Outfall	Receiving Watercourse	Catchment Area (km²)	Impermeable Area Draining to Outfall (m^2)	Mean flow (m^3/s)	Maximum Discharge Rate (l/s)	Outflow Concentration of $NaCl^-$ (ppm)	Outflow Concentration of Cl^- (ppm)	Comparison to Canadian WQG-S (640 $mgCl^-/l$)
A	Allt Girnaig (WF89)	39.5	24500	0.80	17	169	103	Pass
B	Allt Girnaig (WF89)	39.6	27200	0.81	16	165	101	Pass
C	Allt Chluain (WF98)	7.40	19500	0.13	13	404	247	Pass
D(1)	Allt Chluain (WF98)	7.48	35600	0.13	23.6	611	373	Pass
D(2)	WF178	0.36	3600	0.01	3.8	1398	853	Fail
E(1) + E(2)	WF99	0.86	44500	0.02	25.3	2202	1343	Fail
F	River Garry (WF100)	474	32000	5.53	22.3	113	69	Pass
G + H	Allt Bhaic (WF115)	11.1	81500	0.20	57.4	861	525	Pass
I	River Garry (WF100)	454	25300	5.20	13	108	66	Pass
J(1) + J(2)	River Garry (WF100)	380	51400	4.93	40	127	77	Pass
K	River Garry (WF100)	376	20400	4.86	13	109	66	Pass
L	WF136	0.32	21000	0.01	19	2751	1678	Fail
M	River Garry (WF100)	281	25000	4.14	20	116	71	Pass
N	River Garry (WF100)	268	20200	3.94	15	113	69	Pass
O	River Garry (WF100)	265	50700	3.90	32	127	78	Pass
P	Allt Crom Bhruthaich (WF167)	3.35	9800	0.07	8	452	276	Pass
Q + R	Allt Anndeir (WF158)	61.7	77400	0.74	58.5	347	212	Pass
S	Allt Geallaidh(WF164)	8.80	7400	0.11	6.4	289	176	Pass

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5 Summary

HAWRAT Routine Runoff Assessment

5.1.1 After the adoption of mitigation, only outfalls E1+E2 (discharging to WF99), L (discharging to WF136) and P (discharging to WF167) fail components of the HAWRAT routine runoff assessment. The fails recorded at three of the outfalls, post-mitigation, are due to the predicted impact from soluble pollutants under an assumed worst case assessment scenario; no outfalls fail the assessment under a typical exposure period. Outfall L also fails the EQS criteria, however it is noted that the EQS criteria is only marginally exceeded by 0.01mg/l. All of the relevant outfalls pass the cumulative routine runoff assessments.

5.1.2 The failure of the HAWRAT routine runoff assessment at outfalls E1+E2, L and P, after the implementation of mitigation, is due to the low Q_{95} value (<0.002 m^3/s) estimated for these watercourses. The Q_{95} is so low, that no matter how much mitigation (SuDS) is installed, it will not sufficiently improve the situation to give a 'pass' result. However, once the sensitivity of the watercourse has been taken into consideration, no significant impact is reported within Chapter 11 (Road Drainage and Water Environment), and therefore a 'fail' of the HAWRAT routine runoff assessments does not prerequisite a redesign or adoption of further mitigation in this instance.

5.1.3 Reporting of the significance of impacts resulting from the routine runoff assessment, both pre-mitigation and post-mitigation, is provided in Appendix A11.7 (Impact Assessment), with impacts of Moderate significance and greater reported in Chapter 11 (Road Drainage and the Water Environment). No residual impacts on water quality are considered to be significant in accordance with the EIA regulations.

5.1.4 For water features currently receiving routine runoff from the existing A9, but not included within the drainage design for the proposed scheme, beneficial impacts are anticipated. The River Tay (SAC) catchment as a whole will benefit from the adoption of SuDS treatment following the dualling of the A9, as there is generally no such treatment associated with the existing A9 drainage.

Accidental Spillage Assessment

5.1.5 The annual probability of a serious pollution incident occurring within each highway catchment draining to an individual outfall has been estimated to be well below the 0.5% AEP (1:200) guidance quoted in DMRB HD 45/09 for sensitive areas. Likewise, the summed annual probability of a serious pollution incident occurring across cumulative drainage catchments is observed to be well below the 0.5% AEP (1:200).

5.1.6 While the assessment has identified that no measures are required to mitigate spillage risk, it is noted that the assessment does not allow for local road accident data to be incorporated. It is reported, for example, that HGVs are nearly three times more likely to be involved in an accident on single carriageways of the A9 (Perth to Inverness) than they are on other Scottish trunk road single carriageways (The A9 Safety Group, accessed 17/02/2017). Furthermore, winter weather has the potential to significantly impact on the Perth to Inverness section of the A9. The A9 road reaches its highest level of 460mAOD at the Pass of Drumochter, the highest point on the Scottish trunk road network. The surrounding area can experience severe adverse winter weather between November and March and the potential for snow accumulation at these locations is significant. Analysis of STATS19 contributory factors highlights a relatively high proportion of accidents being caused by 'slippery road due to weather' (Jacobs, 2014).

5.1.7 While the proposed scheme will increase safety by upgrading the A9 to a dual carriageway, when interpreting the results of the assessment, the reader should recognise that the assessment does not consider inherent risk resulting from the road environment.

Simple Index Approach for Tier 3 Accesses

5.1.8 The results of the SIA Assessment indicate that the proposed groundwater protection will be sufficient to mitigate pollution from the Tier 3 accesses. Although assumptions have been made regarding the soil and vegetation conditions adjacent to the Tier 3 accesses, it is also noted that the PHI value selected for Tier 3 accesses is considered to be conservative due to the very low traffic levels that will be experienced (AADT of <100vpd and in some instances <10vpd). Therefore, the actual pollutant loading of TSS, Metals and Hydrocarbons from vehicles are likely to be lower than suggested by the PHI values.

5.1.9 It is noted that the PMI for Groundwater Protection for these treatment methods is subject to 'design conditions' as outlined within the SuDS Manual (CIRIA, 2015); this includes suitable soil conditions and a minimum of 1m unsaturated depth of subsoil or aquifer material. Where these conditions cannot be achieved, sufficient mitigation will be provided through SNH (2015) and SEPA (2016) guidance on constructed tracks and SuDS.

Salt Assessment

5.1.10 The results of the salt assessment (Table 20) show that concentrations of Cl^- exceed the Canadian short-term exposure guideline concentration at three (16.7%) of the outfall locations (D2, E1+E2 and L). These outfalls discharge into watercourses WF99, WF167 and WF178. These watercourses are of a low sensitivity, as they are generally unsuitable for fish species therefore the impact is considered insignificant (refer to Appendix 11.1 (Baseline)).

5.1.11 In addition, the removal of Cl^- from SuDS has not been assessed as there are currently no published values available that represent a SuDS feature's treatment efficiency of Cl-. Salt loading from the existing A9 is a further consideration that has not been included within the assessment.

5.1.12 Concentrations of Cl^- within WF99, WF167 and WF178 will become further diluted when they discharge into the River Garry, which forms part of the wider River Tay SAC and the nearest location where protected species could be impacted by Cl^- concentrations. The assessment shows that the significant dilution would reduce Cl- levels to below the Canadian short-term water quality guideline concentrations.

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