UK Technical Advisory Group

on the Water Framework Directive

UK ENVIRONMENTAL STANDARDS AND CONDITIONS

(PHASE 1)

Final report

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SECTION 1 – INTRODUCTION

The UK Technical Advisory Group on the Water Framework Directive (UKTAG) is developing environmental standards[1] and conditions to underpin the implementation of the Directive.

The UKTAG is a working group of experts drawn from environment and conservation agencies[2]. It was formed to provide technical advice to the UK's government administrations and its own member agencies. The UKTAG also includes representatives from the Republic of Ireland.

This is a technical report that presents the first set of environmental standards and conditions proposed by the UKTAG. Our report outlines the background to our proposals and describes the role they could play.

Our report defines environmental conditions that we think will support healthy communities of aquatic plants and animals. This draws on new work to develop biological methods and classification. These standards will help focus efforts to protect the water environment.

Our report covers standards for water quality, and for water flow and water levels. It also proposes a system for assessing the structure and condition of the beds and banks of rivers.

In some cases our work has led us to apply the same standards and conditions for several types of waters. These groupings may be refined into smaller divisions as we learn more. Similarly, as understanding improves, we will re-assess the standards and conditions.

This is the first time that standards and conditions have been developed on a UK basis. The UKTAG will propose further standards in future reports. We expect that the standards and conditions will be used to help develop policy, and to guide the Directive's first cycle of River Basin Management Plans.

Implementation and adoption of the standards

UKTAG has undertaken a scientific review involving stakeholders. Where possible, we have amended and clarified the report. Our response can be found via the UKTAG website: http://www.wfduk.org./UK_Environmental_Standards/ along with supporting reports.

[1] These encompass the words in Annex V of the Directive - values, concentrations and Environmental Quality Standards.

[2] Countryside Council for Wales (CCW), English Nature (EN), Environment Agency (for England and Wales), Environment and Heritage Service (Northern Ireland) (EHS), Joint Nature Conservation Council (JNCC), Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH), Republic of Ireland's Department of Environment Heritage and Local Government (DEHLG)

The approach to the implementation and adoption of proposals like ours is likely to vary for each country within the UK, depending on present and proposed legislation and on policy in each country. It will also depend on the need for Ireland and the UK, as separate Member States, to harmonise standards, where appropriate, within shared River Basin Districts.

This is a matter for Ministers to decide; it is subject to the normal policy-making considerations of the administrations and their respective agencies. Some of these agencies have been designated as Competent Authorities under the legislation that transposed the Directive into UK law.

Scope of the report

New standards and conditions are being developed in stages. This is because, in some cases, progress depends on the completion of classification schemes, or on European negotiations.

This report sets out proposals to support Good Ecological Status[1]. Table 1 summarises what is in this report and what we plan in future. Details of the latter are in Section 3.

A set of standards noted in Table 1 as part of the work of UKTAG, but not covered in this report, is for Specific Pollutants[2]. Failure for Specific Pollutants will mean failure of Good Ecological Status.

There are also standards that will be important for the Water Framework Directive but which are beyond the scope of the work of the UKTAG. These cover pollutants that have been identified at EU level as Priority Substances. Standards for these are being developed at the European level.

Also outside the scope of this report are the procedures associated with protected areas identified under other European water legislation. These may require tighter standards and conditions than proposed in this report. The protected areas include, for example, Bathing Waters (under the Bathing Water Directive) and Special Areas of Conservation (under the Habitats and Birds Directives). Standards and procedures for protected areas are already set out in the legislation establishing the protected areas, or they are being derived through separate processes.

The report does not address the detail of the regimes for monitoring, for assessing compliance and for using the standards to take decisions. But UKTAG has aimed to define standards that are suitable for the correct execution of these activities. This is matter for individual country consideration.

[1] Our report concentrates on the boundary between Good and Moderate Status. Where we can we also make proposals for the boundary between High and Good Status, and those between Moderate and Poor, and Poor and Bad.

[2] Work on specific pollutants has been delayed with anticipated release of early 2007. The list of Specific Pollutants proposed for the first planning cycle is anticipated to be released in future government consultation on standards.

Table 1: Environmental conditions and standards – this and future reports

Environmental condition	Category	This report	Future reports
Surface water – supporting conditions			
General water quality (General physico-chemical quality elements)	Rivers	Biochemical Oxygen Demand and Dissolved Oxygen, Ammonia	Other nutrients Temperature Salinity Turbidity
		pH	
		Nutrient: phosphorus	
	Lakes	Dissolved oxygen	Transparency Temperature Other nutrients
		Salinity	
		Acidification	
		Nutrient: phosphorus – now in the phase 2 report	
	Estuaries and Coastal	Dissolved Oxygen	Transparency Temperature Other nutrients
		Nutrient: nitrogen – now in the phase 2 report	
Water flow and water levels	Rivers	Change from natural flow conditions	Compensation flows
	Lakes	Change in the outflow from the lake	
	Estuaries and coastal		Hydrological inputs to estuaries
Physical structure and condition of the bed, banks and shores (morphological quality elements)	Rivers	Type and degree of physical alteration	
	Lakes		Type and degree of physical alteration
	Estuaries and coastal		
Chemical pollutants			
Toxic pollutants (called Specific Pollutants)	Rivers, lakes, estuaries and coastal		Standards for pollutants discharged in significant quantities
Groundwater			
Water balance and water levels	Groundwater		Groundwater standards
Water quality			

Environmental objectives and standards in the Water Framework Directive

The Water Framework Directive (2000/60/EC) came into force on 22 December 2000. It sets out objectives for the water environment. These include the following default objectives[5]:

- prevent deterioration of the status of all surface water and groundwater bodies;
- protect, enhance and restore all bodies of surface water and groundwater with the aim of achieving Good Status for surface water and groundwater by 2015.

Alternative objectives

The UK does not always have to achieve the Directive's default objective of Good Status by 2015. Alternative Objectives can be set if, for example, the measures required to achieve Good Status by 2015 would be technically infeasible or disproportionately expensive[6].

For example, it may turn out to be infeasible to improve a discharge by the extent required to meet an environmental standard. In such a case, the Directive allows us to extend the timetable for achieving Good Status by up to 12 years, or to set an objective that is less stringent than Good Status.

It is important to note that:

1. alternative Objectives cannot be set without first assessing the measures that might have to undertake to achieve Good Status by 2015;

2. the standards and conditions that we propose in this report will not, alone, determine the costs of implementation. This is because the cost depends very largely on the objective setting process.

This differs from other water Directives. Most of these specify environmental standards or emission standards but provide little flexibility to set other objectives. The Water Framework Directive is the first to allow an approach that is truly based on risk, and where action can be taken in proportion to what it can achieve and what it will cost.

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[5] Article 4(1) of the Directive sets out its objectives for the water environment including those not set out above. When we refer to objectives in this report, we refer to these default objectives listed above.

[6] The circumstances under which these Alternative Objectives may be used is outlined in UKTAG guidance 13c 'Draft principles for an objective setting framework for river basin management planning in accordance with the Water Framework Directive' (refer: http://www.wfduk.org/tag_guidance/Article%20_11/POMObjectivesetting/WFD13cObjectivesetting) and also in the European guidance on objective setting (refer: http://ec.europa.eu/environment/water/water-framework/objectives.html).

Biology and setting standards

The UK agencies have been developing biological methods and associated standards alongside environmental standards that describe the ecology. This has focused on identifying the relationship between the biology and human pressures.

Where possible, the environmental standards in this report have been checked against the emerging biological methods. For example, phosphorous standards for rivers were checked against biological and chemical data on sites across the UK. Similarly, we are checking our proposals against the European Intercalibration Exercise. This focuses on biology.

Research reports outlining the biological methods will become available later in 2007 on the UKTAG web-site.

If biological monitoring over the first river basin planning cycle shows that the environmental standards do not protect the biology, or that they are too strict, the reasons will be investigated and, as necessary, new standards will be proposed in line with options permitted by the Directive.

Role of standards in taking action

UK agencies need environmental standards and conditions in order to work out, for example, how much water can be abstracted, or how much of a pollutant can enter the environment, without causing harm to the health of aquatic plants and animals[7] - harm that would compromise the achievement of the Directive's default objectives.

For example: suppose a standard specifies that for Good Status a particular chemical in river water should be less than an annual average concentration of 20 milligrams per litre. UK agencies might monitor the concentration of the chemical in the water and find that a discharge has raised it to an annual average of 31 milligrams per litre. Their assessment would be that there is a significant risk to the health of the plants and animals. To restore the water body to conditions that are consistent with Good Status, they would aim to reduce the annual average in the water to at least 20 milligrams per litre.

Similarly there might be a standard for water resources that applies to a river when flows are low. This might require that no more than 10 per cent of such flows are abstracted.

[7] This is in addition to any established standards needed to protect other uses of water. These may be seen as part of the Water Framework Directive and this footnote then serves only as a reminder that such standards are applied. The standards cover, for example, the established requirements for drinking water and spray irrigation.

Use of Standards and Conditions in decision making

There are at least two distinct ways by which environmental standards are used to take decisions. Both have been used with confidence to establish big programmes of investments in improvements over the past two decades. An important consideration in using standards is to specify the rules by which the standards will be used to take decisions.

The first approach is called the Direct Model. It applies where UK agencies are able to estimate with high confidence, the actual impact of an activity on the receiving water. This means they can calculate the effect of the activity on compliance with the environmental standard. The Direct Model applies where there is confidence that compliance with the standard defines all that is needed from the activities that cause failure. There is no absolute need, for example, to seek corroboration by looking at biological data. An example of the Direct Model is setting numeric limits in discharge permits for ammonia, in order to meet a water quality standard for ammonia in a river. Another might be the control of abstractions so that no more than a set proportion of the natural flow is taken.

The second approach is the Indirect Model. This applies where there is not so much confidence that simple failure of the standard is enough to judge the cause of damage or risk. We may need supporting evidence. The Indirect Model applies where the agencies are less able (than for standards that can use the Direct Model) to calculate the impact of an activity on the receiving water. This means they would be less able to calculate what is needed to secure compliance with the environmental standard.

In the Indirect Model we might propose the use a checklist to confirm whether the water is damaged or at risk. This checklist may include compliance with a numeric standard as in the Direct Model but it will include more than this. It could include, for example, the absence of key species, or the occurrence of nuisance species. The checklist might lead to action such as uniform emission standards for particular discharges, or uniform controls on particular abstractions. It might not be possible to calculate directly whether this action is enough. It might be treated as a “step in the right direction” that will be reviewed at the next opportunity, using data collected on the status of the environment.

As an example of the Indirect Method, a chemical standard is used to help decide when to designate Sensitive Areas under certain Directives. Failing the standard is taken with other indicators, some biological, as indicating that action is needed. The action that follows a decision that the water has "failed" is not always calculated in a precise manner as the action needed to meet the standard in the receiving water. It may be that a uniform emission standard is imposed at all discharges above a certain size, or a that ban is applied to activities that pose risks to groundwaters.

In the Indirect Model the scale of action is a balance of the confidence that the level of risk is real, and the confidence that the action will help. In the Water Framework Directive such matching of "action" to "failure" will be developed under the Directive’s Programmes of Measures.

UKTAG has provided this discussion on the Direct and Indirect Model because it is critical to explain how standards lead to decisions. In the past, standards with an established effect on the environment have been associated with the Direct Model. Standards associated with more complex or subtle impacts have used the Indirect Model.

Similarly, there is the issue of assessing compliance with standards. In many cases this involves using data from monitoring to make some form of comparison with the standard. In other cases it might involve calculations using models. Nearly always these data or models will be associated with errors and uncertainty, and these translate into statements of confidence that a standard has been met or has been failed.

The Directive expects us to know and report these levels of confidence. Along with the other factors mentioned in Annex V to the Directive, they will be used to decide the amount of monitoring required to detect particular levels of failure or deterioration. The outcome, the confidence that the standard has been failed, will be considered when deciding what action to take under the Programmes of Measures.

Existing standards

There is already a wide of range of standards in use in the UK, especially for water quality. These have either been drawn from other European Directives, or developed independently at a country level. They inform the planning of protection and improvement of the environment by the environment agencies.

The level of protection for the environment provided by standards and procedures used in other Directives will, after review, transfer to the Water Framework Directive either directly, or as the equivalent. The standards and conditions set out in this report will augment these to define some of the extra requirements of the Water Framework Directive.

The environment agencies already use standards to assess and control the impact of industry andland use, both urban and rural. They use environmental standards to work out where action might be needed. They use them, for example, to work out the controls they must impose on discharges in order to protect water quality.

The Water Framework Directive defines new targets for rivers, lakes, estuaries and coastal waters. The environmental standards must reflect these. As outlined above, the Directive requires that Member States protect the ecological status of water bodies from deterioration and, where necessary and proportionate, aim to restore water bodies to Good Status. UKTAG proposed standards and conditions will help work out what might need to be done.

In 2004, the UKTAG initiated a review designed to lead to standards and conditions to support Good Ecological Status. The review covers rivers, lakes, estuaries and coastal waters and:

- water quality standards;
- standards for water flow and water level;
- a framework to support decisions about the structure and condition of beds, banks and shores of water bodies (i.e. their morphology).

The review has involved many of the UK's leading independent experts in ecology, hydrology, geomorphology and chemistry. The results of monitoring from thousands of sites across the UK, and scientific literature from around the world, have informed the process. We believe the review has provided the best possible technical assessment, given current scientific understanding.

Classification

Classification is a way of reporting the state of the environment. If done properly it shows where the environment is good quality and where it is worse than required. Classification provides a way of comparing waters and a way of looking at changes over time.

Classification schemes are being developed by environment agencies across the UK for the Water Framework Directive. Surface water bodies will be assigned to one of the five ecological status classes - High; Good; Moderate; Poor; or Bad.

To classify water bodies, UK agencies need to monitor and assess the health of their plants and animals using the new methods of biological assessment. This monitoring must start at the end of 2006. However, it will be some years before there is enough information to classify every water body with sufficient accuracy.

Certain water uses, such as the generation of hydropower, navigation and flood defence, might depend on substantial physical alterations to a water body. These might be incompatible with the achievement of Good Status. Where appropriate, such waters can be designated under the Directive as Heavily Modified. Objectives can be set for them that can be achieved without significantly effecting the identified use. Each such Heavily Modified Water Body[8] will be assigned to one of the five classes of Ecological Potential - Maximum; Good; Moderate; Poor; or Bad – as required by the Directive.

[8] And any waters designated as an Artificial Water Body under the Directive.

For all water bodies, the achievement of relevant environmental standards will be taken into account, along with the results of biological monitoring, in deciding the status class of a water body. For example, if a water quality standard identified for Good Status is not met, the water body will be Moderate or worse. For a water body to be High Status, it must meet all the environmental standards associated with High Status – water quality; water flow; water levels; and the requirements for morphology.

It may not always be possible, with current knowledge, to identify standards or conditions that would not be over or under protective in some situations. To reduce this over time, European guidance proposes that Member States assess mismatches between the monitoring for biological quality and the physico-chemical elements. This is called a “checking procedure”. If such assessments indicate that a standard or condition is too lax or too stringent, Member States are advised to revise them.

It might be that as a result of this “checking procedure”, that some standards used as discussed above in the context of an Indirect Model, can be replaced eventually by standards that can be used in a Direct Model. By this we mean that failure of the new standard can be taken as sufficient evidence of the requirement to take strong action to protect a water body, in the absence of corroborative evidence from biology for that water body. It may then be possible that uniform controls across a catchment can be replaced with specific actions at particular sites that have been calculated precisely to achieve the standard in the water body[9].

The first results of classification will be published in the first River Basin Management Plans. These must be finished in 2009. These classifications will be based on only two years of monitoring, and will therefore provide only an initial view.

We will first use the results of classification to review the pressures and impacts on water bodies. This must be completed by 2013. It will provide the basis for the second cycle of River Basin Management Plans. The second Plans must be finished in 2015.

Further information on classification is on the UKTAG website: www.wfduk.org[10].

Ecological status

The Water Framework Directive provides, in the Normative Definitions of Annex V, a description of High, Good, Moderate, Poor and Bad ecological status. Each describes a different degree of impact on the plants and animals.

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[9] But we doubt that this would lead us to suggest changes in the approaches we have recommended, for example, for nutrients. There are statistical difficulties in applying the “checking procedure” to individual waters and for groups of water bodies the results will probably match the data that led to the standard in the first place.

[10] TAG PAPER WP 11a (i) provides an overview of the classification schemes for surface waters and groundwaters that are needed for River Basin Planning.

UKTAG is required to use these descriptions to set out what each class means in biological terms. For example, we might specify the number of different groups of species we expect to find in a river of Good Status. To enable us to do this, we are developing new methods for assessing biology. Some of these, such as one for the assessment of invertebrates in rivers, are built on methods that have been used for many years[11].

This has meant that in some cases we could take data previously collected from hundreds or thousands of sites across the UK and use them to develop new methods. Where this has been possible, we have also looked for corresponding information on the environmental conditions to which the biology is most sensitive. This has helped identify standards that correspond to sites at our current view of Good Status, in terms of their most sensitive plants or animals.

For example, we have based our standards for dissolved oxygen in rivers in terms of the oxygen regime and invertebrate communities that we find at sites with Good Status. Similarly, we have set our phosphorus standards for rivers by looking at sites which have Good Status for plant communities[12].

In other cases, in estuaries and coastal waters for example, and generally for pollutants not subject to national programmes of monitoring, we have insufficient data to derive standards in this way. Instead, we have used the most up-to-date scientific understanding of the causes of ecological changes. We have then compared this understanding with the Directive's descriptions of the condition of plants and animals in the different status classes. In doing this, we have relied on advice from leading independent experts from a range of scientific disciplines.

We have used the latter approach to identify environmental standards for water flow and water levels, and to set up our proposed framework for morphology.

These standards and protected areas

The procedures associated with protected areas identified under other European water legislation are outside the scope of this report.

Ecological status for water bodies under the Water Framework Directive needs to be interpreted separately from those standards and objectives set under the relevant source legislation for the protected areas. Article 4(1c) of the Water Framework Directive, states that member states are required to achieve compliance with those standards and objectives specified in the community legislation under which the individual protected areas have been established. Where a water body has more than one objective, the most stringent applies.

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[11] The established approach for reporting river quality for invertebrates – RIVPACS (River InVertebrate Prediction and Classification System) [26].

[12] Diatoms.

For example, the Habitats Directive contains a number of obligations for Special Areas of Conservation and Special Protected Areas (which make up the Natura 2000 network). The aim of these obligations is to achieve “the favourable conservation status” of such sites, for example, by requiring that appropriate steps be taken to avoid the deterioration of the habitats that they host.

Ideally, favourable conservation status (and on individual sites, favourable condition) would equate to High Ecological Status as defined by the normative definitions of the Water Framework Directive, but some types of habitat are so degraded that restoration of designated sites to this class is not practical or reasonable. In these cases, restoration effort will aim to achieve something lower than High Ecological Status.

In addition, there will be instances where the standards required to achieve Good Ecological Status, or other environmental objectives, may provide a higher level of protection than the Habitats and Birds Directives. This may affect the spatial area that is covered or reflect that the Water Framework Directive applies to a wider range of pressures. This will need to be assessed by the conservation agencies on a site specific basis.

The UK conservation agencies also have responsibility for designating and setting objectives for nationally designated wildlife sites such as Sites of Special Scientific Interest (SSSIs). Although SSSIs do not have the status of protected areas under the Water Framework Directive, the proposed UKTAG standards are distinct from those used in the assessment of the condition of SSSIs for national reporting. The relationship between the “favourable condition” of Sites of Special Scientific Interest, and High and Good Ecological Status under the Water Framework Directive, is the same as that outlined above for the Habitats and Birds Directives.

Comparisons with other Member States

The other 24 Member States, Norway, and a number of accession countries, are also attempting to quantify what the Directive means by Good Status. The UK has been working with these countries, and with the European Commission, to compare methods of biological assessment and classification. This is a formal process known as Intercalibration.

The aim of Intercalibration is to ensure that the boundaries for Good Status given by each country’s biological methods are consistent with the Directive’s descriptions of Good Status. Because of constraints on data, the first exercise will consider only a limited number of the groups of plants and animals included in the Directive’s descriptions of Good Status. It will also consider the effects of only a limited range of environmental conditions.

For example, Intercalibration is not expected to produce harmonised class boundaries for methods of biological classification that are sensitive to the impact of man-made alterations to water flows, water levels or morphology. Work has started on undertaking fundamental research but this will not inform the development of our proposals for the first river basin planning cycle.

On the other hand, our work on standards for nutrients and dissolved oxygen has benefited, and will continue to benefit, from the information gathered through Intercalibration. This may still lead to changes in the proposals we make in this report.

The UK has taken a very active role in Intercalibration. For example, the UK has helped develop EU guidance on:

- the process of Intercalibration;
- the protocol for deriving biological class boundaries;
- the interpretation of class boundaries.

All the UK work on methods of biological classification has followed this guidance.

The UK is also co-ordinating the technical work for transitional[13] and coastal waters across the EU, and playing a leading role on Intercalibration for rivers and lakes for countries of central and northern Europe.

Because of our involvement, UKTAG has been able to take account of emerging European views. This has ensured that our proposals correspond to the current consensus on the biological boundaries for Good Status.

Intercalibration is expected to produce its first draft recommendations later in 2006. This will allow us to take account of the results as we finalise our first report. Of all the proposals we make in this report, those for phosphorus in lakes appear the most likely to change as a consequence of Intercalibration.

River Basin Management Plans

UK Competent Authorities are required to produce the first draft River Basin Management Plans for public consultation by the end of 2008. These plans must set out the objectives we think appropriate for each water body and, where this objective is not Good Status by 2015, the reasons for this.

To prepare these plans, the environment agencies will work out the shortfall between the existing environmental characteristics and the standards and conditions associated with Good Status. The UK must do this for all the water bodies identified at risk of failing Good Status. The environment agencies will often need to do more monitoring and assessment, targeted at the water bodies at risk, and focused on the reasons for these risks.

They will then have to calculate by how much the pressures on each water body at risk would have to be reduced to achieve the standards.

[13] The Directive's term for estuaries.

It is an important aspect of the Directive, that in making decisions on which measures are required, that all the causes of failure are considered. This will mean looking in an integrated way at water quality, water quantity, and the impact of man-made structures. It will involve the contributions from groundwater to the failure of surface water standards. The agencies will look at the impact of physical changes to water bodies, and at the impact of present and future abstractions.

The Directive's Competent Authorities, in partnership with others, will appraise options to meet the objectives, and identify the most cost-effective combination of measures.

For many activities that could harm the water environment, there is an option to control them through licences or permits. All significant point source discharges and abstractions are and will be subject to such controls. For pressures for which this option is unavailable, such as some activities of land use that give rise to diffuse pollution, the environment agencies will use standards to work out the level of change to these activities needed to contribute to achieving Good Status.

The Directive's provisions for setting objectives allow environmental improvements to be phased over the cycles of River Basin Management Plans, whilst enabling sustainable uses of the water environment to continue. We have mentioned above the Directive's process for setting Alternative Objectives.

Protecting the environment from deterioration

The standards and conditions associated with Good Status give, for example, the concentrations of a pollutant, or the change in water flows, that we believe can be accommodated without causing any significant harm to aquatic plants and animals.

We need to know this so that the environment agencies and others can assess whether, for example, a proposed new discharge or abstraction would result in a standard being exceeded and so compromise the Directive's objective of preventing deterioration of status. (This requires standards and conditions for High Status, and for Moderate and Poor).

The existence of a standard does not necessarily mean, for example, that a new discharge will be allowed to cause a pollutant in a water body to increase up to the limit defined by the environmental standard. This would place the water body at risk of deterioration from its present status. It would also prevent others from making sustainable use of the capacity of the water body to absorb change.

The environment agencies will continue to control developments and growth in a way that manages the risk of deterioration of status[14] and ensures that sustainable uses of the environment can continue and develop. They will assess the effectiveness of their efforts through the classification of water bodies, and by calculating the impacts of changes in terms of movement within classes.

Revising the standards

The UKTAG believes the proposals in this report are based on the most robust assessment possible, given current scientific understanding. Our report aims to advise the UK administrations on the standards and conditions that we believe the environment agencies should use for the first River Basin Management Plans.

A small number of our proposals may be reviewed in the short term as a result of the current round of Intercalibration. Most standards will be subject to review over the longer term.

It is important that UK agencies revise the standards if understanding improves as a result of:

- the application over the next few years, to a large number of water bodies, of the new methods of biological classification. This is part of the monitoring required by the Directive;
- research;
- information from other countries in future rounds of Intercalibration;
- the collation of new data across the International River Basin Districts on the island of Ireland. The application of some of the standards in Ireland and Northern Ireland[15] may be subject to further harmonisation as standards are developed in the Republic of Ireland.

We anticipate that this review will be done in 2012. This will mean that the environment agencies can use the new monitoring information and take account of further European work on Intercalibration. They will be able to use the results of the review for the second River Basin Management Plans[16]. The latter will be published in 2015.

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[14] This is explained more fully in TAG guidance: *UKTAG (2006) WP 13e) Prevent Deterioration of Status.*

[15] Ecoregion 17 under the Water Framework Directive

[16] For more information on how standards will be used, refer to: Water Framework Directive (WFD): Note from the UK administrations on the development of environmental standards and conditions.

SECTION 2 - SUMMARY OF STANDARDS FOR SURFACE WATERS

Technical details can be found in background documents. We provide a list of some of these at the back of this report.

Documents are available on the UKTAG website. The reports describe where leading experts have contributed, and where we have compared our methods with best practice in the UK and Europe (and wider if appropriate). The reports show how work across Europe, and our own research, might bring changes. They also contain details of research within the UKTAG and the agencies that we have not included at this time. We shall update these reports as knowledge improves.

General approach for standards to support biology

We set out to develop standards for which compliance can and will be assessed properly – standards which mean that the ecology is protected if compliance is achieved. We require standards by which the regulatory action needed to achieve them can be determined properly. For this we aimed to express standards as Ideal Standards[17].

There are different groups of surface water standards and conditions. These are:

- **physico-chemical:** numeric values have been developed which have been matched to biology;
- **hydrological:** numeric values supported by modelling have been developed, based upon the best available understanding of links to biology;
- **morphological:** a decision framework using best available knowledge supported by numeric thresholds.

Typology

Rivers, lakes, estuaries and other transitional waters and coastal waters were grouped[18] mainly on the basis of natural characteristics that might influence ecological communities – altitude, latitude, longitude, geology and size. The method by which waters of similar ecological sensitivity are grouped into types for the Directive, is referred to as a typology[19]. For example, to assign rivers to types we used a typology based on altitude and alkalinity.

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[17] We mean “ideal” in the context of being able to make a sound and correct assessment of compliance as intended by the 1997 Royal Commission on Environmental Standards [18]. It does not necessarily mean that the standard is “ideal” in terms of getting a perfect match between the value of the standard and the risk of damage. That depends on the derivation of the standard. Once a standard has been derived it is then necessary to express it as a “ideal” standard in order to assess compliance properly and in order to calculate the action needed to secure compliance.

[18] In accordance with Annex II of the Directive.

[19] The term, type, has particular meaning and use in the Directive. The Directive sees the ecology as determined by type and so seeks to characterise water bodies according to type.

There are a number of typologies already operating in the UK. The Freshwater Fish Directive has separate water quality standards for waters classified as salmonid and cyprinid. Another example is the scoring system in the Environment Agency's Resource Assessment and Management Framework (RAM). This has a typology that reflects the ecological considerations associated with water flows and water levels.

Environmental standards for the Water Framework Directive will be type specific - different types of waters will have different standards. This may result in a more detailed typology than that previously reported as part of the characterisation report in order to best reflect the relationship between the standard and the biology.

Alternatively in developing the standards and conditions, we have found, in some cases and for present data, that we can use a single standard for several or all types[20]. In other cases, we have used a number of types. As we gain a better understanding of the environment through monitoring, and by applying these standards, we expect to be able to refine and develop the typologies and so amend some of the standards.

[20] Where we have combined types in this way it may appear we used less differentiation than required by Annex II - but the original analyses were at least as differentiated as required by Annex II.

WATER QUALITY STANDARDS

UKTAG aimed to use the following approach for each parameter[21] considered for rivers, lakes, and transitional and coastal waters:

1. identify the biological conditions associated with High and Good Status;

2. decide the summary statistic for the standard;

3. where possible, look at the distribution of the measured value of the summary statistic across sites of a particular type and class. We then select a point on this distribution for the class boundary.

We aimed to provide environmental standards for High and Good Status. In all cases the standards have been set according to best information available, and set to protect the biological element that is most sensitive to each pressure.

We repeat that our proposals for standards for the Water Framework Directive augment the protection provided by a large number of standards and controls already established through other Directives and national legislation, and other types of standards that will be established by the Water Framework Directive. If a risk is not covered by our proposals, this does not mean that there are no standards when implementing the Directive.

We repeat also that the relevant water quality standards and procedures used in other Directives will, after review, transfer to the Water Framework Directive either directly, or so as to provide the equivalent degree of protection. A range of standards and controls will continue to operate though these routes and the standards and conditions set out in this report will augment these to define some of the extra requirements of the Water Framework Directive.

We expect that the environment agencies will continue the policies that have been agreed in support of these standards and drivers. This includes, for example, policies on the control of the risk of deterioration, and on the regulation of intermittent discharges.

[21] This may be a pollutant or any other measured characteristic of water quality.

WATER QUALITY STANDARDS FOR RIVERS

The Directive requires that we consider particular physico-chemical conditions. Table 2 shows the biological element we consider most sensitive for these conditions and the key parameters.

Table 2: Standards for river water quality covered in this report

Conditions	Parameter	Biological Element
Oxygen	BOD, Dissolved Oxygen	Macro-invertebrates
Ammonia	Ammonia	Macro-invertebrates
Acid	pH	Fish
Nutrient	Phosphorus	Diatoms
Standards for future development – see Section 3		

Our process for deriving standards took thousands of sites of “good” biological quality and looked at a selected summary statistic of physico-chemical water quality for all of these. The value achieved by 90 per cent of the sites is picked as the standard. The outcome depends on the sites defined as “good” and so included in the analysis.

The advantages of this approach lie in the large number of sites. This gives high (and easily quantified) precision in the values picked as standards. When there are this many sites, the effect of any random errors in the data, on the value set as the standard, will be very small. For example, in estimating the 90-percentile from the values for 1000 sites, we rank the 1000 values and select the 900th biggest. If all 1000 values have big random errors this may affect which actual site gives the 900th biggest, but it will not much affect the value of the summary statistic for the 900th biggest[22].

Another advantage is that the summary statistic used can be set up in the exact form required for a useful water quality standard – as, say, an annual mean or annual percentile. Such a form is needed in order to assess compliance statistically, and in order to provide the correct basis for the calculation of limits on discharges to water. This avoids the problem for standards derived directly from tests of toxicity – how to convert values from laboratory results to the field. This typically involves the use of uncertain safety factors to scale the laboratory results by several orders of magnitude.

[22] If the set of data contained 1000 sites, the 90-percentile is given as the 900th biggest. The statistical sampling error associated with this estimate is given by the range between 885th and 916th biggest values.

In theory, the water quality standard should be taken as the biggest value found in the thousands of good sites. The choice of the 10 per cent point allows for the inevitability that some of the sites chosen as good biological quality may in truth be poorer than good, and included wrongly because errors in the biological data meant they were classed wrongly as good.

This way of setting standards gives only a statistical association between biology and chemistry. To apply it to a chemical we need good supporting evidence of cause and effect. The process could produce “standards” for a chemical that actually had no effect on the ecology – chloride or sulphate in rivers, for example. So the process might be misleading for nitrate and phosphorus, and other nutrients, in looking for standards that will control eutrophication, unless there is good evidence on cause and effect which can back up the statistical association. Consequently, we have derived standards only for chemicals where there is general confidence that they cause biological impacts.

Deriving standards from statistical associations has particular advantages. The standard takes the form of an association between chemistry and biology. The actual cause of damage might be direct and toxic. But the impact might be caused in truth by some other chemical whose concentration is correlated with the chemical in the standard. Another possibility is that the actual damage is caused by rare peaks seldom captured by occasional sampling. None of this matters very often because the achievement of the standard usually acts on all the causes, direct or correlated, in a consistent way[23]. We discuss these points and the issue of collecting data by sampling in Annex 1.

Typology for water quality and rivers

The typology contains two factors – alkalinity and altitude. Alkalinity is expressed as five divisions of the concentration of calcium carbonate (which cover the range found in UK rivers). Altitude is split into two types – less than or greater than 80 metres. These two descriptors have been shown to play important roles in determining the biota of UK rivers.

This assessment agrees with the approach taken in the established way of reporting river quality for invertebrates – RIVPACS (River InVertebrate Prediction and Classification System [26]). River gradient also plays an important role, but this is associated with altitude. The typology is shown in Table 3.

Our present data have led us to a fairly broad-based typology for rivers. This may require refinement as it is applied it and we learn more about the relation between typology, ecology and water quality.

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[23] In other words, actions targeted at risk, or actions that reduce the amount of pollution, that are actually directed at achieving compliance with standards expressed as the annual mean or an annual percentile, also act on the underlying causes of more extreme events. Improvements in the mean and percentiles of river water quality are associated with parallel reductions in the frequency and scale of more extreme events. These dependencies have long been part of technical basis of securing improvements by setting standards, by monitoring for compliance, and so in the management of risk. It is possible to imagine circumstances where this may not be the case – illegal activities, for example. These need special attention and to be managed in the same ways that we provide extra protection against the risk of accidents, for example.

Table 3: Basic typology for rivers					
Site Altitude	Alkalinity (as mg/l CaCO3)				
	Less than 10	10 to 50	50 to 100	100 to 200	Over 200
Under 80 metres	Type 1	Type 2	Type 3	Type 5	Type 7
Over 80 metres			Type 4	Type 6	

Where the resulting standards for types turned out to be similar, we amalgamated types. In each case the standards for combined types were then produced by combining their sets of data and performing the analysis on the combined set. This process allowed us to simplify the typology into two types, as shown in Table 4 for dissolved oxygen and ammonia.

Table 4: Final typology for oxygen and ammonia for rivers	
Upland and low alkalinity	Types: (1+2), 4 and 6
Lowland and high alkalinity	Types: 3, 5 and 7.

Oxygenation and ammonia conditions for rivers

UKTAG propose standards for dissolved oxygen (DO), Biochemical Oxygen Demand (BOD) and ammonia. They have been developed following the same procedures and for the same typologies. They have been developed on the basis of conditions associated with macro-invertebrate communities.

Dissolved Oxygen and Biochemical Oxygen Demand

Oxygen in rivers is affected by complex interactions between ecological processes, and by anthropogenic pressures. Additions of organic matter such as discharges from sewage treatment works and storm overflows, and agricultural sources such as slurry and silage liquor, reduce dissolved oxygen due to the enhanced microbial respiration**.**

The standards are presented in Tables 5 and 6. The tables also show a comparison with standards from the environment agencies' present classification schemes. For comparison with existing standards, the following matches with the Freshwater Fish Directive (FWFD) are made:

- Salmonid Waters (FWFD) - Upland and Low Alkalinity Type (2, 4 and 6)
- Cyprinid Water (FWFD) - Lowland and High Alkalinity Type (3, 5, and 7)

Note: In Tables 5 and 6, and other tables in this report, "High" refers to the boundary between High and Good. To achieve High Status the standard must be bettered or equalled. Similarly Good refers to the boundary between Good and Moderate, and so on through the status classes.

Generally, UKTAG proposed standards should be used in the same way as the existing standards. We suggest that the standard for dissolved oxygen is used for assessing and reporting compliance of rivers, and that the standard for BOD is used for deciding action to meet the standard for dissolved oxygen in the river. This is because the levels of BOD can be misleading in clean rivers, and because the link between BOD and dissolved oxygen is a complex and uncertain issue if dealt with on a site-by-site basis.

<table>
<tr><th colspan="5">Table 5: Standards for oxygen in rivers</th></tr>
<tr><td colspan="5">Dissolved Oxygen (per cent saturation)</td></tr>
<tr><td colspan="5">(10-percentile)</td></tr>
<tr><td>Type</td><td>High</td><td>Good</td><td>Moderate</td><td>Poor</td></tr>
<tr><td>Upland and low alkalinity</td><td>80</td><td>75</td><td>64</td><td>50</td></tr>
<tr><td>Lowland and high alkalinity</td><td>70</td><td>60</td><td>54</td><td>45</td></tr>
</table>

<table>
<tr><th colspan="3">Existing standards</th></tr>
<tr><td colspan="3">Dissolved Oxygen (per cent saturation)</td></tr>
<tr><td colspan="2">(10-percentile)</td><td>(5-percentile)</td></tr>
<tr><td>High</td><td colspan="2">Good</td></tr>
<tr><td colspan="2">Existing classification schemes (note 1)</td><td>Freshwater Fish Directive (note 2)</td></tr>
<tr><td rowspan="2">80</td><td rowspan="2">70</td><td>65 - 75
Salmonid</td></tr>
<tr><td>45 55
Cyprinid</td></tr>
</table>

Note:

1. The existing values are those for River Quality Objectives, RE1 and RE2 for England and Wales and for the best two classes of the schemes used in all countries.
2. The values from the Freshwater Fish Directive as 6 mg/l would typically represent a 10-percentile of percentage saturation of approximately 65 to 75%. The value of 4 mg/l would represent a 10-percentile of percentage saturation between 45 to 55%.

Where a lowland, high alkalinity water body is a salmonid river, the standards for the upland, low alkalinity type will apply. This is because in these conditions the standards required by fish are tighter than those required by invertebrates.

Table 6: Standards for oxygen conditions (BOD)					**Existing standards (note 1)**	
Biochemical Oxygen Demand (mg/l)					Biochemical Oxygen Demand (mg/l)	
(90-percentile)					(90-percentile)	
Type	High	Good	Moderate	Poor	High	Good
Upland and low alkalinity	3	4	6	7.5	2.5	4
Lowland and high alkalinity (note 2)	4	5	6.5	9		

Note:

1. The existing values are the thresholds for the River Quality Objectives, RE1 and RE2 for England and Wales, and for the best two classes of the schemes used in all countries.
2. Where a lowland, high alkalinity water body is a salmonid river then the standards for the upland, low alkalinity type will apply.

The standards have been developed on the basis of oxygen conditions associated with macro-invertebrate communities as these are most sensitive biota to this pressure [1]. Invertebrate communities at Reference Condition[24] in these river types require higher oxygen levels than fish.

[24] The term used by the Directive to define conditions that are close to pristine.

The approach is in broad alignment with the scientific literature describing the relationship between macro-invertebrates and dissolved oxygen and we have demonstrated compliance with the Directive's class definitions [2].

Ammonia

Ammonia is hazardous due to its toxic and sub-lethal impacts on fish and macro-invertebrates. It is a decay product of nitrogenous organic wastes and of the breakdown of animal and vegetable wastes. Sewage effluent from treatment works is a major source of ammonia in rivers. Agricultural diffuse sources of ammonia are also important. Our draft standards for ammonia are in Table 7.

Table 7: Standards for ammonia				
Total Ammonia (mg/l)				
(90-percentile)				
Type	High	Good	Moderate	Poor
Upland and low alkalinity	0.2	0.3	0.75	1.1
Lowland and high alkalinity	0.3	0.6	1.1	2.5

Existing standards	
Total Ammonia (mg/l)	
(90-percentile)	
High	Good
Existing classification schemes (note 1)	
0.25	0.6

1. The existing values are the thresholds used for the River Quality Objectives, RE1 and RE2, for England and Wales, and for Class A and B of the General Quality Assessment.

The standards have been developed on the basis of ammonia conditions associated with macro-invertebrate communities at High and Good Status. Further work will be done during the first cycle of River Basin Management Plans to confirm that the proposed values also protect communities of freshwater fish, though this seems likely from the comparison with present standards.

The approach is in broad alignment with the relationship between macro-invertebrates and ammonia described in the literature, and we have demonstrated compliance with the Directive's class definitions [2].

Acid conditions for rivers

The effects of anthropogenic acidification are complex and include toxic effects on biota. The UKTAG tried to develop new standards across the UK but the level of resolution at which most invertebrate analysis is undertaken by the environment agencies prevented this. In addition discussions indicated that a standard based on Acid Neutralising Capacity would be better than pH. As a consequence of these factors we propose to retain the existing standards for the first cycle of River Basin Management Plans. These standards are in Tables 8a and 8b.

Table 8: Standards for acid conditions in rivers

pH – all river types in England. Wales and Northern Ireland			
High	Good	Moderate	Poor
(5 and 95 percentile)		10 percentile	10 percentile
>=6 to <=9		4.7	4.2
pH – all river types in Scotland			
High	Good	Moderate	Poor
(5 and 95 percentile)	10 percentile	10 percentile	10 percentile
>=6 to <=9	5.2	4.7	4.2

Nutrient conditions in rivers

Increasing nutrient concentrations in rivers are thought to change the biomass and composition of biological communities. The most obvious primary impact is enhanced plant and algal production, which in extreme cases can lead to the physical blockage of river channels. Secondary impacts include reduced dissolved oxygen caused by overnight respiration of macrophytes, which in extreme cases can lead to fish kills. The impacts can include blooms and scums of blue-green algae that in extreme conditions have caused the death of wild animals, farm livestock, domestic pets and fish.

Typology for nutrient conditions for rivers

We identified that the following thresholds of alkalinity and altitude created suitable levels of sensitivity to pressures from nutrients:

- Alkalinity: up to, then above 50 mg/l of calcium carbonate;
- Altitude: up to, then above 80 metres.

This produces the following types (Table 9):

Table 9: Typology for nutrient conditions for rivers

Altitude	Annual mean alkalinity (as mg/l calcium carbonate)	
	< 50	> 50
Under 80 metres	Type 1n	Type 3n
Over 80 metres	Type 2n	Type 4n

We have a problem with the data for Type 3n. There are concerns that some of the sites thought to be high quality are actually impacted. For the present the standards calculated for Type 4n will be applied also to Type 3n.

Nutrient conditions for rivers

Analysis has indicated that diatoms show greater levels of sensitivity to nutrient pressures than macrophytes. The proposals were developed by a team of international experts on diatoms, based in the UK [3]. The team used the protocol for setting boundaries for Intercalibration.

The standards associated with diatom communities at High and Good Status are listed in Table 10. Also shown are values used previously for various purposes though none of these have yet been used as general standards in the way, for example, standards for ammonia have been used to determine permit conditions for discharges. A comparison with the Habitats Directive [27] is provided in Table 11.

Table 10a: Standards for phosphorus in rivers

Soluble Reactive Phosphorus (μg/l) (annual mean)				
Type (Table 9)	High	Good	Moderate	Poor
1n	30	50	150	500
2n	20	40	150	500
3n + 4n	50	120	250	1000

Table 10b: Values used for various other purposes

Soluble Reactive Phosphorus (μg/l) (annual mean)		
High Value used for characterisation and classification	Good Value used for characterisation	
20	Sil[25] 40	100
	Cal [26] 100	

[25] Sil: a water body in a siliceous typed section in the typology used in the characterisation for the Water Framework Directive. See paper WP2a (03) Rivers typology (Pv3-4-02-04) on the UKTAG website.

[26] Cal: a water body in a calcareous typed section in the typology used for the Water Framework Directive in work on characterisation, see paper WP2a (03) Rivers typology (Pv3-4-02-04) on the UKTAG website.

A comparison with the Habitats Directive [27] is provided. Table 11 gives guidelines that the Environment Agency has developed in with the Countryside Council for Wales and English Nature as part of the process of reviewing permit conditions in order to meet the requirements of the regulations for the Habitats Directive.

Table 11: Existing values: Habitat and Species Directive (note 1)

	High	Good
Range of values in Table 10	20 - 50	40 – 120

Habitats Directive

Total Reactive Phosphorus (µg/l) (note 2)

	Headwaters	Most rivers	Large rivers
Natural (mid-High) (note 3)	0 - 20	20 - 30	20 - 30
Guideline (mid-Good) (note 4)	20 - 60	40 - 100	60 - 100
Threshold (just into Moderate) (note 5)	40 - 100	60- 200	100 -200

Note:

It is not possible to make a direct comparison of the values in Table 11 for the Habitats Directive [27], with those in Table 10, because of how and why the values are used to take decisions. The following points can be made.

1. The criteria for the Habitats Directive represent the views of experts for the nutrient conditions as relevant to the ranges of conservation interests associated with Favourable Conservation Status under the Habitats Directive. This is in the context of the processes by which the Habitats Directive leads to its Review of Permits.
2. The criteria for the Habitats Directive are as Total Reactive Phosphorus and the proposed standards are Soluble Reactive Phosphorus. The differences between these are small.
3. The level described in Table 11 as “natural” is the estimate in the absence of anthropogenic activity. This could equate to a mid point in High Status under the Water Framework Directive.
4. The level described as “guideline” is likely to represent conditions somewhere in the middle of Good Status.
5. The level described in Table 11 as “threshold” is the level beyond which an ecological response to changing levels might be expected. This could equate to a mid point between the middle of Moderate and Good Status

We have noted above that this process for setting standards gives only a statistical association between biology and chemistry. To use the standards we need good supporting evidence of cause and effect. For phosphorus there is a balance of evidence and the strong view of most experts that phosphorus is instrumental in the eutrophication in freshwaters. It is this understanding that underpins the standards proposed in this report.

It remains a possibility, however, that the story may be more complex. For this reason, the use of standards to take important decisions about the control of eutrophication has in the past required an indication of actual or potential biological impact[27], in addition to the failure of a nutrient threshold. This is the approach for the Directives on Urban Waste Water Treatment and Nitrate, and for the methods devised for the Oslo and Paris Convention. We propose that a similar approach is used for the Water Framework Directive.

Although nitrogen may have a role in the eutrophication in some types of freshwaters, we consider the general understanding of this to be insufficient at present for it to be used as a basis for setting standards or conditions. The possibility is too strong that the statistical associations produced by these methods would represent correlation between nitrogen and phosphorus (and other factors), and not the standards for nitrogen that are truly needed to protect the biology. For these reasons no standards for nitrogen are proposed in this report.

Implications for rivers

We present in Table 12 the extent of rivers length that might be reported as worse than Good as a result of our proposals. We compare these with the results from the existing classification schemes. The values for the existing situation refer to stretches that are currently worse than Class A2 in Scotland and less than Class B in England and Wales. Northern Ireland uses a similar classification scheme to England and Wales.

These are the kind of classifications that are used to produce the coloured maps showing the status of rivers. In this context there is little change in the proportions of rivers reported as worse than "good".

In all this the implications of the standards depend on the processes we have discussed in Section 1 for Alternative Objectives. It is also possible that further work may lead to a more detailed typology.

[27] Such as enhanced levels of chlorophyll.

Table 12: Implications of existing thresholds and proposed standards								
	BOD		Dissolved oxygen		Ammonia		Phosphorus[28]	
	Per cent of river length reported as less than good							
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
England	25.6	18.7	30.8	24.6	14.6	17.3	65.0	63.3
Wales	3.7	3.7	2.4	4.1	1.4	2.7	11.4	12.8
Scotland	8.2	7.6	7.5	8.9	7	10.7	13.6	14.1
Northern Ireland	19.0	16.3	27.8	37.2	4.4	16.3	22.2	17.0

England and Wales

This kind of classification is not used directly to take decisions about improvements to particular rivers. First there is the issue of statistical confidence. Because of uncertainties in monitoring, even with three years of monthly sampling for chemical parameters, 20 per cent of rivers in England or Wales are placed in the wrong class – either worse or better than the true class.

The risk of wrong decisions caused by these uncertainties is managed in England and Wales through River Quality Objectives. In these terms 10 per cent of rivers (4 per cent in Wales and 12 per cent in England) fail with at least 95 per cent confidence, their River Quality Objectives for BOD, dissolved oxygen or ammonia. This value increases towards 20 per cent for England and 7 per cent for Wales as result of our proposed standards for BOD, Dissolved Oxygen and Ammonia.

For phosphorus in England and Wales, the classification for phosphorus has not been regarded as suitable for regulatory purposes because of uncertainties over cause and effect. Classification has been used to monitor general changes over time. Improvements for phosphorus have been made on the basis of the substantial requirements of Directives on the Urban Waste Water Treatment, the Habitats Directive, and through Government targets for Sites of Special Scientific Interest.

[28] For phosphorus in particular, as we discuss later, these particular "existing" standards are used for the reporting of trends in, for example, the General Quality Assessment used for England and Wales. As a rule these existing thresholds for phosphorus are not used to take decisions on action to improve water quality.

Our proposed standards for phosphorus would imply that 64 per cent of rivers in England and 14 per cent in Wales would be reported as worse than Good Status with at least 50 per cent confidence. The total length of failed river is 50 per cent for England at 95 per cent confidence; it is 7 per cent for Wales at 95 per cent confidence. We propose that action on these rivers is based on continued use of the model (an Indirect Model) used for the Directive on Urban Waste Water Treatment. This involves the use of chemical standards coupled with biological evidence of impact.

Scotland

In Scotland investment to improve river water quality is initially assessed on the basis of the river classification scheme. In particular the Scottish Environment Protection Agency has focused on restoring water bodies that have the poorest water quality, the bottom two classes in its scheme – classes C and D.

When managing nutrients, it has been the norm to require that biological impacts and enhanced nutrient levels must be observed prior to improvement action being taken. By giving priority to water bodies with poorest quality, the approach in Scotland is similar in outcome to that taken for England and Wales.

The new standards will result in limited changes in Scotland - the majority of water bodies will continue to be classed as better than Good.

Northern Ireland

The existing classifications for Northern Ireland for BOD, Dissolved Oxygen and Ammonia are calculated in a similar way to those for England and Wales and are therefore subject to the same statistical uncertainties. The values in Table 12 for the existing standards for Northern Ireland are based on the General Quality Assessment scheme, for monitoring over the years 2002-2004.

The situation for phosphorus is also similar to that for England and Wales. The existing 'standard' has not been used for regulatory purposes, though it is being used, in conjunction with biological indicators, in the 2005 review of the assessment of Sensitive Areas (Eutrophic) under the Directive for Urban Waste Water Treatment.

The comparison between existing and proposed standards in Table 12 should be considered as indicative because the move to typology based standards has meant a different approach which is not directly comparable with that used previously. The assessment for the proposed standards depends on the availability of data on alkalinity (Table 3 and Table 9). These data have not previously been available for all monitoring stations. It has only been possible, therefore, to estimate compliance for the part of the monitoring network.

WATER QUALITY STANDARDS FOR LAKES[29]

The Directive requires that we consider particular physico-chemical conditions. Table 13 shows the biological element we consider most sensitive for these conditions and the key parameters

Table 13: Summary of standards for lakes

Conditions	Parameter	Biological Element
Oxygenation	Dissolved Oxygen	Fish
Salinity	Conductivity	All
Acidification status	Acid Neutralising Capacity	Diatoms
Nutrient conditions	Total Phosphorus	Phytoplankton biomass (Macrophytes and phytobenthos)
Standards in Future Phases of development – see Section 3		

For lakes we lack the data on thousands of waters that were so helpful for rivers. We must rely on other methods to support the derivation of standards and conditions.

Oxygenation conditions for lakes

Oxygen consumption depends on the natural productivity of the lake and the shape of its basin. Enrichment by nutrients (eutrophication) or the direct addition of an organic load will decrease the oxygen in the deeper water and in the sediment. This may give rise to changes in benthic animal communities, and affect fish.

We propose two morphological types: mixed, and stratified during summer. We propose also to divide lakes into those that support natural populations of salmonid fish, and those with natural populations of cyprinids.

Our proposed standards are based on the protection of fish. They are an interpretation, based on expert judgement, of the existing standards.

Our proposals for dissolved oxygen are in Table 14. We propose that dissolved oxygen is measured on a single occasion each year of a 3-5 year period, and that this is done in July or

[29] Defined as standing waters in the Directive.

August. It is in these months that the thermal conditions in lakes are likely to produce the greatest impact[30]. We propose that the standard is the mean of these measurements:

- for the whole water column in fully mixed lakes;
- for the water column below the thermocline in stratified lakes.

The current Swedish scheme is shown in Table 14 for comparison. Here too, dissolved oxygen is based on mean of whole water column for mixed lakes, but the bottom of stratified lakes.

There is uncertainty over the natural levels of dissolved oxygen in stratified layers of lakes that are naturally productive, and about lakes in which a small deep hole focuses the decomposition of organic matter. The application of our proposed standards to such lakes should be treated with caution.

Table 14: Standards for dissolved oxygen		
Status	Proposed boundary (all UK lakes)	
	mean in July – August (mg/l)	
	Salmonid	Cyprinid
High	9	8
Good	7	6
Moderate	4	4
Poor	1	1

Existing standards	
From the Swedish Environment Protection Agency	
For units see the text	
Oxygen rich	≥ 7
Moderately rich	5
Moderately deficient	3
Oxygen deficient	1
Almost no oxygen	< 1

Salinity standards for lakes

We propose that the salinity criteria used to identify brackish lakes are used as the Good Status boundary for all lakes other than those identified as naturally brackish because they are close to the sea. Table 15 gives the standard.

[30] Oxygen conditions in lakes are strongly influenced by depth and thermal stratification. It is necessary to take this into account when measuring oxygen conditions in lakes. This will require measurement from boats. However, unlike transparency, dissolved oxygen changes more predictably and it is proposed that a single DO profile collected in summer will provide a useful measure of lake status.

Table 15: Standards for salinity for all lakes	
Status	Proposed boundary
	Annual mean (micro Siemens per centimetre)
Good	1000

Standards for acidification of lakes

The effects of anthropogenic acidification on the biota in surface waters are complex. They include the direct toxicity of the acidity itself, chemical changes that lead to other toxic effects, changes in the trophic relationships, changes to the buffering capacity of organic acids, and changes in the availability of dissolved carbon.

The measurement known as Acid Neutralising Capacity provides an indicator that integrates the geologically based sensitivity to acidification with the pressure from acid deposition from rainfall. It also takes account of the effect of organic acids in buffering lakes against the impact of acid deposition [4]. The impediment to using pH as a standard is that many upland lakes and lochs/loughs have a naturally high acidity and low pH.

The proposed standards are based on Acid Neutralising Capacity and given in Table 16. In general only lakes of low alkalinity[31] will be vulnerable to acidification and require a standard. We propose a single value of Acid Neutralising Capacity as the boundary between High and Good Status, and a single value as the boundary between Good and Moderate. The long residence time in lakes suggests that the episodic periods of acidity seen in rivers need not be taken into account. Therefore we propose annual mean values for the standards (Table 16).

Table 16: Standards for acidity for lakes		
Type	High	Good
	Acid Neutralising Capacity (micro equivalents per litre)	
All UK lakes	> 40	> 20[32]

Existing standards	
Defra's proposal for 2004 critical loads	Norwegian standard set for salmonid fish
Acid Neutralising Capacity (micro equivalents per litre)	
> 20	> 20

The proposed standards were derived from the work of one of the leading groups in this field in the UK [4]. International peer review is underway.

[31] Defined in the UK typology as those having less than 10 mg/l of mean annual alkalinity.

[32] If there is palaeolimnological or other evidence that the pre-industrial value was less than 20, zero is recommended.

Standards for phosphorus in lakes

The UKTAG has reviewed the outcomes of Intercalibration and updated its proposals for phosphorous standards for lakes. The updated version is in the report by the UKTAG on its second tranche of standards.

The UKTAG recommended that the UK Administrations did not cover phosphorus in lakes in their consultations on the first tranche of standards.

STANDARDS FOR TRANSITIONAL AND COASTAL WATERS

The Directive requires that we consider thermal conditions, oxygen conditions, transparency and nutrients. Table 20 shows the biological element considered most sensitive for oxygen and nutrients, and the key parameters.

Table 20: Summary of the standards for transitional and coastal waters		
	Parameter	Biological Element
Oxygenation conditions	Dissolved oxygen	Fish
Nutrient Conditions	Dissolved Inorganic Nitrogen	Plants
Standards in Future Phases of development – see Section 3		

With the exception of waters designated under the Directives on Bathing Waters or Shellfish Waters, there are no sets of data covering transitional and coastal waters that would allow the approaches used to derive standards for rivers. Partly this is the result of the way actions have been decided under the Directive on Urban Waste Water Treatment, and other Directives. Big improvements have been made to discharges, but these tend to take the form of uniform standards across all discharges of the same kind, and have not depended on a widespread and systematic monitoring of the environment[33].

Our proposals for Dissolved Inorganic Nitrogen (DIN) were developed primarily by the UKTAG Teams working on the classification of plants for the Water Framework Directive. The team working on the classification of fish developed our proposals for dissolved oxygen. These teams had expert advice from other teams.

In addition, we sought advice from the science groups of the environment agencies, and other academic experts involved in the UKTAG's work on classification. A wide search of the literature has also been included in the development of the standards. All this is to ensure that the most up to date scientific knowledge and principles have been used.

Other organisations, not represented on the UKTAG, were represented on the UKTAG's sub-groups. They have approved the information in this section of our report. These organisations include the Centre for Environment Fisheries and Aquaculture Science (CEFAS), and the Fisheries Research Services (FRS).

[33] They have been based on the type of Indirect Model discussed in Section 1.

Standards for oxygenation conditions

The standards proposed for dissolved oxygen have been developed because they are required by the Water Framework Directive for classification. They vary with salinity because the solubility of oxygen declines with increasing salinity.

100 per cent saturation is unlikely to be achieved for more than a small fraction of the time in all parts of even a pristine estuary. This is particularly true around the most turbid zones where an oxygen demand from sediment will be expressed. Despite this, fish tend to favour the most turbid areas because of the availability of food [7, 8]. Recent studies indicate that an upper limit of 7 mg/l will normally satisfy most requirements [9].

Our proposals reflect these recent studies, while remaining generally similar to previous standards. They are all set as annual 5-percentiles – the concentrations that should be bettered for 95% of the time. They are summarised as follows and in Table 21:

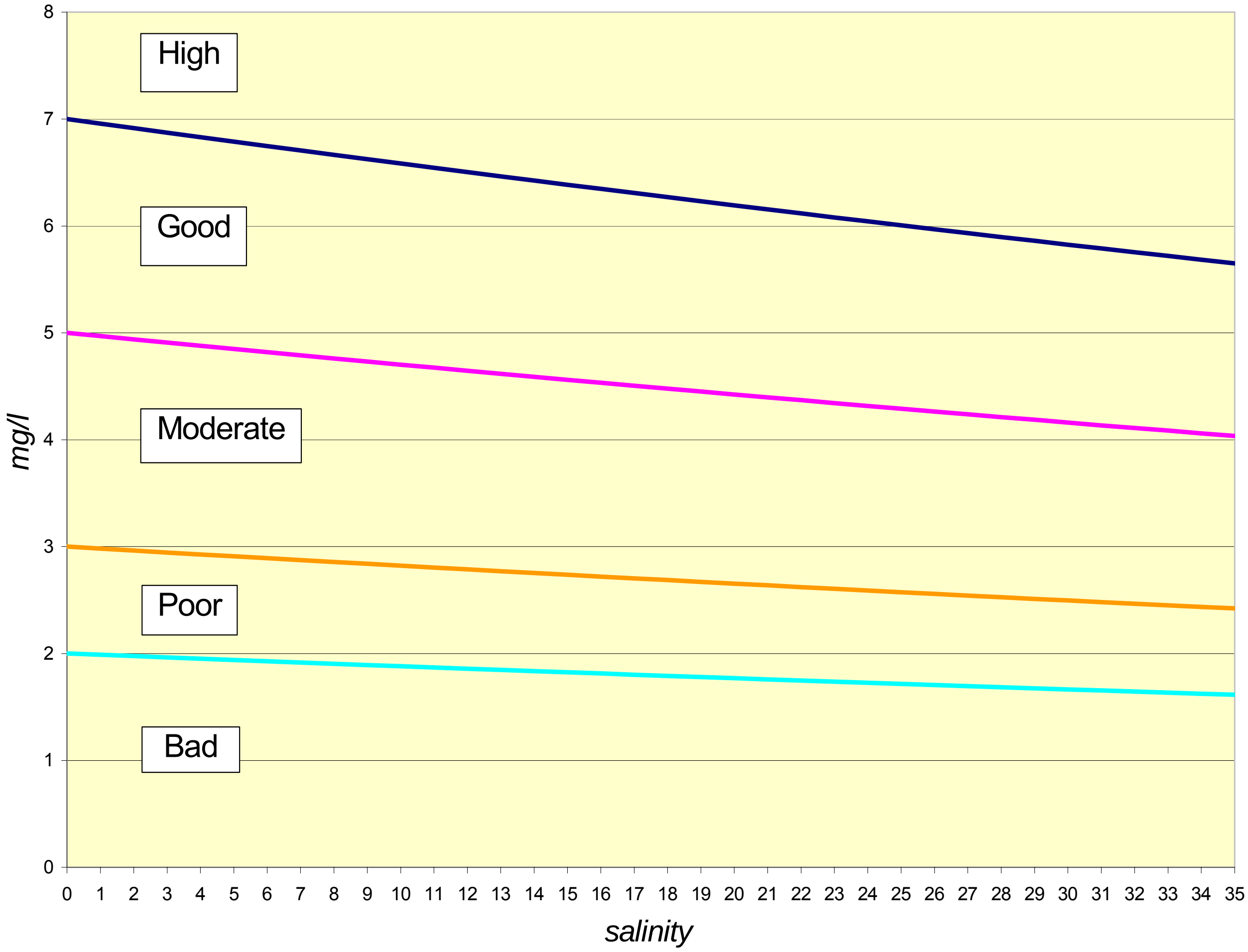
- in transitional and coastal waters a dissolved oxygen level of 2 mg/l stresses the majority of fish species;
- we exclude the naturally deoxygenated waters of deep basins [10].

Table 21: Dissolved oxygen standards for transitional and coastal waters

	Freshwater	Marine	Description
	5-percentile (mg/l)		
High	7	5.7	Protects all life-stages of salmonid fish
Good	5 - 7	4.0 – 5.7	Resident salmonid fish
Moderate	3 - 5	2.4 – 4.0	Protects most life-stages of Non-salmonid adults
Poor	2 - 3	1.6 – 2.4	Resident non-salmonid fish, poor survival of salmonid fish
Bad	2	1.6	No salmonid fish. Marginal survival of resident species

Table 21 takes no account of the reducing solubility of oxygen as salinity increases. If standards need to be set for particular areas of transitional waters then they should be read from Figure 1.

Figure 1: Variation of oxygen standards with salinity



In addition to the 5-percentile standards in Table 21, there is a need to protect against more extreme events. Dissolved oxygen should not fall below 2 mg/l at the freshwater end for more than one 6 hour tidal cycle over a 6 year period. This is achieved by assuming that the standards will continue to be supported by existing policies for the regulation of intermittent discharges.

These can be based on the principles of Fundamental Intermittent Standards[34]. These specify return periods for particular thresholds of dissolved oxygen. In most cases these standards are met automatically by the action take under Directives, or by action taken to meet the standards in Table 21 (and Figure 1).

The most likely reasons to apply the Fundamental Intermittent Standards would be where there is a known and strong variability in water quality, such as might be caused by significant intermittent discharges. The use of such standards would be tailored, as in present policy, to meet individual situations. This includes, for example, where it is clear that intermittent discharges are likely to cause the biology to fail to meet objectives under the Water Framework Directive. Table 22 illustrates the return periods to be applied.

[34] Set up for methods under Urban Pollution Management Manual (UPM) - 1994 and 1998. See [28] listed in references.

Table 22: Standards for action on intermittent discharges		
	Minimum dissolved oxygen (mg/l)	Return period (years)
Good	2	1 in 6
Moderate	2	1 in 3

Implications for oxygen conditions

Data for transitional and coastal waters are limited. As discussed above, this is partly because of the way improvements have been decided under various Directives, without the need for detailed and systematic monitoring.

Initial analysis points to the big estuaries with known problems with dissolved oxygen as likely to be worse than Good Status. These are estuaries like the Thames, Humber and Mersey.

Standards for nutrients in transitional and coastal waters

This topic has been updated and included in the UKTAG's report on its second tranche of standards.

WATER RESOURCES STANDARDS

The Water Framework Directive requires hydromorphology (which includes flow and water level) to be protected for its own sake at sites of High Status. Elsewhere, it must be protected as far as required to meet the ecological objectives of the Directive (and other established objectives). Standards are needed that define the required regimes of flow and water level. Table 28 describes the standards we have considered in this report.

Table 28: Types of standard for water resources

	Parameter	Biological Element
Rivers	Per cent change from natural flow conditions	Fish, Macrophytes and Macro-invertebrates
Lakes	Per cent change in the annual range in the natural water level range Per cent allowable deviation from the natural net inflow	Fish, Macrophytes and Macro-invertebrates
Standards for future development – see Section 3		

To promote the sustainable use of water and to allow water users to continue to operate without unnecessary restrictions, the environment agencies and others must look at the effects of flows and water levels on ecological communities. We have identified parameters (Table 29) that reflect the sensitivity of the ecology to changes in flow and water level. (The background information to the selection of parameters is found in the Stage 1 technical report [19]). We propose thresholds that we believe are important to the ecological status. We have applied the best current scientific understanding.

Heavily Modified Water Bodies

Many of the Heavily Modified Water Bodies that have been provisionally identified are, for example, reservoirs created for public water supply (or hydropower or recreation), and the river reaches immediately downstream of them. For such sites the standards and conditions presented here may not apply. For these the aim must be to achieve Good Ecological Potential.

Standards for rivers

Typology for rivers

The water resource standards and conditions for rivers are based on a typology developed by Holmes [18] and shown in Table 29. It is based on a similar management approach (i.e. restrictive management for run of river abstractions) to that used in England and Wales.

The typology in Table 29 was selected after a review of approaches. The details of this review are in our Stage 2 technical report [20]. We propose that the typology best reflects the ecological sensitivity of rivers to changes in flow and level. The sensitive biological component (that is macrophyte communities) has been analysed against a number of catchment physical parameters. The physical parameters will reflect regional differences across the UK.

As macrophyte data is not available for all UK rivers, the Base Flow Index[35], Catchment Area and a standard measure of average annual rainfall were identified as the most reliable predictive variables for the macrophyte types identified in Table 28; they have been used to map the types across the UK.

Note: The typology is different to that used for England and Wales as part of the Environment Agency's Resource Assessment and Management Framework (RAM). This, in turn, is a component of the Catchment Abstraction Management Strategies being developed for England and Wales.

In any typology there is a risk of error in using a high level summary of catchment data to derive the characteristics of a particular site. We have found that where there is a risk of this, it tends to involve types of similar sensitivity. As result we have grouped these types as listed in Table 29. Any such uncertainties should not significantly affect the actual standards that are applied.

How the standards were developed

There is insufficient field data at the UK level to derive statistically significant relationships between the level of hydrological change and the degree of ecological impact. Therefore we used workshops to draw on expert advice of UK experts to develop the standards.

The workshops covered the key biological elements – macrophytes, macro-invertebrates and fish. Those invited were selected for their expertise on the biological elements. For each of the river types in Table 29, standards were put forward for each of these three elements. These standards were then consolidated into a single standard for each type.

[35] A measure of the proportion of the proportion of a river's runoff which originates from stored sources like groundwater.

The output from the first workshop was reviewed by the UKTAG. Subsequently it was reviewed by a second workshop. This led to the proposals presented here. In addition, we asked experts from The Netherlands and the United States of America to review and comment on our proposal.

Our proposed standards are generally not as restrictive as those initially put forward in the first workshops. The experts sought a more complex regime of flow restrictions with a higher degree of variation throughout the year. There was lack of existing field data to support a more complex regime of water resource standards being imposed. As a result UKTAG simplified the grouping of the standards for each type into two seasons where restrictions on abstractions would be applied (as in Table 31). This will enable field data to be collected over the first river basin plan to confirm whether a more complex regime is warranted.

In considering our proposals, we decided that there was insufficient quantitative evidence to justify moving towards an approach that was significantly more precautionary than, for example, that used for the Environment Agency's Catchment Abstraction Management Strategies. Therefore our proposals are broadly in line with current standards and conditions applied in England and Wales

In the standards we proposed for river water quality we faced the limitations imposed by sampling frequency. This leads to high errors in the estimates of summary statistics like the annual mean or annual percentile that are used as standards. This is because there may be, for example, only 12 samples per year.

Further detail on the technical basis for these standards is outlined in the Final Technical Report [21].

For river flow, estimates of summary statistics can be based on continuous measurement at river flow gauges. This means that the standards for water resources need not face the same types of problem faced for water quality in using only a few measurements to classify a water using standards. In this respect at least, there can be more confidence that the water has been assigned to the correct class. Against this, there may be relatively few places where river flow is measured continuously, and river flow is much more variable than water quality.

<table>
<tr><th colspan="6">Table 29: Typology for water resources standards for rivers</th></tr>
<tr><td colspan="2" rowspan="2"></td><td>Type</td><td>Gradient</td><td>Altitude</td><td>Description</td></tr>
<tr><td></td><td>(Metres per kilometre)</td><td>(metres)</td><td></td></tr>
<tr><td rowspan="2">Type A</td><td rowspan="2">Clay and/or Chalk; low altitude; low slope

Eutrophic; silt-gravel bed</td><td>A1</td><td>0.8+/- 0.4</td><td>36 +/- 25</td><td>Predominantly clay. South East England, East Anglia and Cheshire plain</td></tr>
<tr><td>A2*</td><td>Slightly steeper
1.7 +/- 0.8</td><td>low altitude
55 +/- 38</td><td>Chalk catchments; predominantly gravel beds; base-rich</td></tr>
<tr><td rowspan="2">Type B</td><td rowspan="2">Hard limestone and sandstone; low-medium altitude; low-medium slope; typically mesotrophic with gravel-boulder or pebble-cobble) bed</td><td>B1</td><td>4.1 +/-9.9</td><td>93 +/- 69</td><td>Hard sandstone, Calcareous shales; Predominantly South and South West England and South West Wales</td></tr>
<tr><td>B2</td><td>Shallower than B1
2.7 +/- 10.7</td><td>71 +/- 58</td><td>Predominantly North West and East Scotland</td></tr>
<tr><td rowspan="2">Type C</td><td rowspan="2">Non-calcareous shales, hard limestone and sandstone; medium altitude; medium slope; oligomeso-trophic with pebble, cobble and/or boulder bed</td><td>C1</td><td>5.4 +/- 6.5</td><td>101 +/-84</td><td>Hard limestone; more silt and sand than C2; mesotrophic</td></tr>
<tr><td>C2</td><td>Steeper than C1
7.3 +/- 10.8</td><td>130 +/- 90</td><td>Non-calcareous shales; pebblebedrock; Oligomeso-trophic</td></tr>
<tr><td rowspan="2">Type D</td><td rowspan="2">Granites and other hard rocks; low and high altitudes; gentle to steep slopes; ultra-oligo

Oligo-trophic, with cobble, boulder, bedrock, and/or pebble bed</td><td>D1</td><td>Medium gradient
11.3+/- 15.6</td><td>low altitude
93+/- 92</td><td>Oligotrophic, substrate finer than D2 (including silt and sand); more slow flow areas than D2</td></tr>
<tr><td>D2</td><td>High gradient
25.5 +/- 33</td><td>High Altitude
178 ± 131</td><td>Stream order 1 and 2 bed rock and boulder; ultra-oligo trophic torrential</td></tr>
<tr><td></td><td colspan="5">* To reflect the different sensitivities of the headwaters of chalk streams to the downstream reaches, type A2 was split into two – A2 (headwaters) and A2 (downstream)</td></tr>
</table>

Models are used to assess the flow regime at ungauged points, though the estimate of, say, the 95-percentile low flow can have errors that are inherent to uncertainties in the model itself.

However, the assessment of the gap between a water resource standard – the impact of a particular level of abstractions and the conditions set in the licences for these abstractions – is a routine exercise of water resource planning that we consider will continue into the future.

The experts advised that we should apply ‘hands-off’ flow[36], in a wider set of circumstances. This was not addressed in the report as it was viewed as a matter for operational procedures at a country level (i.e. to ensure the correct consideration of local conditions and to meet the requirements of different legislation).

Hands-off flows have been included in Environment Agency operational guidance for many years and will also be introduced into Scotland water resource framework. Consideration will be given to the introduction of “hands off” flows in Northern Ireland.

Standards for High Status

For High Status our proposals are linked directly to the formal classification scheme for the Water Framework Directive.

The proposed standards are in Table 30. The abbreviation, QN95, stands for the natural flow that is exceeded for 95 per cent of the time[37]. The values in the table mean that natural flows exceeded for 95 per cent of the time could be reduced by up to 10 per cent, and lower flows could be reduced by 5 per cent.

[36] A hands-off flow is a level of river flow below which, for example, no abstraction is permitted.
[37] QN95 is the 95 percentile for normally 10 years of flow records. This value will usually be higher than the QN95 for the driest year, and therefore provides more protection than using data from driest years. This will be applied in England and Wales. The natural Q95 (QN95) is the flow expected to be exceeded 95% of the time within a long-term record. In Northern Ireland the observed long-term flow statistics, if data available, are expressed for at least 20 years but generally the whole period of record is considered to mirror the 30 year representative long term climate statistics expressed by the Met Office.

Table 30: Water resources standards for rivers and High Status		
Types	Flows greater than QN95	Flows less than QN95
	(allowed per cent change from the natural flow)	
All Types	Up to 10	Up to 5

Standards for Good Status

The standards we propose for Good Status for the types listed in Table 29 are in Table 31. They are expressed as the maximum permitted amount of change from the natural flow. The abbreviations, QN60, for example, refer to the natural flow exceeded for 60 per cent of the time.

Table 31: Water resources standards for rivers and Good Status					
Types	**Season**	**Flow > QN60**	**Flow > QN70**	**Flow > QN95**	**Flow < QN95**
	(% change allowed from the natural flow)				
A1	April –Oct	30	25	20	15
	Nov –March	35	30	25	20
A2 (downstream), B1, B2, C1, D1	April –Oct	25	20	15	10
	Nov –March	30	25	20	15
A2 (headwaters), C2, D2	April –Oct	20	15	10	7.5
	Nov –March	25	20	15	10
Salmonid spawning and nursery areas (not Chalk rivers)	April –Oct	25	20	15	10
	Nov –March	20	15	flow > QN80 10	Flow < QN80 7.5

The standards in Table 31 reduce the degree of change that is allowed during the spring and summer. They are designed to protect macrophytes in spring and early summer, and macro-invertebrates and fish in the late summer and early autumn. (The standards provide additional protection at times of the year when species are at key stages of their life cycles).

As an example take a river of type A1 in May. For all natural flows bigger than QN60, 30 per cent is available for abstraction.

The environment agencies' operational guidance will continue to apply 'hands-off' flows based on annual flow data, where required. A 'hands-off' flow is a particular flow at which abstraction is forbidden or reduced. Using the same example, type A1 in May, Table 31 also shows the percentage of flow available for abstraction at flows smaller than the flow exceeded 95 per cent of the time, QN95. This is 15 per cent of the natural flow.

This 15 per cent could, for some rivers, allow the whole flow to be taken at the more extreme low flows exceeded for 98 or more per cent of the time. (Such flows would be QN98 or QN99, etc). Where the 15 per cent would exceed 25 per cent of the flow at QN98 or QN99, a 'hands-off' condition should be put in place below which additional restrictions on abstraction are applied. (This means that the need for 'hands-off' flows will depend on the characteristics of the hydrology - the relative sizes of QN95 and, say, QN99).

The seasonal standards on Table 31, and the additional conditions placed for low flows, would be applied where the local environmental conditions dictate, or where an abstractor has sufficient flexibility, or where the water supply infrastructure can accommodate them.

Standards for Moderate and Poor Status

A reduction of 15 per cent of the natural flow, compared with the standards for Good Ecological status was tentatively proposed as the boundary between Moderate and Poor, but with a recommendation that further work was required to assess this. Taking the example from Table 31 of type A1 in May, the allowed 15 per cent reduction of flows less than QN95 would in this case increase to 30 per cent.

The UKTAG has undertaken further work and has developed revised non-good standards on the basis of the risk that rivers will dry up as a result of abstractions. Where abstractions are of the scale of 60-70% of the QN95, river flows are likely to fall to zero for a few days per year. It is clear when a river dries up that this causes serious environmental impacts.

Consequently the UKTAG considers that when abstractions reduce QN95 flows by 60-70 per cent then this is likely to result in bad status with most aquatic species being impacted. The UKTAG consequently recommends the use of incremental bands of 25 per cent on the good standards instead of the previously proposed increments of 15 per cent that defined the moderate/poor and the poor/bad boundary.

The UKTAG suggests that these revised incremental bands will provide a firmer basis to categorise the full range of potential impacts of abstraction. This will help the agencies set priorities for measures of mitigation.

Improving the Standards

As the understanding improves of the links between ecology and flow and water level, and as the monitoring required by the Water Framework Directive begins to deliver data and to support more research, the standards will be re-assessed for future River Basin Management Plans.

Catchments with Artificially Increased Flows

Some waters have flows that are significantly increased over the natural position due to the transfers of water into the catchment. This happens if drinking water originating from abstractions in one catchment is discharged as treated effluent from a sewage treatment works in a different catchment. Less common is the case where there is a pumped transfer of raw water between catchments, for the purposes of distributing water resources.

Where these situations arise, the percentage values available for abstraction would be based on the actual flow regime and not on the natural regime.

Comparison with existing standards for rivers

There are big differences in the way water resources are managed in different parts of the UK. As result the implications of our proposals differ.

Water resource standards in the Environment Agency

There is a long established regime in England and Wales - many thousands of abstraction and impoundment licences have been issued over 40 years.

The Environment Agency has standards for its Catchment Abstraction Management Strategies (CAMS)[38]. A review of the results of CAMS and the standards has been started as part of the preparation of the guidance for the second round of CAMS. This second round starts in 2007.

Initial results from CAMS suggest that most sites fall into a range of standards that cite an allowance of 5 to 20 per cent change. This is consistent with our proposals. When these results are complete, and consideration has been given to standards for lakes and estuaries, a decision will be made on the standards to be adopted by the Environment Agency. These will be used in the second round of CAMS.

The approximate amounts of natural flow that may be abstracted in the Environment Agency's Resource Assessment and Management Framework are in Table 32.

[38] See the home page for CAMS under "Water Resources" on the Environment Agency's internet pages

Table 32: Abstraction standards from the RAM framework				
Sensitivity to flow	Approximate allowable change in to natural flow (per cent)			
	at QN5	at QN50	at QN70	At <QN95
Very High	-	-	10	5
High	20	20	15	10
Moderate	25	25	20	15
Low	40	40	30	25
Very Low	-	-	-	30

The standards proposed in this work comprise only three groups of types (plus salmonids) versus the five types used in CAMS by the Environment Agency.

Fixed quantities are specified in abstraction licences, and the translation of a change in the percentage flow into a regulatory regime is done through a number of ‘hands-off’ flows.

The standards for high flows are couched in terms of QN5 in Table 32. They apply primarily to impoundments, where storage can intercept high flows during floods.

Our work has produced standards expressed as a percentage change from natural flow. These may turn out to be similar to those in CAMS, with a typology that may be similar to that for CAMS. As yet our proposed typology has not yet been produced on a national scale. Until this is done a full comparison cannot be made. A project to develop a map of the new typology for all of the UK will get underway shortly.

We need then to compare the application of the proposed standards with those in CAMS. Careful consideration must also be given to the implications of changing standards and how the standards are used in the regulatory framework for managing the impact of abstractions.

Scotland and Northern Ireland

Scotland and Northern Ireland have no comprehensive abstraction licensing systems and so do not have well developed methods for linking ecological assessment to water resources management. Scotland began the implementation of a regime from April 2006. Northern Ireland is due to begin the implementation of a licensing regime from January 2007.

In Scotland and Northern Ireland, where there are no issues involved in moving from one system to the new, we suggest that the proposal in this report provide the best available approach.

Standards for lakes and lochs

Water resources standards for lakes and lochs - Typology for lakes

The proposed standards are based primarily on catchment geology. It has six types: Peat (P), Low Alkalinity (LA), Medium Alkalinity (MA), High Alkalinity (HA), Marl, and Brackish (B). The typology has been augmented by other factors (depth, altitude, size and the form of the basin) to better reflect sensitivity to changes in flow and water level (Table 33).

Table 33: Typology for lakes

Tier	distinguishing variable(s); (units)	Class names and criteria					
Geological type	as UK lakes typology (UKTAG 2003)	P	LA	MA	HA	Marl	B
Depth		Very shallow (Sh)			Deep (D)		
	D_{mean} (m)	< 3 m			= 3 m		
Altitude		Lowland (Low)		Mid-altitude (Mid)		High-altitude (High)	
	(m)	< 200		200 – < 800		= 800	
Size		VS/S			L/VL		
(lake area)	A (ha)	1 - < 50			= 50		
Season		summer			winter		
	months	February to September			October to January		
Basin form		vex (VCx/Cx)			lin (SCx/L/C)		
	$V_d = 3D_{mean}/D_{max}$	< 0.67			= 0.67		

Note: the order of tiers reflects that of the UK lakes typology, and does not necessarily reflect order of importance in terms of sensitivity to alteration of the water level.

Standards for High Status for lakes and lochs

We are still working on these.

Standards for Good Status for lakes and lochs

Table 34 below shows standards for Good Status expressed in terms the percentage allowable change from the natural net inflow.

Table 34: Standards for Good Status for lakes

	Per cent change in natural inflow

Geology		Altitude	Low				Mid				High			
		Size	VS/S		L/VL		VS/S		L/VL		VS/S		L/VL	
		Basin form	lin	vex	lin	vex	lin	vex	lin	vex	lin	vex	lin	vex
	Depth	Season												
P	summer	D	15	15	15	10	15	15	15	10	15	15	15	10
		Sh	15	10	10	10	15	10	10	10	15	10	10	10
	winter	D	15	15	15	10	15	10	10	10	12	10	10	10
		Sh	15	10	10	10	10	10	10	10	10	10	10	5
LA	summer	D	30	25	25	25	30	25	25	25	30	25	25	25
	summer	Sh	25	25	25	25	25	25	25	25	25	25	25	25
	winter	D	20	20	20	20	20	20	20	15	20	15	15	15
	winter	Sh	20	20	20	15	20	15	15	15	15	15	15	15
MA	summer	D	20	20	20	20	20	20	20	20	20	20	20	20
		Sh	20	20	20	15	20	20	20	15	20	20	20	15
	winter	D	20	20	20	20	20	20	20	15	20	15	15	15
		Sh	20	20	20	15	20	15	15	15	15	15	15	15
HA, Marl	summer	D	30	25	25	25	30	25	25	25	30	25	25	25
		Sh	25	25	25	25	25	25	25	25	25	25	25	25
	winter	D	30	25	25	25	25	25	25	25	25	25	25	25
		Sh	25	25	25	25	25	25	25	25	25	25	25	20
B	summer	D	20	20	20	20	20	20	20	20	20	20	20	20
		Sh	20	20	20	15	20	20	20	15	20	20	20	15
	winter	D	30	25	25	25	30	25	25	25	25	25	25	25
		Sh	25	25	25	25	25	25	25	25	25	25	25	25

Standards for Moderate and Poor Status

As with rivers the UKTAG recommends the use of incremental bands of 25 per cent on the good standards defined for the moderate/poor and the poor/bad boundary. These percentage increments for the moderate/poor boundary are based on the summer values outlined in Table 34. Whereas the percentage increments for the poor/bad boundary are based on the summer values except for the brackish loch where the winter value is used.

Existing standards for lochs and lakes

There are no consistent UK standards beyond the criteria used for the characterisation of water bodies and to assess risk under the Water Framework Directive. If used as standards these criteria would allow rates of abstraction of between 15 and 25 per cent of the flow (Table 35).

Table 35: Characterisation criteria for lakes and lochs			
Sensitivity to flow	Per cent change from natural flow		
	at QN50	At QN70	At QN95
All categories	25	20	15

The proposals in Table 34 allow between 7 and 35 per cent of the flow to be taken when expressed in the way used in Table 35. This expands the range relative to Table 35. The increased variation seems to be related to the ecological sensitivity of different types. Most of the natural lakes and lochs/loughs subject to this level of abstraction pressure are in Scotland.

Where abstraction takes place from a loch or lake the river outflow is likely to be more sensitive to flow change impacts than the lake.

Using and developing the lake standards

We will use the standards help guide decision on the management of lakes but will also continue to work on the development of these standards.

Because the UK has not had these kinds of standards, our proposals will be tried out for selected lakes. The results of these trials will be put on the UKTAG website.

ASSESSING MORPHOLOGICAL ALTERATIONS TO RIVERS

This chapter of the report describes a risk assessment tool that has been developed to help regulators determine whether changes to the morphology of rivers could pose a risk to the ecological objectives of the Water Framework Directive.

Introduction

There are no environmental standards available to assess the ecological impacts of alterations to the morphology of rivers. Where regulation occurs, decisions are largely based on expert judgement.

Under the Water Framework Directive (WFD), the UK is required to manage morphological change to ensure that all surface water bodies aim to achieve “Good Ecological status” and that there is no deterioration in status. In terms of classification, the Directive specifies that hydromorphological quality elements must be explicitly considered when classifying for high status. For other status boundaries, the Directive requires that morphological conditions are consistent with the achievement of the values required for the biological quality elements.

There is limited quantitative data describing the relationships between hydromorphological conditions and ecological status. It is clear however that human induced hydromorphological pressures impact on ecology. Furthermore, it is recognised that different biological parameters may be more sensitive to certain hydrological or morphological processes than others, and that the relative sensitivities will differ according to variables such as river type.

In the absence of suitable data to empirically derive standards for morphological conditions, a risk assessment tool has been developed. The tool employs best available information on common morphological alterations and how these alterations affect morphological features and the flora and fauna these features support. Due to the lack of suitable empirical data, the tool is currently underpinned by professional judgement. Over time, the aim will be to confirm or replace professional judgment with empirically tested data.

The risk assessment tool is intended to help regulators determine whether proposals to alter morphological features could threaten the objectives of the Water Framework Directive. The tool will not replace case specific use of expert judgment or case specific impact assessments. The tool will complement these areas and provide risk-based guidance to inform regulatory decisions.

General approach to regulating new proposals to alter morphology

The river MImAS tool has been developed to help regulators determine whether morphological alterations could:

- Threaten the achievement of ‘good ecological status; or
- Result in a deterioration of ecological status

Information on risks to ecological status will help regulators determine:

- When more detailed assessments will be necessary; and
- When deteriorations of status may need to be managed, for instance, by considering an exemption (WFD Article 4.7) on the basis of benefits to human health, human safety or sustainable development.

Each UK agency will develop their own approach to undertaking more detailed assessments. These assessments would be likely to incorporate site specific case work and may include validation of the risk assessment, more detailed assessment of current morphological conditions and consideration of proposed mitigation measures.

The exact scope of any such assessment will be determined by the nature and complexity of the proposed activity and the perceived degree of risk to ecological status. Many such proposals already require a full or limited environmental assessment. The developer is usually responsible for undertaking the assessment to the satisfaction of the regulatory body.

Other elements of regulatory decision-making include:

- Ensuring that good practice guidelines are followed;
- Ensuring proposals meet flood management requirements;
- Ensuring that conservation and biodiversity objectives are met; and
- Ensuring that the needs of other water users are appropriately considered.

River-MImAS- Concepts and Definitions

The River-MImAS tool comprises a series of interdependent modules. Collectively, the modules provide an assessment of the risk of impacts to *morphological conditions* from combinations of *morphological alterations*.

Morphological conditions- *refers to the list of attributes in Annex V of the Directive. This includes depth and width variation, structure and substrate of riverbed, structure of riparian zone.*

Morphological alterations- *any pressures acting on the water environment that could affect morphological conditions. Examples of morphological alterations include shoreline reinforcement and dredging.*

The tool uses a concept of ‘system capacity’ to measure impacts to morphological conditions. It is assumed that different morphological alterations will use up different amounts of system capacity, with the amount of capacity being used dependant on:

- The type of alterations;
- The sensitivity of the water environment to the alterations; and
- The spatial scale of the alterations.

System Capacity – *a measure of the ability of the water environment to absorb morphological alterations. The likelihood (or risk) that morphological and ecological conditions are degraded will increase as system capacity is consumed. This concept does not infer that degradation of the environment is acceptable; rather it assumes that there is a degree to which minor changes can be tolerated by the system.*

Where a new morphological alteration is proposed, for instance dredging or channel straightening, the tool can be used to predict the impact of the proposal on 'system capacity'. By considering such impacts, the tool can be used to assess the level of risk presented by a proposal. This information can then be used to inform regulatory decisions and/or identify where more detailed assessments are required.

To help quantify the risk that a new morphological alteration could impair achievement of the objectives of the Water Framework Directive, a series of 'morphological condition limits' have been defined. Details of the proposed limits are provided in the following sections. Exceeding a morphological condition limit would indicate a risk to the ecological status of a water body.

Morphological Condition Limits (MCLs)- *Thresholds of alteration to morphological conditions beyond which there is a risk that the Ecological status objectives of the WFD could be threatened. The limits are expressed in percentage capacity.*

The River-MImAS tool employs a series of assumptions:

- *The section of river under assessment has some capacity to accommodate morphological change without changes to its ecological status;*
- *There is a relationship between the extent of morphological alteration and the impact on ecological status;*
- *The response of a rivers morphology to an engineering or other pressure is predictable for that type of water body; and*
- *The response of the ecology to morphological change is predictable and depends on the sensitivity of the ecology of the water body.*

The MImAS tool is used to undertake risk assessments. The tool is not intended to:

- Replace the need for detailed assessments or professional judgment;
- Act as an engineering design tool;
- Define remediation options;
- Provide a quantitative assessment of the presence or quality of habitats; or
- Consider conservation requirements (protected habitats/species or special features)[39].

[39] Conservation objectives will be dealt with through separate regulatory procedures. River-MImAS would not replace or supersede any existing conservation assessments, targets or duties.

Validation and Review

In recognition of the limited empirical information describing how morphological alterations influence flora and fauna, particularly for relatively moderate alterations, a programme of validation and refinement is being developed. In the medium to long term, the aspiration is to incorporate information generated from WFD monitoring and from dedicated scientific research programmes. Effort in this area will focus on:

- Reviewing and test the assumptions underpinning the River-MImAS tool;
- Refining the tool to reflect new evidence on the interaction between morphology and ecology, including replacing expert judgment with empirical data where possible; and
- Generating further scientific evidence on the links between morphological alterations and ecological status.

In the short term, the tool has been subject to peer review and field trialling. The following reports outline the results of this work:

- WFD49 (Rivers) (2006). Peer review short summary (August 2006); and
- WFD49c CRESS (2006). Trialling of River-MImAS and proposed Morphological Condition Limits

Details of the regulatory application of River-MImAS

It is envisaged that River-MImAS would be applied within a two-stage regulatory screening process. This two-stage process would support the implementation of an efficient, risk-based regulatory procedure. In the Stage 1 and 2 screening exercises, River-MImAS would first be applied to assess current conditions. The tool would then be applied to assess whether there is a risk that a proposed alteration would cause a deterioration of ecological status. This assessment would be based on an examination of whether a proposed morphological alteration would cause a condition limit to be exceeded.

Stage 1 would be a preliminary risk assessment. Within a Stage 1 assessment it is expected that River-MImAS would be applied at a local-scale (500m). This local-scale assessment would be used to identify low risk proposals that do not threaten ecological status.

Proposals that exceed the morphological condition limits at a local scale would be subject to a Stage 2 assessment. Within a Stage 2 assessment, River-MImAS would be applied at a larger scale to determine if the morphological condition and/or ecology of a river water body could be threatened by a morphological alteration. This assessment may require input of supplementary data including information on the condition of the surrounding catchment.

The outputs from the Stage 1 and Stage 2 assessments would help regulators determine:

- When more detailed regulatory assessments will be necessary; and
- When deteriorations of status may need to be managed, for instance, by considering an exemption (WFD Article 4.7) on the basis of benefits to human health, human safety or sustainable development.

A description of the spatial scaling rules that would be applied to assess risks to water bodies is provided in the final section of this chapter.

The most detailed assessments, including any further assessments to determine whether an exemption test would be required, would typically be reserved for proposals exceeding the morphological condition limits at a water body scale. When determining if a regulatory exemption would be required, each UK agency would be responsible for defining standard protocols for determining where additional expert judgment or other information (including information from detailed assessments) should be used to complement and/or validate the risk assessment made using River-MImAS.

Details of the River MImAS tool and condition limits

This tool is based on five interrelated modules. Collectively the modules provide an assessment of impacts to morphological conditions. All impacts are measured in terms of impacts to 'system capacity'. Each module is designed to be semi-independent of the others, thereby allowing individual modules to be updated over time as more information becomes available. The modules are described below.

1. The Attribute Module

This module defines a list of attributes that can be used to assess morphological and ecological function and condition. The attributes are closely related to the morphological quality elements in Annex V of the WFD. They cover such things as bed forms, substrate condition and the structure of the riparian vegetation. Each attribute was chosen for its role in the direct or indirect support of ecological communities and the processes needed to create and maintain the physical environment on which ecological communities depend. Attributes have been defined for two river zones- (i) channel and (ii) bank and riparian.

2. The Typology Module

The typology contains six classes of river type (named A to F). These range from high energy upland types such as bedrock channels, to low energy types such as lowland meandering rivers. The types are based on an assessment of similarities in physical characteristics and similarities in the likely responses to morphological alterations. These types will be subject to further review through validation and testing.

The typology supports an assessment of the relevance of the attributes (contained in the attribute module) to the different river types. Where attributes are not relevant, they would be excluded from assessments carried out on that channel type. For attributes that are relevant to a particular river type, the assumption is that they will display responses to morphological alterations that can be predicted.

Although typologies are simplified representations of complex and dynamic physical characteristics, they have been shown to be useful when assessing the likely physical and ecological responses to morphological alterations.

Table 36 summarises the channel typology and principal determinants of channel type. Columns 1 to 4 in this Table describe a range of characteristics which are indicative of each river type in the absence of morphological alterations. Column 5 in this Table describes further characteristics that can be taken into account if the river type cannot readily be distinguished in accordance with Columns 1 to 4.

3. Sensitivity Module

The Sensitivity Module is divided into two parts- ecological sensitivity and morphological sensitivity. The sensitivity assessment has incorporated consideration of the resistance to change (ability to absorb change) and the resilience to change (ability to recover from change).

For the morphology component, the assessment considers the intrinsic sensitivities of each attribute to physical disturbances. This is carried out for each River type. For the ecology component, the assessment considers whether a degradation of community or species integrity is likely to occur in response to a disturbance to individual attributes. Again, this is carried out for each river type. The ecological assessment considers all WFD biological quality elements- fish, benthic invertebrates, phytoplankton, and other aquatic flora.

All assessments within the sensitivity module are based on professional judgement. This was necessary given the current lack of empirical data on the links between biology and morphology. Testing and validating the sensitivity module will be a priority, and the module will be updated to reflect new evidence.

4. The Pressure Module

This module comprises two components- (i) assessment of the likelihood that a morphological alteration will have an impact on an attribute (contained within the attribute module) and (ii) an assessment of whether impacts are likely to be contained within the vicinity of the pressure, or whether the impact will extend beyond the local vicinity of the pressure. The latter assessment is termed the ‘zone of Impact’.

Fifteen pressures have been incorporated in this module (Table 37). They include pressures such as ‘hard’ engineering for bank protection, dredging and culverting. The Pressure Module is not type specific. The difference in response to the pressures between river types is captured by combining the Sensitivity Module with the Pressure Module.

Table 36: River morphology typology

		Column 1	Column 2	Column 3	Column 4	Column 5
Type	**Channel descriptions**	**Typical Valley Form**	**Typical Channel slope**	**Typical Sinuosity**	**Dominant Geology**	**Typical bed characteristics**
A	*Bedrock and Peat channels*	Confined	Variable	< 1.5	Peat or Solid	Channel bed characterised by exposed bedrock or peat deposits. Occasional sediment deposits may be present.
B	*Cascading channels*	Confined	> 0.04	< 1.1	Solid	Channel bed characterised by exposed bedrock and disorganised accumulations of boulders and cobbles.
	Step-pool channels:	Confined to Partly Confined	0.01-0.08	< 1.1	Drift	Channel bed characterised by accumulations of boulders and cobbles forming steps separated by intervening pools containing finer sediments
	Plane bed channels	Confined to Partly Confined	0.005-0.03	< 1.2	Drift	Channel bed characterised by an armoured and relatively featureless gravel/cobble bed which tends to lack deep pools. Isolated boulders may be present.
C	*Pool-riffle channels and plane-riffle channels*	Partly Confined to Unconfined	0.002-0.03	< 1.5	Drift	Characterised at low flows by sequences of pools and riffles (typical spacing 5-15 channel widths). Bed material predominantly gravel with occasional patches of larger or smaller sediments. Gravel bar features typically located on outside of bends.
	Wandering channel	Unconfined	0.008-0.03	< 1.1	Drift	Bed characteristics similar to pool-riffle but may contain vegetated islands and larger bar features.
	Braided channels:	Unconfined	0.0005-0.03	< 1.2	Drift	Bed characterised by gravel bar deposits that split the channel into multiple threads. Pools and riffles will be present.
D	*Low gradient actively meandering channels*	Unconfined	0.0001-0.001	> 1.4	Drift	Pools and riffles associated with gravel bar formations on meander bends. Bed sediments dominated by sand and gravel.
E	*Groundwater dominated channels*	Unconfined	<0.001	< 1.5	Drift, Chalk or Lime	Substrate generally comprises gravels, pebbles and sands. Sections of featureless, armoured bed are common, although pools and riffles may be present. Marcrophyte beds are often extensive.
F	*Low gradient passively meandering channels*	Unconfined	< 0.0001	< 1.5	Drift	Bed sediments dominated by sand and silts with occasional gravel bar deposits. Flows typically non-turbulent.

Unconfined: Channel lateral movement not constrained by narrowness of valley;
Partly confined: Channel lateral movement restricted to narrow flood plain by narrowness of valley
Confined: Lateral movement of channel prevented by constraining valley sides
Channel slope - the ratio of stream length between two points and the drop in elevation between those two points.
Sinuosity - the ratio of stream length between two points divided by the valley length between those two points.

Table 37: Morphology alterations considered with River-MImAS

Morphological alteration	*Description*
Set-back embankment	Artificial walls, artificial earth banks or other artificial structures that are > 10m from the edge of the channel and which are used to raise the height of the bank.
Embankment	Artificial walls, artificial earth banks or other artificial structures that are < 10m from the edge of the channel and which are used to raise the height of the bank.
Condition of Riparian (bankside) vegetation	Alteration of the structural complexity of vegetation within 5 metres of the channel, ranging from complete removal of vegetation to a partial change one component of the vegetation, such as loss of woody vegetation
Soft (or green) bank reinforcement	Bank revetment using vegetation; biodegradable geotextiles; wood placed at the toe of the bank; or non-grouted stone rip-rap placed at the toe of the bank
Hard (or grey) bank reinforcement	Bank revetment using materials or methods other than vegetation; biodegradable geotextiles; wood placed at the toe of the bank; or non-grouted stone rip-rap placed at the toe of the bank where:
Culvert with natural bed (e.g. arch culvert)	A closed conduit for the conveyance of water under infrastructure or land that has a natural channel bed, Includes culveting used for river crossings.
Pipe or Box culvert	A closed conduit for the conveyance of water under infrastructure or land that has a manmade river bed, Includes culveting used for river crossings.
Sediment removal	Removal of sediment from the channel bed where the sediment is removed from ≤ 50 % of the channel width
Dredging	Removal of sediment from the channel bed where the sediment is removed from > 50 % of the channel width
Bed reinforcement	Alterations to the channel bed which increase its resistance to erosion, such as the lining of the bed, or the replacement of the bed, with concrete; bricks; wood; sediments larger than those typically capable of being transported by the river; or any other materials resistant to erosion
Croys or groynes or other flow deflectors	Placement of any structure on the bed of the channel such that the structure abuts one of the banks and deflects part of the river flow to another part of the channel
Piled structures (including bridge piers)	Placement of a structure on the bed of the channel such that the structure deflects part of the river flow to another part of the channel
Impoundments	Any dam, weir or other works by which water is impounded
High impact channel realignment, e.g. straightening	Alterations of the channel length or the channel width which pose a high risk of destabilising the balance between erosion and deposition of sediment and hence the structure and condition of the bed or banks
Low impact channel realignment, e.g. historic channel realignments	Alterations of the channel length or the channel width which pose a low risk of destabilising the balance between erosion and deposition of sediment and hence the structure and condition of the bed or banks

5. The Scoring System

The scoring system combines the information contained in each module to calculate a numerical 'impact rating'. Each morphological alteration contained with the pressure module has its own impact rating, which is specific to each channel type. The impact rating is calculated for each attribute in turn, and then averaged for attributes within channel, and bank and riparian zone. This value is then multiplied by the zone of impact to give an overall impact rating for each morphological alteration.

The formula used to calculate the impact rating can be summarised as:

Equation 1

Impact rating										
	=	Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact	X	Zone of Impact
		Output from typology module		Output from sensitivity module		Output from sensitivity module		Output from pressure module		Output from pressure module

Table 38 and 39 summarise the impact ratings for the channel, and bank and riparian zone calculated using River-MImAS.

To determine the percentage capacity used within a particular water body or section of water body, the impact ratings are combined with 'alteration footprints' for all morphological alterations present within the length of river being assessed.

An 'alteration footprint' describes the type and extent of a morphological alteration. Different alterations will have different footprints, for instance, the footprint for bank reinforcement is the length over which the reinforcement occurs.

The formula used to calculate the capacity consumed by a single pressure, or combination of pressures within a predetermined assessment area/length, can be summarised as:

Equation 2

$$\text{Capacity Used (\%)} = \sum n \left(\frac{\text{Impact rating} \times \text{Footprint of morphological alteration}}{\text{Length of assessment}} \right) \times 100$$

Where n is the number of morphological alterations within the assessed length; and ∑ ( ) is the sum of results given by the equation specified in the parenthesis for each of the 'n' alterations. For alterations to the river channel, the length of the assessment is based on the length of river channel. For alteration to the banks, the length of the assessment is based on the total length of the banks adjacent to the channel.

Table 38: Impact ratings for morphological alterations – channel zone

Morphological alteration	*River types to which the morphological conditions apply*					
	A	**B**	**C**	**D**	**E**	**F**
Set-back embankment	0.01	0.02	0.06	0.04	0.04	0.02
Embankment	0.21	0.33	0.83	0.58	0.58	0.29
Condition of Riparian (bankside) vegetation	0-0.03	0-0.08	0.-0.11	0.01-0.16	0.01-0.16	0-0.05
Soft (or green) bank reinforcement	0.03	0.08	0.11	0.16	0.16	0.05
Hard (or grey) bank reinforcement	0.08	0.16	0.38	0.28	0.28	0.13
Culvert with natural bed (e.g. arch culvert)	0.42	0.67	1.67	1.17	1.17	0.58
Pipe or Box culvert	0.54	0.81	1.85	1.44	1.44	0.69
Sediment removal	0.25	0.42	0.63	0.71	0.71	0.38
Dredging	0.42	0.67	0.92	1.08	1.08	0.58
Bed reinforcement	0.33	0.58	1.58	1.08	1.08	0.5
Croys or groynes or other flow deflectors	0.13	0.25	0.72	0.47	0.47	0.22
Piled structures (including bridge piers)	0.16	0.28	0.88	0.56	0.56	0.25
Impoundments	0.42	0.67	1.67	1.17	1.17	0.58
High impact channel realignment	0.33	0.58	1.67	1.17	1.17	0.5
Low impact channel realignment	0.13	0.22	0.31	0.38	0.41	0.19

Where a range is given, UK agencies would apply a score that falls within the range and, which in the opinion of the agency, reflects the severity of the alteration.

Table 39: Impact ratings for morphological alterations – bank and riparian zone

Morphological alteration	*River types to which the morphological conditions apply*					
	A	**B**	**C**	**D**	**E**	**F**
Set-back embankment	0	0	0	0	0	0
Embankment	0	0.19	0.38	0.31	0.19	0.19
Condition of Riparian (bankside) vegetation	0	0-0.09	0.01-0.16	0.01-0.16	0-0.09	0-0.09
Soft (or green) bank reinforcement	0	0.09	0.16	0.16	0.09	0.09
Hard (or grey) bank reinforcement	0	0.19	0.38	0.31	0.19	0.19
Culvert with natural bed (e.g. arch culvert)	0	0.50	1.00	0.83	0.50	0.50
Pipe or Box culvert	0	0.50	1.00	0.83	0.50	0.50
Sediment removal	0	0	0	0	0	0
Dredging	0	0.31	0.50	0.56	0.31	0.31
Bed reinforcement	0	0.13	0.25	0.19	0.13	0.13
Croys or groynes or other flow deflectors	0	0.38	0.75	0.63	0.38	0.38
Piled structures (including bridge piers)	0	0.08	0.17	0.17	0.08	0.08
Impoundments	0	0.33	0.67	0.58	0.33	0.33
High impact channel realignment	0	0.50	1.00	0.83	0.5	0.50
Low impact channel realignment	0	0.13	0.19	0.19	0.13	0.13

Where a range is given, UK agencies would apply a score that falls within the range and, which in the opinion of the agency, reflects the severity of the alteration.

Morphological Condition Limits for River Morphology

Morphological condition limits (MCLs) are defined for each river zone: channel, and bank and riparian. Distinguishing between these zones provides regulators with a simple method of identifying which aspect of a river is likely to be impacted. This information would be useful when defining the scope of a more detailed assessment.

The morphological condition limits proposed for these zones are set out in Table 40. Exceeding these limits would indicate a risk to WFD status objectives. All morphological condition limits will be subject to review as new evidence becomes available.

Table 40: Proposals for condition limits for river morphology

Zone	*System capacity used (%)*			
	High	**Good**	**Moderate**	**Poor**
Channel	5	25[1]	50	75
Bank and Riparian	5	25[1]	50	75

[1] To help ensure that Stage 1 assessments only screen out low risk proposals, the agencies may adopt a Condition Limit of 15% for the Good-Moderate boundary when undertaking a Stage 1 assessment.

The condition limits presented in Table 40 are not type specific. The differences in response between river types are taken into account within the risk assessment tools scoring system.

As the impact rating for a particular morphological alteration influences how much system capacity an alteration consumes, the limits do not simply mean, for instance, that 5% of the bank can be reinforced before a risk to high status is identified.

Operational guidelines will be developed to protect those high status sites with special features that are not explicitly considered within River-MImAS.

Spatial scaling rules for assessing risks to water bodies

Two rules for applying River-MImAS to assess risks to water bodies have been defined.

Spatial scaling rule one

Equation 2 will be used to calculate the capacity consumed within a river water body from all current and proposed morphological alterations. The capacity used by these alterations will be compared with the condition limits to assess risks to ecological status. For these assessments, the ‘assessment length’ will be based on the length of the water body.

River-MImAS will not be applied directly to river water bodies that are less than 5km long. This is because the capacity of such water bodies to accommodate alterations depends to an important extent on the morphological condition of their neighbouring water bodies. Where a proposed morphological alteration occurs in a water body less then 5km in length, the water body will be assessed in conjunction with the nearest upstream or downstream water body that is on the same tributary or main stem river, provided the combined length of the water bodies is greater than 5km. If this option is not appropriate, an assessment length of 5km will be applied in Equation 2.

Spatial Scaling rule two

Discrete morphological alterations can have an adverse ecological impact of sufficient magnitude to affect the status of a water body even though the overall capacity of the water body in terms of cumulative impacts has not been exceeded.

The following formula would be applied to determine if the extent of any discrete alteration is sufficient to result in a risk of deterioration in status:

Equation 3:

$$\text{Extent in km of discrete morphological alteration} = \frac{\text{Condition limit}^{1} \times \text{length of assessment}^{2}}{\text{Impact rating}}$$

[1] The condition limits described in Table 40 would be applied.

[2] For rule two (Equation 3), the length of the assessment is fixed at 10km for alterations affecting the river channel and 10 km for alterations affecting the river banks.

ANNEX 1: SPOT SAMPLING AND CONTINUOUS MONITORING

In general, chemical data are collected through routine visits to sites at which measurements are made, or samples taken for analysis at a laboratory. 12 visits might be made in a year.

This is sometimes criticised because an isolated event will escape detection. As we have discussed in the text of our report, the nature of the Environmental Quality Standards, the way they are expressed, and the way action is designed and implemented to meet them, means that the risk from isolated events is managed.

Data from monitoring are used to estimate summary statistics like annual averages and annual percentiles. This step is necessary in order to allow a proper statistical assessment of compliance with standards, and to be able to check correctly for deterioration and improvement. It also allows the correct calculation of, for example, the quality of discharges needed to meet environmental standards. All this is in line with the report by the Royal Commission [25].

The estimation of summary statistics involves errors, particularly a dominant error associated with taking only a few samples in a year (statistical sampling error). The extent of this error is calculated by standard statistical techniques. It reduces with the number of samples. Other errors, like those in chemical analysis, are usually less important overall, but they are also taken into account in the assessments of compliance with standards.

With a continuous monitor there can be an infinite number of samples and the statistical sampling error vanishes to leave only any error from bias in the instrument, or from breakdowns that lead to lack of cover and to a set of data that might be unrepresentative. Such monitors are expensive and cover only a few pollutants. Spot samples are still used to allow the environment agencies to cover most rivers and tributaries, along their length, and to measure all the important pollutants. The use of spot samples is an approach based on risk and cost-effectiveness that works because water quality standards can be and are set as summary statistics that are correlated with the events that are much rarer than implied by the summary statistic.

There are some sites where the risks are unusual, or the water especially sensitive. The environment agencies might use continuous monitors and telemetry for these to augment the scrutiny provided by routine spot sampling. Such sites include, for example, waters that face particularly big threats of pollution incidents, or which are key in the management of waters used as supplies of drinking water.

A related issue is that samples are usually taken in office hours and that one or two aspects of water quality may show strong and regular fluctuations within a 24-hour period. They may also show poorer quality outside office hours. As discussed in the main text of our report – in our discussion of the development of our standards – such phenomena will simply lead to tighter numeric values for Environmental Quality Standards (based on sampling in office hours) than would be the case of round-the-clock sampling. If the use of sampling in office hours can continue to be accepted, it allows more samples to be taken for any fixed cost (because out-of-hours sampling is expensive). In terms of overall confidence in taking decisions, and in picking up deterioration earlier, these extra samples are nearly always worth more than fewer samples that are guaranteed representative of all hours in the week.

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