Appendix 5-A

Evaluation of Sediment Loads in the Upper Elk River Watershed for Conformance with the Turbidity Water Quality Objective

This appendix expands upon the description, presented in Chapter 5 of the *Staff Report for the Upper Elk River Sediment TMDL* (Upper Elk TMDL), that describes the methods used to evaluate Upper Elk River specific water quality data related to suspended sediment loads for conformance of those loads to the water quality standards, in particular the water quality objective established for turbidity in the North Coast Region.

The *Water Quality Control Plan for the North Coast Region* (Basin Plan) contains the following water quality objective for instream turbidity:

> Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.

As part of the analysis Regional Water Board staff evaluate instream water quality data collected during water years 2004 to 2007. The data set used in the evaluation included turbidity, suspended sediment concentration, and stream discharge (flow) collected in Upper Little South Fork Elk River. The Upper Little South Fork Elk River, as used in the Upper Elk TMDL, is considered a reference subbasin. A reference watershed is needed to be able to compare data sets between similar watersheds (Study Subbasin approach). See Chapter 4 and Appendix 4C of the Staff Report for more information on the Study Subbasin approach

Calculation of Suspended Sediment Loads in the Reference Subbasin

The instream monitoring system installed in the Upper Little South Fork Elk River (hereafter referred to as the reference subbasin) was instrumented to collect time series data at 10 to 15 minute increments throughout the data collection cycle. For each time step, a measurement of turbidity level and stream stage was collected. Empirical relationships for turbidity-suspended sediment concentration and stage-discharge allow estimates of suspended sediment concentration (SSC) and stream discharge (flow) to be calculated for each time step.

Suspended sediment load within a time step is calculated as the product of the suspended sediment concentration, the estimated stream discharge, and the length of each time step (Equation 1).

$$SSLoad = SSC_n \times Q_n \times lengthoftimestep \qquad \textbf{(Equation 1)}$$

The annual suspended sediment load is simply the summation of the suspended sediment loads of each of the time steps. Table 1 presents the annual empirical turbidity-suspended sediment concentration relationships for 2004-2007, as well as the resulting estimates of suspended sediment load for the reference subbasin. These estimates provide an estimate of annual suspended sediment loads consistent with naturally occurring background turbidity in the Upper Elk River watershed.

Table 1. Estimated annual suspended sediment load based on naturally occurring background turbidity.

Year	Percentage of average annual rainfall[1]	Annual Empirical Turbidity-SSC Relationship	Estimated Annual Suspended Sediment Load Based upon Naturally Occurring Background Turbidity in Reference Watershed ($SSL_{Background\ Turbidity}$)	
			(tons/mi^2)	(yd^3/mi^2)[2]
2004	96%	SSC=0.0091*T^2+0.4574*T	16.29	11.64
2005	103%	SSC=0.0119*T^2+1.1584*T	31.25	22.32
2006	150%	SSC=0.0158*T^2+0.7895*T	46.29	33.06
2007	92%	SSC=0.0263*T^2+0.6277*T	15.04	10.74

Calculation of Suspended Sediment Loads for Conformance with Turbidity Objective

As used in the Upper Elk TMDL, turbidity regimes established from the reference watershed are deemed representative of naturally occurring background turbidity levels. To establish turbidity levels that achieve compliance with the turbidity objective (no increase greater than 20% over natural) the background turbidity value was multiplied by 1.2 (Equation 2). This calculation was performed for data generated at each of the 10 to 15 minute time steps.

$$Turbidity_{Objective} = Turbidity_{Background} \times 1.2 \qquad \textbf{(Equation 2)}$$

Where:

$Turbidity_{Objective}$ = Turbidity levels in conformance with Basin Plan objective

$Turbidity_{Background}$ = Turbidity levels representing naturally occurring background turbidity

The empirical turbidity-SSC relationships presented in Table 6A.1 were then used to calculate the suspended sediment concentration for data associated with each of the time steps. The annual suspended sediment loads were then calculated using the formula presented in Equation 1. The estimated annual suspended sediment loads are presented in Table 2.

[1] NWS station at Woodley Island, Eureka, CA. Long-term average annual rainfall is 39.2 inches.

[2] Calculated using a bulk density of 1.4 tons/yd^3.

Table 2. Estimated annual suspended sediment load based upon 120% of naturally occurring background turbidity.

Year	Estimated Annual Suspended Sediment Load Based upon 120% of Naturally Occurring Background Turbidity ***(SSL 120% Background Turbidity)***
2004	7.76
2005	15.26
2006	20.61
2007	7.65

Determination of Percentage of Natural Sediment Loading to Achieve Conformance with the Water Quality Objective for Turbidity

The ratio of the suspended sediment loading associated with "naturally occurring background turbidity" (background turbidity) and the suspended sediment loading associated with 120% of background turbidity can be expressed mathematically as in Equation 3. Table 3 presents the resulting percentages.

$$Linkage\ Ratio = (SSL_{120\%\ Background\ Turbidity}) \div (SSL_{Background\ Turbidity}) \times 100 \qquad \textbf{(Equation 3)}$$

Where:

$SSL_{120\%\ Background\ Turbidity}$ = Suspended sediment load representing 120% of background loading

$SSL_{Background\ Turbidity}$ = Suspended sediment load levels representing naturally occurring background turbidity

Table 6A.3 Percentage of background suspended sediment loading to attain turbidity objective

Year	Percentage of Natural Suspended Sediment Loading in Conformance with Turbidity Objective
2004	123%
2005	126%
2006	115%
2007	132%
Mean 2004-2007	**124%**

For the purposes of the Upper Elk TMDL, a suspended sediment load of no more than 120% of the naturally occurring background turbidity load was established as the increase in loading the would still achieve compliance the turbidity objective.

Suspended sediment load is a portion of the total load. In the case of Upper Elk River, where the geologic formations produce primarily fined grained material, it is expected that the majority of the sediment loading is suspended. For any given change is total sediment load, a corresponding similar change in suspended sediment load is expected. As such, and for the purposes of the Upper Elk River Sediment TMDL staff recommend that a total sediment of loading of 120% of natural is deemed in conformance with the turbidity objective.