# 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 (RDWE)).

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 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 has 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 (Controlled Activities) (Scotland) Regulations 2011 (as amended) and have been included within the DMRB Stage 3 design process. Four SuDS components are included as part of the proposed scheme: filter drains, filter strips, hydrodynamic vortex separators and retention ponds. These components are proposed in differing combinations, or 'treatment trains', dependent on the varying treatment efficiencies required or site constraints associated with each proposed drainage catchment.

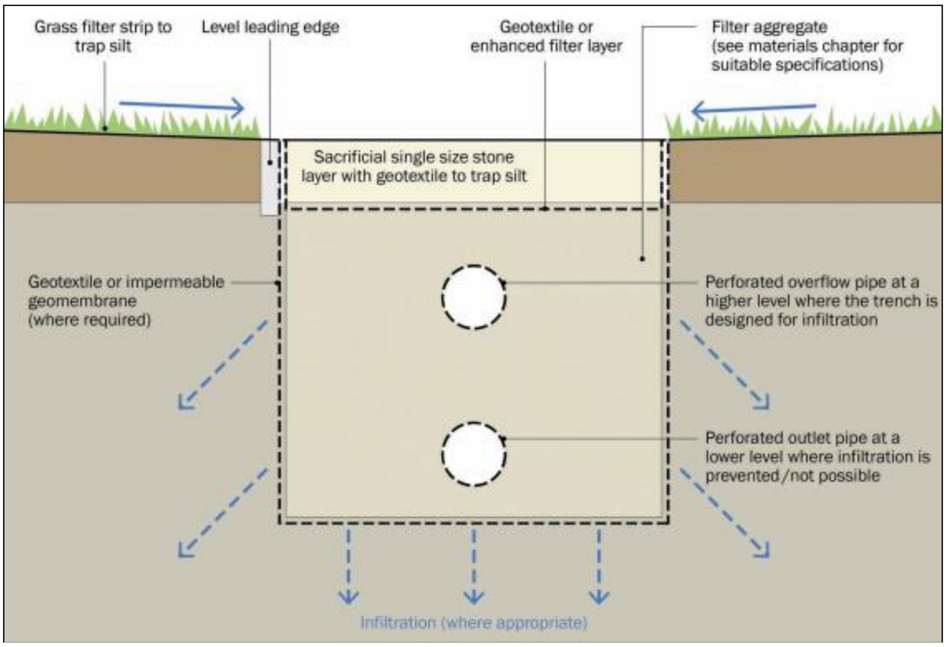
2.1.2 The treatment performances of these features, as detailed in Section 3 'Treatment Efficiency Calculations', will be dependent on their correct design and maintenance, as detailed below.

**Filter drains**

2.1.3 Filter drains are trenches along the roadside 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 are only preceded by a grass filter strip for one drainage catchment 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:

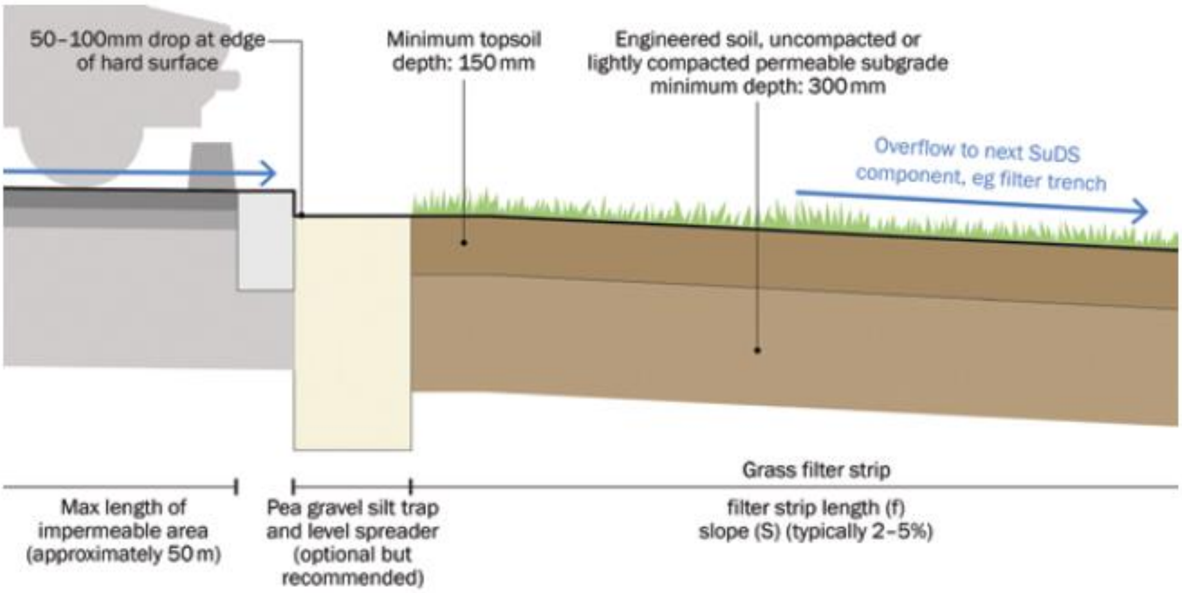
- inspection of the filter drain surface, and litter and debris removal;
- inspection of inlet/outlet pipework and perforated pipework, and control systems for silt accumulation blockages, clogging, standing water and structural damage with clearance as required;
- removal of vegetation, weed control 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).

**Filter strips**

2.1.8 Filters strips are ribbons of grass or other dense vegetation with shallow, even gradients, situated adjacent to impermeable surfaces. Runoff from impermeable areas is designed to flow at low velocities over the filter strips enabling pollutant removal via sedimentation, filtration and infiltration. Filter strips are commonly used as a pre-treatment component in combination with other SuDS components and due to their ability to capture sediment, installing them can help extend the life of subsequent treatment components. Diagram 2 shows a typical schematic of a filter strip (CIRIA, 2015).

**Diagram 2: Typical schematic of a filter strip (from CIRIA, 2015)**




2.1.9 Design considerations for filter strips include:

- Drainage areas, where strips are deployed, should have shallow gradients (1-10%), where drainage slopes are =>20%, 1m of filter strip should be provided for every 6m of impermeable flow path length.
- The strips themselves should have slopes of at least 1% (to prevent ponding) but no more than 5% (to prevent flow channelling).

- Filter strips should extend the entire length of the areas being drained.
- Maximum likely groundwater should always be at least 1m below the lowest level of the filter strip, where infiltration is to be permitted.
- Maximum flow velocities should be limited to 1.5m/s to limit erosion and to encourage effective sedimentation ideally flows across the strips should be <0.3m/s. Residence time within the filter strip should be at least 9 minutes.
- A drop of at least 50mm should be incorporated from the pavement edge to avoid formation of a sediment lip.
- A wider range of planting species will encourage more diverse biodiversity within the strip.

2.1.10 Filter strips 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. 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 strips should include:

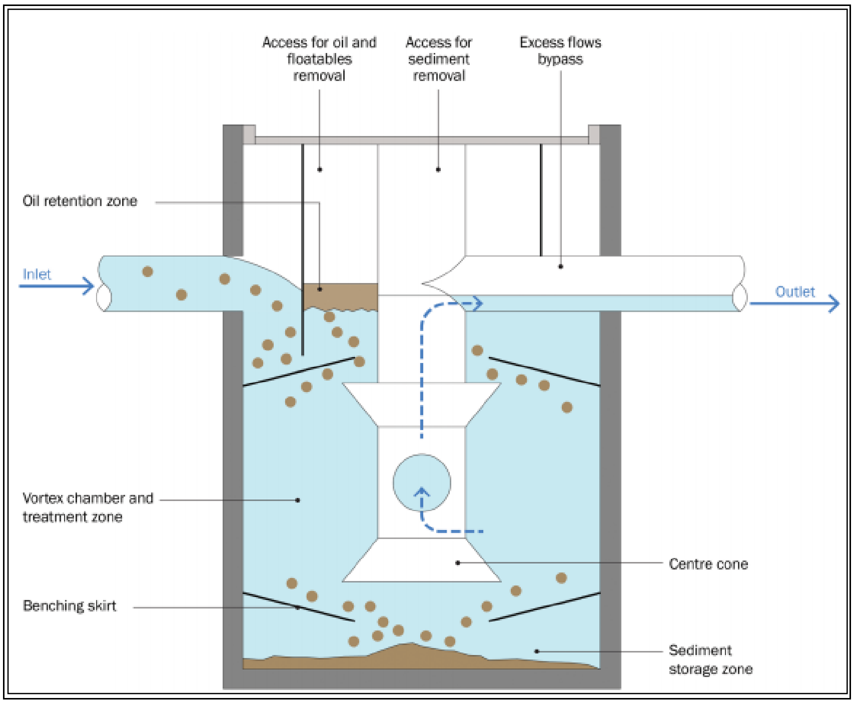
- remove litter and debris;
- cut grass to maintain appropriate grass height and remove nuisance plants;
- inspect gravel flow spreader upstream of filter strip for clogging and remove sediment when required;
- reseed areas of poor vegetation growth when area of bare soil exceeds >10%; and
- maintain even gradients across the strip and relevel ground when/where necessary.

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

**Hydrodynamic Vortex Separators**

2.1.12 Hydrodynamic Vortex Separators (HVS) are proprietary treatment devices designed as a source control measure to separate pollutants (predominantly sediment) through centrifugal force, allowing sediments to settle at the base and oils and floatables to rise to the top (access is provided for removal). Diagram 3 shows a typical schematic of a HVS (CIRIA, 2015). These features are typically adopted where there is insufficient space to install other treatment elements (e.g. swales or ponds).

**Diagram 3: Typical schematic of a hydrodynamic vortex separator (CIRIA (2015) courtesy of Hydro International)**




2.1.13 The HVS for the proposed scheme are of the ‘Advanced’ type as they contain components to enhance separation of pollutants and store them to prevent re-suspension.

2.1.14 The HVS 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 ‘Treatment Efficiency Calculations’ and is dependent on the correct design, maintenance, and commitment to a management schedule. An indicative maintenance schedule for HVS is provided in Table 1.

**Table 1: Indicative maintenance schedule for HVS (adapted from CIRIA, 2015 and Hydro International, undated).**

| Maintenance Schedule | Required Action | Typical/recommended frequency |
|---|---|---|
| Routine maintenance | Remove litter and debris and inspect for sediment oil and grease accumulation | Every 6 months |
| | Change the filter media | At least once a year but site specific depending on hydrological loading |
| | Remove sediment, oil, greases and floatables | Once annually OR indicated by system inspections or immediately following significant spill |
| Remedial actions | Replace malfunctioning parts or structures | As required |
| Monitoring | Inspect for evidence of poor operation | Every 6 months |
| | Inspect filter media and establish appropriate replacement frequencies | Every 6 months |
| | Inspect sediment accumulation rates and establish appropriate removal frequencies | Monthly during the first 6 months then every 6 months thereafter |

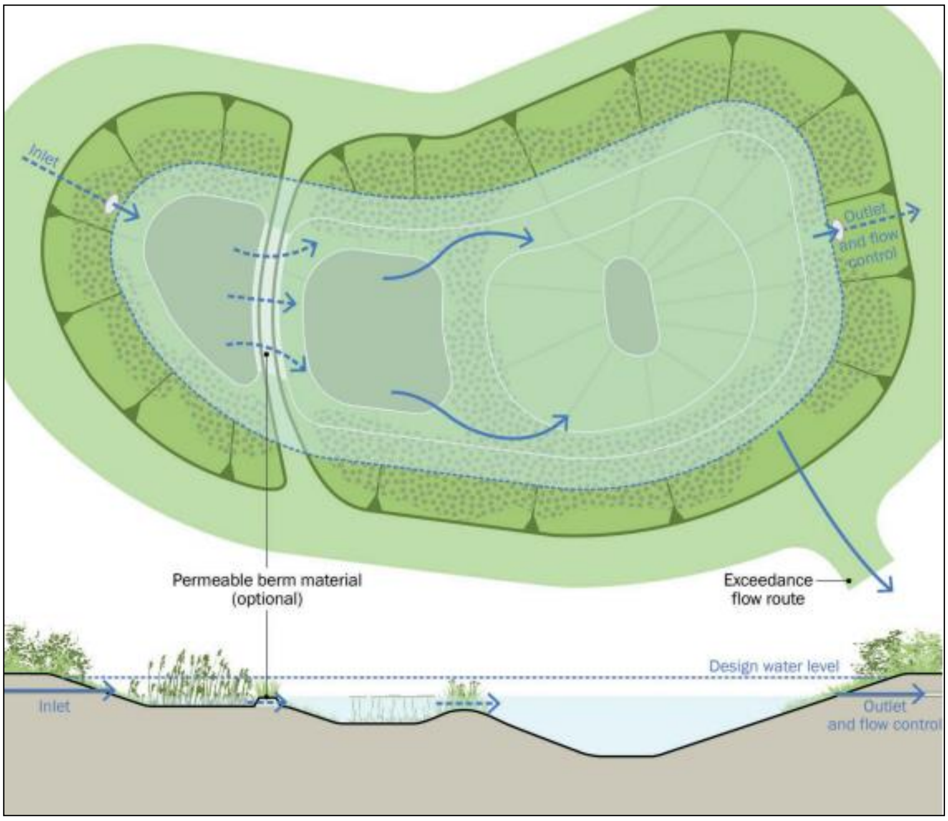
### Retention ponds

2.1.15 Retention ponds 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. Diagram 4 shows a typical schematic of a retention pond (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)**




2.1.16 To maximise treatment efficiency, retention ponds should include a forebay 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 pond.

2.1.17 Planting aquatic vegetation within and across the retention pond 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.

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

2.1.19 The retention ponds 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 retention ponds should include:

- removal of litter and debris;

- management of vegetation through grass cutting, pruning of any marginal or aquatic vegetation and removal of any nuisance plants, especially trees;
- 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
- removal of accumulated sediment from inlets, outlets and within pond.

# 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 specified 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 2 summarises the RSTs for dissolved Cu and dissolved Zn used within HAWRAT.

**Table 2: RSTs for short-term exposure (WRc, 2007 cited within Highways Agency et al., 2009)**

| | | Zn (µg/l) Hardness | | |
|---|---|---|---|---|
| Threshold | Cu (µg/l) | Low (<50mg $CaCO_3$/l) | Medium (50 – 200mg $CaCO_3$/l) | High (>200mg $CaCO_3$/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 3 shows the number of exceedances used to determine a HAWRAT 'pass'.

**Table 3: 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 4.

**Table 4: 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 total 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 5 details TELs and PELs for a range of sediment-bound pollutants found in highway runoff.

**Table 5: TELs and PELs for highway pollutants (Gaskell et al., 2008 cited within Highways Agency et al., 2009)**

| 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 four variants of SuDS treatment train components, comprising:

- Treatment Train 1: filter drains and a retention pond;
- Treatment Train 2: filter drains and a Hydrodynamic Vortex Separator (HVS); and
- Treatment Train 3: filter strips and filter drains.

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 retention ponds and filter strips are based on the average percentage removal derived from the inflow and outflow concentrations provided in Table 26.13 of 'The SuDS Manual'. As an example, Table 6 and the calculation below shows how the treatment efficiency has been derived from Table 26.13.

**Table 6: 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 retention pond | 4 - 28 | 16 |
| Outflow from filter strip** | 10 – 35 | 22.5 |

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

** % of mean inflow concentration remaining after treatment = *22.5 / 67 x 100 = 34%* thus; removal efficiency = *100% - 34% = 66%*

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 or HVS; consequently, the DMRB HD 33/16 values have also been used for filter drains and HVS for TSS, dissolved Cu and dissolved Zn.

3.1.18 The subsequent removal efficiencies derived for each SuDS component are provided in Table 7.

**Table 7: Treatment efficiencies of SuDS components**

| Drainage System | Treatment Efficiencies (%) | | |
|---|---|---|---|
| | Dissolved Cu | Dissolved Zn | TSS |
| Filter drain | 0 | 45 | 60 |
| Filter strip | 15 | 15 | 66 |
| HVS | 0 | 15 | 40 |
| Retention pond (wet) | 40 | 30 | 76 |

3.1.19 The overall treatment efficiencies of the four treatment train components in combination are shown in the following section. '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.

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

*Treatment of Cu:*

- Treatment train 1 includes **40%** treatment for dissolved Cu;
- Treatment train 2 does not include any (**0%**) treatment for dissolved Cu; and
- Treatment train 3 includes **15%** treatment for dissolved Cu

*Treatment of Zn:*

- Treatment train 1: 100% x (1 – 0.45) x (1 – 0.15) = 47% of dissolved Zn remaining, therefore the treatment efficiency is **53%**;
- Treatment train 2: 100% x (1 – 0.45) x (1 – 0.07) = 52% of dissolved Zn remaining, therefore the treatment efficiency is **48%**; and
- Treatment train 3: 100% x (1 – 0.15) x (1 – 0.22) x (1 – 0.67) = 67% of dissolved Zn remaining, therefore the treatment efficiency is **33%.**

*Calculation for Settlement of Suspended Sediment:*

- Treatment train 1: 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%**;
- Treatment train 2: 100% x (1 – 0.60) x (1 – 0.20) = 32% sediment remaining after treatment, therefore the settlement efficiency (relevant to sediment chronic impacts is **68%**; and
- Treatment train 3: 100% x (1 – 0.66) x (1 – 0.30) x (1 – 0.38) = 24% sediment remaining after treatment, therefore the settlement efficiency (relevant to sediment chronic impacts) is **76%.**

3.1.21 Table 8 below, shows the different pollutant removal efficiencies for TSS, dissolved Cu and dissolved Zn, for treatment trains 1 to 3.

**Table 8: Treatment train 1, 2 & 3 – summary of pollutant removal efficiencies**

| Drainage System | Treatment Efficiencies (%) | | |
|---|---|---|---|
| | Dissolved Cu | Dissolved Zn | TSS |
| **Treatment Train 1** | | | |
| Filter drain | 0 | 45 | 60 |
| Retention Pond (Wet) | 40 | 15* | 38* |
| *Total system* | *40* | *53* | *75* |
| **Treatment Train 2** | | | |
| Filter drain | 0 | 45 | 60 |
| HVS | 0 | 7* | 20* |
| *Total system* | *0* | *48* | *68* |
| **Treatment Train 3** | | | |
| Filter strip | 15 | 15 | 66 |
| Filter drain | 0 | 22* | 30* |
| *Total system* | *15* | *33* | *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 9. The location of SuDS ponds and outfalls in relation to the proposed scheme and watercourses are provided in Figure 11.1. Where cumulative assessments have been undertaken, the most downstream outfall location has been selected (as required by HD45/09 guidance).

3.1.23 It is noted that on drainage runs A and B, it is proposed to discharge to existing drainage associated with the already dualled A9 and the location of these outfalls has been assumed based on the survey data and topography. No new outfalls are proposed for these drainage runs and therefore these are not shown with the proposed scheme on Figure 11.1.

3.1.24 For drainage run B, Geocellular Storage will also be incorporated to provide attenuation; however, this component is not discussed further within this appendix as it does not provide any water quality benefits. It is noted that drainage catchments D1 and D2 share the same outfall (D) but have been assessed individually due to their different treatment trains.

**Table 9: Location details**

| Outfall(s) | Assessment | Receiving Watercourse | OS Grid Reference of Assessment/Outfall Location | | Proposed Treatment Train |
|---|---|---|---|---|---|
| | | | Easting | Northing | |
| A | Non-cumulative | Altrory Burn (WF57) | 295900 | 756134 | 2 – Filter Drains and HVS |
| B | Non-cumulative | River Tummel (WF70) | 295673 | 755646 | 3 – Filter Strips and Filter Drains |
| C | Non-cumulative | River Tummel (WF70) | 295237 | 756778 | 1 – Filter Drains and Retention Pond |
| D (Drainage Catchment D1) | Non-cumulative | WF191 | 294724 | 756624 | 2 – Filter Drains and HVS |
| D (Drainage Catchment D2) | Non-cumulative | WF191 | 294724 | 756624 | 1 – Filter Drains and Retention Pond |
| E | Non-cumulative | Loch Faskally (WF70) | 292864 | 758530 | 2 – Filter Drains and HVS |
| F | Non-cumulative | Loch Faskally (WF70) | 292875 | 758629 | 2 – Filter Drains and HVS |
| G | Non-cumulative | Loch Faskally (WF70) | 292875 | 758629 | 1 – Filter Drains and Retention Pond |
| H | Non-cumulative | Un-named burn (WF74) | 292193 | 759475 | 1 – Filter Drains and Retention Pond |
| I | Non-cumulative | Un-named burn (WF77) | 291628 | 760565 | 1 – Filter Drains and Retention Pond |
| B + C | Cumulative | River Tummel (WF70) | 295673 | 755646 | 1 – Filter Drains and Retention Pond |
| D (Drainage Catchments D1+D2) | Cumulative | WF191 | 294724 | 756624 | 1 – Filter Drains and Retention Pond |
| E + F + G | Cumulative | Loch Faskally (WF70) | 292875 | 758629 | 1 – Filter Drains and Retention Pond |
| F + G | Cumulative | Loch Faskally (WF70) | 292875 | 758629 | 1 – Filter Drains and Retention Pond |

3.1.25 Input parameters (both generic to all outfalls and specific to individual outfalls) and data sources used within the assessments are presented in Tables 10-12.

**Table 10: Generic user parameters applied to all outfalls**

| Parameter | Units | Value Used | Notes/Sources |
|---|---|---|---|
| AADT | vpd | >10,000 and <50,000 | Design year 2041<br>Source: Jacobs' traffic modelling team. |
| Climatic Region | - | Colder Wet | Source: HAWRAT Help v1.0 |
| Rainfall Site | - | Ardtalnaig (SAAR 1343.9 mm) | Source: HAWRAT Help v1.0 |

JACOBS

| Parameter | Units | Value Used | Notes/Sources |
|---|---|---|---|
| Hardness | $CaCO_3$ mg/l | Low = <50mg $CaCO_3$/l | Worst-case scenario. SEPA water quality monitoring data for River Tay at Pitnacree to provide information (here). |

**Table 11: Information sources**

| Parameter | Notes/Sources |
|---|---|
| 95%ile River Flow ($m^3$/s) | Source: Jacobs' hydrologists (see Appendix A11.2 for more details) |
| 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, River Tummel and Loch Faskally form part of the River Tay SAC (GIS data provided through consultation with SNH) |
| 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 levels of treatment (from list of four different treatment components): filter drains, filter strips, retention pond, HVS) were selected for each of the three treatment trains<br>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 levels of treatment (from list of four different treatment train components: filter drains, filter strips, retention pond, HVS) were selected for each of the three treatment trains. 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 12: Specific user parameters – Outfalls A to I**

| Parameter | Outfall | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D(1) | D(2) | E | F | G | H | I |
| Receiving Watercourse | WF57 | WF70 | WF70 | WF191 | WF191 | WF75 | WF75 | WF75 | WF74 | WF77 |
| 95%ile River Flow ($m^3$/s) | 0.002 | 19.84 | 19.81 | 0.003 | 0.003 | 19.34 | 19.34 | 19.34 | 0.003 | 0.002 |
| Baseflow Index (BFI) | 0.599 | 0.418 | 0.418 | 0.64 | 0.64 | 0.418 | 0.418 | 0.418 | 0.598 | 0.568 |
| Impermeable road area drained (ha) | 1.29 | 0.344 | 1.047 | 1.355 | 5.304 | 2.503 | 0.74 | 3.827 | 0.97 | 3.483 |
| Permeable area draining to outfall (ha) | 0.269 | 0.523 | 0.21 | 0.164 | 2.876 | 0.947 | 0.076 | 1.926 | 3.585 | 5.509 |
| Within 1km upstream of a protected site? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

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| Parameter | Outfall | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D(1) | D(2) | E | F | G | H | I |
| Downstream structure that reduces the velocity <100m? | Yes | Yes | No | No | No | No | No | No | Yes | Yes |
| Tier 1 / Tier 2t | Tier 2 | Tier 1 | Tier 1 | Tier 2 | Tier 2 | Tier 1 | Tier 1 | Tier 1 | Tier 2 | Tier 2 |
| Estimated river width at Q95 (m) | 1.0 | 60 | 90 | 1 | 1 | 70 | 110 | 110 | 1.10 | 1.50 |
| Tier 2 Bed width (m) | 0.8 | - | - | 1 | 1 | - | - | - | 1.10 | 1.50 |
| Tier 2 Side slope (m/m) | 1.18 | - | - | 0.5 | 0.5 | - | - | - | 1.09 | 7.80 |
| Tier 2 Long slope (m/m) | 0.0003 | - | - | 0.0086 | 0.0086 | - | - | - | 0.077 | 0.092 |
| Tier 2 Manning's n | 0.030 | - | - | 0.070 | 0.070 | - | - | - | 0.030 | 0.030 |
| 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) 48 (Zn) | 15 (Cu) 33 (Zn) | 40 (Cu) 53 (Zn) | 0 (Cu) 48 (Zn) | 40 (Cu) 53 (Zn) | 0 (Cu) 48 (Zn) | 0 (Cu) 48 (Zn) | 40 (Cu) 53 (Zn) | 40 (Cu) 53 (Zn) | 40 (Cu) 53 (Zn) |
| Proposed attenuation – restricted discharge rate (l/s) | n/a | n/a | 2.40 | n/a | 34.9 | n/a | n/a | 21.6 | 12.7 | 13.8 |
| Proposed settlement of sediments (%) | 68 | 76 | 75 | 68 | 75 | 68 | 68 | 75 | 75 | 75 |

<u>Limitations</u>

3.1.26 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.

3.1.27 HAWRAT is primarily designed for 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). Calculations by the Jacobs traffic modelling team 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**

3.1.28 Method D of HD 45/09 has been designed to calculate spillage risk during operation of the 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 watercourse.

3.1.29 The risk factors applicable to the A9 Dualling: Pitlochry to Killiecrankie project 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 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 (Highways Agency et al. 2009)

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

3.1.30 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 13;
- AADT = Annual Average Daily Traffic (in design year 2041); and
- %HGV = percentage of Heavy Goods Vehicles (in design year 2041).

3.1.31 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 Scheme).

3.1.32 In line with HD 45/09 (Highways Agency et al., 2009), 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.

3.1.33 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**

3.1.34 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 associated with the accesses.

3.1.35 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:

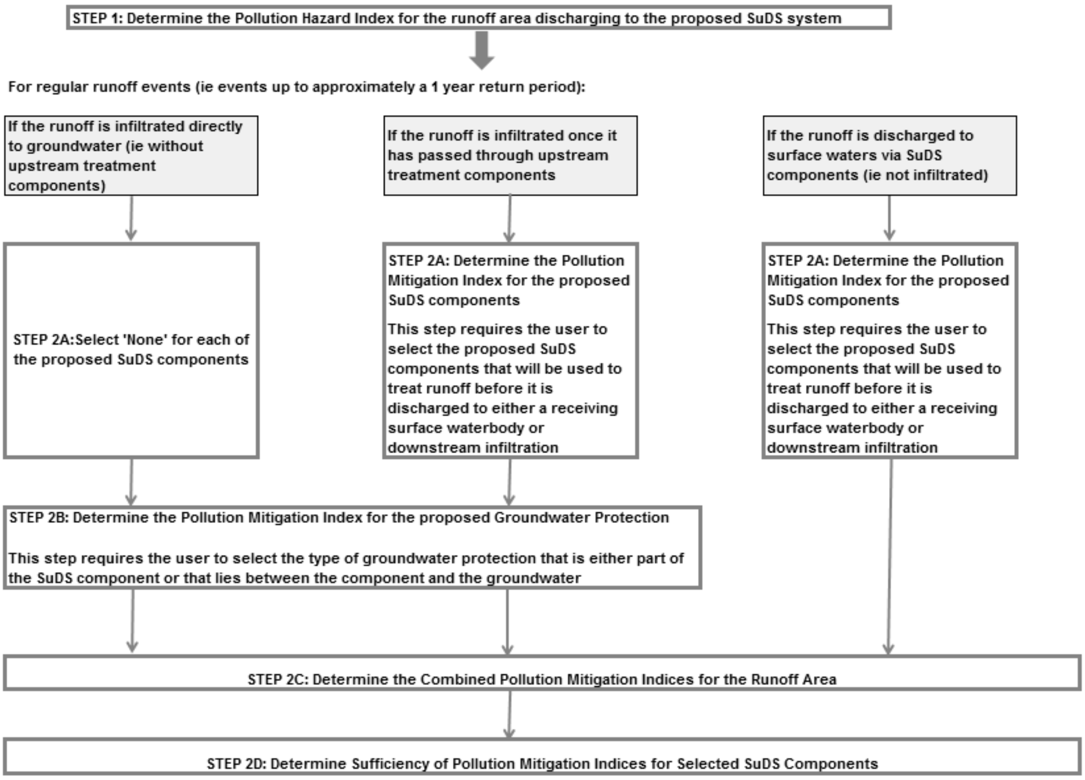
- Pollution Hazard Indices (PHI) of between 0 and 1, based on the pollutant levels likely for different land-use types, where higher values indicate higher pollutant levels; and
- Pollution Mitigation Indices (PMI) of between 0 and 1, based on the ability of SuDS components or groundwater protection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

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

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

3.1.37 A simple flow chart, containing up to five steps, is then followed as shown in Diagram 4 below:

**Diagram 4: Simple Index Approach: Process Flow Chart (from the SIA tool produced on behalf of SEPA by (CIRIA, 2015))**




3.1.38 The Tier 3 accesses will generally be unsurfaced and will be 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 (CIRIA, 2015).

3.1.39 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 (CIRIA, 2015).

3.1.40 The adoption of infiltration trenches and dispersal of runoff over dense vegetation will provide treatment and attenuation 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.

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

<u>Limitations</u>

3.1.42 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 design stage.

**Salt Assessment**

3.1.43 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).

3.1.44 Research by Jacobs has not identified an applicable methodology for the assessment of salt from other reference sources, and specifically the concentration of chloride ions on the water environment, however, it is known that chloride 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, however, 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).

3.1.45 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 environment.

3.1.46 In the absence of an existing method for assessing salt concentrations in 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.

3.1.47 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 outfall. 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).

3.1.48 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.

3.1.49 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. Resultant $Cl^-$ concentrations are then compared against guidance concentrations reported by the Canadian Council of Ministers to the Environment for short-term exposure of 640mg/l. The Canadian guidance is based on chloride 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 chloride.

3.1.50 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) |

<u>Limitations</u>

3.1.51 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'.

4.1.2 Where a 'fail' is recorded at Step 2 of the assessment, the required mitigation percentage to achieve a 'pass' is stated. The resulting Magnitude of Impact, as used within Chapter 11 (Road Drainage and Water Environment), is also provided.

4.1.3 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.

4.1.4 At Step 2 (pre-mitigation), four outfalls (A, D, H and I) fail the HAWRAT routine runoff assessment. The fail for Outfall A is reported for both sediment and soluble impacts. The fail for Outfall D occurs for:

- the non-cumulative assessment of Drainage Catchment D1 for soluble impacts only;
- the non-cumulative assessment of Drainage Catchment D2 for soluble impacts including EQS compliance; and
- the cumulative assessment for Drainage Catchments D1 and D2 for soluble impacts including EQS compliance.

4.1.5 The fail for Outfall H is reported for soluble impacts only. The fail for Outfall I is reported for soluble impacts including EQS compliance.

4.1.6 At Step 3 (post-mitigation), outfalls A, D and I continue to fail the HAWRAT routine runoff assessment. The fail for outfall A is reported for both soluble and sediment impacts. The fail for outfall D is for soluble pollutants for the non-cumulative assessment of Drainage Catchment D2 and for soluble pollutants including EQS for the cumulative assessment of Drainage Catchments D1 and D2. The fail at outfall I is reported only for soluble impacts. However, both outfalls pass the EQS criteria after mitigation.

**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 | 1.8 (21%) | 2.9 (50%) | 0.2 | 0.7 | 0.84 | 2.59 | 0.07 | 451 (78%) | **Moderate** | 1.8 | 1.3 | 0.2 | 0 | 0.84 | 1.34 | 0.07 | 144 | **Moderate** |
| B | 0 | 0 | 0 | 0 | 0 | 0 | 0.19 | - | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | 0.19 | - | Negligible |
| C | 0 | 0 | 0 | 0 | 0 | 0 | 0.10 | 0 | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | 0.10 | 0 | Negligible |
| D1 | 1.1 (12%) | 2.2 (42%) | 0 | 0.6 | 0.65 | 2 | 0.13 | - | Minor | 0 | 0.6 | 0 | 0 | 0.65 | 1.04 | 0.13 | - | Negligible |
| D2 | 5.5 (47%) | 5.9 (63%) | 0.8 | 1.6 | 1.6 | 4.94 | 0.13 | - | **Major** | 1.80 | 1.30 | 0.20 | 0 | 0.95 | 2.18 | 0.19 | - | Minor |
| E | 0 | 0 | 0 | 0 | 0 | 0 | 0.14 | - | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | 0.14 | - | Negligible |
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0 | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0 | Negligible |
| G | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 2 | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0 | Negligible |
| H | 0.4 | 1.4 (21%) | 0 | 0.1 | 0.47 | 1.44 | 0.41 | - | Minor | 0.1 | 0.3 | 0 | 0 | 0.32 | 0.77 | 0.41 | - | Negligible |
| I | 4.6 (45%) | 5.2 (60%) | 0.50 | 1.50 | 1.55 | 4.71 | 0.33 | - | **Major** | 1.10 | 0.9 | 0.20 | 0 | 0.93 | 2.29 | 0.33 | - | Minor |

* Refer to Appendix A11.7 (Road Drainage and Water Environmental – Impact Assessment Tables) for full operational impact assessment results

**Table 16: Results of 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 | | | |
| B + C | 0 | 0 | 0 | 0 | 0 | 0 | - | - | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | - | - | Negligible |
| D1 + D2 | 6.2 | 6.8 | 1 | 2.3 | 1.82 | 5.66 | 0.13 | - | **Major** | 1.7 | 1.8 | 0.2 | 0.4 | 1.1 | 2.7 | 0.13 | - | **Major** |
| E + F + G | 0 | 0 | 0 | 0 | 0 | 0 | - | - | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | - | - | Negligible |
| F + G | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 3 | Negligible | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0 | Negligible |

* Refer to Appendix A11.7 (Road Drainage and Water Environmental – Impact Assessment Tables) for full operational impact assessment results

**Accidental Spillage Assessment**

4.1.7 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.

4.1.8 The annual probability of a serious pollution incident occurring within each highway catchment draining to an individual outfall, and cumulatively draining to the River Tummel (WF70) and Loch Faskally (WF75), has been estimated to be far below the 0.5% AEP (1:200 year) guidance quoted in DMRB HD 45/09 for sensitive areas.

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**Table 17: 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 ($P_{POL}$) | Probability of Spillage ($P_{SPL}$) | Probability of Incident ($P_{INC}$) | Probability of Incident ($P_{INC}$) % | Return Period (Years) | Within Acceptable Limits? * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Outfall A** | | | | | | | | | | | |
| Altrory Burn (WF57) | Mainline | 0.29 | 0.361 | 23,117 | 14 | 0.6 | 0.0001237 | 0.000074 | 0.007 | 13,477 | **Yes** |
| | Pitlochry South Junction SB Merge | 0.83 | 0.279 | 3,660 | 9 | 0.6 | 0.0000278 | 0.000017 | 0.002 | 59,858 | |
| | | | | | | **Total:** | **0.0001515** | **0.000091** | **0.009** | **11,000** | |
| **Outfall B** | | | | | | | | | | | |
| River Tummel (WF70) | Pitlochry South Junction NB Diverge | 0.83 | 0.4 | 3,446 | 9 | 0.6 | 0.0000376 | 0.000023 | 0.002 | 44,347 | **Yes** |
| | | | | | | **Total:** | **0.0000376** | **0.000023** | **0.0023** | **44,347** | |
| **Outfall C** | | | | | | | | | | | |
| River Tummel (WF70) | Mainline | 0.29 | 0.26 | 16,013 | 15 | 0.6 | 0.0000661 | 0.000040 | 0.004 | 25,213 | **Yes** |
| | Pitlochry South Junction SB Merge | 0.83 | 0.186 | 3,660 | 9 | 0.6 | 0.0000186 | 0.000011 | 0.001 | 89,793 | |
| | | | | | | **Total:** | **0.0000847** | **0.000051** | **0.005** | **19,685** | |
| **Outfall D(1)** | | | | | | | | | | | |
| WF191 | Mainline | 0.29 | 0.45 | 16,013 | 15 | 0.6 | 0.0001144 | 0.000069 | 0.01 | 14,567 | **Yes** |
| | | | | | | **Total:** | **0.0001144** | **0.000069** | **0.01** | **14,567** | |
| **Outfall D(2)** | | | | | | | | | | | |
| WF191 | Mainline | 0.29 | 1.85 | 16,013 | 15 | 0.6 | 0.0004704 | 0.000282 | 0.03 | 3543 | Yes |
| | Foss Road | 0.93 | 0.313 | 350 | 10 | 0.6 | 0.000037 | 0.000002 | 0.00 | 448188 | |
| | | | | | | **Total:** | **0.0004741** | **0.000274** | **0.03** | **3516** | |
| **Outfall E** | | | | | | | | | | | |
| Loch Faskally (WF75) | Mainline | 0.29 | 0.56 | 16,049 | 15 | 0.6 | 0.0001435 | 0.000086 | 0.00861 | 11,617 | **Yes** |
| | Pitlochry Estate Access | 0.93 | 0.35 | 0 | 0 | 0.6 | - | - | - | - | |
| | Clunie-Foss Road | 0.93 | 0.49 | 414 | 9 | 0.6 | 0.0000062 | 0.000004 | 0.00037 | 267,834 | |
| | | | | | | **Total:** | **0.0001497** | **0.000090** | **0.00898** | **11,134** | |
| **Outfall F** | | | | | | | | | | | |

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| Receiving water feature | Section | Risk Weighting | Length within catchment (km) | Annual Average Daily Traffic (vpd) | %HGV | Probability Score ($P_{POL}$) | Probability of Spillage ($P_{SPL}$) | Probability of Incident ($P_{INC}$) | Probability of Incident ($P_{INC}$) % | Return Period (Years) | Within Acceptable Limits? * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Loch Faskally (WF75) | Mainline | 0.29 | 0.25 | 16,673 | 15 | 0.6 | 0.0000662 | 0.000040 | 0.0040 | 25,183 | Yes |
| | | | | | | **Total:** | **0.0000662** | **0.000040** | **0.0040** | **25,183** | |
| **Outfall G** | | | | | | | | | | | |
| Loch Faskally (WF75) | Mainline | 0.29 | 0.50 | 16,673 | 15 | 0.6 | 0.0001334 | 0.000080 | 0.0080 | 12,492 | Yes |
| | Pitlochry North Junction NB Diverge | 0.83 | 0.35 | 439 | 11 | 0.6 | 0.0000051 | 0.000003 | 0.0003 | 327,246 | |
| | Pitlochry North Junction SB Merge | 0.83 | 0.31 | 397 | 9 | 0.6 | 0.0000033 | 0.000002 | 0.0002 | 499,907 | |
| | A924/B819 Side Road | 0.93 | 0.78 | 2,857 | 10 | 0.6 | 0.0000756 | 0.000045 | 0.0045 | 22,033 | |
| | | | | | | **Total:** | **0.0002175** | **0.000130** | **0.0130** | **7,663** | |
| **Outfall H** | | | | | | | | | | | |
| Un-named burn (WF74) | Pitlochry North Junction NB Diverge | 0.83 | 0.350 | 439 | 4 | 0.6 | 0.0000019 | 0.000001 | 0.0001 | 895,128 | Yes |
| | Pitlochry North Junction NB Merge | 0.83 | 0.180 | 763 | 9 | 0.6 | 0.0000037 | 0.000002 | 0.0002 | 445,080 | |
| | Pitlochry North Junction NB Diverge (100m from side road) | 0.93 | 0.100 | 439 | 4 | 0.6 | 0.0000006 | 0.000000 | 0.0000 | 2,796,072 | |
| | Pitlochry North Junction NB Merge (100m from side road) | 0.93 | 0.100 | 763 | 9 | 0.6 | 0.0000023 | 0.000001 | 0.0001 | 715,000 | |
| | Pitlochry North Junction Underbridge | 0.93 | 0.010 | 2,857 | 10 | 0.6 | 0.0000010 | 0.000001 | 0.0001 | 1,718,552 | |
| | Pitlochry North Junction SB Diverge | 0.83 | 0.120 | 397 | 9 | 0.6 | 0.0000013 | 0.000001 | 0.0001 | 1,283,109 | |
| | Pitlochry North Junction SB Merge | 0.83 | 0.200 | 690 | 10 | 0.6 | 0.0000042 | 0.000003 | 0.0003 | 398,656 | |
| | SB Diverge 100 m from Roundabout | 3.09 | 0.100 | 397 | 9 | 0.6 | 0.0000040 | 0.000002 | 0.0002 | 413,585 | |

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| Receiving water feature | Section | Risk Weighting | Length within catchment (km) | Annual Average Daily Traffic (vpd) | %HGV | Probability Score ($P_{POL}$) | Probability of Spillage ($P_{SPL}$) | Probability of Incident ($P_{INC}$) | Probability of Incident ($P_{INC}$) % | Return Period (Years) | Within Acceptable Limits? * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SB Merge 100 m from Roundabout | 3.09 | 0.100 | 690 | 10 | 0.6 | 0.0000078 | 0.000005 | 0.0005 | 214,165 | |
| | Underbridge 100 m from Roundabout | 3.09 | 0.100 | 2,857 | 10 | 0.6 | 0.0000322 | 0.000019 | 0.0019 | 51,723 | |
| | | | | | | **Total:** | **0.0000590** | **0.000035** | **0.0035** | **28,240** | |
| **Outfall I** | | | | | | | | | | | |
| Un-named burn (WF77) | Mainline | 0.29 | 0.785 | 16,673 | 15 | 0.6 | 0.0002078 | 0.000125 | 0.0125 | 8,020 | **Yes** |
| | Pitlochry North Junction SB Diverge | 0.83 | 0.593 | 763 | 9 | 0.6 | 0.0000123 | 0.000007 | 0.0007 | 135,214 | |
| | Pitlochry North Junction NB Merge | 0.83 | 0.493 | 397 | 9 | 0.6 | 0.0000053 | 0.000003 | 0.0003 | 312,636 | |
| | | | | | | **Total:** | **0.0002255** | **0.000135** | **0.0135** | **7,392** | |

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

**Table 18: Spillage risk assessment – cumulative outfalls pre-mitigation**

| Receiving water feature | Outfall | Probability of Spillage ($P_{SPL}$) | Probability of Incident ($P_{INC}$) | Probability of Incident ($P_{INC}$) % | Return Period (Years) | Within Acceptable Limits? * |
|---|---|---|---|---|---|---|
| River Tummel (WF70) | B | 0.00004 | 0.00002 | 0.00225 | 44,347 | Yes |
| | C | 0.00008 | 0.00005 | 0.00508 | 19,685 | Yes |
| | **Total** | **0.00012** | **0.00007** | **0.00703** | **14,225** | **Yes** |
| WF191 | D1 | 0.0001144 | 0.000069 | 0.01 | 14,567 | Yes |
| | D2 | 0.0004741 | 0.000274 | 0.03 | 3516 | Yes |
| | Total | 0.0005885 | 0.000343 | 0.04 | 2915 | Yes |
| Loch Faskally (WF75) | E | 0.00015 | 0.00009 | 0.00898 | 11,134 | Yes |
| | F | 0.00007 | 0.00004 | 0.00397 | 25,183 | Yes |
| | G | 0.00022 | 0.00013 | 0.01305 | 7,663 | Yes |
| | **Total** | **0.00043** | **0.00026** | **0.02600** | **3,846** | **Yes** |

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

### Simple Index Approach for Tier 3 Accesses

4.1.9 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) will be 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 |
| SPMI SuDS | None | 0 | 0 | 0 |
| PMI Groundwater Protection | Dense vegetation layer underlain by 300 mm minimum depth of soils with good contamination attenuation potential' | 0.6 | 0.5 | 0.6 |
| | 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 |
| **Sufficiency of Pollutant Mitigation Indices (PHI≤PMI)** | | **Sufficient** | **Sufficient** | **Sufficient** |

### Salt Assessment

4.1.10 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’.

4.1.11 The results show that concentrations of Cl- exceed the Canadian short-term guideline concentration at four water features (WF57, WF74, WF77 and WF191), when the maximum spreading rate is applied to the road surface in conjunction with a 15mm depth rainfall event.

**Table 20: Specific input parameters and results**

| Outfall | Receiving Watercourse | Catchment Area (ha) | Impermeable Area Draining to Outfall ($m^2$) | Mean flow ($m^3/s$) | Maximum Discharge Rate (l/s) | Outflow Concentration of NaCl (mg/l) | Outflow Concentration of $Cl^-$ (mg/l) | Comparison to Canadian WQG-S (640 mg$Cl^-$/l) |
|---|---|---|---|---|---|---|---|---|
| A | Altrory Burn (WF57) | 1.56 | 12,880 | 0.011 | 15.8* | 2,045 | 1,247 | Fail |
| B | River Tummel (WF70) | 0.87 | 3,440 | 75.1 | 7.70* | 100 | 61 | Pass |
| C | River Tummel (WF70) | 1.26 | 10,470 | 75.0 | 2.4 | 100 | 61 | Pass |
| D(1) | WF191 | 1.52 | 13,550 | 0.015 | 10.3* | 1463 | 896 | Fail |
| D(2) | WF191 | 8.18 | 53,040 | 0.015 | 34.9 | 2442 | 1490 | Fail |
| E | Loch Faskally (WF75) | 3.45 | 25,030 | 73.2 | 134* | 106 | 65 | Pass |
| F | Loch Faskally (WF75) | 0.82 | 7,400 | 73.2 | 9.01* | 100 | 61 | Pass |
| G | Loch Faskally (WF75) | 5.75 | 38,270 | 73.2 | 21.6 | 101 | 62 | Pass |
| H | Un-named burn (WF74) | 4.56 | 9,700 | 0.016 | 12.7 | 1,592 | 971 | Fail |
| I | Un-named burn (WF77) | 6.54 | 34,520 | 0.011 | 13.8 | 1,963 | 1,197 | Fail |

*At the time of assessment, maximum discharge rates have not been received. A conservative approach whereby the maximum discharge rate is based on the specific 200-year (plus climate change) design flow (i.e. the Q200 +CC flow per unit area in $m^3/s/km^2$ or l/s/ha) is adopted. It is noted that a maximum discharge rate based on the specific QMED per unit area does not change the result in terms of ‘pass’ or ‘fail’.

# 5 Summary

**HAWRAT Routine Runoff Assessment**

5.1.1 After the adoption of mitigation, only outfalls A (discharging to WF57), D1/D2 (discharging to WF191) and I (discharging to WF77) fail components of the HAWRAT routine runoff assessment. The fail for outfall A is reported for both soluble and sediment impacts, the fail for outfalls D1 and D2 is reported for soluble impacts and exceedance of AA-EQS for dissolved Cu, and the fail at outfall I is reported only for soluble impacts. Except for combined outfall D1/D2, all of the outfalls assessed cumulatively, pass the routine runoff assessments.

5.1.2 The failure of the HAWRAT routine runoff assessment at outfalls A, D and I, after the implementation of mitigation, is due to the low $Q_{95}$ value (0.002 – 0.003m$^3$/s) estimated for these watercourses. The $Q_{95}$ in these watercourses is so low, that no matter how much mitigation (SuDS) is installed, the results will not improve sufficiently give a 'pass' result. However, once the sensitivity of the watercourse has been taken into consideration (WF57 and WF191 have 'low' sensitivities for Water Quality and WF77 'medium' respectively); no watercourse is reported as having a significant impact ('Moderate adverse' or above) within Chapter 11 (Road Drainage and Water Environment). 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 WF57 and WF191 discharge to the River Tummel and WF77 discharges to the River Garry. Both the River Tummel and River Garry are large watercourses with a high dilution capacity, therefore water quality will only be impacted in a relatively short section of the smaller watercourses (WF57, WF191 and WF77 all have catchment areas of <1.1 km$^2$).

5.1.4 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).

5.1.5 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 Tummel (SAC) catchment as a whole will benefit from the adoption of SuDS treatment with the dualling of the A9, as there is generally no such treatment associated with the existing A9 drainage.

**Accidental Spillage Assessment**

5.1.6 The annual probability of a serious pollution incident occurring within each highway catchment draining to an individual outfall has been estimated to be far 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).

5.1.7 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. Both locations and the surrounding areas 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).

5.1.8 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 the localised risks resulting from the road environment.

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### Simple Index Approach for Tier 3 Accesses

5.1.9 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.

5.1.10 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

5.1.11 The results of the salt assessment show that concentrations of $Cl^-$ exceed the Canadian short-term water quality guideline of 640mg/l (based on chloride toxicity tests) at four water features (WF57, WF74, WF77 and WF191). These water features are of a low sensitivity, as they are generally unsuitable for fish species (presently and likely to continue to be the case in the future) and no protected aquatic ecological species have been identified within them, therefore the impact is considered insignificant.

5.1.12 In addition, 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.

5.1.13 Concentrations of $Cl^-$ within WF57, WF74, WF77 and WF191 will become further diluted when they discharge into the River Tummel, which forms part of the wider River Tay SAC and the nearest location where protected species could be impacted by $Cl^-$. The assessment shows that the significant dilution would reduce $Cl^-$ levels to below the Canadian short-term water quality guideline value.

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