Adequacy of current methods of suspended sediment monitoring for recent European legislative requirements

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INTRODUCTION

Recent European environmental legislation has been combined with an increasing focus on the use of suspended sediment monitoring in pro-active catchment management strategies. These factors have prompted a review of the adequacy of current widely accepted methodologies for suspended sediment monitoring. This paper discusses the impact that two recent EC Directives, namely the Habitat and Species Directive (92/43/EEC) and the Water Framework Directive (2000/60/EC) may have on the techniques and strategies used for suspended sediment monitoring within European rivers in future years. An example is provided of the application of current thinking on suspended sediment measurement and sampling strategies to a proposed set of monitoring requirements for a freshwater Special Area of Conservation as designated under the EC Habitat and Species Directive (92/43/EEC).

THE HABITAT AND SPECIES DIRECTIVE

The EC Habitat and Species Directive (92/43/EEC) prompts member countries to identify Special Areas of Conservation (SAC), and report on the condition of these SACs every six years. The Directive designates specific species as worthy of conservation, and encourages countries to establish conservation measures, undertake surveillance of conservation status and partake in necessary research and scientific work. To report on the condition of SACs it may be sufficient to report on species status but it may be preferable to report additionally on habitat status.

In undertaking surveillance monitoring of habitat status to see if favourable conditions exist for relevant species, conservation objectives may be set which can be couched in statistical terms. With regard to sediment, examples may include limits for mean annual suspended sediment concentrations or particular quartiles such as the median and 90th percentile. If this is done there is a corresponding requirement for rigorously designed monitoring strategies that will allow the assessment of compliance with these objectives as well as any change in status over the six year reporting time frame.

Much of the existing operational monitoring of freshwater suspended sediment concentrations is carried out at a monthly frequency using bottle sampling (The major exception to this is in response to pollution incidents, when a small number of high time frequency bottle samples may be collected). Table 1 shows data from a set of research catchments which illustrate the variability in suspended sediment concentrations. From this information it is possible to calculate the number of samples required to characterise the mean suspended sediment concentration in these drainage basins. For example, Fig. 1 outlines the number of samples required to estimate the mean for different levels of variability, represented by standard deviation, to within various levels of precision. At low levels of variability, for example the Cyff basin, annual means can be successfully characterized using nine samples, a level of sampling already achieved in most operational monitoring schemes.

However in other catchments, much larger numbers of samples are required to achieve the same purpose. In many cases, given typical levels of variability detected during high resolution suspended sediment monitoring in UK rivers, the number of samples required is in most cases well above that currently collected. The large numbers of samples needed suggest that the use of flow-stratified sampling or proxy methods of instrumented monitoring such as sample calibrated turbidity probes may be needed.

Clearly, the application of new approaches to measurement techniques and monitoring strategies are required. However, such initiatives are constrained by the limited resources under which many national regulatory authorities and conservation agencies operate. These agencies often prefer simple monitoring solutions which give rapid answers, a task for which "research-level" methods are often not ideally suited. In response to the above points, an example is given of a proposed monitoring strategy suitable for a freshwater SAC designated under the Habitat and Species Directive. This example is intended to provide a compromise between research level activity and the constraints under which day to day monitoring operates. Relevant lessons from a long term event-based and annual suspended sediment study in mid-Wales are applied to allow the creation of the proposed strategy. The reasons for choice of measurement technology, and important issues regarding possible implementation of this strategy are outlined.

Table 1 Suspended sediment concentrations in three example UK rivers[†].

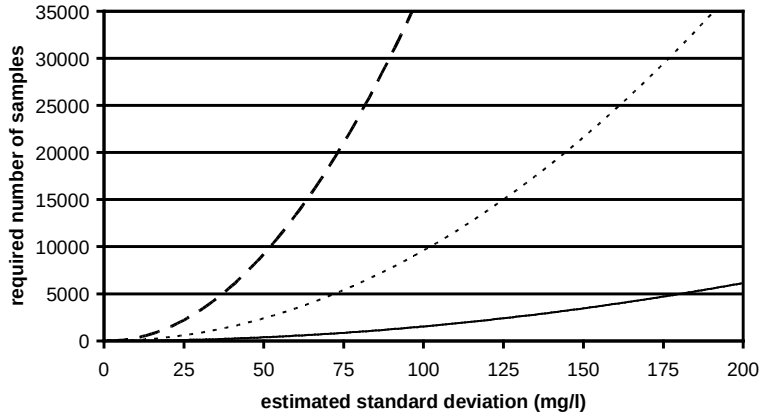
	Catchment type	Catchment size	Mean SSC (mg l^{-1})	Std. dev. SSC (mg l^{-1})	No. of samples required*
Tanllwyth	Forest	<1 km^2	8.9	12.7	138
Cyff	Moorland	3 km^2	1.8	3.0	9
Swale at Catterick	Mixed agriculture, 10% urban	500 km^2	23.2	77.9	Approx. 6000

[†]Data from intensive monitoring using 15 minute frequency recording of turbidity probe output, routinely recalibrated using suspended sediment concentrations determined from storm and low flow samples.
*no of samples required is the number to determine annual mean to a precision of 2 mg l^{-1}. This is a reasonable required precision for assessment of year to year change and compliance with threshold objectives.

THE WATER FRAMEWORK DIRECTIVE

The EC Directive (2000/60/EC) is establishing a framework for community action in the field of water policy. It is commonly known as the Water Framework Directive (WFD) and came into force on the 22nd December 2000. Consequently, implementation of this Directive is not as far advanced as the implementation of the Habitat and Species Directive. The overriding goal of the Directive is that Member States should aim to achieve at least "Good Ecological Status" in all bodies of surface water (lakes, rivers, estuaries and marine) and groundwater, and also aim to prevent deterioration in the status of those water bodies. It will eventually repeal and subsume all previous EU water directives. In common with the Habitat and Species directive it works on a six year planning cycle. Key implementation dates are listed in Table 2.

(a)



(b)

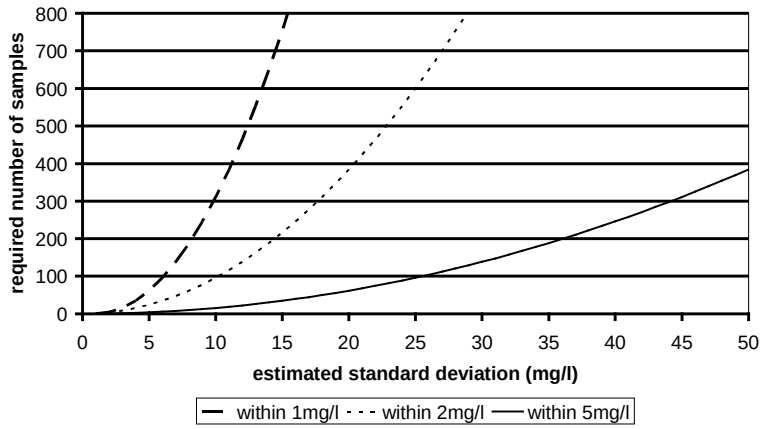


Fig. 1 Number of samples required to estimate the mean to within a specified precision (1, 2 or 5 mgl^{-1}) given the sample standard deviation (a) Standard deviation range 0 to 200 mgl^{-1}; (b) Enlargement of Fig. 1(a) for standard deviation range 0 to 50 mgl^{-1}.

The WFD has a broad scope does not just cover chemical water quality. Ecology is judged the key measure of status, although final status is judged to be the lower of ecological and chemical status. Status is measured by comparison to "type-specific" reference conditions. There is a strong emphasis on monitoring, for example status assessments are intended to be based on monitoring. The Directive distinguishes between operational monitoring – to define current status, and investigative monitoring – when good status requirements are failed.

Table 2 Key dates for WFD implementation.

Date (end of)	Action
2004	Initial characterization of river basin districts
2006	Monitoring programmes established
2006	Timetable for River Basin Management Plans (RBMPs)
2008	Draft RBMPs
2009	Final RBMPs including objectives and programmes of measures
2012	Operational programmes of measures
2015 (and every six years thereafter)	Review and update plans

The need for sediment monitoring to comply with the WFD is unclear. There are obvious links between sediment transport and river morphology, and "hydromorphology" is a supporting status element. Sediment transport is more clearly acknowledged elsewhere, such as in its link with river continuity, and by the recognition that differing sediment regimes may contribute to water body typology. Pollutant association with sediment is also specifically acknowledged, and must be monitored. However the role and monitoring of sediment loads in themselves is unclear. It is also surprising that suspended sediment is not included as a physico-chemical element requiring monitoring and assessment.

CONCLUSIONS

The two Directives described here are currently having, and will continue to have, a major influence on the suspended sediment monitoring requirements of regulatory and conservation agencies across Europe. In many cases, existing methods and strategies may struggle to provide fit for purpose results, and innovative solutions may be required in future. Implementation of the Habitat and Species Directive is at a relatively advanced stage, but the full impact of the Water Framework Directive is as yet unclear. Consequently the final implications of the implementation of these two Directives for sediment transport monitoring across Europe have still to emerge.