Section 2

Regulatory Aspects

2. SECTION 2. REGULATORY ASPECTS

Section 2 of the Manual presents a range of wet weather related design criteria based on standards to protect beneficial uses of receiving waters; for example, river aquatic life, bathing, shellfish harvesting and general amenity use. The standards presented are illustrative of the type of criteria that may be specified by a particular environmental regulator to manage the impact of intermittent urban wastewater system discharges in response to wet weather episodes. However, as identified in Section 1, the UPM Manual does not present the specific policies or requirements that may be applied by a particular environmental regulator. Site specific, use based, wet weather criteria form the foundation to the UPM Procedure.

Section 2 considers the following environmental aspects of regulation of urban wet weather discharges:

2.1 Environmental regulation of wet weather discharges.

2.2 Performance criteria for CSOs.

2.3 Wet weather standards for protecting river aquatic life.

2.4 Standards for protecting bathing waters.

2.5 Standards for protecting shellfish waters

2.6 Standards for protecting amenity use.

2.7 Location of Outfalls.

Further information on the derivation and use of these standards can be found in the accompanying Appendices A, B and C.

2.1 Environmental regulation of wet weather discharges

2.1.1 Technical guidance

All applications of the UPM Procedure must meet the site specific requirements set by the appropriate environmental regulatory body; for example, in the United Kingdom this is the Environment Agency, SEPA and NIEA. These requirements, set out as policy statements, aim to ensure that beneficial uses of receiving waters will not be compromised by wet weather urban wastewater discharges from CSOs, SWOs, storm tanks and STWs.

Environmental policy will differ between environmental regulators and a particular regulator's policy may change with time. The UPM Procedure provides a rational basis for a discharger to demonstrate that proposed plans will be compliant with any specific environmental policy. The specific objective of Section 2 is not to present or evaluate any particular environmental policy but to provide technical guidance on the potential choices of appropriate environmental criteria. The criteria, presented by way of illustration, for the management of intermittent urban wastewater discharges have a strong scientific basis and are in common use in the United Kingdom and some other European countries. Identification of the appropriate site specific environmental criteria is one of the first key stages in the application of the UPM Procedure at a particular location. It is crucial that both the discharger and the regulator agree on the nature of the wet weather problem, the basic environmental framework and key criteria (standards) before proceeding further with a UPM study.

An environmental regulator may choose, as a matter of policy, to vary the quoted values or to apply alternative forms of environmental criteria. Hence, the need to identify actual environmental requirements at the stage of Initial Planning, as described in Section 3. Environmental regulators are also increasingly likely to require climate change scenarios to be carried out.

2.1.2 Environmental Quality Objectives and Standards (EQOs and EQSs)

A general principle underlying UK policy (DoE, 1977 see UPM2 References, Section 1.2) for the protection of the aquatic environment is that standards to which individual discharges are required to conform should be set by reference to the ability of the receiving waters to accommodate contaminants, without detriment to the uses specified for those waters. In applying this principle, Environmental Quality Objectives (EQOs) are used to specify the desired uses of a water body. Environmental Quality Standards (EQSs) are then defined as concentrations of target substances such that, when achieved, these EQOs are met and the desired uses are protected.

EQSs can serve two functions. First, they can provide a reference against which the actual quality of a body of water can be judged by monitoring. Second, where EQSs are set above the level of detection for a particular substance they provide the criteria for deciding, based on calculations, whether or not a proposed scheme or upgrading solution will provide adequate environmental protection. It is this second function that is most important in the application of the UPM Procedure.

2.1.3 Relevant beneficial uses for receiving waters

There are a number of legitimate uses that can be recognised for surface waters. These include, for example, fisheries, recreation, potable water supply, industrial abstraction and agricultural abstraction. All these uses can be affected to some extent by wet weather discharges from wastewater systems. The uses that have been identified as most likely to be impacted by intermittent discharges include the following.

- **River aquatic life**
  Frequent short periods of low DO or high un-ionised ammonia concentrations in a river or other freshwater body can affect invertebrates and fish and so hinder the establishment of a sustainable fishery. Wet weather discharges can be the cause of such events.

- **Bathing**
  This use applies to identified bathing waters, where there is a requirement to ensure compliance with the EC Bathing Water Directives (1976 and 2006). Intermittent discharges of storm sewage can increase the risk of non-compliance with these Directives.

- **Shellfish Harvesting**
  This use applies to designated shellfish waters, where there is a requirement to protect or improve compliance with the Shellfish Water Directive and shellfish harvesting areas (protected Areas under the Water Framework Directive) where there is a requirement to protect or improve water quality to meet any targets under the Shellfish Hygiene Directive that may have been agreed for these areas with the environmental

regulator. Intermittent discharges of storm sewage can increase the risk of non-compliance with these Directives.

- **General amenity**
  The amenity value of a body of water is affected by many visual factors including the presence of gross sewage solids and sewage related debris. Discharges from CSOs are often a major source of gross solids.

The potential wet weather standards for each of these four uses, and how these standards may be applied, are discussed in the following sections. Additional criteria may be required to protect other uses; for example, relevant EC Directives to protect drinking water abstraction and user requirements for industry and agricultural uses.

In theory, a water body could be designated for any or all of these uses. At present it is rarely appropriate to consider both the river aquatic life and the bathing or shellfish standards for an individual water body in the UK. This will not be true in other countries.

All surface waters will have some amenity use and compliance with the standards designed to protect this use will need to be checked in all cases.

The general applicability of all the `wet weather' standards and the order in which they are used in the planning phase is shown in Figure 2.1.

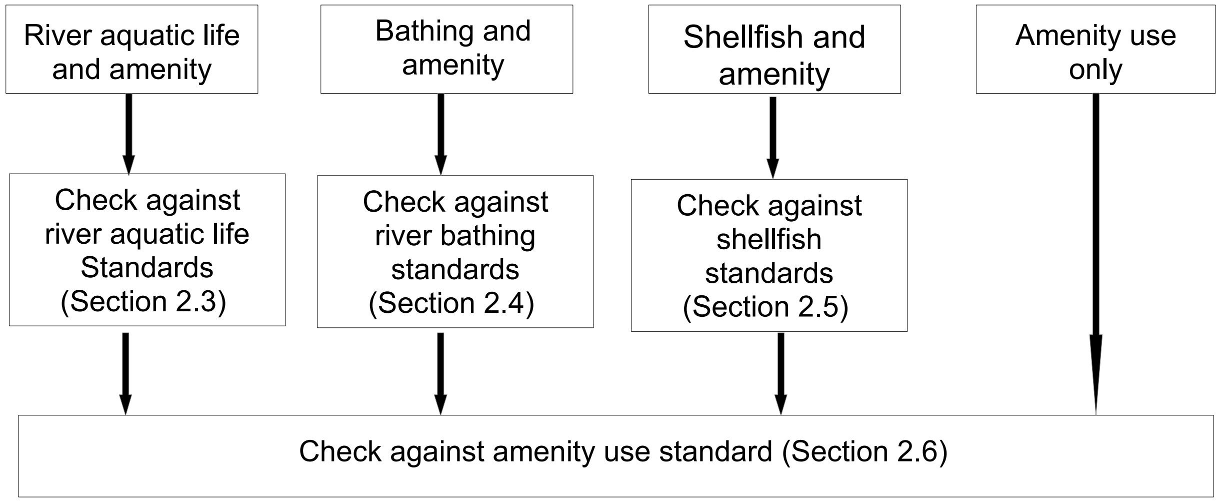

Figure 2.1 Applicability of standards in the planning phase

2.1.4 Types of standard

Most of the standards developed to protect beneficial uses from wet weather pollution are EQSs that describe concentrations that must be achieved in the receiving water. Others applied to discharges are emission standards that describe the concentrations that must not be exceeded by a discharge. Emission standards may be applied where EQSs to protect designated uses have not been identified; for example amenity uses, as described in Section 2.6, or where control is based on a specified level of wastewater system performance. Emission standards are also used as surrogates for EQSs. For example, a maximum spill frequency may be set that will ensure that an EQS will be met, as illustrated in Sections 2.4 and 2.5; or, an emission standard may be set to reduce the discharge of nutrients.

A particular environmental regulator’s policy may also have a requirement for a minimum level of wastewater system capacity or performance over and above that required to meet a specific EQS or emission standard. This minimum requirement may, therefore, override a solution identified by the application of the UPM Procedure. Expressions for minimum requirement criteria may, for example, take the form of: a minimum retained flow within the system (as a multiple of DWF, or some derivative) or a minimum storage capacity, related to catchment area or DWF.

2.2 Performance criteria for CSOs

A requirement of the EC Urban Waste Water Treatment Directive (UWWTD) is to limit pollution of receiving waters resulting from storm discharges. To meet this requirement, pollution of receiving waters caused by CSOs must be assessed in some way by all EC Member States. In the UK, general performance criteria are used to assess CSO impact in order to designate CSOs as either 'satisfactory' or 'unsatisfactory'. The following criteria have been used in the United Kingdom to identify 'unsatisfactory' performance (DETR, 1997 see References UPM2, Section 1.2) (updated Environment Agency 2011)).

- CSO causes significant visual or aesthetic impact due to solids (i.e. sewage-derived litter such as sanitary hygiene products, contraceptives and alike) or sewage fungus (cotton-wool like growths of attached micro-organisms associated with heavy organic enrichment) .
- CSO causes or makes a significant contribution to a deterioration in river chemical or biological quality/class.
- CSO causes or makes a significant contribution to a failure to comply with Bathing Water Quality Standards for identified bathing waters.
- CSO operates in dry weather conditions.
- CSO operates in breach of consent conditions provided that they are still appropriate.
- CSO causes a breach of water quality standards and other EC Directives.
- Causes unacceptable pollution of groundwater.
- Due regard should also be paid to the presence of shellfish waters designated under the Shellfish Waters Directive or Shellfish Hygiene Directive in the vicinity of the CSO.

2.3 Wet weather standards for protecting river aquatic life

2.3.1 The need for wet weather standards

Many environmental regulators specify percentile based water quality standards to define river use classes. For example, such criteria for England and Wales were formerly set out in the Rivers Ecosystem Classification (DoE 1994) and are now set out in the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. These criteria may include BOD, dissolved oxygen (DO), total ammonia and un-ionised ammonia, expressed in terms of percentiles (90 or 95 percentiles for BOD, ammonia and un-ionised ammonia and 10 percentiles for DO), as illustrated in Tables 2.1 and 2.2. One of the prime uses of the annual percentile based standards is to ensure an adequate level of protection to ecosystems that receive continuous discharges.

Table 2.1 Illustration of percentile based river quality standards (DoE, 1994)

Class	Dissolved oxygen % saturation 10 percentile	BOD (ATU) mg/l 90 percentile	Total ammonia mg N/l 90 percentile	Un-ionised ammonia mg N/l 95 percentile
RE1	80	2.5	0.25	0.021

Class	Dissolved oxygen % saturation 10 percentile	BOD (ATU) mg/l 90 percentile	Total ammonia mg N/l 90 percentile	Un-ionised ammonia mg N/l 95 percentile
RE2	70	4.0	0.6	0.021
RE3	60	6.0	1.3	0.021
RE4	50	8.0	2.5	-
RE5	20	15.0	9.0	-

Note: Additional RE criteria for pH, Hardness, Dissolved Copper and Total Zinc are not illustrated.

Table 2.2 Illustration of percentile based Water Framework Directive water quality standards for rivers (Defra 2010)

Status	Dissolved oxygen % saturation 10 percentile		BOD (ATU) mg/l 90 percentile		Total ammonia mg N/l 90 percentile	
Waterbody Type	1,2,4 and 6 Salmonid	3,5 and 7	1,2,4 and 6 Salmonid	3,5 and 7	1,2,4 and 6	3,5 and 7
High	80	70	3.0	4.0	0.20	0.30
Good	75	60	4.0	5.0	0.30	0.60
Moderate	64	54	6.0	6.5	0.75	1.10
Poor	50	45	7.5	9.0	1.10	2.50

Wet weather discharges may affect river water quality for relatively short periods of time. However, these short term events can have a disproportionate impact upon river aquatic life. Furthermore, the quality of a river during these events may not be related in any simple fashion to the more general quality of the river. Figure 2.2 shows a comparison between the BOD frequency distributions for a river, with and without intermittent discharges. The 90 and 95 percentile qualities are similar in both cases (4 mg/l and 5 mg/l, respectively) such that the river would have the same river ecosystem class based on these criteria. However, with intermittent discharges, the short duration, high concentration events (that can have a significant impact upon the river aquatic life) extend the tail of the frequency distribution. The shape of this extended tail reflects the size and frequency of the intermittent discharges and the dilution capacity of the river at the time of the discharges. In Figure 2.2 the distribution without CSO discharges has a 99 percentile of 7 mg/l while the distribution with CSO discharges has a 99 percentile of 30 mg/l. Frequent, unsatisfactory intermittent discharges will significantly extend the tail. The frequency distribution tail will be unique to a particular river system.

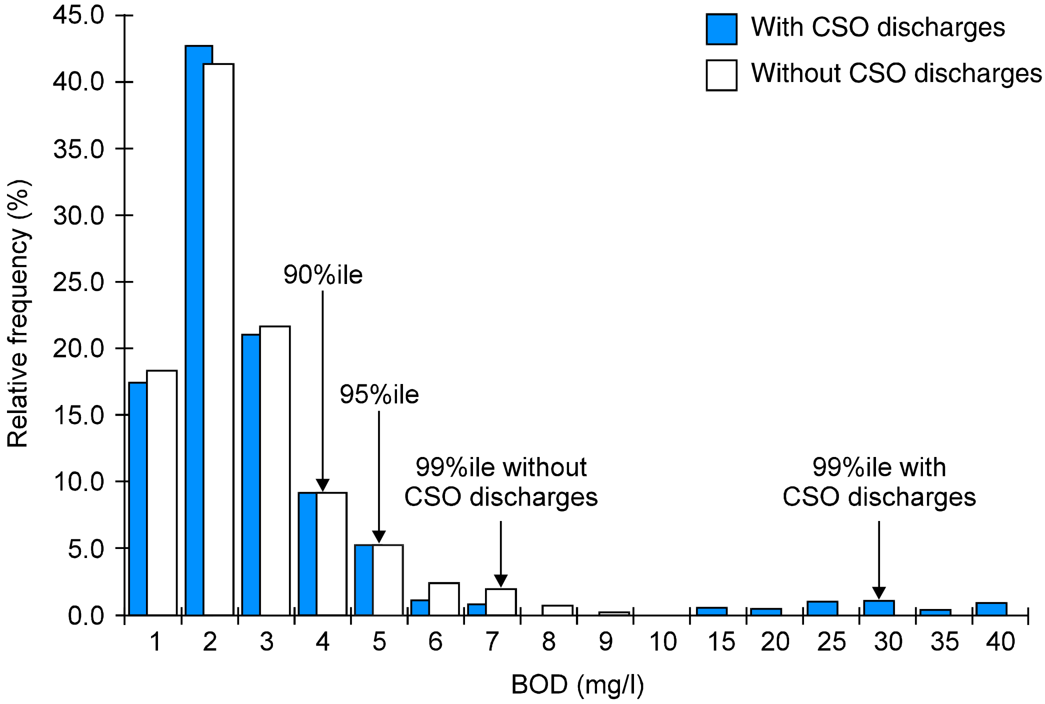

Figure 2.2 River BOD frequency distributions, with and without intermittent CSO discharges

Hence, there is a need for separate standards related to the specific quality of a particular river water that can be allowed during short duration intermittent events. In effect, these intermittent standards are needed to define an acceptable tail to the frequency distribution. As such, they are complementary to the 90/95 percentile criteria used in the UK to define river ecosystem classes and Water Framework Directive status.

Two approaches are available to identify standards to protect freshwater aquatic life from wet-weather pollution episodes. These are:

- intermittent standards that are directly related to the characteristics of events that cause stress in river ecosystems. These standards are expressed in terms of concentration-duration thresholds with an allowable return period or frequency; and,
- high percentile standards (such as 99 percentiles) based on an extrapolation of the 90/95 percentile thresholds used for protecting ecosystems that receive intermittent polluting discharges.

Demonstration of compliance with either or both types of criteria may be required, depending on environmental policy with respect to site specific conditions.

2.3.2 Fundamental Intermittent standards

In response to the need for wet weather environmental standards that are directly related to conditions that cause stress in freshwater ecosystems, ecotoxicological research was first carried out to develop wet weather standards (Milne *et al*, 1992 see UPM2 References, Section 1.2). This has led to the formulation of Fundamental Intermittent standards for DO and un-ionised ammonia. These standards are expressed in terms of concentration and duration thresholds for a range of return periods (RPs) for individual pollution episodes. Further consideration of this research led to the development of three sets of standards, relating to different levels of protection for episodes up to a return period of 1 year. These three sets of standards were first documented in the 2nd version of this Urban Pollution Manual and are for:

a) ecosystems suitable for sustainable salmonid fishery;
b) ecosystems suitable for sustainable cyprinid fishery; and,
c) marginal cyprinid fishery ecosystems.

For a) and b), above, the standards provide protection to all life-stages of all aquatic life (fish, invertebrates, plants) associated with the specified ecosystem type. For c), the standards provide adequate protection for adult coarse fish, with the possible exception of the most sensitive coarse fish species and may not afford adequate protection to sensitive life-forms of all coarse fish species.

The standards for DO are presented in Table 2.3 and those for un-ionised ammonia in Table 2.4. Correction factors may need to be applied, as identified in Tables 2.3 and 2.4, to account for changes in the toxicity of un-ionised ammonia under different environmental conditions and the synergistic toxic effects of high un-ionised ammonia and low DO occurring together. Further details relating to the development of these standards, their scientific basis and on the application of appropriate correction factors are discussed in Appendix A.

If a river of a specified ecosystem type meets the appropriate standards, or can be shown to meet them by a suitable planning procedure, aquatic life in the river should have adequate protection against the effects of short term exposure to storm sewage discharges, subject to the following two provisos.

The DO thresholds for salmonid spawning grounds, should be met not only in the water column but also in the intergravel water where the eggs and larvae are developing. Typically, the intergravel DO can be up to 3 mg/l less than the water column DO. Therefore, in this situation 3 mg O/l should be added to the standards that represent the water column concentration. Further guidance is presented in Appendix A of the dynamic section/document.

It is important to check that the storm sewage discharges do not contain high levels of other substances that may be damaging to aquatic life.

The standards are based on the objective of no long term detrimental effects on the aquatic ecosystem type and no fish mortality for wet weather pollution episodes of up to one year RP. Events with longer RPs are likely to have a more severe impact on the receiving water. Identification of an acceptable risk (RP) of fish mortality from more extreme episodes will require further investigation before standards for events with longer RPs can be identified (Appendix A).

Table 2.3 Examples of Fundamental Intermittent standards for dissolved oxygen - concentration/duration thresholds not to be breached more frequently than shown

a) Ecosystem suitable for sustainable salmonid fishery

Return period	**Dissolved Oxygen concentrations (mg/l)**		
	1 hour	**6 hours**	**24 hours**
1 month	5.0	5.5	6.0
3 months	4.5	5.0	5.5
1 year	4.0	4.5	5.0

b) Ecosystem suitable for sustainable cyprinid fishery

Return period	Dissolved Oxygen concentrations (mg/l)		
	1 hour	6 hours	24 hours
1 month	4.0	5.0	5.5
3 months	3.5	4.5	5.0
1 year	3.0	4.0	4.5

c) Marginal cyprinid fishery ecosystem

Return period	Dissolved Oxygen concentrations (mg/l)		
	1 hour	6 hours	24 hours
1 month	3.0	3.5	4.0
3 months	2.5	3.0	3.5
1 year	2.0	2.5	3.0

Notes

1. These limits apply when the concurrent un-ionised ammonia (NH_3-N) concentration is below 0.02 mg/l. The following correction factors apply at higher concurrent un-ionised ammonia concentrations:

   0.02 - 0.15 mg NH_3-N/l: correction factor = + (0.97 x $\log_e$(mg NH_3-N/l) + 3.8) mg O/l

   >0.15 mg NH_3-N/l: correction factor = +2 mg O/l.

2. A correction factor of 3 mg O/l is aaded for salmonid spawning grounds.

Table 2.4 Examples of Fundamental Intermittent standards for un-ionised ammonia - concentration/duration thresholds not to be breached more frequently than shown

a) Ecosystem suitable for sustainable salmonid fishery

Return period	Un-ionised ammonia concentrations (mg NH_3-N/l)		
	1 hour	6 hours	24 hours
1 month	0.065	0.025	0.018
3 months	0.095	0.035	0.025
1 year	0.105	0.040	0.030

b) Ecosystem suitable for sustainable cyprinid fishery

Return period	Un-ionised ammonia concentrations (mg NH_3-N/l)		
	1 hour	6 hours	24 hours
1 month	0.150	0.075	0.030
3 months	0.225	0.125	0.050
1 year	0.250	0.150	0.065

c) Marginal cyprinid fishery ecosystem

Return period	Un-ionised ammonia concentrations (mg NH_3-N/l)		
	1 hour	**6 hours**	**24 hours**
1 month	0.175	0.100	0.050
3 months	0.250	0.150	0.080
1 year	0.300	0.200	0.140

Notes

1. These limits apply when the concurrent dissolved oxygen concentration is above 5 mg/l. At lower concurrent dissolved oxygen concentrations the following correction factor applies:

   <5 mg/l DO, multiplicative correction factor = 0.0126 (mg DO/l)$^{2.72}$

2. The standards also assume that the concurrent pH is greater than 7 and temperature is greater than 5°C. For lower pH and temperatures the following correction factors apply:

   pH <7, multiplicative correction factor = 0.0003(pH)$^{4.17}$

   Temperature <5°C, multiplicative correction factor = 0.5

The Fundamental Intermittent standards comprise a number of concentration/duration conditions each of that must not have a RP shorter than that shown in Tables 2.2 and 2.3. To interpret these standards, it is important to understand the term RP. The RP of a particular set of conditions (e.g. 5 mg DO/l for six hours) is the average period of time over a sequence of years which elapses between two events when the river conditions are equal to or worse than the stated conditions.

Consider the river condition where DO is below 4 mg/l for one hour or longer. According to Table 2.4b (cyprinid fishery standards), this condition has an allowable RP of one month and may be referred to as the *4 mg/l - one hour - one month* standard. This means that the DO concentration at any given point in the river can occasionally fall below 4 mg/l for periods equal to or longer than one hour provided that the average interval between such events is not less than one month. Thus, there could be 12 such events per year on average (assuming that the events are randomly distributed throughout a year - see below).

Continuing with this example, the durations (when DO is less than 4 mg/l) for most of these 12 events must be less than six hours. Indeed, the standards allow for only one event per year on average to have a duration equal to or in excess of six hours - this is the *4 mg/l - six hour - one year* standard shown in Table 2.2b.

Figure 2.3 illustrates this interpretation of the Fundamental Intermittent standards by reference to a hypothetical time series of DO values in a river during an ‘average’ year. The time series shows that the 4 mg/l DO threshold is breached for more than one hour six times in the year. The actual RP for this river condition is, thus, about two months. If this was a real record, it could be said that the *4 mg/l - one hour - one month* DO standard is met. Furthermore, the *4 mg/l - six hour - one year* DO standard is also met as the 4 mg/l threshold is breached for more than six hours only once in the year. In a similar way, it can be shown that other thresholds may also be met such that the river at this point is fully compliant with the Fundamental Intermittent standards for DO.

Application of the Fundamental Intermittent standards for DO and un-ionised ammonia allows the full potential benefits of the site specific environmental needs approach to be gained that forms the foundation to the UPM Procedure. The Fundamental Intermittent standards should only be used for design purposes and not for compliance assessment based on observed data.

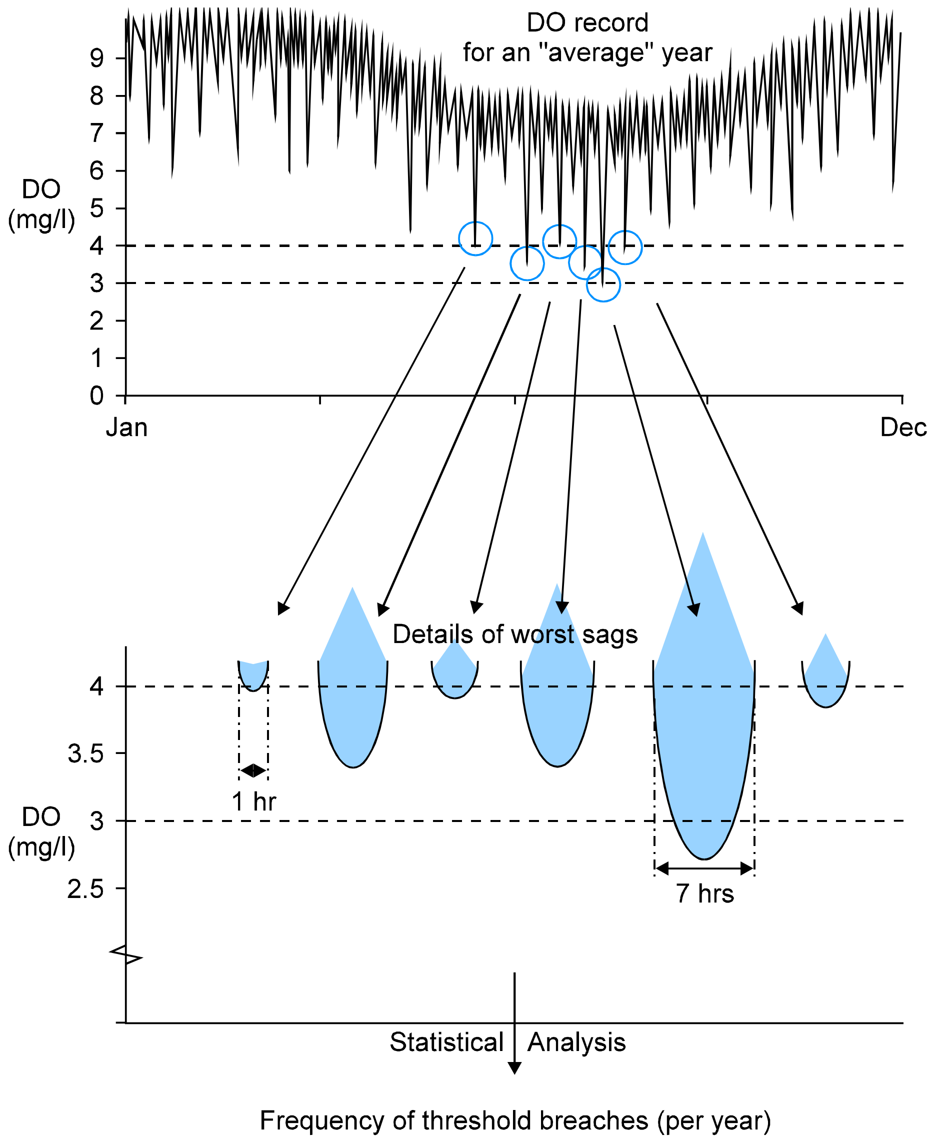

Figure 2.3 Hypothetical DO record for a river illustrating the meaning of the Fundamental Intermittent standards

The following subsections give further guidance on the application of the Fundamental Intermittent standards.

a) Random clustering of events

It can be seen that in the example given in Figure 2.3, there is some clustering of events in one part of the year. Generally, it is to be expected that the occurrence of river conditions that breach a particular threshold will not be evenly distributed throughout a year, or from year to year. Some of this clustering will simply reflect the random nature of the rainfall and other factors that contribute to the river events. For this reason it is important to analyse performance over a suitable period of time so that RPs can be properly assessed.

In particular, when considering the one year RP thresholds, it is important to look at performance over a number of years as the pattern of DO sags will vary from year to year. For example, consider a ten year period during which there are nine occasions when DO dropped below 4 mg/l for more than six hours. As this river condition has an allowable RP of one year, the situation would be in compliance with the intermittent standards.

In any given year there may be more than one event when the one year RP condition is breached. This does not necessarily breach the Fundamental Intermittent standards when used to assess the long term performance of a design, unless the average number of failures is greater than 1 per year. For example, the actual year to year sequence of these DO sags might well be:

	Year									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
No of times DO falls below 4 mg/l for 6 hours or more	0	0	1	0	2	1	0	3	1	1

b) Seasonal clustering of events

If there is a pronounced clustering of events in a particular season of the year as illustrated in Figure 2.3, this is a different situation and must be taken into account when calculating actual RPs.

For example, consider the situation where the *4 mg/l - one hour* threshold (allowable RP of one month for sustainable cyprinid fishery standards) is breached on 80 occasions in a ten year period. If these breaches are randomly distributed throughout the ten years, and throughout each year, then the actual RP would be: 120 months / 80 = 1.5 months, representing a compliant situation. However, if the breaches always occur in the summer months (because, for example, river flows are low and temperatures high) the actual RP should be calculated based on these summer months only. For example, assuming that the breaches always occur in a 5 month summer period, the RP would be: 50 months / 80 = 0.63 months.

This situation would not meet the Fundamental Intermittent standards as the actual return period is less than 1 month.

c) Closely spaced events - recovery period

There is a recovery period for exposure to ammonia or to low DO during which fish will be more susceptible to further exposure to any contaminants. This is probably of most consequence in the case for exposure to un-ionised ammonia. Currently, it is not possible to define this recovery period with any certainty as it will vary according to the exposure duration and concentration. This problem typically arises when predicted concentrations exceed a threshold for a period, briefly recover and then exceed the threshold again later. In this situation, it is recommended that the total exceedance period for the event is taken as the sum of the separate exceedance periods, if the intervening period (when concentrations recover) is less than or equal to 6 hours. If the intervening period is more than 6 hours, the exceedances should be treated as separate events.

Figure 2.4 shows a hypothetical example of two closely spaced exceedances of a threshold. In a river where the salmonid fishery standards are applied, the 1 hour, 1 month RP un-ionised ammonia threshold (0.065 mg/l) was exceeded for 3 hours early in the event. Un-ionised ammonia then fell below 0.065 mg/l for a period of 2.5 hours, before again exceeding 0.065 mg/l, this time for a period of 4 hours. Taken separately, these two exceedances would each be allowed once a month, on average. However, because they are separated by less than 6 hours, the exceedance periods should be combined, giving a total exceedance period of 7 hours. This now breaches the 6 hour 1 year RP threshold (0.04 mg/l). Hence, this combined event would only be allowed once a year, on average.

d) Diurnal fluctuations in DO

In some situations, particularly lowland, nutrient rich, effluent-dominated rivers there may be extreme diurnal fluctuations in DO due to the effects of eutrophication. In this situation there are three main issues, which influence the application of the Fundamental Intermittent standards:

- The DO impact of a wet weather event can be very dependent on time of day the discharge occurs - during the day the extra DO from photosynthesis may mitigate the extra BOD;
- Night-time DO sags may be of sufficient magnitude to cause daily breaches of the 1 month RP, or even 1 year RP, thresholds; and,
- The low night time DO may require severe correction factors for un-ionised ammonia.

A simple approach in such situations is that extreme diurnal fluctuations due to eutrophication are ignored when considering wet weather DO impacts. Thus, in modelling studies, photosynthesis and respiration processes could be ignored or set to average values and background river DO concentrations set at an average value. This allows the impact of the extra wet weather load to be quantified and compared for different upgrading solutions. The environmental regulator may provide further guidance on the use of the standards, or on alternative standards (e.g. spill frequency standards), in these circumstances.

Section 2.3.2 (f) **'Timing of DO sags and un-ionised ammonia peaks leading to the need for correction factors'** provides advice where diurnal variations are not due to the effects of eutrophication and are less severe.

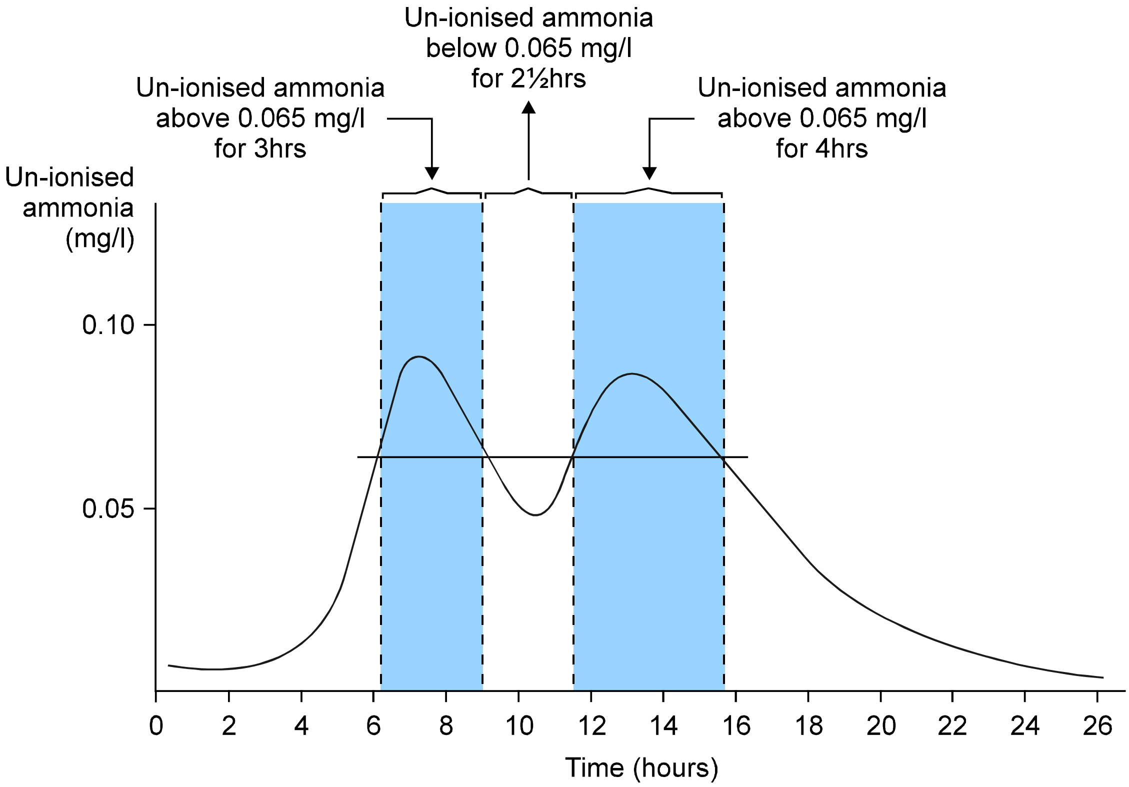

Figure 2.4 Hypothetical example of closely spaced high un-ionised ammonia episodes

e) Background failure of DO thresholds

In addition to situations where low night time DO values are produced by diurnal fluctuations in DO, in some rivers the DO threshold concentrations identified in Table 2.2 may be breached regularly or continuously for a period of several days or weeks under dry weather conditions. Typically, this occurs where high water temperatures are associated with summer low flows. In some cases, the level of oxygen depletion may require artificial re-aeration or other remedial measures to prevent fish deaths. Despite this, these poorer quality rivers may still achieve some water quality objectives (e.g. RE class 4 or 5) which allows for long periods of low DO and may still maintain coarse fish populations.

Without separating out the non compliant situations occurring in dry weather conditions from the non compliant situations occurring after wet weather it is not possible to apply the Fundamental Intermittent standards for DO to these rivers in assessing the impact of storm discharges. Checking for compliance with the Fundamental Intermittent standards for un-ionised ammonia (corrected for low DO where necessary) could be carried out. Alternatively, it may be appropriate to separate out the non compliant situations occurring in dry weather conditions from the non compliant situations occurring after wet weather in order to develop improvements and measures to address both dry weather and wet weather impacts. It is important that these situations and the actual environmental requirements are identified at the stage of Initial Planning as described in Section 3.

The environmental regulator may provide further guidance on the use of the DO standards or other criteria (such as high percentile standards for BOD, as illustrated in Section 2.3.3 or spill frequency standards) in these circumstances. For example, DO performance could still be quantified in terms of concentration/duration/frequency and these statistics used for comparing the impact of different options

f) Timing of DO sags and un-ionised ammonia peaks leading to the need for correction factors

If a wet weather low DO episode occurs at the same time as a critical un-ionised ammonia peak, there will be a requirement to use the relevant correction factor, as described above. As noted above, following exposure to ammonia or to low DO there is a recovery period during which fish will be more susceptible to further exposure to any contaminants. Therefore, the correction factor may also need to be applied in cases where the two events (low DO and high un-ionised ammonia) are not exactly coincident.

As a practical rule, if the timing of the maximum un-ionised ammonia and minimum DO during an event are within less than 12 hours of each other, they should be considered coincident for the purposes of calculating correction factors. In addition, the appropriate correction factor is dependent upon the threshold being checked. Thus, if the 1 year RP 1 hour duration DO threshold is being checked, the correction factor should be based on the un-ionised ammonia level that is exceeded for 1 hour. An illustrative example of this principle is given in Appendix A A.1.3. If there is uncertainty in the timing of critical events, as defined by model runs, a cautionary approach should be taken and the events considered coincident.

It is recommended that large diurnal fluctuations in DO due to eutrophication should be ignored when considering wet weather DO impacts. When it comes to the possible application of correction factors, however, normal diurnal variation in DO should be considered. Thus, night-time DO sags might lead to the requirement for the correction of un-ionised ammonia thresholds.

g) Critical thresholds

Clearly, to meet the Fundamental Intermittent standards, it is necessary to meet all the individual thresholds shown in Tables 2.2 and 2.3. In many cases it will be obvious that one set of thresholds is more critical than others. Planning procedures will then hinge on demonstrating compliance with these critical thresholds only, in the knowledge that the other thresholds will be met automatically. In other cases, demonstration of compliance with all thresholds may be required.

h) Application to lakes and brackish waters

The Fundamental Intermittent standards were designed for the protection of freshwater life and were derived from data relating exclusively to freshwater life. Therefore, they are applicable to both rivers and lakes. Application to lakes may require consideration of 2 and 3 dimensional changes in water quality. Environmental regulators may require spill frequency solutions in situations where initial mixing is limited.

The dissolved oxygen standards should provide adequate protection to aquatic life in brackish waters/tidal rivers, if applied in similar ecosystem contexts. For ammonia, less information is available but there is no reason to suppose that similar levels of protection should not be afforded to aquatic life in brackish waters/tidal rivers. However, it is recommended that local considerations are taken into account when applying intermittent standards to tidal/brackish waters.

The largest brackish waters study that has been carried out in the United Kingdom is the Thames Tideway Strategic Study. Considerable scientific work was carried out to derive site specific Environmental Quality Standards (EQSs) for the Thames Estuary. The standards that were derived are similar in format to the fundamental intermittent standards and are tabulated below.

Table 2.5

UPM Standards for the Thames Estuary		
Dissolved Oxygen mg/l	**Return Period (years)**	**Duration (no of 6 hour tides)**
4.0	1	29
3.0	3	3
2.0	5	1
1.5	10	1

Note: The objectives apply to any continuous length of river >=3km. Duration means that the DO must not fall below the limit for more than the stated number of tides. A tide is a single ebb or flood.

2.3.3 Percentile standards

The second potential approach to setting wet weather standards is to define high percentile criteria, such as the 99 percentile based on an extrapolation of the 90/95 percentile thresholds used to protect ecosystems that receive continuous discharges.

Tables 2.6 and 2.7 illustrate the 99 percentile criteria for BOD, total ammonia and un-ionised ammonia that were formerly used in the United Kingdom with the Rivers Ecosystem classes, and have subsequently been revised for use with the Water Framework Directive. 99 percentile standards have been used in the United Kingdom since 1998. The environment regulator should be contacted for further guidance on the applicability of the high percentile standards.

Table 2.6 Example of 99 percentile values for BOD associated with the RE class and WFD ecological status 90 percentile standards

Type of river (see Tables 2.1 and 2.2)	Biochemical oxygen demand (mg/l)	
	90 percentile	99 percentile
RE1 Class	**2.5**	**5.0**
WFD High Status for Types 1,2,4,6 and Salmonid	3.0	7.0
RE2 Class and WFD Good Status for Types 1,2,4 and 6 and Salmonid and High Status for Types 3,5 and 7	4.0	9.0
WFD Good Status for Types 3,5 and 7	5.0	11.0
RE3 Class and WFD Moderate Status for Types 1,2,4 and 6 and Salmonid	**6.0**	**14.0**
WFD Moderate Status for Types 1,3,5 and 7	6.5	14.0
WFD Poor status for Types 1,2,4 and 6 and Salmonid	7.5	16.0
RE4 Class	**8.0**	**19.0**
WFD Poor Status for Types 1,3,5 and 7	9.0	19.0
RE5 Class	**15.0**	**30.0**

Table 2.7 Example of 99 percentile values for ammonia associated with the RE class

Type of river (see Tables 2.1 and 2.2)	Total ammonia (mg/l)		Unionised ammonia (mg/l)
	90 percentile	99 percentile	99 percentile
WFD High Status for Types 1,2,4,6	0.2	0.5	0.04
RE1 Class	**0.25**	**0.6**	**0.04**
WFD Good Status for Types 1,2,4 and 6 and High Status for Types 3,5 and 7	0.3	0.7	0.04
RE2 Class and WFD Good Status for Types 3,5 and 7	**0.6**	**1.5**	**0.04**
WFD Moderate Status for Types 1,2,4 and 6	0.75	1.8	0.04
WFD Moderate Status for Types 1,3,5 and 7 and Poor status for Types 1,2,4 and 6	1.1	2.6	0.04
RE3 Class	**1.3**	**3.0**	**0.04**
RE 4 Class and Poor Status for Types 1,3,5 and 7	2.5	6.0	No value
RE5 Class	**9.0**	**25.0**	No value

The Fundamental Intermittent standards and the 99 percentile criteria given in Tables 2.6 and 2.7 differ in three key aspects:

- they use different statistics to describe concentration exceedances in the extended tail of the frequency distribution caused by wet weather events;
- they use different determinands (except for un-ionised ammonia); and,
- the Fundamental Intermittent standards allow for correction factors to account for synergistic effects and site specific environmental conditions that influence toxicity.

The 99 percentile criteria in Tables 2.6 and 2.7 use BOD (and total ammonia) to limit organic loading while the Fundamental Intermittent standards use DO and un-ionised ammonia because these are more directly relevant to ecosystem impact. High BOD levels can be sustained in well aerated rivers with little impact on DO, while in sluggish rivers relatively low BOD levels can cause DO problems.

While the two approaches provide alternative descriptions of the acceptability of extreme events, the comparable levels of environmental protection provided cannot currently be directly quantified. Hence, an environmental regulator may require demonstration of compliance against Fundamental Intermittent standards and High Percentile Criteria.

2.4 Standards for protecting bathing waters

2.4.1 Introduction

Wet weather standards to protect bathing waters are designed to ensure that the requirements of the Bathing Waters Directive are met. There are two approaches in common use to achieve this:

- spill frequency emission standards; and,
- risk based EQSs for bacteriological contaminants associated with sewage pollution.

In addition, an environmental regulator may specify a variety of minimum performance or capacity requirements, such as the length of storm outfalls relative to the location of the bathing water.

2.4.2 Spill frequency standards for bathing waters

Spill frequency emission standards can be used without the need for environmental modelling studies. In the UK, the standard that has been used since 1995 is that:

> “The maximum number of independent storm event discharges via the CSOs to identified bathing waters, or in close proximity to such waters, must not, on average, exceed the spill frequency standard of 3 spills per bathing season.”

A design which complies with this type of ‘emission’ standard should ensure a low risk (less than 5 %) of non compliance with the requirements of the Bathing Water Directives. The standard has universal application and is easily applied and understood. However, a universal standard of this sort, which avoids the need for environmental modelling, will usually have a large in-built safety factor.

In the UK it has been determined that where the design aim is for the ‘Excellent’ class of the 2006 Bathing Water Directive then the spill frequency standard would need to be reduced from 3 to 2 spills per bathing season on average (Environment Agency Guidance 2010).

The spill frequency standard is an average over a number of bathing seasons. For planning purposes, an analysis should use rainfall records covering at least 10 seasons and use of up to 25 seasons should be considered. Spill frequencies can be greater than 2 or 3 in some seasons provided that the average over at least ten seasons is less than 2 or 3.

Alternative spill frequency standards may be required elsewhere or used by agreement with the environmental regulator.

2.4.3 EQSs for identified bathing waters

Risk based EQSs may be used for coliform bacteria in waters which have been identified under the provisions of the Bathing Water Directives (1996 and 2006).

These EQSs are also designed to ensure a low risk of non-compliance with the Bathing Water Directives as a result of storm overflows and other discharges.

Agreement should always be obtained from the environmental regulator that the EQS approach is appropriate for the discharge(s) under consideration. This would usually require, for instance, that assumptions made in the modelling concerning mixing are reasonable. Agreement should also be obtained from the environmental regulator over the level of risk of non-compliance that should be used in the analysis.

In the UK, for the mandatory standards of the 1976 Bathing Water Directive, the EQSs for design purposes have been set as exceedance periods of 1.8 percent of the bathing season, on average, as illustrated in Table 2.8 (DETR, 1997 as amended for the 2006 Bathing Water Directive).

The mandatory standards in the 1976 Bathing Water Directive themselves require compliance with the threshold concentrations for 95 % of the samples taken in a bathing season. The EQSs require improvements to be designed to ensure that concentrations are below the threshold concentrations for 98.2 % of the bathing season. This higher compliance duration is necessary to ensure that the risk of non-compliance, based on the routine sampling regime, is less than 5 %.

A similar approach can be applied to the other threshold standards, including those for the 2006 Bathing Water Directive. For the thresholds associated with the good and excellent classes of the 2006 Bathing Water Directive, which are set as 95%iles, examples are provided below of EQSs that may be applied.

Environmental regulators may require different approaches based on the use of alternative bacterial parameters or may accept alternative approaches to dealing with risk, for example by considering the confidence in a modelled outcome.

Table 2.8 Examples of EQSs for coliform bacteria in identified bathing waters (DETR, 1997 as amended for the 2007 Directive)

Parameter	Threshold concentration (No./100 ml)	Total duration for which threshold can be exceeded (% of bathing season)
Mandatory Standards in 1976 Bathing Water Directive:		
Faecal coliforms	2000 (95% of samples)	1.8(<5% risk)
Total coliforms	10000 (95% of samples)	1.8(<5% risk)
Guideline Standards 1976 Bathing Water Directive:		
Faecal coliforms	100 (80% of samples)	10.4(<5% risk)
Faecal Streptococci	100 (80% of samples)	4.2(<5% risk)
Good Status Standards of 2006 Bathing Water		

Parameter	Threshold concentration (No./100 ml)	Total duration for which threshold can be exceeded (% of bathing season)
Directive: Intestinal Enterococci *Escherichia Coli* Excellent Status Standards of 2006 Bathing Water Directive: Intestinal Enterococci *Escherichia Coli*	 200 (95%ile) 500 (95%ile) 100 (95%ile) 250 (95%ile)	 1.8 – 2.4 (1 to 5% risk) 1.8 – 2.4 (1 to 5% risk) 1.8 - 2.4 (1 to 5% risk) 1.8 - 2.4 (1 to 5% risk)

Notes: The exceedance period shown in Table 2.6 is an average period over a number of bathing seasons. For planning purposes, an analysis using rainfall records should cover at least 10 seasons and use of up to 25 seasons should be considered. For example, exceedance periods can be greater than 1.8% in some seasons provided that the average over at least ten seasons is less than 1.8%.

2.4.1 Spill Definition

Guidance from the environmental regulator should be sought to identify agreed interpretations of a spill, in terms of minimum spill size, inter spill period and amalgamation of spills from the same or several CSOs.

In the UK a spill is defined as follows - one or more discharge overflow events within a period of 12 hours or less will be considered to be one spill, one or more discharge overflow events extending over a period of greater than 12 hours up to 36 hours will be considered to be 2 spills. Each subsequent 24 hour duration counts as 1 additional spill and the whole of the 24 hour block is included.

In the UK where more than one discharge impacts on the bathing water then spills must be aggregated and there must be no more than 3 significant spills to the bathing water on average. The size of spill which qualifies as significant will depend upon a number of factors. In general, however, in the UK, for design purposes a spill greater than 50 m^3 will be significant.

2.5 Standards for protecting shellfish waters

2.5.1 Introduction

In the UK wet weather standards to protect shellfish waters are designed to protect shellfish waters designated as protected areas under the Water Framework Directive which in turn protects shellfish production areas classified by the Food Standard Agency under the Food Hygiene Regulations.

The UK Government's aims in respect of shellfish waters are:

- to improve to category B the quality of shellfish waters with production areas that either achieve category C, or where harvesting is prohibited,
- to ensure that the classification for those shellfish waters with production areas which currently achieve category B or A does not deteriorate,
- to work towards meeting the Water Framework Directive shellfish waters standard of 300 *E.coli* per 100 ml in shellfish flesh and intervalvular fluids provided that it is feasible and not disproportionately expensive to do so, and

- to prevent any deterioration in the status of the Water Framework Directive shellfish water protected areas.

There are two approaches in use in the UK to meet these requirements:

- spill frequency emission standards. This is the approach most commonly used in the UK.

- risk based EQSs for bacteriological contaminants associated with sewage pollution.

In addition, an environmental regulator may specify a variety of minimum performance or capacity requirements, such as the length of storm outfalls relative to the location of the shellfish water.

2.5.2 Spill Frequency Standards for designated shellfish beds

Spill frequency emission standards can be used without the need for environmental modelling studies. In the UK the following standard for shellfish waters has been used since 2000 and requires that:

> "The maximum number of independent storm event discharges via the CSOs to identified shellfish waters, or in close proximity to such waters, must not, on average, exceed the spill frequency standard of 10 spills per year."
>
> In the UK the same spill definition is used as described in 2.4.4 above and where more than one storm overflow discharges to a shellfish water, then spills should be aggregated.

This spill frequency standard may be limited to less than 10 per annum on average on a site-specific basis, if the duration of impact of the CSO is considered to be longer than 24 hours.

The spill frequency standard is an average period over a number of years. For planning purposes, an analysis using rainfall records covering at least 10 years and use of up to 25 years should be considered. Spill frequencies can be greater than 10 in some years provided that the average over at least ten years is less than 10.

Spill frequency standards have universal application and are easily applied and understood. However, a universal standard of this sort, which avoids the need for environmental modelling, will usually have a large in-built safety factor

2.5.3 EQS approach for shellfish waters

In the UK a number of EQSs have been derived for bacteria in shellfish waters to ensure that compliance within the shellfish water is not compromised by the adverse effect of CSO discharges. These EQSs are set as water quality standards and are aimed at achieving compliance with the standards in shellfish flesh.

To ensure that shellfish flesh samples comply with category B of the Food Hygiene Regulations an EQS was derived that required that all discharges (both continuous and intermittent) when considered together are designed to achieve a water quality standard of 1,500 faecal coliforms per 100ml for at least 97% of the time in the long term. An alternative EQS that may be used is to determine the significant spill volume for the CSO discharge or CSO agglomeration based on the shellfish water achieving a geometric mean of 110 *E.coli* per 100 ml.

To ensure that shellfish flesh samples comply with the Water Framework Directive shellfish flesh standard the regulator may require that the significant spill volume for the CSO discharge or CSO agglomeration be based on the shellfish water achieving a geometric mean of 5 *E.coli* per 100 ml.

The total duration of impacts when EQSs are used applies to any location within the shellfish water and not just the monitoring point.

Agreement should always be obtained from the environmental regulator over the EQS to be used and that the EQS approach is appropriate for the discharge(s) under consideration. This would usually require, for instance, that assumptions made in the modelling concerning mixing are reasonable.

The exceedance periods and geometric means referred to above are to be used as an average over a number of years. For planning purposes, an analysis using rainfall records covering at least 10 years and use of up to 25 years should be considered. Exceedance periods and geometric means can be exceeded in some years provided that the average over at least ten years is met.

2.6 Standards for protecting amenity use

All receiving waters have an intrinsic amenity value which may be reduced by the presence of colour, odour and solids originating from urban wastewater discharges. Hence, amenity standards are applicable to the majority of receiving waters. The form and status of such standards will be the subject of the appropriate regulatory body's policy. At present, the only defined environmental criteria for amenity use are for the discharge of aesthetically polluting gross solids. The materials of concern are generally those solids which are obviously of sewage origin and which are of sufficiently large size to be readily visible to the naked eye; i.e. faecal solids, toilet tissue, condoms, sanitary towels, plastic release strips and cotton buds, etc.

The fundamental need is to protect the amenity use value of the receiving water by controlling the aesthetic quality of the waters. In general, no satisfactory way has been found for expressing EQSs for gross solids in receiving waters which are applicable in a design or monitoring context. Hence, the accepted practical approach to controlling pollution by gross solids is to set emission standards at the point of discharge to the receiving water. As far as possible, such standards should take into account the factors which are likely to affect the degree of impact, whilst allowing the designer freedom of choice in the engineering solution adopted to achieve compliance.

Hence, the principal factors affecting amenity use standards are:

- the amenity use category of the affected receiving waters;
- the type and size of gross solids in the sewage flow which are likely to cause aesthetic problems;
- the volume and frequency of discharges from the urban wastewater system to the receiving water, since this will affect the risk of aesthetic pollution problems occurring; and,
- the practical limitations of available control measures.

An example of the range of standards which have were adopted in the United Kingdom to meet the requirements of the UWWTD for the period 1995-2015 can be found in each Government's Guidance policy (for example DETR (1997) see UPM2 References, Section 1.2). These include examples of emission standards and minimum performance requirements (i.e. good engineering design).

However, subsequently in the UK the most cost effective solution is usually for 6mm screens to be fitted to address unsatisfactory intermittent discharges causing aesthetic problems, regardless of the amenity or spill frequency.

The 6mm standard, together with the explanatory definitions and the referenced design guidance documentation, give a clear indication of both the required performance to suit any specific set of circumstances and the nature of conventional devices which can be sure of achieving the required performance. However, a potential problem exists when there is a desire to employ novel or unconventional technology. The descriptive nature of the standard definitions makes it difficult to evaluate whether the performance of the novel technology is likely to be acceptable. In recognition of this, research was undertaken to develop an objective understanding of the performance of conventional CSO devices (Environment Agency, 1997 see UPM2 References, Section 1.2). The findings of this work are reported in Appendix C. Having numerical descriptions of the performance of the types of device known to achieve the emission standards for amenity uses may assist in allowing alternative technology to the existing "tried-and-tested" devices to be developed and applied in appropriate circumstances.

Where a novel type of solids separation is proposed then this should always be discussed with the environmental regulator. Performance testing is likely to be required.

2.7 Location of Outfalls

For discharges into coastal waters outfalls should usually be located below the Mean Low Water Springs Level (MLWS). Where there are particular local extenuating circumstances which either prevent, or render it impractical to locate the outfall below MLWS then the in the UK discharges will require the design to limit the number of spills that are made through these outfalls. For outfalls that are above the Mean High Water Springs (MHWS) level then the spill frequency could be limited to 1 spill in every 5 years.

In England and Wales the risk based EQSs approach for designing improvements for discharges of bacteriological contaminants associated with sewage pollution into bathing or shellfish waters can only usually be used where the storm outfall(s) taking CSO spills discharges into coastal waters and are located some distance offshore (a minimum distance of 200m from MLWS).

Environmental regulators may require relocation of an outfall, or modification of an outfall, in a sensitive high amenity area.