A9.3: Water Quality Calculations

1 Introduction

1.1.1 This appendix provides additional information on the calculations used to inform the water quality assessment of the proposed scheme, as reported in ES Chapter 9 (Road Drainage and the Water Environment).

1.1.2 As part of the water quality assessment, routine runoff and accidental spillage risk to the watercourses proposed to receive road drainage were assessed using the Highways Agency's Water Risk Assessment Tool (HAWRAT), in line with DMRB HD 45/09 guidance (Highways Agency et al., 2009a). The approach and methods used in these assessments are described below.

Routine Runoff Calculations

1.1.3 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), including over a typical exposure period of six hours (RST 6 hour) and for a worst-case scenario of 24 hours (RST 24 hour). Dissolved copper and dissolved zinc are used as indicators of the level of impact as they can result in particularly acute toxic effects to aquatic life in certain concentrations. Table 1 summarises the RSTs for dissolved copper and dissolved zinc used within HAWRAT.

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

		Zinc (µg/l) Hardness		
Threshold	**Copper (µg/l)**	**Low (<50mg CaCO3/l)**	**Medium (50 to 200mg CaCO3/l)**	**High (>200mg CaCO3/l)**
RST 24 hour	21	60	92	385
RST 6 hour	42	120	184	770

1.1.4 HAWRAT also assesses chronic impacts associated with sediment-bound pollutants on aquatic ecology within watercourses. Two standards have been devised for metal and polycyclic aromatic hydrocarbon (PAH) concentrations within sediment, namely Threshold Effects Levels (TELs) (i.e. the concentration below which toxic effects are extremely rare) and Probable Effects Levels (PELs) (i.e. the concentration above which toxic effects are observed on most occasions). Table 2 summarises some of the key sediment-bound pollutant thresholds used within HAWRAT.

Table 2: Sediment Concentrations TELs and PELs (Gaskell et al., 2008 cited within Highways Agency et al., 2009a)

Parameter	**TEL (units are in mg/kg unless stated otherwise)**	**PEL (units are in mg/kg unless stated otherwise)**
Copper	35.7	197
Zinc	123	315
Cadmium	0.6	3.5
Total PAH	**1,684 µg/kg**	**16,770 µg/kg**

1.1.5 HAWRAT estimates in-river annual average concentrations for soluble pollutants (dissolved copper and dissolved zinc) which includes the contribution from road runoff. These concentrations can be compared with published Environmental Quality Standards (EQS) values to assess whether there is likely to be a long-term impact on ecology, as shown in Table 3. These figures have been taken

from the DMRB HD 45/09 guidance (Highways Agency et al., 2009a), where it is noted that the figures for dissolved zinc are only provisional.

Table 3: EQS for the Protection of all Freshwater Life

Parameter	Hardness Range (mg/l CaCO3)	Freshwater EQS (µg/l) (annual average)
Dissolved Copper	0 – 50	1
	>50 – 100	6
	>100 – 250	10
	>250	28
Dissolved Zinc	0 – 50	7.8
	>50 – 100	
	>100 – 250	
	>250	

1.1.6 HAWRAT uses a three-stage tiered approach to assessing the impacts of both soluble pollutants and sediment-bound pollutants. Each pollutant type is given a status of 'Pass' or 'Fail' depending on whether the risk is within or exceeds the published thresholds. The impact of routine runoff to each receiving watercourse is summarised by a 'traffic light' reporting, whereby:

- Red = unacceptable impact (i.e. one or more pollutant concentrations exceed thresholds and therefore incur a Fail result) or a need to carry out further stages of assessment.
- Green = no significant impact (i.e. pollutant concentrations are within thresholds and therefore incur a Pass result) with no need for further assessment.
- Amber = for assessment of sediment-bound pollutants, where the assessment would otherwise indicate a Pass result, the tool produces an 'Alert' result indicating that the presence of protected nature sites and/or a downstream structure impacting on flow velocity may require further site-specific consideration.

1.1.7 Where a given scenario produces a Fail result for one or more of the pollutant types, the next step is required based on increasing levels of input parameters and assessment. The three step approach is summarised below:

- Step 1: Runoff Quality (predicts the concentrations of pollutants in untreated and undiluted highway runoff prior to any treatment and dilution in a water body). This is the 'worst case' scenario.
- Step 2: In-River Impacts (predicts the concentrations of pollutants after mixing within the receiving water body). At this stage, the ability of the receiving watercourse to disperse sediments is considered and, if sediment is predicted to accumulate, the potential extent of sediment coverage (i.e. the deposition index, DI) is also considered.
- Step 3: In-River Impacts with mitigation. Steps 1 and 2 assume that the road drainage system incorporates no mitigation measures to reduce the risk. Step 3 includes mitigation, in the form of sustainable drainage systems (SUDS), which takes into account the risk reduction associated with any existing measures or any proposed new measures. SUDS are a requirement under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) for new development, even if the risks in HAWRAT are shown to be acceptable, i.e. Pass, prior to any mitigation. Refer to ES Chapter 9 (Road Drainage and the Water Environment) for details on SUDS measures for the proposed scheme.

1.1.8 Step 2 also incorporates two 'tiers' of assessment for sediment accumulation, based on different levels of input parameters. If one or more risks are defined as unacceptable at Tier 1, i.e. Fail, then a more detailed Tier 2 assessment is undertaken, which requires further parameters relating to the

physical dimensions of the receiving watercourse, including bed width, Manning's 'n', bank slope and channel gradient.

1.1.9 In the event that predicted annual average concentrations exceed EQS values for either dissolved copper or zinc after the implementation of mitigation measures, a 'Detailed' assessment would be required (Method B). For further details refer to the DMRB HD 45/09 (Highways Agency et al., 2009a).

Spillage Risk Calculations

1.1.10 Along any road, there is a risk of vehicular collision that could result in the spillage of fuels, oils or chemicals, particularly if tankers are involved. A risk assessment of a serious spillage causing a pollution incident was undertaken using the methodology outlined in the DMRB HD 45/09 (Highways Agency et al., 2009a).

1.1.11 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 and the type of road / junction (Table 4 of this appendix). The annual probability of a serious accidental spillage leading to a serious pollution incident also depends upon the emergency services response time. A risk factor is applied depending on the location and likely response time and the type of receiving water body (Table 5 of this appendix).

Table 4: Serious Accidental Spillages per Billion HGV (km/year)

	Motorways	Rural Trunk Roads	Urban Trunk Roads
No Junction	0.36	0.29	0.31
Slip Road	0.43	0.83	0.36
Roundabout	3.09	3.09	5.35
Crossroad	n/a	0.88	1.46
Side Road	n/a	0.93	1.81
Total	0.37	0.45	0.85

Source: DMRB HD 45/09 (Highways Agency et al., 2009a).

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

Table 5: Probability of a Serious Accidental Spillage Leading to a Serious Pollution Incident

Receiving Waterbody	Urban (response time to site <20 mins)	Rural (response time to site <1 hour)	Remote (response time to site >1 hour)
Surface Watercourse	0.45	0.6	0.75
Groundwater	0.3	0.3	0.5

Source: DMRB HD 45/09 (Highways Agency et al., 2009a).

1.1.12 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 = serious spillage rates from Table 4 of this appendix (or local data if available).
- AADT = Annual Average Daily Traffic (in design year 2034).
- %HGV = percentage of Heavy Goods Vehicles (in design year 2034).

1.1.13 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 (Table 5 of this appendix).

1.1.14 In line with the DMRB (Highways Agency et al., 2009a), where spillage risk is calculated as less than 1% Annual Exceedance Probability (AEP) or less frequent than 1 in 100 years, the spillage falls within acceptable limits and no further spillage prevention measures will be required. Where assessed to be greater than 1% AEP (more frequent than 1 in 100 years), the risk is unacceptable and mitigation will be required to reduce the risk of an impact occurring.

1.1.15 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, such as Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSIs) and salmonid waters, or could affect supplies for potable water or other important abstractions. In these cases, it is more appropriate to achieve a spillage risk of less than 0.5% AEP (less frequent than 1 in 200 years). Where assessed to be greater than 0.5% AEP (more frequent than 1 in 200 years), mitigation will be required to reduce the risk of an impact occurring.

2 Routine Runoff Assessment – HAWRAT Output Sheets (Location Details, User Parameters and Results)

Table 6: Location Details: Outfall A – Shochie Burn

Assessment Type	Non-cumulative assessment (single outfall)	
Receiving watercourse	Shochie Burn	
OS grid reference of assessment point (m)	**Easting**	309200
	Northing	730300
OS grid reference of outfall structure (m)	**Easting**	309200
	Northing	730300
Outfall number	A – Shochie	
List of outfalls in cumulative assessment	n/a	

Table 7: Location Details: Outfall B – Ordie Burn

Assessment Type	Non-cumulative assessment (single outfall)	
Receiving watercourse	Ordie Burn	
OS grid reference of assessment point (m)	**Easting**	308500
	Northing	731900
OS grid reference of outfall structure (m)	**Easting**	308500
	Northing	731900
Outfall number	B – Ordie	
List of outfalls in cumulative assessment	n/a	

Table 8: Location Details: Outfall D – Garry Burn

Assessment Type	Non-cumulative assessment (single outfall)	
Receiving watercourse	Garry Burn	
OS grid reference of assessment point (m)	**Easting**	307160
	Northing	734800
OS grid reference of outfall structure (m)	**Easting**	307160
	Northing	734800
Outfall number	D – Garry	
List of outfalls in cumulative assessment	n/a	

Table 9: Location Details: Outfall E – Gelly Burn

Assessment Type	Non-cumulative assessment (single outfall)	
Receiving watercourse	Gelly Burn	
OS grid reference of assessment point (m)	**Easting**	306800
	Northing	737400
OS grid reference of outfall structure (m)	**Easting**	306800
	Northing	737400
Outfall number	E – Gelly	
List of outfalls in cumulative assessment	n/a	

Table 10: User Parameters: Outfall A – Shochie Burn

Parameter	Units	Default Value	Value used	Notes/Sources
Runoff Risk Assessments				
AADT	vpd	>10,000 and <50,000	>10,000 and <50,000	Design year 2034 (whole scheme) Source: Traffic data (July 2013)
Climatic Region	-	Warm Dry	Colder Wet	Source: HAWRAT Help v1.0 (2009b
Rainfall Site	-	Ashford (SAAR 710mm)	Ardtalnaig (SAAR 1343.9mm)	Source: HAWRAT Help v1.0 (2009b)
95%ile River flow	m3/s	0	0.056	Source: Jacobs hydrologists
Baseflow Index	-	0.5	0.514	Source: FEH CD-Rom (IH, 2009)
Impermeable road area drained	ha	1	5.50	Source: scheme information
Permeable area draining to outfall	ha	1	0	This area makes up the remaining portion of 'Interior Catchment' such as verges, adjacent cuttings and embankments which are assumed to be free from highway-derived pollutants. More difficult to accurately estimate compared to the impermeable road area; precautionary approach is to assume a value of zero. Source: DMRB HD 45/09 (2009)
Is the discharge in or within 1 km upstream of a protected site for conservation?	-	No	Yes	Shochie Burn designated as part of the River Tay SAC and salmonid waters.
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge?	-	No	No	

Parameter	Units	Default Value	Value used	Notes/Sources
Hardness	-	Low = <50mg CaCO3/l	Low <50 mg CaCO3/l	Worst-case scenario based on underlying geology, in absence of hardness data.
Use Tier 1	-	TRUE	FALSE	
Use Tier 2		FALSE	TRUE	
Tier 1 Estimated river width at Q95	0	5	8.5	Source: site information, cross-section survey data
Tier 2 Bed width	m	3	6.2	Source: site information, cross-section survey data
Tier 2 Side slope	m/m	0.5	0.3	Source: site information, cross-section survey data
Tier 2 Long slope	m/m	0.0001	0.0064	Source: long-section survey data
Tier 2 Manning's n	-	0.07	0.04	Lowland Streams: 3 – Clean, winding, some pools and shoals Source: DMRB HA 107/04 (2004) Table 2.1
Existing treatment for solubles	%	0	0	Only partial treatment on existing A9. Precautionary approach to assume no existing treatment.
Existing attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Existing settlement of sediments	%	0	0	
Proposed treatment for solubles	%	0	40	Two levels of treatment: filter drains, SUDS pond (dry) Source: DMRB HA 103/06 (2006) Table 3.2 – Indicative Treatment Efficiencies of Drainage Systems
Proposed attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Proposed settlement of sediments	%	0	15	

Table 11: User Parameters: Outfall B – Ordie Burn

Parameter	Units	Default Value	Value used	Notes/Sources
Runoff Risk Assessments				
AADT	vpd	>10,000 and <50,000	>10,000 and <50,000	Design year 2034 (whole scheme) Source: Traffic data (July 2013)
Climatic Region	-	Warm Dry	Colder Wet	Source: HAWRAT Help v1.0 (2009b)
Rainfall Site	-	Ashford (SAAR 710mm)	Ardtalnaig (SAAR 1343.9mm)	Source: HAWRAT Help v1.0 (2009b)
95%ile River flow	m3/s	0	0.053	Source: Jacobs hydrologists
Baseflow Index	-	0.5	0.587	Source: FEH CD-Rom (IH, 2009)
Impermeable road area drained	ha	1	9.87	Source: scheme information
Permeable area draining to outfall	ha	1	0	This area makes up the remaining portion of 'Interior Catchment' such as verges, adjacent cuttings and embankments which are assumed to be free from highway-derived pollutants. More difficult to accurately estimate compared to the impermeable road area; precautionary approach is to assume a value of zero Source: DMRB HD45/09 (2009)

Parameter	Units	Default Value	Value used	Notes/Sources
Is the discharge in or within 1 km upstream of a protected site for conservation?	-	No	Yes	Shochie Burn designated as part of the River Tay Special Area of Conservation (SAC) and salmonid waters
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge?	-	No	No	
Hardness	-	Low = <50mg CaCO3/l	Low <50 mg CaCO3/l	Worst-case scenario based on knowledge of underlying geology, in the absence of hardness data.
Use Tier 1	-	TRUE	FALSE	
Use Tier 2		FALSE	TRUE	
Tier 1 Estimated river width at Q95	0	5	8.4	Source: site information, cross-section survey data
Tier 2 Bed width	m	3	5.5	Source: site information, cross-section survey data
Tier 2 Side slope	m/m	0.5	0.73	Source: site information, cross-section survey data
Tier 2 Long slope	m/m	0.0001	0.00503	Source: long-section survey data
Tier 2 Manning's n	-	0.07	0.04	Lowland Streams: 3 – Clean, winding, some pools and shoals Source: DMRB HA107/04 (2004) Table 2.1
Existing treatment for solubles	%	0	0	Only partial treatment on existing A9. Precautionary approach to assume no existing treatment.
Existing attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Existing settlement of sediments	%	0	0	
Proposed treatment for solubles	%	0	40	Two levels of treatment: filter drains, SUDS pond (dry) Source: DMRB HA 103/06 (2006) Table 3.2 – Indicative Treatment Efficiencies of Drainage Systems
Proposed attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Proposed settlement of sediments	%	0	15	

Table 12: User Parameters: Outfall D – Garry Burn

Parameter	Units	Default Value	Value used	Notes/Sources
Runoff Risk Assessments				
AADT	vpd	>10,000 and <50,000	>10,000 and <50,000	Design year 2034 (whole scheme) Source: Traffic data (July 2013)
Climatic Region	-	Warm Dry	Colder Wet	Source: HAWRAT Help v1.0 (2009b)
Rainfall Site	-	Ashford (SAAR 710mm)	Ardtalnaig (SAAR 1343.9mm)	Source: HAWRAT Help v1.0 (2009b)
95%ile River flow	m3/s	0	0.019	Source: Jacobs hydrologists
Baseflow Index	-	0.5	0.573	Source: FEH CD-Rom (IH, 2009)
Impermeable road area drained	ha	1	4.59	Source: scheme information
Permeable area draining to outfall	ha	1	0	This area makes up the remaining portion of 'Interior Catchment' such as verges, adjacent cuttings and embankments which are assumed to be free from highway-derived

Parameter	Units	Default Value	Value used	Notes/Sources
				pollutants. More difficult to accurately estimate compared to the impermeable road area; precautionary approach is to assume a value of zero. Source: DMRB HD45/09 (2009)
Is the discharge in or within 1 km upstream of a protected site for conservation?	-	No	Yes	Shochie Burn designated as part of the River Tay Special Area of Conservation (SAC) and salmonid waters.
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge?	-	No	No	
Hardness	-	Low = <50mg CaCO3/l	Low <50 mg CaCO3/l	Worst-case scenario based on knowledge of underlying geology, in the absence of hardness data.
Use Tier 1	-	TRUE	FALSE	
Use Tier 2		FALSE	TRUE	
Tier 1 Estimated river width at Q95	0	5	7.1	Source: site information, cross-section survey data
Tier 2 Bed width	m	3	5.5	Source: site information, cross-section survey data
Tier 2 Side slope	m/m	0.5	0.83	Source: site information, cross-section survey data
Tier 2 Long slope	m/m	0.0001	0.0084	Source: long-section survey data
Tier 2 Manning's n	-	0.07	0.050	Excavated Channel: 8 – Dredged light brush on banks Source: DMRB HA107/04 (2004) Table 2.1
Existing treatment for solubles	%	0	0	Only partial treatment on existing A9. Precautionary approach to assume no existing treatment.
Existing attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Existing settlement of sediments	%	0	0	
Proposed treatment for solubles	%	0	40	Two levels of treatment: filter drains, SUDS pond (dry) Source: DMRB HA 103/06 (2006) Table 3.2 – Indicative Treatment Efficiencies of Drainage Systems
Proposed attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Proposed settlement of sediments	%	0	15	

Table 13: User Parameters: Outfall E – Gelly Burn

Parameter	Units	Default Value	Value used	Notes/Sources
Runoff Risk Assessments				
AADT	vpd	>10,000 and <50,000	>10,000 and <50,000	Design year 2034 (whole scheme) Source: Traffic data (July 2013)
Climatic Region	-	Warm Dry	Colder Wet	Source: HAWRAT Help v1.0 (2009b)
Rainfall Site	-	Ashford (SAAR 710mm)	Ardtalnaig (SAAR 1343.9mm)	Source: HAWRAT Help v1.0 (2009b)
95%ile River flow	m3/s	0	0.0001	Source: Jacobs hydrologists
Baseflow Index	-	0.5	0.625	Source: FEH CD-Rom (IH, 2009)

Parameter	Units	Default Value	Value used	Notes/Sources
Impermeable road area drained	ha	1	3.90	Source: scheme information
Permeable area draining to outfall	ha	1	0	This area makes up the remaining portion of 'Interior Catchment' such as verges, adjacent cuttings and embankments which are assumed to be free from highway-derived pollutants. More difficult to accurately estimate compared to the impermeable road area; precautionary approach is to assume a value of zero. Source: DMRB HD45/09 (2009)
Is the discharge in or within 1 km upstream of a protected site for conservation?	-	No	No	Shochie Burn designated as part of the River Tay Special Area of Conservation (SAC) and salmonid waters.
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge?	-	No	No	
Hardness	-	Low = <50mg CaCO3/l	Low <50 mg CaCO3/l	Worst-case scenario based on knowledge of underlying geology, in the absence of hardness data.
Use Tier 1	-	TRUE	FALSE	
Use Tier 2		FALSE	TRUE	
Tier 1 Estimated river width at Q95	0	5	1.6	Source: site information, cross-section survey data
Tier 2 Bed width	m	3	1.2	Source: site information, cross-section survey data
Tier 2 Side slope	m/m	0.5	0.71	Source: site information, cross-section survey data
Tier 2 Long slope	m/m	0.0001	0.012	Source: long-section survey data
Tier 2 Manning's n	-	0.07	0.08	Unmaintained excavated channel: 1 – Dense weeds, high as flow depth Source: DMRB HA107/04 (2004) Table 2.1
Existing treatment for solubles	%	0	0	Only partial treatment on existing A9. Precautionary approach to assume no existing treatment.
Existing attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Existing settlement of sediments	%	0	0	
Proposed treatment for solubles	%	0	40	Two levels of treatment: filter drains, SUDS pond (dry) Source: DMRB HA 103/06 (2006) Table 3.2 – Indicative Treatment Efficiencies of Drainage Systems
Proposed attenuation – restricted discharge rate	l/s	Unlimited	Unlimited	
Proposed settlement of sediments	%	0	15	

Table 14: Detailed Results Outfall A – Shochie Burn

Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Soluble - Acute Impact: Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

DETAILED RESULTS

In Runoff

	Step 1 Copper	Step 1 Zinc	Step 1 Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
	RST24		Toxicity Threshold							
Allowable Exceedances/year	1	1	1	1	1	1	1	1	1	1
No. of exceedances/year	63.00	56.70	83.80	112.10	2.20	48.30	111.00	48.30	23.00	91.00
No. of exceedances/worst year	81	64	97	128	7	59	127	59	32	101
	RST6									
Allowable Exceedances/year	1	1								
No. of exceedances/year	18.00	20.60								
No. of exceedances/worst year	24	27								
	(ug/l)	(ug/l)	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Thresholds RST24	21	60	Toxicity 197	315	3.5	16770	875	2355	245	515
Thresholds RST6	42	120								
Event Statistics Mean	23.36	67.70	331	1165	1	16068	2780	2667	170	752
90%ile	45.65	147.58	733	2672	2	35481	6138	5890	376	1661
95%ile	54.99	194.62	962	3572	3	70795	12247	11752	750	3313
99%ile	96.36	372.28	1383	5637	4	89125	15419	14795	945	4171

In River (no mitigation)

	Step 2 Copper	Step 2 Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0.1
No. of exceedances/worst year	0	1
No. of exceedances/summer	0	0.1
No. of exceedances/worst summer	0	1
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.09	0.29
	(ug/l)	(ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	0.30	0.99
90%ile	0.74	1.83
95%ile	1.55	3.95
99%ile	4.39	18.87

Velocity 0.26 m/s — Tier 2 is used for the calculation

DI -

% settlement needed - %

In River (with mitigation)

	Step 3 Copper	Step 3 Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	0.00	0.00
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0.00	0.00
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.06	0.17
	(ug/l)	(ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	0.18	0.59
90%ile	0.45	1.10
95%ile	0.93	2.37
99%ile	2.63	11.32

DI -

Details of the chosen rainfall site

SAAR (mm)	1343.9
Altitude (m)	130
Easting	2704
Northing	7389
Coastal distance (km)	58

Table 15: Detailed Results Outfall B – Ordie Burn

Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Soluble - Acute Impact: Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

DETAILED RESULTS

In Runoff

Step 1

	Copper	Zinc	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
	RST24		Toxicity Threshold							
Allowable Exceedances/year	1	1	1	1	1	1	1	1	1	1
No. of exceedances/year	63.00	56.70	83.80	112.10	2.20	48.30	111.00	48.30	23.00	91.00
No. of exceedances/worst year	81	64	97	128	7	59	127	59	32	101
	RST6									
Allowable Exceedances/year	1	1								
No. of exceedances/year	18.00	20.60								
No. of exceedances/worst year	24	27								
	(ug/l)	(ug/l)	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Thresholds RST24	21	60	Toxicity 197	315	3.5	16770	875	2355	245	515
Thresholds RST6	42	120								
Event Statistics Mean	23.36	67.70	331	1165	1	16068	2780	2667	170	752
90%ile	45.65	147.58	733	2672	2	35481	6138	5890	376	1661
95%ile	54.99	194.62	962	3572	3	70795	12247	11752	750	3313
99%ile	96.36	372.28	1383	5637	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

	Copper	Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0.3
No. of exceedances/worst year	0	2
No. of exceedances/summer	0	0.1
No. of exceedances/worst summer	0	1
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.17	0.54
	(ug/l)	(ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	0.54	1.74
90%ile	1.42	3.56
95%ile	2.87	7.15
99%ile	7.26	31.92

Step 2

Velocity 0.25 m/s — Tier 2 is used for the calculation

DI -

% settlement needed - %

In River (with mitigation)

Step 3

	Copper	Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	0.00	0.00
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0.00	0.00
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.10	0.33
	(ug/l)	(ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	0.32	1.05
90%ile	0.85	2.14
95%ile	1.72	4.29
99%ile	4.36	19.15

DI -

Details of the chosen rainfall site	
SAAR (mm)	1343.9
Altitude (m)	130
Easting	2704
Northing	7389
Coastal distance (km)	58

Table 16: Detailed Results Outfall D – Garry Burn

Summary of predictions

Soluble - Acute Impact

Prediction of impacts	Copper	Zinc
Step1		
Step2		
Step3		

Sediment - Chronic Impact

Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene

DETAILED RESULTS

In Runoff

Step 1

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/ year	63.00	56.70
No. of exceedances/worst year	81	64

RST6

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/ year	18.00	20.60
No. of exceedances/worst year	24	27

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	60
Thresholds	RST6	42	120
Event Statistics Mean		23.36	67.70
90%ile		45.65	147.58
95%ile		54.99	194.62
99%ile		96.36	372.28

Step 1

Toxicity Threshold

	Copper (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)	Total PAH (ug/kg)	Pyrene (ug/kg)	Fluoranthene (ug/kg)	Anthracene (ug/kg)	Phenanthrene (ug/kg)
	1	1	1	1	1	1	1	1
	83.80	112.10	2.20	48.30	111.00	48.30	23.00	91.00
	97	129	7	59	127	59	32	101
Toxicity	197	315	3.5	16770	875	2355	245	515
	331	1165	1	16068	2780	2667	170	752
	733	2672	2	35481	6138	5890	376	1661
	962	3572	3	70795	12247	11752	750	3313
	1383	5637	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/ year	0	0.6
No. of exceedances/worst year	0	2
No. of exceedances/summer	0	0.6
No. of exceedances/worst summer	0	2

RST6

	Copper	Zinc
Allowable Exceedances/year	0.5	0.5
No. of exceedances/ year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.22	0.68

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	60
Thresholds	RST6	42	120
Event Statistics Mean		0.67	2.14
90%ile		1.79	4.54
95%ile		3.64	8.75
99%ile		8.91	37.17

Step 2

Velocity 0.17 m/s — Tier 2 is used for the calculation

DI -

% settlement needed - %

In River (with mitigation)

Step 3

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/ year	0.00	0.10
No. of exceedances/worst year	0	1
No. of exceedances/summer	0	0.1
No. of exceedances/worst summer	0	1

DI -

RST6

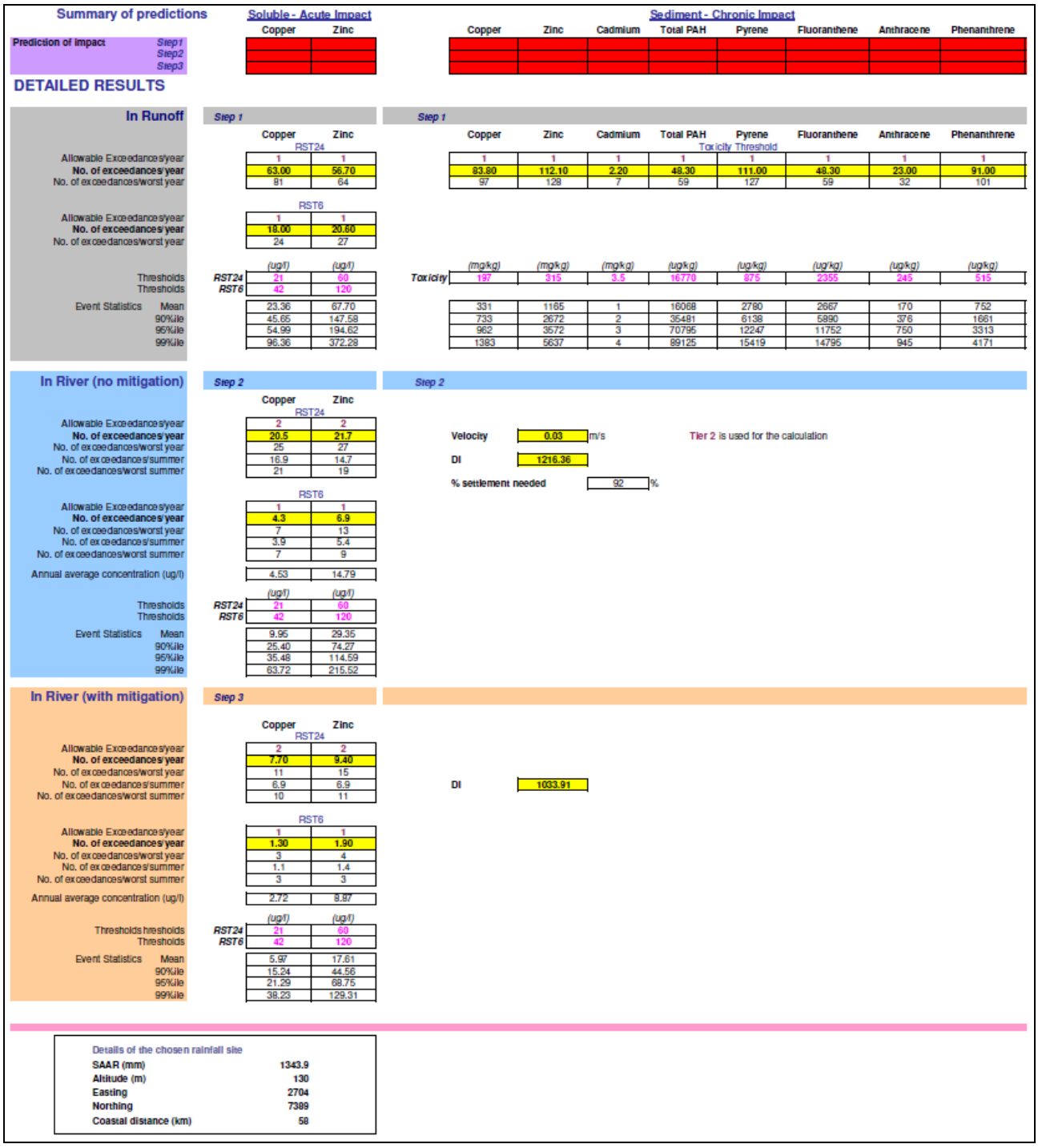
	Copper	Zinc
Allowable Exceedances/year	0.5	0.5
No. of exceedances/ year	0.00	0.00
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.13	0.41

		Copper (ug/l)	Zinc (ug/l)
Thresholds hresholds	RST24	21	60
Thresholds	RST6	42	120
Event Statistics Mean		0.40	1.29
90%ile		1.08	2.72
95%ile		2.19	5.25
99%ile		5.35	22.30

Details of the chosen rainfall site

SAAR (mm)	1343.9
Altitude (m)	130
Easting	2704
Northing	7389
Coastal distance (km)	58

Table 17: Detailed Results Outfall E – Gelly Burn



Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Soluble - Acute Impact: Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

DETAILED RESULTS

In Runoff

Step 1

	Soluble - Acute Impact: Copper	Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
	RST24		Toxicity Threshold							
Allowable Exceedances/year	1	1	1	1	1	1	1	1	1	1
No. of exceedances/year	**63.00**	**56.70**	**83.60**	**112.10**	**2.20**	**48.30**	**111.00**	**48.30**	**23.00**	**91.00**
No. of exceedances/worst year	91	64	97	129	7	59	127	59	32	101
	RST6									
Allowable Exceedances/year	1	1								
No. of exceedances/year	**18.00**	**20.60**								
No. of exceedances/worst year	24	27								
	(ug/l)	(ug/l)	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Thresholds RST24	21	60	Toxicity 197	315	3.5	16770	875	2355	245	515
Thresholds RST6	42	120								
Event Statistics Mean	23.36	67.70	331	1165	1	16068	2780	2667	170	752
90%ile	45.65	147.58	733	2672	2	35481	6138	5890	376	1661
95%ile	54.99	194.62	982	3572	3	70795	12247	11752	750	3313
99%ile	96.36	372.28	1383	5637	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

	Copper	Zinc
	RST24	
Allowable Exceedances/year	2	2
No. of exceedances/year	**20.5**	**21.7**
No. of exceedances/worst year	25	27
No. of exceedances/summer	16.9	14.7
No. of exceedances/worst summer	21	19
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	**4.3**	**6.9**
No. of exceedances/worst year	7	13
No. of exceedances/summer	3.9	5.4
No. of exceedances/worst summer	7	9
Annual average concentration (ug/l)	4.53	14.79
	(ug/l)	(ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	9.96	29.35
90%ile	25.40	74.27
95%ile	35.48	114.59
99%ile	63.72	215.52

Step 2

Velocity 0.03 m/s — Tier 2 is used for the calculation

DI 1216.36

% settlement needed 92 %

In River (with mitigation)

Step 3

	Copper	Zinc
	RST24	
Allowable Exceedances/year	2	2
No. of exceedances/year	**7.70**	**9.40**
No. of exceedances/worst year	11	15
No. of exceedances/summer	6.9	6.9
No. of exceedances/worst summer	10	11
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	**1.30**	**1.90**
No. of exceedances/worst year	3	4
No. of exceedances/summer	1.1	1.4
No. of exceedances/worst summer	3	3
Annual average concentration (ug/l)	2.72	8.87
	(ug/l)	(ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	5.97	17.61
90%ile	15.24	44.56
95%ile	21.29	68.75
99%ile	38.23	129.31

DI 1033.91

Details of the chosen rainfall site

SAAR (mm)	**1343.9**
Altitude (m)	**130**
Easting	**2704**
Northing	**7389**
Coastal distance (km)	**58**

3 Accidental Spillage Risk Assessment – Calculation Tables

Table 18: Spillage Risk Assessment Outfall A – Shochie Burn

HIGHWAYS AGENCY

View Spillage Assessment Parameters | Reset | Go To Runoff Risk Assessment Interface

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage		A (main road)	Additional columns for use if other roads drain to the same outfall B	C	D	E	F		
D1	Water body type	Surface watercourse							
D2	Length of road draining to outfall *(m)*	2,080							
D3	Road Type *(A-road or Motorway)*	A							
D4	If A road, is site urban or rural?	Rural							
D5	Junction type	No junction							
D6	Location	< 1 hour							
D7	Traffic flow (AADT two way)	20,328							
D8	% HGV	12							
D8	Spillage factor *(no'10^{9} HGVkm/year)*	0.29							
D9	Risk of accidental spillage	0.00054	0.00000	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.60							
D11	Risk of pollution incident	0.00032	0.00000	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**						**Totals**	**Return Period (years)**
D13	Return period without pollution reduction measures	0.00032	0.00000	0.00000	0.00000	0.00000	0.00000	0.0003	3103
D14	Existing measures factor	1							
D15	Return period with existing pollution reduction measures	0.00032	0.00000	0.00000	0.00000	0.00000	0.00000	0.0003	3103
D16	Proposed measures factor	0.5							
D17	Residual with proposed Pollution reduction measures	0.00016	0.00000	0.00000	0.00000	0.00000	0.00000	0.0002	6207

Justification for choice of existing measures factors:

None

Justification for choice of proposed measures factors:

2 levels: filter drains 0.6 (40%); dry pond 0.5 (50%). In series 0.5 (50%)

Table D1

Location	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

Table 19: Spillage Risk Assessment Outfall B – Ordie Burn

HIGHWAYS AGENCY

View Spillage Assessment Parameters | Reset | Go To Runoff Risk Assessment Interface

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage		A (main road)	Additional columns for use if other roads drain to the same outfall: B	C	D	E	F	Totals	Return Period (years)
D1	Water body type	Surface watercourse							
D2	Length of road draining to outfall *(m)*	3,450							
D3	Road Type *(A-road or Motorway)*	A							
D4	If A road, is site urban or rural?	Rural							
D5	Junction type	No junction							
D6	Location	< 1 hour							
D7	Traffic flow (AADT two way)	20,506							
D8	% HGV	12							
D8	Spillage factor *(no/10⁹ HGVkm/year)*	0.29							
D9	Risk of accidental spillage	0.00090	0.00000	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.60							
D11	Risk of pollution incident	0.00054	0.00000	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**							
D13	Return period without pollution reduction measures	0.00054	0.00000	0.00000	0.00000	0.00000	0.00000	0.0005	1855
D14	Existing measures factor	1							
D15	Return period with existing pollution reduction measures	0.00054	0.00000	0.00000	0.00000	0.00000	0.00000	0.0005	1855
D16	Proposed measures factor	0.5							
D17	Residual with proposed Pollution reduction measures	0.00027	0.00000	0.00000	0.00000	0.00000	0.00000	0.0003	3709

Justification for choice of existing measures factors:

None.

Justification for choice of proposed measures factors:

2 SUDS levels: filter drains 0.6 (40%); dry pond 0.5 (50%). In series 0.5 (50%)

Table D1

Location	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

Table 20: Spillage Risk Assessment Outfall D – Garry Burn

HIGHWAYS AGENCY

View Spillage Assessment Parameters | Reset | Go To Runoff Risk Assessment Interface

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage

		A (main road)	Additional columns for use if other roads drain to the same outfall: B	C	D	E	F		
D1	Water body type	Surface watercourse	Surface watercourse	Surface watercourse	Surface watercourse				
D2	Length of road draining to outfall *(m)*	1,330	400	279	436				
D3	Road Type *(A-road or Motorway)*	A	A	A	A				
D4	If A road, is site urban or rural?	Rural	Rural	Rural	Rural				
D5	Junction type	No junction	Slip road	Slip road	Side road				
D6	Location	< 1 hour	< 1 hour	< 1 hour	< 1 hour				
D7	Traffic flow (AADT two way)	17,306	17,306	17,306	1,959				
D8	% HGV	13	13	13	4				
D8	Spillage factor *(no/10^9 HGVkm/year)*	0.29	0.83	0.83	0.93				
D9	Risk of accidental spillage	0.00032	0.00027	0.00019	0.00001	0.00000	0.00000		
D10	Probability factor	0.60	0.60	0.60	0.60				
D11	Risk of pollution incident	0.00019	0.00016	0.00011	0.00001	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**	**No**	**No**	**No**			**Totals**	**Return Period (years)**
D13	Return period without pollution reduction measures	0.00019	0.00016	0.00011	0.00001	0.00000	0.00000	0.0005	2107
D14	Existing measures factor	1	1	1	1				
D15	Return period with existing pollution reduction measures	0.00019	0.00016	0.00011	0.00001	0.00000	0.00000	0.0005	2107
D16	Proposed measures factor	0.5	0.5	0.5	0.5				
D17	Residual with proposed Pollution reduction measures	0.00010	0.00008	0.00006	0.00000	0.00000	0.00000	0.0002	4213

Justification for choice of existing measures factors:

None.

Justification for choice of proposed measures factors:

2 SUDS levels: filter drains 0.6 (40%); dry pond 0.5 (50%). In series 0.5 (50%)

Table D1

	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
Location	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

Table 21: Spillage Risk Assessment Outfall E – Gelly Burn

HIGHWAYS AGENCY

View Spillage Assessment Parameters | Reset | Go To Runoff Risk Assessment Interface

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage		A (main road)	Additional columns for use if other roads drain to the same outfall B	C	D	E	F		
D1	Water body type	Surface watercourse							
D2	Length of road draining to outfall *(m)*	1,800							
D3	Road Type *(A-road or Motorway)*	A							
D4	If A road, is site urban or rural?	Rural							
D5	Junction type	No junction							
D6	Location	< 1 hour							
D7	Traffic flow (AADT two way)	17,306							
D8	% HGV	13							
D8	Spillage factor *(no'10^7 HGVkm/year)*	0.29							
D9	Risk of accidental spillage	0.00043	0.00000	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.60	0.60	0.60	0.60				
D11	Risk of pollution incident	0.00026	0.00000	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**	**No**	**No**	**No**			**Totals**	**Return Period (years)**
D13	Return period without pollution reduction measures	0.00026	0.00000	0.00000	0.00000	0.00000	0.00000	0.0003	3888
D14	Existing measures factor	1							
D15	Return period with existing pollution reduction measures	0.00026	0.00000	0.00000	0.00000	0.00000	0.00000	0.0003	3888
D16	Proposed measures factor	0.5							
D17	Residual with proposed Pollution reduction measures	0.00013	0.00000	0.00000	0.00000	0.00000	0.00000	0.0001	7776

Justification for choice of existing measures factors:

None

Justification for choice of proposed measures factors:

2 SUDS levels: filter drains 0.6 (40%); dry pond 0.5 (50%). In series 0.5 (50%)

Table D1

Location	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

4 References

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