THRESHOLDS

Adoption of the EU Water Framework Directive (2000) introduced a comprehensive river basin management planning system to protect and improve the ecological health of our rivers, lakes, estuaries, coastal and groundwaters (EA, 2015). It set out to restore water bodies to good ecological status by 2015 –or at the latest – 2021 (Defra, 2016). As part its requirements, the WFD sets out a series of water quality standards (WQS) against which the health of all water bodies is assessed. Acute (annual average) and chronic (maximum allowable concentration) WQS have been developed for a range of metals and organic substances, with additional WQS identified for further substances of concern within the UK (see Table 2.1).

Table 0.1 Receiving water quality standards for selected road runoff pollutants

Pollutant	Receiving water quality standards	Key traffic sources	Notes
Cadmium (Cd)	0.25 µg/l*	Brake linings	EU Priority Substances Directive (PSD; 2013) Refers to dissolved concentrations
Copper (Cu)	1µg/l	Brake linings	UK Technical Advisory Group (TAG) WFD (2015) Refers to bioavailable concentrations
Zinc (Zn)	10.9µg/l plus ambient background concentration**	Tyres, brake linings	UK TAG WFD (2015) Refers to bioavailable concentrations
Benzo (a) pyrene (BaP)	1.7 x 10^{-4} µg/l	Exhaust emissions; oil leakages; tyres;	EU PSD (2013). Refers to total concentrations
Total suspended solids (TSS)	25mg/l	Wear and tear of road surfaces and vehicles	Value taken from the CIRIA SuDs Manual (2015)

Notes: * standards vary with water hardness; water hardness within the River Lea and Thames falls within class 5 (≥ 200 mg $CaCO_3$ /l); ** annual average background Zn concentration for the River Thames is 3.3µg/l)

The developed approach predicts total pollutant concentrations within road runoff based on traffic volume and type. This needs to be adjusted to enable comparison with the WQS identified in Table 2.1 which are relevant to receiving waters. To do this, a staged approach is adopted which varies in relation to the pollutant fraction to which the WQS refers (i.e. the bioavailable fraction for Cu and Zn ; dissolved fraction for the Cd WQS and the total concentration for TSS and BaP).

The pertinent receiving WQS has been used to 'back-calculate' the total concentration in road runoff entering a receiving water which would lead to its exceedance. To implement this approach, the following criteria have been used:

- The relationship between dissolved and bioavailable metal fractions can be predicted using a biotic ligand model (BLM) which predicts the bioavailable fraction based on site specific dissolved metal, calcium (Ca), dissolved organic carbon (DOC) and pH concentrations.
- The dilution ratio of receiving water to runoff volumes is assumed to be 8:1
- The partitioning of metals between the total and dissolved fractions can be predicted using data from the literature

The methodology is described in more detail below, including the identification of threshold values used to prioritise road sections in terms of the extent to which predicted pollutant runoff concentrations can lead to exceedance of identified WQS. To illustrate the approach, a worked example is provided below for Cu.

Pollutants for which the receiving water quality standard refers to the bioavailable fraction As the bioavailable fraction is analytically challenging to measure, the EU supports the use of biotic ligand modelling (BLM) to predict the fraction of the total metal which is likely to be bioavailable under local receiving water conditions. Data on pH, DOC and Ca concentrations for the River Thames catchment were sourced from the literature and, together with the pertinent bioavailable WQS, used in the BLM BIO-MET (2019) to work backwards to predict the dissolved metal concentration which would generate the identified bioavailable concentration.

Conversion of dissolved concentrations in the receiving water to equivalent dissolved concentrations in road runoff This stage of the prediction process converts the receiving water concentration to an equivalent road runoff concentration. This is achieved by applying a factor to address the dilution of runoff on entering a receiving water. Whilst the level of dilution offered by a receiving water will vary greatly in relation to, for example, rainfall, a dilution ratio of 8:1 is assumed as a minimum indicative value. Where WQS are quoted as total concentrations (e.g. TSS and B(a)P), these total concentrations were also multiplied by 8 to correct for dilution.

Conversion of dissolved concentrations to total concentrations Several studies in the peer-review literature have reported the distribution of selected metals between dissolved and total fractions. An evaluation of this data provide evidence of the following dissolved percentages for the selected metals: Cd (45% dissolved); Cu (40% dissolved);Zn (40% dissolved). These percentages were used as multiplication factors to calculate associated total concentrations

Development of runoff thresholds using risk characterisation ratios The risk characterisation ratio is calculated by dividing the predicted environmental concentration (PEC) by the predicted no-effect concentration (PNEC). Values equal to or greater than 1 present a potential risk. The approach outlined above, supports identification of a PNEC in road runoff i.e. the total concentration back-calculated from the receiving water WQS. Using an RCR of 1 can then be used to identify the total concentration of the selected pollutant in road runoff which would equal this concentration (i.e. the PNEC). The following ranges of RCR have been used to develop a prioritised scale which is indicative of risks to the receiving water:

- RCR ≥ 1.0 the runoff poses a risk to receiving waters
- RCR 0.75-1.0 the runoff may pose a risk to receiving waters
- RCR <0.75 the runoff is unlikely to pose a risk to receiving waters

Worked example for Cu The WQS for Cu is 1 μg/l in the bioavailable fraction. Using River Thames catchment data, the following values were selected for pH (7.9), DOC (4.4mg/l) and Ca (75.9mg/l) for use in the BIO-MET BLM. Under these ambient receiving water conditions, BIO-MET predicts a bioavailable fraction of 1 μg/l is associated with a dissolved Cu concentration of 11.2 μg/l. A dissolved concentration of 11.2 μg/l Cu in a receiving water would derive from a runoff concentration of 89.6 μg/l Cu (i.e. following an 8 fold dilution). A dissolved concentration of 89.6 μg/l of Cu in road runoff is equivalent to a total concentration of 179.2 μg/l (based on a 40% dissolved Cu composition). Using the RCR threshold approach described above, an RCR ≥ 1 (i.e. a concentration ≥ 179.2 μg/l) represents a high risk of the WQS in the receiving water being exceeded. The relationship between RCR ranges, total metal concentrations and the colours used to highlight sections of road in the GIS maps is given in Table 2.2.

Table 2.2 Relationship between RCR, total Cu concentration in road runoff and allocation of road colours in GIS maps

RCR	Total Cu concentration in runoff (µg/l)	Associated road colour on GIS map
≥1.0	≥179.2	
0.75-1.0	147.2-179.1	
<0.75	<147.1	

Table 2.3 presents the relationship between RCR ranges, concentrations of selected pollutants and the colours used to highlight sections of road in the GIS maps.

Table 2.3 Relationship between RCR, total pollutant concentrations in road runoff and allocation of road colours in GIS maps

RCR	Total Zn (µg/l)	Total Cd (µg/l)	Benzo (a) pyrene (µg/l)	TSS (mg/l)	Associated road colour on GIS map
≥1.0	≥770	≥4.4	≥0.0014	≥280	
0.75-1.0	590-769	3.3-4.3	0.00102-0.0013	210-279	
<0.75	<590	<3.3	<0.00102	<210	