Natural England Research Information Note RIN007

Investigations into the use of critical sediment yields for assessing and managing fine sediment inputs into freshwater ecosystems

The effects of anthropogenically enhanced loads of fine sediment on aquatic wildlife are a major environmental concern. In addition to well-documented effects of siltation on the early life stages of salmon and trout, excessive fine sediment loads also create unfavourable conditions for many other fish, invertebrate and plant species, in terms of enhanced water turbidity, excessive sedimentation rates, and the clogging up of interstitial habitat in coarse substrates.

Natural England is responsible for defining conservation objectives for sites designated for wildlife. This involves the specification of "favourable condition", in which targets are defined for a range of biological and environmental attributes in different habitat types, including rivers, lakes, ditch systems and coastal waters. Suspended solids and siltation levels are explicitly included in the list of attributes for rivers, and also need to be managed to secure favourable condition in other habitat types.

In a parallel but related process, the Environment Agency is involved in the specification of Good Ecological Status (GES) under the Water Framework Directive. This similarly involves the definition of critical values of biological and environmental attributes consistent with GES. "Suspended material" is listed as one of the "main pollutants" in Annex VIII of the Directive, for which critical values may need to be set.

To date, work to define critical thresholds in relation to sediment input has focused on trying to specify the most ecologically relevant end-points, such as the level of fine sediment in salmonid spawning gravels, or suspended solids levels. Whilst thresholds of this type are vital, they are notoriously difficult to define against a background of high natural spatial and temporal variability, and the exact specification of relevant end-point varies from species to species and habitat to habitat.

Ecological requirements relating to fine sediment load need to be defined using a common denominator that has practical relevance to catchment management. Catchment sediment yield, and related parameters characterising fine sediment delivery, seem to have the potential to fulfil this role, linking into catchment management models such as PSYCHIC that can help provide the basis for determining appropriate management action.

What was done

The research had the following objectives:

- To review the available information on fine sediment yields in catchments of relevance to the UK.
- To review management approaches to target-setting for fine sediment control adopted in other countries.

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- To provide a rationale for the use of fine sediment yields in the definition of environmental status consistent with Favourable Condition and Good Ecological Status of aquatic habitats.
- Where possible, provide best estimates of critical sediment yields in different catchment types.
- To recommend further work aimed at developing a refined procedure for determining critical sediment yields.

The work was undertaken by literature and web-based review and the collation and analysis of existing data.

Results and conclusions

The work has confirmed the limited quantitative understanding of the relationships between fine sediment delivery, sediment fate in aquatic systems, and resultant ecological impacts. Fine sediment yields alone are currently therefore a poor metric for characterising environmental status in respect of the ecological impacts of fine sediment, but they can be very useful in monitoring the effects of remediation measures and for assessing compliance with specific objectives set in terms of deviations from reference levels of sediment delivery.

A total of 146 yield estimates were collated and classified according to a simple catchment typology based on topography, catchment size and land use. Of these, 107 sites were considered to provide data of high or medium quality. Sediment yield values for these sites range from a minimum of 1 t km² per year to a maximum of 311 t km² per year. The average sediment yield value reported is 44 t km² per year.

Constraints and limitations of existing sediment yield data relate to a range of factors that include data quality; the inherent spatial and temporal variability of sediment delivery systems; and the "lumped" nature of sediment yield data. The associated need to consider complementary indicators of sediment yield, such as sediment "rating curves" (river flow/suspended solids relationships) and sediment sources is stressed by the researchers.

Approaches to setting fine sediment targets in selected countries were considered in detail, in Europe, Canada, Australia, New Zealand; and the USA. Of these, the USA is the only country to date that has implemented a statutory programme of target-setting for sediment loads. These targets take the form of Total Maximum Daily Loads (TMDLs), generated using local information and using approaches ranging in complexity from quantitative, data-intensive modelling to qualitative, "narrative" targets based on best professional judgement.

The researchers explored possible operational models for using sediment yield-related targets within a catchment management regime. A contrast was drawn between a potential top-down model, in which generic targets are used in a strict regulatory context, and a potential bottom-up approach, in which "soft" targets are defined through local evaluation. Initial attempts were made to specify catchment type-specific generic targets for sediment yield, which might be used to support either operational model.

The researchers highlight the likelihood of increased impacts from fine sediment delivery as a result of climate change. Predictions of more energetic rainfall imply reduced stability of catchment soils and further enhancement of fine sediment delivery to aquatic ecosystems. Climate change predictions of higher water temperatures and prolonged drought periods compound this added ecological stress.

Recommended areas for further work include:

- the development of a strategic national monitoring programme for suspended solids and fine sediment delivery, covering all UK catchment types;
- further work to generate robust generic targets for sediment yield and sediment rating curves in different UK catchment types;
- fundamental process-based studies to quantify relationships between fine sediment delivery to aquatic systems, redistribution within those

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systems, and specific mechanisms of impact on aquatic flora and fauna; and
- improved catchment modelling to better evaluate fine sediment delivery and management measures for its control.

Natural England's viewpoint

This work has provided a good insight into the current state of play with respect to target-setting for fine sediment delivery. The justification for Natural England's inclusion of suspended solids and siltation in conservation objectives for designated rivers is reinforced by the report, but better quantification of sediment-related targets is elusive and the report only offers possibilities.

Further research (NERR008) has subsequently been undertaken, building on this initial work, which has allowed us refine our views in this difficult area. An information note *Setting and applying sediment targets to protect designated wildlife sites* has been generated that provides guidance on how to establish fine sediment targets for a site within the context of a strategic management regime for fine sediment delivery. This Information Note is available from Chris Mainstone, Senior Freshwater Ecologist, Natural England.

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Further information

For the full details of the research covered by this information note see Natural England Research Report NERR007 *Investigations into the use of critical sediment yields for assessing and managing fine sediment inputs into freshwater ecosystems*.

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Report authors

Des Walling, Bruce Webb and Jo Shanahan, University of Exeter, Department of Geography, Amory Building, Rennes Drive, Exeter, Devon EX4 4RJ