TECHNICAL ASSESSMENT METHOD

Water Category	Rivers
Significant Pressure	Sediment Delivery

1. PURPOSE

This paper describes the assessment of the likelihood of river water bodies achieving the relevant Water Framework Directive objectives as a result of siltation by sediment delivery from diffuse agricultural sources.

This method identifies pressure, rather than the ecological impact. As it gives an assessment of sediment delivery to waterbodies, it can be viewed as risk of water body exposure to siltation rather than risk of ecological impact.

Small quantities of silt are constantly introduced into watercourses through the natural processes of erosion and runoff. Aquatic communities are adapted to cope with these natural levels of input. Anthropogenic influences can, however, lead to a large increase in the amount of silt entering a stream, which can have detrimental effects on the aquatic community. High levels of silt can affect all levels of the food chain, from suppressing the growth of plants (Edwards, 1969), to the reduction of numbers and diversity of invertebrates (Cummins and Lauff, 1969), to impacts on fish (Crouse *et al.*, 1981).

2. CONCEPTUAL MODEL

Vulnerability is greatest in areas where the aquatic community relies on clean, clear water. Benthic communities which require clean gravels are at risk, as are species which lay eggs within gravels, such as salmon, trout and sea lamprey. These sensitivities will be covered in more detail in the sensitivities section.

Hydrological conditions can also increase susceptibility. Chalk streams, with a high groundwater flow may be particularly at risk due to the reduced flushing of sediment from the system.

Data which could be used to assess vulnerability includes evidence of chalk streams (geology data), salmon and sea trout rivers (Salmon Action Plan catchments) and conservation designated areas (e.g. Sites of Special Scientific Interest (SSSIs)).

Figure 1 summarises the risk pathway from human activity to resulting impacts.

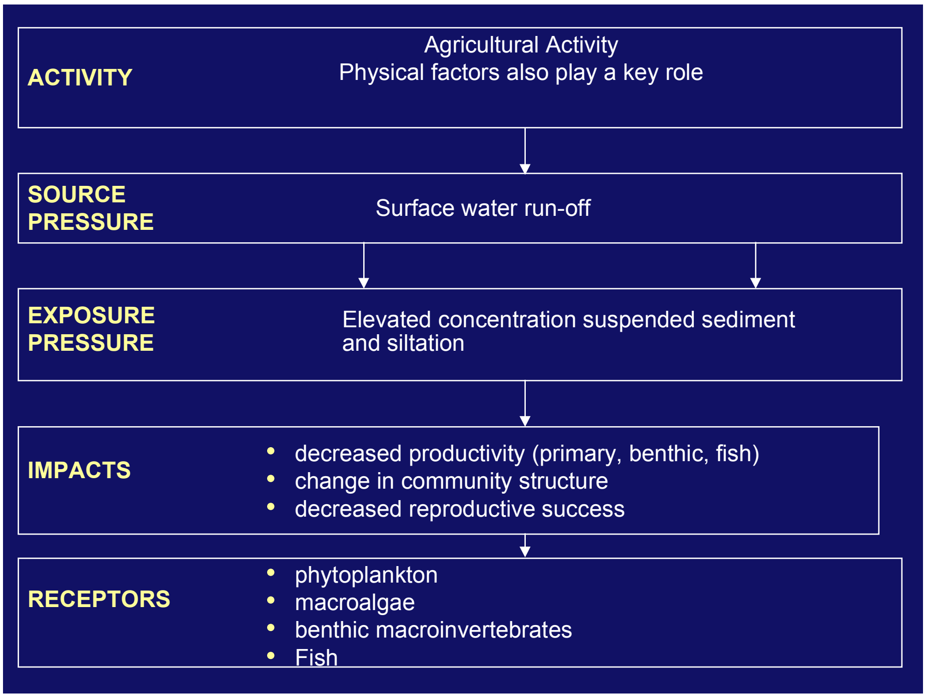

Figure 1: A conceptual model showing the environmental pathway for sediment delivery and the possible impacts upon sensitive receptors

3. METHODOLOGY

3.1 General

An overall national risk assessment was carried out as outlined below. The results from this exercise were reviewed by local Environment Agency staff. If local studies had provided evidence for siltation from agriculture, this information was used to override the national risk assessment.

Sediment delivery

This methodology uses the outputs from Prediction of Sediment Delivery to Watercourses from Land Phase II, R & D Technical Report to the Environment Agency, No P2-209 (McHugh *et al* 2003) and Erosion Risk of Catchments in England and Wales Environmental Policy – Risk and Forecasting report number 45 (Wood *et al* 2003). These are modelled data sets and have not been validated against sampling data, although they were based on experimental data from MAFF/DEFRA. It is also worth noting that this methodology takes account only of sediment delivery from the catchment surface: field drains and eroding river banks, which can supply significant quantities of silt, are not included. Point sources of problems such as mines, quarries and gravels extraction sites are also omitted.

To refine this methodology further, a sensitivity layer was included, as well as a layer of 'risky' agricultural land uses. In this draft the agricultural land use is restricted to arable only. Both the sensitivity layer and the risky land use layer were scaled so that the default value was one, with the value increasing as risky land uses or sensitivity increase. The final risk assessment layer was then calculated as:

Risk assessment = Sediment delivery * sensitivity * risky land use score.

The average score is then calculated on a by catchment basis.

Sensitivity
A sensitivity layer was developed to try to take account of the receptors of silt. Due to the difficulties involved in assessing the impact of silt on different receptors, a simplistic approach was taken;

- The whole of England and Wales were given a default value of 1.
- Chalk areas were given a value of 1 (based on 1km^2 geology data)
- Areas supporting wild salmonid populations (Salmon Action Plan (SAP) catchments and catchments with principal brown trout fisheries) were given a value of 1, again on 1 1km^2 scale.

A simple addition was carried out to give values in the range 1-3, with SAP catchments on chalk having a value of 3.

High risk land uses.
The risk of sediment delivery to watercourses R&D output is linked mainly to the physical factors. The only land use which is taken into account is the broad categorisation of land as 'arable', 'pasture' or 'upland'. To properly assess the risk posed by anthropogenic factors, it is necessary to take into account land uses which have a high risk of sediment delivery.

3.2 Data sources

Sediment delivery
The data used is the Risk of sediment delivery to watercourses, 1 in 10 year event. This represents the risk of sediment delivery in a year of high rainfall. The data is a raster grid of 1km^2 resolution, covering England and Wales.

This data set was created within the R&D project by using GIS to:

- determine a spatially-averaged slope class for each 1 x 1 km pixel using data from the Ordnance Survey 50 m PANORAMA digital elevation model;
- describe the soil composition of each 1 x 1 km pixel according to the areal proportion of the dominant, second and third most common soil sub-groups, based on the National Soil Map of England and Wales;
- describe the land use composition of each 1 x 1 km pixel according to the area proportion under lowland arable, lowland grassland and upland, based on the 1990 Land Cover Map of Great Britain produced by the Centre for Ecology and Hydrology;
- calculate the annual erosion rate expected with a ten-year return period for each 1 x 1 km pixel, spatially averaged over the combination of soil, slope and land cover classes;
- apply the appropriate connectivity ratio for each 1 x 1 km pixel to estimate the annual rate of sediment supply to the river system with a ten-year return period;

Sensitivity.
The British Geological Survey underlying geology layer was used. The chalk category was converted to a 1km2 raster grid with chalk given a value of 1, and other geologies given a value of 0.

Risky land use
Risky land uses were taken from the MAFF document 'controlling soil erosion' (MAFF, 1999), as shown below in tables 1a and 1b.

Table 1a: Highly susceptible land use

Land use	Use within risk assessment
Late sown winter cereal	No information on whether crop is early or late sown. Only barley is listed as winter or spring sown.
Potatoes	Map well to agricultural census data
Sugar beet	Map well to agricultural census data
Field vegetables	Map well to agricultural census data
Outdoor pigs	No information on the housing of livestock
Grass re-seeds	No information on re-seeds
Forage maize	All maize can be derived from agricultural census data
Bare soil	Bare fallow used from agricultural census

Table 1b: Moderately susceptible land use

Land use	Use within risk assessment
Early sown winter cereal	No information on whether crop is early or late sown. Only barley is listed as winter or spring sown.
Oil seed rape	Map well to agricultural census data
Spring sown cereals	No information on whether crop is early or late sown
Spring sown linseed	No information on whether crop is early or late sown
Short rotation coppice	No information on coppice

This, using the agricultural census data was implemented as:

High (score 3):
A2 Winter Barley
A10 Potatoes (early)
A11 Potatoes (maincrop)
A12 Sugar beet not for stockfeed
B99 Total vegetables & salad grown in the open
A32 Bare Fallow
A23 Maize (includes stockfeed)

Moderate (score 2):
G8 Industrial Winter Oil Seed Rape grown on set-aside
G9 Industrial Spring Oil Seed Rape grown on set-aside
A24 Industrial Spring Oil Seed Rape grown on set-aside
A25 Spring Oil Seed Rape (not on set-aside)
A27 Linseed (not on set-aside)
G10 Industrial linseed grown on set-aside

A3 Spring Barley
A1 Wheat
A4 Oats
A6 Rye

All other land uses were assumed to be neutral and given a value of 1.

3.3 Thresholds and risk classification

The threshold at which risk to a waterbody occurs is difficult to determine, as the sediment delivery does not correspond directly to suspended sediment due to some inputs to the system are nor considered, nor are losses from the system. In addition the hydrological factors and dilution are not considered.

There are no universally accepted definitions of tolerable or allowable erosion rates. However, American scientists have proposed that annual soil erosion rates of greater than 1 t/ha at a field scale are sufficient to cause erosion damage and pollution off-site (Moldenhauer and Onstad, 1975). Assuming a bulk density of 1.4 g/cm^3, this would equate to 0.7 m^3/ha. With a typical connectivity ratio of 0.5, this would give a threshold value of annual sediment delivery of 0.35 m^3/ha. When describing the specific suspended sediment yields of both world and British rivers, an annual value of 0.5 t/ha was used by Walling (1990) and Walling and Webb (1996) to separate areas of low erosion from areas of moderate erosion. On a global scale, 0.5 t/ha also clearly distinguishes those drainage basins under reasonably natural land cover conditions from those where human impact exerts a major control over erosion (Dedkov and Mozzherin, 1996). A specific annual suspended sediment yield of 0.5 t/ha is approximately equivalent to 0.35 m^3/ha. Sediment delivery rates of 0.35 m^3/ha have therefore been used here as indicators of vulnerable conditions.

The estimates from the original sediment delivery model have been modified by using the sensitivity and risky land use layers. The result of this is for original estimates of sediment delivery to remain the same or to be revised upwards. The final risk assessment score no longer represents a direct estimate of sediment delivery to the watercourse. The cut-off value of 0.35 was however maintained in the absence of a more appropriate threshold.

The other cut-off points were more arbitrary but have been set as follows in Table 2:

Table 2: Threshold values for determining risk status

Average Sediment Risk Score	**Risk status**
< 0.1	No
> 0.1 to 0.2	Low
> 0.2 to 0.35	Moderate
>0.35	High

Environment Agency staff were then given the opportunity to review these assessments. In cases where local studies provided evidence that the national scale assessment was wrong, the results of the local studies were used to override the outputs of the national assessment.

3.4 Pedigree and Validation of method

The sediment delivery data set being used was prepared by experts in the field using the latest available data sets. Validation of the methodology has not been carried out.

The sensitivity layer is very basic, but factually correct. It does not, however, represent a comprehensive assessment of the sensitivity of a watercourse to silt, and is based on a broad ecology and fisheries understanding. It is not receptor specific. The sensitivity score has not been validated and is a simple addition of the number of sensitive features within a $1km^2$ grid cell.

The risky land use layer is not comprehensive. It covers only arable land use, using risk categorisation from a document designed for use in lowland England. As this is where the vast majority of arable farming in England and Wales is carried out, this document should be relevant. The scores assigned to each category of land use have not been scaled or validated against any real data.

3.5 Confidence

The confidence in this assessment is low. This is due to uncontrolled errors in the data used to model silt delivery, the low spatial resolution and the fact that no validation has been carried out on the silt delivery, sensitivity or risky land use data layers.

3.6 Assumptions and limitations

Assumption that the data used in the model is representative and has been extrapolated appropriately, that the model is a good match with reality. That the categories of risky land use in the document Controlling Soil Erosion (MAFF 1999), designed for use in lowland England, can be extrapolated to cover England and Wales. That the scaling factors used for risky land use and sensitivity is appropriate.

4. FURTHER DEVELOPMENT

After 2004, validation of the model should be carried out. Many aspects of the model could be improved with more research. The possible developments would need to be investigated and prioritised in order to improve the product to be fit for purpose. Depending on the requirements for further characterisation it may be that a new, more complex model tool may be required rather than a development of this method.

Both the sensitivity and the risky land use layer could be improved with more factors taken into consideration. The risky land use layer could be modified to take into account livestock numbers. Validation of the relative riskiness could be carried out. The current method is a very basic categorisation into high risk medium risk and low risk factors. It is based on a document released for lowland England, but was felt to be acceptable for the arable uses. It does not take into account livestock or non-agricultural uses, nor does it scale relative impact within categories. There is therefore considerable scope for refinement.

Further siltation risk assessments could be carried out to provide risk of siltation from point sources and eroding river banks.

It may be possible to incorporate an 'impact' layer where siltation is observed to be impacting aquatic communities, yet the primary source of the silt has not been determined.

5. REFERENCES

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