UK Technical Advisory Group on the Water Framework Directive

Nutrient Thresholds Related to Turbidity

(Public Working Draft)

This Guidance Paper is a working draft defined by the UKTAG. It documents the principles to be adopted by agencies responsible for implementing the Water Framework Directive (WFD) in the UK. This method will evolve as it is tested, with this draft being amended accordingly.			
Working Paper Version:	WP14	**Status:**	Public Working Draft
WFD Requirement:	Marine nutrient thresholds, turbidity	**UKTAG Review:**	Approved UKTAG Feb 2007

Effective strategies for assessment of regulatory thresholds of nutrients in coastal and transitional waterbodies requires an understanding of how different types of estuaries respond to nutrient inputs. Plant growth is dependent on a supply of nutrients and light. The light that is available for growth is a product of mixing depth and optical depth (Kd). Susceptibility to nutrient enrichment is controlled by light attenuation within the waterbody, which in turn is partly controlled by the amount of suspended particulate matter in the water column.

To account for this, we have established a series of nutrient thresholds related to three types of waterbodies, based on the level of turbidity within the waterbody. This is based on work by Devlin et al (2007) who made measurements of sub-surface light attenuation (Kd), Secchi depth and suspended particulate material (SPM) at 382 locations in transitional, coastal and offshore waters around the UK coast between August 2004 and December 2005. This data was supplemented with 12000 values of SPM taken from the Environment Agency database. The latter allows us to crudely characterise waterbodies by their SPM and consequently potential light climate (see Fig 1).

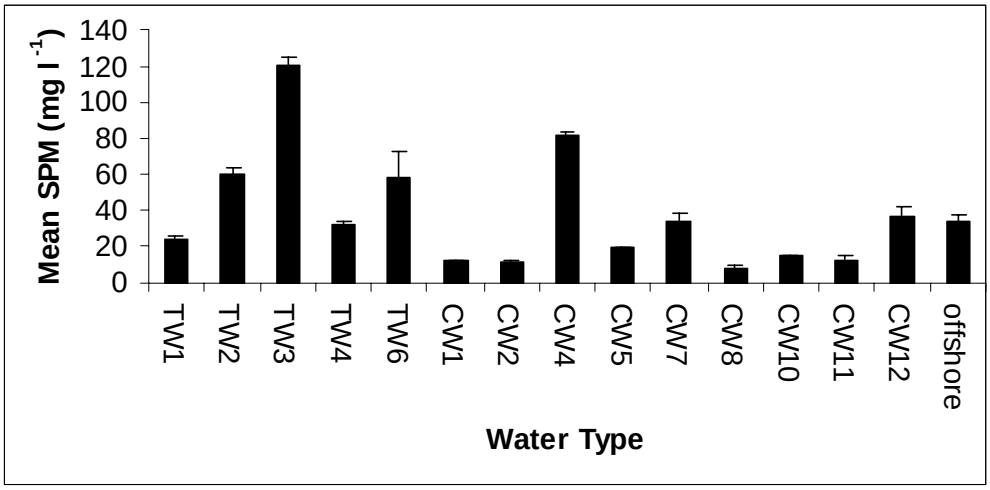

Figure 1: Mean water type concentrations of SPM (mg l^{-1}) derived from the UK Environment Agency database. The error bars are 95 % confidence limits based on the standard error

Figure 2 shows the potential production response (using chlorophyll biomass as an indicator) to increasing nitrogen. The degree of this response is influenced by turbidity (through light availability).

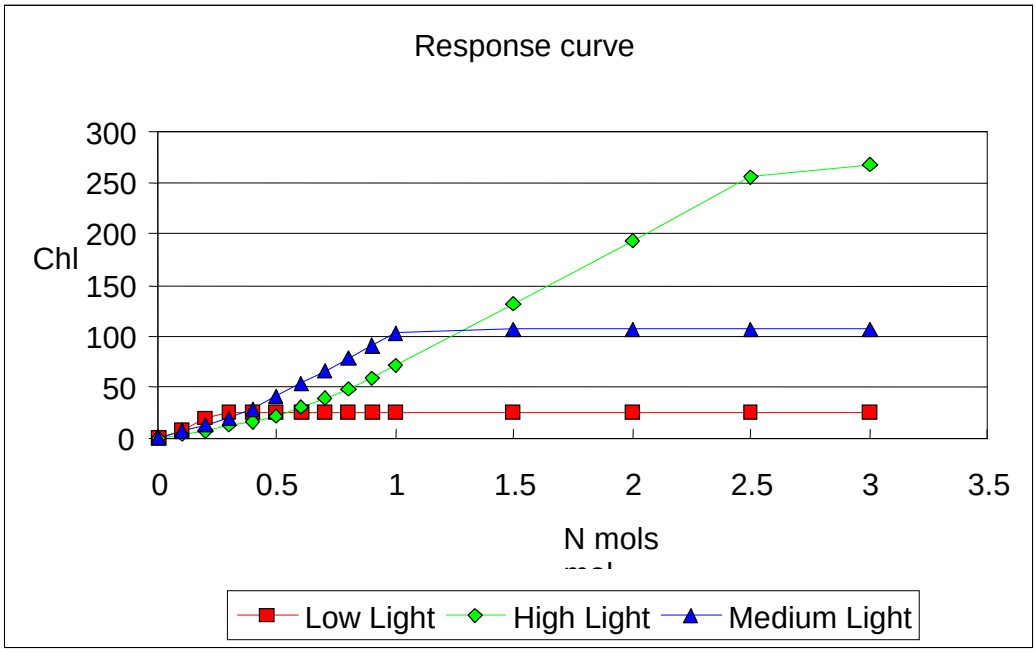

Figure 2: Response of chlorophyll biomass to nitrogen enrichment through 3 different scenarios of light availability

The proposed regulatory thresholds have been calculated using the Painting *et al* (2006) model, which estimates the potential primary production within a waterbody in response to concentrations of dissolved nutrients. Maximum production rates are strongly influenced by light availability. The model is used here to calculate the maximum dissolved inorganic nitrogen concentrations that would be required for a waterbody to achieve a high level of primary production (>300 g Cm^{-2} y^{-1}). This threshold was proposed by Nixon (1995) for assessing the trophic status of a waterbody as "eutrophic". However, water bodies which may be identified as being eutrophic by Nixon's scale may not necessarily show any signs of eutrophication. Additional attributes need to be considered to assess negative impacts. For example this "biological override" may be signs of dense green mats of nuisance macroalgae on estuarine mudflats.

Relative turbidity index	**Light availability**	**Estuary Type**	**Mean SPM (mg/l)**	**Estimated Kd (m^{-1})**	**Default values used in model**
Very turbid	Low light	A	**>300**	> 6.6	8.3
Turbid	Medium light	B	**100-300**	2.3 - 6.6	4.96
Intermediate/ Clear	High light	C	**10-100**	0.8 - 2.3	0.97

Table 1. Estimates of relative values for light attenuation (Kd, m^{-1}) from Suspended Particulate Material ($mg\ l^{-1}$) in different types of estuaries using the equation Y = 0.0213X + 0.183 (Painting et al. 2006).

Table 1 summarises 3 types of estuaries based on mean SPM values, and the corresponding default values for light attenuation, (Kd m^{-1}) used in the model.

Using the Environment Agency SPM data and calculated Kds, about 2% of surveyed waterbodies are in the very turbid category, about 5 % are in the medium turbidity category with 65% in the intermediate/clear category. Additionally a further 30% of waterbodies have a very low SPM and could be classed as very clear.

Table 2 gives the nutrient concentrations in the waterbody, which would result in annual net primary production exceeding the threshold of 300 g C m^{-2}. The final column suggests the typologies most likely to meet these SPM conditions.

Turbidity category	SPM range	Kd (m^{-1})	1% Light Depth (m)	Nitrogen Threshold (maximim) (μM)	Likely WFD Types
Very turbid	**>300**	**8.3**	**0.5**	**271**	**TW1, TW3**
Medium turbidity	**100-300**	**4.96**	**1**	**186**	**TW2, TW4**
Intermediate/ Clear	**<100**	**0.97**	**5**	**70**	**TW5, TW6**

Table 2. Nitrogen thresholds for determining eutrophic status in each estuary category, using the model of Painting *et al.* (2006) and potential annual net primary production of 300 g C m^{-2} y^{-1} as a reference point. Thresholds are given as equilibrium concentrations (which are equivalent to measured values) of dissolved inorganic nitrogen (DIN) and are based on 1% light depths calculated from Kd values used in the model. In turbid waterbodies net production is minimal where depths are >1m, resulting in thresholds of infinity (~) for nutrients.

Table 2 also shows how the WFD typologies relate to the three estuarine categories.
However further analysis of SPM is required before agreement on these separations. Thus for the WFD reporting period (6 years), the threshold nutrient concentration associated with that waterbody should be considered as a maximum that can not be exceeded at any point**.**

In summary it is proposed that the general standards in transitional waters are used together with these values. So the thresholds based on winter mean nutrients would be assessed first and if passed then status is at least good. If the mean threshold is failed then the turbidity related maximum values are assessed and a waterbody only downgraded to moderate status if both standards are failed. However it is recognised that it is impossible to regulate against an absolute maximum value, so it is proposed that these thresholds are set as 99%iles (the values are thus rounded down from those in table 2).

Table 3 shows the values for the thresholds in all waters based on generic mean values and 99%iles related to turbidity and WFD typology.

Area	Salinity range	DIN (uM) Winter mean H/G	DIN (uM) Winter mean G/M
Offshore	**>34.5**	**10**	**15**
Coastal (at salinity 32)	**30-34.5**	**12**	**18**
Transitional (at salinity 25)	**<30**	**20**	**30**
If fail first iteration consider the turbidity type of the estuary	**Salinity**	**DIN (uM) Winter mean H/G**	**DIN (uM) 99%ile G/M**
Transitional (at salinity 25) Very turbid, TW1,TW3	**<30**	**30**	**270**
Transitional (at salinity 25) Medium turbidity, TW2, TW4	**<30**	**30**	**180**
Transitional (at salinity 25) Intermediate/Clear, TW5, TW6	**<30**	**30**	**70**

Table 3. Threshold values for all waters

Figure 2 illustrates the process for transitional waters as a flow chart.