This publication was withdrawn on 17 June 2025.

This guidance has been withdrawn because it contains information that is out of date.

For guidance on carrying out modelling for discharges to surface water that may containing hazardous chemicals and elements, contact the Environment Agency.

LIT 10419 Modelling: surface water pollution risk assessment risk assessment

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Introduction

If your risk assessment screening tests for estuaries and coastal waters didn't screen out pollutants you need to carry out detailed tests called modelling. You need to find a consultant to do this for you. Consultant should read this guidance and contact the Environment Agency to find out more about modelling.

The Environment Agency will carry out the modelling tests for you if your screening tests for freshwaters showed that your discharge is a risk to the environment, unless you're discharging into a lake or canal, then you must carry out modelling.

Modelling tests will show whether your discharge will cause pollution or not. If the modelling tests show that your discharge will cause pollution, the Environment Agency will include conditions to control the hazardous pollutant in your permit or they may refuse your permit application if the impact on the environment is unacceptable.

Modelling: surface water pollution risk assessment

1. Preparing the data for modelling

Summary statistics need to be generated for use in the modelling. To allow these statistics to be generated, the raw sample data need to be further assessed and “cleaned up”. This involves:

- checking whether the discharge is truly “liable to contain” a substance
- checking that the data are truly “fit for purpose”
- Data “clean up”

1.1. Liable to contain test

In some situations, a substance may have been carried through to modelling even though it was not *really* detected in many of the samples. This is because the “less thans” are taken at face value in the precautionary screening stage. In order to see whether it is necessary to carry out modelling for such substances, you should first check whether the effluent is truly “liable to contain” them.

Providing the “less than” value is at, or very close to, the accepted Limit of Detection (LOD), you can use Table 2 on page 6 to check that a minimum number of samples exceed the LOD. If the required number of samples were reported above the limit of detection (LOD), modelling should be carried out for this substance. If not, the substance can be considered insignificant and the substance requires no further assessment and no control on the permit, **unless** any of the positive samples exceeded the MAC (or 95 percentile) EQS for that substance, in which case the substance should be modelled.

If the limit of detection used was not sufficiently low, you should carry out modelling and, if required, either impose a precautionary limit on the permit (if there is a threat to the EQS, or the potential for a marked deterioration in receiving water quality) or use a monitoring condition to require further monitoring of the substance. If the discharge is to a TraC water and the modelling is potentially complex, the operator should contact the Environment Agency to discuss the specific discharge and receiving water and agree on a way forward.

Table 2 Liable to contain table

Number of samples in assessment period	Minimum number of samples which need to be equal to or above the required LOD
12 – 14	4
15 – 20	5
21 – 27	6
28 – 34	7
35 – 41	8
42 – 48	9
49 – 56	10
57 – 63	11
64 – 71	12
72 – 79	13
80 – 86	14
87 – 94	15
95 – 102	16

1.2. Are the data "fit for purpose"?

Before using any discharge or water body chemical data in the modelling, you should check the dataset to ensure that it is representative of the current situation. Your checks should include the following:

1. Step changes in effluent quality

Step changes are significant changes in the data over a period of time. They can be caused by, for example, changes in effluent treatment or changes in trade inputs to a sewage works.

The data can be assessed for step changes using computer packages, such as 'Aardvark' or Excel to analyse and graphically represent data.

If there are significant step changes in your dataset then you should select a time period which reflects current quality, even if this means that you are using fewer than three years' data. The final dataset with the step changes removed should contain a minimum number of 12 samples.

2. Unevenly distributed sampling, reflecting seasonal or other periodic changes

If the data are not evenly distributed e.g. with a seasonal bias, they can still be used, but you should take account of the uneven spread when interpreting the results. Analysis for statistically significant seasonal variation can be carried out in Aardvark or other statistics packages. You may need local or operational knowledge to help with interpretation of the dataset.

3. Are the data representative of the effluent?

It is important to check that the data being used are representative of current effluent quality e.g. a trade effluent discharge into a sewer/effluent could have recently closed, or the effluent could be subject to a new treatment process.

4. Outliers (exceptionally high or low values)

Outliers in a dataset may distort the data analysis and give a misleading result.

Sometimes a data point in a dataset may look much higher or lower than the other data points. You must decide whether this is a true result or an exception or error, and therefore whether you are going to exclude or retain that data point in your dataset. This decision can affect the subsequent analysis of your data and the conclusions made.

There are a number of reasons why a value may be considerably higher or lower than the rest of the dataset:

- It is incorrect, for instance because of sampling, recording or coding errors. This value should be excluded from your assessment.
- It is correct but relates to exceptional circumstances, such as treatment failure. This value should be excluded from your assessment.
- It is correct and is a high value but part of the normal performance of the permitted activity. Include this value in your assessment.

High values resulting from exceptional circumstances or normal performance may be identified by looking at other substances sampled on the same date and/or results from the same time period in different years and/or by checking with Environment Agency area operational teams.

The influence of an outlier can be checked by calculating the summary statistics with and without the potential outlier in the dataset, and run the modelling tests below to see if the effect on the outcome of the modelling.

1.3. Adjustment of “less than” values and low results in the data

Once you are satisfied that the data are representative of the effluent, you will need to “clean up” the data ready for calculation of summary statistics by adjusting “less than” values. Once you have assessed and adjusted the data, you should calculate a mean and standard deviation, for input into the River Quality Planning tool Monte-Carlo. You can request a copy of this tool from the Environment Agency.

“Less thans” need to be adjusted to half their face value before calculating summary statistics. This is because less than values suggest that a substance has not been detected in the sample, so we should not make any assumption about what the true value might have been if the substance had been detected.

The limit of detection of hazardous pollutants can vary between samples, and also over time, due to variations in other properties of the sample or changes in the laboratory analytical procedures. Results may therefore be reported as a “less than” value rather than a specific value, and the less than values quoted may vary throughout the data set e.g. one result may be reported as <20µg/l, and the next may be <10 µg/l.

The computer program ‘Aardvark’ can be set up to adjust all less than values to half face value and calculate the summary statistics accordingly.

If you do not have access to Aardvark you should use Excel or a similar package to adjust less than results to half their face value and then assume that these results are actual results. For example, a result of <10 should be assumed to be a result of 5 for modelling, and a result of <50 should be assumed to be 25.

In addition, sometimes positive values are reported below the LOD e.g. the LOD for a substance may be 10, but the reported value may be 8.8. In this situation the result of 8.8 should be assumed to be accurate and should be retained for modelling.

If modelling using data which is primarily less thans shows that a substance is liable to cause pollution, it may be appropriate to require monitoring at a lower limit of detection rather than impose a numeric emission limit on the permit (unless modelling shows that there is a threat to the EQS, in which case a numeric emission limit should be applied). These monitoring data can then be used to accurately assess whether the substance is liable to cause pollution, and the substance can then be controlled by a numeric limit if it is liable to cause pollution, or the requirement for monitoring removed from the permit if it is not.

1.4. Discharges to sewer from installations

When installations discharges are screened, they are treated as standalone discharges. To prepare data from installations sites for modelling, the existing concentration of effluents in the sewer and dilution in the sewer need to be taken into account, as well as sewage treatment reduction factors.

By the time effluent discharged to sewer from an installation reaches a sewage treatment works (STW), it will be mixed with other effluents within the sewer. Treatment within the STW will also remove a proportion of a discharged substance from the final effluent discharged to environment. Both of these need to be taken into account when calculating the concentration of a hazardous pollutant which will be discharged to a receiving water.

a. Sewage Treatment Reduction Factors

Where a substance is released first to sewer and then treated at a sewage treatment works, it may undergo physical, chemical and biological changes that affect its form, concentration and subsequent environmental impact on the receiving water. The extent of removal during sewage treatment will depend on the interaction between the properties of the substance, the degree of treatment and operational characteristics of the works. It can be assumed that temperature and pH of releases to sewer do not need to be further assessed at the final point of discharge.

The release concentration of substances discharged to sewer can be adjusted to take account of the sewage treatment process by:

RCcorr = RCact x STRF

Where:

RCcorr = corrected release concentration allowing for any attenuation of pollutant during sewage treatment (mg/l)

RCact = actual release concentration of pollutants discharged to sewer (mg/l)

STRF = sewage treatment reduction factor representing the remaining proportion of the pollutant in the effluent following treatment.

The guide Surface water pollution risk assessment for your environmental permit gives generic substance-specific sewage treatment reduction factors (STRF) for a number of substances. You may also use site-specific measured reduction factors if they are available and you can provide details of their derivation. Apart from some highly soluble ionic species, removal efficiencies are only occasionally less than 40 percent and often greater than 80-90 percent.

The calculated RCcorr should then be used in b. below to calculate the combined predicted concentration (CPC) to be used in Monte Carlo modelling.

b. Existing effluents within the sewer and treatment works

There are two factors to include when considering the existing effluent flows within the sewer and treatment works:

- the volume of effluent that will dilute the new/greater volume of effluent from the Installation; and
- the concentration of substances already present in those effluents that will combine with the new/increased concentration from the Installation.

So in order to obtain the combined predicted concentration (CPC) of the substance for use in modelling, the effluents must be combined:

[(flow1 x conc1) + (flow2 x conc2)] / (flow1 + flow2)

Note: only a new volume/concentration or additional volume/concentration from the Installation should be used in the calculation, as existing flows will already be accounted for in the volume/concentration at the STW.

Therefore, if flow1 and conc1 are from the Installation and flow2 and conc2 are those existing at the STW:

CPC = [(EFR x RCcorr) + (STWF x STWC)] / (EFR + STWF)

Where:

EFR = Effluent Flow rate (to sewer)

RCcorr = Effluent release concentration after accounting for STRF (sewage treatment reduction factor)

STWF = Flow of final effluent from STW

STWC = Concentration in final effluent from STW

CPC is the concentration value for input to Monte Carlo. If the substance has an AA EQS, you will require the mean CPC, so when calculating this you should use the mean values for all parameters in the above equation. If the substance has a MAC (or 95 percentile) EQS, you should calculate the 95 percentile release concentration.

Note that for input to Monte Carlo, the mean effluent flow rate to surface water must include the mean flow from the installation (be that new, revised or existing).

See section 3.1 for calculating standard deviation (SD) figures for input to Monte Carlo.

1.5. Metals

For the modelling tests, metals are assessed using both total and dissolved metal data. This will give a fairer assessment of the impact on receiving water quality, as not all total metals will exist in the dissolved form (most metal EQSs are for dissolved metals).

In modelling, the risk to EQS is assessed using total metal data. Although this may still be precautionary, this ensures that the EQS will be met downstream (as it is rarely possible to predict how much total metal will partition to the dissolved phase in the receiving environment with time) and also controls the total load discharged to the catchment.

The risk of deterioration of river quality is assessed using dissolved metal data, where these are available. As this test looks at the percentage change to EQS caused by the discharge, it is fairer to compare the predicted downstream concentration for all substances expressed in the same form as the EQS. If dissolved data are not available, total metal data should be used, but judgement will be needed when assessing the modelling results.

2. The modelling

Substances are modelled to calculate the expected concentration and load of a substance in the environment after a discharge is made. The modelling looks at a number of scenarios (tests) and you must complete all the relevant tests for each substance being modelled. Where any of these tests are failed, the substance is classed as “liable to cause pollution”. These substances will require regulatory control (permit conditions).

Different modelling tools are appropriate depending upon the receiving environment and also, to some extent, the discharge regime.

2.1. Freshwaters – inland rivers and streams

Modelling of discharges to freshwater rivers and streams is carried out using the Monte Carlo RQP (River Quality Planning) software, which is available by requesting a copy from the Environment Agency. The modelling tests assess the following:

a. Risk to EQS

This test assesses whether the proposed, or permitted, load could cause failure of the receiving water EQS.

b. Significant deterioration of receiving water quality

This test determines whether the discharge causes upstream/background quality to deteriorate by more than 10 percent of the EQS.

c. Risk of significant deterioration of effluent quality

This test is only appropriate for some effluents. For example, if a number of trade effluents are discharged into a sewerage catchment, and these effluents are being discharged consistently below the consented limit, an assessment must be carried out to determine the impact of the full consented load on the watercourse.

These modelling tests are described in more detail in section 3.

For information about modelling discharges to still waters (e.g. lakes and reservoirs) see section 5.5.

2.2. TraC Waters

There are potentially three stages to the modelling:

- Initial Dilution
- Simple models (e.g. plume model)
- Complex hydrodynamic model.

Note that the entry point for the modelling stage can vary. For a very large discharge it might be quite clear that complex modelling will have to be undertaken without first going through the earlier simpler modelling stages.

The objectives of each of these modelling stages are described in more detail in section 4.

3. Running the modelling tests for freshwaters

The three different modelling tests for freshwaters are described in detail below.

The modelling tests for freshwaters are run in Monte Carlo. Monte Carlo is a mass balance model which can carry out two types of calculation:

1. Forward calculation

This calculation will assess the impact that a discharge of known quality will have on the watercourse. This calculation is typically used to assess whether a discharge is "liable to cause pollution".

2. Backward calculation

This calculation will assess the quality of discharge required to maintain current water quality or to meet a specific quality target. This calculation is used for setting numeric permit limits.

Note that it is also important to confirm if there are any local water body issues (for example where hazardous pollutants are being investigated as a possible cause for failure of good ecological status) which need to be taken into account when assessing the potential impact of any substances in the discharge. This is not a modelling test, but potential impacts need to be assessed after modelling before any permit limits are set.

If any downstream data are available for existing discharges for the substances being modelled, these data should be used to validate the conclusions of the modelling, to increase the confidence in any assumed input data which have been used.

3.1. Modelling test 1 - risk to EQS

This test assesses the impact of the proposed or permitted load on the receiving water EQS. The test is run in Monte Carlo "Monte Carlo Simulation" to determine whether there is a risk to EQS compliance downstream of the discharge. Note that it may be necessary to convert some effluent and river concentrations into nanograms for the purposes of Monte Carlo modelling, as the model only works to two decimal places. If the impact of any metal is being modelled, total metal data should be used for this test.

Note: If the EQS is already failed in the receiving watercourse upstream of the discharge, then it may still be possible to permit the discharge. Deterioration should be limited to a <3 percent change in the concentration relative to the EQS, providing this will not prevent the water body achieving good status if all other improvement measures for the water body are implemented. This would be determined by the Environment Agency.

Step 1

The following data need to be entered into “Monte Carlo Simulation” in Monte Carlo for each substance.

For AA and MAC (or 95 percentile) EQSs

- Mean and 95 percent exceeded (Q95) river flow
- Mean and standard deviation of upstream/background river quality
- Mean and standard deviation of effluent flow
- Mean and standard deviation of effluent quality

Assumptions will need to be made about some parameters where data are not available, as follows:

- If there is only a maximum concentration rather than a mean for a substance in a discharge and a mean value is needed, the maximum value should be treated as a 95 percentile. This figure can be entered into the “Calculation of mean and standard deviation from a percentile” in Monte Carlo to calculate a mean and standard deviation. For sewage discharges, the coefficient of variation (CoV) for this calculation should be taken from Table 3 below. For trade discharges, the CoV from a similar type of discharge should be used where possible. If a comparable site is not available, a sensitivity analysis with varying CoVs should be carried out.

- If assumed upstream/background quality has been used rather than actual data, the CoV for all upstream substances should be assumed to be 1.

- In the absence of flow data, mean flow for a sewage treatment works should be assumed to be 1.25 x the permitted dry weather flow, and the standard deviation should be 33 percent of the mean flow. For trade effluents assumptions of mean and standard deviation need to be site-specific depending on the process. E.g. a cooling water discharge may show very little variation and may have a CoV of 0.1.

Table 3 – Coefficients of variation for sewage effluents

Substance	Coefficient of Variation
Cadmium (Cd)	0.8
Chromium (Cr)	0.8
Copper (Cu)	0.5
Lead (Pb)	0.7
Nickel (Ni)	0.5
Zinc (Zn)	0.5
Other metals	0.7
Organics	1.0

Step 2

Use the **forward calculation** in Monte Carlo to determine the downstream quality.

Note: This calculation assumes that discharges will contain an element of rainfall as the default assumptions are set for sewage discharges i.e. it assumes that when river flow increases with rainfall, the flow of the discharge will similarly increase. For trade discharges which do not contain an element of rainfall, set the correlation coefficient for river flow and discharge flow to “zero”. This can be accessed in ‘further data’, after the calculation is first run.

Note: If the discharge is existing and there are downstream data available, a validation check should be carried out (including confidence limits) to check that the modelled results correlate with the actual downstream data. If they do not, some of the model assumptions may need to be revised.

Step 3

Check compliance with the relevant EQS.

MAC (or 95 percentile) EQSs

For MAC (or 95 percentile) EQSs, if the 95 percentile downstream quality is less than the EQS, the discharge is not predicted to cause an EQS failure and this modelling test has been passed. In this situation, continue on to modelling test 2. If 95 percentile downstream quality exceeds the EQS, the substance is considered significant and a numeric emission limit for this substance will be required on the permit.

AA EQSs

For AA EQSs, the confidence that the EQS is exceeded needs to be calculated using the “RQP Compliance Suite – compliance with mean standards” test. The following data are required for this calculation:

- Mean downstream water quality
- Standard deviation of downstream water quality
- Number of effluent samples (if effluent data are assumed i.e. you are assessing a new discharge, use a default value of 12 samples).
- EQS (mean standard i.e. annual average)

The test will give the percentage confidence of the EQS being exceeded. If the result is 5 percent or more confidence of failure i.e. exceedence of the EQS, you cannot be confident that EQS is complied with for more than 95 percent of the time. The substance is therefore considered to be significant and a numeric emission limit for this substance will be required on the permit.

Note: If there are no effluent data for an existing sewage works discharge, and data from the water company trade effluent returns have been used, a monitoring requirement rather than a numeric emission limit should be added to the permit if the substance is significant, unless there is an observed risk to the EQS and/or a potential marked deterioration in receiving water quality. These monitoring data should then be reviewed to determine if the substance either needs to be controlled by a numeric limit, or if the monitoring requirement can be removed from the permit.

3.2. Modelling test 2 - deterioration of receiving water quality

In this test, you are determining whether the discharge causes upstream quality to deteriorate by more than 10 percent of the EQS. This test uses dissolved metal data (if dissolved metal data are not available, total metal data should be used; the results from modelling with total metal data will be more pessimistic as they represent a worst case scenario where all the total metal data will be assumed to be dissolved).

For non-metals, the results from the Monte Carlo modelling for modelling test 1 (section 3.1) can be used to carry out this assessment, so a second Monte Carlo run is not required. For metals, this test requires **dissolved** metal data rather than the total metal data used in modelling test 1 so a new calculation will be required.

The mean upstream quality should be compared to the calculated mean downstream quality for AA EQSs, or, where the substance has only a MAC (or 95 percentile) EQS, to the calculated 95 percentile downstream quality. If the calculated downstream concentration is higher than the upstream concentration plus 10 percent of the EQS, the substance is considered significant and a numeric emission limit is required for this substance on the permit.

Note: If water company trade effluent consent data have been used for this test and there are no effluent data, a monitoring requirement rather than a numeric emission limit should be added to the permit if the substance is significant, unless there is an observed risk to the EQS and/or a potential marked deterioration in receiving water quality. These monitoring data should then be reviewed to determine if the substance either needs to be controlled by a numeric limit, or if the monitoring requirement can be removed from the permit.

3.3. Modelling test 3 - risk of effluent quality deteriorating significantly

In order to protect against an unacceptable risk of effluent quality deteriorating significantly, it may be necessary to include a numeric emission limit or monitoring requirement on the permit. Below are a number of examples of how the Environment Agency might approach a perceived risk of effluent quality deteriorating.

It may be the case that only a small percentage of the permitted trade effluent into a sewage catchment has historically been used, and so using the current discharge quality there is no threat to EQS, or a significant deterioration in receiving water quality. However, if a greater proportion of the authorised trade effluent load were utilised, the load of hazardous pollutants in the sewage effluent may increase to the degree that there could be a significant deterioration, or even threat to the EQS in the receiving water. If this is the case then a standstill limit would be appropriate, until such time as the Water Company reviews the trade authorisations to reduce the consented load.

An additional example is where a substance is added as part of a treatment process (e.g. the addition of iron or aluminium compounds to assist sedimentation, and nutrient removal) (see separate dosing guidance in EPR 7.01 in the “Use of chemicals in treatment” section. In addition to the iron and aluminium (the primary cation), these dosing chemicals also contain small quantities of other substances such as cadmium and manganese. Where possible we expect the operator to minimise the input of these impurities by sourcing dosing material that contain minimal impurities.

It is worth noting that Water Companies often use standard emission limits for sulphate on trade discharges to sewer. This is primarily to protect the concrete of the sewer rather than sewage quality arriving at the works. Where limits are applied as a matter of routine to trade discharges within a sewerage catchment, the Environment Agency would not normally apply a numeric emission limit to the final effluent from the sewage works unless monitoring data showed that any modelling tests were being failed.

Silver and total cyanide are often permitted to sewer in trader inputs to the catchment with often no or little monitoring data for the final effluent or receiving watercourse for these substances. Removal rates for these substances are normally expected to be high and it is anticipated that the final effluent would be unlikely to contain these substance at significant levels. Where the modelling tests are predicted to be failed based on trader data alone, the Environment Agency would not normally apply a numeric emission limit, provided the Water Company agrees to obtain one year (12 samples) of effluent monitoring data for the substance, after which time the Environment Agency will confirm whether a numeric emission limit is required.

3.4. Local water body issues

When all the modelling tests have been completed, the Environment Agency will consult with its area water quality staff to ensure that there are no local issues which need to be taken into account. These local issues may override the modelling outcomes and mean that a limit is required when the modelling has shown that one is not needed. Where this is the case the justification for taking this approach must be robust.

Permits for new and varied discharges should be determined to ensure, as a minimum, that the current status for each element (including environmental standards) reported in the River Basin Management Plans is maintained. The no deterioration baseline for each water body is the current status that is reported in the River Basin Management Plans published in December 2009.

See section 5 for information on different approaches to take in response to specific water body issues.

4. Running the modelling tests for TraC waters

The modelling tests outlined below do not necessarily all need to be followed. For example, the Initial Dilution (ID) test can only be applied to buoyant discharges and is not applicable to inter-tidal discharges. In addition, a substance is unlikely to be screened out by the ID test unless the ID is expected to be large (e.g. discharge through an outfall with an extensive array of diffusers to deep water with strong currents).

Similarly, it may be clear from the outset that the discharge requires complex hydrodynamic modelling.

a. Initial Dilution (ID)

Initial dilution for a buoyant discharge is the dilution afforded to it as it rises to the surface, and determines the concentration of substances at the surface above the discharge. For example, if the ID is 10, then the concentration of pollutants at the surface would be reduced by a factor of 10.

The objective of ID modelling would be to check if the EQS is met after ID, taking into account the background concentrations. If it is met then the substance is not liable to cause pollution, and needs no further assessment. Note that this test needs to be undertaken for both the AA and MAC (or 95 percentile) EQS. For the former, use the average ID, and for the latter use the minimum ID.

b. Simple modelling

The objective of using a simple model, such as a spreading disc plume model, is to check whether the size of the mixing zone is acceptable or not. Such simple models are not site-specific hydrodynamic models, and may be simple spreadsheets. Usually, a number of scenarios must be undertaken to check the size of the mixing zone under different tidal conditions. The mixing zone relating to the Annual Average EQS is particularly difficult to determine, and decisions should normally be based on the size of the instantaneous mixing zone. However, site-specific aspects can also be relevant, and may need to be considered in assessing the modelling output. These may include additional dilution from a local stream, the sensitivity of the receiving waters and the local ecology, and/or the scale of the discharge relative to the local environmental setting.

c. Complex hydrodynamic modelling

This is used when the results from simple modelling are not sufficiently reliable to provide an answer which can be used with confidence, or the scale of the discharge warrants more complex modelling. At this stage, a site-specific hydrodynamic model will be used to model a whole range of scenarios. The objective is to produce graphical representations of the mixing zones in conjunction with maps showing the relevant receiving water features such as bathing waters, shellfish waters, SACs, SPAs, SSSIs, etc.

All the above modelling should be undertaken by the applicant, or by a consultant working for the applicant. The Environment Agency can give guidance as to what modelling is required, and may either undertake an audit of the modelling itself or, if necessary, require the applicant to have the model independently audited by an appropriate third party.

Are the Mixing Zones acceptable?

As described above, the output from the modelling will be a series of plotted Mixing Zones, possibly in 3-D. The next stage is to determine if these Mixing Zones are acceptable or not. The European technical guidelines for the identification of mixing zones should be consulted, as their use is a requirement of the EQS directive.

If a modelled Mixing Zone is acceptable, then permit limits can reflect the effluent flow and concentrations used in the modelling. If a Mixing Zone is not acceptable, then the Environment Agency either has to set permit limits which will deliver an acceptable Mixing Zone, or refuse the application.

5. Specific approaches

5.1. Discharges from abandoned mines

Abandoned mines are a significant source of hazardous pollutants, notably metals such as iron, lead, zinc, cadmium and copper, and anions such as chloride and sulphate. They contribute to eight percent of failures of good ecological status in surface waters. Research has shown that half of the total metals' load discharged to our rivers arises from abandoned mines. Defra policy, pollution reduction plans and River Basin Management Plans stress that abandoned mines need to be tackled for us to comply with our Water Framework Directive obligations and objectives.

The owners or operators of mines which were abandoned on or before 31 December 1999 cannot be held liable for permitting discharges from mines after they have closed and where there is no person causing a discharge. As there is no liable person, these discharges are not subject to regulation through the Environmental Permitting Regulations. Improvements in the quality of these mine waters cannot therefore be made by regulatory means alone.

For these mines, a significant programme of mine water treatment is conducted by the Coal Authority in partnership with the Environment Agency and other organisations. These programmes capture and treat mine waters before they discharge to rivers or sensitive groundwater. The programmes rely on government funding and there is no obligation on the operator to either build or operate the plants.

Once a treatment plant is built, it is subject to environmental permitting for a water discharge activity or, in certain cases, a mining waste operation. These permits provide a defence against a charge of causing or knowingly permitting a water discharge or groundwater activity for the operator. They also ensure that the plant is operated and maintained appropriately to reduce the pollution to the environment.

Mine waters carry very high loads of metals, public funds are limited and only limited control is possible over the sustainable, passive systems often employed to treat the mine waters. For these reasons it is not always possible for the discharge quality to meet EQS in the receiving water without entailing a disproportionate cost. However, the provision of treatment will make a significant improvement to the water environment by greatly reducing the load and concentration discharged and therefore the magnitude of the failure to achieve chemical standards.

Our memorandum of understanding with the Coal Authority states that, wherever possible, we will use descriptive permits for these discharges. Under some circumstances it may be appropriate to include numeric emission limits on a permit. Such circumstances would include where the discharge is new, for example where rising mine water has been intercepted before it has reached surface to avoid uncontrolled discharges, or is to a previously unpolluted part of a water body. The engineering requirements of the mine water capture and treatment could move the discharge between water bodies.

Recognising the environmental improvements made by providing these mine water treatment plants, where numeric emission limits are required it is appropriate to set limits which do not necessarily guarantee compliance with EQS in the receiving water body. Limits should be set based on predicted or actual performance. This course of action should be taken where the following conditions are met and the applicant has provided evidence for each condition:

- The discharge is from any mine abandoned on or before the 31 December 1999
- The treatment is being provided in line with River Basin Management Plan measures and objectives
- The operator is not legally obliged to improve the quality of the minewater
- The approach is approved by the Environment Agency's local environment management in consultation with regional water quality planning teams
- The design of the treatment plant is best practice taking into account the site-specific circumstances and the sustainability of the operation
- A suitable cost and benefit assessment has been carried out to determine that the costs are not disproportionate
- The plant is subject to suitable flow and quality monitoring to prove the effectiveness of the treatment

For mines that closed after 31 December 1999 the operator is liable for any discharge that occurs and the normal permitting process should apply.

We receive a small number of requests each year, often from academic institutions, for permission to build and operate experimental mine water treatment plants. These plants are small scale and involve diverting a proportion of the mine water flow, passing it through the experimental plant and returning it to the same channel. The operators carry out monitoring to determine how the plant is functioning.

The risk of pollution resulting from such plants is low; therefore the Environment Agency can agree that it will not pursue an application for a permit. Their local environment management team will notify the operator in writing of its position and stress that they must still take precautions to prevent pollution occurring. The operator may be prosecuted if pollution does occur as a result of their activity.

5.2. Small rivers, tributaries and dry ditches

In some situations, an effluent will be discharged to a small receiving water, tributary or dry ditch where dilution is very limited. In this situation, modelling is likely to show that some or all of the substances in an effluent will require a numeric emission limit.

In some cases, the calculated discharge limits that are needed to prevent deterioration by more than 10 percent of EQS may be too tight for the operator to comply with. If an acceptable amount of EQS deterioration is not achievable in the receiving small watercourse, we will usually expect the effluent to be treated to BAT standards or, where BAT is not available, the best technically feasible option should be used (unless the discharge is a temporary one - see further details on how to deal with these in section 5 – or if the discharge is to a designated sensitive area, in which case treatment to BAT standards may not be sufficient).

In some cases, it may be acceptable to allow more than 10 percent deterioration of the EQS in a watercourse, providing the downstream "main river" is not adversely impacted. In this situation, a permit limit protective of the main watercourse should be applied to the permit. All situations will be site-specific, and will depend upon the status of the receiving water and any susceptible/protected biota which may be present (this information can be obtained from the Environment Agency's area water quality staff).

Upstream and/or flow data will often be limited or unavailable in these watercourses. Where data are not available, alternative data appropriate for the site may be used. For example, where the receiving watercourse is a dry ditch of low ecological and amenity value which joins a larger watercourse within a short distance, flows and quality data (minus any discharge flows or concentrations) from the larger watercourse can be used in the calculations. If the discharge is rainfall-dependent, annual rainfall data for the site could be used to assess the impact of the discharge. Modelling cannot be carried out with no river flow data as the outcome of the modelling test would effectively be the same as the screening tests. However, If the discharge itself has a concentration of <10 percent EQS, the substance will be screened out. If the discharge quality is < EQS, it will not cause or contribute to a failure of EQS.

If the potential impacts of the discharge are unacceptable, the application for the permit may need to be refused if the impacts cannot be mitigated.

5.3. Rainfall-dependent and non-continuous discharges containing hazardous pollutants.

Non-continuous discharges include, amongst others, trade discharges from quarries, dewatering activities and contaminated land remediation schemes. These can be pumped discharges or can occur passively as a result of rainfall. These types of discharges can contain significant concentrations of hazardous pollutants. However, the discharge volumes and concentrations of substances discharged at these sites can vary widely over time, so it is often difficult to accurately define what the impact of such discharges will be, and whether or not the hazardous pollutants need to be controlled by a numeric emission limit.

Note: Rainfall-dependent discharges of site drainage will not normally be permitted, as operators must make every effort to remove sources of contamination from these discharges. A permit will only be granted for a discharge of contaminated surface water if stopping the contamination is unsustainable, and the contamination would not pollute the receiving water.

Note: This guidance does not apply to combined sewer overflows (CSOs). Guidance on assessing discharges from CSOs is given in the UPM guidance.

So how should these discharges be assessed?

Given the variability of these discharges, it is not possible to define a single methodology for assessing them. The dilution available in the receiving water will form part of the assessment, along with site operation, discharge regime and the uses, targets and objectives of the receiving environment. Listed below are some of the aspects which should be considered, along with possible approaches to use in assessing the impact of the discharge. It should be noted that not all these approaches will be suitable to use in all cases.

What volume should be used?

The volume of pumped discharges will depend upon the frequency and intensity of pumping. The maximum daily volume, based upon the maximum pump rate, can be used for screening and modelling purposes, and will appear as the maximum volume of the permit.

The maximum daily volume from passive site drainage discharges will depend upon the surface area of the site and the storm return periods being considered. For this reason, any permits for site drainage will have a 'rainfall-dependent' discharge volume.

Assessments will need to be pragmatic. The maximum daily volume will need to be calculated from the size of the site and the rainfall intensity. The choice of storm return period to be used in the screening exercise or other assessments will depend upon the site itself. Choose a longer return period for permanent sites (1 in 25 year or more), and a shorter return period for temporary sites, such as from land reclamation schemes, or construction schemes.

What is the concentration?

In order to be confident of the discharge quality the Environment Agency will need to see results from analysis. The more sample results available the more likely it is that they will be representative of the discharge.

If the discharge is rainfall-dependent site drainage, it is likely that analysis following a prolonged dry period would show higher concentrations of substances than analysis of the discharge after a prolonged wet period. The concentration of substances in discharges made via a settlement lagoon will be less variable than direct discharges.

Similarly, a discharge from a dewatering activity may have higher concentrations of a substance at the beginning of the dewatering activity than at the end of a period of pumping, unless the discharge is made via a lagoon, or if there is mobilisation of pollutants from adjacent contaminated land.

Choice of EQS for screening and assessment

The MAC (or 95 percentile) EQS should be used to prevent acute short-term impacts. This will be the most appropriate EQS to protect the watercourse when assessing discharges that occur infrequently. If there is no MAC (or 95 percentile) EQS, judgement should be used to determine whether the AA EQS is appropriate to use in any assessments. It may be possible, for example, to use acute toxicity data to derive a suitable threshold value.

For discharges that occur frequently (daily or weekly), protection against long-term effects is important, and the aim should be to comply with the AA EQS in the watercourse.

Options for assessment:

For frequently occurring discharges, one option is to treat the discharge as though it occurs continuously and use Monte Carlo to assess the impact. In this situation, there will be uncertainty surrounding the input data, due to the reasons outlined above, but this type of assessment might be considered precautionary if the EQS is an AA EQS. For this assessment, it would be assumed that the discharge occurs continuously at the maximum volume and at a concentration based on sample data. As always, the feasibility, and cost, of achieving the calculated permit limit needs to be considered.

Alternatively, if it is deemed necessary to have a numeric emission limit on the permit, it is possible to apply a numeric emission limit based upon available dilution i.e. the dilution of the receiving water can be used to 'back calculate' an allowable discharge concentration. It is important to consider whether to use a Q95 or mean flow for the receiving water in this calculation, and whether to use a maximum, or mean, discharge volume for the discharge. The decisions made will depend on the substance and the type of EQS (MAC/95 percentile or AA). The percentage deterioration also needs to be considered; where the discharge occurs to a small ditch or tributary, more than 10 percent deterioration of EQS, or even EQS failure, may be an option if the EQS is an AA and the discharge is temporary.

5.4. Temporary dewatering activities

The intermittent nature of dewatering activities makes the setting of permit limits difficult. In addition, setting permit limits on temporary discharges can be problematic, as the costs of any required treatment improvements are often not feasible. In both cases, it may be appropriate to set the permit limit to achieve the MAC (or 95 percentile) EQS (if there is one) rather than the AA EQS. If these permit limits are still unachievable, the guidance for small rivers, tributaries and ditches above can also be applied to these types of discharge.

However, if the potential impacts of the discharge are unacceptable, the application for the permit will need to be refused.

5.5. Discharges to lakes or still waters

Modelling the impact of discharges on lakes, canals, reservoirs and other still waters is highly site-specific and may require a different approach according to the watercourse being modelled. The most appropriate approach is to request the applicant to provide a full assessment of likely impacts with any application for a new discharge. This should take account of accumulation and the extent to which the water body is impacted. This could include assessment of the mixing zone(s) in the water body and any potential breaches of EQS.

When modelling the discharge, the applicant will not be expected to demonstrate compliance with the 10 percent deterioration test but should ensure that the relevant EQS is achieved in the receiving body of water. The assessment should include an estimate of the potential for any substances to accumulate within the full cross-sectional area of the receiving environment.

If appropriate for the receiving environment, discharges should be permitted using an end of pipe limit set at the appropriate EQS for any potentially polluting hazardous pollutant known to be present.

5.6. Chloride & sulphate in domestic sewage effluents

Chloride is a ubiquitous anion in the environment and is present in sewage from urine and many other sources. It is not considered to have an adverse environmental impact at levels normally associated with final effluent concentrations (around 100 - 150 mg/l) and it is Environment Agency practice not to control chloride by a numeric emission limit unless there is a risk to EQS or there is particular receptor sensitivity. Where chloride or sulphate is associated with chemical dosing at a sewage works, the control of the primary cation (usually iron or aluminium) is sufficient to control this addition.

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