Proposals for environmental quality standards and conditions – phase 2

Surface water standards and conditions

Joint Links' response to the UKTAG consultation

Please note that this is a joint response from Wildlife and Countryside Link, Scottish Environment LINK, Northern Ireland Environment Link and Wales Environment Link representing the views of 16 environmental non-governmental organisations from across the UK

Wildlife and Countryside Link brings together 38 environmental voluntary organisations in the UK united by their common interest in the conservation and enjoyment of the natural and historic environment.

Scottish Environment LINK, with its 36 member bodies, is the forum for Scotland's voluntary environment organisations representing a broad spectrum of environmental interests with the common goal of contributing to a more environmentally sustainable society.

Northern Ireland Environment Link's 37 Full Members work together to promote the care and protection of the natural and built environment of Northern Ireland.

Wales Environment Link is a network of voluntary environmental and countryside organisations in Wales, most of whom have an all-Wales remit. WEL is the official link between the government and the voluntary environmental sector in Wales. As an umbrella body WEL helps represent the shared interests of its 30 member organisations.

The following organisations have contributed to, and support this response:

- Anglers' Conservation Association
- Association of Rivers Trusts
- Buglife – Invertebrate Conservation Trust (England & Scotland)
- Butterfly Conservation Wales
- Herpetological Conservation Trust
- Marine Conservation Society
- National Trust
- Pond Conservation – The Water Habitats Trust
- RSPB and RSPB Scotland
- Salmon & Trout Association
- Scottish Wildlife Trust
- The Wildlife Trusts
- WWF UK and WWF Scotland
- Zoological Society of London

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Summary

The Standards and Conditions that will be required to meet Good Ecological Status (GES) are an essential part of the Water Framework Directive (WFD). We welcome the effort that has been put into developing these standards, and recognise the difficulties in developing new environmental standards from scratch across the UK, and before the full results of the intercalibration exercise are published. Despite this, we have some concerns over the draft proposals for the phase 2 standards and conditions. Some of these concerns are general in nature, and some relate to specific standards, such as turbidity and temperature. Our major concern in relation to the UK TAG process is that scientific objectivity has been compromised by considerations of expediency, achievability, or the continuation of the status quo. We hope that our comments can be considered in drawing up the final standards.

In our detailed comments in this response, we highlight the following concerns:

- We are generally concerned that some of these standards **are not based on ecology**, but rather a set of chemical parameters with no apparent links to biological impacts.
- We are disappointed that a list of reference sites has not yet been published, and **ask that the list of all reference sites is made public as a matter of urgency.**
- The UK TAG papers **fail to explain the concept of good ecological status**, and the meaning of 'slight' deviation in relation to WFD normative definitions. This lack of interpretation creates much uncertainty in understanding how the UK has transposed the concept of high, good and moderate status.
- There is a need to further explain the links between the existing **imperative and guideline** standards under other Directives and the WFD standards.
- There is a need for further development of standards for **Nitrogen in rivers and lakes**
- We argue that temperature standards should be cross-checked with **temperature** requirements for macroinvertebrates and that **temperature** standards should be brought in line with the imperative standards under the Freshwater Fish Directive.
- There is a wealth of scientific evidence on the impacts of **suspended solids, turbidity and deposited solids** on fish and invertebrates. We are extremely concerned over the lack of proposals for a new standard and argue that there are reliable ways of monitoring suspended solids and setting new standards.
- A wide range of impacts needs to be considered when assessing the impacts of **managed flows** and an involvement of a multi-disciplinary team of experts is required.
- **We strongly support the principle of revising and reviewing standards on a continuous basis,** and in relation to further work on Intercalibration. All WFD standards should also be reviewed on regular basis and updated, where it becomes obvious that the given standard is not achieving good ecological status.
- We also recommend that a further consultation process be undertaken that reviews the entirety of the WFD classification process. Without being able to see the whole picture, it is difficult to link WFD classification and the individual standards which are supposed to represent ecological classes.

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Introduction and general comments

The introduction of environmental standards is a key aspect of implementing the Water Framework Directive (WFD). The WFD has an enormous potential to protect and improve the status of the water environment. The proposed ecological standards will guide the improvements that may be necessary to achieve good ecological status in all water bodies across the UK.

We again express our disappointment that the UKTAG has chosen to develop these Standards and Conditions without engaging the wider scientific community and other stakeholders. We believe that ongoing scrutiny and involvement of academics and eNGOs in this process would have increased the legitimacy of the process and the resulting standards. Our major concern in relation to the UK TAG process is that scientific objectivity has been compromised by considerations of expediency, achievability, or the continuation of the status quo. The WFD requires the standards to be purely based on technical and scientific basis and not pre-judge legitimate social, economic and political considerations, which are dealt with through the derogation tests.

We find the release of this consultation for a period of 5 weeks over the summer holidays inadequate and badly planned. The volume of all three consultations, including technical supporting papers, amounts to hundreds of pages of technical literature. The UK TAG has had at least two years, if not longer, to develop these standards, and it is unrealistic to expect a robust stakeholder review of all three volumes in just 5 weeks. We are thankful for the extension of the deadline for responding to the groundwater standards and will send our response in due course. However, we would like to stress that the short timescales have affected our ability to fully review the proposed standards. In this response, we therefore concentrate our efforts on reviewing a selection of standards, including temperature, phosphorus in lakes, impacts of managed flows and suspended solids which most concern us. **Please note that due to the time constraints we are not able to submit a response on Specific pollutants. However, this does not mean that we are content with the proposed standards.**

We strongly support the principle of revising and reviewing standards on a continuous basis, and in relation to further work on Intercalibration. We believe that further development of these standards should more closely involve all relevant stakeholders. We strongly recommend that all WFD standards are reviewed on regular basis and updated, where it becomes obvious that the given standard is not achieving good ecological status. Further consultation process should be undertaken to review the entirety of the WFD classification process. Without being able to see the whole picture, it is difficult to link WFD classification and the individual standards which are supposed to represent ecological classes.

Considering the level of our concerns in relation to some of the proposed standards**, we would like to request a meeting with the UK TAG's Chair and the relevant task group leaders. In the light of this, we have also written to the UK TAG administration and the Chair requesting such meeting.**

Reference condition

The success of the standards depends entirely on the selection of sites which have been considered as being at reference condition. Given the importance of reference sites to the whole WFD and UK TAG process, the ability of stakeholders to inspect independently the list of sites should have been one of the main priorities of this review**.** We are disappointed that a list of reference sites has not yet been published, and **ask that the list of all reference sites is made public as a matter of urgency.**

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Interpretation of normative definitions

In developing standards for WFD, the UK TAG used the Directive's definition of classes. The understanding of the meaning of the WFD normative definitions of high, good and moderate status is therefore key in the setting of the WFD standards. Central to the setting of standards to achieve Good Status is the concept of 'slight' in relation to 'deviation from high status'. **The UK TAG technical papers fail to explain these concepts and how they have been translated into standards.** This lack of interpretation creates much uncertainty in understanding how the UK has transposed the concept of high, good and moderate status.

Complying with the existing standards and conditions

The relationship between the standards and conditions proposed by the UK TAG in the draft consultation and standards in existing Directives needs to be made clearer. The UK TAG proposes some changes to the current standards under the Freshwater Fish Directive (FwFD) in relation to temperature. The Freshwater Fish Directive will be repealed in 2013 by the WFD, and any relevant standards and conditions for FwFD will need to be incorporated with the WFD. However, WFD requires that standards and objectives for waters designated under FwFD and other sites in the Protected Areas register, to be achieved by 2015. **It is therefore our understanding that imperative standards for sites included in the Register of Protected Areas should remain according to the legislation under which they are designated.** Changes to imperative standards under other legislation might have legal implications.

The need for a Nitrogen standard for lakes and rivers

In our previous response to Phase 1 standards, we argued for the inclusion of Nitrogen (N) standard for freshwaters. This need is especially evident in some lakes, where Nitrogen is increasingly recognised as an important nutrient. We previously argued that the role of N should be considered in specific cases on lake eutrophication where there is a known history of Phosphorus (P) enrichment. N and P may be limiting in some low nutrient/acidic lakes and some hypertrophic lakes with some large P inputs. In such cases, a separate process on identifying the appropriate limited nutrient may be required. Whilst we recognise that there is little data available to set specific standards for N, further work is needed in this area. In fact, it is difficult to see how the Nitrate Directive (91/676/EEC) and the Freshwater Fish Directive (78/659/EEC) can be incorporated under the umbrella of the WFD unless standards for N and its compounds are set. **Given the very extensive contamination of freshwaters by N, we recommend that a review of the recent technical literature be conducted with a view of investigating the need for a national standard on N.**

The need for additional standards and conditions to assess water quality spikes

International scientific opinion is increasingly focusing on the importance of water quality incidents of short duration and higher intensity. These water quality 'spikes' can have very significant ecological impacts, but may not be picked up under the proposed annual average approach. This includes diffuse pollution events which often cause significant ecological damage. We recommend that standards should reflect the potentially negative impact of water quality spikes. This could be achieved by *supplementing* annual average standards with a limit on the number and depth of water quality spikes allowed within fixed periods of time. Potentially costly monitoring for such spikes might then be undertaken under circumstances where the risk is assessed as being highest.

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Comments on specific standards

1. Temperature

1.1 Overview

We are concerned that the UKTAG has recommended that **temperature should not form part of the routine assessment of the ecological condition of waters.** There is a significant body of evidence in published literature that demonstrates the effect temperature has on both fish and invertebrates. Depending on the temperature range these effects can cause alterations in metabolic rate, behavioural change, or indeed they could be catastrophic, i.e. above about 22 degrees salmonid mortalities start to increase exponentially. Oxygen concentration is also directly linked to temperature saturation reaching its highest point at 4 degrees. Many scientific papers and even books (e.g. work by Elliot formerly of the FBA) have been written about the impacts of temperature on Salmonids. Unsurprisingly invertebrates have the same physiological relationship to temperature as it largely acts on cell processes and enzyme function rate. We have estimated that temperature uplifts as large as those proposed by the UK TAG of 3^{o}C for good status and 2^{o}C for high status, could potentially result in a 40% decrease in species in waters of high ecological status and a 60% decrease in all other cases. **Considering the significant affect that even a 1^{o}C rise in temperature can have on macroinvertebrate assemblages we therefore recommend that temperature uplift values and temperature range be cross-checked with the temperature requirements for macroinvertebrates.**

We also believe that the UK may risk infraction if it adopts the UKTAG proposal to relax the imperative standards set out in the Freshwater Fish Directive (FwFD) for the upper temperature limits and the exclude the lower limit for spawning in salmonid waters from classification criteria.

We argue that temperature limits should be brought in line with the requirements of the Freshwater Fish Directive and uplift values should form part of a standard under the WFD. However, we recommend that temperature values should be reviewed in relation to climate change impacts in future as and when becomes necessary. Should any direct impacts on the aquatic ecology be detected due to climate change, full consideration needs to be given to mitigation measures such as increasing tree cover in the uplands, where this may be an appropriate solution.

1.2 Imperative standards under existing legislation

One advantage of the WFD is that it will rationalise the Community's water legislation by replacing seven of the old directives, including the freshwater fish waters, shellfish waters, and groundwater directives; and the directive on dangerous substances discharges. However it is clear that it was not the intention of Parliament and the Council that repealing these Directives should lead to any reduction in environmental ambition (Recital 51). By contrast we believe **that the UKTAG proposals represent a significant relaxation of protection and could lead to significant deterioration in fish population. It is essential, therefore that the temperature standards and conditions for FwFD will need to be incorporated with the WFD**. Further weight is given to this argument by the inclusion of standards and objectives for waters designated under FwFD in the Protected Areas register and achieved by 2015. It is therefore our understanding that imperative standards for these areas should remain according to the legislation under which they were designated. Changing these imperative standards at this stage could potentially have legal implications.

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We are further concerned that omitting the temperature limit for spawning salmonids from the classification of waters would ignore a key factor determining the ability of salmonids to reproduce and therefore the ecological status of the water. **We therefore propose that temperature limits for salmonid spawning be kept in areas designated for the importance of fish.**

1.3 The importance of temperature to ecological status

The low weighting given by UKTAG to temperature belies its importance for the ability of fish, invertebrates and other species to thrive and survive. Temperature is a population-limiting factor for fish and invertebrates in that it affects their metabolism, reproduction, feeding, egg incubation and migration. Temperature also plays a major role in defining the significance of other factors affecting ecological status. We understand that climate change might impact on water temperatures, and the ecological standards on temperatures may therefore need to be reviewed in the light of any changes caused by climate change.

The UKTAG proposes that temperature standard is not used in classification of lakes, estuaries and coastal waters for the Water Framework Directive but used, where appropriate, to regulate the operation of thermal discharges. **We would argue that temperature is an important parameter in meeting good ecological status in aquatic ecosystems**. Although regulation of thermal discharges is important, **there are many other factors which can affect temperature to a similar degree as such discharges, such as abstractions, riparian tree management, river flows and reservoir releases, enhanced chemical and biological activity and urban runoff.** They should also be monitored and regulated for the achievement of good ecological status. Temperature affects the resilience of ecosystems to other environmental stresses and should therefore form part of the overall classification of all waters. Whilst the assessment of appropriate standards for lakes and estuaries may be complicated, **this should not be a reason for excluding temperature as a criterion for classification.**

Elevated temperature can cause the behaviour of chemicals in water to change. The Anglers' Conservation Association (ACA) is currently investigating a legal claim for damages arising from warm water being discharged into the River Llynfi in South Wales for example. Cooling water discharges from Georgia Pacific paper mill clearly have an impact on water quality by causing, it is thought, the conversion of ionised ammonia (from Sewage Treatment Works' discharges further upstream) to unionised ammonia which is much more toxic to fish. This has led to significant fish kills and this hypothesis has been accepted by Environment Agency Wales.

There is a direct relationship between temperature and dissolved oxygen in water. Dissolved oxygen declines rapidly with even small increases in temperature, which would greatly affect the ecological status of water bodies. **Temperature also affects the behaviour of viruses in fish.** 2006 saw a widespread outbreak of Koi Herpes Virus, a disease affecting some cyprinid fish. Fish seem most susceptible at water temperatures of 72-81°F (22-27°C).

1.4 Sensitivity of macroinvertebrates to temperature increases in relation to proposed temperature uplift values

This current UKTAG review has focused on fish research although it acknowledges that the PRINCE project (Preparing for Climate Change Impacts on Freshwater Ecosystems) is investigating temperature impacts on macroinvertebrates. We believe that such cursory examination of the evidence base is inadequate and are concerned UKTAG have **not considered any of the currently available macroinvertebrate research in this assessment despite its significant impact on temperature standards**. Although research

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on freshwater invertebrates and temperature is limited, a number of significant papers have highlighted the effect of temperature increase on invertebrate communities. The most significant is a recent paper by Durance and Ormerod (2007)[1] which observed temperature increases removing scarcer taxa and reducing springtime abundance in circumneutral upland streams. Other research has also witnessed affects, for example energetic effects, increased temperature resulting in increased predation by fish (Kishi et al., 2005)[2] and increased decomposition reducing litter levels (e.g. Lepori et al., 2005)[3]; both of which can potentially reduce macroinvertebrate numbers. The effect of small temperature changes on growth rate has been observed (Briers et al., 2004[4], Elliott et al., 1988[5]) and temperature also regulates the growth and development of aquatic invertebrates so that emergence occurs at favourable times (Vannote & Sweeney, 1980[6]; Voelz et al., 1994[7]; Chadwick & Feminella, 2001[8]).

Durance and Ormerod (2007), funded by the Environment Agency, studied upland streams in Wales utilising a dataset spanning 25 years (1981-2005) and examined North Atlantic Oscillations effects in this system. These findings showed significant effects on macroinvertebrates confined to circumneutral streams, with a reduction in assemblage stability during positive phases. Spring macroinvertebrates numbers declined on average by 21% for every 1^{o}C rise in temperature and projections of future increases saw abundances reduced up to 60% with progressive increases of +1, +2, +3 ^{o}C. Many core common species had wider temperature amplitudes, which is characteristic of high latitude species, able to persist through interannual variations and surviving temperature gains of 3^{o}C. However variations mostly affected less common species, in comparison 4-10 of the scarce taxa (5-12% of the species pool) were at risk of local extinction. Temperature increases also threaten stenotherms, in particular restricted cooler-water species, potentially eliminating them from freshwater systems (Duafresne *et al*. 2004[9]). Other research has also shown an increase of 1.5^{o}C decreases species richness and density of gastropods and bivalves (Mouthon & Daufresne 2007[10]). Although not all research has shown an effect of temperature change on freshwater systems (Langford & Ashton 1972[11]; Markowski 1960[12]), however the Durance & Ormerod (2007) study demonstrates that some systems are more sensitive than others and have the potential for significant and detrimental species reductions as a direct result of temperature increases; in particular systems supporting scarce freshwater invertebrates. **In relation to the above, we**

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[1] Durance I, Ormerod SJ (2007) Climate change effects on upland streams macroinvertebrates over a 25-year period. *Global Change Biology*, **13**, 942-957.
[2] Kishi D, Murakami M, Nakano S, Maekawa K (2005) Water temperature determines strength of top-down control in a stream food web. *Freshwater Biology*, **50**, 1315–1322.
[3] Lepori F, Palm D, Malmqvist B (2005) Effects of stream restoration on ecosystem functioning: detritus retentiveness and decomposition. *Journal of Applied Ecology*, **42**, 228–238.
[4] Briers RA, Gee JHR, Geoghegan R (2004) Effects of the North Atlantic Oscillation on growth and phenology of stream insects. *Ecography*, **27**, 811–817.
[5] Elliott JM, Humpesch UH, Macan TT (1988) Larvae of the British Ephemeroptera: a key with ecological notes. *Scientific Publications of the Freshwater Biological Association No 49*. Freshwater Biological Association, Ambleside
[6] Vannote RL, Sweeney BW (1980) Geographic analysis of thermal equilibria – a conceptual-model for evaluating the effect of natural and modified thermal regimes on aquatic insect communities. *American Naturalist*, **115**, 667–695.
[7] Voelz NJ, Poff NL, Ward JV (1994) Differential effects of a brief thermal disturbance on caddisflies (Trichoptera) in a regulated river. *American Midland Naturalist*, **132**, 173–182.
[8] Chadwick MA, Feminella JW (2001) Influence of salinity and temperature on the growth and production of a freshwater mayfly in the Lower Mobile River, Alabama. *Limnology and Oceanography*, **46**, 532–542.
[9] Daufresne M, Roger MC, Capra H, Lamouroux N (2004) Long-term changes within the invertebrate and fish communities of the Upper Rhone River: effects of climatic factors. *Global Change Biology*, **10**, 124–140.
[10] Mouthon J, Daufresne M (2006) Effects of the 2003 heatwave and climatic warming on mollusc communities of the Saone: a large lowland river and of its two main tributaries (France). *Global Change Biology*, **12**, 441–449.
[11] Langford TE. and Ashton, RJ. (1972) The ecology of some British rivers in relation to warm water discharges from power stations. *Proc. Roy. Soc., Lond., B.,* **180**, 407-419.
[12] Markowski S. (1960) Observations on the Response of Some Benthonic Organisms to Power Station Cooling Water. *The Journal of Animal Ecology,* **29 (2)**, 349-357

therefore recommend that the proposed standards be crosschecked against the temperature requirements for macroinvertebrates.

1.5 Uplift and drop values and lower limit for salmonids and invertebrates

The UK TAG proposes to change the uplift values from the FwFD's mandatory standards of 1.5 degrees, to 3 degree for both the upper and lower limits in temperature changes for good status, and 2 degrees for high status. Although UKTAG may not have found evidence for the reality of thermal barriers created by temperature uplifts and drops of less than 3ºC, it does not mean that such discharges do not have a significant impact on the receiving waters. **We would oppose the modification of either the uplift or drop standards which were established in the Freshwater Fish Directive.** The temperature values have only been developed in relation to fish requirements, but in previous text we argue that there is enough evidence that other aquatic life, including invertebrates, are also sensitive to water temperature changes. **On the basis of this evidence we have estimated that temperature uplifts as large as those proposed, 3^{o}C for good status and below and 2^{o}C for high status, could potentially result in a 40% decrease in macroinvertebrate species in waters of high ecological status and a 60% decrease in all other cases.** These temperature increases would particularly threaten the scarce species present. Such a reduction in macroinvertebrate abundance could also affect associated predators during annual reproduction. **The relationship between temperature and macroinvertebrates needs to be further investigated.**

1.6 Summary and recommendations

Due to the evidence given above, we do not believe that the proposed standards for temperature are adequate for achieving good ecological status under the WFD. The UK TAG proposal for setting the boundary between good/moderate status at 23 degrees is too high. We recommend that this value be brought in line with the requirements of the Freshwater Fish Directive of 21.5 degrees.

We further recommend that there is significant evidence to support the use of imperative standards under FwFD for uplift and drop values for the classification of good ecological status. Even the use of these standards may not be adequate for the protection of macroinvertebrates and further research is needed to quantify this.

2. Phosphorus in lakes

We understand that the lakes require a more complex typology. However, the UK TAG proposal is very unclear how the standard for individual lakes will be derived. For example, setting individual standards for every lake also means setting individual reference conditions. Setting these for each of thousands of lakes in the UK may prove very time consuming. We therefore ask that the final Standards paper contains explanation of the detail processes that will be used to determine the P-values for lakes.

There is also the possibility of using some general models, as it is generally accepted that the level of understanding of the processes by which increases in nutrients can increase the biomass is sufficiently well understood. A number of models have been developed that predict biomass production, and make predictions of concurrent changes in nutrient concentrations, planktonic and zooplanktonic biomass as well as algal community structure[13].

[13] J. Hilton at al./Science of total environment 365 (2006) 66 - 83

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Total catchment phosphate models are also available, such as Protec etc. see papers by Colin Reynolds.

2.1 The role of Nitrogen in the euthrophication of lakes

In the previous chapters we raised the concern over the lack of proposals fro Nitrogen standard for freshwater. We reiterate this point again here. Some lakes, Nitrogen is increasingly recognised as an important nutrient. The role of N should be considered in specific cases on lake eutrophication where there is a known history of P enrichment. N and P may be limiting in some low nutrient/acidic lakes and some hypertrophic lakes with some large P inputs. In such cases, a separate process on identifying the appropriate limited nutrient may be required.

3. Suspended solids and turbidity

3.1 Overview

In our previous response to the UK TAG Phase 1 standards, we argued for the inclusion of an appropriate standard for suspended solids and turbidity. **We do not believe that the Phase 2 proposal for dealing with suspended solids has been addressed in adequate manner.** The proposed approach by the UK TAG is no different to what is already in existence – the screening of suspended solids in discharges has been in place for some time, and codes of good practice have been in existence for decades. Despite this, significant damage to aquatic life in lochs, lakes and rivers is still being caused as a result of sedimentation and turbidity. **It is clear that a new standard for turbidity and suspended solids is needed to address this issue.** We argue that there is considerable evidence that sedimentation and turbidity are significant contributors to declines in populations of aquatic organisms. Sometimes, the effect on the habitat is direct, especially where there is a sudden and catastrophic release of material, resulting in fish and invertebrate mortalities. At other times, sediment may fill waterspace and affect the bed profile of a river or lake. We also argue that there are reliable methods for monitoring suspended sediment, and a number of ways by which a relevant standard could be developed.

WWF-UK and Environment Link partners have commissioned APEM consultancy, a specialists in aquatic science, to review the UK TAG proposals for suspended solids and turbidity. The report includes literature review of ecological impacts of suspended solids and turbidity, critical review of the UK TAG proposed approach and proposals for alternative standards and methods. The recommendations of this report have been incorporated in this response. Full report is attached for your information.

3.2 The importance of sedimentation and turbidity to ecological status

Britain's rivers and lakes, whether rural or urban, are increasingly under threat of pollution from sediment. The construction of housing and industrial estates, new roads, quarry workings, bridges, wind farms and pipelines all involve the disturbance of vast quantities of soil and substrate which often ends up in rivers and lakes. Intensive farming, especially ploughing on steep slopes, high stock densities and an absence of fencing to keep animals off riverbanks, can lead to very significant sediment loads in rivers.

However, in most cases, sediment pollution involves subtle but very significant effects on ecology. When silt settles on gravels used by spawning fish and as habitat for invertebrates, it often fills the interstices of the gravels, impeding the flow of fresh oxygenated water and rendering them incapable of supporting fish eggs and invertebrates. Sediments can also

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adsorb a range of pollutants including nutrients and heavy metals carrying them into water bodies.

The environmental, economic and social impact of sediment erosion is much wider than its impact on ecology. It can lead to: enhanced flood risk by reducing channel capacity; hugely increased costs, energy consumption and landfill demand associated with treating water for public supply; and an increase in the need for environmentally-damaging and expensive dredging.

3.3 Impacts of sedimentation, suspended solids and turbidity on fish

The impact of sedimentation and suspended solids on fish, particularly salmonids, is very well documented[14]. River and lake sediment loads both in suspension and deposited in the bed can impact upon fish by affecting spawning site selection, intergravel survival, swim-up fry emergence and juvenile and adult survival. All species have the potential to be impacted through physical and behavioural mechanism including choking and feeding disruptions. Studies show large egg mortalities in salmonid redds due to oxygen starvation caused by small increases in interstitial fine sediments (Greig *et al*., 2005)[15]. Mortality figures of between 98 and 100% have been observed for salmonid eggs incubating within spawning gravels suffering from high siltation leads (Turnpenny & Williams, 1980)[16]. There are good ways of linking turbidity in terms of gravel in-filling rate, fish stress and mortality and egg survival for example the paper by Newcombe & Jensen (1996) gives a methodology for modelling the impacts of turbidity on all life stages of cyprinid and salmonid fish. A number of studies summarised within Crisp (1996)[17] on the incubation success of salmonid eggs and fry emergence suggest that substrata containing > 15% of fine sediments (<1.0mm) are unsuitable for their successful survival. Percentages of 10% and below are considered ideal for survival success. Other lithophilous species including bullhead, UK lamprey species, and a number of cyprinids including barbel, chub, gudgeon and dace all require similar spawning habitat to salmonids, in particular good intergravel flow and oxygen supply. The work of the Environment Agency (EA) on the Torridge (The impact of Land Use on Salmonids) clearly demonstrates the impact of silt on salmoinds once it is in the gravel. The Anglers' Conservation Association (ACA) is currently handling seven siltation cases on behalf of its members in different parts of the UK. The case on the River Ribble is a good example of long-term damage from silt pollution. Whilst there has not been a detectable fish kill, worrying levels of siltation have been experienced in the main river and two of its tributaries following the laying of a gas pipeline by the contractors Entrepose. Due to the severity of the problem, the ACA has instructed fisheries experts to investigate the effect of the siltation on future fish stocks and fishing.

The ACA is also currently handling a number of cases involving run-off or discharge of silt from quarries, including Tick Hill Lakes, Sixmile Water (see below), and the Derwent. In the last two of these cases, the failure to provide adequate settlement or filtration for silt-laden wastewaters has led to vast amounts of quarry material being flushed into ACA members' rivers. On the Derwent, enormous quantities of fine sediment originating from a "tailings" lagoon were released into Stoke Brook and then into the River Derwent, wiping out fish in the

[14] The most relevant study linking this impact to the cause is *The Impact of Land Use on Salmonids: A Study of the River Torridge Catchment* (National Rivers Authority, R & D Report: 30).
[15] Greig *et al*., (2005). The most relevant study linking this impact to the cause is: The Impact of Land Use on Salmonids: A Study of the River Torridge Catchment, National Rivers Authority, R & D Report: 30.
[16] Turnpenny and Williams (1982). A conductiometric technique for measuring the water velocity in salmonid spawning beds. Water res. 16: 1383 - 1390
[17] Crisp, D.T. (1996). Environmental requirements of common riverine European salmonid fish species in fresh water with particular reference to physical and chemical aspects. Hydrobiologia, 323: 201 - 221

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stream and leaving thick layers of silt on the spawning gravels. There are further worries that the silt may contain toxic material including heavy metals.

In 2005, when Lanivet Stream – a tributary of the river Camel in Cornwall – was contaminated by tonnes of silt from a road construction site, the waters turning bright orange. An employee of the council's own construction unit had cut through a bund in a lagoon, allowing the silt to find its way into the stream. As in most of the ACA siltation cases, the failure to contain run-off material properly has harmed spawning redds.

Sometimes, when large quantities of water are released rapidly into rivers and lakes, it can cause erosion of vast amounts of soil, which can transform the bed profile of the receiving water. When United Utilities allowed chlorinated water to discharge into the Lodges in Rochdale, sand and soil were stripped from an open ditch and deposited into the terraced pools of the fishery, taking with them nutrients which will promote algal growth. Removing the silt will be highly expensive and damaging to the ecology of the water. It has also smothered the habitat work previously undertaken by the angling club.

3.4 Impact of sedimentation, suspended solids and turbidity on invertebrates

There is considerable evidence that sedimentation and turbidity are significant contributors to declines in populations of aquatic organisms. Tsui and McCart (1981)[18] found that densities and standing stocks of lotic insects were inversely related to levels of sedimentation. Wagener and La Perriere (1985)[19] reported that sedimentation decreased both density and biomass of benthic macro-invertebrate communities and stated that turbidity was the strongest descriptor related to such reductions. Gammon (1970)[20] found that shifts in benthic invertebrate communities were characterised by increases in silt-tolerant genera and these shifts were observed at suspended sediment concentrations as low as approximately $53 mgl^{-1}$.

Ryan (1991)[21] concluded that a 12 to 17 percent increase in interstitial fine sediment may be associated with a 16 to 40 percent reduction in the total abundance of invertebrates. Flume experiments have shown that several species of mayfly, stonefly and caddisfly all choose un-sedimented substrate when offered a choice. Sedimented regions were avoided due to the loss of interstitial space between stones. In several other cases documented in Rosenberg & Resh (1993)[22], reductions in densities of aquatic insects and in the general diversity of benthic macro-invertebrate communities were associated with areas of stream exposed to heavy siltation. Decreases in in-stream (autochthonous) primary production has been associated with increases in sedimentation and turbidity through reduced light penetration, smothering and abrasion, and this can produce negative cascading effects through depleted food availability to zooplankton, insects, and fish (Henley *et al*, 2000)[23].

[18] Tsui, P. and McCart, P. (1981) Effects of stream-crossing by a pipeline on the benthic macro-invertebrate communities of a small mountain stream. *Hydrobiologia*, **79**: pp. 271 - 276.
[19] Wagener, S. and La Perriere J. (1985) Effects of placer gold mining on primary production in subartic streams of Alaska. *Water Research Bulletin*, 22: pp. 91 - 99
[20] Gammon, J.R. (1970) The effect of inorganic sediment on stream biota. *Water Pollution Control Research Series*. Report No. 18050 DWC 12/70, U. S. Environmental Protection Agency, Government Printing Office, Washington DC.
[21] Ryan P. (1991) Environmental effects of sediment in New Zealand streams: a review. *New Zealand Journal of Marine Freshwater Research,* 25: pp. 207 - 221.
[22] Rosenberg, D. and Resh, V. (1993) Introduction to Freshwater Bio-monitoring and Benthic Macro-invertebrates in Freshwater Bio-monitoring and Benthic Macro-invertebrates. Chapman Hall, New York, 10: 488pp.
[23] Henley *et al.*, (2000) Effects of Sedimentation and Turbidity on Lotic Food Webs: A Concise Review for Natural Resource Managers, *Reviews in Fisheries Science*, Vol.8, No.2, pp.458-139

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These cases demonstrate, we hope, that regulation of sediment needs to go much further than it does at present, and that there is a real ongoing problem with this issue. In chapters below, we propose new ways of monitoring the effects of suspended solids and turbidity on ecological status and propose a new standard.

3.5 Methods for monitoring suspended sediments

There are reliable methods for monitoring suspended sediment. Data loggers or gravel baskets can be used. The proportion of fine sediment in gravel is the most ecologically relevant measure, and one which only requires granulometry. The refill rate of gravel interstitial space is a very useful measure. Fluvial geomorphological assessment would enable the establishment of a standard representing good ecological status for different sections of different rivers towards which we could progress.

3.6 Management of sediment release using codes of practice and general binding rules

We support, of course, initiatives to prevent pollution through awareness-raising, partnership working and distillation of regulatory requirements into practical guides. However, we have seen many codes of good practice fail to be adopted by the worst practitioners and little or no enforcement action taken to punish them. This in turn has demotivated those following the code to continue doing so. It is therefore clear that a new way of identifying and dealing with sediment release and turbidity is needed.

3.7 Proposals for a new standard and monitoring

Evidence review undertaken by the Environment Link organisations and independent consultants suggests that there is a genuine and pressing need to address the issue of water quality standard, in particular for suspended solids, both for the use within the WFD classification and to protect the aquatic environment. We agree that the current standard under FwFD of 25mg/l is not sufficient for the assessment of risk of damaging events. However, we do not agree with the UK TAG statement that *'there is no useful water quality standard by which to assess this in a reliable way'*. In fact, we argue that it is possible to derive new standards which reflect the level of risk to the ecological status based on existing tools and knowledge. We understand, however, that further investigations and research of actual damaging events may help to develop more stringent standards for the use within the WFD.

An independent review of the UK TAG proposals[24] for suspended solids gives the following recommendations:

- A single national standard may not be the most appropriate way of assessing ecological status.
- A more appropriate assessment should be based upon individual catchment characteristics and the monitoring of damaging events. It is recommended that a single standard be replaced by a number of thresholds taking into consideration exposure length, return period and population recovery time.
- For example, fish may be able to withstand a higher suspended solid concentration for a short period of time, than they would be able to withstand over a prolonged period
- Further research may be need to develop more stringent standards, which will apply within the WFD, which might take time.
- However, setting of interim standards may be required to prevent further deterioration in status.

[24] APEM Scientific report, 2007

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- Existing standards developed for FwFD and the EIFAC working party for mining operations in the Yukon (DFO, 2000) can be used as basis for the interim standards, and adapted to take into consideration exposure periods and recovery times.
- In addition to suspended solids, standards should be set for **deposited solids,** and the inclusion of such standards is not currently referred to in the UK TAG report.
- The standard for deposited solids needs to be developed, dependant on a number of characteristics including particle size, water velocity and a degree of turbulence.
- The UK TAG proposals do not indicate the assessment methods for measuring the concentration of suspended solids, in particular during incidents of high sediment release for example, during heavy rainfall.
- There are ways in which turbidity can be monitored continuously through light scattering data loggers.
- Deposited solids sampling is also essential assessment of good ecological status, and there is a variety of methods that can be used, including the assessment of scour and fill in riverbeds, the collection of samples for analysis, and the deployment of sediment baskets and traps.

3.8 Summary and recommendations

There is a wealth of scientific evidence on the impacts of suspended solids, turbidity and deposited solids on fish and invertebrates. We are extremely concerned over the lack of proposals for a new standard and argue that there are reliable ways of monitoring suspended solids and setting new standards. Existing standards developed for FwFD and the EIFAC working party for mining operations in the Yukon (DFO, 2000) can be used as interim standards, and adapted to take into consideration exposure periods and recovery times. We understand that further investigations and research of actual damaging events may help to develop more stringent standards for the use within the WFD.

4. Water resources and managed flows

4.1 Overview

We disagree with the statement on p.46 that there is limited quantitative data on impacts of managed flows on the ecology. In fact, we would argue that this area is probably one of the best-studied areas of anthropogenic impacts on ecological functioning. Large numbers of studies have been undertaken that quantify the impacts of managed flows both on fish, macrophytes and invertebrates. Some of these are summarised below.

4.2 Impacts of managed flows on fish and benthic invertebrates

Benthic invertebrates play a key role in aquatic ecosystems due to their intermediate position in the food chain. They are also sensitive to change in their ecosystem, which makes them a good indicator of ecological disturbance. In regulated rivers, there are often significant differences in invertebrate diversity when compared with a similar, non-regulated river. Many studies (Loffler, 1990, Scullion atal. 1982, Armitage, 1978, Inverarity et al. 1983) show that regulation causes a decrease in channel species diversity, often with an increase in abundance of common species such as Beatidea and a decrease in more sensitive species, such as Ephemeridae.

Fish

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Due to their complex habitat requirements, fish communities, especially larval and juvenile fish, are good indicators of habitat structure and ecological integrity of large river systems. Water regulation can have particularly severe impacts on fish.

Modification of natural flow regimes of rivers can affect biota at the population and community levels (Schlosser, 1991[25]; Marchetti & Moyle, 2001[26]) and may cause changes to the natural river habitat. Many of these impacts are linked with changes in sediment transport and natural deposition of sediments. Often, scouring of fine sediments is intensified in the reach immediately below a dam, which can in turn impact marcoinvertebrate biomass and physical characteristics of a river bed. The modification of a natural habitat for invertebrate communities is of major concerns as major changes can impact directly or indirectly on co-occurring fish communities. The influx of fine solids at increased levels may result in shifts in habitats and invertebrate distribution and/or reduce species diversity.

4.3 Managing the impacts of modified flows

We generally agree with the proposals by the UK TAG that setting a standard for managed flows would be unreliable. Each river considered to be at risk will have specific requirements, which should be considered on a case by case basis. The requirements of fish, invertebrates and macrophytes can be made with a carefully designed and implemented environmental release flow programmes. **We recommend that an involvement of a multi-disciplinary team of experts, including biologists, hydrologists, hydro engineers, chemists and geomorphologists is needed in order to assess the level of ecological damage and recommend compensation measures.**

We are concerned that the only measure that is being considered in the UK TAG paper is the impact of managed flows on hydrology, or the % deviation from natural flows. In modified systems, other criteria are also relevant, including temperature, sediments and water chemistry. As explained above, managed flows can have major impacts on sediment transport and deposition. **All of these impacts need to be considered when deciding about the degree of damage and action required to address these impacts.**

[25] Schlosser (1991) Stream fish ecology: A landscape perspective, BioScience 41: 704 - 712
[26] Marchetti & Moyle (2001) effects of flow regime on fish assemblages in a regulated California stream. Ecological Applications 11: 530 – 539

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