TURBIDITY AS A SURROGATE TO ESTIMATE THE EFFLUENT SUSPENDED SEDIMENT CONCENTRATION OF SEDIMENT CONTROLS AT A CONSTRUCTION SITE IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

Study Objective: The objective of this applied research was to explore the interaction between effluent sediment concentration and turbidity for sediment controls that are currently being implemented at construction sites. Turbidity can be continuously monitored through an effluent pipe, a flume or in the receiving stream. Monitoring throughout a storm event enables making a more informed decision about the potential impact of effluent on the receiving waters. The impact of Total Suspended Solids (TSS) on various aquatic invertebrates and fish has been extensively documented for certain species. Additionally, the relationship between stream TSS and other environmental factors such as light penetration, growth of aquatic plants, temperature, etc. has been developed for some streams and lakes. If a reliable relationship can be developed between turbidity (TUR) and either suspended sediment concentration (SSC), measured in terms of the mass of sediment in the entire sample, or TSS, then turbidity can be potentially used as a surrogate enabling monitoring that can be readily accomplished at a construction site discharge point.

Regulatory Setting: Many government entities are now considering a maximum sediment concentration or turbidity value. These are often applied at the effluent point or sometimes as an in-stream increase, depending upon the type of stream receiving the sediment-laden discharge. Similarly, methodologies are currently being explored to determine the Total Maximum Daily Load (ASAE, 2002) for sediments. When setting regulations it is advisable to not only consider a maximum value based on a large design storm, e.g. 10-year, 24-hour, but to also consider a broader perspective encompassing (1) the occurrence of smaller, more frequent storms during the construction period, (2) the ability to efficiently control the sediment effluent concentration from these many smaller events, (3) the overall impact to the fluvial system and (4) the effect of land

disturbance on the complete sedimentgraph versus just the peak value. The impact to fish and aquatic invertebrates as well as aesthetic impacts are highly correlated to both sediment concentration and duration. Continuous monitoring of the entire storm event via a turbidity meter can afford greater flexibility in developing meaningful regulations.

Sediment Controls Analyzed: The database for this applied effort was obtained from an active construction site north of Atlanta, Georgia (Warner and Collins-Camargo, 2001). The objectives of the overall study were to design, implement and monitor a system of erosion and sediment controls that would be cost-effective and environmentally-efficient, integrate the riparian zone as a secondary synergistic passive treatment system, and to influence management decisions with respect to timing of installation of controls and construction. The types of controls monitored, for the effluent portion of this research, include: (1) two external sand filters receiving discharge from sediment ponds, (2) a floating siphon that discharged from a multi-chamber (in series) sediment basin and (3) a perforated riser installed in one sediment basin and one seep berm system.

Sand filters were employed to further reduce the effluent sediment concentration below that which is normally discharged through a sediment pond. The sand filter was an intermediate treatment process inserted between the sediment basin and a forested riparian zone. It was nominally 37-m^2 in surface area and constructed with a 15-cm depth of river-washed sand overlying an 8-cm gravel bed. The floating siphon was installed in one sediment basin and passively decanted the upper 5 to 15-cm of surface water once the first flush of sediment was retained below the outlet crest of the siphon. Perforated risers were installed in one sediment basin and one chamber of a seep berm. A seep berm is essentially an elongated basin with a large number of passive dewatering outlets along its length. Discharge from the seep berm spreads through a forested riparian zone where it partially or totally infiltrates prior to entering a stream. The Sediment, Erosion and Discharge by Computer Aided Design (SEDCAD) model was used for the design of the system (Warner and Schwab, 1998).

Turbidity Function of Particle Size and Sediment Concentration: Ideally, the prediction of turbidity would be linked with the effluent sediment concentration and the effluent particle size distribution being discharged from a sediment control. Knowing these values over the entire discharge time for the sediment control should enable the best prediction of turbidity. SEDCAD 4 has the capability to predict the complete sedimentgraph and a temporal-composite effluent particle size distribution. Controls such as the sand filter and the floating siphon have very high efficiencies resulting in low sediment concentrations. Sampling from these devices yields very small quantities of sediment. Suspended sediment concentration and turbidity were determined for 92 samples. To obtain a sufficient quantity of sediment for particle size distribution analysis, composite samples were used. Since the number of composite samples was too small to reliably be used in developing a methodology based on an effluent particle size distribution, a linkage between a predictive equation and functionality (efficiency) of sediment controls was developed. Some sediment controls inherently perform better than others. The monitoring period was during active construction, June 29 through Sept. 22, 2000. The resulting ratios of turbidity to suspended sediment concentration in the effluent from different erosion controls were based on 77 automatic pumped samples and 15 grab samples that were obtained from three storm events.

Turbidity – Suspended Sediment Concentration Predictive Relationships: To explore potential relationships between turbidity (TUR) and suspended sediment concentration (SSC), the ratio of TUR/SSC was calculated for all automatic and grab samples. Within a sample set from a given event and sediment control, the resulting ratios were summed and averaged to determine a single value representing that sediment control type for a given storm event. Specifically, a weighted ratio was calculated in which the average ratio of the automatic samples for each event is multiplied by the total number of samples in each event data set and then individual grab samples are added into the data set. The summation value for both automatic and grab samples is simply divided by the total number of samples taken from the sand filter resulting in a ratio of 1.7:1 (TUR/SSC) for the sand filter. Similarly, the resultant TUR/SSC ratios for the floating siphon and perforated riser are 1.7 and 1.4, respectively. To predict the effluent turbidity from the suspended sediment concentration, it is only necessary to multiply the concentration, which is the output of SEDCAD, by the ratio of 1.7, 1.7 and 1.4 for the sand filter, floating siphon and perforated riser, respectively. It should be noted that these are very preliminary values for the specific soils tested in the Atlanta area and these ratios may not be applicable to other soils or certainly not to other sediment controls.

Discharge from the sand filter and the floating siphon contains a higher fraction of finer grain particles than the perforated riser due to the filtering and skimming actions of these devices. The sand filter and floating siphon consequently have a lower effluent sediment concentration than the perforated riser. The derived TUR/SSC ratios of these two devices are higher than the perforated riser due to the higher contribution per unit mass of the finer grain particles. The perforated riser discharges sediment throughout its vertical height wherever there is an outlet hole. Hence, there is a higher potential for sand and/or larger silt particle release than for the floating siphon.

REFERENCES

"Quality Criteria for Water," Environmental Protection Agency. July 1976.

Total Maximum Daily Load Conference Proceedings. 2002. ASAE Publication 701P0102. 2002. ISBN 1-892769-24-7. March 11-13, 2002, Fort Worth, TX.

Warner, Richard C. and Francis X Collins-Camargo. 2001. "Erosion Prevention and Sediment Control Computer Modeling Project: Executive Summary", Chattahoochee-Flint Regional Development Center Dirt II Committee. Surface Mining Institute, Lexington, KY. June 2001. 30 pgs.

Warner, Richard C., and Pam Schwab. 1998. SEDCAD 4 for Windows 95/98 & NT, Design Manual and User's Guide. Civil Software Design, Ames, IA.