Water Use

# Supporting Guidance (WAT-SG-02)

## Modelling Continuous Discharges to Rivers

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**Update Summary**

| Version | Description |
|---|---|
| v1.0 | First issue for Water Use reference using approved content from the following documents:<br>*SG02 - Modelling Continuous discharges to rivers.doc* |
| v2.0 | *Consent* renamed *Licence*, New base template applied, links to docs revised for new SEPA website, Nov 2008 |
| v3.0 | Expired CMS links reviewed and updated. |
| v4 | Simplified method (s2) for Spotfire MCMB tool, Aardvark refs now refer to Spotfire DAVE Chemistry. Available capacity guidance now consistent with WAT-RM-21. Note: Original v3 doc content now available in separate new doc *WAT-SG-03 (v4) Data Analysis and River Quality Planning Model* |

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# 1. Key Points

This document provides guidance on the use of *Monte-Carlo Mass Balance (MCMB)* software in determining numeric standards for continuous discharges to rivers.

Table A below sets out the approach to be taken for different levels of risk. The level of modelling required increases as the environmental risk of the discharge increases. No modelling is required for the lowest risk discharges – registrations and small unsampled licensed discharges (i.e. <200pe) with reasonable dilution (i.e. with dilution > 200 or >100:1 depending on pollution pressures). All other discharges require modelling and the Spotfire MCMB tool is likely to suffice in most cases.

A Modelling Summary using standard values for sewage discharges is provided in section 2, with a Recording Template available as Annex A.

For sites where there is more environmental risk, it may be important to undertake a more detailed assessment including sensitivity analysis. This can be done by using Spotfire DAVE for data analysis and River Quality Planning (RQP) software for MCMB modelling. (Refer to WAT-SG-03)

Further information, training resources and exercises are available on the ESIU webpage.

**Table A: Indicative Modelling Approach for different scenarios**

| | Scenario | Modelling Requirement | Tools |
|---|---|---|---|
| Increasing Risk/'Complexity ↓ | Registrations<br>Licensed unsampled discharges (i.e. <200pe) with dilution > 200 or >100:1<br>*WAT-RM-03* Table 2 | None | Registrations<br>*WAT-RM-03* Table 1<br>Licences<br>*WAT-RM-03* Table 2 |
| | All other unsampled licensed discharges[1]<br>(i.e. <200pe with dilution < 200 or <100:1)<br>*WAT-RM-03* Table 2 | Simple Modelling | *Spotfire MCMB tool*<br>Section 2 |
| | All sampled licensed discharges (i.e. >200pe) | Detailed Modelling | *Spotfire DAVE* for data analysis and River Quality Planning software (with sensitivity analysis)<br>*WAT-SG-03* |
| | Wider catchment implications requiring catchment modelling | SIMCAT/SAGIS | *WAT-SG-03* section 9 |

1 In certain cases staff may wish to consider undertaking Detailed Modelling which has greater functionality such as allowing sensitivity analysis.

# 2. Modelling Summary

The *Spotfire MCMB tool* allows local Regulatory Services staff to determine the discharge limits for licensed sewage and organic trade discharges as required by *WAT-RM-03* and *WAT-RM-05*. This tool is likely to be adequate in most cases.

Licensed sewage and organic trade discharges should be modelled if the discharge is >200p.e. (e.g. sampled) or dilution is < 200 or <100:1 (depending on pollution pressures).

The following information is needed to run the Spotfire model. Details about how to obtain this information is included within this section:

- River flow
- Discharge flow
- Discharge Quality
- Upstream River Quality
- Downstream River Target

The Recording Template available as Annex A should be used with result outputs from the Spotfire model and kept on the file in order to demonstrate how discharge limits have been derived.

Further detail on allocation of capacity is available in *WAT-RM-21*.

## 2.1 River Flow

Gather river flow data from Hydrology (see *Low Flow Estimation Workbook*).

## 2.2 Discharge Flow

Convert discharge population equivalent (pe) to maximum flow using the most recent Flows & Loads document (150l/head for domestic sewage in F&L 4).

Assume mean = maximum flow (this is precautionary)
Assume the standard deviation (SD) is 1/3 of the mean.

## 2.3 Discharge Quality

The Spotfire MCMB Tool requires a discharge quality described by the mean and SD. For secondary treated discharges, values of 10mg/l for the mean and standard deviation for both BOD and ammonia should be used. (The absolute values do not matter; it is the ratio of mean/SD that is important and for secondary discharges this ratio can be approximated to 1).

See Table 3 in the Recording Template (Annex A).

## 2.4 Upstream river quality

Populate Table 4 in the Recording Template with the most reliable data. The following hierarchy should be used.

### 2.4.1 If river quality data available

Use river sampling data if an appropriate dataset exists which is representative of river water quality.

### 2.4.2 No river quality data

If there is no river sampling data, an estimate of water quality can be made using *Spotfire Source Apportionment GIS* (SAGIS). SAGIS allows an estimate to be made of water quality (BOD, ammonia and phosphorus) in any location in any water body. An assessment of water quality on smaller tributaries may be possible by assuming water quality is similar to that in the main stem water body (which has SAGIS water quality information). Care should be taken not to use main stem SAGIS water quality impacted by discharges into that water body which may not be relevant to the smaller tributary. Contact *ESIU* for more details if required.

### 2.4.3 No river quality data and no estimate possible using SAGIS

If no river sampling data is available, and no estimate is possible using SAGIS, then it should be assumed that water quality is at 60% of the way through the class (i.e. the quality is 40% from the next lower class boundary). This is slightly worse than the mid-point 50% assumption in previous guidance. This slightly precautionary assumption is needed because it is just as likely that water quality is worse than 50% and therefore water quality may breach a standard when the new discharge is allowed.

Refer to Table B below. If the watercourse is clearly unpolluted then assume 60% through high status, otherwise assume 60% through good status. Check GIS Standards to determine the class boundaries (*WAT-SG-03*).

The 60% of the way through the class is based on WFD standards which are 90%iles for BOD and ammonia, but the *Spotfire MCMB Tool* accepts only a mean and SD. Table B therefore provides the mean and SDs for the various 90%iles.

**Table B: Upstream Water Quality Data (where no river data and not on waterbody)[1]**

| | | WFD Stds | | Assumed 60% through High | | | Assumed 60% through Good | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Typology (see GIS)** | **High 90%ile** | **Good 90%ile** | **High 90%ile** | **Mean** | **SD** | **Good 90%ile** | **Mean** | **SD** |
| BOD | 1,2,4,6 | 3 | 4 | **1.8** | 1.023 | 0.628 | **3.6** | 2.047 | 1.256 |
| BOD | 3,5,7 | 4 | 5 | **2.4** | 1.365 | 0.837 | **4.6** | 2.615 | 1.605 |
| $NH_3$ | 1,2,4,6 | 0.2 | 0.3 | **0.12** | 0.0592 | 0.0564 | **0.26** | 0.128 | 0.122 |
| $NH_3$ | 3,5,7 | 0.3 | 0.6 | **0.18** | 0.0888 | 0.0845 | **0.48** | 0.237 | 0.225 |

1 The ratios between 90%iles, mean and SDs were determined from all river datasets from Jan 2000 to Dec 2015, which led to the following conclusions:

For BOD, assume SD = Mean/1.63
For $NH_3$ (ammonia), assume SD = Mean/1.05

## 2.5 Downstream Target

Table C sets out the RAG categories – i.e. risk of deterioration.

**Table C: Categorisation of the risk of deterioration**

| RAG status | Remaining capacity | Trends in quality |
|---|---|---|
| GREEN - not at significant risk | More than 20% of the environmental capacity remaining | No trend, positive trend or minor adverse trend (i.e. no adverse impact anticipated for > 12 years) |
| AMBER - potentially at risk of deterioration | Between 3% and 20% of the environmental capacity remaining | Significant adverse trend expected to breach an environmental standard within 6 to 12 years |
| RED - at significant risk of deterioration | Less than 3% of the environmental capacity remaining | Significant adverse trend expected to breach an environmental standard within 6 years |

## 2.5.1 If existing quality is green

**Figure 1 Overview of factors affecting Good status in water environment**

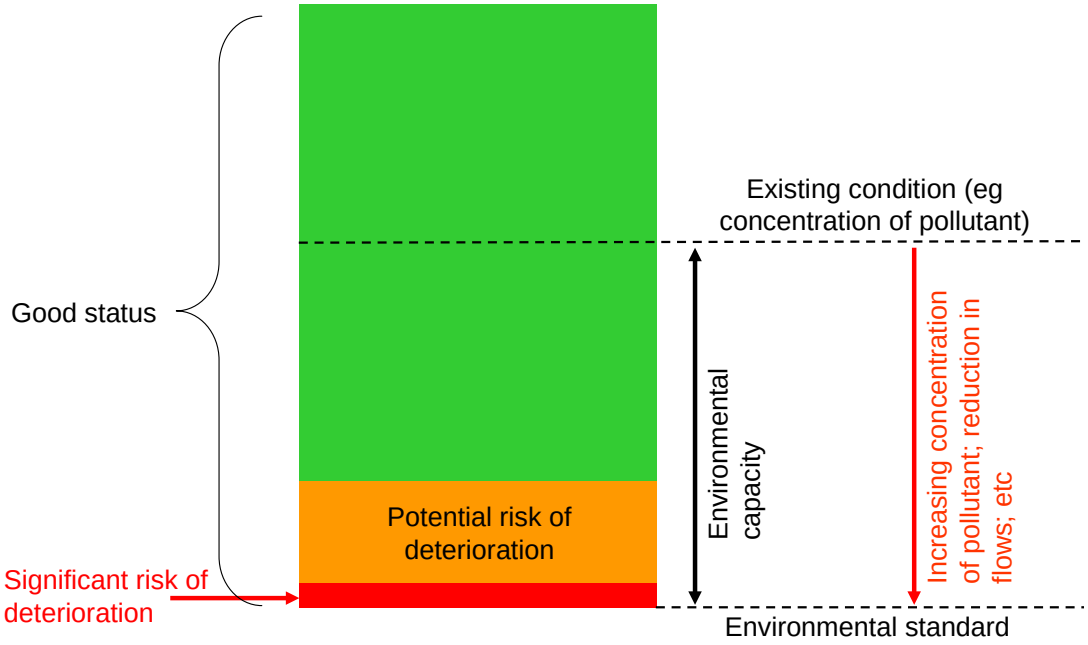



Figure 1 sets out the scenario of an upstream RAG status of green in Good status.

Since we do not want to move from green to amber, then the discharge should be modelled with the green/amber boundary as the target.

Downstream target – Green/amber band limit is 80% of status band (eg if in Good status, e.g. between 0.3 and 0.6mg/l, green/amber band limit is 0.54mg/l.

Downstream targets for differing situations are given in Table D.

**Table D: Downstream Target**

| | Typology | High/Good boundaries (mg/l) | Existing Status | Target 80% class width (mg/l) |
|---|---|---|---|---|
| BOD | 1,2,4,6 | 3/4 | High | 2.4 |
| | | | Good | 3.8 |
| BOD | 3,5,7 | 4/5 | High | 3.2 |
| | | | Good | 4.8 |
| $NH_3$ | 1,2,4,6 | 0.2/0.3 | High | 0.16 |
| | | | Good | 0.28 |
| $NH_3$ | 3,5,7 | 0.3/0.6 | High | 0.24 |
| | | | Good | 0.54 |

These effluent standards should be no more relaxed than the 'basic, low cost, good practice measures' outlined in Table E below, i.e. these are minimum standards.

If remaining in green is not possible using 'basic, low cost, good practice measures', then water quality can be allowed to move into amber, as long as Best Available Techniques (BAT) standards (Table F) are used. NB The amber / red boundary must not be breached.

**Table E: Basic, low cost, good practice measures**

| |
|---|
| This may include septic tank discharges where there is very large dilution (refer to *WAT-RM-03*).<br>Normally, secondary treatment is required and for unsampled secondary treated discharges, an effluent standard of a mean BOD of 20mg/l would be acceptable.<br>For sampled 2 tier discharges, a BOD 95%ile standard of no more than 30mg/l |

**Table F: BAT Standards**

| |
|---|
| For unsampled secondary treated discharges, an effluent standard would be expected to be tighter than a mean ammonia of 3mg/l. (3mg/l mean ammonia is a standard that better performing package treatment plants can produce)<br>BAT 95%ile standards of 1/1/5mg/l SRP/ammonia/BOD are applicable at most Scottish Water treatment works (including large sampled private discharges), but they may not be realistic for smaller scale sewage discharges. |

### 2.5.2 If existing quality is amber

Model discharge assuming BAT standards outlined in Table F above

- If downstream quality is still amber, then authorise at BAT
- If downstream quality is now red or status is downgraded, then refuse

(unless treatment standards tighter than BAT can keep the discharge in amber).

### 2.5.3 If existing quality is red

Refuse the application unless negligible additional demand (refer to WAT-RM-21 for more detail).

## 2.6 Recording data/Assumptions and model outputs

A record of relevant data/assumptions and model outputs should be kept. This may include the time series of existing river quality and any filtering of this dataset. The results output table from MCMB should be saved to file, as this provides a record of the data used for the calculation.

Annex A Modelling Recording Template should be completed and attached to the CAR Licence Decision Record (WAT-FORM-19).

## 2.7 Detailed guidance for MCMB

*WAT-SG-03* provides more detailed guidance covering underlying principles and considerations where a more detailed assessment may be required. This allows sensitivity analysis to be undertaken to check how sensitive results are to input values. *WAT-SG-03* also describes the use of *Spotfire DAVE Chemistry* software for data analysis and River Quality Planning software for MCMB modelling, which provides greater functionality than Spotfire MCMB.

Further information, training resources and exercises including a Modelling Checklist and a Summary Statistics Checklist are available on the *ESIU* intranet page.

# Annex A: Modelling Recording Template

### River Flow Data

| NGR | Q95 (l/second) | Mean |
|---|---|---|
| | | |
| | | |

### Sewage Discharge Flow Data

| p.e.[1] | l/day | l/sec | SD |
|---|---|---|---|
| | | | |
| | | | |

1: p.e. based on Flows and Loads document

### Discharge Quality Data for secondary treated discharge[2]

| | Mean (mg/l) | SD |
|---|---|---|
| BOD | 10 | 10 |
| $NH_3$ | 10 | 10 |

2: It is only the ratio of the mean to SD that is important for modelling purposes. For typical secondary treated discharges, a 1:1 ratio is appropriate.

### Upstream Water Quality Data (if applicable)

| Location Code: | | Location Code Description | | |
|---|---|---|---|---|
| | 90%ile | Mean | SD | Status |
| BOD | | | | |
| $NH_3$ | | | | |

### Downstream Target

| | High/Good boundaries | Existing Status | Target (80% class width) |
|---|---|---|---|
| BOD | | | |
| $NH_3$ | | | |

### Required Discharge Quality (output from Spotfire MCMB)

| | 95%ile (mg/l) (if sampled) | Mean (mg/l) (if unsampled) |
|---|---|---|
| BOD | | |
| $NH_3$ | | |

# Key References

## Regulatory Methods & Supporting Guidance

- *WAT-FORM-19: CAR Licence Decision Record*
- *WAT-RM-03 Sewage Discharges to Surface Waters*
- *WAT-RM-05: Trade Effluent Discharges to Surface Waters*
- WAT-RM-21: No Deterioration and Allocation of Capacity
- *WAT-SG-03: Data Analysis and River Quality Planning Model*
- *WAT-SG-53: Environmental Quality Standards and Standards for Discharges to Surface Waters*

## Tools

- Environmental and Spatial Informatics Unit (SEPA Intranet page)
- *Low Flow Estimation Workbook* (QP Doc: FEW)
- Monte-Carlo Mass Balance (MCMB)
- River Quality Planning software (Monte Carlo software - contact IS to have this available)
- Spotfire DAVE Chemistry
- Spotfire MCMB
- Spotfire Source Apportionment GIS SAGIS, (SEPA Intranet page)

*- End of Document -*