VOLUME 11 ENVIRONMENTAL ASSESSMENT
SECTION 3 ENVIRONMENTAL ASSESSMENT TECHNIQUES

Part 10

HD 45/09

ROAD DRAINAGE AND THE WATER ENVIRONMENT

SUMMARY

This Standard gives guidance on the assessment and management of the impacts that road projects may have on the water environment. These include possible impacts on the quality of water bodies and on the existing hydrology of the catchments through which roads pass. Where appropriate, the Standard may be applied to existing roads.

INSTRUCTIONS FOR USE

This revised Standard is to be incorporated in the Manual.

1. This document supersedes 'HA 216/06 Road Drainage and the Water Environment', Volume 11, Section 3, Part 10 which is now withdrawn.

2. Remove existing contents pages for Volume 11, and insert new contents page for Volume 11, dated November 2009.

3. Remove HA 216/06, which is superseded by HD 45/09, and archive as appropriate.

4. Insert HD 45/09 in Volume 11, Section 3, Part 10.

5. Please archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

THE HIGHWAYS AGENCY

TRANSPORT SCOTLAND

WELSH ASSEMBLY GOVERNMENT
LLYWODRAETH CYNULLIAD CYMRU

THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Road Drainage and the Water Environment

Summary: This Standard gives guidance on the assessment and management of the impacts that road projects may have on the water environment. These include possible impacts on the quality of water bodies and on the existing hydrology of the catchments through which roads pass. Where appropriate, the Standard may be applied to existing roads.

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

VOLUME 11 ENVIRONMENTAL ASSESSMENT
SECTION 3 ENVIRONMENTAL ASSESSMENT TECHNIQUES

Part 10

HD 45/09

ROAD DRAINAGE AND THE WATER ENVIRONMENT

Contents

Chapter

1. INTRODUCTION

Background

1.1 Water is vital for all living plants and animals. For human beings it is not only essential to life and health, but also of crucial importance in industry and agriculture, for waste disposal, as a means of transport and for informal recreation and organised sports. The Government is committed to maintaining and, where justified, improving the quality of Britain's drinking water, surface waters, groundwater and coastal waters. It also attaches great importance to the management of flood risk in the planning process, acting on a precautionary basis and taking account of climate change. To achieve these aims, the Government sets standards for protection of the water environment, makes regulations to prevent its degradation and issues advice on how it can be avoided.

1.2 Roads are designed to drain freely to prevent build-up of standing water on the carriageway whilst avoiding exposure to or causing flooding. Contaminants deposited on the road surface are quickly washed off during rainfall. Where traffic levels are high the level of contamination increases and therefore, the potential for unacceptable harm being caused to the receiving water also increases. Although there are many circumstances in which runoff from roads is likely to have no discernible effect, a precautionary and best practice approach indicates the need for the assessment of the possible impact of discharges from proposed trunk roads and motorways.

Scope

1.3 This Standard gives guidance on the assessment and management of the impacts that new construction, improvement, technology and maintenance projects may have on the water environment. These include possible impacts on the quality of water bodies and on the existing hydrology of the catchments through which roads pass. The Standard considers four principal areas:

i) Effects of Routine Runoff on Surface Waters;

ii) Effects of Routine Runoff on Groundwater;

iii) Pollution Impacts from Spillages; and

iv) Assessing Flood Impacts.

1.4 The assessment techniques described in this Part are associated with discharges to water bodies from the development and/or improvement of trunk roads and motorways in the UK but can be applied wherever surface or groundwater resources are affected by road runoff. Where appropriate, the Standard may be applied to existing roads identified through the Overseeing Organisation's management processes. In the UK, water bodies include all controlled waters and are essentially all waters, either above or below ground, that are neither in the drinking water supply nor the sewerage networks. They do not include waters in features such as ponds, ditches and soakaways in land owned by the Overseeing Organisation.

1.5 It should be recognised that assessments made for water quality should, where appropriate, be considered in context with the Environmental Impact Assessment (EIA) process as a whole. For further guidance reference should be made to Design Manual for Roads and Bridges (DMRB) 11.2 General Principles of Environmental Assessment. In particular, HD 48 'Reporting of Environmental Impact Assessments' gives general guidance on reporting the results of the processes described in this Standard.

Purpose

1.6 Methods are provided in Annex I for predicting the potential impact of proposed road projects on the water environment. The methods are intended to be used during the environmental assessment process to provide the most objective and structured evaluation of the potential impacts of proposed road projects, and hence ensuring that:

i) the need for the avoidance, and reduction, of impacts on the water environment is taken fully into account in the environmental evaluation of projects and in route selection; and

ii) the selection of appropriate means of preventing any significant predicted impacts of the chosen route is made, through modification of the drainage design, choice of discharge location(s) and/or adoption of runoff treatment methods, with the objective of designing out potential adverse environmental impacts.

Mandatory Sections

1.7 Sections of this document containing mandatory requirements are identified by being contained in boxes. These requirements must be complied with or a prior agreement to a Departure from Standard must be obtained from the Overseeing Organisation. The text outside boxes contains advice and explanation, which is commended to users for consideration.

1.8 While this Standard provides a series of general methods for assessing potential impacts on the water environment, it is inevitable that there will be unique situations where a requirement of the Standard is inappropriate or that an aspect is not covered by the Standard. GD 01 (Introduction to the Design Manual for Roads and Bridges) provides further details on the process of applying for a Departure from Standard.

Equality Impact Assessment

1.9 This guidance seeks to improve the water environment and, in turn, should benefit all human users. Any adverse or beneficial impacts that result from the introduction and adoption of this guidance are not expected to discriminate against any defined group in society. No equality impact assessment has been carried out in the development of this Standard as it is not considered relevant.

Overseeing Organisation Issues

1.10 Where appropriate this document reflects wherever possible policy and practice that is applicable within the respective Devolved Administrations.

Implementation

1.11 This Standard must be used forthwith for the assessment of all new construction, improvement and maintenance projects including technology projects on the motorway and all purpose trunk road network (and roads designated by the Overseeing Organisation in Northern Ireland) except where procurement of such works has reached a stage at which, in the opinion of the Overseeing Organisation, its use would result in a significant additional expenditure or delay progress (in which the decision must be recorded in accordance with the procedure required by the Overseeing Organisation).

Definitions and Abbreviations

1.12 In most of the UK the term ‘highways’ is equivalent to the Scottish ‘roads’. In this Part ‘roads’ will be used as the standard terminology.

1.13 Pollution from road drainage can arise from a variety of sources including: collisions, general vehicle and road degradation, incomplete fuel combustion, leaks of oil, fuel or other pollutants, fires and atmospheric deposition. Road runoff may also contain runoff from adjacent properties, and in rural areas from agricultural land. The following terms are commonly used to define types of pollution and are used in this Standard:

i) **Diffuse pollution** arises from widespread activities, for example herbicide/salt application, or from numerous small point source discharges. Point source discharges, which are at definable locations, are subject to consents from the appropriate Environment Agencies (EAs). Typical point sources are sewage or industrial discharges. Pollution resulting from road runoff is generally regarded as diffuse pollution by the EAs, but can in some instances be categorised as point source pollution. Pollution may be either acute or chronic in its effects on aquatic organisms.

ii) **Acute pollution** occurs as a result of a severe, usually transient, impact. For road runoff, these impacts usually result from a spillage of pollutants, but can result from routine runoff. High loads of suspended solids may have similar effects in certain circumstances. The impacts are generally associated with readily dissolved forms of the pollutants which, on discharge into the water environment, are sufficiently toxic above certain concentrations to result in the death of organisms over a relatively short period of time (usually hours/days).

iii) **Chronic pollution** is the result of ongoing low levels of pollution which may result in the accumulation of sediment-bound pollutants over a longer period of time (months/years). These low levels of pollutants can result in non-lethal effects, such as reduced feeding, growth rates and reproduction, or may result in the death of organisms. Sediment can also have indirect effects on ecosystems such as the burial of spawning beds and the changing of a gravel dominated substrate to a substrate dominated by finer sediments.

iv) **Routine runoff** is the normal runoff from roads that may include the contaminants washed off the surface in a rainfall event and can result in either **acute** or **chronic** impacts. It excludes the effect of spillages and major leaks which usually result in acute impacts.

Feedback

1.14 Attention is drawn to the requirements of DMRB Standard GD 03/08 for Designers to use the Standards Improvement System (SIS) to generate feedback reports to help improve the performance of standards.

2. WATER RESOURCE MANAGEMENT IN THE UK

Key Legislation and Government Policy

2.1 Water resource management in the UK is reflected through the following key pieces of legislation:

i) The Water Framework Directive (WFD), 2000/60/EC.

ii) The Groundwater Daughter Directive, 2006/118/EC.

iii) PPS25 (England), SPP7 (Scotland), PPS15 (Northern Ireland), and TAN15 (Wales).

2.2 An outline of this and other relevant legislation is given below to explain the legal basis for the assessment of the impacts on water bodies.

The Water Framework Directive and Groundwater Daughter Directive

2.3 The WFD established a framework for management of water resources throughout the European Union. The Directive was translated into English and Welsh law through The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003, which came into force in January 2004 and in Northern Ireland through the Water Environment (Water Framework Directive) (Northern Ireland) Regulations 2003, which came into force in January 2004. The Directive became law in Scotland through The Water Environment and Water Services (Scotland) Act 2003 and The Water Environment (Controlled Activities) (Scotland) Regulations 2005 (as amended) (CAR), which came into force in April 2006. The WFD will be fully effective by 2015 and its key objectives, provided for in River Basin Management Plans (RBMPs), are to:

i) prevent deterioration, enhance and restore bodies of surface water, achieve good chemical and ecological status of such water and reduce pollution from discharges and emissions of hazardous substances;

ii) protect, enhance and restore all bodies of groundwater, achieve good chemical and quantitative status of groundwater, prevent the pollution and deterioration of groundwater, and ensure a balance between groundwater abstraction and replenishment;

iii) preserve protected areas (such as those defined in paragraph 2.13).

2.4 The WFD places most importance on the health of animal and plant groups. It requires that the water environment be looked at as a whole, integrating water quality, quantity and physical habitat with ecological indicators. Information gathered through the Environment Agencies' (EAs) monitoring programmes will allow the classification of surface water bodies into one of five WFD ecological status classes (High, Good, Moderate, Poor, Bad) and one of two chemical status classes (Pass/Fail). In addition, there is a separate classification system for groundwater, with two stages (groundwater quantitative status and groundwater chemical status), each of which has two status classes (Good/Poor). One of the main goals of the Directive is to aim for at least 'good' ecological and 'good' chemical status for surface waters, and 'good' chemical and 'good' quantitative status for groundwaters by 2015. For water bodies designated as 'artificial or heavily modified', such as canals or reservoirs, the Directive aims to achieve 'good ecological potential' rather than 'good ecological status'.

2.5 The Groundwater Daughter Directive was adopted in December 2006. This Daughter Directive not only establishes the criteria by which groundwater chemical status is assessed, it also sets out the requirements for the identification of trends in groundwater quality and the mechanisms required to identify and prompt actions to bring about the reversal of downward trends in groundwater quality. The Daughter Directive also updates (and will replace) the existing Groundwater Directive (8068/EEC) requirements to prevent or limit the introduction of pollutants into groundwater. In addition to the requirements of the Groundwater Daughter Directive, if the groundwater is abstracted for drinking water supply, then additional restrictions may apply in order to protect Drinking Water Standards as outlined in the Drinking Water Directive (80/778/EEC as amended by Directive 98/83/EC). Further details are available on the Department for Environment, Food and Rural Affairs (Defra) website (**www.defra.gov.uk**) and Environmental Agency (EA) website (**www.environment-agency.gov.uk**).

2.6 The WFD has already repealed a number of other Directives. The following are the Directives that will be repealed by December 2013:

- Freshwater Fish Directive, 78/659/EEC;
- Shellfish Waters Directive, 79/923/EEC;
- Groundwater Directive, 80/68/EEC; and
- Dangerous Substances Directive, 76/464/EEC.

Flood Risk, Development and Planning

2.7 Government guidance on flood risk, planning and development is found in the following:

i) In England, PPS25 – Planning Policy Statement 25: Development and Flood Risk;

ii) In Scotland, SPP7 – Scottish Planning Policy 7: Planning and Flooding;

iii) In Northern Ireland, PPS15 – Planning Policy Statement 15: Planning and Flood Risk Policy; and

iv) In Wales, TAN15 – Technical Advice Note 15: Development and Flood Risk.

2.8 In England, the prime purpose of PPS25 is to explain how flood risk should be considered at all stages of the planning process and to indicate the importance attached to the management and reduction of flood risk. While advising primarily on the planning of development, Table D.1 of PPS25 sets out policy to be followed when transport infrastructure has to be constructed in floodplains. Paragraphs 16 and 17 of PPS25 introduce a sequential test, via the identification of flood zones, advocating that development, such as new or improved roads, should be sited in the lowest zone possible.

The Role of the Environment Agencies

2.9 Under the WFD, EAs are appointed as the 'Competent Authorities' with statutory powers and duties for protecting and monitoring the bodies of water as defined in river basin districts. This is an area identified on a deposited map, being made up of a river basin or neighbouring river basins, together with associated groundwater, estuarial waters and coastal waters within 3 km. The EAs are required to identify river basin districts and prepare deposited maps and plans so as to achieve the desired water quality status. RBMPs are the delivery mechanism, considering both qualitative and quantitative water issues. Guidance on the application of the WFD should be obtained from the Overseeing Organisation. Further information can be found on the EAs' websites. The relevant EAs and their websites are:

i) In England and Wales, the EA: **www.environment-agency.gov.uk**

ii) In Scotland, the Scottish Environment Protection Agency (SEPA): **www.sepa.org.uk**

iii) In Northern Ireland, there are two organisations involved. The Rivers Agency is the statutory drainage and flood defence authority for Northern Ireland: **www.riversagencyni.gov.uk**. The Northern Ireland Environment Agency (NIEA) seeks to safeguard the quality of water bodies: **www.ni-environment.gov.uk**

2.10 In England and Wales, The Water Resources Act 1991 (WRA) and The Environment Act 1995 establish EA powers and duties for protection of water resources, flood defence, fisheries, recreation, conservation and navigation. In Scotland, the flood defence role of SEPA is limited to flood risk assessment and provision of advice thereon, the provision of early warning of floods and river flow gauging. SEPA has general duties to conserve water resources and to promote conservation and enhancement of natural beauty. However, it has no navigation role, nor is it directly responsible for fisheries protection, for which responsibility (for salmon and sea trout) falls to the District Salmon Fisheries Boards (DSFBs). The British Waterways Board (BWB) is responsible for the maintenance of a number of inland waterways (mostly canals) for both recreational and commercial navigation. In Northern Ireland, the NIEA has similar duties and powers to the EA relating to pollution prevention, while the Rivers Agency is responsible for flood defence. Fisheries and water recreational activities are controlled by other organisations such as Waterways Ireland.

Rights, Duties and Consents to Discharge to Water Bodies

2.11 One way EAs manage the impacts on water bodies is by means of discharge consents, as described in Section 88 and Schedule 10 of the WRA, except in Scotland, where the Act and Regulations described in paragraph 2.3 are the governing law. Highway authorities in England and Wales are exempt from the need to apply for discharge consents for road runoff under the WRA, or authorisations to discharge to ground under The Groundwater Regulations 1998 by virtue of Section 89(5) of the WRA. If pollution is occurring, the EA (in England and Wales) can, however, control a discharge to water bodies by serving a prohibition notice under Section 86 of the WRA. For discharges to ground, the EA has a **duty** to use Section 86 powers where necessary to prevent pollution. In Scotland, SEPA regulates activities such as abstraction, impoundment, engineering works and pollution by authorisation under Part II of CAR. In Northern Ireland, the highway authority is the Roads Service, a Government Agency with power to discharge a road drain to any watercourse. **The responsibility for ensuring that highway discharges comply with pollution legislation rests with the highway authorities, advised by their agents, consultants, contractors and the EAs.**

2.12 Consent is required if any work (e.g. a new outfall, bridge repairs) is proposed that would physically affect a watercourse or an adjacent flood defence structure. In England and Wales, the consenting authority, who should be consulted as soon as reasonably possible, will be the EA if the watercourse is a **main river** (or a **critical ordinary watercourse**), or other drainage authority such as an Internal Drainage Board (IDB) or the local authority. In Northern Ireland, the consenting authority will be Rivers Agency. In Scotland, consent is required under the regulations described in paragraph 2.3.

2.13 In some situations, more stringent requirements may apply to specific water bodies. For example, those within areas designated Sites of Special Scientific Interest (SSSI), Special Protection Areas (SPAs), Special Areas of Conservation (SAC), Water Protection Zones (WPZs) or Ramsar Wetlands may be especially sensitive to impacts. Non-designated sites classed as salmonid waters under the Freshwater Fish Directive may also be especially sensitive to impacts. Other water bodies and related habitats inhabited by protected species may also be particularly susceptible to impacts. Consultation with the statutory nature conservation organisations will be required if these sites could be affected. HD 44 'Assessment of implications (of highways and/or roads projects) on European sites' (DMRB 11.4) considers the implications on European designated sites and should be consulted where appropriate.

2.14 Where a body of surface or groundwater supports more than one use, the overall requirements will derive from a combination of the most stringent criteria for any of the uses concerned. No discharge, which could cause any of the overall requirements to be breached, will be acceptable. Hence, the assessment of new roads or road improvements should include consideration of all of the uses of a receiving water body. A surface water body should be assessed not only downstream of any discharge or river crossing, but also upstream where interests such as migratory fisheries are potentially present. During the planning and consultation process, the EAs will advise on any uses as well as the appropriate water body classification defined in paragraph 2.4, and any physical constraints.

2.15 Under Section 85 of the WRA in England and Wales, a person commits an offence if (s)he knowingly introduces any poisonous, noxious or polluting matter or any solid waste matter into controlled waters. In Scotland and Northern Ireland similar offences pertain to the legislation described in paragraph 2.3.

Surface Waters

> 2.16 When considering road runoff, relevant pollutants and their limiting concentrations need to be identified. Discharges from roads must not lead to a deterioration in the classification status of the receiving surface water body as determined in the relevant RBMP.

2.17 Under WFD the status of each surface water body is judged using separate 'Ecological classification' and 'Chemical classification' systems. The overall status of the water body will be determined by whichever of these is the poorer. To achieve 'good status' overall, a water body needs to achieve both good ecological and good chemical status. Further details are available on the Defra website (**www.defra.gov.uk**) and EA website (**www.environment-agency.gov.uk**).

2.18 Under the WFD, Environmental Quality Standards (EQSs) are expressed as annual average concentrations and are most appropriate for comparison against continuous discharges. Road runoff is an intermittent discharge and any breach of the annual average concentrations is only likely to persist for a short duration (minutes/hours). This may go unnoticed by standard monitoring regimes for chemical parameters but may have environmental impacts nonetheless. Research has been undertaken with the EAs to develop a set of standards for the assessment of toxicological effects specifically related to road runoff and its intermittent nature (Refs 7, 13, 24 and 35). This research is discussed in further detail in Chapter 3 and forms the basis of the risk assessment procedure discussed in Chapter 5.

Groundwater

2.19 The Groundwater Directive 80/68/EEC (as transposed in the Groundwater Regulations 1998) and the Groundwater Daughter Directive (2006/118/EC) will operate alongside each other until the repeal of the former in December 2013. These set out the key legislation that forms the basis of an assessment of the potential effects of road drainage on groundwater. The Groundwater Regulations give absolute protection to groundwaters, regardless of the presence of abstraction and associated Source Protection Zones (SPZs). Aquifers are regarded as valuable in their own right whether or not they are currently used for potable water supplies. Discharges to a groundwater body must:

i) prevent the introduction of hazardous substances and limit the introduction of pollutants into groundwater;

ii) not compromise the existing groundwater classification (where this exists);

iii) not lead to sustained downward trends in the quality of the receiving groundwater.

Currently hazardous substances are considered to be those identified by List I of the Groundwater Directive 80/68/EEC, as transposed by the Groundwater Regulations 1998.

> 2.20 Discharges from roads must not lead to a deterioration in the classification status of the receiving groundwater as determined in the relevant RBMP.
>
> 2.21 No discharges of road drainage to ground shall be permitted within an SPZ 1 unless a site specific risk assessment demonstrates both to the Overseeing Organisation and the Environment Protection Agency (EPA) that this would represent no or minimal risk to both groundwater and the source of abstraction.

2.22 The legislation and regulations pertinent to groundwater are described in more detail in Annex I. However, under the WFD, groundwater classification uses two systems: 'Groundwater quantitative' status, which assesses the status of a groundwater body against whether there is sufficient water to maintain the health of the ecosystems it feeds (and assesses total abstractions against groundwater recharge), and 'Groundwater chemical status', which assesses the chemical quality against certain criteria established for each groundwater body.

2.23 Under the Groundwater Regulations 1998, the EAs have supported the view that the point of compliance for List I contaminants (Table C1.1, Annex I) is within the unsaturated zone, immediately above the water table. In the case of List II substances (Table C1.1, Annex I), the point of compliance may be a short distance in the direction of groundwater flow, so that the owner of the discharge can demonstrate that pollution is not occurring. It is, therefore, permissible under current legislation to take into account any attenuating capacity that the soil or unsaturated zone may possess when assessing the impact of the indirect discharge of pollutants. Thus, where road runoff is discharged via infiltration to the ground, the potential attenuating effect of the unsaturated zone may be taken into account when assessing potential impacts on groundwater of both List I and List II substances, but attenuation in groundwater may only be considered when assessing List II substances.

2.24 The technical requirements to meet the groundwater objectives of the WFD are set out in a number of documents (Ref 42) that include guidance on the compliance regime (in which objective criteria are applied). These suggest that compliance with respect to the prevention of the introduction of hazardous substances should be assessed at the unsaturated zone immediately before entry into groundwater – i.e. similar to the requirements to those for List I above. Compliance with respect to the limitation of other substances (that might cause pollution) may be assessed with respect to the actual or likely harmful effect to a receptor. This allows for compliance points away from the point of introduction of the polluting substance, and is interpreted as allowing for the effects of dilution (and other attenuation) within the groundwater itself. This is similar to the requirements for List II above. The guidance suggests that harm includes impairment of potential future uses of groundwater.

2.25 The WFD adopts a risk assessment approach that considers the Source-Pathway-Receptor (S-P-R) linkage. The use of this practice may be followed where the groundwater is already of poor quality, for example, as a result of saline intrusion, to demonstrate that more significant discharges of polluting substances to groundwater may be permissible. However, direct discharge of hazardous substances will remain prohibited except in very exceptional circumstances.

2.26 The Groundwater Protection: Policy and Practice (GP3) documents (Refs 15, 16, 17, 18) set out the approach to groundwater protection and management in England and Wales and presents a series of policies designed to protect groundwater. The Scottish equivalent is *'Groundwater Protection Policy for Scotland', (SEPA, 2003)* (Ref 40). The Scottish Strategy adopts the same philosophy as that which applies in England and Wales, although there are specific differences which should be checked. Where discharges to the ground are proposed, and as road drainage may be deemed to be potentially contaminated, the EAs should be consulted.

2.27 With respect to the potential impact of roads on groundwater the key policy statements set out in GP3 are those with respect to:

(i) the general approach to groundwater protection;

(ii) the protection of water intended for human consumption;

(iii) the discharge of liquid effluents to the ground;

(iv) diffuse sources; and

(v) groundwater flooding.

These policy statements should be considered if discharges to groundwater may occur as a result of road development.

2.28 In support of its general policy statements with respect to water intended for human consumption, the EA defines groundwater SPZ around potable abstraction sources (springs, wells, boreholes) to protect them from pollution. These are designed as screening tools to support the EA with respect to their responses to developers and planners. Figure 2.1 shows a typical arrangement of zones around an abstraction source. The process of revising the location of these zones is ongoing. There are no groundwater SPZs yet in Scotland and Northern Ireland. The SPZs commonly have three subdivisions that can be summarised as follows:

i) **Zone 1 (Inner Source Protection)**

Immediately adjacent to the source and based upon a 50-day travel time from any point below the water table to the source (50 days being the decay period for most biological contaminants). All potable sources have a minimum Zone 1 of 50 m radius.

ii) **Zone 2 (Outer Source Protection)**

Defined by a 400-day travel time (to provide delay and attenuation of slowly degrading pollutants).

iii) **Zone 3 (Source Catchment)**

Defined by the entire catchment area of a groundwater source.

An additional 'Zone of Special Interest' may also be defined in some areas that may be outside the normal catchment of the source.

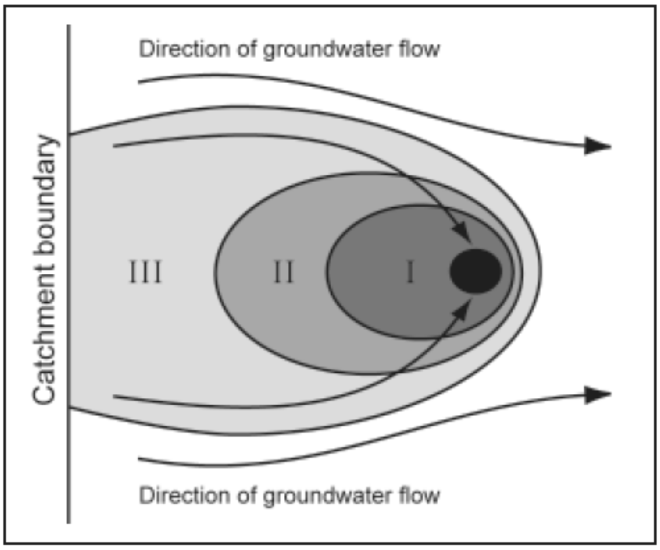

Figure 2.1 – Schematic of Source Protection Zones

2.29 The assessment of groundwater vulnerability is a key factor in determining the potential risk to an underlying groundwater body. The EA in England and Wales is developing more sophisticated approaches to the assessment of aquifer vulnerability. As these have yet to be published, advice with respect to aquifer vulnerability should be sought from the relevant EA.

2.30 In Scotland, vulnerability maps at a scale of 1:100,000 are proposed for the main aquifers only. Isolated valley deposits within the Highlands and Islands will be presented as collective maps. In Northern Ireland, the equivalent vulnerability maps are scaled at 1:250,000. For areas where no maps are published, the EAs can advise on vulnerability.

2.31 A balance needs to be struck when considering whether road runoff should be discharged to surface waters or to ground. In some cases the effect on receiving surface waters could be such that discharge to ground may be appropriate. This could apply where the discharge would aggravate an existing flooding risk, or where it could have a potentially disproportionate effect on pollution within the receiving waters.

Management of Spillages

2.32 When considering the risk of spillages from a highway and potential pollution to the receiving environment, the following factors must be considered:

i) the calculated spillage risk return period must not be greater than 1 in 100 years;

ii) the calculated spillage risk return period must not be greater than 1 in 200 years where spillage could affect: protected areas for conservation (such as those listed in 2.13), important drinking water supplies or important commercial activities; and

iii) spillage risk from existing outfalls must not be increased.

2.33 When considering the impacts on water bodies from road runoff, acute pollution is most commonly associated with spillages of vehicle fuel and substances carried on roads. It can also occur on construction sites.

2.34 The EAs maintain a database of pollution incidents. Incidents are categorised by officers of the EAs according to the impact the incident has on the water environment. The categories used by the EA in England and Wales are listed in Table 2.1. There is no similar system of classification in Scotland, but Northern Ireland has a similar range of categories, described as High, Medium and Low.

2.35 The management of pollution incidents usually involves the isolation of part of the road drainage system, so that the pollutant can be recovered or treated. For minor incidents, the use of booms, drain mats or absorbent materials may suffice. Larger incidents are likely to require closure of valves or penstocks, and/or blocking of outfalls/drainage ditches to avoid damage to surface waters and groundwaters. A rapid and appropriate response can often prevent a spillage from causing a severe pollution incident. Pollution Prevention Guideline 22 *'Dealing with Spillages on Highways' is of particular relevance and is located on the EAs'* websites.

IMPACTS UPON SURFACE AND GROUNDWATERS	**CATEGORY 1 The most serious**	**CATEGORY 2 Significant but less severe**	**CATEGORY 3 Relatively Minor**
Effects on Quality	Persistent and extensive	Significant	Minimal
Damage to the Ecosystem	Major damage	Significant damage	Minor damage to local ecosystems
Potable Abstraction	Justified closure	Non-routine notification to abstractors	
Amenity Value	Major impact	Reduction	Marginal effect
Damage to Agriculture and/or Commerce	Major damage	Significant damage	Minimal impact
Human	Serious impact	Impact	

Note: If no impact has occurred, the incident is reported as Category 4.

Table 2.1 – Categories of Pollution Incident

2.36 Signage of pollution control devices should be clear so they can be located quickly and used correctly. HD 33 (DMRB 4.2) gives details of how such devices are to be signed. Signs should relate to contingency plans.

Management of Flood Risk

2.37 Transport infrastructure in the functional floodplain must be designed and constructed to:

i) remain operational and safe for users in times of flood;

ii) result in no net loss of floodplain storage;

iii) not impede water flows; and

iv) not increase flood risk elsewhere.

2.38 The EAs are responsible for advising local planning authorities on the planning of development so as to minimise flood risk.

2.39 Floodplain extents are defined by the probability of a flood event. In England, PPS25 identifies four flood zones (for Scotland a similar but slightly different set of categories is identified in SPP7):

i) Zone 1 Low Probability: This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding in any year (<0.1%).

ii) Zone 2 Medium Probability: This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.

iii) Zone 3a High Probability: This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

iv) Zone 3b The Functional Floodplain: This zone comprises land where water has to flow or be stored in times of flood. Strategic Flood Risk Assessments (SFRAs) should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the Local Planning Authority and the EA, including water conveyance routes).

2.40 Table D.1 of PPS25 notes that *'Only the water-compatible uses and the essential infrastructure [including transport infrastructure] that has to be there should be permitted in the functional floodplain.*

Essential infrastructure in this zone should pass the Exception Test, which is defined in paragraphs D9 to D16 of PPS25. It requires developers to provide a flood risk assessment to demonstrate; the development is safe and where possible reduces flood risk overall, that it provides wider sustainability benefits that outweigh flood risk and that it is built on previously developed land.

In this zone, developers and local authorities should seek opportunities to:

i. reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage techniques; and

ii. relocate existing development to land with a lower probability of flooding.'

2.41 Within England and Wales, the EA has produced the Flood Map for the fluvial and tidal flood envelopes. This shows the approximate extent of floods with a 1% annual probability of occurrence for river floods and a 0.5% annual probability of occurrence for tidal floods (not distinguishing between the source) and a 0.1% annual probability for both. The map is readily available on the EA website. In Scotland, information for areas prone to flooding is available from SEPA. There is no similar map available in Northern Ireland.

2.42 In Wales, TAN15: 'Development and Flood Risk' provides advice on the development control process using Development Advice Maps, assessments comparing the zone of risk involved (A, B, C, C1 and C2), the development type, planning requirements and acceptability criteria. Transport is considered to be a less vulnerable development.

2.43 When an embankment crosses a flood plain and that embankment is designed to retain more than 25,000 m^3 of flood water, it is required to be considered as a 'raised reservoir' under the Reservoirs Act 1975. The Overseeing Organisation must appoint and retain 'Panel Engineers' for the design, supervision of construction and maintenance of such reservoirs. Further details of Panel Engineers and their responsibilities under the Act are given in Annex III. In England and Wales, the EA is the enforcement authority, in Scotland this role is performed by the local authorities. There is similar legislation in Northern Ireland.

3. POTENTIAL IMPACTS

General

3.1 This chapter describes possible impacts on the water environment that may arise from a road project. These may include the potential impact to the quality of receiving water bodies, from either routine runoff or spillages. The water bodies may be either surface watercourses or groundwaters. Another potential impact is the change to the risk of flooding within the catchment. The possible impact on any existing amenity or economic value of affected water bodies may also need to be considered.

3.2 There is a potential for the diffuse pollution of the water environment arising from the construction, operation and maintenance of roads. The type of pollution and consequences depend on the particular activity and local circumstances as well as the design and operational usage for any given road.

New Construction, Improvement Projects

3.3 During the construction of new or improved roads or maintenance of existing roads, pollution from mobilised suspended solids is generally the prime concern (Ref 34), but spillage of fuels, lubricants, hydraulic fluids and cement from construction plant may lead to incidents, especially where there are inadequate pollution mitigation measures. Other risks include:

i) water abstraction, which may cause contamination if, for example, saline groundwater migrates to replace what is abstracted or reduced flows leads to a reduction in dissolved oxygen;

ii) pollution due to vandalism of stores or plant;

iii) pollution due to waste materials, dust or residues from handling contaminated land;

iv) pollution from pumped discharges, for example, dewatering. These can also cause erosion.

CIRIA 648 *'Control of Water Pollution from Linear Construction Projects'* (Ref 36) provides further advice on potential impacts arising during the construction phase and the assessment and mitigation of these risks.

Operation

3.4 A broad range of potential pollutants is associated with routine runoff from operational roads. These are combustion products of hydrocarbons, fuel and fuel additives, catalytic converter materials, metal from friction and corrosion of vehicle parts, lubricants, and materials spread during gritting and de-icing. Particulate contaminants originating from vehicles and vehicle related activities include carbon, rubber, plastics, grit, rust and metal filings.

3.5 Most organic compounds have very low solubility in water. Such compounds can occur in routine runoff and include a wide range of polycyclic aromatic hydrocarbons (PAHs). Other materials may be deposited on road surfaces such as wind blown soils from adjacent land.

3.6 Studies (Refs 1, 7, 10, 27, 28, 29, 30, 34, 35, 38) show that routine road runoff contains both dissolved and particulate contaminants. A large number of studies have investigated the concentrations of contaminants in road runoff. These studies have investigated a variety of road types in a number of countries. Research into the concentrations of contaminants in road runoff shows a large variation in concentrations of those contaminants detected. Applied road salt may also enhance the release of toxic metals from silts and sludge.

3.7 The Highways Agency (HA) has undertaken collaborative research in England with the Environment Agency (EA) to significantly improve the reliability and extent of existing data for pollutants and their concentrations found in road runoff from non-urban trunk roads and motorways (Refs 7, 13, 23, 24, 35). The results were used to identify a list of significant pollutants that are routinely found in road runoff and which pose a risk of short-term acute impacts (from soluble pollutants) and/or long-term chronic impacts (from sediment-bound pollutants) on ecosystems. The study also identified those site characteristics that influence pollutant concentrations. The 'significant' pollutants have been agreed with the EA and are listed in Table 3.1. The table summarises the data from the monitoring programme for the significant pollutants showing the mean (and median) runoff concentrations found, based on Event Mean Concentrations (EMCs) from the 340 rainfall events monitored at the 30 sites sampled. The results from this research have been integrated into the assessment tools described in Chapter 5. Some studies (Refs 3, 11, 12, 31, 37, 41) have indicated that concentrations of pollutants may be somewhat higher in urban settings.

Determinand	**Runoff Concentration**						**Runoff Load**	
	Units	**LOD**	**Min. EMC**	**Mean EMC**	**Median EMC**	**Max. EMC**	**Mean/ 1000m²**	**Units**
Total Copper	µg/l	0.3	4.00	91.22	42.99	876.80	0.66	g
Dissolved Copper	µg/l	0.3	2.15	31.31	23.30	304.00	0.16	g
Total Zinc	µg/l	0.6	9.73	352.63	140.00	3510.00	2.44	g
Dissolved Zinc	µg/l	0.6	4.99	111.09	58.27	1360.00	0.50	g
Total Cadmium	µg/l	0.01	<0.01	0.63	0.29	5.40	0.00	g
Total Fluoranthene	µg/l	0.01	<0.01	1.02	0.30	12.50	0.01	g
Total Pyrene	µg/l	0.01	<0.01	1.03	0.31	12.50	0.01	g
Total PAHs (Total)	µg/l	0.01	<0.01	7.52	3.33	62.18	0.04	g

LOD = Analytical limit of detection

Table 3.1 – Summary of EMCs and Loads Found in Road Runoff for Significant Pollutants (from WRc 2008, Ref 7)

Maintenance Projects

3.8 A broad range of potential pollutants are also associated with maintenance projects which may range from routine cleaning of gully pots and similar entrapment structures to carriageway maintenance work. The flushing-out of gully pots has been identified as a potential source of pollutants, which may be as damaging as some spillage impacts. The use of herbicides for the control of plant growth along road verges and central reservations may also lead to contamination of road runoff.

Ecological Impacts

3.9 Potential pollution effects can be classified into two groups; those which directly and indirectly affect water quality, and those which affect the aquatic habitat quality. In broad terms, the former are metals which chemically impair biological functions and the latter are sediments which smother feeding and breeding grounds (especially for trout and salmon) and physically alter the habitat (Ref 34).

3.10 Depending on the type and form of the pollutant and its concentration and uptake by the organisms, the potential impact of the chemical pollutants can be either acute or chronic in nature, as described in paragraph 1.13.

3.11 Acute effects are usually associated with certain metals and organic pollutants. Copper in a soluble form is particularly toxic and there are standards for concentrations in respect of general quality and sensitivity to fish. The more soluble or short chained organic pollutants such as herbicides may also cause acute effects.

3.12 Collaborative research has been undertaken by the HA and EA to investigate the acute (short-term) effects of soluble pollutants on the ecology of receiving waters (Ref 24). Using relevant toxicity data from tests on a range of aquatic organisms (see paragraph 3.13) the results have been used to develop Runoff Specific Thresholds (RSTs) to protect receiving organisms from short-term exposure (six hours and 24 hours) to those significant pollutants identified in highway runoff (Table 3.1). The RST 24 hour is designed to protect against worst case conditions whereas the RST 6 hour is designed to protect against more typical exposure conditions of aquatic organisms to soluble pollutants in highway runoff. For zinc, water hardness was found to have a significant effect on short-term toxicity such that toxicity values decreased with increasing water hardness (Ref 24). For cadmium and copper, water hardness was not found to have a significant effect on short-term toxicity.

3.13 Data from short-term toxicity tests carried out by Kings College London on a range of 13 algal, invertebrate and fish species (Ref 23) along with literature data for other relevant species, were used in the development of the RSTs. The species used in the RST derivation were largely UK resident species and included those with a range of sensitivities to the significant pollutants. The same taxonomic group proved not to be the most sensitive for all the pollutants of interest. In generating the RSTs a further assessment (safety) factor was applied to the no-effects threshold from the dataset to account for any possible effects on potentially more sensitive species that were not tested during the research. In this way the RSTs are protective against possible short-term effects on tested and untested (sensitive) species. The approach used to generate the RSTs is consistent with that adopted for the derivation of Evironmental Quality Standards (EQSs) under the Water Framework Directive (WFD).

3.14 The RSTs are designed to be used alongside relevant WFD EQSs for soluble pollutants which are designed to protect against long-term exposure. Table 3.2 summarises the RSTs developed from the study. The RSTs have been agreed with the EA and incorporated within the assessment tools and guidance discussed further in Chapter 5.

		Zinc (µg/l)		
		Hardness		
Threshold Name	**Copper (µg/l)**	**Low (<50mg $CaCO_3$/l)**	**Medium (50 to 200mg $CaCO_3$/l)**	**High (>200mg $CaCO_3$/l)**
RST 24 hour	21	60	92	385
RST 6 hour	42	120	184	770

Table 3.2 – RSTs for short-term exposure (WRc 2007)

3.15 Chronic effects are associated with sparingly soluble metals such as zinc, chromium, nickel and lead, where there is toxicity through accumulation of the metals in animal tissue. More persistent hydrocarbons such as PAHs are also considered as constituents of the sediment-bound fraction.

3.16 The physical accumulation of sediment (silt and clays) can alter habitats by covering surfaces as well as smothering flora and fauna. Where the sediment is contaminated with metals and PAHs, chronic effects can develop over time as a result of the leaching of the toxins from sediments or can directly affect sediment dwelling organisms.

3.17 Collaborative research has been undertaken by the HA and EA to investigate the chronic effects of sediment-bound pollutants on the ecology of receiving waters (Ref 13). This research identifies the scenarios under which contaminated sediment in runoff would be likely to have a negative impact on receiving-water ecology. The results have been used to develop Threshold Effects Levels (TELs) and Probable Effects Levels (PELs) for metal and PAH concentrations in sediment. The TEL is the concentration below which toxic effects are extremely rare. The PEL is the concentration above which toxic effects are observed on most occasions. Table 3.3 summarises the TELs and PELs derived from the study. In the absence of nationally agreed sediment guideline standards, the TELs and PELs have been agreed with the EA as a pragmatic approach reflecting current best practice. They have been incorporated within the assessment tools discussed within Chapter 5 and will be reviewed regularly and amended as necessary to reflect changing legislation or regulatory requirements.

Sediment-bound Pollutant	Units	TEL	PEL
Copper	mg/kg	35.7	197
Zinc	mg/kg	123	315
Cadmium	mg/kg	0.6	3.5
Total PAH	µg/kg	1,684	16,770
Pyrene	µg/kg	53	875
Fluoranthene	µg/kg	111	2,355

Table 3.3 – TELs and PELs for Metal and PAH Concentrations in Sediment (Gaskell *et al.* 2008, Ref 13)

Influencing Factors

3.18 There are a number of factors which influence both the pollutant concentrations in routine runoff and whether the runoff is likely to have an impact on the receiving water body. These factors are outlined below.

3.19 Collaborative research between the HA and EA (Ref 7) identified factors related to site and rainfall event characteristics that influence the pollutant concentrations in routine runoff. Site characteristics found to have some significant influence on copper and zinc concentrations were Annual Average Daily Traffic (AADT) Flows and climatic region. Influential event characteristics were: month of rainfall event, maximum hourly rainfall intensity and antecedent dry weather period. These influencing factors have been incorporated within the assessment tool described further in Chapter 5. Other factors that were investigated but not found to have a significant influence on pollutant concentrations were total event rainfall and mean event rainfall intensity.

3.20 The potential impact of pollutants on the ecology of surface waters is also dependent on the characteristics of the receiving waters, particularly its water quality, hardness, flow rate and flow velocity. For example, watercourses having low flow rates have less potential for diluting road runoff and are more vulnerable than those with high flow rates. Similarly, where soft water is encountered metals are more toxic. Where flow velocities are low or even zero (such as lakes and canals) there is an increased risk from sedimentation around the point of discharge.

3.21 The risk of groundwater pollution is affected by the mineralogy of the soil or rock, the depth of the unsaturated zone and the nature of the pathways between the point of discharge and the receiving groundwater, as further described in Chapter 5. In general terms groundwater is less susceptible to pollution by particulates, but remains at risk from soluble contaminants.

Spillages

3.22 On all roads, there is a risk that a spillage or vehicle fire may lead to an acute pollution incident. It is generally accepted that the risk on any road is proportionate to the risk of a Heavy Goods Vehicle (HGV) road traffic collision. As new or improved roads are designed to reduce the collision rate, they will also lead to fewer acute pollution impacts. Where spillages do reach a surface watercourse the pollution impact can be severe, but is usually of short duration, typical of an acute pollution impact. If groundwater is polluted the impact can be long lasting and difficult, if not impossible, to remediate.

3.23 Goods transported as road freight and which pose a risk to people are covered by The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2007, which allows rapid identification of the materials present and provides guidance on how to handle those materials safely. Many materials, however, which are not classified under this system, may cause significant pollution to water bodies. Such substances include milk/cream, fruit juices, alcoholic beverages, organic sludges and detergents.

3.24 All traffic collisions have the potential to cause pollution. In practice, relatively few do, largely because of the efficiency of the Fire and Rescue Service, Highway Authorities and staff from the EAs in controlling the spillages which may arise. Even fewer spillages lead to incidents that are in Category 1 or 2, as defined in Table 2.1. Table 3.4 gives the recent figures for water pollution incidents on all roads in England and Wales, as recorded by the EA.

Year	Incident Categories (1 to 3)	Incident Categories 1 and 2
1999	902	45
2000	776	24
2001	660	21
2002	480	16
2003	366	10
2004	294	19
2005	283	12
2006	212	11
2007	173	3
Nine year average	461	18
Average per EA region per year	57.6	2.2

Table 3.4 – Water Pollution Incidents on All Roads in England and Wales

3.25 On average about two Category 1 or 2 incidents occur within England and Wales in each of the eight EA regions each year. About a fifth of these occur on motorways or trunk roads, so fewer than four Category 1 or 2 incidents can be expected to occur each year on motorways and trunk roads in England and Wales.

3.26 There is little available data on the acute pollution impacts resulting from construction of road projects. Potentially, the main causes are likely to be due to spillages/leaks of fuels/oils or waste materials from runoff from the site, and or dewatering activities. The Construction Industry Research and Information Association (CIRIA) 648 (Ref 36) provides further advice on identifying and managing the risks.

3.27 Although acute groundwater pollution from roads is a relatively rare event, the consequences of spillage of highly mobile pollutants such as fuel or pesticides on groundwater are potentially the most severe form of pollution. Halting the spread of such pollutants, and remediation of the affected groundwaters can both be extremely difficult.

Possible Flooding Risks and Impacts to Local Drainage

3.28 Construction in floodplains can affect the nature and extent of the flood envelope in the area of construction and for some distance upstream and downstream. This could have a serious impact on property owners within or near the floodplain, who may become exposed to a new or increased risk of flooding. Bridges and embankments, in particular, can obstruct or change the path of floodwaters, thereby changing the shape and/or extent of the flood envelope. A change in upstream flood levels, resulting from such an obstruction, is known as **afflux**. In Annex I (Method F, Hydraulic Assessment), guidance is provided in assessing the afflux using the appropriate methodology and providing suitable mitigation.

3.29 A road built across a major floodplain can have a significant effect on flood levels, whereas one built alongside will be less. Providing compensatory flood storage can significantly mitigate the effect of the project on the maximum flood level. The effect on floodwater levels in any area of floodplain caused by any one element of road construction may be small. However, using the precautionary principle, the consequence of developing the whole floodplain (through both road construction and unrelated projects) could lead to a significant cumulative loss of floodplain storage. Consequently, storage is required for all developments regardless of their anticipated effect, so as to result in no net change to the catchment hydrology and to the capacity of the floodplain. Failure to do this would lead to a higher risk of flooding to properties within the catchment.

3.30 New roads or improvements should only be located within functional floodplains (defined in paragraph 2.39) if there is no acceptable alternative and should be restricted to the shortest practical crossing, avoiding extensive construction within the floodplain. Where this is unavoidable, the level of the road should be above the level of the predicted flood event, i.e. an event with a 1% annual probability of occurrence for river floodplains, or the 0.5% annual event for tidal floodplains. For major projects, a sensitivity check with the 0.1% annual event is advisable and should be discussed with the Overseeing Organisation. If a project is constructed in, or is likely to create, a passive floodplain, the consequences of overtopping or breach should be considered.

3.31 Other sources of flooding should also be considered. Groundwater flooding, caused by higher than normal groundwater levels in pervious strata causing springs to surface, can flood roads, making their use hazardous, and severely compromise the structural integrity of the pavement.

3.32 Flooding caused by surface water runoff in an undrained area or across a saturated, frozen or impermeable surface, sometimes referred to as 'pluvial' flooding, may also flood a road surface and was a major cause of flooding in the events of summer 2007. This type of event is usually associated with high intensity rainfall (>30 mm/hr) and can result in overland flow and ponding in local depressions. Drainage systems may be overwhelmed, preventing runoff through the usual routes.

3.33 Discharges to ground should also be considered as a possible source of flooding. Infiltration of road runoff may surcharge local groundwater and cause a local rise in the water table, which in turn may lead to increased groundwater discharges, and possible flooding down gradient. The topography of the discharge site, the nature of the receiving aquifer, the groundwater level and the design of the discharge system may all affect the susceptibility of a site to groundwater flooding. The potential waterlogging of ground in the vicinity of discharge systems should also be considered.

3.34 The EAs should be consulted as early as possible where proposed projects may have an impact on a floodplain or local drainage and the parameters for the assessment established. The EAs may be able to make available additional data, such as the results of local studies carried out for other purposes and locations where flooding has been recorded. Agreement should be sought, where possible, on the type and scope of investigations of flood behaviour, and the parameters to apply in judging the acceptability of the results to the investigations undertaken.

3.35 Even where roads are not within floodplains, their construction can cause local changes to catchment drainage patterns. The amount of runoff will increase as a greater area is paved, and without attenuation, there will be an increase in the rate at which runoff reaches the receiving water bodies. The increase from one drainage outfall alone may not make a significant difference to the water body, but the cumulative effect of all the outfalls in a road project, or the effects of its construction, may affect flood risk elsewhere in the catchment. Designers should satisfy the EAs that there is no increase in flood risk, and should be prepared to demonstrate this as part of their design.

3.36 The construction of a new road forms a barrier that may cross existing drainage routes, causing potential blockage and altering local catchment areas and boundaries. It is usual practice to keep the existing land drainage separate from the road drainage where possible, using ditches and culverts beneath the road embankment. Where there are existing culverts within a length of road to be upgraded, their capacity should always be checked, even if there is no requirement for the culvert to be amended as a result of the project. This is particularly important if flooding upstream is a known problem. It is possible that there may have been changes to the upstream catchment since the culvert was built, resulting in the culvert's capacity being inadequate. HA 106 (DMRB 4.2) considers the effect of runoff from existing land drainage on road drainage, and HA 107 (DMRB 4.2), considers the design of culverts and outfalls.

3.37 The construction of the road, its sub-surface drainage and its foundations (for example, deep structures associated with bridges) may also intercept shallow groundwater flow. Particularly where roads are in tunnels or cuttings, there may be a significant interception of groundwater flow which may influence the down gradient movement of groundwater. Interception of groundwater flow, if not appropriately drained, may also cause waterlogging or groundwater flooding up gradient. These impacts may be especially important where shallow groundwater systems support low flow in streams or where they feed wetlands. Any such impacts should be considered in project design and the EAs consulted with respect to the mitigation approach adopted.

3.38 In many locations, embanked flood defences and other structures such as weirs contribute to flood protection for areas at risk. It is necessary to ensure the integrity of such defences for the future, with suitable access preserved for inspection and maintenance of the defence. The EAs should be consulted to advise of the presence of any defences, and how they should be considered in a project design.

3.39 The methods of construction can also increase flood risk:

i) temporary paved surfaces or roofed areas of site compounds may increase the rate of runoff;

ii) any works within the floodplain are likely to affect the local hydrology;

iii) ditch or drainage diversions may affect catchment characteristics;

iv) temporary bunding or material stockpiles may alter runoff from upstream areas; and

v) large areas stripped of vegetation can discharge runoff at a much higher rate than if grassed, and some provision for temporary storage of surface water may be needed.

Other Possible Impacts

3.40 A new or improved road may impact on the amenity value of a watercourse. Where a river, reservoir or canal is used for leisure activities, such as fishing or boating, these may be affected by the project. The project may interfere with (or improve) the access to the facility or the enjoyment of the activity. A consequential impact of the project may be economic, if, for example, a business on the waterfront is affected due to the impact of the project on the watercourse.

Project Objectives

3.41 It is important for projects to set project design objectives. These may be based on legal compliances or Overseeing Organisation's policy objectives or they may be constructed to deliver particular local requirements for projects. Examples can be seen in boxed paragraphs 2.16 and 2.20. In undertaking an assessment of the impacts and effects, designers need to be aware of these and understand that the assessment process should support the delivery of such objectives.

4. CLIMATE CHANGE

4.1 Climate refers to *'the average weather experienced over a long period, typically 30 years'* (United Kingdom Climate Impacts Programme). Climate includes wind and rainfall patterns alongside temperature. Over the past centuries the climate of the Earth has changed many times in response to a variety of natural causes and is by definition not static. The term 'climate change' usually refers to recent changes in climate that have been observed since the early 1900s.

4.2 The United Kingdom Climate Impacts Programme (UKCIP) **www.ukcip.org.uk** is assessing implications of climate change in the UK. This includes the associated changes to flood risk and river flows, which are also being investigated by the Centre for Ecology and Hydrology (CEH). Rises in sea level are likely to result in increased risk of coastal flooding, and may require improvements to existing sea defences.

4.3 Climate change scenarios for the UK predict that:

i) winters will become wetter by up to 15% by the 2020s (up to 25% by the 2050s) for some regions and scenarios (Ref 43);

ii) summers will possibly be drier by up to 20% by the 2020s (up to 40% by the 2050s) for some regions (Ref 43);

iii) snowfall amounts will decrease significantly throughout the UK, perhaps by between 30% and 90% by the 2080s (Ref 22); and

iv) extreme winter precipitation will become more frequent. By the 2080s, rainfall intensities that are currently experienced around once every two years may become up to 20% more intense (Ref 22).

4.4 With UK summers becoming hotter and drier and winters becoming milder and wetter the seasonality of river volumes may change, particularly in rivers with a high proportion of base flow from groundwater. Low flow conditions may persist later into the autumn, and recharge from groundwater will be delayed until later in winter or early spring (Ref 43). The flow rate of rivers under low flow conditions is expected to decrease in all months except January (which remains equal) and February (which increases), although the uncertainty of these forecasts is high for the winter months. Change in levels and timing of flows could increase the risk of extreme low river flows if winter recharge were insufficient. However, wetter winters and more frequent extreme winter precipitation may lead to increases in river flows and, therefore, the likelihood of flooding. Future impacts on river flows are also likely to vary between catchments within the UK.

4.5 Estimation of potential climate change impacts is an area of on-going research. Annex B of PPS25 presents recommended contingency allowances for sea level rise, peak rainfall intensity, peak river flow, offshore wind speed and extreme wave height. As climate change allowances are continually being reviewed they are subject to change and it is therefore recommended that the designer should consult with the Environment Agencies (EAs) to agree the allowances to be made.

5. PROCEDURE FOR ASSESSING IMPACTS

General

5.1 The general procedure for assessing impacts on the water environment as part of any environmental assessment process follows the principles as set out in DMRB Volume 11, Sections 1 and 2.

5.2 The first step in the process will be to scope any assessment. For scoping criteria refer to paragraph 6.8. Where this exercise concludes that assessment is warranted the methods set out below must be used.

5.3 This chapter describes the procedures that must be used when assessing the potential impacts from road projects on the water environment. Methods are described in Annex I for the following topic areas:

i) Methods A and B – Effects of Routine Runoff on Surface Waters;

ii) Method C – Effects of Routine Runoff on Groundwater;

iii) Method D – Pollution Impacts from Accidental Spillages;

iv) Methods E and F – Assessing Flood Impacts.

5.4 Guidance is also provided on: assessing the potential for erosion during construction, identifying cumulative impacts, and gauging the significance of any potential environmental effects that are identified as part of the assessment process.

Effects of Routine Runoff on Surface Waters

5.5 Research (Ref 7) has shown that pollution impacts from routine runoff on receiving waters appear to be broadly correlated with Annual Average Daily Traffic (AADT). The site with the lowest traffic flow which was studied during the research had an AADT of 11,000. The traffic flow below which potential pollution impacts are insignificant is not clear. Many trunk roads, particularly in Scotland, Wales and Northern Ireland, carry less than 10,000 AADT and for these sites the Overseeing Organisation should be consulted as to whether an assessment of the potential impacts needs to be made. On such lightly trafficked roads, pollutants will occur in lower concentrations and devoting resources to the assessment process will rarely be justified. However, where discharges from these lightly trafficked roads feed into sensitive water bodies (such as Site of Special Scientific Interests (SSSIs), Special Protection Areas (SPAs), Special Area for Conservations (SACs), Water Protection Zones (WPZs), Ramsar Wetlands and salmonid waters) an assessment of the potential impacts should be made using the normal methods described below.

5.6 An assessment of the potential ecological impacts of routine runoff on surface waters is required in order to determine whether there is an environmental risk and if pollution mitigation measures are needed in specific circumstances. The Highways Agency Water Risk Assessment Tool (HAWRAT) has been developed for this purpose and the methodology behind it has been derived from a collaborative research programme undertaken by the Highways Agency (HA) and Environment Agency (EA) which investigated the effects of routine road runoff on receiving waters and their ecology (Refs 7, 13, 23, 24, 35). The toxicity thresholds determined through the research programme, and which are used by the tool, have been designed to prevent adverse ecological effects in the receiving water. Equally, in artificial and heavily modified water bodies, the thresholds have been designed to prevent adverse effects on ecological potential. The thresholds have been developed with the EA and are consistent with the requirements of the Water Framework Directive (WFD). Previously, in order to undertake an HA 216/06 assessment, the River Ecosystem Class (RE Class) of the receiving watercourse was required and watercourses with a lower RE Class were more likely to pass the assessment. As the WFD aims to achieve ‘good’ ecological status in all water bodies, it is not appropriate to allow existing water quality to influence the outcome of the assessment. The RE Class and ecological status of the receiving water are, therefore, not considered by HAWRAT, rather, the tool applies the same toxicity thresholds to all assessments regardless of receiving water quality. The EA have approved the method of assessment used by HAWRAT and have agreed that the outputs from the tool can be used in the Environmental Impact Assessment (EIA). The tool’s design is also consistent with the consequential levels of assessment approach described in Chapter 6 and requires relatively little site-specific data to make an assessment.

5.7 HAWRAT is a Microsoft Excel application which can be downloaded from the Highways Agency Drainage Data Management System (HADDMS) **www.haddms.com**. Further information about HADDMS is given in HD 43 'Drainage Data Management System for Highways' (DMRB 4.2). HAWRAT may be upgraded periodically and users should check that the most up-to-date version is being used. Reporting of assessments using HADDMS is discussed further in paragraph 7.5.

5.8 The principal features of HAWRAT are outlined below. An explanation of how to use the tool is given in Annex I and worked examples are given in Annex II. For a full description of the tool refer to the associated Help Guide and Technical Manual (Ref 21).

5.9 The following pollutants have been incorporated within the assessment process (and HAWRAT):

i) soluble pollutants associated with acute pollution impacts, expressed as Even Mean Concentrations (EMCs) for dissolved copper and zinc;

ii) sediment-bound pollutants associated with chronic pollution impacts, expressed as Event Mean Sediment Concentrations (EMSCs) for total copper, zinc, cadmium, pyrene, fluoranthene, anthracene, phenanthrene and total polycyclic aromatic hydrocarbons (PAH).

5.10 As shown in Table 5.1, HAWRAT adopts a tiered consequential approach to assessment and can report the results at three different stages depending upon the level of assessment required for any given site. These are:

i) Step 1, the runoff quality (prior to any pre-treatment and discharge into a water body);

ii) Step 2, in river impacts (after dilution and dispersion);

iii) Step 3, in river impacts post-mitigation.

5.11 At Step 1, HAWRAT predicts the statistical distribution of key pollutant concentrations in untreated and undiluted highway runoff (the 'worst case' scenario) over a long release period (Ref 7). The distribution uses a statistical model, developed through research (Refs 7, 13, 23, 24), which is based on a ten year rainfall series relevant for the chosen site and its climatic region. The results are assessed on a pass/fail basis against the toxicity thresholds described in paragraphs 3.12 and 3.17. These represent a guideline emission standard in the absence of any pre-treatment within the drainage system or in-river dilution and dispersion.

5.12 At Step 2 the assessment becomes more realistic and is only applied if one or both the toxicity thresholds are predicted to fail at Step 1. HAWRAT uses details of the highway catchment draining to the outfall, the flow rate of the receiving watercourse and its physical dimensions to calculate the available dilution of soluble pollutants and potential dispersion of sediments. A further comparison with the pollutant thresholds is then made. For the soluble pollutants that cause acute impact this involves a simple mass balance approach. For the sediment-bound pollutants that cause chronic impact, the ability of the receiving watercourse to disperse sediments is considered and, if sediment is expected to accumulate, the potential extent of sediment coverage (the deposition index) is also considered. Additionally, Step 2 contains two tiers of assessment for sediment accumulation: Tier 1 is a simple assessment requiring only an estimate of the river width. If required, Tier 2 is a more detailed assessment which requires a site visit to measure the physical dimensions of the river. If a Tier 1 assessment indicates no risk then unnecessary work for a Tier 2 assessment is avoided. Annex V contains a field log sheet designed to assist in site visits and should, if fully completed, ensure all information is captured and repeat visits are minimised.

5.13 The pollution risk estimated at Steps 1 and 2 assumes the drainage system includes no pollution control measures to mitigate the risk. Where this risk is considered unacceptable, pollution control can be included at Step 3 in order to assess either the effectiveness of existing measures or the required scale of any proposed new measures (including retained existing measures). It should be noted that in Scotland Sustainable Drainage Systems (SuDS) are a mandatory requirement under Controlled Activities Regulations (CAR), and the need for SuDS cannot necessarily be ruled out if the tool indicates that the discharge will pass at Steps 1 or 2.

5.14 As shown in Table 5.1, the HAWRAT tool uses a pass/fail reporting method whereby:

- 'Fail' indicates either; an unacceptable impact, a need to carry out further assessment steps, or a need to refer the situation to specialist judgement;

- 'Pass' indicates that there will be no short-term impact associated with road runoff (long-term impact should be assessed separately).

Stage of Assessment	Inputs	Outputs
Step 1 **Runoff quality**	• Traffic volume • Geographic location • 10 years of rainfall data, ~1000 rainfall events (embedded in HAWRAT)	• Runoff concentrations of soluble pollutants and sediment-bound pollutants for each event • Pass/Fail standards
Step 2 **In river**	• Outputs from Step 1 • Area draining to outfall • Characteristics of receiving watercourse	• Concentration of soluble pollutants after dilution • Stream velocity at low flow • Deposition index (extent of sediment coverage) • Pass/Fail standards • Percentage settlement required to comply with deposition index • Annual average concentrations of soluble pollutants
Step 3 **After mitigation**	• Outputs from Steps 1 and 2 • Existing and proposed mitigation measures o Treatment of soluble pollutants o Flow attenuation o Settlement of sediments	• Concentration of soluble pollutants after treatment • Concentration of soluble pollutants after further dilution • Pass/Fail standards • Annual average concentrations of soluble pollutants after mitigation

Table 5.1 – Stages of Assessment in HAWRAT

5.15 If HAWRAT indicates low risk, there is a high level of confidence that there will be minimal short-term impact. The methodology uses tighter pollutant thresholds for more sensitive watercourses such as SSSIs and SACs.

5.16 HAWRAT is designed to make an assessment of the short-term risks to receiving-water ecology which relate to the intermittent nature of road runoff. An assessment of the long-term risks (using annual average concentrations) is also required to complete the risk assessment process. HAWRAT estimates in-river annual average concentrations for soluble pollutants (dissolved copper and dissolved zinc) which include the contribution from road runoff. These concentrations can be compared with published Environmental Quality Standards (EQSs) to assess whether there is likely to be a long-term impact on ecology. The procedure for long-term assessment is discussed in more detail in Annex I, Methods A and B.

5.17 When the potential for both short-term and long-term impacts have been assessed there will be a number of possible outcomes. These are listed in Table 5.2 together with the actions that will need to be taken in each scenario.

HAWRAT Assessment[1]	**Assessment against EQSs**[2]	**Action**
Pass	Pass	No further action
Fail	Pass	1. Factor in effects of proposed design and reassess 2. Consider implications of redesign and reassess 3. Weigh up benefits over whole scheme 4. Agree action with regulator (may require continued monitoring)
Pass	Fail	1. Check sensitivity of modelling to input parameters e.g. Q_{95} 2. Discuss with regulator
Fail	Fail	Redesign

1 To Pass the HAWRAT assessment requires both solubles and sediments to pass. If either fail, then use fail in this table.
2 To Pass the EQS assessment requires both dissolved zinc and dissolved copper to pass. If either fail, then use fail in this table.

Table 5.2 – Assessment Outcomes and Actions to Take

5.18 The risks to each receiving watercourse should be assessed for each individual discharge. Where outfalls discharge to the same watercourse or river reach, the combined risk should be assessed according to the principles given in Annex I. HAWRAT is not specifically designed to assess any proposed discharges to lakes although the tool does require the form of the receiving water to be considered. Lakes within 100 m downstream of the outfall (along the river) are assumed to accumulate highway derived sediments and the tool will identify this as an unacceptable risk.

> 5.19 Discharges must not be made into lakes, ponds or canals. If a proposed discharge into a lake, pond or canal is unavoidable the methods adopted in the assessment of any potential impacts should be agreed with both the relevant EA and Overseeing Organisation.

5.20 A key input parameter for HAWRAT is the flow rate of the river under low flow conditions when exceedances of the ecological thresholds are more likely. This parameter is used by the tool to calculate both dilution of soluble pollutants and the river velocity which, in turn, is used to estimate whether sediment is likely to accumulate. The usual low flow parameter is the Q_{95}, which is defined as the flow equalled or exceeded in a watercourse 95% of the time. Q_{95} is not as commonly reported as flood flows, though data are available from major gauging stations and these are the most reliable figures to use. These values are actual Q_{95} flows and include the effects of any artificial influences, such as abstractions or discharges. It may be possible to use data from a catchment with similar characteristics. Flows in the majority of water courses in the UK are affected by artificial influences: either abstractions, discharges or both, such that actual Q_{95} flows usually differ from natural Q_{95} flows. Natural flows can be estimated using either the method in Institute of Hydrology (IOH) Report No. 108 (Ref 19), or from a commercial software package called LowFlows™ available from Wallingford Hydrosolutions. Either method can be used to give a first order estimate of the natural Q_{95} flow, but neither is entirely reliable and judgement needs to be applied to ensure an appropriate value is used. Where artificial influences are known to exist (the EAs will usually be able to advise on this) a further allowance will have to be made to any estimated value of the natural Q_{95} flow to enable the actual Q_{95} flow to be derived. It is pertinent to quote the cautionary note in the British Geological Survey (BGS) Hydrometric Register and Statistics (Ref 32) describing the Q_{95} flow data. *'The reliability of the 95 percentile flows must be considered carefully as representative measures of low flow. The values should be used with caution in view of the problems associated with both the measurement of very low discharges and the increasing proportional variability between the natural flow and the artificial influences, such as abstractions, discharges and storage changes as the river flow diminishes.'* The outputs from the LowFlows™ software are subject to similar cautions to those described above. In addition, care should be taken in interpreting the results for catchments less than 1 km^2 as this is the spatial resolution of the underlying catchment characteristic datasets. Where there is any doubt over the Q_{95} used, the Overseeing Organisation should be referred to.

5.21 HAWRAT has adopted within its design a precautionary approach. It produces a conservative estimate of the potential impact of water quality downstream of a discharge. One advantage of this approach is that it readily differentiates between low risk sites requiring no further assessment or mitigation and those sites that may require further detailed assessment and/or mitigation. This allows earlier identification of potential polluting sites and more effective use of resources. Specific assumptions within HAWRAT include:

i) Tier 1 map-based estimation of river width. A regression equation is used to calculate the cross-sectional area of the river from the river width. The area is then used for calculation of river velocity and depositional index. The stream dimensions used to generate this equation represent a small subset of the potential full range of conditions. As a precaution the upper 95% confidence interval of the regression equation is applied. Therefore, in most cases the stream velocity will be underestimated and the depositional index overestimated. Tier 1 is provided as a simple and conservative check, which, if no risk is identified, will save further work being carried out. More accurate assessment for Tier 2 requires a site visit for the river dimensions to be measured.

ii) In situations where highway derived sediment is likely to accumulate the extent of deposition is assessed against a dimensionless deposition index value of 100. The research (Ref 13) and subsequent validation (Ref 14) was not able to provide detailed information on the extent of sediment deposition that is likely to have an ecological impact. It was agreed with the EA that initially a starting value of 100 should be used. This value is considered conservative and will be subject to review.

iii) HAWRAT assumes that the highway pavement represents an infinite source of sediment, which may lead to an overestimate of the extent of deposition. Sediment exhaustion is likely to be a factor of the antecedent dry weather period and the duration and intensity of the rainfall. There are currently no data available from which to establish a sediment exhaustion factor.

iv) Sediment arriving in the river when the velocity is less than 0.1 m/s is assumed to accumulate, the rest is assumed to disperse. The deposition index is a consideration of the extent of sediment coverage. It is likely that when velocities are higher, part of the accumulated sediment will be removed. However, the tool is not able to incorporate this removal mechanism and all accumulating sediment is considered to remain and add to the annual total. Refinement of the assessment tool in this respect is a future consideration. Such a refinement will require an understanding of how long the polluted sediment needs to remain for it to have an adverse ecological impact.

v) The estimated river flow for a given rainfall event will be generated by the model at the start of the event, i.e. it will not be influenced by the event itself. This is a conservative approach and recognises that the highway runoff response will generally be much faster than the river flow response. However, if there is any increase in the river flow rate and flow velocity there will be greater dilution and an increased chance of reaching the dispersing velocity threshold of 0.1 m/s. This is thought to be especially significant in smaller streams where highway runoff can represent a significant part of the flow and increase velocities considerably.

5.22 HAWRAT provides a safe means of identifying those proposed discharges which will not adversely affect receiving water quality with respect to soluble and sediment-bound pollutants.

5.23 HAWRAT was developed primarily for use on non-urban trunk roads and motorways in England and has been adapted to reflect conditions within Wales, Scotland and Northern Ireland. However, it has a number of limitations and is not directly applicable in some circumstances. Care should be taken when considering its use in the following situations and, where appropriate, approval and guidance should be obtained from the Overseeing Organisation:

i) urban highways (where a wider range of pollutants and larger concentrations might arise which may be under-represented by HAWRAT because of the reference datasets);

ii) highways outside the UK (due to differences in rainfall, climate, vehicle fleet and other factors); and

iii) highways where the receiving water course is tidal.

Effects of Routine Runoff on Groundwater

5.24 For discharges to groundwater, a risk assessment procedure has been developed and is included in Annex I (Method C, Groundwater Assessment). The following section describes a simple step-wise framework for identifying and assessing the individual components of the overall risk to groundwater quality posed by the disposal of road runoff to the ground. The framework is based on an examination of the 'Source-Pathway-Receptor protocol' (S-P-R) used in risk assessment procedures developed and supported by the EAs for contaminated land evaluation. This principle may be readily applied to the disposal of road drainage whereby the:

i) source term comprises the road drainage, as it enters the soakaway discharge system with any pollutants contained therein;

ii) pathway term represents the processes, which may modify the pollutants during transmission through the discharge system and soil and subsoil until the actual 'point of entry' to groundwater (this includes the unsaturated zone);

iii) receptor, which is the groundwater.

5.25 The principle applied is that all elements of the S-P-R linkage have to be present to create a pollutant linkage. The presence of the pollutant in itself does not pose a risk to groundwater if there is no identifiable pathway. Breakage of an existing or potential pollutant linkage provides an effective means of reducing the risk to a receptor, in this case groundwater, to an acceptable level. There may be a number of ways of doing this, for example by:

i) demonstrating that the routine runoff (i.e. the source) itself is generating no discernable discharge of harmful pollutants (although it should be noted that a high spillage risk may still represent a threat to groundwater and should be considered in site assessment);

ii) removal of pollutants through the pathway, notably through attenuation in the soil or unsaturated zone possibly by using more sustainable solutions, such as swales.

5.26 Conversely, the future establishment of a pathway in a system currently void of one, for example, due to maintenance engineering, can increase the potential for groundwater pollution. The key factors affecting the persistence and movement of pollutants within the pathway to groundwater and linkages between them are illustrated in Figure 5.1. From these factors, and the concepts developed on the diagram, an interim risk assessment matrix has been evolved, as shown in Table C1.2 in Annex I. This provides a means of ranking specific sites in terms of their potential risks to groundwater. Drainage system construction may then be more closely tailored to address that risk.

5.27 There are a number of recognised component properties or parameters that relate to site-specific road and drainage conditions and provide a means of quantifying the vulnerability of the aquifer to the presence of pollutants in routine runoff. However, as the appropriate data may not be readily available, not all these properties or parameters can be readily adopted into a usable risk assessment matrix. Therefore, properties incorporated into the risk assessment matrix are those that may be evaluated with minimal effort by the engineer using readily available generic data, and data from preliminary site investigation work.

5.28 For each component, risk category allocation (high, medium or low) is defined by ranges of values or defined characteristics. This initial assessment will identify those hydrogeological situations, i.e. high risk cases that warrant collection of further data and a higher level of assessment. Before applying the assessment it is essential to understand the individual components (properties or parameters) that are used in the risk assessment process. These are further described with the methodology presented in Annex I.

5.29 In the absence of real data on the fate of pollutants in the unsaturated zone and in soakaways, the risk assessment matrix has been developed using expert judgement and it provides an interim guidance. Further laboratory and field studies are required to:

i) validate the selection of criteria;

ii) better quantify the boundary conditions set for each risk category; and

iii) identify the sensitivity of the assessment to the selected criteria and boundary conditions.

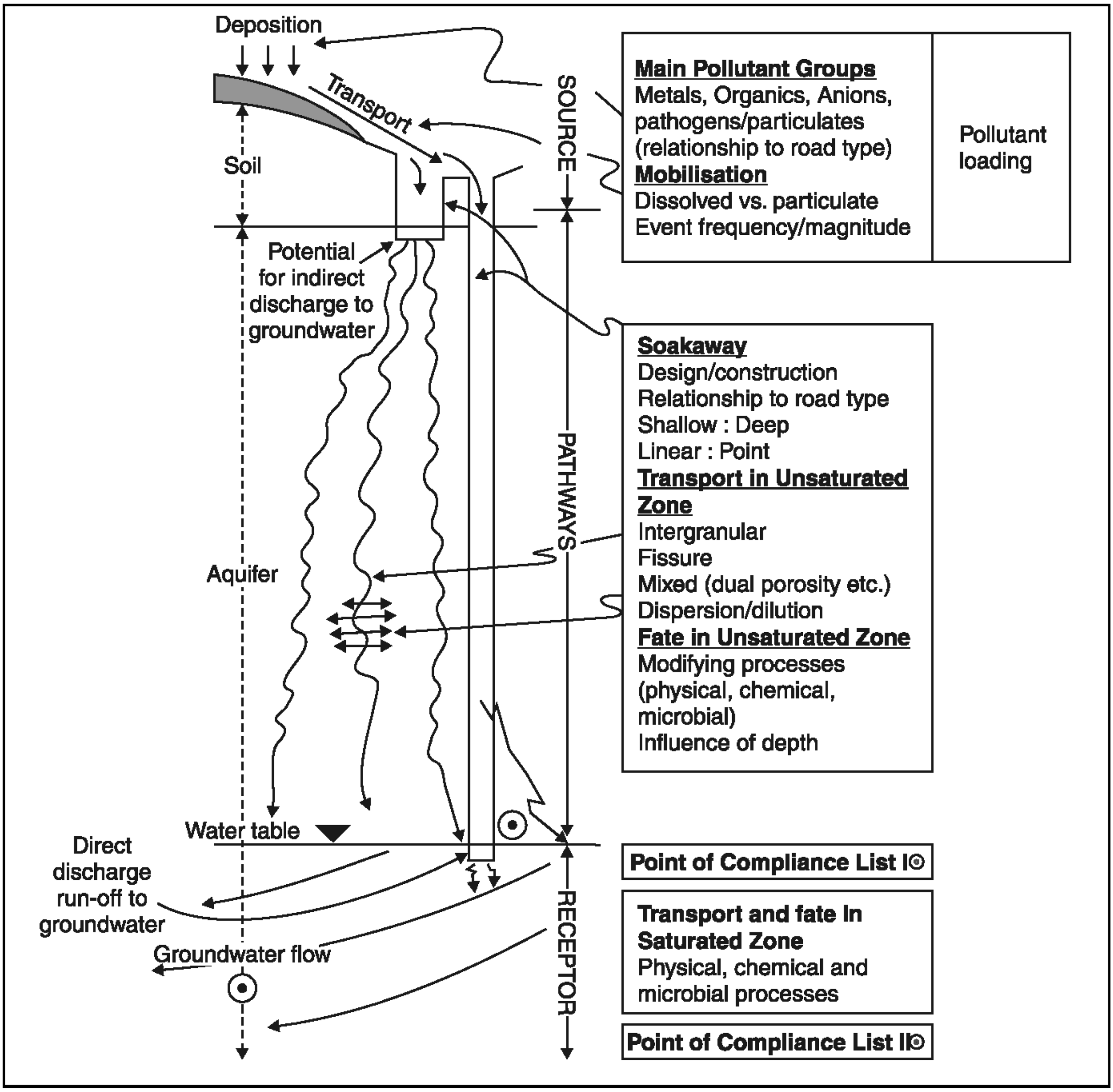

Figure 5.1 – Schematic of Source, Transport and Fate of Road Runoff

Pollution Impacts from Spillages

5.30 Spillages caused by accident or other causes can occur anywhere on the road network. Although the effect of many road projects will be to reduce the overall risks of collisions, it is important to assess the risks of an acute pollution impact. Assessment will allow routes to be chosen to minimise the environmental risks and to target mitigation measures at the highest risk areas.

5.31 Method D in Annex I contains a step-by-step guide to the calculation of these risks. HAWRAT also includes a facility to assess spillage risk using the same method. The method initially estimates the risk that there will be a collision involving the spillage of a potentially polluting substance somewhere on the length of road being assessed. It then calculates the risk, assuming a spillage has occurred, that the pollutant will reach and impact on the receiving watercourse. The pollution impacts considered are those that fall into either Category 1 or 2, as defined in Table 2.1, which are hereafter described in this Part as **‘serious pollution incidents’**.

5.32 These risks can conveniently be expressed as annual probabilities of such an event occurring. This allows objective decisions to be made as to their acceptability, or whether measures are needed to reduce the risk. The risks to each receiving watercourse should be assessed. Where more than one outfall discharges to the same watercourse, the combined risk from all such outfalls should be assessed. This is especially important if several outfalls discharge to the same **reach** of a river.

5.33 The Overseeing Organisation will advise on acceptable risks. As a guide, watercourses should be protected so that the risk of a serious pollution incident has an annual probability of less than 1% (this is the same as the general probability standard to which properties should be protected against river flooding). In circumstances where an outfall discharges within close proximity to (i.e. within 1 km) a protected area for conservation (such as those listed in paragraph 2.13) or could affect important drinking water supplies or other important abstractions, a higher standard of protection will be required such that the risk of a serious pollution incident has an annual probability of less than 0.5%.

5.34 The assessment methodology has been derived from an analysis of spillage incidents in England and Wales. In considering the risk of a spillage occurring, it has been assumed that they are distributed across the network in the same way as personal injury collisions involving Heavy Goods Vehicles (HGVs). The spillage rates given in Table D1.1 Annex I are for motorways and for both rural and urban all purpose trunk roads. An urban all purpose trunk road is defined as a road within a built-up area having a speed limit of 40 mph or less if single carriageway, or 60 mph or less if dual carriageway. The rates given for junctions apply to the lengths of road within 100 m of the centre of junctions. Occasionally, allowance will have to be made where it is known that a road carries an unusually high proportion of vehicles with hazardous loads.

5.35 The methodology gives a higher risk for more sensitive watercourses, and for those in remote locations. This recognises that where there is a prompt and effective response to a spillage, the risk of a pollution incident is significantly lower, and such responses are less likely in remote locations.

5.36 The pollution risk is initially estimated assuming the drainage system includes no measures to mitigate the risk. Where this risk is assessed to be in excess of the acceptable limit, some form of pollution control should be included to reduce the risk. Mitigation measures and their effect on pollution risks are discussed in Chapter 8.

Assessing Flood Impacts

5.37 A summary of the principal stages in the procedure for assessing potential flood impacts is given in Annex I, Method E (Hydrological Assessment of Design Floods) and Method F (Hydraulic Assessment). The most important decisions in the planning stages are as follows:

i) to ensure that any route options which avoid floodplains are fully investigated;

ii) outline bridge designs may require alteration to achieve the no net afflux target. The cost effectiveness of achieving this should be compared to other options such as providing separate flood relief culverts;

iii) costs and benefits should be assessed when considering the need for compensatory flood storage, alternative measures to reduce floodwater levels or the protection of areas where the flood risk would otherwise be increased.

5.38 Other factors which may require more detailed assessment at the design stage are:

i) the hydraulic performance of bridge structures and culverts;

ii) the effect of any works affecting rivers both upstream and downstream;

iii) the impact of road runoff on river flows;

iv) the effects of road construction on hydrological regimes and catchments;

v) consequential impacts on aquatic and other environments.

5.39 In the lowest reaches of some rivers, where water levels are mainly determined by tidal effects, it is probable that flooding will be caused by tidal water levels alone. The upstream limit of tidal flooding will be determined by river flows. There will also be an intermediate zone where flooding may be either fluvial, or tidal, or caused by a combination of the two.

5.40 In the intermediate flooding zone, it is important to select a design event that takes tides and river flows into account. For example, a suitable design event may be a river flood with an annual probability of 2% combined with the estimated tidal flood level having a 1% annual probability. A variety of combinations of fluvial and tidal flooding conditions should be tested to identify the most significant combination. Joint probability studies have been carried out in several estuaries across the UK and this information is often available through the local EAs' office or local authority.

5.41 In tidal reaches where water levels are continually rising or falling, the time of the peak tide will vary along the river. Unsteady flow modelling will be required to determine the resultant impacts of coincident high tides and flooding levels. For example, tidal effects should consider the following events:

i) Spring Tide and a Mean Annual Flood;

ii) Spring Tide and a tidal flood with a 2% annual probability;

iii) Spring Tide and a tidal flood with a 1% annual probability;

iv) maximum recorded high tide and a tidal flood with a 1% annual probability.

An estimate should also be made as to what is the likelihood of coincidence of these events.

5.42 The design flood event is commonly set as defined above. It should be discussed with the EAs. The return periods should be appropriate for river flooding, and not necessarily the same as those used for scour, forces on bridges, and other design considerations. If the EAs request an event with a lower annual probability than 1% for fluvial flooding, or 0.5% for tidal flooding, the Overseeing Organisation should be consulted prior to any agreement on the use of such events in the assessment.

5.43 The assessment procedure is intended to provide a first order estimate of the effects of the crossing on flooding. Where the effects on floodwater levels are significant, sensitivity tests should be carried out for floods across a range of annual probabilities (from 50% to 0.01%) and should take account of possible climate change impacts discussed in Chapter 4.

5.44 The acceptable amount of afflux should be agreed with the EAs at an early stage in the planning procedure. It is common that a target of zero afflux is used. The extent of environmental impact, changes in the flooding regime and any residual impacts should always be considered.

5.45 A range of design options should be assessed to ensure that the afflux value can be justified in terms of value for money. Further details of afflux design can be found in BA 59 (DMRB 1.3).

5.46 Any construction within a river or estuarial floodplain will occupy areas which were previously available for flood storage or flows. Therefore, flood storage compensation should be provided. For example, if an embankment is built within a floodplain, the EAs will request that material is removed in areas as close as possible to the proposed road crossing, so that the compensation works relate hydraulically to loss of floodplain. Works located remote from the infill site will not be acceptable, as these can change the natural hydrology of the catchment. The compensation storage should be designed to provide at least the same volume at every level as is occupied in the existing situation. In some cases it may be possible to reduce the overall flood risk. The impact of the loss of floodplain storage should be calculated using Method F (Hydraulic Assessment) in Annex I. Although in many cases the storage volume will be small for a single project, works should be carried out to avoid increasing flood risk by cumulative impact.

5.47 Occasionally, a road embankment may be designed as a barrier to store floodwater on the floodplain upstream of a town and compensation for the loss of floodplain storage may not be appropriate. In this case the embankment would cause significant afflux but reduce flood risk downstream. Where this is a design option, there are two major considerations:

i) if the retaining embankment will hold a volume greater than 25,000 m3 it will be regulated under the Reservoirs Act 1975 (see paragraph 2.43, Ref 20 and Annex III);

ii) consideration should be made of the failure scenario, if the embankment breaches or is overtopped, and the resultant effects on people and property.

5.48 The provision of compensatory storage can have environmental impacts with regard to habitats. These impacts should be compared with the alternative impact of higher floodwater levels in the catchment. Consultation with the EAs will be required when assessing these impacts.

Assessing Potential for Erosion During Construction

5.49 At the planning stage, environmental assessments for construction projects must include an erosion prevention and sediment control plan.

5.50 The first aim of the erosion prevention and sediment control plan should be to minimise erosion by reducing disturbance and stabilising exposed materials. The plan should then consider control measures to minimise the release of mobilised sediment which results despite the erosion control measures. Measures to prevent erosion are more effective than controlling sediment once mobilised. Further advice on preparing an erosion and sediment control plan is provided in CIRIA 648 (Ref 36). The potential risk from erosion and sediment control issues should be identified and reported in the Environmental Statement (ES) where construction impacts are considered. Ideally, and where necessary, a commitment would be made in the Construction Environmental Management Plan (CEMP). This is sufficient at the planning stage, however, the detail of such plans should be worked up as part of the CEMP after ES publication.

Assessing Cumulative Impacts

5.51 Many environmental impacts are caused by the cumulative effects of one or more separate impacts. These may be due to the coincidence of impacts, or the cumulative impact of separate events occurring at different times. They may be impacts on one aspect, e.g. landscape, caused by works to mitigate the impact of the water environment.

5.52 In assessing the impacts to the water environment, it is necessary to consider how the impacts may affect the relevant catchment or river basin. The WFD requires the preparation of River Basin Management Plans (RBMPs) showing all significant impacts to the waters in a particular river basin. The interaction of new impacts from highway works with existing impacts may well produce cumulative impacts. The EAs should be consulted where it is considered such cumulative impacts are possible and a copy of the RBMP examined.

5.53 An example of a cumulative impact to a river basin is the situation where two or more streams in the same river basin are affected by the same project. This situation is likely to arise where a road runs parallel to a watercourse for more than a kilometre. In assessing the cumulative impact, consideration should be given to the possibility of an impact to the receiving river, as well as to the streams themselves, even if that river is remote from the site.

5.54 The RBMP will show where development in a river basin may have increased the rate of runoff. As noted in paragraph 3.36, where highways are being improved and include existing culverts, an assessment should be made of the culvert's capacity, even if it will not be affected by the project. Where in such circumstances it appears that the culvert is inadequate, the Overseeing Organisation should be consulted for advice on whether the capacity should be increased as part of the project.

5.55 As noted in paragraph 5.39, in areas within the tidal floodplain, the cumulative impact of the possible combination of tidal and fluvial flooding should be considered. Furthermore, there is the possibility of the combined impact of either of the above forms of flooding with flooding caused by rising groundwater, as described in paragraph 3.31. The effect of flooding is usually most severe when heavy rain falls on ground that is already waterlogged, either from earlier rain or by high groundwater levels.

5.56 As noted in paragraph 5.46, where new construction within a floodplain is unavoidable, there will usually be a requirement for compensation to be provided elsewhere. The compensatory flood storage may well cause other environmental impacts, for example on the landscape or existing ecology, as well as the water environment, and these should be assessed along with the direct impacts of the project.

5.57 Temporary effects from the construction of a project may be cumulative. For example, spoil from an excavation could be washed into a river as a result of a severe rainfall or flood event. The risk of such a flooding event and the consequential damage to the water quality should be assessed, together with the risk of spoil being deposited in a flood prone location. Depending on the nature of the watercourse, small discharges of spoil could accumulate on the river bed, leading to a risk of ecological damage to any fish and their spawning areas. There can be a particular risk if the material washed into the river has been imported to the site, as its presence may cause a change to the chemical as well as physical quality of the water.

Assessing the Significance of Effects

5.58 It is not sufficient to assess the size and probability of possible impacts: their significance should also be assessed. For example, the impact of a large spill will be more significant if the stream it discharges to is a source of potable water, and a flood will be more significant if it affects a residential area. Where the risk of an impact is uncertain, as a result of a lack of information, this should be considered as part of the assessment.

5.59 Having identified the potential impacts, it will be possible to define the area within which the project is likely to have an influence. It can be useful to distinguish between impacts arising directly from a new or widened road, and those arising from changes to existing patterns in the use of an existing road, as a result of, say, a traffic management project. An assessment should be made of the importance of the water environment by considering the features within the study area. The environmental value of a feature such as a river is characterised by identifying and analysing its attributes, such as its use as a source of water, whether for potable or other use, its use for recreation, its function as a drainage channel or its value to the economy. Table A4.1 (Annex IV) shows the commonest features and their attributes found in the water environment. The EAs are likely to have a view on the importance of these features and should be consulted. Where the attributes have landscape, biodiversity, economic or cultural heritage value, impacts likely to affect those attributes should be considered in the parts of the assessment dealing with those environmental aspects. Attributes having qualities likely to require assessment outside the remit of this Part are marked with an asterisk in Table A4.1.

5.60 The importance of the attributes of water features that could be affected by the project should be recorded using a sheet, such as the one shown in Table A4.2. A guide to estimating the importance of water features is given in Table A4.3.

5.61 Potential impacts should be assessed in two steps: estimation of the magnitude of the impact, and then the significance of the impact. Tables A4.4 and A4.5 give guidance for estimating these, following which the Table A4.2 worksheet can be completed, using the qualifying conditions given in Table A4.6. Further comments may be added, if appropriate. This would certainly be helpful where there is a probability, but not certainty, of an impact, such as in the case of pollution from a spillage. In such cases a judgement should be made of the significance, based on the probability and the importance of the affected attribute. Comments will also be helpful where the impacts on some attributes are beneficial, but other impacts are adverse.

6. LEVELS OF ASSESSMENT OF IMPACTS

6.1 This chapter gives guidance on the appropriate level of assessment to be used when assessing the potential impacts from routine runoff, spillages and flooding arising out of road construction, operation and maintenance projects. Following the overall approach (as set out in DMRB 11.2.5) the level of assessment is generally related to the risk, however, for this subject the four key areas of assessment (surface water, groundwater, spillage and flood risk) have different requirements for scoping, simple and detailed assessments. For example, Highways Agency Water Risk Assessment Tool (HAWRAT) has integrated simple and detailed assessments for surface water and Method D is the only method of assessment for spillage.

6.2 The levels of assessment, where applicable, are consequential and progression is dependent on the type of proposed project, the location of the site and local circumstances, as well as the nature of the potential impact (routine runoff, spillages, flooding). For example, where sensitive receptors (e.g. a Special Area for Conservation (SAC), Ramsar Site, Site of Special Scientific Interest (SSSI), Source Protection Zone (SPZ), Water Protection Zone (WPZ), salmonid fishery or a Flood Zone) are identified during the scoping process, direct progression to detailed assessment may be appropriate. The process is also cyclical and is only completed when either no adverse impacts are predicted or other options avoid, treat or mitigate the potential impact, or an adverse impact is deemed to be outweighed by a beneficial impact. Where there is an adverse impact resulting in a change of project, design or mitigation or treatment, there is an obligation to re-assess the changed design or efficacy of treatment. The relationship between assessment level and project stage is shown in Figure 6.1.

6.3 An important part of the process is liaison with the Evironment Agencies (EAs) and other bodies such as the statutory nature conservation organisations where appropriate. This not only serves to acquire information, but to consult on levels of assessment necessary and the outcomes, this will ultimately save time and costs, and result in better solutions.

Methods of Assessment

6.4 Each possible impact has standard methodologies, which will normally be deployed. For example, for flooding, this may include the analysis of bridge afflux and floodplain storage. For water quality this may involve compliance of water quality standards for drinking water, fisheries and the general water environment for specific pollutants. For spillage it will involve an assessment of the risks of an incident within the length of road under consideration. The methodologies for each topic are set out in Annex I, with worked examples in Annex II. Figure 6.2 shows the approach to be used.

6.5 Figure 6.3 gives an indication of the stage of the project at which detailed calculations of crossing afflux and associated flooding problems need to be taken into account.

		Stage of project		
		Establishing Feasibility Considering Options	Evaluating Options	Evaluation of Preferred Option
Level of Assessment	Scoping	Essential	Essential if project enters at this stage	Essential if project enters at this stage
	Simple Assessment	Greater level of detail for higher potential impact ↓	→ Assessments reviewed as more data becomes available	
	Detailed Assessment			

Figure 6.1 – Levels of Assessment Needed at Various Stages of Project Development

Scoping

6.6 A definition of Scoping is given in HA 204 (DMRB 11.2).

6.7 Scoping is a desk-based exercise to determine if there is need for any assessment of the impact of the project on the water environment. It is also a liaison and data collection exercise giving opportunity for the EAs and other bodies to register concerns or particular requirements during the assessment process. It will need a full appreciation of the proposed works and some knowledge of the landscape, hydrogeology and drainage pattern and process in which the project is taking place. Depending on the project, this may be over a catchment/river basin, coastal area or local specific length of watercourse.

6.8 An assessment will be required where there is a potential for any road project to adversely affect water quality, flood risk or spillage risk. For example, if the answer to any of the following is yes, some form of assessment will be required:

i) Will the project affect an existing watercourse or floodplain?

ii) Will the project change either the road drainage or natural land drainage catchments?

iii) Will the project lead to an increase in traffic flow of more than 20%?

iv) Will the project change the number or type of junctions?

v) Is any of the project located within an Indicative Floodplain or an SPZ?

vi) Will earthworks result in sediment being carried to watercourses?

vii) Will the project allow drainage discharges to the ground?

Where these scenarios definitely are not the case, no assessment will normally be required (where appropriate this should be checked by consultation with the EAs). If there is any doubt, assessment should be carried out.

Simple Assessment

6.9 This level of assessment, whilst termed ‘simple’, can vary in its complexity depending upon the level or knowledge and sophistication of the assessment tools available within a subject area. The key feature of the simple assessment is the level of information required to arrive at an understanding of potential risks. On the whole a simple assessment is largely a desk-based exercise using the collected data to determine if there is a potential for impact (from routine runoff, spillage and/or flooding) on the water environment. For example, to identify the potential impact of routine runoff on surface waters, Method A would be used (as represented in HAWRAT). For groundwater, Method C would consider the pathways and the vulnerability of the aquifer. For spillage, Method D would be used to consider: local collision data, existing incident response arrangements and the vulnerability of receiving water bodies. For flooding, Methods E and F would identify areas at risk of flooding and the consequences of the proposed project. Where the simple assessment identifies that there are likely to be no impacts on the water environment due to the project, no further assessment will usually be required. Where potential impacts are required, an assessment will normally be required at the detailed level.

Detailed Assessment

6.10 This will generally build upon the desk-based exercise by supplementing it with information collected on site that enables a more detailed site-specific quantitative assessment to be made. At the time of writing, Method B (for assessing the risk of pollution to surface waters) is the only Detailed Assessment methodology currently available. At this level, if it is identified that further detailed assessment is required for flooding, groundwater or spillage risk, this will require close consultation with the EAs. It may also involve specialist/particular surveys and monitoring, which need to be determined at an early stage as they may have implications for programmes and budgets. In all instances the methodology to be adopted should be agreed with the Overseeing Organisation.

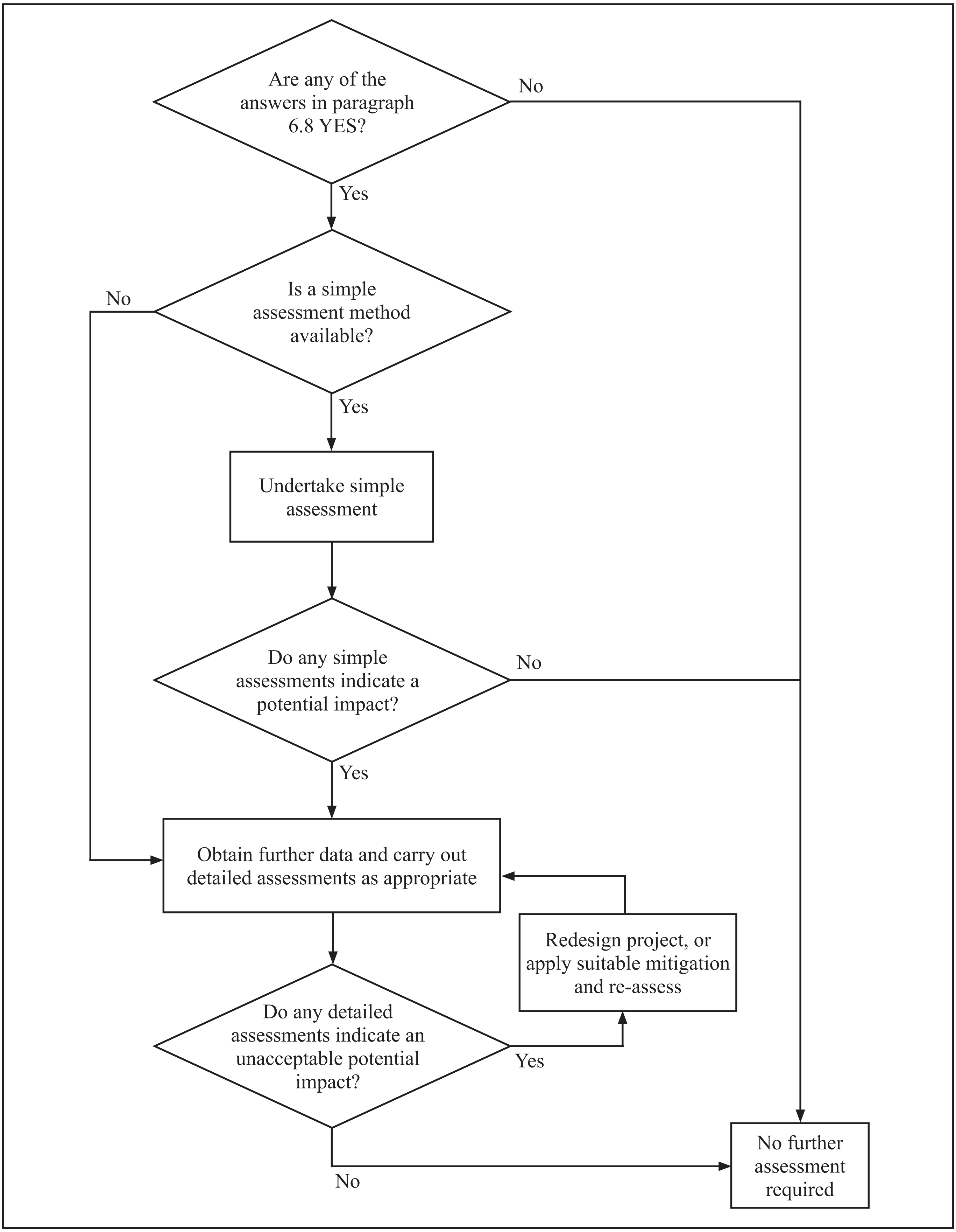

Figure 6.2 – Procedure for Assessment of Potential Impacts to the Water Environment

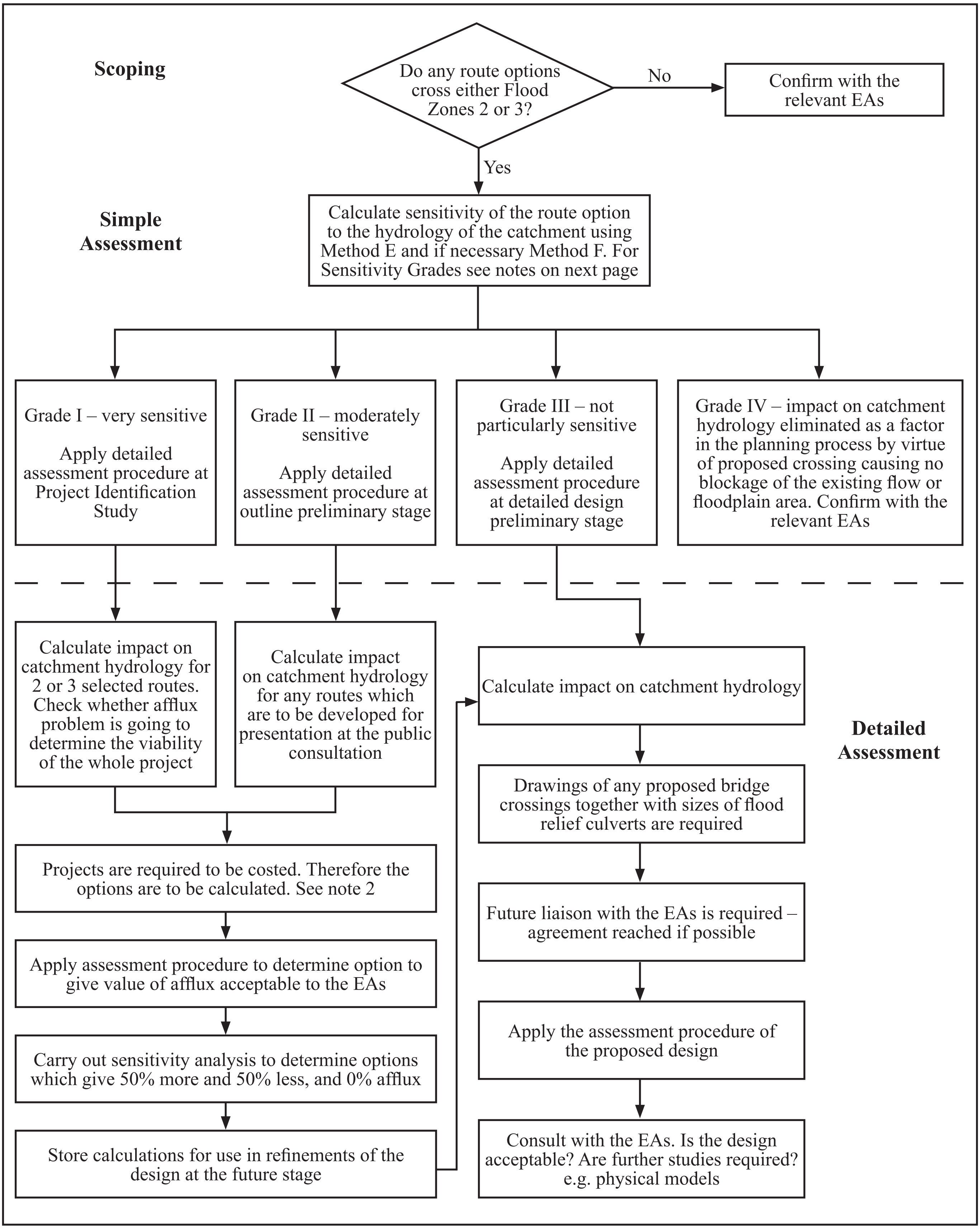

Figure 6.3 – Flowchart for Implementing the Assessment of Flood Risk due to Projects Crossing a Floodplain

Notes to Figure 6.3

1. Estimate the difference in cost between providing the maximum feasible flow width (total width of floodplain) and the minimum feasible flow width (width of existing channel). To obtain the floodplain width in England and Wales, look at the EA Flood Map website. Contact the relevant EAs to see if more detailed flood information is available.

2. Using the estimated value of cost difference, calculate what proportion of the overall cost of the route option this represents.

3. The greater this proportion, the more sensitive the route option to the catchment hydrology problem and the earlier it is necessary to carry out an assessment of the impact.

% of the overall route cost		**Effect on project of catchment hydrology**
>25%	Grade I	Very sensitive
5-25%	Grade II	Moderately sensitive
£20,000 – 5%	Grade III	Not particularly sensitive
<£20,000	Grade IV	Of minimal sensitivity, hence provide maximum flow area and ensure no increase in blockage of the existing flow area

4. The location of the route crossing should also be taken into account. For example, a route crossing in a more rural area, e.g. where only agricultural fields may be flooded could be classed as a Grade I. However, as it only impacts agricultural land, it would not be as sensitive as a similar route option in an urban area. This should also be identified as it will influence the cost and regulatory approval for the route option.

5. To simplify the calculation at this stage when a large number of outline crossing designs are being examined, any floodplain culverts should be included representing them as an equivalent flow area under the main bridge opening i.e. the width of main opening is increased in the calculation procedure to allow for the effects of flood relief culverts. Calculation of the effects of loss of floodplain storage should be omitted at this stage.

7. REPORTING

General

7.1 When reporting the potential effects of a road project on the water environment, a completed Table A4.2 (Summary of Potential Effects) should be supported by the results of the assessment methods as well as other technical and qualitative information sufficient to provide a transparent decision-making process. The results of the assessments may be intended for inclusion in Environment Statements (ESs) or non-statutory environmental impact assessments to document and support decision making. The results should be capable of bearing public scrutiny and debate and should, therefore, be robust enough to withstand such scrutiny. Records of assessments, consultations, analyses and conclusions should be comprehensive, meticulous and consistent. For further general guidance on reporting potential effects DMRB 11.2 'General Principles of Environmental Assessment' should be consulted. In particular, HD 48 'Reporting of Environmental Impact Assessments' gives guidance on reporting the results of the processes described in this Standard.

7.2 The assessments will produce reports in various formats for different purposes. Technical reports on data collection or fieldwork may often be stand-alone documents, but they should be prepared bearing in mind that certain aspects may contribute to the environmental plans or management plans (or equivalent) for the scheme.

7.3 Reports should conform to the Overseeing Organisation's preferred style of formatting, and observe any protocols for the presentation of electronic documents.

7.4 Reports should be prepared on the results of all assessments, whether at Scoping, Simple or Detailed level, giving careful consideration to how much detail is required for the particular stage in scheme delivery and decision making process.

7.5 The results of assessments should contribute to the Overseeing Organisation's environmental databases. Where the Overseeing Organisation is the Highways Agency (HA), the results must be recorded on Highways Agency Drainage Data Management System (HADDMS) if assessments have been made of:

i) the effects of routine runoff on surface waters;

ii) the effects of routine runoff on groundwater; and

iii) the likelihood and effects of spillage.

7.6 The Overseeing Organisation will confirm in writing any recommendation for the need to proceed to formal Environmental Impact Assessment (EIA).

Scoping Assessment Reporting

7.7 The report of any scoping exercise should record the following:

i) the results of any scoping criteria found in paragraph 6.8;

ii) if applicable, the reason(s) why any further assessment is not warranted;

iii) where further assessment is necessary, which methods (of Annex I Methods A to F) are to be used for subsequent assessment;

iv) baseline information;

v) the proposed consultation strategy to be followed.

Simple Assessment Reporting

7.8 The report on the Simple Assessment should contain the following key sections:

i) Introduction/Overview: information on the scheme background and context.

ii) Identification of the water features/attributes that may be affected (based on Table A4.1).

iii) Method Statement: a description of the assessment sources, and methods adopted for data gathering, fieldwork, evaluation, assessment of impacts and mitigation.

iv) Regulatory and Research Framework: the relevant legislation, policy and codes of practice, and the results of relevant consultations, together with a statement of the Project Objectives.

v) Results of assessments from each of the four principal areas considered:

- Effects of Routine Runoff on Surface Waters (see paragraph 7.9);
- Effects of Routine Runoff on Groundwater (see paragraph 7.10);
- Spillages (see paragraph 7.11);
- Flood Impacts (see paragraph 7.12).

vi) Assessment of the importance of the water features/attributes and the magnitude of the impact of the scheme (based on Tables A4.3 and A4.4). This should take into account any agreed mitigation measures or strategies, including the likely effectiveness of the mitigation. In Wales and Scotland the impact of the unmitigated scheme should also be reported. There should be a description and discussion of potential alternatives.

vii) Significance of effects (from Table A4.5): the assessment of the significance of the effects on the water environment based on the importance of the attribute and the magnitude of the impact taking agreed mitigation into account (in Scotland and Wales the significance of the effect of the unmitigated scheme should also be reported).

viii) A summary of the potential effects on the water environment (including a completed Table A4.2) and a statement identifying any remaining risks or uncertainties.

7.9 For the effects of routine runoff on surface waters, the results of Method A assessments should be reported. These will be the interpreted outputs from Highways Agency Water Risk Assessment Tool (HAWRAT). The full results of each assessment should be reproduced; this includes the 'Detailed Results' sheet and the 'User Parameters' sheet, both of which are generated when the assessment is saved through the HAWRAT menu (see the HAWRAT Help Guide Ref 21). Where more than one outfall has been assessed for the scheme under consideration it will be necessary to include a summary table showing the results of each of the assessments undertaken. As a minimum the table should include the outfall number, the Pass/Fail result for solubles and for sediments, the predicted low flow velocity of the receiving water, the deposition index, the annual average concentrations of soluble copper and zinc (and whether these pass or fail the Environmental Quality Standards (EQSs)) and whether mitigating measures should be considered to protect groundwater.

7.10 For the effects of routine runoff on groundwater, the results of Method C risk assessments should be reported. As described in Annex I, Method C, the assessment is carried out using the matrix in Table C1.2. The full derivation of each risk score should be presented, the format for which is illustrated in the worked examples (Annex II, Method C). Where more than one outfall has been assessed for the scheme under consideration it will be necessary to include a summary table showing the results of each of the assessments undertaken. As a minimum the table should include the outfall number, the overall risk score, the risk category, whether mitigating measures should be considered to protect groundwater and whether a more detailed risk assessment need be undertaken.

7.11 For the assessment of pollution impacts from spillages, the results of Method D risk assessments should be reported, particularly the annual probability of a serious pollution incident and whether this is an acceptable risk. The report should also consider whether mitigating measures are required to protect the water environment and whether a more detailed risk assessment need be undertaken. The full results of each assessment should be reproduced; if the spillage risk assessment has been completed in HAWRAT a summary results sheet labelled 'Spillage Risk' is generated when the assessment is saved through the HAWRAT menu (see the HAWRAT Help Guide Ref 21). Where more than one outfall has been assessed it will be necessary to include a summary table presenting the results of each of the assessments undertaken.

7.12 For the assessment of flood risk the results of Method E and Method F should be reported. The minimum documentation to be included is listed in paragraph E.10. For Method E the report should include, for any water courses within the scheme, the flow rate expected for a flood of 1% annual probability (plus an allowance for climate change) and whether this changes as a result of the scheme. If there is an increase in the expected flow rate the report should consider what mitigation is needed, whether attenuation of the road runoff is required and if so what the required storage volume will be. For Method F the report should include a statement of the expected change in water surface elevations that will result from the scheme (the afflux), the approximate change in floodplain volume and the change in flood potential resulting from a change in runoff. If there is an adverse change then the report should identify mitigation options.

Detailed Assessment Reporting

7.13 Where detailed reporting is required it is probable that consultations will have been held and field surveys undertaken. The detailed report will include details of the methodologies adopted and agreed with the Overseeing Organisation and Environment Agencies (EAs) together with the findings from any field surveys and analysis undertaken.

7.14 The report on the Detailed Assessment should contain all the information required on the Simple Assessment plus the following:

i) For the effects of routine runoff on surface waters, if Method B assessments are required, these should be reported in the detailed assessment report. The reported figures should include: the annual average concentrations predicted by HAWRAT, the EQSs (for the appropriate hardness band), the water quality results from field sampling and the outcome of the Biotic Ligand Model (BLM) assessments. Details should also be given of any proposed mitigation and its effect on the result of the assessment.

ii) For the effects of routine runoff on groundwater, if the need for mitigation measures was identified from a Method C assessment, the nature and effectiveness of these measures should be informed by an additional risk assessment and this should be reported here. If the Method C assessment identified a high impact scenario, then further data will need to have been collected to inform a more detailed risk assessment carried out using hydrogeological expertise. These data and the results of the more detailed assessment should be reported here.

8. MITIGATION OF IMPACTS

Pollution Mitigation Measures

8.1 Where the assessment of the risks of pollution from road runoff shows the need for mitigation, there are several options available. The use of conventional drainage systems to reduce pollution is described in HD 33 (DMRB 4.2). Vegetated drainage systems are described in HA 103 (DMRB 4.2) and guidance on design of soakaways is given in HA 118 (DMRB 4.2). Advice on Grassed Surface Water Channels for Highway Runoff is given in HA 119 (DMRB 4.2). These systems can be included as part of the drainage network but currently there is only limited information regarding their capabilities in removing pollution from routine highway runoff. When properly selected, designed and built, many of these can, however, reduce the pollution risks. Vegetated systems can also enhance aspects of the water environment and landscape as well as benefiting biodiversity, and in such cases should be designed with the assistance of the appropriate specialist for landscape/biodiversity. However, it should be recognised that the primary function of the drainage system will usually be the attenuation and treatment of highway runoff. When considering mitigation of potential impacts to surface waters using the Highways Agency Water Risk Assessment Tool (HAWRAT), attention is drawn to paragraphs A.19 to A.21 regarding the interpretation of required treatment, dilution (flow attenuation) and sediment removal.

8.2 Drainage systems may be either active or passive in operation:

i) **Active systems (requiring operators)**
Penstocks, valves, notched weirs.

ii) **Passive systems**
Swales, ponds, wetlands, ditches, basins, silt traps, filter drains, soakaways, oil separators.

Many of these passive systems can be termed Sustainable Drainage Systems (SuDS). In Scotland SuDS are a legal requirement for new developments which have surface water drainage systems draining to the water environment.

8.3 Possible mitigation measures could include the following:

i) source – consider whether it is possible to amend:

- road geometry to reduce the spillage risk, or by changing catchment boundaries or cross falls;
- percentage of Heavy Goods Vehicles (HGVs);
- number/location of outfalls;
- choice of routes/route options;

ii) pathway – amend:

- choice of drainage system, as noted in paragraph 8.1;

iii) planning – use of signage, emergency plans, pollution equipment (see Pollution Prevention Guidelines 21 and 22 (Ref 11);

iv) during construction, as advised in Pollution Prevention Guideline 6 (Ref 11), ensure action is taken on:

- bunding;
- plans;
- routes of temporary traffic diversions;
- storage of hazardous/waste materials;
- procedures for concreting;
- wash down areas;
- the disposal of surface water runoff from excavations which may be contaminated with silt.

Further guidance on measures to reduce the risks of pollution impact from construction activities is available in two Construction Industry Research and Information Association (CIRIA) Reports (Refs 33, 36).

8.4 Table 8.1 gives optimum indicative factors by which certain measures can be expected to reduce the risk of a spillage causing a pollution incident, as calculated using Method D (Spillage Risk Assessment), Annex I. If the risk without the system is found to be P, then the risk with the system in the drainage network is given by P x R_F, where R_F is the risk reduction factor for that system.

System	Optimum Risk Reduction Factor R_F (%)
Passive Systems	
Filter Drain	0.6 (40%)
Grassed Ditch/Swale	0.6 (40%)
Pond	0.5 (50%)
Wetland	0.5 (50%)
Infiltration basin	0.6 (40%)
Sediment Trap	0.6 (40%)
Vegetated Ditch	0.7 (30%)
Active Systems	
Penstock/valve	0.4 (60%)
Notched Weir	0.6 (40%)
Other Systems	
Oil Separator	0.5 (50%)

Table 8.1 – Spillages – Indicative Pollution Risk Reduction Factors

Note: These factors and corresponding percentage reductions represent what is considered achievable. In many situations a higher factor, representing a lower risk reduction, may be more appropriate. For example, a short length of filter drain may only reduce a spillage risk by 20%, so a factor of 0.8 should be used.

Flood Mitigation Measures

8.5 If it is impractical to design a project achieving the acceptable water levels, additional works may be required to mitigate the water level changes caused by the project. Measures may include amending the road geometry, provision of flood relief culverts or, as a last recourse, alterations to the channel, floodplain and other river structures. However, these alterations should not adversely affect the water levels of areas elsewhere in the catchment, but should aim to maintain them at existing levels whilst affording protection to those areas affected by the project.

8.6 The hydrological and hydraulic assessment (Methods E and F, Annex I) should demonstrate what sustainable options there are for flood level management in the locality. Options such as large-scale straightening or deepening of rivers will not be acceptable to the Environment Agencies (EAs) unless these options can offer demonstrable improvements to flood risk management and the natural environment. Works of this kind should only be considered when all other options are exhausted, following consultation with the EAs.

8.7 The purpose of floodplain mitigation measures is to manage floodwater levels in a way that reduces the impact of flooding on the road itself and elsewhere in the catchment. This may include changing the resistance of the floodplain to flood flow, thereby lowering floodwater levels. Floodplain improvements may include:

i) removal of existing obstructions, which may include vegetation (however, the downstream effects need to be considered, so as not to increase flooding elsewhere);

ii) ground lowering;

iii) new openings in existing embankments (to increase conveyance);

iv) new flood storage areas;

v) local embankments to protect isolated features (particularly in association with (ii) above).

Any improvements made should not have a detrimental effect on the performance of the project under any other flow conditions or result in a major downstream increase in flood levels.

8.8 Flood mitigation measures require consideration and investigation before implementation. For example, channel alteration works will have implications for river maintenance, as the river will try to recover its original shape unless regular maintenance is undertaken. Berms and floodplain lowering may produce waterlogging, with consequent land use and maintenance problems. Berms may also prevent access to the river for maintenance or public enjoyment. The cost of such increased maintenance should be taken into account in the project assessment.

8.9 It should be noted that any increase of conveyance can increase the velocity of floodwaters possibly causing scouring or a flooding problem elsewhere. This should be taken into account within the hydraulic assessment.

8.10 In order to assess the impact of flood mitigation measures an unsteady hydraulic model will be required to simulate the changes in water levels both upstream and downstream.

Flood Protection Measures

8.11 Where new road crossings increase the risk of flooding it will be necessary to include local flood protection measures as part of the road project to reduce the risk to an acceptable level. These may include flood walls, flood protection embankments or levees, flood storage areas and other measures.

8.12 Flood walls or embankments could be constructed around areas where flood risk has increased, making due allowance for the discharge of local drainage water during a flood. In this case the impact of loss of floodplain storage caused by embanking part of the floodplain should be considered with regard to effects on upstream and downstream flood levels.

8.13 In constructing any flood protection measures it is common to apply a fluvial freeboard of at least 500 mm above the design flood level. It is now recognised procedure for this freeboard to be calculated. Designers are directed to the EA R&D Technical Report (Ref 25).

8.14 Care should be taken to ensure that the construction of these measures will not have a detrimental impact on upstream or downstream habitats of biodiversity importance, though in some instances they may be beneficiaries.

8.15 Advice on the design of culverts and outfalls is given in HA 107 (DMRB 4.2) and advice on mitigating the possible impact of land drainage on roads is given in HA 106 (DMRB 4.2).

9. REFERENCES

Design Manual for Roads and Bridges (DMRB)

BA 59 Design of Highway Bridges for Hydraulic Action (DMRB 1.3)

GD 01 Introduction to the Design Manual for Roads and Bridges (DMRB 0.1)

GD 03 Implementation and Use of the Standards Improvement System (DMRB 0.2)

HA 103 Vegetative Treatment Systems for Highway Runoff (DMRB 4.2)

HA 106 Drainage of Runoff from Natural Catchments (DMRB 4.2)

HA 107 Design of Outfall and Culvert Details (DMRB 4.2)

HA 118 Design of Soakaways (DMRB 4.2)

HA 119 Grassed Surface Water Channels for Highway Runoff (DMRB 4.2)

HA 204 Scoping of Environmental Impact Assessments (DMRB 11.2)

HD 33 Surface and Sub-Surface Drainage Systems for Highways (DMRB 4.2)

HD 43 Drainage Data Management System for Highways (DMRB 4.2)

HD 44 Assessment of Implications (of Highways and/or Roads Projects) on European Sites (DMRB 11.4)

HD 47 Screening of Projects for Environmental Impact Assessment (DMRB 11.2)

HD 48 Reporting of Environmental Impact Assessments (DMRB 11.2)

The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2007 (SI 2007 No. 1573)

Dangerous Substances Directive 76/464/EEC

Drinking Water Directive 80/778/EEC

The Environment Act 1995 (c. 25)

The Environmental Damage (Prevention and Remediation) Regulations 2009 (SI 2009 No. 153)

Environmental Liability Directive 2004/35/EC

Freshwater Fish Directive 78/659/EEC

Groundwater Daughter Directive 2006/118/EC

Groundwater Directive 80/68/EEC

Shellfish Waters Directive 79/923/EEC

The Groundwater Regulations 1998 (SI 1998 No. 2746)

The Reservoirs Act 1975 (c. 23)

The Water Environment and Water Services (Scotland) Act 2003

The Water Environment (Controlled Activities) (Scotland) Regulations 2005 (SI 2005 No. 348)

The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (SI 2003 No. 3242)

The Water Environment (Water Framework Directive) (Northern Ireland) Regulations 2003 (SR 2003 No. 544)

The Water Resources Act 1991 (c. 57)

1. Barrett, M.E., Irish, L.B., Malina, J.F. and Charbeneau, R. J., 1998, Characterisation of highway runoff in Austin, Texas area, Journal of Environmental Engineering 124(2): 131-137.

2. Benn, J.R., Mantz, P., Lamb, R., Riddell, J. and Nalluri, C., 2004, 2005, Hydraulic Performance of River Bridges and Other Structures at High Flows (different volumes) Defra/Environment Agency Flood and Coastal Defence R&D Programme.

3. Boxall, A.B.A., 1998, Long term monitoring of pollution from highway runoff: Literature review on the environmental impact of highway runoff, WRc Report to the Highways Agency Ref. UC 3161.

4. Brater, E.F., Lindell, J.E., Wei, C.Y. and King, H.W., 1996, Handbook of Hydraulics, Seventh Edition.

5. BS 6068-6.12:1996 Water quality – Part 6: Sampling – Section 6.12 Guidance on sampling of bottom sediments.

6. Chow, V.T., 1973, Open Channel Hydraulics.

7. Crabtree, R.W., Dempsey, P., Moy, F., Brown, C. and Song, M., 2008, Improved Determination of Pollutants in Highway Runoff – Phase 2: Final Report, WRc Plc, Report No.: UC 7697, UK Highways Agency.

8. Crowder, R.A., Pepper, A.T., Whitlow, C., Sleigh, A., Wright, N. and Tomlin, C., 2005, Benchmarking of Hydraulic River Modelling Software Packages, R&D Technical Report: W5-105/TR0, Defra/Environment Agency.

9. EC Risk Assessment Report for Zinc Metal, Final draft September 2006.

10. Ellis, J.B., Revitt, D.M. and Llewellyn, N., 1997, Transport and the environment: effects of organic pollutants on water quality, J CIWEM 11: 170- 177.

11. Environmental Alliance, Pollution Prevention Guidelines 6, 21 and 22, SEPA, Environment Agency, and EHSNI. Available from: www.environment-agency.gov.uk

12. Fam, S., Stenstrom, M.K. and Silverman, G., 1987, Hydrocarbons in urban runoff, Journal of Environmental Engineering 113: 1032-1046.

13. Gaskell, P., Maltby, L. and Guymer, I., 2008, Accumulation and Dispersal of Suspended Solids in Watercourses, ECUS, University of Sheffield, University of Warwick, Report No.: HA3/368, UK Highways Agency.

14. Gifford, 2008, Tackling Diffuse Pollution from Highway Runoff, Evaluation of New Highways Agency Water Risk Assessment Tool (HAWRAT), Gifford Report No. 14235 – 002.

15. Groundwater Protection: Policy and Practice. Part 1 – Overview, Environment Agency; 2006.

16. Groundwater Protection: Policy and Practice. Part 2 – Technical Framework, Environment Agency; 2006.

17. Groundwater Protection: Policy and Practice. Part 3 – Tools, Environment Agency; 2006.

18. Groundwater Protection: Policy and Practice. Part 4 – Legislation and Policies, Environment Agency; 2008.

19. Gustard, A., Bullock, A. and Dixon, J.M., 1992, Low flow estimation in the United Kingdom, Institute of Hydrology Report No. 108.

20. Hall, M.J., Hockin, D.L. and Ellis, J.B., 1993, Design of Flood Storage Reservoirs, CIRIA & Butterworth-Heinemann Ltd.

21. Highways Agency Water Risk Assessment Tool, Help Guide and Technical Manual. Available to download with the tool from www.haddms.com

22. Hulme, M., Jenkins, G.J., Lu, X. Turnpenny, J.R., Mitchell, T.D., Jones, R.G., Lowe, J., Murphy, J.M., Hassell, D., Boorman, P., McDonald, R. and Hill, S., 2002, Climate Change Scenarios for the United Kingdom, The UKCIP02 Scientific Report.

23. Hurle, R.E., Bark, A.W., Bury, N.R. and Caswell, B., 2006, The Effects of Soluble Pollutants on the Ecology of Receiving Waters. Kings College London, Final Report on Highways Agency Project No. 00Y91924, UK Highways Agency.

24. Johnson, I. and Crabtree, R.W., 2007, Effects of Soluble Pollutants on the Ecology of Receiving Waters, WRc Plc, Report No.: UC 7486/1, UK Highways Agency.

25. Kellagher, R., 2005, Preliminary rainfall runoff management for developments – Defra/Environment Agency Flood and Coastal Defence R&D Programme Technical report W5-074/A/TR/1 revision C.

26. Lancaster, J. and Preene, M., 2004, C624 Development and flood risk – guidance for the construction industry, CIRIA, London, UK.

27. Latimer, J.S., Hoffman, E.J., Hoffman, G., Fasching, J.L. and Quinn, J.G., 1990, Sources of petroleum hydrocarbons in urban runoff, Water Air and Soil Pollution 52: 1-21.

28. Legret, M. and Pagotto, C., 1999, Evaluation of pollutant loadings in runoff waters from a major rural highway, Science of the Total Environment 235: 143-150.

29. Luker, M. and Montague, K., 1994, Control of pollution from road drainage discharges, CIRIA Report 142, UK.

30. Maestri, B., Dorman, H.E., and Hartigan, J., 1998, Managing Pollution from Road Stormwater Runoff, Transportation Research Record (No. 1166).

31. Makepeace, D.K., Smith, D.W. and Stanley, S.J., 1995, Urban stormwater quality: summary of contaminant data, Critical Reviews in Environmental Science and Technology 25(2): 93-139.

32. Marsh, T.J. and Lees, M.L., 2003, Hydrological Data, UK. Hydrometric Register and Statistics 1996 – 2000, Centre for Ecology and Hydrology, Wallingford, UK.

33. Masters-Williams, H., 2001, C532 Control of water pollution from construction sites, Guidance for consultants and contractors, CIRIA, London, UK.

34. McNeill, A., June 1996, Road Construction and River Pollution in South-West Scotland, The Journal of the Chartered Institution of Water and Environmental Management. Vol. 10, No.3.

35. Moy, F., Crabtree, R.W. and Simms, T., 2002, Long Term Monitoring of Pollution from Road Runoff: Final Report, WRc Plc, Report No.: UC 6037, UK Highways Agency.

36. Murname, E., Heap, A. and Swain, A., 2006, C648 Control of Water Pollution from Linear Construction Sites, CIRIA, London, UK.

37. Muschack, W., 1990, Pollution of street runoff by traffic and local conditions, Science of the Total Environment 93: 419-431.

38. Pagotto, C., Legret, M. and Le Cloirec, P., 2000, Comparison of the hydraulic behaviour and the quality of highway runoff water according to the type of pavement, Water Research 34(18): 4446-4454.

39. Reed, D. *et al.*, 1999, Flood Estimation Handbook, Institute of Hydrology, Wallingford, UK.

40. Scottish Environment Protection Agency (SEPA), 2003, Groundwater Protection Policy for Scotland.

41. Shinya, M., Tsuchinaga, T., Kitano, M., Yamada, Y. and Ishikawa, M., 2000, Characterization of heavy metals and polycyclic aromatic hydrocarbons in urban highway runoff, Water Science and Technology 42(7-8): 201-208.

42. UKTAG 2007 Paper 11b (iii) Application of Groundwater Standards to Regulation, UK Technical Advisory Group on the Water Framework Directive.

43. West, C.C. and Gawith, M.J. (Eds.) 2005 Measuring progress: Preparing for climate change through the UK Climate Impacts Programme. UKCIP, Oxford.

10. ACRONYMS

AADT	Annual Average Daily Traffic
AR	All Reservoirs
BFI	Base Flow Index
BGS	British Geological Survey
BLM	Biotic Ligand Model
BWB	British Waterways Board
CAR	Controlled Activities Regulations
CEH	Centre for Ecology and Hydrology
CEMP	Construction Environmental Management Plan
CIRIA	Construction Industry Research and Information Association
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
DOC	Dissolved Organic Carbon
DSFB	District Salmon Fisheries Board
EA	Environment Agency (England and Wales)
EAs	Environment Agencies
EC	European Community/European Commission
EHSNI	Environmental and Heritage Services, Northern Ireland
EIA	Environmental Impact Assessment
EMC	Event Mean Concentration
EMSC	Event Mean Sediment Concentration
EPA	Environment Protection Agency
EQS	Environmental Quality Standard
ES	Environmental Statement
EU	European Union
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
FRS	Fire and Rescue Service
FSR	Flood Studies Report
HA	Highways Agency
HADDMS	Highways Agency Drainage Data Management System
HAWRAT	Highways Agency Water Risk Assessment Tool
HGV	Heavy Goods Vehicle
IDB	Internal Drainage Board
IOH	Institute of Hydrology
NIEA	Northern Ireland Environment Agency
NIR	Non-Impounding Reservoirs
PAH	Polycyclic Aromatic Hydrocarbons
PEL	Probable Effects Level
PNEC	Probable Non-Effect Concentration
PPG	Pollution Prevention Guidelines
PPS	Planning Policy Statement
$\mathbf{Q_{95}}$	95% low flow (in rivers)
RBD	River Basin Distrct
RBMP	River Basin Management Plan
RE Class	River Ecosystem Class
ReFH	Revitalised Flood Hydrograph
RL	Road Length

RST	Runoff Specific Threshold
SAC	Special Area for Conservation
SEPA	Scottish Environment Protection Agency
SFRA	Strategic Flood Risk Assessment
SIS	Standards Improvement System
SPA	Special Protection Area (for Birds)
SPP	Scottish Planning Policy
SPZ	Source Protection Zone
S-P-R	Source-Pathway-Receptor
SR	Service Reservoirs
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
SuPE	Supervising Engineers
TAN	Technical Advice Note
TEL	Threshold Effects Level
UKCIP	UK Climate Impacts Programme
WFD	Water Framework Directive
WPZ	Water Protection Zone
WRA	Water Resources Act 1991

11. GLOSSARY

Afflux	The increase in water level caused by a restriction to flow.
Aquatic	Growing, living or found in water.
Aquifer	A subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.
Base Flow Index	The proportion of the flow in a watercourse made up of groundwater and discharges. Base flow sustains the watercourse in dry weather.
Coastal water	Surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional water.
Compound	A substance that contains atoms of two or more chemical elements held together by chemical bonds.
Controlled Waters	In England, Scotland and Wales, a term used to describe groundwater and surface waters.
Critical Ordinary Watercourse	Watercourses, other than main rivers, which are maintained at Environment Agency (EA) expenses, as they pose a higher than average flood risk to property.
Cyprinid	Coarse fish such as carp, tench, barbel, rudd, and roach. These fish are generally found in slower flowing waters that often flow through lowlands.
Deposited map	(For England and Wales) the map and related information recorded on the CD-ROM which is: entitled ‘River Basin Districts (England and Wales) 2003’ and deposited in the principal library of the Department for Environment, Food and Rural Affairs (Defra).
Deposition Index	A dimensionless index value that considers the extent of sediment coverage on the stream bed.
Discharge consent	Consent obtained from the Environment Agencies (EAs) under Water Resources Act 1991 (WRA) for England and Wales or under the Control of Pollution Act 1974 for Scotland.
Ecological status	An expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V of the Water Framework Directive (WFD).
Environment Agencies	In England and Wales the Environment Agency, in Scotland the Scottish Environment Protection Agency and in Northern Ireland, the Northern Ireland Environment Agency.
Environmental Quality Standard	The maximum permissible concentration of a potentially hazardous chemical. It is used to assess the risk to the health of aquatic flora and fauna.

Event Mean Concentration	The concentration measured in a flow weighted composite sample made up from discrete samples collected at a fixed sampling time interval during a runoff event.
Groundwater	All water which is below the surface of the ground in the saturation zone (below the water table) and in direct contact with the ground or subsoil.
Groundwater body	A distinct volume of groundwater within an aquifer or aquifers.
Groundwater status	The general expression of the status of a body of groundwater, determined by the poorer of its quantitative status and its chemical status.
Heavy metals	Lead (Pb), Zinc (Zn), Copper (Cu), Chromium (Cr), Cadmium (Cd), Manganese (Mn), Iron (Fe), Nickel (Ni), and Cobalt (Co) – a group of ferrous and non-ferrous metals commonly known as heavy metals found in motorway or road surface runoff. Pb is a specific product of vehicle exhaust emissions from petrol driven engines, Zn is present in car tyres and motor vehicle components and Cu, Cr and Cd are released principally as corrosion products.
Inland water	All standing and flowing water on the surface of the land, and all groundwater on the landward side of the baseline from which the breadth of the territorial sea is measured.
Lake	A body of standing inland surface water.
Leaching	The washing out of a soluble constituent.
Main River	A river maintained directly by the EAs.
Manning's n	The effective channel roughness which is a function of channel velocity, flow area and channel slope. Vegetation can have a major influence on Manning's n and may account for marked seasonal variation in n. Channel irregularity may also increase n, as will sharp curvature in a channel.
Oil	Viscose liquid of vegetable or mineral origin. Inflammable and usually insoluble in water. Chiefly composed of Carbon and Hydrogen.
Organic	The description of a material composed of Carbon combined with Hydrogen and also often containing Oxygen, Nitrogen and other elements.
Principal aquifer	Geological strata that exhibit high permeability and usually provide a high level of water storage. They are capable of supporting water supply on a strategic scale and are often of major importance to river base flow (formerly known as major aquifer).
Probable Effects Level	The probable effects level (PEL) is the concentration above which toxic effects are observed in aquatic fauna on most occasions.
$\mathbf{Q_{95}}$	The flow rate of the watercourse that is exceeded for 95% of the time.
$\mathbf{Q_{BAR}}$	Median annual peak flow in a watercourse.
$\mathbf{Q_{MED}}$	Mean annual flood event in a watercourse.

Quantitative status	An expression of the degree to which a groundwater body is affected by direct and indirect abstractions.
Ramsar site	Wetland site classified under the Ramsar convention.
Reach	A stretch of a river used in the assessment of river water quality.
River	A body of inland water flowing for the most part on the surface of the land but which may flow underground for part of its course.
River basin	The area of land from which all surface runoff flows through a sequence of streams, rivers and possibly, lakes into the sea at a single river mouth, estuary or delta.
River Basin Management Plan	Under the WFD, all river catchments are assigned to administrative River Basin Districts (RBDs). The River Basin Management Plans (RBMPs) set out environmental objectives for all groundwater and surface water bodies and Protected Areas within an RBD. The plans include a programme of measures to meet these objectives.
Runoff specific threshold	Time dependent (24 hour or six hour) soluble pollutant concentration above which adverse effects may be observed in aquatic fauna.
Salmonid	Salmon and trout. These fish are generally found in waters that are fast flowing stretches of river that have a high oxygen content and a low level of nutrients.
Secondary aquifer	A wide range of geological strata with a correspondingly wide range of permeability and storage. Depending on the specific geology, these subdivide into permeable formations capable of supporting small to moderate water supplies and base flows to some rivers, and those with generally low permeability but with some localised resource potential. (Includes the former minor aquifers but also some of the former non-aquifers.)
Surface water	Waters including rivers, lakes, lochs, loughs, reservoirs, canals, streams, ditches, coastal waters and estuaries.
Surface water body	A discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.
The precautionary principle	Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
Threshold Effects Level	The TEL is the concentration below which toxic effects in aquatic fauna are extremely rare.
Transitional water	Bodies of surface water in the vicinity of river mouths which are partly saline in character as result of their proximity to coastal waters but which are substantially influenced by freshwater flows.
Unproductive strata	These are geological strata with low permeability that have negligible significance for water supply or river base flow (formerly formed part of the non-aquifers).

12. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

Chief Highway Engineer The Highways Agency 123 Buckingham Palace Road London SW1W 9HA	G CLARKE Chief Highway Engineer
Director, Major Transport Infrastructure Projects Transport Scotland Buchanan House 58 Port Dundas Road Glasgow G4 0HF	A C McLAUGHLIN Director, Major Transport Infrastructure Projects
Chief Highway Engineer The Welsh Assembly Government Llywodraeth Cynulliad Cymru Crown Buildings Cathays Park Cardiff CF10 3NQ	S C SHOULER (BSc(Hons), C.Eng.MICE) Chief Highway Engineer
Director of Engineering The Department for Regional Development Roads Service Clarence Court 10-18 Adelaide Street Belfast BT2 8GB	R J M CAIRNS Director of Engineering

ANNEX I ASSESSMENT METHODS

Assessment of Pollution Impacts from Routine Runoff to Surface Waters

Method A – Simple Assessment

A.1 The assessment method for determining whether routine runoff is likely to have an ecological impact on receiving surface watercourses uses the Highways Agency Water Risk Assessment Tool (HAWRAT). HAWRAT is designed to make an assessment of the short-term risks related to the intermittent nature of road runoff. An assessment of the long-term risks over the period of one year is also required (paragraph A.11) to complete the risk assessment process. The method of assessment used by HAWRAT has been approved by the Environment Agency (EA) such that the outputs can be used in Environmental Impact Assessments (EIAs).

A.2 The assessment should begin with an understanding of the natural drainage network operating in the vicinity of the outfalls of interest, notably the presence and position of downstream confluences and river structures such as lakes and weirs. Such data can be obtained from local mapping, the website of the relevant EA, the Highways Agency Drainage Data Management System (HADDMS) (in England) and other appropriate references. This knowledge is particularly important for establishing whether the discharge from two or more outfalls should be combined for assessment purposes (paragraph A.16).

A.3 HAWRAT is a Microsoft Excel application which can be downloaded from (HADDMS) **www.haddms.com**. The principal features and workings of HAWRAT are discussed in Chapters 3 and 5. Given below is an overview of how to use the tool and the input parameters required. The Help Guide and Technical Manual (Ref 21), which can be downloaded with HAWRAT, gives a full description of the tool and how to use it. In England (as described in paragraph 7.5) the results of assessments made for projects on the HA's strategic road network using HAWRAT must be recorded on HADDMS.

A.4 The user interface of the tool is shown in Figure A1.1. The user is required to enter a series of parameters on this interface which relate to the outfall under assessment. These may be actual values or values within a range that can be selected from a drop down menu. Once the parameters have been entered the 'Predict Impact' button is clicked. The tool then calculates the runoff pollutant concentrations associated with a ten year series of rainfall events and the coincident flow in the receiving watercourse during each event. These calculations may take up to a minute, after which the tool displays either Pass or Fail for each of the pollutants considered. The 'Detailed Results' sheet gives a more detailed explanation of the outputs of the last run. The Help Guide and Technical Manual (Ref 21) provides further explanation of the internal processes of the tool and the calculations performed. The logic flowcharts which HAWRAT follows are shown in Figures A1.2 (soluble pollutants) and A1.3 (sediment-bound pollutants).

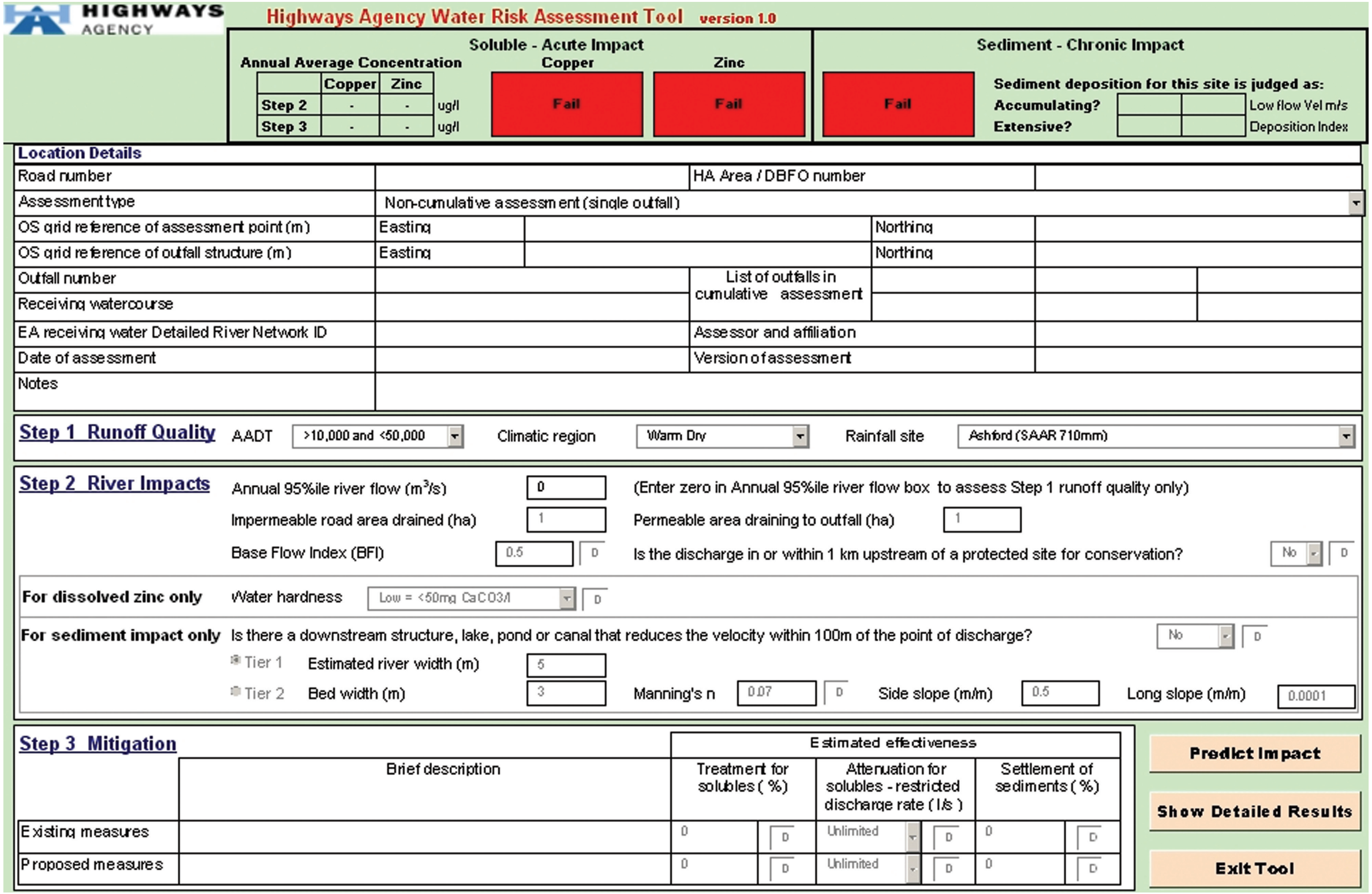

Figure A1.1 – User Interface of HAWRAT

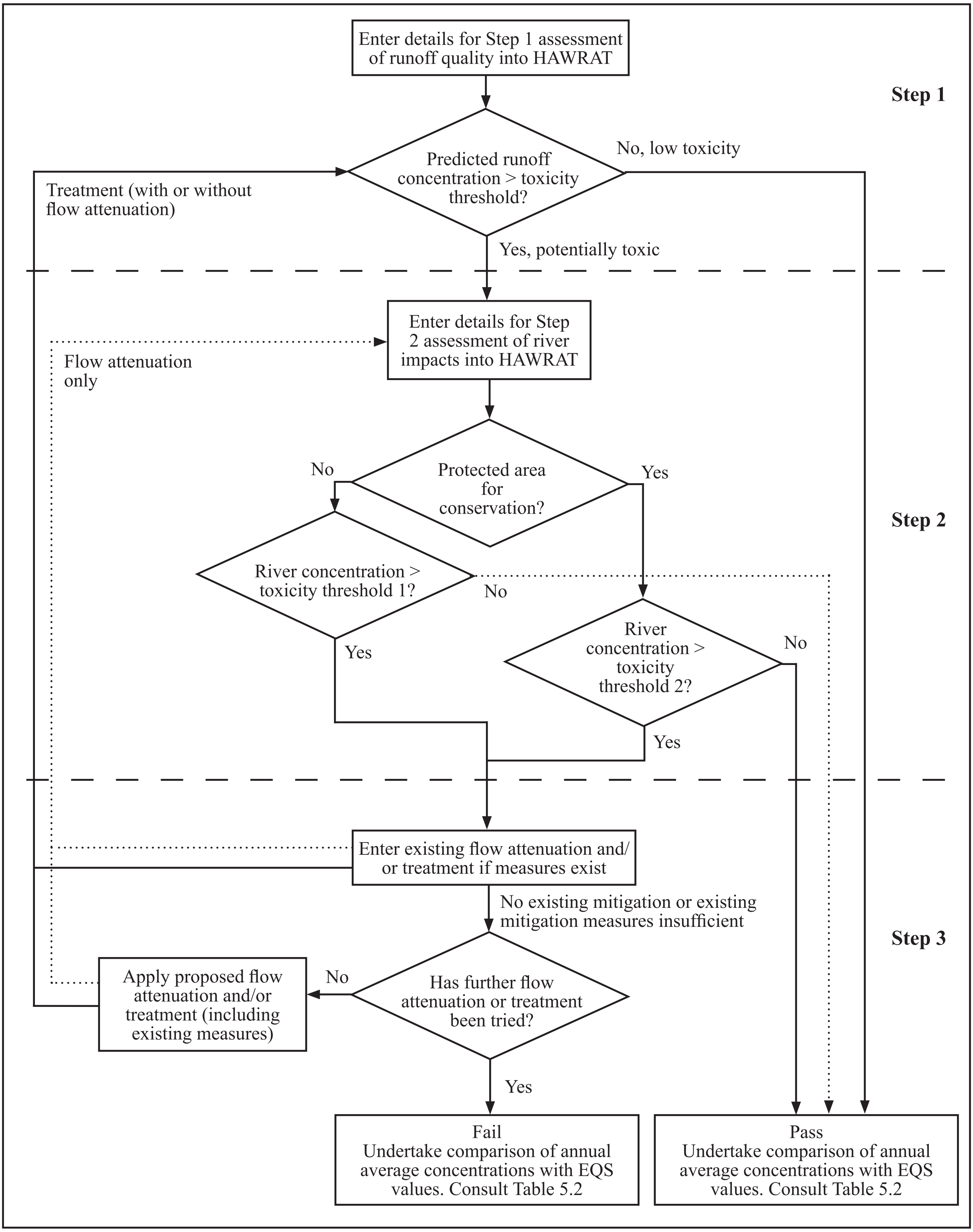

Figure A1.2 – Procedure for Assessment of Soluble Pollutants

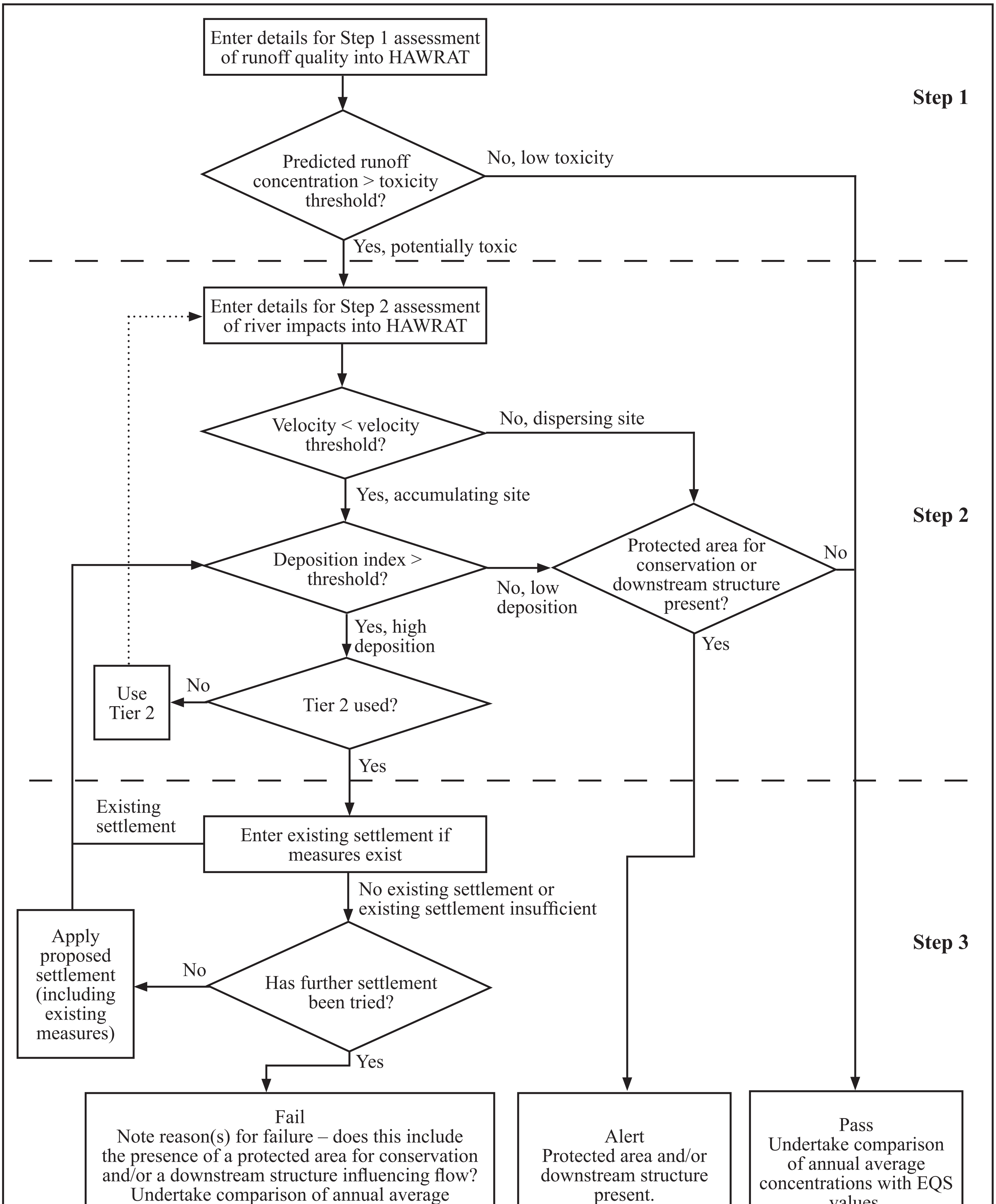

Figure A1.3 – Procedure for Assessment of Sediment-Bound Pollutants

A.5 HAWRAT includes three assessment stages.

i) Step 1 allows an initial check to assess the quality of the direct highway runoff against the toxicity thresholds assuming no in-river dilution and no treatment or attenuation. If Step 1 shows that the toxicity is acceptable, then no further assessment is necessary. To perform a Step 1 assessment the following information is required:

- The existing or design traffic flow of the road (two-way Annual Average Daily Traffic (AADT)). One of three traffic bands can be selected from:

  ≥10,000 to <50,000

  ≥50,000 to <100,000

  ≥100,000

- The climatic region of the site using the UK maps in the HAWRAT Help Guide (Ref 21).

- The nearest rainfall site within that climatic region using the UK maps in the HAWRAT Help Guide (Ref 21).

For this initial check of runoff quality, the 'Annual 95%ile river flow' (Q_{95} low flow) needs to be set to zero.

ii) For the acute impacts of soluble pollutants, Step 2 takes account of the diluting capacity of the watercourse which receives the road runoff. For the chronic impacts of sediment-bound pollutants, Step 2 takes account of the likelihood and extent of sediment deposition. Step 2 contains two tiers of assessment for sediment-bound pollutants: Tier 1 is a quick, conservative and desk-based assessment; Tier 2 is a more detailed assessment requiring a site visit to measure the dimensions of the watercourse. Annex V contains a field log sheet designed to assist in site visits and should, if fully completed, ensure all information is captured and repeat visits are minimised. If a Tier 1 assessment indicates there is no risk then unnecessary work for a Tier 2 assessment is avoided. Step 2 assumes no mitigation. To perform a Step 2 assessment the following information is required:

- the annual 95%ile river flow (m^3/s), or Q_{95} flow, discussed in paragraphs 5.20 and A.6;

- the Base Flow Index (BFI) (if this is unknown 0.5 can be used as a default, BFI values can be obtained from LowFlows™ software or the Flood Estimation Handbook (FEH));

- the impermeable road area which drains to the outfall (ha);

- any permeable (non-road surface) area which also drains to the outfall (ha), discussed in paragraph A.7;

- whether the discharge is likely to impact on a protected site for conservation, discussed in paragraph A.8;

- the hardness of the receiving water (mg $CaCO_3$/l);

- whether there is a downstream structure, lake or pond that reduces the river velocity near the point of discharge (discussed in paragraph A.9);

- for Tier 1 assessments, an estimate of the river width (m); and

- for Tier 2 assessments, site measurements of bed width (m), side slope (m/m), long slope (m/m) and an estimate of Manning's n.

iii) For soluble pollutants, Step 3 allows the effectiveness of existing and proposed treatment systems to be assessed. Assessments can be made iteratively for:

- the effect of attenuating the flow (l/s) – limiting the discharge rate from the outfall to increase in river dilution (flow attenuation may be stipulated by the Environment Agencies (EAs) or, in Scotland, as a consequence of the mandatory Sustainable Drainage Systems (SuDS) requirement); and

- reducing the pollutant concentration through treatment (% treatment).

For sediment-bound pollutants, recognising that settlement is the only viable 'treatment' option, if the site is predicted to accumulate sediments, the tool reports the percentage of settlement required to ensure the extent of sediment coverage complies with the threshold deposition index value. Further information on how to interpret the mitigation values required at Step 3 is given in paragraphs A.19 to A.21. Available data on the treatment efficiencies and degree of settlement offered by conventional treatment systems is limited and specialist judgement is likely to be needed if mitigation is required.

Influencing Factors

A.6 The annual 95%ile river flow of the watercourse (Q_{95}) is the flow exceeded in the river for 95% of the time. Where no gauging data are available this parameter can be calculated using the methods discussed in paragraph 5.20. Where the value of Q_{95} is less than 0.001 m^3/s (either calculated or from gauging data), a figure of 0.001 m^3/s should be used in the assessment method. Alternatively, the receiving water course could be considered as a soakaway, and the appropriate groundwater assessment method used (Annex I, Method C).

A.7 For the purpose of calculating a value to enter into HAWRAT for impermeable and permeable areas, only surface water runoff deriving from the road-cross section should be included. As defined in HA 106 (DMRB 4.2) this 'Interior Catchment' includes the road surface, verges and adjacent cuttings or embankments. In HAWRAT, runoff from the permeable area which drains to the outfall is assumed to be free from highway derived pollutants and has the effect of increasing the dilution of soluble pollutants derived from the impermeable area. It should be noted that the HAWRAT calculations are not particularly sensitive to the permeable area parameter as the associated runoff coefficient is low. If the size of the permeable area is not clear then the precautionary approach is to assume a value of zero.

A.8 At Step 2, HAWRAT asks whether the outfall(s) being assessed discharge upstream of sites that are protected for nature conservation. Examples of protected sites include: Site of Special Scientific Interests (SSSIs), Water Protection Zones (WPZs), Ramsar and EU Natura 2000 (Special Area for Conservations (SACs) and Special Protection Areas (SPAs)) sites. Non-designated sites classed as salmonid waters under the Freshwater Fish Directive may also be especially sensitive to impacts. Where these sites lie within 1 km downstream of the outfalls the parameter for HAWRAT should be switched to 'yes'. For assessment of soluble pollutants, where protected sites are present, stricter exceedance frequencies for the Runoff Special Thresholds (RSTs) will be applied (Help Guide, Ref 21). For assessment of sediment-bound pollutants, the assessment thresholds remain the same but in situations that would otherwise Pass, the tool reports an Alert result indicating that the presence of protected nature sites will require further site-specific consideration. In such cases, further measures should be agreed with the Overseeing Organisation.

A.9 At Step 2, HAWRAT also asks whether there is any downstream structure, lake or pond that reduces the river velocity within 100 m downstream of the point of discharge. While the site immediately downstream of the outfall may be regarded as a dispersing site, such features as weirs and ponds may slow the river velocity and cause accumulation of potentially contaminated sediments. For sites that would otherwise Pass the HAWRAT assessment of sediment-bound pollutants, the presence of these features will lead to an Alert result indicating the need for further site-specific consideration. The presence of downstream features does not affect the solubles assessment.

Summer Exceedances

A.10 In addition to the number of exceedances of the RSTs, the 'Detailed Results' sheet of HAWRAT provides information on the number of exceedances occurring during the summer. This provides further insight as to what time of year ecological impacts might occur and thereby informs the need for (and design of) mitigation solutions. For example, the discharge may impact a SSSI that is designated as such in order to protect a particular aquatic population. If the RST exceedances coincide with the breeding and development periods of that species then there may be a greater impact than if the exceedances occurred at another time of year. The default 'summer' period of HAWRAT is set to the six months from April to September (inclusive) when many aquatic species produce their offspring to take advantage of higher water temperatures and greater food availability. If desired, the start and end months of this period can be changed by a HAWRAT user with Administrator rights (the Overseeing Organisations).

Assessment of Annual Average Pollutant Concentrations

A.11 The EAs require that annual average concentrations in the receiving watercourse do not exceed published Water Framework Directive (WFD) Environmental Quality Standards (EQSs). EQSs are based on annual average concentrations. In addition to determining the short-term risks using HAWRAT, an assessment of the risks over the duration of a year is, therefore, required to complete the risk assessment process. The logic flowchart which should be followed for the assessment of long-term risks over the period of one year is shown in Figure A1.4.

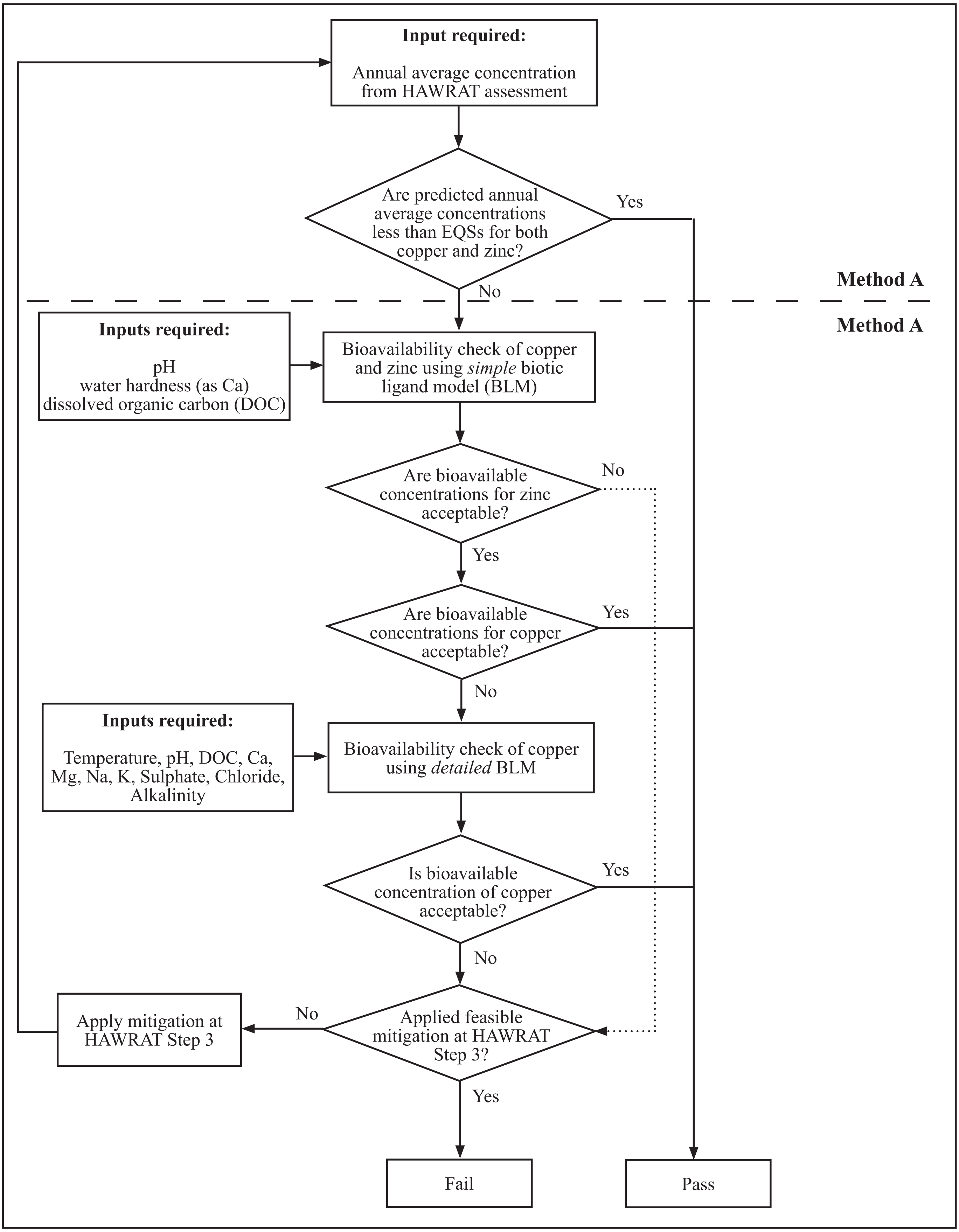

Figure A1.4 – Procedure for Assessment of Annual Average Impacts from Routine Road Runoff

A.12 HAWRAT reports the annual average concentration of dissolved copper and dissolved zinc at Step 2 (in-river before mitigation). In calculating the annual average concentrations of dissolved copper and dissolved zinc, HAWRAT assumes the background/upstream concentrations are zero. This enables an assessment of the added risk rather than total risk, i.e. the additional risk to organisms in the receiving water when they are exposed to road runoff. These values should be compared with the EQSs in Table A1.1 to determine whether there is a long-term impact or not. HAWRAT also reports the annual average concentration at Step 3 (after mitigation), so if mitigation is included then these values should be used for comparison with the EQSs. It should be noted that incorporating flow attenuation into the drainage system will not reduce the annual average concentration (all the annual runoff will still be discharged within the year), only treatment of the soluble pollutants prior to discharge will reduce the annual average concentrations.

Water hardness bands (mg/l $CaCO_3$)	**EQS for dissolved copper (µg/l)**	**EQS for dissolved zinc* (µg/l)**
0 – 50	1	7.8
>50 – 100	6	
>100 – 250	10	
>250	28	

*Proposed values

Table A1.1 – Environmental Quality Standards for Dissolved Copper and Zinc

A.13 At the time of writing, published EQS values existed for total zinc but not dissolved zinc. The values for dissolved zinc in Table A1.1 are proposed (Ref 9) and are likely to be adopted before 2013. The currency of the values in this table should be checked before use.

A.14 Following the logic of Figure A1.4, if the predicted annual average concentrations are found to be below the EQS thresholds then no further action need be taken with respect to long-term risks (if potential short-term impacts have been identified through HAWRAT then Table 5.2 should be consulted for advice on how to proceed). If the predicted annual averages exceed either of the EQS values for copper or zinc then the bioavailability of these metals will need to be assessed using a Method B (detailed assessment) which incorporates a Biotic Ligand Model (BLM).

Point of Assessment and Aggregation of Outfalls

A.15 The point of assessment should be within an identified natural downstream receiving watercourse (or heavily modified watercourse if appropriate). If a discharge is into a ditch or drain (owned by the highway authority) that discharges into a natural watercourse after a short distance then the designer (for the purpose of data input to HAWRAT) should focus the environmental assessment on the natural watercourse and not the ditch or drain. In many cases a judgement will be required at a local level in relation to the point of assessment and where there is any doubt the Overseeing Organisation should be consulted in conjunction with the appropriate EA.

A.16 When assessing potential impacts each outfall should be individually assessed in the first instance and the point of assessment clearly identified. Where more than one outfall discharges into the same reach of a watercourse the combined effects will be more significant. In these circumstances the outfalls should be aggregated for purposes of cumulative assessment within HAWRAT (subject to the proximity of the outfalls discussed in paragraph A.17). To aggregate the outfalls the drained areas are simply added together. Care should be taken over the Q_{95} value used as, in small streams, this may increase significantly along the reach being assessed. The point for cumulative assessment should be clearly identified and should be downstream of the last outfall in the reach. For this purpose a reach is defined as a length of watercourse between two confluences. The reason for this is that the available dilution and stream velocity will naturally change at confluences and influence the assessment.

A.17 Reaches can vary greatly in length and, for assessment of impacts associated with soluble pollutants, where the reach is longer than 1 km (measured along the watercourse) only outfalls within 1 km should be aggregated for assessment. When assessing the potential impacts associated with sediment-bound pollutants, where the reach is longer than 100 m only outfalls lying within 100 m should be aggregated for assessment. Beyond 100 m the sediment, if it settles at all, is likely to be sufficiently diluted with natural sediment. If it is not clear whether outfalls should be aggregated, the precautionary approach is to combine them and seek confirmation from the Overseeing Organisation. Figure A1.5 and Table A1.2 provide an illustration of when outfalls could be combined for assessment of soluble pollutants. Figure A1.6 and Table A1.3 provide an example of when outfalls could be combined for assessment of sediment-bound pollutants.

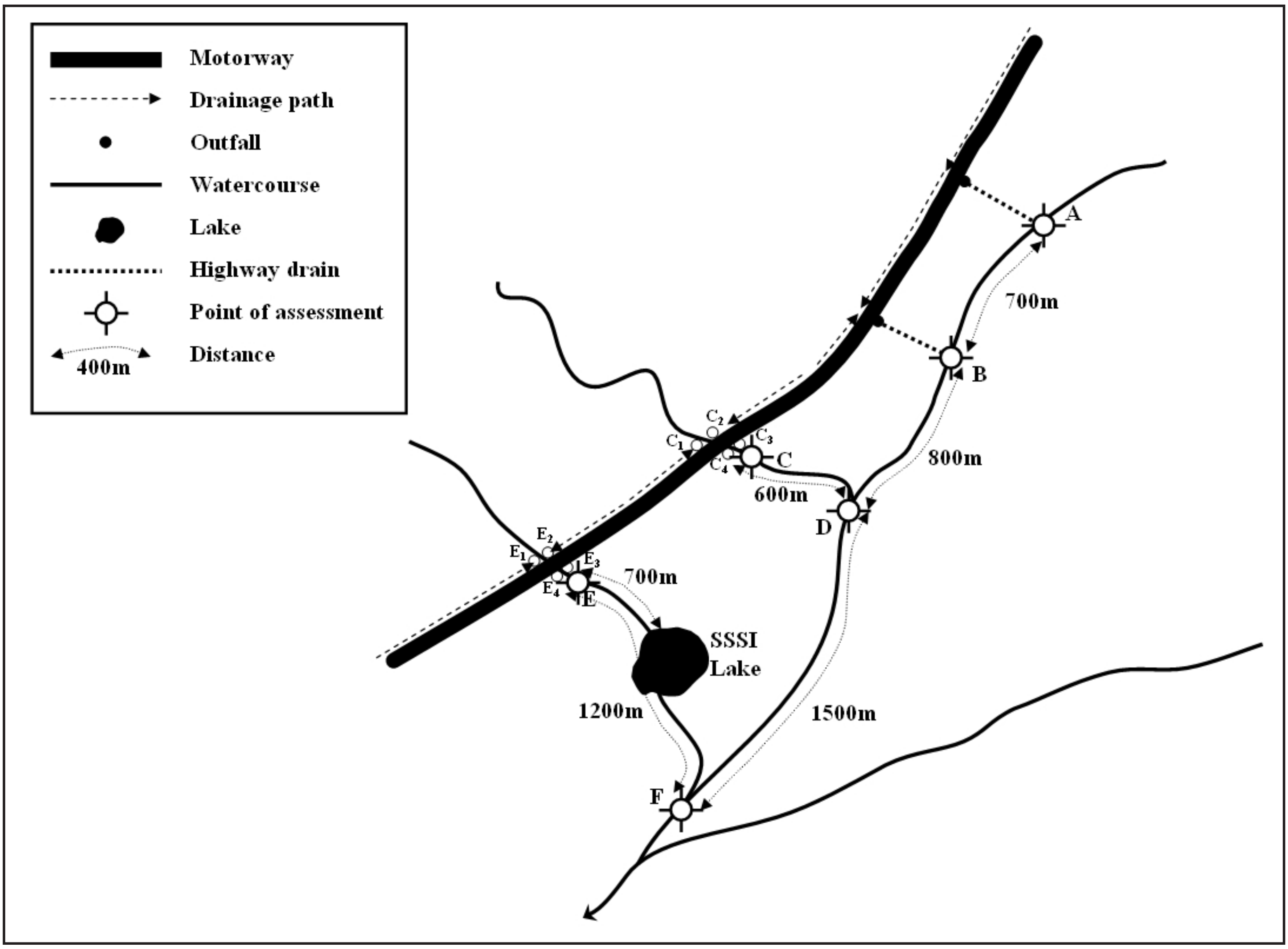

Figure A1.5 – Point of Assessment and Aggregation of Outfalls for Soluble Pollutants

Point of Assessment	Individual assessment(s) required?	Combined assessment required?	Notes
A	Yes	Yes A + B (but at B)	Individual assessment at A. Combined assessment at B as below.
B	Yes	Yes A + B	Individual assessment plus combined assessment for A + B (outfalls in same reach and within 1 km).
C	Yes C_1, C_2, C_3, C_4	Yes $C_1 + C_2 + C_3 + C_4$	The four outfalls on either side of the highway and watercourse should first be assessed individually and then combined to identify cumulative risks.
D	n/a	Optional A + B + C	Assessment is optional as outfall A and B and outfall C discharge into different reaches and there is no direct discharge into the reach between point D and F. The need for an assessment should be based on local environmental considerations and agreed with the Overseeing Organisation. If required, this might include a combined assessment for A, B and C.
E	Yes E_1, E_2, E_3, E_4	Yes $E_1 + E_2 + E_3 + E_4$	The four outfalls on either side of the highway and watercourse should first be assessed individually and then combined to identify cumulative risks. The discharge reaches a protected area (SSSI) within 1 km and this should be reflected in the assessments.
F	n/a	No	No assessment required. Point F is within a different reach.

Table A1.2 – Point of Assessment and Aggregation of Outfalls for Soluble Pollutants

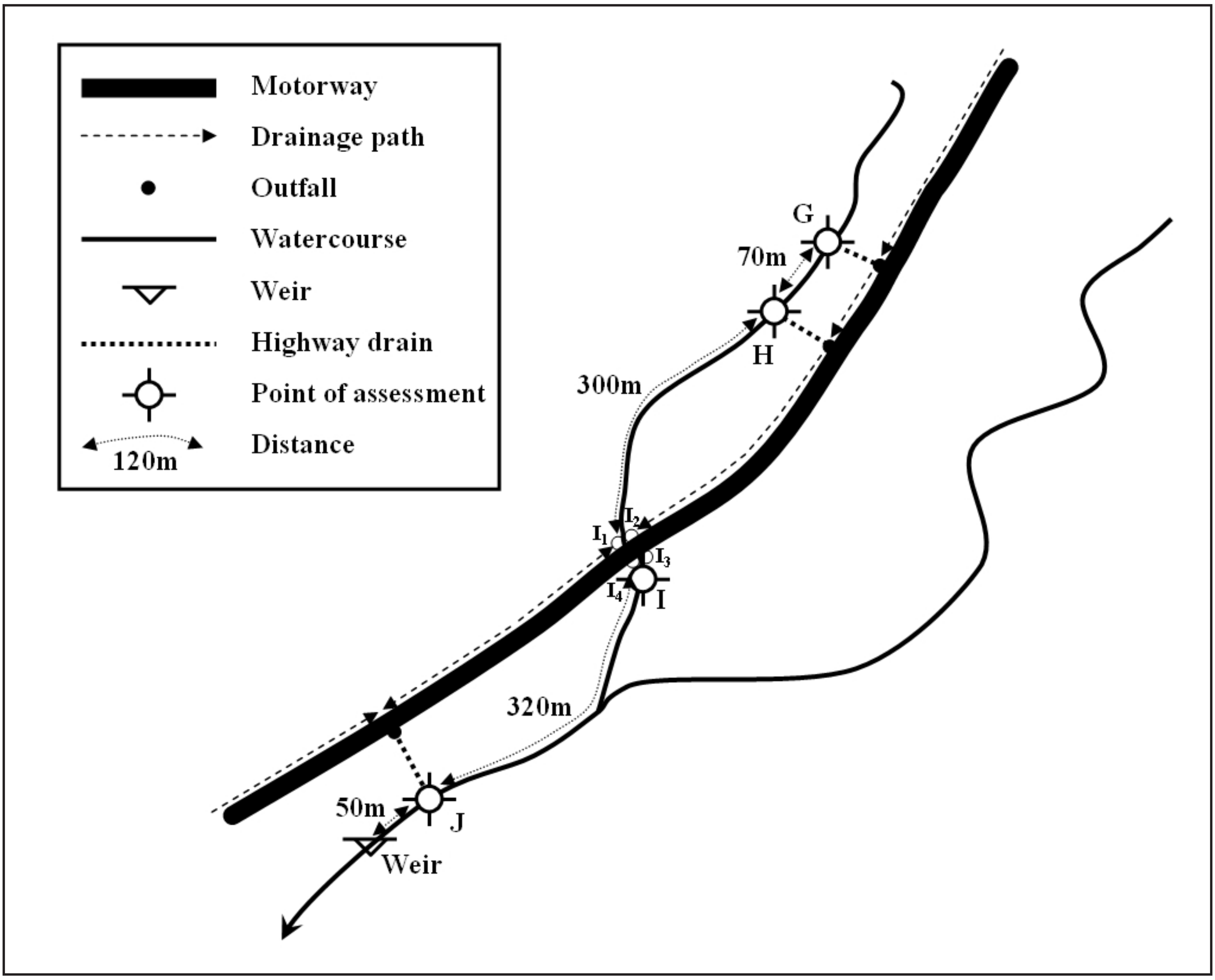

Figure A1.6 – Point of Assessment and Aggregation of Outfalls for Sediment-Bound Pollutants

Point of Assessment	**Individual assessment(s) required?**	**Combined assessment required?**	**Notes**
G	Yes	Yes G + H (but at H)	Individual assessment at G. Combined assessment at H as below.
H	Yes	Yes G + H	Individual assessment plus combined assessment for G + H (outfalls in same reach and within 100 m).
I	Yes I_1, I_2, I_3, I_4	Yes $I_1 + I_2 + I_3 + I_4$	The four outfalls on either side of the highway and watercourse should first be assessed individually and then combined to identify cumulative risks.
J	Yes	No	Individual assessment only. A downstream structure (weir) lies within 100 m of the discharge point. This should be reflected in the assessment as the structure may cause sediment to accumulate.

Table A1.3 – Point of Assessment and Aggregation of Outfalls for Sediment-Bound Pollutants

A.18 Where a cumulative assessment for a proposed project or an existing situation identifies a potential environmental risk the procedure should be to first identify which, if any, individual outfall(s) fails the assessment. This failing outfall(s) should then be re-evaluated with mitigation applied (in HAWRAT) and then re-assessed cumulatively. In determining which individual outfall(s) fails the assessment it is useful to remember that, when all others parameters are equal, the outfall draining the largest impermeable road area will be the most likely to fail the assessment.

Interpretation of HAWRAT for Purposes of Mitigation

A.19 When outfalls fail the Method A and B assessments for likely impacts from routine runoff, HAWRAT provides an indication of the scale of mitigation required. To reduce the impacts from soluble pollutants there are two options for mitigation: limiting the discharge rate (thereby increasing the dilution) and/or treating the runoff to reduce the concentration of soluble pollutants reaching the watercourse. The degree of flow attenuation and/or treatment required can be investigated iteratively using Step 3 of HAWRAT. If this exercise determines that, for example, a maximum discharge rate of '5 l/s' is required, the drainage system would need to be designed to restrict the discharge rate to 5 l/s. Exceeding this discharge rate could result in inadequate dilution in the watercourse and an exceedance of the toxicological thresholds (the RSTs). The percentage of treatment required indicates the percentage by which the concentrations of soluble pollutants in the runoff will need to be reduced in order to achieve compliance with the toxicological thresholds. The treatment percentages given by HAWRAT are very precise, however, current best practice does not provide precise, accurate or robust treatment efficiencies for the available treatment options. Therefore, a degree of pragmatism will be required when designing a drainage system to meet the required treatment percentages. The treatment train should be sufficient to reasonably treat the runoff.

A.20 If Method B reports a failure of the EQSs it is likely that the RSTs are also being exceeded. It is also likely that a lesser degree of treatment is required to comply with the EQSs than for the RSTs. The designer should aim to achieve compliance with both EQSs and RSTs but at sites where this is difficult the design should at least provide sufficient treatment to comply with the EQSs. In considering mitigation options, it should be noted that flow attenuation will not reduce annual average concentrations (against which EQS compliance is measured) as all the runoff will eventually reach the river within the year.

A.21 For impacts associated with sediment-bound pollutants, HAWRAT indicates the degree of settlement required in order to reduce the extent of deposition to an acceptable level. For example, '18% settlement needed' requires that the volume of sediment in the runoff needs to be reduced by 18% before discharge to the watercourse. As with the treatment of soluble pollutants, the percentages given by HAWRAT are very precise but current best practice does not provide precise, accurate or robust settlement efficiencies for the available settlement options and a degree of pragmatism will be required.

Health and Safety During Site Visits

A.22 A Tier 2 assessment requires a site visit to measure river dimensions. Appropriate health and safety procedures should be followed when working in and around water and a method statement and risk assessment should be prepared and understood by field staff before going to site. Site visits and the collection of samples may also be required for a Method B assessment of bioavailability (see paragraph B.3). BS 6068 (Ref 5) gives the following health and safety advice:

'When samples are to be taken by wading into a river or stream, account should be taken of the possible presence of soft mud, quicksand, deep holes and swift currents. A wading rod or similar probing instrument is essential to ensure safe wading. By probing ahead, the person sampling can estimate the current and locate holes, benches, soft mud and quicksand. If in doubt, a safety line should be attached to a secure object on the bank or shore for support. The increased volume of chest waders (as compared to thigh waders) can be an impairment to rescue, should total immersion occur. If circumstances dictate that sampling needs to take place at sites where a fall could occur and in the vicinity of deep water, by any person, a life jacket must be worn and an appropriate system of regular reporting to a central control point must be employed. A life jacket must be worn in all cases when working on boats. It should be recognised that there may be chemical, bacteriological, virological and zoological hazards in many aquatic sampling situations.'

Method B – Detailed Assessment

B.1 If in-river annual average concentrations of soluble pollutants exceed the EQSs in Table A1.1 there may be a need to assess the bioavailability of the soluble pollutants using BLMs. The BLMs will be available on the EA's website from late 2009. Assessment using a BLM is only likely to be required in exceptional circumstances and, due to the monitoring requirements, discussion with the Overseeing Organisation will be needed before proceeding. One reason that the need for a bioavailability assessment will be exceptional is that if annual average concentrations exceed EQSs it is likely that the RSTs are also being exceeded. Treatment of soluble pollutants to meet the RSTs will also reduce the annual average concentrations and may result in compliance with the EQSs without need for a bioavailability assessment. Note that mitigation through flow attenuation will not reduce annual average concentrations as all the highway-derived runoff will continue to reach the river in the course of a year.

B.2 The toxicity of soluble pollutants depends on their availability to exposed organisms. Metals will bind to Dissolved Organic Carbon (DOC) and thereby become unavailable to aquatic organisms. In general, the greater the DOC the lower the bioavailability. The degree of binding is modified by other parameters such as pH and hardness. EQSs are not site-specific and do not account for bioavailability. The BLM effectively refines the EQS on a site-specific basis. The dissolved copper and zinc concentrations predicted by HAWRAT are then compared with the BLM derived Probable Non-Effect Concentration (PNEC) to determine whether or not there is likely to be an impact. Following the procedures illustrated in Figure A1.4, there are two tiers of BLM assessment for copper (but only one for zinc). The first, and more simple assessment, requires the following inputs:

i) predicted in-river concentrations of dissolved copper and dissolved zinc (from HAWRAT);

ii) pH;

iii) water hardness (as Ca) of watercourse; and

iv) DOC concentration of watercourse.

B.3 To establish the values of these parameters with sufficient confidence a series of samples will be required from the watercourse at the point of assessment. As a general guide, at least five water samples spread over a six month period will be required. However, existing data may be used if DOC and pH show little variation over time. Health and safety advice with respect to sampling is given in paragraph A.22. The sample analysis results should be run through the BLM assessment to determine whether there is likely to be an impact.

B.4 The simple BLM assessment for copper is precautionary and does not consider all the mitigating factors. Consequently, if the result indicates that there may be an impact, it will be necessary to run a more detailed BLM assessment (Figure A1.4). In addition to the inputs listed above, the following watercourse parameters are required for a detailed assessment:

i) temperature;

ii) magnesium;

iii) sodium;

iv) potassium;

v) sulphate;

vi) chloride; and

vii) alkalinity.

As with the simple BLM assessment, at least five water samples spread over a six month period will be required. It is advised that all parameters are included in the original analyses so that the sampling procedure does not need to be repeated if a detailed BLM assessment is required.

B.5 Following the procedure in Figure A1.4, if the bioavailability tests show that no ecological impact is expected then no further action need be taken with respect to annual average concentrations. If an impact is predicted then mitigation should be considered. Mitigation can be included in HAWRAT at Step 3 (refer to paragraphs A.19 to A.21 for further information). The post-mitigation annual average concentrations of copper and zinc can then be re-run through the procedure shown in Figure A1.4. Once both Method A and Method B assessments have been completed, Table 5.2 should be consulted for advice on how to proceed.

Method C – Assessment of Pollution Impacts from Routine Runoff on Groundwaters

C.1 This method should be used to assess the potential impact on the quality of groundwater resources from routine runoff discharges to the ground. It provides a means of understanding and assessing generic processes that influence the level of groundwater protection inherent to different source and pathway characteristics. The risk assessment is carried out using the matrix presented in Table C1.2.

C.2 The Groundwater Regulations 1998 completed the transposition into legislation of requirements set out in the Groundwater Directive (80/68/EEC). The Directive, which will remain in force until December 2013, specifically requires that the discharge to groundwater of substances, contained in two lists, shall be prevented or controlled. The direct or indirect discharge of List I substances to groundwater is prohibited as they are considered extremely polluting. Direct discharge to groundwater means any overlying materials are bypassed for example via a borehole completed below the water table. Indirect discharge includes transport through the unsaturated zone before reaching the water table. Substances in List II must not cause pollution of groundwater whether the discharge is direct or indirect. List I and II substances are presented in Table C1.1. On the basis of the current legislation it is likely that regulators will consider both lists when assessing the potential impact of activities on groundwater resources.

C.3 Since January 2009 the Groundwater Daughter Directive (2006/118/EC) has operated alongside the Groundwater Directive (80/68/EEC) and will continue to do so until the latter is repealed in December 2013. The Groundwater Daughter Directive requires the prevention of all inputs of hazardous substances (for practical purposes, presently considered as being the same as List I) into groundwater. It also requires the limitation of any inputs of all other pollutants (presently considered as being the same as List II but likely to be extended in the future) into groundwater so as to prevent pollution, deterioration in status or any significant downward trends in quality.

C.4 The method described in this section provides a means to assess the potential overall risk to groundwater and identifies sites at high risk. It also provides a means to identify where particular sensitivities (for example, risks to human health through groundwater supplies) should be taken into account in assessing the overall risks.

C.5 The assessment should form the basis of a decision making process to determine whether action is needed (or indeed available) to mitigate risks to groundwater, for example, the adoption of alternate drainage strategies. The findings of the assessment and any decisions to be made on the basis of the assessment should be subject to consultation with the EAs.

C.6 In this guidance, eight component properties or parameters are recognised which influence the pollutant loading carried by road runoff and the extent to which passage through the soil to groundwater may modify the polluting potential of the routine runoff. The first three components influence the source term and the remaining five components the pathway function. Seven of these components have been incorporated into the risk assessment matrix (Table C1.2) although a Source Protection Zone (SPZ) (described in paragraph C.25) may also be considered by applying further professional judgement as to the likely level of risk to groundwater. (Note: the numbers in parentheses in the following component section headings refer to rows in the risk assessment matrix. The significance of the potential pollution impact on receptors of differing vulnerabilities is considered below.)

LIST I OF FAMILIES AND GROUPS OF SUBSTANCES	LIST II OF FAMILIES AND GROUPS OF SUBSTANCES
These substances should be prevented from being discharged into groundwater. List I contains the individual substances which belong to the families and groups of substances specified below, with the exception of those which are considered inappropriate to List I on the basis of a low risk toxicity, persistence and bioaccumulation. Such substances which with regard to toxicity, persistence and bioaccumulation are appropriate to List II are to be classed in List II. 1 Organohalogen compounds and substances which may form such compounds in the aquatic environment. 2 Organophosphorous compounds. 3 Organotin compounds. 4 Substances which possess carcinogenic, mutagenic or teratogenic properties in or via the aquatic environment (Note 1). 5 Mercury and its compounds. 6 Cadmium and its compounds. 7 Minerals oils and hydrocarbons. 8 Cyanides.	Discharges of these substances into groundwater should be minimised. List II contains the individual substances and the categories of substances belonging to the families and groups of substances listed below which could have a harmful effect on groundwater. 1 The following metalloids and metals and their compounds: 1 Zinc; 11 Tin 2 Copper; 12 Barium 3 Nickel; 13 Beryllium 4 Chrome; 14 Boron 5 Lead; 15 Uranium 6 Selenium; 16 Vanadium 7 Arsenic; 17 Cobalt 8 Antimony; 18 Thallium 9 Molybdenum; 19 Tellurium 10 Titanium; 20 Silver 2 Biocides and their derivatives not appearing in List I. 3 Substances which have a deleterious effect on the taste and/or odour of groundwater and compounds liable to cause the formation of such substances in such water and to render it unfit for human consumption. 4 Toxic or persistent organic compounds of silicon and substances which may cause the formation of such compounds in water, excluding those which are biologically harmless or are rapidly converted in water into harmless substances. 5 Inorganic compounds of phosphorous and elemental phosphorus. 6 Fluorides. 7 Ammonia and nitrites.

Note 1: When certain substances in List II are carcinogenic, mutagenic or teratogenic they are included in category 4 of List I.

Table C1.1 – List I and List II Substances as Defined by EC Groundwater Directive

Component Number (see text)		Weighting Factor (see text)	Property or Parameter	Low Risk (Score 1)	Medium Risk (Score 2)	High Risk (Score 3)
1	**SOURCE**	15	Traffic density	<50,000 AADT	≥50,000 to <100,000 AADT	≥100,000 AADT
2		15	Rainfall volume (annual averages)	<740 mm rainfall	740-1060 mm	>1060 mm rainfall
			Rainfall intensity	Even (<35 mm FEH 1 hour rainfall)	Uneven (35-47 mm FEH 1 hour rainfall)	Concentrated (>47 mm FEH 1 hour rainfall)
3	**PATHWAY**	15	Soakaway geometry	Continuous linear (e.g. ditch, grassed channel)	Single point, or shallow soakaway (e.g. (lagoon) serving low road area	Single point, deep serving high road area (>5,000 m^2)
4		20	Unsaturated zone	Depth to water table >15 m and unproductive strata	Depth to water table <15 >5m	Depth to water table <5m
5		20	Flow type	Unconsolidated or non-fractured consolidated deposits (i.e. dominantly intergranular flow)	Consolidated deposits (i.e. mixed fracture and intergranular flow)	Heavily consolidated sedimentary deposits, igneous and metamorphic rocks (dominated by fracture porosity)
6		7.5	Effective grain size	Fine sand and below	Coarse sand	Very coarse sand and above
7		7.5	Lithology	>15% clay minerals	<5% - >1% clay minerals	<1% clay minerals

AADT = Annual Average Daily Traffic (two way)

Table C1.2 – Matrix to Determine Risk of Impact of Pollution to Groundwater from Routine Runoff

C.7 **Source – Pollutant Concentrations.** The study described in 3.7 (Ref 35) showed there is only a relatively small list of contaminants that are routinely detected in routine runoff. Some studies (Refs 3, 11, 12, 31, 37, 41) have indicated that concentrations of pollutants may be somewhat higher in urban settings. To provide a practical evaluation of the source term, and in lieu of the pollution concentration parameter, it is considered that traffic density is likely to provide a reasonable estimate of effective pollutant loading. This information would also be more accessible to the designer or specifier. On this basis, although pollutant concentration is recognised as a key factor in influencing the risk to groundwater and may be used in further professional or expert judgement of risk, it is not presently included in the risk assessment matrix used in this Method.

C.8 **Source – Traffic Density (1).** Although the same study (Ref 35) identified no clear quantifiable relationship between traffic density and pollutant concentrations in runoff, this has been suggested from earlier studies. The traffic data (AADT two-way) have been split into 3 levels of risk based on the following ranges:

Level 1 AADT <50,000
Level 2 AADT ≥50,000 to <100,000
Level 3 AADT ≥100,000

C.9 **Source – Rainfall (2).** In common with previous studies, recent work has established that there is a relationship between rainfall intensity and concentrations of pollutants in runoff. There is also a relationship between total rainfall (hence runoff volume) and the pollutant loading (i.e. the total mass of pollutant received by the groundwater, irrespective of its concentration) to the receiving groundwater. It also follows that as these inputs (rainfall intensity and volume) are related, they should form only a single component of the matrix – with an associated weighting. Following the precautionary principle, the risk grade selected (i.e. low, medium or high) would be set according to the **higher** of the individual risks represented by intensity or volume.

C.10 The potentially most damaging situations occur where a significant proportion of the rain falls as storms, rather than where the (same volume of) rainfall is spread over longer periods of time. The mean annual rainfall in the UK varies relatively systematically west to east, from in excess of 2,000 mm in the Welsh and Scottish mountains, to less than 500 mm in East Anglia. Not only do the western areas have higher absolute rainfalls, but the number of days in which events exceed 10 mm (for example) is also greatest in the western highland areas (between 40 and 60 per year) and least (not more than 20 per year) in much of the Midlands and East Anglia. Information on average rainfall and on the occurrence of heavy falls, rainfall days and on the severity of shorter term high intensity events has been collected by the Meteorological Office and reference to such data should allow an area under investigation to be placed in the appropriate risk category. The web site (**www.metoffice.gov.uk**) also provides a wide range of information. Variations in rainfall intensity are also described in the FEH (Ref 39). This provides maps of modelled rainfall intensity throughout the country. The mapped distribution of modelled 1 hour design rainfall (in mm) for a 1 in 100 year return period (Figure 11.6 in FEH Volume 2) has been used as the basis for determining the high, medium and low risk categories in the risk assessment matrix.

C.11 **Pathway – Soakaway design and geometry (3).** A wide variety of systems allow discharge of runoff to ground. These include purpose designed soakaways, which can range from shallow excavations to deep circular pits. Guidance on the design of soakaways for road drainage is given in HA 118 (DMRB 4.2). Other than traditional soakaways, there are numerous other features that discharge all, or part of, the road drainage to groundwater. These may be linear features such as informal over the edge drainage, linear ditches or more formally designed systems including (for example) grassed channels or filter drains. Alternatively, the discharge may be through unlined retention and sedimentation ponds, infiltration ponds or constructed wetlands. These different types of drainage and their design are further described in HD 33 (DMRB 4.2) and HA 103 (DMRB 4.2).

C.12 Risks to groundwater from these various systems depend primarily on the directness of the pathway to groundwater, such that single point deep soakaways represent a greater risk than shallow more distributed structures. In addition, the distribution of the road drainage will also affect the risk – i.e. where the discharge is at a single location or lagoon (such as an infiltration basin) this constitutes a greater risk than where the discharge is dispersed over a greater area or length (such as in an unlined ditch) The risk assessment matrix has been set out to reflect these variations although distinction between drainage types and the risks they represent may not be so clearly defined. It should be noted that unsealed discharging systems of any description may put groundwater at risk from acute pollution impacts. These should be factored into any design whatever the ultimate discharge method.

C.13 **Pathway – Depth of unsaturated flow (4).** Discharges of road runoff and any accompanying dissolved or particulate contaminants has to pass through the unsaturated zone before reaching groundwater. Greater depths of unsaturated zone increase the opportunity for attenuating processes to operate. The depth of unsaturated zone may vary seasonally by several metres and zones of less than five metres depth may offer little attenuation potential. Conversely, a 40+ metre deep unsaturated zone in Sherwood Sandstone beneath a non-contained landfill near Nottingham has been found to provide significant attenuation to potentially polluting leachate. In the risk assessment matrix intermediate divisions have been based on a pragmatic view that less than 5 m of unsaturated depth is unlikely to provide significant attenuation capacity, with a value of 15 m used to provide the boundary between medium and low risk. The most appropriate data for the depth of the unsaturated zone is likely to be that derived from site-specific investigations or from other groundwater level observations made close to the proposed site of the soakaway. Seasonal variations in groundwater level should be considered when establishing the depth of the unsaturated zone and, adopting the precautionary principle, the default value used in establishing the risk should be the minimum seasonally recorded value.

C.14 **Pathway – Flow type (5).** Intergranular flow of infiltrating waters provides the maximum opportunity for beneficial interaction between migrating fluids and the soil and rock materials, inhibits bypass flows (which offer more direct pathways to underlying groundwater) and minimises the rate of advance of fluid and pollution fronts. In contrast, fissure flow systems have a low flux volume to wetted perimeter ratio and encourage rapid and often irregular long-distance movement of liquids and contaminants. Fissures are by definition, of greater dimensions than the pore dimensions of materials through which they cut and are less likely to offer valuable filtering than does intergranular flow through a porous matrix. The degree to which runoff water remains in contact with the soil matrix also affects the capacity for cation exchange to attenuate some contaminants, with intergranular flow offering greater potential than fissure. In natural systems there is a continuum between these two ‘end’ members. Typical examples are provided in Table C1.3, which also shows the risk category allocation appropriate for use in Table C1.2.

Flow System	**Example Formations**	**Risk Category (see Table C1.2)**
Dominantly Intergranular (Generally high porosity and permeability within rock matrix)	Lower Greensand	Low
Dual Permeability (High matrix porosity and permeability with high flow in fracture systems, bedding, joints and other discontinuities)	Sherwood Sandstone	Medium
Dual Porosity (High porosity but low permeability rock matrix; high flow in fractures and joints)	Chalk	High
Dominantly Fissure (Low porosity and permeability, flow generally confined to secondary fracture and joint systems)	Carboniferous Limestone Jurassic Limestone Magnesian Limestone Fractured granite	High

Table C1.3 – Examples of Groundwater Flow Systems

The table does not provide an exhaustive list. For example, many parts of the UK feature thick glacial or other superficial deposits or complex (possibly fractured and weathered) metamorphic and igneous strata. In these areas, an evaluation of the local hydrogeological system is essential to determine the predominant flow mechanism and assign the unit to the correct risk category.

C.15 **Pathway – Grain size (6).** The grain size of soils and rocks is a principal control on their hydraulic conductivity (permeability) and the rate at which liquids may move. So long as the permeability is sufficient to prevent surcharging and flooding under high input conditions, the finer materials provide both the greatest moisture storage and the longest delay in migration from the surface to the water table and are therefore assessed as representing the most desirable situation with regard to the attenuation of pollutants. However, if the grain size is lower than about 0.07 mm diameter drainage is likely to be inhibited and ponding and surface flooding may be a potential problem – i.e. the soakaway cannot function hydraulically as required. Conversely, coarse materials (coarse sand/gravel) offer little groundwater protection and are vulnerable to surface derived pollution in much the same way as fissured systems.

C.16 **Pathway – Lithology (7).** Mono-mineralic rock types, especially those composed of resistant minerals such as silica (SiO_2 ~ sand) do not generally provide significant sites for synergistic attenuation processes, such as cation exchange, to take place. Nor do these rock types provide the sites and inherent nutrients which encourage colonisation by populations of microbial organisms which mediate degradation of pollutants. In contrast, formations of mixed mineralogy and lithology, especially those with significant clay mineral and organic content, offer increased potential for beneficial attenuation. However, if the clay mineral content exceeds about 30%, the resultant reduction in permeability and increased potential for inhibition of drainage generally makes such formations unsuitable to locate soakaways (similarly to the effect of very fine grained materials described above) and further detailed assessment would be required.

C.17 The guidance in this Standard is intended to be both intuitive and transparent such that the risk category for each component property or parameter may be readily determined using freely available data. It is essential to understand that the basis of the guidance is to identify the relative risk to groundwater from discharges of road drainage and whilst it may be used to inform design decisions, the potential effects of the discharge should be assessed on a site-specific basis to ensure both the hydraulic functionality of the drainage feature and to apply appropriate protection to groundwater.

Weighting Factors

C.18 The risk assessment matrix recognises seven components that have a direct influence on the potential risk to the quality of receiving groundwater. It is also acknowledged that individual components may have a greater or lesser influence on the magnitude of the risk to groundwater – for example, in most circumstances, the depth of the unsaturated zone is likely to be a greater influence on risk than the effective grain size. To recognise this, weighting factors have been applied to each component. These have been applied intuitively and only experience in applying the risk assessment will determine whether such weighting is appropriate. This weighting recognises the significance of aquifer vulnerability (i.e. depth to the saturated zone, flow type, grain size and lithology) whilst also applying a weighting to the source term. This complies with the Source-Pathways-Receptor (S-P-R) linkage principle described in paragraph 5.24 in which the primary focus is the protection of groundwater.

C.19 For each site under investigation, the risk level (low, medium or high) for each component is established and the relevant score (1, 2, 3 respectively) multiplied by the weighting factor for that component to provide a component score. This process is repeated for all categories and the component scores are summed to provide an overall risk score (the lowest possible score being 100 and the highest possible 300). Higher scores will indicate a greater risk to groundwater and should be used to determine whether or not a direct discharge is appropriate or some form of attenuation mechanism should be provided to either break the S-P-R linkage or control the pollutant loading being discharged to ground. In some cases the risks may be considered to be too great and discharges to groundwater may need to be avoided. A discussion of potential mitigating measures is provided in Chapter 8.

C.20 The overall cumulative assessment of risk should now be used to guide the way forward with the design of the groundwater discharge. An interim approach is suggested which places the values obtained in the risk assessment into three action classes:

i) Overall risk score <150 Low Risk of Impact

ii) Overall risk score 150-250 Medium Risk of Impact

iii) Overall risk score >250 High Risk of Impact

It should be noted that these are suggested action classes only and each case should be examined on its own merits and constraints by suitably qualified specialists. Some adjustment to the range for each action class may be needed.

C.21 In the low impact scenario, the identified risks to groundwater are minimal and the design of the discharge to groundwater can be selected to most effectively meet the hydraulic requirements of road drainage. For a medium impact, mitigating measures should be considered to protect groundwater, although the need for and nature of the mitigation measures should be informed by additional risk assessment, undertaken by a specialist. In the high impact scenario, it will be necessary to collect further data and complete a more detailed risk assessment (using hydrogeological expertise). It may be the case that even allowing for the use of treatment measures, the risks to the groundwater system are too high (i.e. not acceptable) to adopt a typical design of groundwater discharge system. Whatever the level of risk identified, it will be necessary to consult the EAs on the appropriateness of any drainage system design initiated.

C.22 This assessment method applies to risks derived from routine runoff only and a spillage risk assessment (Method D herein) should also be carried out. If the spillage risk is unacceptable, mitigation should be applied to suitably protect groundwater.

Groundwater Sensitivity

C.23 It is recognised that all groundwater should be offered protection from pollution. The EAs have, however, developed policies that identify a greater sensitivity of some areas of groundwater bodies. For example, those that form significant groundwater resources or where there are risks to human health related to drinking water sources. These have not been incorporated into the risk matrix, but should form a significant element of the assessment process and the level of mitigation to be included in the project. The significance of the risk of impact, assessed as described in Chapter 5, should be assessed by comparing the ‘resource value’ of the aquifer with the risk of impact derived above.

C.24 The resource potential of an aquifer is to a considerable extent coincident with the aquifer classification provided by the EAs. In GP3 (Refs 15, 16, 17, 18) the EA provides aquifer classifications as principal aquifer, secondary aquifer and unproductive strata. These classifications represent the relative vulnerability of the aquifer based on its importance as a resource that supports both abstraction and support to surface ecosystems. In the Groundwater Protection Strategy for Scotland (SEPA 2003) (Ref 40), similar aquifer classifications are provided, although these are defined as: highly permeable, moderately permeable and weakly permeable. The classification may, with care, be used in the determination of the sensitivity of the resource. This is developed in Table A4.6 (Annex IV).

C.25 SPZs form an important part of groundwater protection policy, as described in Chapter 2, as they provide a significant element in the protection of public drinking water supplies. The sensitivity of these sources should also be addressed in the overall assessment and this is shown in Table A4.6 (Annex IV).

Method D – Assessment of Pollution Impacts from Spillages

D.1 This method provides an indication of the risk of a spillage causing a pollution impact on receiving water bodies.

D.2 This risk is defined as the probability that there will be a spillage of pollutant and that the pollutant will reach and impact the water body to such an extent that either a Category 1 or 2 incident – a serious pollution incident – occurs. Table D1.1 defines these categories. The probability is the product of two separate risks:

i) the probability that there will be a spillage with the potential to cause a serious pollution incident; and

ii) the probability, assuming such a spillage has occurred, that the pollutant will cause a serious pollution incident.

D.3 The risk is expressed as the probability of an incident in any one year. It is initially assessed without any mitigation measures. If mitigation measures are needed, the risk is reduced by the pollution risk reduction factor for each measure given in Table 8.1.

D.4 In most circumstances, the acceptable risk of a serious pollution incident occurring will be where the annual probability is predicted to be less than 1%. In cases where, for example, road runoff discharges within close proximity to (i.e. within 1 km) a natural wetland or designated wetlands, such as SSSIs, SACs, SPAs, WPZs, Ramsar sites and salmonid waters, or it could affect important drinking water supplies or other important abstractions, a higher standard of protection will be required such that the risk of a serious pollution incident has an annual probability of less than 0.5%. In such cases, advice is to be sought from the Overseeing Organisation and the EAs are to be consulted.

D.5 To determine the risk, the following data are required for each reach or section of aquifer into which runoff is to be discharged:

i) the length of road in each of the categories in Table D1.1;

ii) the AADT two way flow for each section of road, other than slip roads, identified above (for new roads, use the design year traffic flow); and

iii) the percentage of the AADT flow that comprises Heavy Goods Vehicles (HGVs) (where roads are known to carry an unusually high proportion of hazardous materials, for example to an oil refinery or creamery, a higher factor may be appropriate).

D.6 HAWRAT (described in Method A) incorporates a spreadsheet which uses these data to automate the calculation of spillage risk and the probability of a serious pollution incident. It is recommended that before using HAWRAT to calculate spillage risk the assessor should be familiar with the manual calculations which are described below.

D.7 Using these data, calculate the annual probability of a spillage for each section of road, using the following formula:

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

Where:

P_{SPL} = annual probability of a spillage with the potential to cause a serious pollution incident

RL = road length in kilometres

SS = spillage rates from Table D1.1

AADT = annual average daily traffic (use design year for new road)

%HGV = percentage of heavy goods vehicles

D.8 Calculate the predicted annual probability of a serious pollution incident for each section of road, using this formula:

P_{INC} = P_{SPL} x P_{POL}

Where:

P_{INC} = the probability of a spillage with an associated risk of a serious pollution incident occurring

P_{POL} = the probability, given a spillage, that a serious pollution incident will result. An appropriate value for this is to be selected from Table D1.2. This will depend on the sensitivity of the water course and how soon it can be reached by the emergency services.

D.9 Add the annual probabilities for each section of road draining into a reach. If this figure is greater than the acceptable risk, repeat the above steps for each individual outfall, to determine the risk from each outfall.

D.10 Select the discharge with the highest individual risk, and consider whether any of the factors can be amended, or if the outfall can be relocated, or if a form of mitigation can be included. Recalculate the risk using the appropriate risk reduction factor for the measure selected. Chapter 8 gives factors to be used.

D.11 Recalculate the overall risk to each reach by adding all the revised individual outfall risks. Where necessary mitigation measures are to be included at other outfalls, until an acceptable overall risk for each reach is achieved.

D.12 In some (rare) instances, two forms of mitigation may be required to reduce the probability to an acceptable level of risk. Where this occurs, the two forms of mitigation should be complementary and should not rely on the same mechanisms for their effect. At least one should be a passive system, as described in Chapter 8.

	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		0.88	1.46
Side Road		0.93	1.81
Total	0.37	0.45	0.85

Table D1.1 – Serious Spillages in Billion HGV km/year

The risk factor applies to all road lengths within 100 m of these junction types. So for a side road joining an urban trunk road the factor is 1.81 for 100 m of the side road and for a 200 m length of the trunk road, centred on the junction.

Receiving water body	**Urban (response time to site <20 minutes)**	**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

Table D1.2 – Probability of a Serious Pollution Incident Occurring as a Result of a Serious Spillage

Method E – Hydrological Assessment of Design Floods

E.1 A range of methodologies is available for calculating flood flows of differing return periods. In 1999, the Institute of Hydrology (now Centre for Ecology and Hydrology (CEH)) published the FEH (Ref 39), which has since become the industry standard method for flood estimation, superseding the Flood Studies Report (FSR).

E.2 The methods recommended for use in the calculation of flood flows for road design are as follows:

i) Flood Estimation Handbook;

ii) Institute of Hydrology Report 124 (devised for catchments up to 25 km^2 but generally recommended for catchments less than 2 km^2).

The FEH provides both a Statistical Method (Volume 3) and a 'Restated' Rainfall-Runoff Method (Volume 4). However, the FEH 'Restated' rainfall-runoff method has been replaced by the 'Revitalised FSR/FEH rainfall-runoff method' (ReFH).

E.3 In general, actual recorded data should always be used for the assessment of a design flood. The data available are discussed in paragraph E.14.

E.4 This document outlines the different methods for the assessment of design floods and provides suggestions for their use. However, it does not detail the methods fully and the source text should be consulted before any calculations are attempted. It should be noted that the FEH is not suitable for inexperienced users, and in many cases an experienced hydrologist should be used to estimate the appropriate design flows.

FEH Statistical Method

E.5 The FEH statistical method is based on the analysis of all available suitable flood flow records from gauging stations throughout the UK. The method comprises the estimation of an index flood and a growth curve that can be applied to the index flood. The index flood used in FEH is the median annual peak flow (the flow with a 50% probability of being exceeded in any one year), also known as Q_{MED}.

E.6 The Q_{MED} at a site of interest is calculated, in the case of a gauged site, from the gauged records and, for an ungauged site, from the catchment characteristics. For ungauged sites Q_{MED} is adjusted using data from a hydrologically similar catchment. This could be an analogue or donor catchment if available. The growth curve is calculated using records from a pooling group of hydrologically similar catchments and applied to Q_{MED} to give a flood frequency curve.

FEH Unit Hydrograph Rainfall Runoff Method

E.7 The unit hydrograph rainfall-runoff method is more complex than the statistical calculations, as it calculates hydrographs rather than simply peak flows. It involves estimating design storms and applying them to the catchment. The catchment is characterised by a series of digital descriptors e.g. area, slope, soil type, drainage path length. Whilst this method takes the local features of the catchment into account, there are still considerable uncertainties and the statistical method is usually preferred as it is based on a larger data set.

The rainfall-runoff method in the FEH should no longer be used as it has been replaced by the ReFH. Although the ReFH method is relatively new, in general it should give similar flood peaks to the FEH statistical method and an improved hydrograph shape compared to the original FEH method. Until more experience has been obtained with the ReFH, it is suggested that when a hydrograph is required, peaks should be estimated by both the statistical and ReFH methods, and the results compared.

IH 124 Method

E.8 This method produces a revised equation to estimate the time to peak of the unit hydrograph for catchments less than 2 km^2 for use in the rainfall-runoff method, and a regression model between Q_{BAR} (the mean annual flood event) and catchment area, rainfall and soil for use in the statistical method. A growth curve is then required to factor Q_{BAR} to the required return period.

Application of Methods

E.9 Predictions produced by both the statistical and rainfall-runoff methods are subject to considerable uncertainties and calibration using local data is desirable. The following six maxims summarise the FEH philosophy:

i) flood frequency is best estimated from gauged data;

ii) while flood data at the subject site are of greatest value, data transfers from a nearby site, or a similar catchment, are also useful;

iii) estimation of key variables from catchment descriptors alone should be a method of last resort; some kind of data transfer will usually be feasible and preferable;

iv) the most appropriate choice of method is a matter of experience and should be influenced by the requirements of the study, the nature of the catchment and, most importantly, the available data;

v) in some cases a hybrid method – combining estimates by statistical and rainfall-runoff approaches – will be appropriate;

vi) there is almost always more information available; an estimate based on limited data may be shown to be suspect by a more enquiring analyst. A visit to the site will usually provide further details. Even a gauged record covering only a few years will considerably improve the accuracy of flow records.

E.10 Clear documentation of calculations and the decisions made should be recorded. The EAs will probably wish to see documentation demonstrating how flow estimates and key variables have been obtained, and will normally be willing to discuss these variables at the start of the work. Documentation should include as a minimum:

i) a clear method statement;

ii) documentation of all decisions;

iii) documentation of all data, calculations and computer printout;

iv) summary of results; and

v) demonstration that the work has been checked and approved by suitably qualified staff.

E.11 Although the FEH is the industry standard method for flood estimation, it should be used with care for very small catchments, and cannot be used simply as designed for catchments of area less than 0.5 km^2. The EA/Defra R&D Report ‘Preliminary rainfall runoff management for developments’ (W5-074/A) (Ref 25) recommends that IH 124 is used to determine peak **greenfield** runoff rates for small catchments. This procedure gives the index flood Q_{BAR}, and regional growth factors from Flood Studies Supplementary Reports 2 and 14 are then used to calculate the greenfield peak flow rates for return period up to 100 years. Where catchments are smaller than 0.5 km^2, W5-074/A recommends that the analysis should use 0.5 km^2 in the IH 124 formula, and then linearly interpolate the flow value to the actual catchment area.

Flood estimation for small catchments can have even greater uncertainties than larger catchments for a range of reasons including:

i) lack of reliable gauged high-flow data for small catchments (from which to derive or confirm any method);

ii) as catchment area decreases, general methods and equations may become less applicable to the peculiarities of a particular catchment.

These latter factor may be relatively more important in small catchments because of:

i) uncertainties in the catchment boundary and hence catchment area;

ii) mapping of drainage paths and artificial drainage effects (such as changes to drainage routes and constrictions such as culverts);

iii) resolution of the soil mapping (0.5 km^2 in the FEH);

iv) variation in the hydrological response from soil types – a small catchment may contain few soil types (perhaps only one), but the hydrological behaviour may not be representative of that soil type as a whole; this may be relatively more important in more permeable soil types (Soil types 1 and 2 in IH 124) for which there are also relatively few gauged catchments.

Flood estimation for small catchments may require a site visit by an experienced hydrologist to give careful consideration of catchment area, drainage, and soil. This would be in addition to inspection maps and of the digital data provided as part of the FEH.

Thus, although FEH methods may be applied down to a catchment area of around 2 km^2, the above factors should be considered for any catchment under around 5 km^2, and possibly even above 5 km^2 where the conditions listed above may be important. In this range above 2 km^2, hydrologists should apply FEH methods with the above points in mind, and some may wish to apply IH 124 for comparison.

E.12 At the start of a project, the following procedure should be adopted:

i) contact the EAs to determine whether any flood information is already available: e.g. a section 105 study in England or Wales, flow gauging records, or a regional flood strategy;

ii) if no local flood predictions are available, estimates should be made following the FEH methodology or IH 124 depending upon the catchment size;

iii) within the FEH, the statistical method should always be applied; where a hydrograph is required, the rainfall-runoff method (ReFH) should then be applied, and the peaks from the two methods compared;

iv) if a hydrograph is required for the analysis, then a hybrid of the rainfall-runoff (ReFH) and statistical methods may be more appropriate, whereby the rainfall-runoff method provides the hydrograph shape, which is scaled to the statistical flow. Comparison should also be made with any recorded flood hydrograph data available within the catchment.

E.13 Detailed guidance on the application of the FEH and IH 124 methods are provided in the reports, and are therefore not restated in this guidance. FEH also has accompanying software FEH CD-ROM which provides a digital data set of UK catchments which drain an area of 0.5 km^2 or greater.

E.14 The data used in developing the FEH statistical method was included within the WINFAP-FEH software released in 1999. However, the EAs have a programme of updating and improving the dataset used for flood peak estimation under HiFlows-UK. The dataset and supplementary information should be used in preference to the original FEH dataset and are located at:

www.environment-agency.gov.uk

This website provides the complete dataset for the FEH statistical method by download, together with important information about each gauging station, including an indication of data quality and applicability. In some circumstances, such as where a recent large flood is known to have occurred (but is not yet recorded in HiFlows-UK) or when there appears to be a problem with the data in HiFlows-UK, the EAs should be consulted.

Method F – Hydraulic Assessment

F.1 If modelled or observed flood levels and extents are not available for the river reach affected by a watercourse it will be necessary to construct a hydraulic model using the flood flows derived in the hydrological analysis (described in the previous section). Hydraulic models may be mathematical or physical, depending on the complexity of the watercourse at the point of interest. It is usual to use mathematical models as physical models are expensive and do not lend themselves to the examination of a range of options. A range of models can be constructed and they may be one or two dimensional, with steady or unsteady flows. In most cases it will be sufficient to construct a one-dimensional model using a software package such as HEC-RAS, ISIS or MIKE11, all of which are likely to be acceptable to the EAs.

Data Input

F.2 The river reach is modelled using a series of cross-sections with associated storage areas, overflows, structures, etc. The choice of energy loss coefficients is fundamental to the validity of the modelled results. Advice on the correct use of coefficients can be found in textbooks, such as 'Open Channel Hydraulics' (Ref 6) and 'Handbook of Hydraulics' (Ref 4) and should be discussed in advance with the EAs to avoid wasted work using inappropriate coefficients. The upstream and downstream model extents, defining the maximum area within the floodplain that could be affected by the scheme, should also be agreed with the EAs.

Calibration and Validation

F.3 The calibration of an hydraulic model involves obtaining water levels for a recorded flood event of known peak flow, and adjusting the model coefficients to obtain a reasonable fit. Therefore, observed water levels and corresponding flow are required for calibration purposes. Recent major floods, such as the events of summer 2007, have been recorded and documented across the UK by the EAs, with most major rivers having a flood extent outline map, and gauged estimates of flow. Low flow conditions are not appropriate for calibration because the values of coefficients vary with river stage.

F.4 The EA guidance document 'Benchmarking of Hydraulic River Modelling Software Packages' (Ref 8) should be consulted prior to undertaking the hydraulic analysis. The EA should be contacted for an initial discussion of proposals.

F.5 It is recommended that the model is calibrated on three or more recorded flood events if possible, and then validated on another, with particular attention being paid to the incidence of blockage. If no calibration data is available for the study site then rigorous sensitivity testing should be undertaken to fully quantify the uncertainties within the model.

Sensitivity Testing

F.6 After a model has been calibrated, a series of sensitivity tests should be carried out in order to determine the models sensitivity to the coefficients and parameters used. For example:

i) by sensitivity testing the roughness coefficient, the analyst can see how the water level would be affected by different types of vegetation and thus be able to assess seasonal variations;

ii) by considering the effects of full or partial blockage of components of a structure, and any resultant increased flood envelope;

iii) by considering the transition details between open channel and structure, to optimise their conveyance of flow into and out of the structure;

iv) testing for the effects of climate change on design flows.

F.7 Where the effects of a road crossing on an adjacent watercourse need to be determined, it is recommended that the methodology be agreed with the EAs prior to any calculations being undertaken. Figure F1.1 indicates the procedure for undertaking the assessment.

F.8 In order to determine the effect of a road or bridge the following tasks should be undertaken:

i) contact the EAs to agree a methodology and collect any available flood data;

ii) either update an existing model, if available or construct a new site-specific model;

iii) determine if the model requires a time dependent input, e.g. for assessment of storage volumes;

iv) apply the proposal to the model, to determine the loss of floodplain storage and effects on upstream and downstream water levels;

v) if the model indicates that the afflux is unacceptable, redesign the proposal to achieve an acceptable impact.

F.9 Detailed guidance on the requirements of hydraulic modelling is available from the EAs (see paragraph F.7), and is therefore not restated within this guidance note. The hydraulic modelling packages also have accompanying detailed hydraulic manuals, which provide guidance on the parameterisation, calibration and sensitivity testing that should be carried out. The joint Defra/EA R&D publication 'Hydraulic performance of river bridges and other structures at high flows (W5A(00)01) – Phases 1 and 2' (Ref 2) should also be consulted.

F.10 As with all models where limited calibration and validation data is available, the results should be treated with caution. The EAs are likely to require the application of the precautionary principle and will also expect consideration of the effects of climate change.

What is Required in a Flood Risk Assessment

F.11 A Flood Risk Assessment (FRA) in England should comply with Appendix C of Planning Policy Statement 25. Paragraph 2.6 (of PPS25) indicates the other regional guidance, which also adopt similar requirements. CIRIA C624 (Ref 26) provides useful practical guidance. In Wales the assessment should cover the requirements of Appendix 1 (E) of TAN 15.

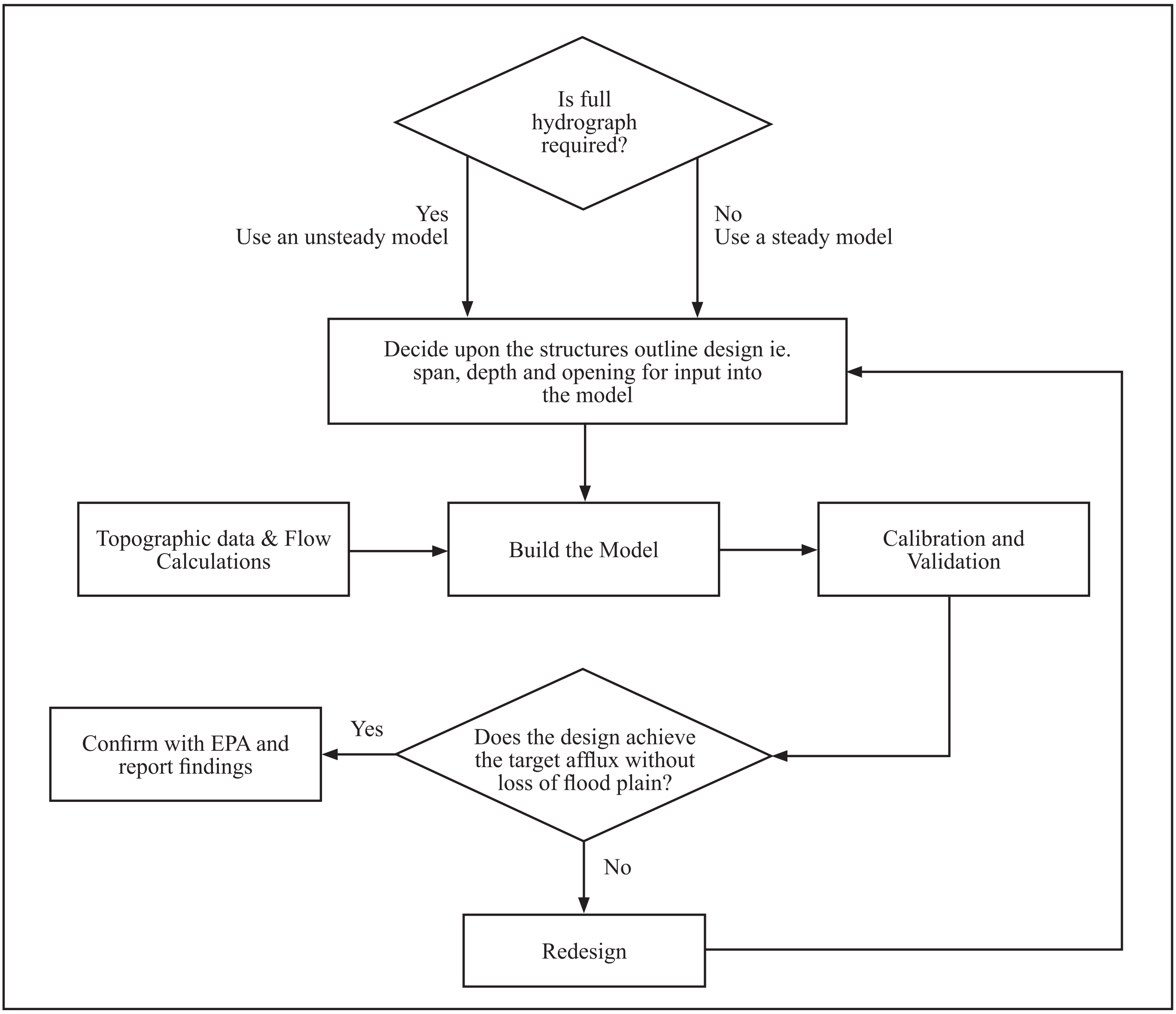

Figure F1.1 – Flowchart for Hydraulic Design

ANNEX II WORKED EXAMPLES

For each of the worked examples in this annex, the significance of the associated potential effects has been recorded in Table G2.1 (at the end of this Annex) according to the procedures described in Annex IV. Table G2.1 is a completed version of the template Table A4.2 (Annex IV).

Assessment of Pollution Impacts from Routine Runoff to Surface Waters

Method A

Worked Examples

Example A1

A motorway is being widened from dual two to dual three lanes, including hard shoulders. The completed motorway will be 28 m wide. A 2 km length of the road drains to a reach of a small good quality river (River Blude). The stream is used for recreational fishing. The following data apply:

Data for Step 1 – Runoff quality:

AADT for two-way flow	115,000 vehicles/day (expected future flow)
Climatic region	Colder-wet (from maps in the Highways Agency Water Risk Assessment Tool (HAWRAT) Help Guide)
Rainfall site	Warrington (from maps in the HAWRAT Help Guide)

Data for Step 2 – River impacts:

95%ile river flow (Q_{95})	0.15 m^3/s
Base flow index	0.6 (from LowFlows™ software)
Impermeable road area drained	5.6 ha (2,000 m × 28 m/10,000)
Permeable area draining to outfall	2.2 ha
Is the discharge in or within 1 km upstream of a protected site for conservation?	No
Water hardness	230 mg $CaCO_3$/l
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100 m downstream of the point of discharge?	No
Tier 1, Estimated river width	4 m (from mapping on Highways Agency Drainage Data Management System (HADDMS))

Initially a Step 1 assessment is carried out. For a Step 1 assessment to work, the 95%ile river flow (Q_{95}) has to be set to zero. The Annual Average Daily Traffic (AADT), climatic region and rainfall site should be selected from the ranges in HAWRAT and the 'Predict Impact' button clicked. In this example, once the tool has completed the calculations, the user interface displays red 'fail' boxes for each of the soluble pollutants and sediment-bound pollutants in the runoff, i.e. the runoff concentrations exceed the toxicity thresholds. A Step 2, river impact, assessment is therefore needed.

The Step 2 data given above are entered into HAWRAT, including the Q_{95} of 0.15 m^3/s, and the 'Predict Impact' button is clicked. The user interface should appear as in Figure A2.1. The detailed results sheet should appear as in Figure A2.2. It can be seen that each of the soluble pollutants and the sediment-bound pollutants pass the Step 2 assessment. The site is non-accumulating as the low flow velocity is 0.13 m/s (i.e. above the depositing threshold of 0.1 m/s).

To complete the risk assessment the annual average concentrations of dissolved copper and zinc need to be compared with the Environmental Quality Standard (EQS) values in Table A1.1. HAWRAT displays the annual average concentration on the user interface. In this example, at Step 2, the annual average copper and zinc concentrations are 0.07 µg/l and 0.36 µg/l respectively. These are below the EQSs.

Both the HAWRAT assessment and the comparison with EQSs give a 'pass'. Table 5.2 shows that no further assessment is required i.e. there is not considered to be a potential for adverse ecological impacts in the receiving river.

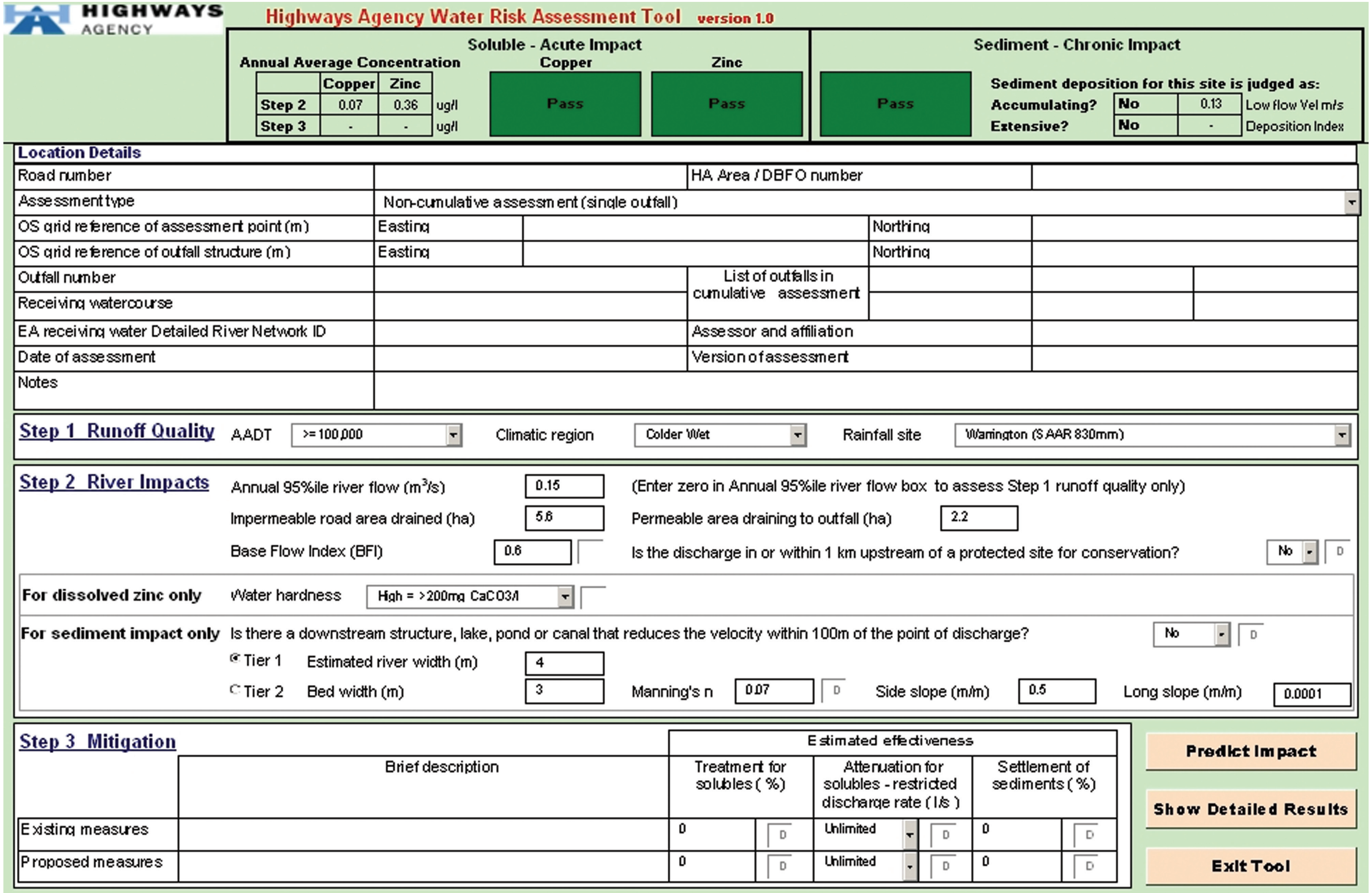

Figure A2.1 HAWRAT User Interface After Running Step 2, Tier 1 Calculations for Worked Example 1

Summary of predictions

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

DETAILED RESULTS

In Runoff — Step 1 (Soluble) / Step 1 (Sediment)

RST24	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**70.70**	**75.80**
No. of exceedances/worst year	82	86

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**39.30**	**54.70**
No. of exceedances/worst year	51	65

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	385
Thresholds	RST6	42	770
Event Statistics	Mean	48.21	214.66
	90%ile	91.86	444.70
	95%ile	124.22	619.82
	99%ile	188.59	1102.82

Toxicity Threshold	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	**77.60**	**85.80**	**3.80**	**28.10**	**67.70**	**28.10**	**13.50**	**55.60**
No. of exceedances/worst year	90	99	9	38	83	38	23	72
Units	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Toxicity	197	315	3.5	16770	875	2355	245	515
Mean	685	2646	1	15514	2684	2575	164	726
90%ile	1384	5695	3	28184	4876	4679	299	1319
95%ile	1733	7416	3	35481	6138	5890	376	1661
99%ile	2268	11124	5	89125	15419	14795	945	4171

In River (no mitigation) — Step 2

RST24	Copper	Zinc
Allowable Exceedances/year	2	2
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

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
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)	0.07	0.36

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	385
Thresholds	RST6	42	770
Event Statistics	Mean	0.37	1.58
	90%ile	0.89	3.69
	95%ile	1.40	6.81
	99%ile	3.98	19.89

Step 2 (Sediment)

Velocity 0.13 m/s — Tier 1 is used for the calculation

DI -

% settlement needed - %

In River (with mitigation) — Step 3

RST24	Copper	Zinc
Allowable Exceedances/year	2	2
No. of exceedances/year	-	-
No. of exceedances/worst year	-	-
No. of exceedances/summer	-	-
No. of exceedances/worst summer	-	-

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	-	-
No. of exceedances/worst year	-	-
No. of exceedances/summer	-	-
No. of exceedances/worst summer	-	-
Annual average concentration (ug/l)	-	-

		Copper (ug/l)	Zinc (ug/l)
Thresholds resholds	RST24	21	385
Thresholds	RST6	42	770
Event Statistics	Mean	-	-
	90%ile	-	-
	95%ile	-	-
	99%ile	-	-

DI -

Figure A2.2 HAWRAT Detailed Results After Running Step 2, Tier 1 Calculations for Worked Example 1

Example A2

A dual three lane motorway is being upgraded for Active Traffic Management. The construction of emergency refuge areas will increase the impermeable area of the carriageway that drains to a small stream of moderate quality (Bricklane Brook). The following data apply:

Data for Step 1 – Runoff quality:

AADT	136,000 vehicles/day (expected future flow)
Climatic region	Warmer-wet
Rainfall site	Southampton

Data for Step 2 – River impacts:

95%ile river flow (Q_{95})	0.006 m^3/s
Base flow index	0.35
Impermeable road area drained	12.8 ha
Permeable area draining to outfall	0.8 ha
Is the discharge in or within 1 km upstream of a protected site for conservation?	No
Water hardness	70 mg $CaCO_3/l$
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100 m downstream of the point of discharge?	No
Tier 1, Estimated river width	1 m

Using HAWRAT, a Step 1 assessment determines that runoff quality exceeds the toxicity thresholds for both soluble and sediment-bound pollutants. For a Step 2 assessment it can be seen that both the soluble pollutants (copper and zinc) fail the assessment. The site is accumulating (the low flow velocity of 0.05 m/s is below the depositing threshold of 0.1 m/s). The deposition index is 306 and is therefore greater than the threshold of 100. As a result, the sediment-bound pollutants fail the assessment. Following the logic chart (Figure A1.3) and as prompted by HAWRAT, the next consideration for the sediments is to use Tier 2. To get the data required for Tier 2, a site visit was made to get the following data:

Bed width	1.3 m
Manning's n	0.045
Side slope	1.09 m/m
Long slope	0.022 m/m

Following the Tier 2 assessment, HAWRAT predicts the low flow velocity will be 0.26 m/s, i.e. a non-accumulating site, and there will be no adverse effect from sediment-bound pollutants. However, using Tier 2 does not affect soluble pollutants and the potential for adverse ecological impacts from soluble pollutants remains.

Before moving to Step 3 and investigating the scale of mitigation required, the annual average concentrations of dissolved copper and zinc should be compared with the EQSs (Table A1.1). In this example, at Step 2, the annual average copper and zinc concentrations are 1.46 µg/l and 8.02 µg/l respectively. The zinc concentration is above the EQS threshold for water in this hardness band and the outfall fails the assessment.

Following the logic chart (Figure A1.4), where the predicted annual average concentration exceeds the EQS, a Method B (detailed assessment) is required (see Method B Worked Example 1 below). However, if a proposed design exists which includes treatment (not just flow attenuation – paragraph A.12) then this will likely reduce the annual average concentrations and may bring them below the EQSs. The relevant advice in Table 5.2 will depend on the outcome of the Method B and/or Step 3 assessment.

For this worked example, interrogation of HAWRAT at Step 3 reveals that it is not possible to pass the HAWRAT assessment through flow attenuation (dilution) alone as the runoff would have to be discharged at a slower rate than it accumulates. Alternatively, without any dilution, a treatment system with a pollutant removal efficiency of more than 60% would be required for the outfall to pass. Such a treatment system would also reduce the annual average concentration and enable compliance with the EQSs. If a combination of dilution and treatment is used then, for example, 50% treatment and a restricted discharge rate of 4 l/s would be sufficient to pass.

In this worked example the mitigation required is considerable. This is perhaps not surprising given that the impermeable road area draining to the outfall is relatively large and the receiving watercourse is relatively small.

Example A3

A roundabout connecting a rural trunk road to a motorway is being upgraded to include filter lanes. Part of the slip road, roundabout and trunk road drains to a stream with a good ecological status (Fraser Stream). The stream is used for irrigation. Of the three road sections that drain to the stream the roundabout carries the greatest traffic load (78,000 vehicles/day). The following data apply:

Data for Step 1 – Runoff quality:

AADT	78,000 vehicles/day (expected future flow)
Climatic region	Colder-dry
Rainfall site	Lincoln

Data for Step 2 – River impacts:

95%ile river flow (Q_{95})	0.03 m^3/s
Base flow index	0.5 (default value, actual value not available)
Impermeable road area drained	7.2 ha
Permeable area draining to outfall	0 ha (not available, use zero as precautionary)
Is the discharge in or within 1 km upstream of a protected site for conservation?	No
Water hardness	286 mg $CaCO^3/l$
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100 m downstream of the point of discharge?	No

Tier 1, Estimated river width 3.5 m

Using HAWRAT, a Step 1 assessment determines that runoff quality exceeds the toxicity thresholds for both soluble and sediment-bound pollutants. For a Step 2 assessment it can be seen that the soluble pollutants pass the assessment. However, the site is accumulating (the low flow velocity of 0.03 m/s is below the depositing threshold of 0.1 m/s) and the deposition index is 141 (and is, therefore, greater than the threshold of 100). As a result, the sediment-bound pollutants fail the assessment. Following the logic chart (Figure A1.3) and as prompted by HAWRAT, the next consideration for the sediments is to use Tier 2. To get the data required for Tier 2, a site visit was made to get the following data:

Bed width	3 m
Manning's n	0.07
Side slope	0.6 m/m
Long slope	0.0004 m/m

Following the Tier 2 assessment HAWRAT predicts the low flow velocity will be 0.08 m/s and the deposition index will be 123, i.e. an accumulating site, with extensive deposition. Therefore, sediment-bound pollutants fail the assessment. HAWRAT advises that in order to avoid an exceedance of the deposition index, 19% of the sediment coming from the road will need to be settled out and removed prior to discharge.

Annual average concentrations of the soluble pollutants, at Step 2, are 0.1 µg/l for dissolved copper and 0.44 µg/l for dissolved zinc. These are below the EQS thresholds (Table A1.1).

Table 5.2 shows that when the HAWRAT assessment fails and the comparison with EQSs passes, there are a number of actions which should be followed. The first is to factor in the effects of the proposed design and reassess.

Example A4

A dual two lane all purpose trunk road is being planned as a rural bypass. 9.1 ha of the road drains to a small stream with a poor ecological status (Raglan Brook). The following data apply:

Data for Step 1 – Runoff quality:

AADT	25,000 vehicles/day
Climatic region	Warm-dry
Rainfall site	Ipswich

Data for Step 2 – River impacts:

95%ile river flow (Q_{95})	0.002 m^3/s
Base flow index	0.8
Impermeable road area drained	9.1 ha
Permeable area draining to outfall	0 ha (not available, use zero as precautionary)
Is the discharge in or within 1 km upstream of a protected site for conservation?	No
Water hardness	35 mg $CaCO_3$/l
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100 m downstream of the point of discharge?	No
Tier 1, Estimated river width	0.5 m

The Step 1 assessment determines that runoff quality exceeds the toxicity thresholds for both soluble and sediment-bound pollutants. For a Step 2 assessment it can be seen that the soluble pollutants fail the assessment. The site is also accumulating (low flow velocity of 0.05 m/s) and deposition is extensive (deposition index of 563) resulting in sediment-bound pollutants failing the assessment. Following the logic chart (Figure A1.3) and as prompted by HAWRAT, the next consideration for the sediments is to use Tier 2. To get the data required for Tier 2, a site visit was made to get the following data:

Bed width	0.3 m
Manning's n	0.07
Side slope	0.5 m/m
Long slope	0.0002 m/m

Following the Tier 2 assessment HAWRAT predicts the low flow velocity will be 0.04 m/s and the deposition index will be 1602, i.e. an accumulating site with very extensive deposition. Therefore, sediment-bound pollutants fail the assessment. HAWRAT advises that in order to avoid an exceedance of the deposition index, 94% of the sediment coming from the road will need to be settled out and removed prior to discharge.

Annual average concentrations of the soluble pollutants, at Step 2, are 1.16 µg/l for dissolved copper and 2.61 µg/l for dissolved zinc. The copper concentration is above the EQS threshold (Table A1.1) for water in this hardness band and the outfall fails the assessment. Following the logic chart (Figure A1.4), where the predicted annual average concentration exceeds the EQS, a Method B (detailed assessment) is required. However, if a proposed design exists which includes treatment (not just flow attenuation – paragraph A.12), then this will likely reduce the annual average concentrations and may bring them below the EQSs. The relevant advice in Table 5.2 will depend on the outcome of the Method B and/or Step 3 assessment.

For this worked example, interrogation of HAWRAT at Step 3 reveals that 15% treatment would be required to reduce the annual average concentration and enable compliance with the EQSs, and 40% treatment would be required to pass the HAWRAT assessment for solubles. If a combination of dilution and treatment is used then, for example, a 30% reduction in both would be sufficient to pass.

The large percentage of settlement required to pass the HAWRAT assessment for sediment-bound pollutants reflects the relatively large road area that drains to a stream that, with low flow rates and low velocities, is not able to disperse the highway derived sediment.

Example A5

A dual three lane all motorway is being widened. 2.5 ha of the road drains to a large chalk river with a high ecological status (River Routt). The river has Site of Special Scientific Interest (SSSI) and Special Area for Conservation (SAC) status, and is used for water supply (for both potable and agricultural use) and receives discharge from a sewage works. The motorway runs through the floodplain of the river. The following data apply:

Data for Step 1 – Runoff quality:

AADT	155,000 vehicles/day
Climatic region	Warm-dry
Rainfall site	London

Data for Step 2 – River impacts:

95%ile river flow (Q_{95})	2.94 m^3/s
Base flow index	0.5 (default value, actual value not available)
Impermeable road area drained	2.5 ha
Permeable area draining to outfall	0 ha (not available, use zero as precautionary)
Is the discharge in or within 1 km upstream of a protected site for conservation?	Yes
Water hardness	322 mg $CaCO_3$/l
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100 m downstream of the point of discharge?	No
Tier 1, Estimated river width	6 m

The Step 1 assessment determines that runoff quality exceeds the toxicity thresholds for both soluble and sediment-bound pollutants. When the discharge is into (or within 1 km of) a protected site for conservation, HAWRAT halves the allowable number of exceedances per year of the toxicity thresholds (refer to Help Guide (Ref 21) for further details). Despite this more stringent requirement, in this example, the soluble pollutants pass the Step 2 assessment.

The velocity of the river is 1.28 m/s (greater than the depositing threshold of 0.1 m/s) and the river is judged to disperse sediments. However, the SSSI and SAC designation of the receiving water produces an alert message on the user interface. This informs the assessor that further consideration needs to be given before the discharge is deemed acceptable. In the first instance this would involve a site visit to make a Tier 2 assessment.

Annual average concentrations of the soluble pollutants, at Step 2, are 0.00 µg/l for dissolved copper and 0.01 µg/l for dissolved zinc. These are below the EQSs.

Method B – Detailed Assessment

Worked Examples

Example B1

A Method A assessment of an outfall discharging from an existing motorway has predicted the annual average concentrations shown in Table B2.1. The hardness of the receiving watercourse is 15 mg/l $CaCO_3$.

Soluble pollutant	HAWRAT predicted annual average concentration (µg/l)	EQS* (µg/l)
Copper	3.91	1
Zinc	18.85	7.8

*corresponding to hardness and without bioavailability correction

Table B2.1 – Method B Worked Example 1

As the predicted concentrations are above the EQSs, the bioavailability of the soluble pollutants should be checked using a simple Biotic Ligand Model (BLM). To get the data to run the model, five water samples were taken from the watercourse just upstream of the outfall over a six month period. The average results from laboratory tests were:

pH	6.7
Water hardness (as Ca)	5.4 mg/l
Dissolved Organic Carbon (DOC)	1.2 mg/l

These data were fed into the simple BLM to determine the site-specific Probable Non-Effect Concentration (PNEC). The PNECs determined by the BLM were:

Dissolved copper	2.7 µg/l
Dissolved zinc	8.0 µg/l

The annual average concentrations predicted by HAWRAT are greater than these PNECs indicating that there may be an impact. For copper (but not zinc), a more comprehensive bioavailability check is available that considers all the mitigating factors. In this example, with zinc failing the BLM, the practitioner may need to look to alternative design and/or mitigation and further consideration of the bioavailability of copper may be unnecessary. However, if there is need (or if zinc had passed the simple BLM) then copper should be checked using the more detailed BLM. To enable this, the water samples taken previously were also analysed for the following parameters:

Temperature	10.4 °C
Magnesium	4.2 mg/l
Sodium	44 mg/l
Potassium	1.1 mg/l
Sulphate	6.6 mg/l
Chloride	56 mg/l
Alkalinity	55 ppm $CaCo_3$

These data were fed into the detailed copper BLM to determine the site-specific PNEC. The PNEC determined by the BLM was:

Dissolved copper 3.8 µg/l

The annual average concentration predicted by HAWRAT remains greater than the PNEC indicating that there may be an impact. Table 5.2 should be consulted as to how to proceed if the predicted annual averages fail against the EQSs.

Example B2

Example A2 from Method A concludes that the predicted annual average concentration of dissolved zinc (without mitigation) is in exceedance of the EQS, as shown in Table B2.2. The hardness of the receiving watercourse is 70 mg/l $CaCO_3$.

Soluble pollutant	HAWRAT predicted annual average concentration (µg/l)	EQS* (µg/l)
Copper	1.46	6
Zinc	8.02	7.8

*corresponding to hardness and without bioavailability correction

Table B2.2 – Method B Worked Example 2

Method A also demonstrated a failure of the HAWRAT assessment for impacts of soluble pollutants in the short-term. If treatment measures were proposed in order to mitigate against these predicted short-term impacts then they may also reduce the annual average concentrations to below the EQSs. Otherwise, an assessment of the bioavailability of the annual soluble pollutant concentrations will need to be made using the BLM.

To get the data to run the simple BLM, five water samples were taken from the watercourse just upstream of the outfall over a six month period. The average results from laboratory tests were:

pH 7.2

Water hardness (as Ca) 32 mg/l

DOC 3.7 mg/l

These data were fed into the simple BLM to determine the site-specific PNEC. The PNECs determined by the BLM were:

Dissolved copper 10.9 µg/l

Dissolved zinc 13.9 µg/l

The annual average concentrations predicted by HAWRAT are less than these PNECs and it can be concluded that the bioavailability is limited and that there is not likely to be a long-term impact (over the course of a year). The short-term failures of the solubles predicted by HAWRAT in Method A will still need to be resolved.

Method C – Groundwater Assessment

Worked Examples

Example C1

A trunk road in the south-west of England, near Salisbury, is being widened from single carriageway to dual 2 lane. This entails complete replacement of the existing drainage. The road passes over a gently rolling Chalk landscape. Being Chalk, the road traverses a number of dry valleys but there are no permanent watercourses. On this basis the designers provisionally propose to use soakaway drainage in the form of excavated soakaway chambers, lined with perforated concrete rings, to an expected depth of 2 m.

A number of locations have been earmarked for soakaways. At each of these individual locations the risk of impacts to groundwater are assessed by evaluation of each component in the risk matrix.

The evaluation for one such location is tabulated as below:

Component Number	Property	Weighting Factor	Site Data	Risk Score	Component Score
1	Traffic density	15	52,000 (AADT)	High – 3	45
2	Rainfall volume	15	735.6 mm	Medium – 2 (see note 1)	30
	Rainfall intensity		35-39 mm/hr		
3	Soakaway geometry	15	Single point shallow. Small area (see note 2)	Medium – 2	30
4	Unsaturated zone (depth to water)	20	<30 m (see note 3)	Low – 1	20
5	Flow type	20	Dominantly Fracture flow (see note 4)	High – 3	60
6	Effective grain size	7.5	Fine (see note 5)	Low – 1	7.5
7	Lithology	7.5	<1% clay minerals (see note 6)	High – 3	22.5
Overall Risk Score					**215**

Table C2.1 – Method C Worked Example C1

Notes:

1. Although rainfall volume (just) falls into the low risk category, rainfall intensity volume falls into the medium risk category, and as the method adopts the precautionary principle, the higher of the risks is assumed in the matrix.

2. The method has to be applied to each soakaway location. Therefore the drainage area to each soakaway should be considered and the proposed design type at each location entered into the matrix.

3. The minimum recorded depth to groundwater should be entered here. However, the hydrogeological map provides a groundwater level for October 1973 – groundwater levels will be higher in the spring due to seasonal fluctuations. In this case a judgement is made that depth to groundwater, even allowing for seasonal fluctuation is sufficiently great, to be placed in the low risk category.

4. Refer Table C1.3.

5. Chalk is only granular at micro scale.

6. The clay content of chalk is highly variable depending upon the presence (or absence) of Marl seams – with a lack of site-specific knowledge, a conservative estimate of minimal clay minerals is therefore assumed.

Data Sources:

Traffic data	Design organisation predicted traffic flow for design year
Rainfall volume	Met Office website – rainfall data at Boscombe Down weather station 1971-2000 averages
Rainfall intensity	Flood Estimation Handbook (FEH) Figure 11.6
Soakaway geometry	Design organisation – initial designs
Unsaturated zone depth	British Geological Survey (BGS) 1:100,000 Hydrogeological Map of Hampshire and the Isle of Wight
Flow type	Refer Table C1.3
Effective grain size	Soils Survey of England and Wales – Soils of South East England 1:250,000 Sheet 6
Lithology	

The overall risk score of 215 puts the site towards the upper end of the medium risk category. On this basis additional risk assessment by a specialist should be undertaken with a view to introducing mitigating measures (for example, pre-treatment) to protect groundwater.

The sensitivity of the impact on the groundwater resource is established by reference to Tables A4.1 to A4.6. In this example the EAs define the aquifer as a principal aquifer of local and not regional importance. With the assessment of medium risk of impact, the sensitivity of the impact is defined as ‘large’.

Full and early discussions with the Environment Agencies (EAs) (in this case the Environment Agency (EA)) should be undertaken to establish constraints on the use of soakaway drainage and what measures are required to protect groundwater.

Example C2

A short stretch of by-pass is to be developed in an area south of Carmarthen. The area of road to be drained is relatively small but there are limited nearby watercourses for significant drainage discharges. The designer wishes to consider a linear unlined ditch as an option for the disposal of road drainage. Groundwater is understood to be present in a local secondary aquifer. Depth to groundwater is not known in the exact location, but wells in the vicinity suggest it is in excess of 15 m. There are no known public water supplies nearby, although there may be local domestic and farm supplies. The evaluation is tabulated as below:

Component Number	Property	Weighting Factor	Site Data	Risk Score	Component Score
1	Traffic density	15	<15,000 (AADT)	Low – 1	15
2	Rainfall volume	15	1,106.5 mm (Tenby) 1,291 – 1,690 mapped average	High – 3 (see note 1)	45
	Rainfall intensity		35-39 mm/hr		
3	Soakaway geometry	15	Continuous linear	Low – 1	15
4	Unsaturated zone (depth to water)	20	>15 m	Low – 1	20
5	Flow type	20	Dominantly Fracture flow (see note 2)	High – 3	60
6	Effective grain size	7.5	Coarse (see note 3)	Medium – 2	15
7	Lithology	7.5	>15% clay minerals (see note 3)	Low – 1	7.5
Overall Risk Score					**177.5**

Table C2.2 – Method C Worked Example C2

Notes:

1. Although rainfall intensity falls into the medium risk category, rainfall volume falls into the high risk category, as above the method adopts the precautionary principle, thus the higher of the risks is assumed in the matrix.

2. The location is underlain by Lower Old Red Sandstone strata. These are cemented sandstones with some intergranular flow, but with groundwater movement primarily in fissures. It has been assumed in the matrix that flow is dominantly through fissures.

3. Soils mapping describes soils in the area as well drained fine loamy soils. This suggests moderate sand content and relatively high clay.

Data Sources:

Traffic data	Design organisation predicted traffic flow for design year
Rainfall volume	Met Office website – rainfall data at Tenby weather station 1971-2000 averages – Met Office mapping shows higher averages South of Carmarthen
Rainfall intensity	FEH Figure 11.6
Soakaway geometry	Design organisation – initial designs
Unsaturated zone depth	Depth to water from locally available information
Flow type	Data retrieved from: Policy and Practice for the Protection of Groundwater: Regional Appendix Welsh Region. This shows the locality is underlain by Lower Old Red Sandstone – cemented sandstones with some intergranular flow but groundwater movement primarily in fissures. It has been assumed in the matrix that flow is dominantly through fissures
Effective grain size	Soils Survey of England and Wales – Sheet 2 Soils of Wales 1:250,000
Lithology	

The overall risk score of 177.5 puts the site into the lower end of the medium risk category. Additional risk assessment by a specialist should be undertaken, although the need for mitigating measures to protect groundwater should be discussed with the EAs.

The sensitivity of the impact on the groundwater resource is established by reference to Tables A4.1 to A4.6. In this example the EAs define the resource as a secondary aquifer. With the assessment of medium risk of impact, the sensitivity of the impact is defined as 'moderate'. There are no source protection zones in the area.

Discussions with the EAs should be undertaken to determine the need for additional groundwater protection given the lack of local use of the resource.

Method D – Spillage Risk Assessment

Worked Examples

Example D1

An urban motorway is being widened from dual 2 to dual 3 lanes, including hard shoulders. A 2 km length of the road drains to a reach of a small river (River Sotner) of moderate ecological status. There is a junction within this length. The response time for emergency is less than 20 minutes. The following data apply:

Water body type	Surface watercourse
Road length (RL)	2 km
AADT for two-way flow	100,000 vehicles/day
HGV %	15
Length of slip roads	0.8 km
AADT for slip roads	8,000 vehicles/day

From Table D1.1 Spillage rates, SS:

For main carriageway	0.36
For slip road	0.43

The probability of a spillage, P_{SPL}, is given by:

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

See Figure D2.1, which shows lengths of road having different spillage probability rates:

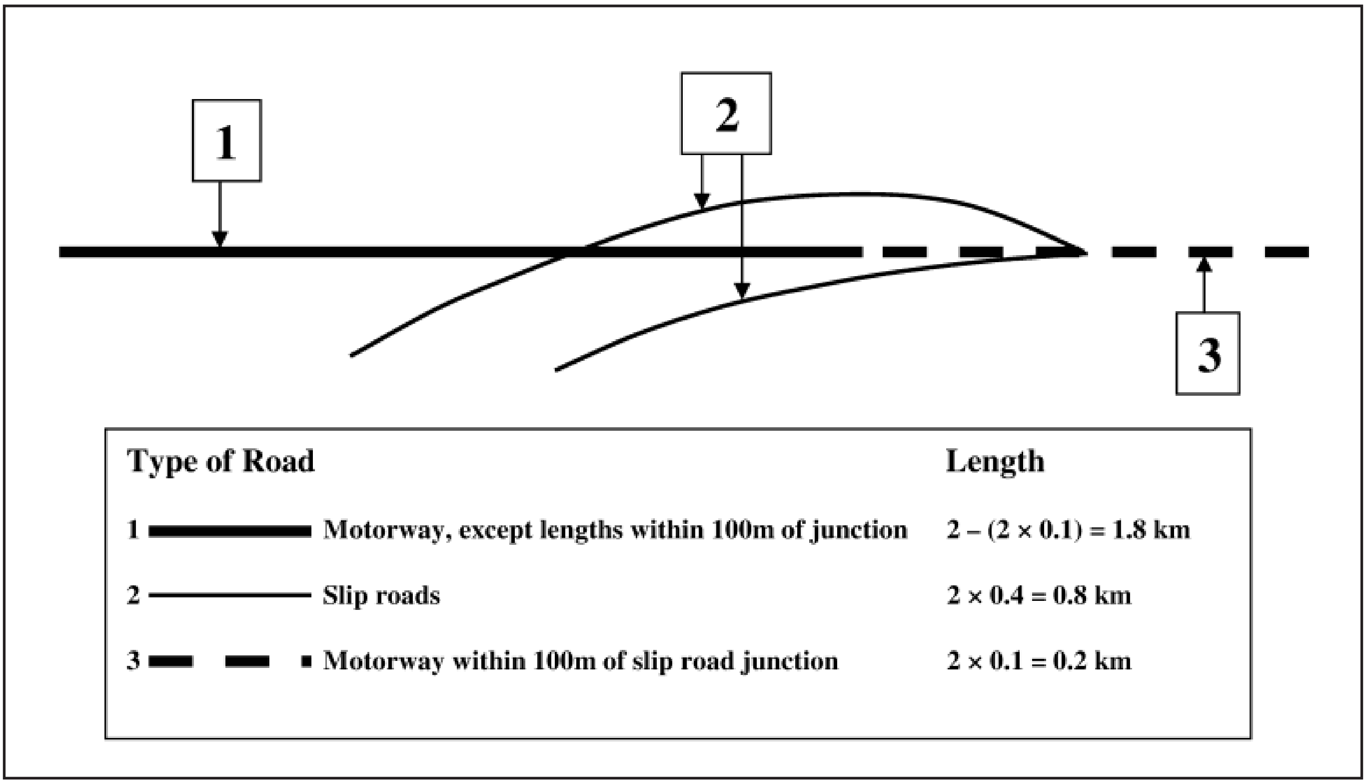

Figure D2.1 – Road Lengths with Different Spillage Probability Rates for Example D1

1 For the length of main road excluding 100 m either side of junction

P_{SPL} = $(2 - 0.2) \times 0.36 \times (100{,}000 \times 365 \times 10^{-9}) \times (15/100)$
= 3.55×10^{-3}

2 For the length of main road within 100 m of the slip road junction:

P_{SPL} = $0.2 \times 0.43 \times (100{,}000 \times 365 \times 10^{-9}) \times (15/100)$
= 4.71×10^{-4}

3 For the slip roads:

P_{SPL} = $0.8 \times 0.43 \times (8{,}000 \times 365 \times 10^{-9}) \times (15/100)$
= 1.51×10^{-4}

Total annual probability of a spillage:

P_{SPL} = $(3.55 + 0.47 + 0.15) \times 10^{-3}$
= 4.17×10^{-3}

From Table D1.2, probability of a serious pollution incident arising as a result of a spillage:

P_{POL} = 0.45

Annual probability of a serious pollution incident is given by:

P_{INC} = $P_{SPL} \times P_{POL}$
= $4.17 \times 10^{-3} \times 0.45$
= 1.9×10^{-3}
= 0.19%

This is less than 1%, so no further spillage prevention measures will be required to reduce the risk of a serious pollution incident.

Example D2

A dual 2 lane all purpose trunk road is being planned as a rural bypass in a remote area. 12 km of the road drains to a high quality river (River Maldarn) which is used for irrigation. Two roundabouts on the main road are located within this length, and there is a grade separated junction leading to a roundabout located above the main road. The following data apply:

Water body type	Surface watercourse
Road length	12 km
AADT for trunk road	40,000 vehicles/day
Slip roads	2 km
AADT for slip roads	6,000 vehicles/day
HGV % on all roads	20

From Table D1.1 Spillage rates, SS:

For main carriageway	0.29
For roundabouts	3.09
For slip roads	0.83

The probability of a spillage, P_{SPL}, is given by:

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

See Figure D2.2, which shows lengths of road having different rates:

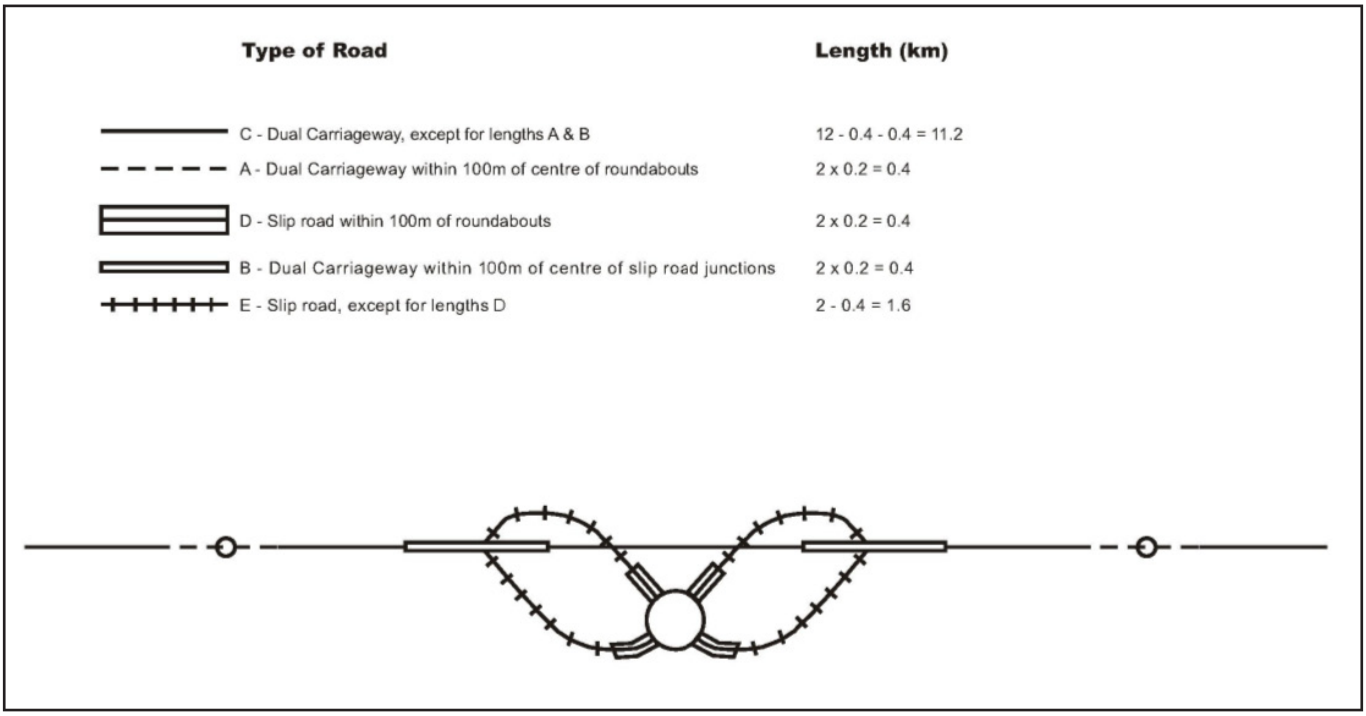

Figure D2.2 – Road Lengths with Different Spillage Probability Rates for Example D2

1 For the length of road excluding the 100 m either side of the two roundabouts and the slip road junctions

P_{SPL} = $(12 - 0.4 - 0.4) \times 0.29 \times (40{,}000 \times 365 \times 10^{-9}) \times (20/100)$
= 9.48×10^{-3}

2 For the length of road within 100 m of the trunk road roundabouts:

P_{SPL} = $0.4 \times 3.09 \times (40{,}000 \times 365 \times 10^{-9}) \times (20/100)$
= 3.61×10^{-3}

3 For the length of road within 100 m of the slip roads:

P_{SPL} = $0.4 \times 0.83 \times (40{,}000 \times 365 \times 10^{-9}) \times (20/100)$
= 9.7×10^{-4}

4 For the slip roads excluding the 100 m either side of the local road roundabouts

P_{SPL} = $(2 - 0.4) \times 0.83 \times (6{,}000 \times 365 \times 10^{-9}) \times (20/100)$
= 5.8×10^{-4}

5 For the length of slip roads within 100 m of the local road roundabouts:

P_{SPL} = $0.4 \times 3.09 \times (6{,}000 \times 365 \times 10^{-9}) \times (20/100)$
= 5.4×10^{-4}

Total annual probability of a spillage:

P_{SPL} = $(9.48 + 3.61 + 0.97 + 0.58 + 0.54) \times 10^{-3}$
= 1.519×10^{-2}

From Table D1.2, the probability of a serious pollution incident arising as a result of a spillage:

P_{POL} = 0.75

Annual probability a serious pollution incident is given by:

P_{INC} = $P_{SPL} \times P_{POL}$
= $1.519 \times 10^{-2} \times 0.75$
= 1.14×10^{-2}
= 1.14%

This is greater than 1%, so spillage prevention measures will be required to reduce the risk of a serious pollution incident.

Methods E and F – Worked Example (E and F1)

Introduction

This section provides a worked example for a new trunk road bypass. It addresses the 'Flood Risk Impact' as the project crossed a main river (the River Darbell). In this example the existing route option had been previously specified, therefore the scoping stage had been completed and only the detailed stage assessment is considered.

Regulatory Discussions

In the initial meetings with the Environment Agency the key issues were discussed. It was agreed that the 1% annual probability flood events would be used as the base case, with the 0.5% probability events used as a sensitivity test. In addition, a 20% allowance was to be made for the possible effects of climate change. Use of the hydrological modelling software: FEH, and the hydraulic software HEC-RAS, used in a steady state, were agreed with the EA. Other agreed matters included the hydraulic model extent, the acceptable afflux and possible mitigation measures.

The river crossing was in a relatively rural area and the aim was to minimise the afflux caused by culverting or bridging. Four scenarios would be run in the hydraulic model. They were:

- existing conditions;
- Option A, 25 m clear span bridge without channel improvements;
- Option B, 25 m clear span bridge with 40 m of channel improvements both up and down stream of the crossing;
- Option C, 6×4 box culvert and 3 No. 900 mm diameter relief pipes (Original Design Recommendations).

The EA had a preference for option A, as it would have zero afflux and minimal/no impacts upstream or downstream. However as the three options had different construction and design costs, it was agreed to test them all. Drainage release rates for the road project had previously been agreed with the EA, but these were subsequently checked using the FEH and IH 124 methodologies.

Hydrological Analysis

The catchment area was derived using the FEH CD-ROM. This was then checked against a 1:25,000 map of the area for consistency. The closest gauging station to the site was an EA gauge about 25 km downstream, but this had a much larger catchment and the additional area had different runoff characteristics making it unsuitable for use as a donor in the statistical method. The gauging station experiences flows out of bank generally above Q_{MED} and was therefore deemed unsuitable for inclusion in the pooling group for the site. Other possible donor and analogue catchment stations were reviewed and rejected for this analysis. The primary method was therefore taken as the Revitalised FSR/FEH rainfall-runoff method (ReFH) with a check comparison with the statistical method; both methods were based on catchment characteristics alone.

Results

The 100 year flow was determined using the rainfall runoff method and then adjusted by a 20% increase to account for possible effects of climate change. Table E2.1 summarises the calculated flows.

Return period	100 year	100 year$^{+20\%}$
Calculated flow (m^3/s)	32.9	39.5

Table E2.1 – Calculated Flows

Hydraulic Assessment

Hydraulic calculations for the road crossing were undertaken in HEC-RAS. The model was built following guidance on river modelling as part of a flood risk assessment, issued by the EA in 2002.

Survey input data for the hydraulic model was obtained from a site-specific topographic survey between the upstream and downstream limits agreed with the EA during the initial discussions. The lateral limits were defined by the areal extent of the 1 in 100 year floodplain. Cross sections were chosen so that they were representative of the channel and floodplain, the spacing between the cross sections being determined from the HEC-RAS documentation. Information on structures, blockages/obstructions to the channel and channel roughness was also collected during the survey.

The model was built to represent the key flood flow routes, flood storage and structures in the area. The study area defined was sufficient to demonstrate the effects of the road crossing on locations away from the proposed structure.

The downstream boundary condition was located at a sufficient distance downstream from the site so that any errors in the downstream ('normal depth') boundary condition used would be reduced to an acceptable level at the road crossing location. Hydraulic coefficients used in the model for roughness, structures and other parameters were estimated from textbooks, specifically (Chow, 1973) (Ref 6).

Model calibration, verification and sensitivity testing were undertaken. As the location of the road crossing was relatively remote, no historical flood data was available for calibration or verification. Rigorous sensitivity analysis was therefore undertaken to determine the model's sensitivity to the key parameters used for the hydraulic computations. These included flow, roughness, structure coefficients, downstream boundary slope and blockages.

Water surface elevations were calculated for the three options plus the existing conditions and are shown in Table E2.2. Option A, which produced a minimal afflux during the 100 year event was recommended to the design and build tenderers at this location. However, it was noted that an alternative structure could be used in its place so long as it was hydraulically equivalent and produced a similar afflux.

	100 year event	
	WS Elev (m)	**Afflux (m)**
Existing Conditions	94.28	-
Option A	94.36	0.08
Option B	94.25	-0.03
Option C	94.70	0.42

Table E2.2 – Summary of Water Surface Elevations

Effects Following Construction

Two effects of the road construction were analysed in this example, the:

- loss of floodplain storage, which would occur due to construction of the road crossing;
- flood potential from increased runoff from the paved area of the road.

Loss of Floodplain

The volume of floodplain occupied by the four options for the 100 year water surface elevation was obtained by comparing the options' geometries with the existing configuration. The total loss of floodplain was determined from the output files within HEC-RAS. Table E2.3 presents the relative loss of floodplain for each option. Detailed measures to compensate for the loss of floodplain storage were not identified at this stage.

Plan Options	Approximate Floodplain Volume Loss (m^3)
Existing Conditions	–
Option A	900
Option B	700
Option C	2,300

Table E2.3 – Floodplain Loss

Increased Runoff

In order to mitigate the risk of increasing flooding elsewhere in the catchment, runoff from the road was to be attenuated to the greenfield rate as agreed with the EA. The greenfield runoff from the road crossing site was calculated using the EA's currently preferred methodology, detailed in IH 124. A greenfield rate of 7 l/s/ha was the prescribed release rate for the surface water drainage system. The calculated runoff rate was 6.5 l/s/ha and the required storage volume of road runoff to achieve the required rate was 1,800 m^3.

Reporting of Significance of Potential Effects – Worked Examples

Tables A4.1 to A4.6 (Annex IV) should be used when reporting the potential effects of a road project. Table A4.2 should be completed and submitted as part of the report. An example of a completed Table A4.2 is given below. The entries in the table reflect the worked examples presented in this annex.

Potential Impact	Feature	Attribute	Quality	Importance	Mitigation	Magnitude[1]	Significance[1]
Water quality	River Blude (Example A1)	Biodiversity	Good	High	–	Negligible	Neutral
Water quality	River Blude (Example A1)	Recreation	Good	Medium	–	Negligible	Neutral
Water quality	Bricklane Brook (Example A2)	Biodiversity	Moderate	Medium	The use of vegetated drainage systems, attenuation ponds	Minor adverse[2]	Slight
Water quality	Fraser Stream (Example A3)	Biodiversity	Good	High	Open ditch	Negligible	Neutral
Water quality	Fraser Stream (Example A3)	Water supply	Good	Medium	Open ditch	Negligible	Neutral
Water quality	Raglan Brook (Example A4)	Biodiversity	Poor	Low	Filter drain, grass lined channel, detention pond	Minor adverse[3]	Neutral
Water quality	River Routt (Example A5)	Biodiversity	High	Very high	–	Negligible	Neutral
Water quality	River Routt (Example A5)	Water supply	High	Very high	–	Negligible	Neutral
Water quality	River Routt (Example A5)	Removal of waste products	Good	High	–	Negligible	Neutral
Water quality	River Routt (Example A5)	Recreation	Good	High	–	Negligible	Neutral
Water quality	River Routt (Example A5)	Value to economy	Good	High	–	Negligible	Neutral

Potential Impact	Feature	Attribute	Quality	Importance	Mitigation	Magnitude[1]	Significance[1]
Flooding	River Routt (Example A5)	Conveyance of flow	High	Very high	–	Negligible	Neutral
Water quality	Principal aquifer (Example C1)	Water supply	High	High	–	Moderate adverse[4]	Large[4]
Water quality	Secondary aquifer (Example C2)	Water supply	High	Medium	–	Moderate adverse[4]	Moderate[4]
Water quality	River Sotner (Example D1)	Biodiversity	Moderate	Medium	–	Negligible	Neutral
Water quality	River Maldarn (Example D2)	Biodiversity	High	Very High	–	Moderate adverse[4]	Large/ Very Large[4]
Water quality	River Maldarn (Example D2)	Water supply	High	Medium	–	Moderate adverse[4]	Moderate/ Large[4]
Floodplain loss	River Darbell (Example E and F1)	Floodwater storage	Good	Medium	–	Moderate adverse[5]	Moderate/ Large[5]
Flooding from increased surface water runoff	River Darbell (Example E and F1)	Conveyance of flow	Good	Medium	The use of SuDS drainage system.	Negligible	Neutral

1 Magnitude and Significance should be post-mitigation.

2 Solubles still fail HAWRAT assessment despite mitigation measures applied at Step 3.

3 Sediments still fail HAWRAT assessment despite settlement measures proposed at Step 3.

4 Mitigation measures not yet proposed.

5 No compensation for loss of floodplain yet proposed.

Table G2.1 – Worked Examples for Reporting of Significance of Potential Effects

ANNEX III PANEL ENGINEERS

Panels of Qualified Civil Engineers Constituted Under Section 4 of Reservoirs Act 1975

The professional aspects of reservoir safety are the responsibility of civil engineers, qualified for the task by their appointment to the panels under the Reservoirs Act 1975. All technical matters relating to safety rely on Panel engineers' expertise and judgement. Appointments to the panels are made by the Secretary of State for the Environment, Food and Rural Affairs on the basis of advice from the Institution of Civil Engineers.

The panel is divided into four categories based on the function and the technical competence required to perform that function:

(a) All Reservoirs Panel (AR);

(b) Non-Impounding Reservoirs Panel (NIR);

(c) Service Reservoirs Panel (SR);

(d) Supervising Engineers Panel (SupE).

All panel engineers are appointed for a period of five years. The first three panels are qualified to design and supervise the construction and alteration of, and to inspect and report upon the different types of reservoir. The fourth panel is qualified to supervise the reservoir in between statutory inspections and advise the 'undertaker' of its behaviour. The first three panels are also qualified to undertake duties of the fourth panel. Details of the panels are listed in Table A3.1.

An up to date list of Panel Engineers in the United Kingdom and further advice on the appointment and retention of Panel members may be obtained from the EA website (**www.environment-agency.gov.uk**). The Institution of Civil Engineers (ICE) Guidance for Applicants, prepared by the Reservoirs Committee of the Institution of Civil Engineers, updates and supersedes the guidance contained in E2 of the Appendices to 'A Guide to the Reservoirs Act 1975'.

PANEL NAME	SCOPE OF PANEL	SIMILAR PANEL UNDER 1930 ACT
AR (All Reservoirs Panel)	Civil engineers qualified to design and supervise the construction and alteration of, to inspect and report upon, to act as supervising engineers and to act as referees under Section 19 and for the purposes of Section 16 of the Act for all reservoirs to which the Act applies.	I
NIR (Non-Impounding Reservoirs Panel)	Civil engineers qualified to design and supervise the construction and alteration of, to inspect and report upon and to act for the purposes of Section 16 on all reservoirs to which the Act applies which are non-impounding reservoirs and to act as supervising engineers for all reservoirs to which the Act supplies.	II
SR (Service Reservoirs Panel)	Civil engineers qualified to design and to supervise the construction and alteration of, to inspect and report upon and to act for the purposes of Section 16 on all reservoirs to which the Act applies which are not impounding reservoirs and which are constructed of brickwork, masonry, concrete or reinforced concrete and to act as supervising engineers for all reservoirs to which the Act applies.	IV
SupE (Supervising Engineers Panel)	Civil engineers qualified to act as supervising engineers for all large raised reservoirs between statutory inspections carried out under the Act.	No equivalent

The term non-impounding reservoir means a reservoir that is not designed to obstruct or impede the flow of a watercourse (SI 1985 NO 1086).

Table A3.1 Scope of Reservoirs Panel Sub-divisions

ANNEX IV REPORTING OF SIGNIFICANCE OF POTENTIAL EFFECTS

When reporting the potential effects of a road project, Tables A4.1 – A4.6 should be used as supported by the results of the assessment methods together with other technical and qualitative information sufficient to provide a transparent decision-making process.

Feature	Attribute	Indicator of Quality	Possible Measure
River/stream	Water Supply/ quality	Amount used for water supply (potable) Amount used for water supply (industrial/agricultural) Chemical water quality	Location and number of abstraction points. Volume abstracted daily WFD chemical status class
	Dilution and Removal of Waste Products	Presence of surface water discharges Effluent discharges	Daily volume of discharge (treated/ untreated)
	Recreation	Access to river* Use of river for recreation*	Length of river used for recreation (fishing, water sports) Number of clubs
	Value to Economy	Value of use of river*	Length of river used for recreation commercially Number of people employed Length of river bank developed Length of river fished commercially
	Conveyance of flow	Presence of water courses	Number and size of water courses
	Biodiversity	Biological Water Quality*	WFD ecological status class
		Fisheries quality*	Fisheries Status, as defined in the Freshwater Fish Directive
Floodplain	Conveyance of flow	Presence of floodplain Flood flows	Developed area within extent of floodplain affected, as determined from hydraulic modelling Flood risk Mean annual flood
Groundwater	Water Supply/ quality	Amount used for water supply (potable) Amount used for water supply (industrial/agricultural)	Location and number of abstraction points Volume abstracted daily Location and grade of source protection zone WFD groundwater quantitative and chemical status
	Soakaway	Presence of soakaways or other discharges to the ground	Location and number of discharge points Daily volume discharged
	Vulnerability	Groundwater vulnerability	Classification of aquifer vulnerability

Feature	**Attribute**	**Indicator of Quality**	**Possible Measure**
	Economic Value	Extent of use for abstractions	Number of people employed
	Conveyance of flow	Presence of groundwater supported water courses Potential for groundwater flooding Groundwater interception by road structures or drainage	Changes to groundwater recharge, levels or flows Number and size of water courses
	Biodiversity	Presence of groundwater supported wetlands*	Changes to groundwater recharge, levels or flows Status or classification of wetland*
Estuaries and Coastal Waters	Water Quality	Chemical water quality	WFD chemical status class
	Dilution and Removal of Waste Products	Presence of surface water discharges Effluent discharges	Daily volume of discharge (treated/untreated)
	Recreation	Access to river/coast* Use of river/coast for recreation*	Length of river used for recreation (fishing, water sports) Number of clubs
	Value to Economy	Extent of employment*	Number of people employed
	Biodiversity	Biological Water Quality*	WFD ecological status class
		Fisheries quality* Wading birds or over-wintering birds* Estuarine/marine features*	Fisheries Status, as defined in the Freshwater Fish Directive Assemblages of wading bird species or numbers of over-wintering birds Meeting site conservation objectives
Lakes, Ponds and Reservoirs	Recreation	Access* Use for recreation*	Area used for recreation (fishing, water sports) Number of clubs
	Water Supply/quality	Amount used for water supply (potable) Amount used for water supply (industrial/agricultural) Chemical water quality	Volume abstracted daily WFD chemical status class
	Dilution and Removal of Waste Products	Presence of surface water discharges Effluent discharges	Daily volume of discharge (treated/untreated)
	Value to Economy	Extent of employment*	Number of people employed
	Biodiversity	Biological Water Quality*	WFD ecological status class
		Fisheries quality* Populations of birds*	Fisheries Status, as defined in the Freshwater Fish Directive Assemblages or number of species of UK Biodiversity Action Plan or birds of conservation concern

Feature	Attribute	Indicator of Quality	Possible Measure
Canals	Water Supply/ quality	Amount used for water supply (potable) Amount used for water supply (industrial/agricultural) Chemical water quality	Location and number of abstraction points Volume abstracted daily WFD chemical status class
	Recreation	Access to canal* Use of canal for recreation*	Length used for recreation (fishing, boating) Number of clubs/marinas
	Value to Economy	Extent of employment*	Number of people employed
	Dilution and Removal of Waste Products	Presence of surface water discharges Effluent discharges	Daily volume of discharge (treated/ untreated)
	Biodiversity	Biological Water Quality*	WFD ecological status class
		Fisheries quality*	Fisheries Status, as defined in the Freshwater Fish Directive

*Note: Many features, such as those marked, will have attributes to be considered in the biodiversity, landscape, economy or cultural heritage Parts.

Table A4.1 – Water Features: Attributes and Indicators of Quality

Summary of all potential impacts and their significance

Potential Impact	Feature	Attribute	Quality	Importance	Mitigation	Magnitude	Significance

Reference Sources:

Other qualitative comments

Note: In Scotland and Wales the significance of a potential effect should be reported prior to mitigation as well as post-mitigation.

Table A4.2 – Summary of Potential Effects – Water Environment

Importance	Criteria	Typical Examples	
Very High	Attribute has a high quality and rarity on regional or national scale	**Surface Water:**	EC Designated Salmonid/Cyprinid fishery WFD Class 'High' Site protected/designated under EC or UK habitat legislation (SAC, SPA, SSSI, WPZ, Ramsar site, salmonid water)/ Species protected by EC legislation
		Groundwater:	Principal aquifer providing a regionally important resource or supporting site protected under EC and UK habitat legislation SPZ1
		Flood Risk:	Floodplain or defence protecting more than 100 residential properties from flooding
High	Attribute has a high quality and rarity on local scale	**Surface Water:**	WFD Class 'Good' Major Cyprinid Fishery Species protected under EC or UK habitat legislation
		Groundwater:	Principal aquifer providing locally important resource or supporting river ecosystem SPZ2
		Flood Risk:	Floodplain or defence protecting between 1 and 100 residential properties or industrial premises from flooding
Medium	Attribute has a medium quality and rarity on local scale	**Surface Water:**	WFD Class 'Moderate'
		Groundwater:	Aquifer providing water for agricultural or industrial use with limited connection to surface water SPZ3
		Flood Risk:	Floodplain or defence protecting 10 or fewer industrial properties from flooding
Low	Attribute has a low quality and rarity on local scale	**Surface Water:**	WFD Class 'Poor'
		Groundwater:	Unproductive strata
		Flood Risk:	Floodplain with limited constraints and a low probability of flooding of residential and industrial properties

Table A4.3 – Estimating the Importance of Water Environment Attributes

Magnitude	Criteria	Typical Example	
Major Adverse	Results in loss of attribute and/ or quality and integrity of the attribute	**Surface Water:**	Failure of **both** soluble and sediment-bound pollutants in HAWRAT (Method A, Annex I) **and** compliance failure with EQS values (Method B) Calculated risk of pollution from a spillage >2% annually (Spillage Risk Assessment, Method D, Annex I) Loss or extensive change to a fishery Loss or extensive change to a designated Nature Conservation Site
		Groundwater:	Loss of, or extensive change to, an aquifer Potential high risk of pollution to groundwater from routine runoff – risk score >250 (Groundwater Assessment, Method C, Annex I) Calculated risk of pollution from spillages >2% annually (Spillage Risk Assessment, Method D, Annex I) Loss of, or extensive change to, groundwater supported designated wetlands
		Flood Risk:	Increase in peak flood level (1% annual probability) >100 mm (Hydrological Assessment of Design Floods and Hydraulic Assessment, Methods E and F, Annex I)
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute	**Surface Water:**	Failure of **both** soluble and sediment-bound pollutants in HAWRAT (Method A, Annex I) but compliance with EQS values (Method B) Calculated risk of pollution from spillages >1% annually and <2% annually Partial loss in productivity of a fishery
		Groundwater:	Partial loss or change to an aquifer Potential medium risk of pollution to groundwater from routine runoff – risk score 150-250 Calculated risk of pollution from spillages >1% annually and <2% annually Partial loss of the integrity of groundwater supported designated wetlands
		Flood Risk:	Increase in peak flood level (1% annual probability) >50 mm
Minor Adverse	Results in some measurable change in attributes quality or vulnerability	**Surface Water:**	Failure of **either** soluble **or** sediment-bound pollutants in HAWRAT Calculated risk of pollution from spillages >0.5% annually and <1% annually
		Groundwater:	Potential low risk of pollution to groundwater from routine runoff – risk score <150 Calculated risk of pollution from spillages >0.5% annually and <1% annually Minor effects on groundwater supported wetlands
		Flood Risk:	Increase in peak flood level (1% annual probability) >10mm

Magnitude	Criteria	Typical Example	
Negligible	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity	The proposed scheme is unlikely to affect the integrity of the water environment	
		Surface Water:	No risk identified by HAWRAT (Pass both soluble and sediment-bound pollutants) Risk of pollution from spillages <0.5%
		Groundwater:	No measurable impact upon an aquifer and risk of pollution from spillages <0.5%
		Flood Risk:	Negligible change in peak flood level (1% annual probability) <+/- 10 mm
Minor Beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring	**Surface Water:**	HAWRAT assessment of **either** soluble or sediment-bound pollutants becomes Pass from an existing site where the baseline was a Fail condition Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is <1% annually)
		Groundwater:	Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually)
		Flood Risk:	Reduction in peak flood level (1% annual probability) >10 mm
Moderate Beneficial	Results in moderate improvement of attribute quality	**Surface Water:**	HAWRAT assessment of **both** soluble and sediment-bound pollutants becomesPass from an existing site where the baseline was a Fail condition Calculated reduction in existing spillage by 50% or more (when existing spillage risk >1% annually)
		Groundwater:	Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually)
		Flood Risk:	Reduction in peak flood level (1% annual probability) >50 mm
Major Beneficial	Results in major improvement of attribute quality	**Surface Water:**	Removal of existing polluting discharge, or removing the likelihood of polluting discharges occurring to a watercourse
		Groundwater:	Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring Recharge of an aquifer
		Flood Risk:	Reduction in peak flood level (1% annual probability) >100 mm

Table A4.4 – Estimating the Magnitude of an Impact on an Attribute

IMPORTANT OF ATTRIBUTE					
	Very High	Neutral	Moderate/Large	Large/Very Large	Very Large
	High	Neutral	Slight/Moderate	Moderate/Large	Large/Very Large
	Medium	Neutral	Slight	Moderate	Large
	Low	Neutral	Neutral	Slight	Slight/Moderate
		Negligible	**Minor**	**Moderate**	**Major**
		MAGNITUDE OF IMPACT			

Table A4.5 – Estimating the Significance of Potential Effects

Note:

1. Potential effects can be either beneficial or adverse. Typical examples of potential beneficial/adverse effects are described in Table A4.6. The level of significance is to be assigned **after** consideration of any proposed mitigation i.e. significance is assigned with mitigation in place allowing for the positive contribution of all mitigation that is proposed. In Scotland and Wales, the level of significance attributed should be reported both prior to mitigation and after mitigation. Particular care should be taken when considering beneficial effects to ensure the positive change is justified.

2. In some cases above the significance is shown as being one of two alternatives. In these cases a single description of significance should be decided based upon a reasoned judgement and, if necessary, consultation with the EAs.

Score	Comment
Very Large Adverse	Where the proposal would result in degradation of the water environment because it results in predicted very significant adverse impacts on at least one water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • Potential failure of both soluble and sediment-bound pollutants in a High or Good watercourse OR in an EC Designated Salmonid fishery, for both short-term and long-term assessment (Methods A and B) • Loss or extensive change to a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) • Calculated risk of pollution from spillages is >2% when discharging into a Good watercourse, >1% for a High watercourse **Groundwater** • Potential high risk (risk score >250) of pollution in the Groundwater Assessment (Method C, Annex I) to a principal aquifer providing a regionally important resource or supporting a site protected under habitat legislation OR a medium to high risk (risk score >150) to a SPZ1 • Calculated risk of pollution from spillages is >1% when discharging into a SPZ1 or principal aquifer • Potential loss or extensive change to a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) through interception of groundwater flow or significant change to groundwater level **Flood Risk** • An increase in peak flood levels (1% annual probability) >100 mm increasing the risk of flooding to >100 residential properties
Large Adverse	Where the proposal would result in a degradation of the water environment because it results in predicted highly significant adverse impacts on a water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • Potential short-term (HAWRAT) failure of both soluble and sediment-bound pollutants in a High or Good watercourse OR in an EC Designated Salmonid fishery • Calculated risk of pollution from spillages is >1% for a Good watercourse (or one of lower ecological class) and >0.5% for a High watercourse • Loss or extensive change to a cyprinid fishery • Loss or extensive change to a Local Nature Reserve **Groundwater** • Potential high risk (risk score >250) of pollution to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting Local Nature Reserves aquifer OR medium risk (risk score 150-250) of pollution of a principal aquifer providing a locally important resource or supporting a site protected under habitat legislation, OR medium to high risk (score >150) to a SPZ2, OR potential low risk (score <150) to a SPZ1 • Calculated risk of pollution from spillages is >0.5% when discharging to a principal aquifer or SPZ1 • Loss or extensive change to a Local Nature Reserve through interception of groundwater flow or change to groundwater level **Flood Risk** • An increase in peak flood levels (1% annual probability) >50 mm increasing the risk of flooding to >100 residential properties OR an increase of >100 mm increasing the risk of flooding to 1-100 residential properties

Score	Comment
Moderate Adverse	Where the proposal may result in the degradation of the water environment because it results in predicted moderate adverse impacts on at least one attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • Potential short-term (HAWRAT) failure of **either** soluble **or** sediment-bound pollutants in a High or Good watercourse • Calculated risk of pollution from spillages is >0.5% for a Good watercourse OR >1% for a Moderate or Poor watercourse • Partial loss or change to a fishery • Effect on the integrity of the existing flora and fauna **Groundwater** • Potential medium risk (score 150-250) to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting Local Nature Reserves OR potential low risk (score <150) of pollution to a principal aquifer providing a regionally important resource or supporting a river ecosystem OR medium to high risk (score >150) to a SPZ3, OR potential low risk (score <150) to a SPZ2, OR high risk (score >250) for a discharge to unproductive strata • Calculated risk of pollution from spillages is >1% for an aquifer or SPZ3 • Effect on the integrity of the existing flora and flora through interception of groundwater flow or change to groundwater level **Flood Risk** • An increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to >100 residential properties OR an increase of >50 mm resulting in an increased risk of flooding to 1-100 residential properties
Slight Adverse	Where the proposal may result in a degradation of the water environment because it results in a predicted slight impact on one or more attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • Potential short-term (HAWRAT) failure of **either** soluble **or** sediment-bound pollutants in a Moderate or Poor watercourse • Calculated risk of pollution from spillages is >0.5% for a Moderate or Poor watercourse • Temporary loss to, or loss in productivity of, a fishery **Groundwater** • Potential low risk of pollution (score <150) to a secondary aquifer with limited agricultural use and connectivity to surface waters and local ecology OR low to medium risk (score <250) for a discharge to unproductive strata, OR low risk (score <150) to a SPZ3 • Calculated risk of pollution from spillages is >0.5% for an aquifer or SPZ3 **Flood Risk** • An increase in peak flood level (1% annual probability) >10 mm resulting in a increased risk of flooding to fewer than 10 industrial properties

Score	Comment
Neutral	Where the net impact of the proposals is neutral, because it results in no appreciable effect, either positive or negative, on the identified attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • No risk identified by Method A or Method B assessment (Pass both solubles and sediment-bound pollutants) • Calculated risk of pollution from spillages <0.5% annually **Groundwater** • No predicted change in quality of any type of aquifer and/or its use as a resource • Calculated risk of pollution from spillages <0.5% annually **Flood Risk** • Negligible change in peak flood (1% annual probability) <+/- 10 mm
Slight Beneficial	All other situations where the proposal provides an opportunity to enhance the water environment or provide an improved level of protection to an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • Method A assessment of either soluble or sediment-bound pollutants becomes Pass from previous Fail condition for **existing** discharges • Reduction by 50% or more in **existing** pollution risk from spillages into High to Poor watercourses (when existing spillage risk is <1%) **Groundwater** • Reduction by 50% or more in **existing** pollution risk from spillages into an aquifer (when existing spillage risk is <1%) **Flood Risk** • A reduction in peak flood level (1% annual probability) >10 mm resulting in a reduced risk of flooding to 1-100 residential properties
Moderate Beneficial	Where the proposal provides an opportunity to enhance the water environment because it results in a moderate improvement for an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • Method A assessment of both soluble and sediment-bound pollutants becomes Pass from previous Refer or Fail condition for **existing** discharges • Reduction by 50% or more in likelihood of pollution to watercourses from spillages from **existing** discharges through retrofitting of pollution control to outfalls into a High to Poor watercourse (existing risk >1%) • Recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat of local nature conservation value i.e. Local Nature Reserve **Groundwater** • Reduction by 50% or more in **existing** likelihood of pollution arising from a spillage to an aquifer through retrofitting of pollution control (existing risk >1%) **Flood Risk** • A reduction in peak flood level (1% annual probability) >10 mm resulting in a reduced risk of flooding to >100 residential properties OR a reduction of >50 mm resulting in a reduced risk of flooding to 1-100 residential properties

Score	**Comment**
Large Beneficial	It is extremely unlikely that any proposal incorporating the construction of a new or improved trunk road would fit into this category. However, proposals could have a large positive impact if it is predicted that it will result in a 'very' or 'highly' significant improvement to a water attribute(s), with insignificant adverse impacts on other water attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** • Removal of an **existing** polluting discharge through provision of pollution prevention measures, or any other measure, affecting a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) • Reduction by 50% or more in the **existing** likelihood of pollution arising from a spillage affecting a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) where existing risk >1% **Groundwater** • Removal of an **existing** polluting discharge within Zone 1 and 2 of a SPZ and/or a principal aquifer • Reduction by 50% or more in the **existing** likelihood of pollution arising from a spillage at discharge points within Zone 1 or 2 of a SPZ, principal aquifer and/or a site supporting a habitat protected under habitat legislation (existing risk >1%) • Recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) **Flood Risk** • A reduction in peak flood levels (1% annual probability) >50 mm reducing the risk of flooding to >100 residential properties OR a reduction of >100 mm resulting in a reduced risk of flooding to 1-100 residential properties

Table A4.6 – Qualifying Conditions for Overall Assessment Scores

ANNEX V FIELD LOG SHEET

Routine Runoff Assessment – Field Logging Sheet	
Date	
HA/Managing Agent Area	
Highway Name	
Outfall Number	
Watercourse	
Grid Reference	
Field Staff & Organisation	

Road and drainage system Description, e.g. number of lanes, road gradient, surfacing material, existing pollution control devices (filter drains, oil interceptors, swales, penstocks, balancing ponds etc), outfall layout.

Long slope of watercourse downstream of outfall (measure three times and take average)			
Level near outfall (m) (to nearest 5 mm or better)	Level downstream (m) (to nearest 5 mm or better)	Distance between points along stream (m)	Gradient (m/m)
1.	1.	1.	1.
2.	2.	2.	2.
3.	3.	3.	3.
		Average:	

Bed width (m)	
Flow width (m)	
Bank full width (m)	
Flow depth (take average across stream) (m)	
Bank full depth (m)	
Manning's n (roughness coefficient from table)	

Bed composition:	Cobbles %	Gravel %	Sand %	Silt & Finer %

Water Quality Location of water sample(s) and qualitative observations of water quality (clear/cloudy/murky, colour, any odour). Other quantitative measurements if made (e.g. temperature, conductivity, pH, redox, dissolved oxygen etc).

Water Sample ID (if taken)	

Qualitative assessment of flow velocity e.g. stagnant, slow, medium, fast (laminar), fast (turbulent)
Is stream bed dry? Is stream likely to dry up in summer?
Is there a protected site for conservation within 1 km downstream? If yes, specify.
Is there a downstream structure, lake, pond or canal which reduces stream velocity within 100 m of the outfall?
Presence/absence of confluences (upstream or downstream of outfall, relative size).
Evidence of recent flooding?
Description of watercourse e.g. straight/meandering, braided channel, river cliffs, substrate type, vegetation, approximate depth, bed composition, river fauna seen.
Other observations Weather and recent rainfall. Is the outfall discharging (if yes, describe appearance of water)? Surrounding land use. Presence of non-highway outfalls (and source of discharge, e.g. sewage works, factory, agricultural runoff). Soil/rock type. Presence of soakaways.

Values of Manning's n for various stream types (from Chow, 1973, Ref 6)

Lowland Streams	**Min**	**Normal**	**Max**
1. Clean, straight, full stage, no riffles or pools	0.025	0.030	0.033
2. As above with more stones and weeds	0.030	0.035	0.400
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. As above with some weeds and stones	0.035	0.045	0.050
5. As above, lower stages, more ineffective slopes & sections	0.040	0.048	0.055
6. As 4 above with more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools & heavy timber stand	0.075	0.100	0.150
Mountain Streams			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
Excavated Channel			
1. Gravel, straight uniform, clean	0.022	0.030	0.033
2. Straight, uniform, short grass and weeds	0.022	0.027	0.033
3. Winding and sluggish, grass some weeds	0.025	0.030	0.033
4. Winding, sluggish, dense weeds or plants in deep channels	0.030	0.035	0.040
5. Winding, sluggish, earth bottom, rubble sides	0.028	0.030	0.035
6. Winding, sluggish, stony bottom, weedy banks	0.025	0.035	0.040
7. Winding, sluggish, cobble bottom, clean sides	0.030	0.040	0.050
8. Dredged light brush on banks	0.035	0.050	0.060
9. Rock smooth and uniform	0.025	0.035	0.040
10. Rock jagged and irregular	0.035	0.040	0.050
Unmaintained excavated channel, weeds/brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on both sides	0.040	0.050	0.080
3. As 2, highest stages of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140