Sediment capture effectiveness of various baffle types in a sediment retention pond

Article in Transactions of the ASAE. American Society of Agricultural Engineers · September 2005
DOI: 10.13031/2013.20013

2 authors:

C. S. Thaxton
Appalachian State University

Richard A. Mclaughlin
North Carolina State University

SEDIMENT CAPTURE EFFECTIVENESS OF VARIOUS BAFFLE TYPES IN A SEDIMENT RETENTION POND

C. S. Thaxton, R. A. McLaughlin

ABSTRACT. *The relative sediment trapping effectiveness of a permanent-pool sediment retention pond was assessed due to the installation of baffles composed of different materials commonly used on construction sites. A suite of experiments was performed at the Sediment and Erosion Control Research and Education Facility (SECREF) at North Carolina State University in which an acoustic Doppler velocimeter was used to record steady-state flow velocity data at 50 grid points within the pond at three steady input flow rates. Hydrodynamic data were taken for free flow and for three different baffle materials: jute germination blanket backed by coir fiber, standard tree protection fence, folded and tied together into three layers to reduce pore size, and standard silt fabric with weirs. The experiments were conducted with a characterized soil injected upstream at a fixed rate with sampling at the outlet. At the completion of each baffle experiment, particle size distribution was determined for sediment deposits at fixed points in the pond bed. Analysis of the hydrodynamic data suggests that all baffles greatly reduced and diffused flow compared to an open pond. The jute/coir baffle outperformed a standard silt fence with weirs and a triple layer of tree protection fence. Results from soil composition analysis and exit turbidity measurements per baffle configuration confirmed that the jute/coir baffle was the most effective in improving sediment retention in the pond.*

Keywords. *Baffles, Basin, Hydrodynamics, Pond, Retention pond, Sedimentation.*

The sediment retention basin is a widely used device for trapping total suspended solids in runoff from construction sites. They are generally used to temporarily impound runoff and allow some portion of the sediment to settle out during that period. The trapping efficiency is affected greatly by the basin design. The length to width ratio has been shown to affect the dead storage volume in a sediment basin (Chen, 1975; Griffin et al., 1985), with a minimum length to width ratio of 2:1 recommended by Barfield et al. (1983), Mills and Clar (1976), and NC DENR (1988). The principal spillway can also affect basin performance. A field study of typical sediment basins found that basins with gravel outlets trapped 59% to 69% of the incoming sediment over the course of up to 20 months (Line and White, 2001). Engineered dewatering methods have been demonstrated to improve sediment capture to 88% or better by using a perforated riser (Fennessey and Jarrett, 1997; Ward et al., 1979; Edwards et al., 1999) or a floating skimmer (Millen et al., 1997). Modeling results have also indicated that surface outlets such as the skimmer will greatly increase sediment capture compared to either bottom or full water column dewatering (Ward et al., 1979). Trapping efficiencies greater than 90% have been estimated to be needed to meet typical water quality standards (Ward et al., 1980).

Within a sediment basin, particle settling is often reduced by both short-circuiting and turbulence. Short-circuiting occurs as the concentrated flow enters the basin and creates a high-velocity zone through the basin to the outlet. Solid baffles near the basin inlet have been suggested to reduce this effect (Goldman et al., 1986) by reducing the mean flow velocity into the basin and dispersing the inflow energy. The use of silt fencing as baffles in sediment ponds has become a common occurrence in North Carolina. Millen et al. (1997) suggested that silt fence baffles can improve sediment retention by diverting the flow through opposing weirs to increase the flow path and residence times. In traditional uses along slopes, silt fences reduce sediment loads in direct proportion to the detention time in pools that form behind them, with capture rates as high as 90% (Barrett et al., 1998). This suggests that the main benefit of having silt fences in a sediment basin may be to pond the water more quickly. As part of a series of studies in the use of the flocculent polyacrylamide (PAM) in sediment ponds, McLaughlin (2003) investigated porous baffles as a means of capturing flocs. Such baffles allow much higher flows through the material than the silt fence, and an obvious reduction in flow turbulence compared to open, or free flow, conditions was observed. These observations suggested that porous baffles may act to capture sediment by reducing mean and turbulent hydrodynamic energy, in contrast to the increased flow path or temporary pooling obtained by silt fence installations.

Thaxton et al. (2004) presented hydrodynamic measurements and analysis within a small sediment retention pond under steady flow conditions with and without three types of baffles installed: silt fence, tree protection fence, and jute germination biotextile backed by coir fiber. These results were used to project a sediment trapping effectiveness for each baffle configuration and for free flow based on Stoke's settling. The most effective baffle in reducing forward

Article was submitted for review in February 2005; approved for publication by the Soil & Water Division of ASABE in August 2005.

The authors are **Christopher S. Thaxton, ASABE Member Engineer,** Adjunct Professor, Department of Physics and Astronomy, Appalachian State University, Boone, North Carolina; and **Richard A. McLaughlin, ASABE Member,** Associate Professor, Department of Soil Science, North Carolina State University, Raleigh, North Carolina. **Corresponding author:** Christopher S. Thaxton, 525 Rivers St., Appalachian State University, Boone, NC 28608; phone: 828-262-6836; fax: 828-2622049; e-mail: thaxtoncs@appstate.edu.

  ISSN 0001−2351

velocity and turbulence was the jute/coir combination, which suggested that the jute/coir baffle would be most effective in capturing more sediment and smaller sized particles than the other baffle configurations and free flow. Since the open space fraction (OSF) of the jute/coir material (in the range of 0.05 to 0.10) is less than that of the tree protection fence but greater than the silt fence, an optimal baffle OSF (or permeability) may exist for maximum sediment capture effectiveness. The purpose of this study was to confirm this supposition with measurements of captured sediment with jute/coir baffles in an experimental basin and to compare this to sediment capture in the open pond and to baffles made of silt fence with weirs and tree protection fence. In addition to reproducing the hydrodynamic results of Thaxton et al. (2004), measurements of the amount of captured sediment and the distribution of captured sediment sizes within the basin were compared to the characterized soil injected upstream from the sediment basin.

METHODS

The experimental design and methods are a reproduction of those outlined in Thaxton et al. (2004). Pond water was gravity-fed through a 0.2 m pipe into a 2:1 rectangular, 23 m^3 retention pond with a 1 m deep permanent pool (fig. 1). Flow rates were adjusted manually at an in-line butterfly valve and monitored at the outflow side of the pond using an ISCO 6712 portable sampler (ISCO, Inc., Lincoln, Neb.) with an ISCO 730 bubble flow module set within an H-flume. The retention pond was roughly rectangular in shape, measuring 8.0 m in length (from intake to spillway), 3.8 m of functional width on average, and 0.92 m deep at its deepest point at the center. The water exited the pond over a 1.10 m wide rectangular plywood weir at the top of the dam. The floor and walls of the pond were lined with geotextile fabric secured with landscape staples to prevent soil detachment within the pond. In addition, rubber sheeting was stapled onto the intake wall to prevent erosion as the water entered the pond.

Experiments were performed with baffles made from three different types of materials: silt fence, tree protection fence, and jute/coir. The jute/coir material was comprised of standard 4 × 100 jute mesh backed by a woven coir erosion control blanket (C-125, North American Green, Evansville, Ind.), joined with zip ties along the top and bottom edges and at several locations throughout the baffle. The medium-weight, orange polyethylene tree protection fence had rectangular openings of 0.10 × 0.05 m. It was folded into three layers and secured with zip ties along the top and bottom edges and at various locations throughout the baffle to reduce its effective permeability to be closer to that of the jute/coir material. The silt fence material was a standard woven polypropylene fiber with 670 threads m^{-1}. A fourth set of experiments was performed for the free flow case with no baffles installed.

For each of the baffle configurations tested, outlet water samples were taken during three fixed intake flow rates: 14, 28, and 42 L s^{-1}. The intake flow rates were monitored during each test, and the intake control valve was adjusted as needed to maintain the flow rate to within 10% of the target rate for each test. In addition, flow measurements identical to those in Thaxton et al. (2004) were taken for these experiments using a Sontek (Sontek/YSI, Inc., San Diego, Cal.) 10 MHz ADV-1 acoustic-Doppler velocimeter. The flow data consisted of a time series of the three fluid velocity spatial components and the corresponding signal-to-noise ratios at depths of 13 and 26 cm from the still ponded water surface for 25 points per depth, corresponding to a 5 × 5 data sampling grid (fig. 2). The longitudinal (parallel to flow) direction was labeled as the *x*-direction and the transverse (perpendicular to flow) direction was labeled as the *y*-direction. At least 1,024 timed data points were taken per position at a sampling rate of 25 Hz with an acoustic frequency of 1 MHz. As a result, the acquisition of each set of 50 hydrodynamic data points per fixed flow rate per baffle configuration took approximately 40 min to complete. Source pond water level and time of day were recorded at the beginning and the end of each run. Source pond water temperature remained between 26°C and 28°C for all experiments performed.

For the experiments that included baffles, three parallel baffles were installed at 0.92 m intervals centered roughly on

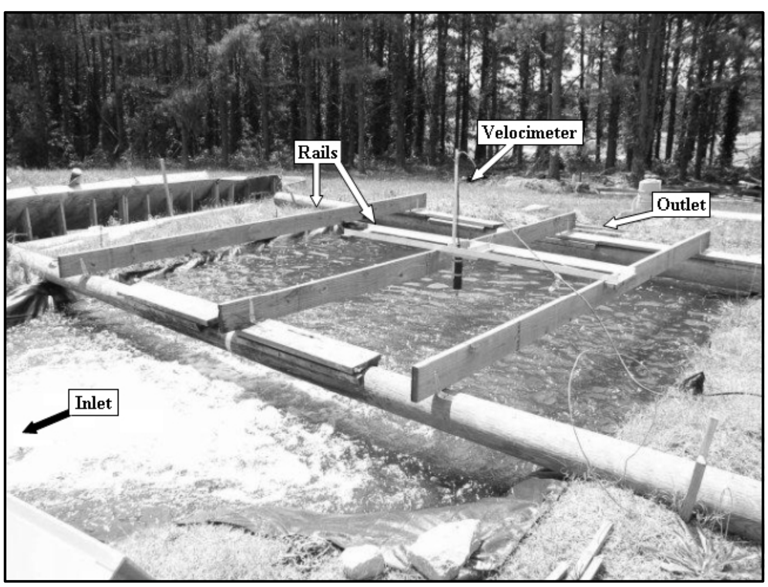

Figure 1. The sediment retention pond used in the experiments.

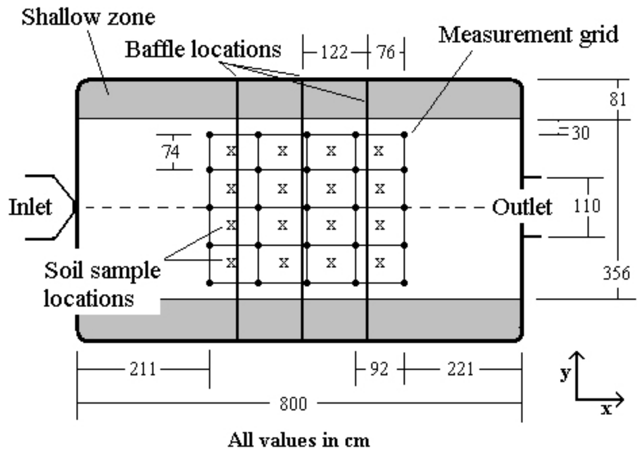

Figure 2. Geometry of the retention pond and the location of the 5×5 data acquisition grid. Flow is left-to-right.

the pond's midpoint and perpendicular to the axis of the pond as defined by the inlet and outlet midpoints (fig. 2). The baffles were supported by three metal stakes spaced evenly across the pond width and were secured with landscape staples along the pond floor and walls to prevent water from "leaking" around the edges. To reproduce the configuration of the silt fence baffles commonly employed at construction sites in North Carolina, each silt fence baffle had one 0.30 × 0.30 m weir centered 0.75 m from the center axis of the pond. The weir on the first silt fence baffle was set to the left of the pond's axis relative to the flow direction, the second to the right, and the third to the left. The sinuous flow path that resulted from this configuration was intended to increase the flow path length (and residence time) within the pond. Once installed, the height of the jute/coir and the tree protection baffles exceeded the ponded water surface height by at least 0.10 m. The pond surface height and the height of the installed silt fence baffles were roughly equivalent during the 14 L s^{-1} experiments; however, in the 28 L s^{-1} experiments, the water occasionally overtopped the silt fence baffles at various locations. During the 42 L s^{-1} experiments, the water consistently overtopped the silt fence baffles by approximately 50 mm.

The open space fraction (OSF), the area of textile that is void of material, was determined for each baffle using an optical method (fig. 3). This method uses a diffused incandescent light source housed within a reflective box that shines through a sample of the geotextile onto a photosensor. Each geotextile tested had been spray painted black to minimize the amount of light passing through the textile material itself. A United Detector Technology optometer (model 61AC, UDT Instruments, Baltimore, Md.) was used to detect the transmitted illuminance for a range of source intensities. The ratio of transmitted to incident light intensity was calibrated to a corresponding OSF for a range of known calibration plates. The resulting optically determined OSF values for the geotextiles in this study were used instead of hydraulic conductivity in comparing sediment capture rates.

Soil was added by hand into the inlet flow pipe approximately 20 m upstream from the pond inlet at a rate of approximately 5.6 kg min^{-1}. The pipe was straight and smooth, and no soil accumulated within the pipe during any of the experiments. The soil was a sandy loam (53% sand, 39% silt, 8% clay) excavated from a depth of 2 to 5 m at a

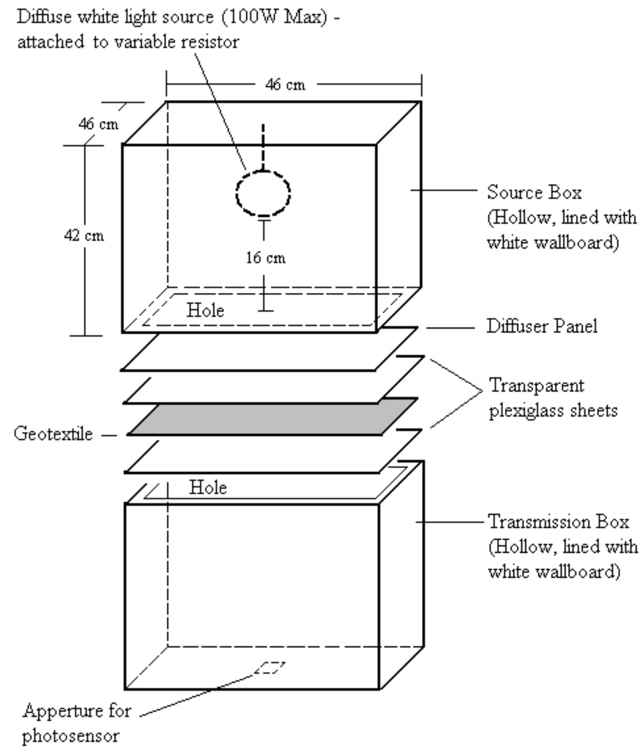

Figure 3. The optical permeameter used to determine the open space fraction (OSF) of each geotextile.

local construction site. It was sieved (2 to 3 cm opening) to remove large clods, rocks, and roots. After about 20 min of adding soil, outlet turbidity stabilized and hydrodynamic data sampling was initiated. Using an ISCO 6712 sampler, water samples were taken at the outlet at 5 min intervals for the duration of the hydrodynamic sampling period, which took approximately 40 min to complete per flow rate. These water samples were later analyzed for turbidity with a nephelometer (Analite 160, McVan Instruments, Mulgrave, Victoria, Australia). Total suspended solids (TSS; mg L^{-1}) were determined by vacuum filtration (Clesceri et al., 1998). The percentage of the injected soil mass captured per flow rate per baffle configuration was computed from the TSS and mass conservation as follows:

$$\%\, m_{captured} = 100\% \cdot \left[1 - \frac{f \cdot \Delta t \cdot \text{TSS}}{\rho_{soil} V_{injected}}\right] \quad (1)$$

where

f = volume flow rate (L s^{-1})
Δt = run time (s)
TSS = total suspended solids (g L^{-1})
ρ_{soil} = 2600 g L^{-1}
$V_{injected}$ = volume of soil injected (L).

After all three of the fixed flow-rate experiments were performed for each baffle configuration, the pond was drained and sediment accumulation depths were measured by inserting a metric ruler into the sediment down to the fixed pond bottom at 16 points within the data acquisition grid (fig. 2). Sediment accumulation depths were also measured at the point of peak accumulation, which in every case was located on the intake side of the sampling grid. Sediment samples were also taken at these locations. The pond was then cleaned out, relined, and baffles were installed (where applicable) for the next configuration to be tested.

The sediment samples were analyzed for sand, silt, and clay composition via the standard hydrometer method (Loch, 2001). For each of the samples, the silt and clay were sieved out and the remaining sand was sieved into six bins corresponding to the standard sieve sizes of 1000, 500, 250, 106, 63, and 53 μm. As a result, a representative grain size (D_{50}) was obtained at each sample location (i) via:

$$D_{50,i} = f_i^{sand} d_{50,i}^{sand} + f_i^{silt} d_{50,i}^{silt} + f_i^{clay} d_{50,i}^{clay} \qquad (2)$$

where f is the fraction of sand, silt, and clay of the sample and:

$$d_{50,i}^{clay}\ (\mu\text{m}) = 1.00$$

$$d_{50,i}^{silt}\ (\mu\text{m}) = 26.0$$

$$d_{50,i}^{sand}\ (\mu\text{m}) = \frac{1}{w_i^{sand}} \sum_{j=1}^{6} w_{i,j}^{sand} \bar{d}_j \qquad (3a)$$

where

w_i^{sand} = weight of sand sample

$w_{i,j}$ = weight of sand in bin j

$\bar{d}_j$ = median diameter of sand bin j (3b)

The median diameters of each of the six sand size bins are defined as:

$$\bar{d}_{j=1...6} = \{1500, 750, 375, 178, 85, 58\ \mu\text{m}\} \qquad (3c)$$

The measured weight of the sand sample as a fraction of the total sample per location should equate to the fraction of sand as determined from the hydrometer readings. At most locations, the difference between these values did not exceed 5%; however, any excess or missing mass as measured by the scale (assumed to be more precise than the hydrometer method) was added to, or subtracted from, the silt and clay fractions determined by the hydrometer method to yield corrected silt and clay fractions used in equation 1. This correction was divided evenly between the silt and clay fractions as an approximation. Since the corrections were normally small, the approximation was assumed valid. The D_{50} value was obtained at each sample location; the D_{50} values at the sampling locations nearest the pond exit were compared to the captured grain size projected from the hydrodynamic data.

A method similar to but simpler than the quickest path method described in Thaxton et al. (2004) was used to project a median grain size of capture for each configuration based solely on the hydrodynamics. In this analysis, it is assumed that the longitudinal ($x-$) component of the flow velocity, averaged over all 25 grid locations and both depths, represents the actual downstream flow field for each baffle configuration:

$$V_x = \frac{1}{n} \sum_{i=1}^{n} V_{i,x} \ ;\ n = 50 \text{ grid locations} \qquad (4)$$

By equating the conventional Stoke's settling velocity for spherical grains at small Reynolds numbers with the ratio of pond depth (h) to minimum residence time ($T_r = L/V_x$, where L = distance from intake to near-exit sample locations = 580 cm), the captured grain diameter can be projected for each baffle configuration as:

$$D(V_x) = \sqrt{\frac{18v}{g(SG-1)} \frac{h}{T_r}} \qquad (5)$$

where

SG = specific gravity of quartz grains (2.65)

d = grain diameter (cm)

g = acceleration due to gravity (980 cm s^{-1})

v = kinematic viscosity of water at 27°C (0.008513 $cm^2\ s^{-1}$).

By averaging $D(V_x)$ over all flow rates to obtain $D_{ave}(V_x)$, it is assumed that $D_{ave}(V_x)$ represents a median capture size that is comparable to a representative grain size (D_{50}) from the hydrometer and sand sieving analysis of samples taken at distance L for each baffle configuration and free flow.

Results and Discussion

Results from the flow data analysis were similar to those presented in Thaxton et al. (2004). With baffles installed, the depth-averaged mean flow velocity magnitude for each of the flow rates, averaged along the five transverse points per longitudinal position (denoted V'_x; see Thaxton et al., 2004), diminished dramatically beyond the first baffle (figs. 4a, 4b, and 4c). After the first baffle (x = 2), a large drop in mean velocity occurred, followed by little or no additional reduction, with the jute/coir baffle producing the greatest reduction. The measured increase in V'_x from the second to the third x-grid position, followed by a subsequent decrease from the third to the fourth x-grid position, was due to the close proximity of the velocimeter to the second baffle at the third x-grid position. Consistent flow overtopping of the silt fence baffle at the 42 L s^{-1} flow rate is demonstrated from the x = 3 data point (fig. 4c).

Aside from the anticipated variability in velocities due to the turbulent nature of the flow, there are two primary differences between the sediment-laden runs (figs. 4a, 4b, and 4c) and the clear-water runs (figs. 4d, 4e, and 4f). The first is the dramatically higher mean velocity (V'_x) in the sediment-laden runs prior to the first baffle near the inlet compared to the clear-water runs. Slight deviations in the angle of the inlet pipe relative to the pond central axis greatly affect the location of the central current and the recirculation currents. In changing from the clear-water runs to the sediment-laden runs, the inlet pipe was moved to allow access to the pond for experiment preparation. Although the inlet pipe was placed in similar horizontal and vertical angles to that for the clear-water runs, enough of a deviation may easily have occurred to affect the measured flow field. This measured deviation would not, however, propagate beyond the first baffle due to the transverse distribution of flow momentum after the first baffle.

The second difference between the clear-water and sediment-laden runs was the higher mean flow velocities (V'_x) for the silt fence and tree protection fence baffles for the sediment-laden runs. A possible cause for this difference for the silt fence baffle runs is that the permeability of the silt fence was reduced due to sediment being captured within the material, forcing higher flow velocities through the weirs, through weak points in the baffle structure, and in overtopping. However, a similar explanation is not valid for the tree

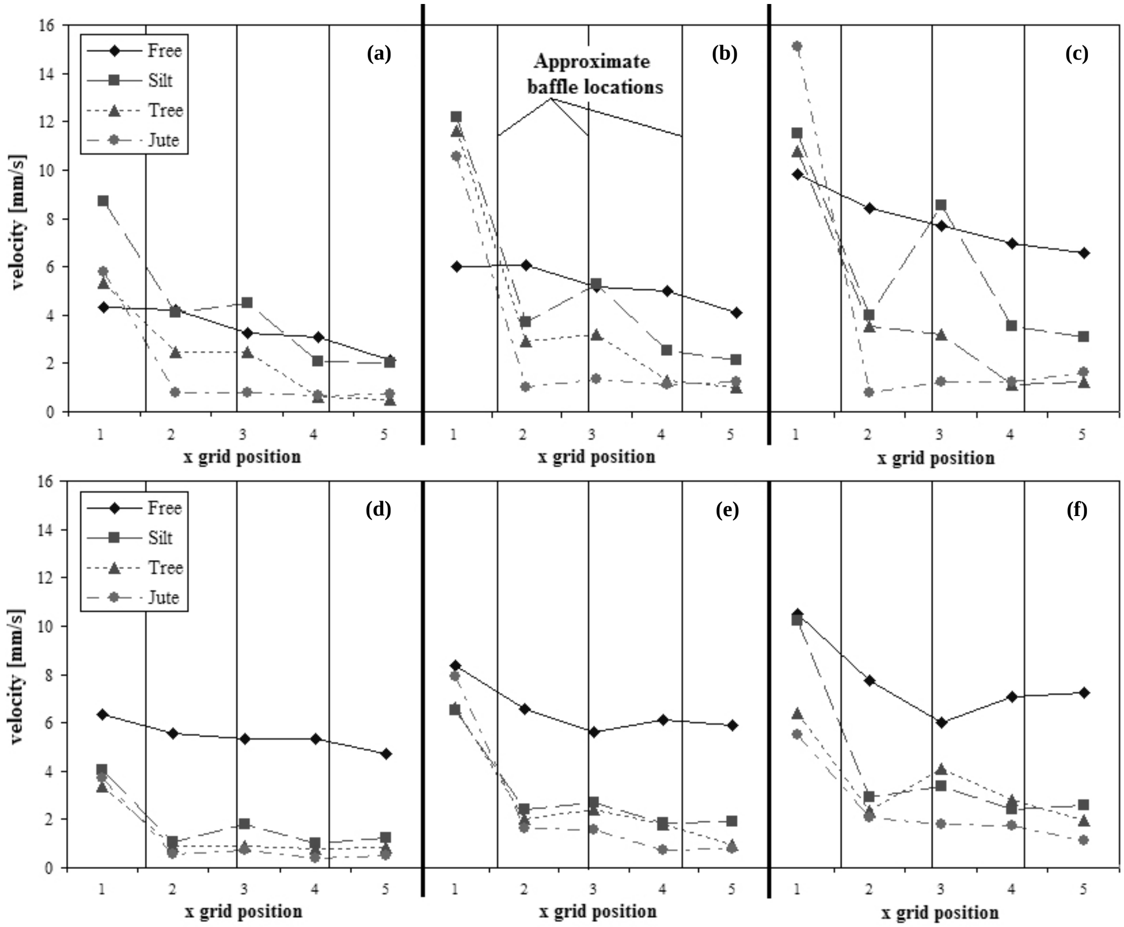

Figure 4. The depth-averaged mean flow velocity magnitude for (a, d) 14 L s^{-1}, (b, e), 28 L s^{-1}, and (c, f), 42 L s^{-1} averaged along the five transverse points per longitudinal ($x-$) position. Graphs a, b, and c are from the experiments described here with sediment injected, while graphs d, e, and f are reproduced from Thaxton et al. (2004). Baffle locations are indicated by the three thin lines.

protection fence. Because the mass of injected sediment was less than 1% of the overall flow mass, the overall flow momentum would not have been affected by the presence of the sediment. The V'_x was similar for the free flow and jute/coir baffle runs with or without sediment. In addition, trends in the transverse velocity variance and signal-to-noise ratios (not shown) were also similar to those presented by Thaxton et al. (2004), where the jute/coir baffle outperformed the other baffle configurations and free flow in distributing mean flow across the width of the pond and in reducing the turbulent energy within the flow.

Total suspended solids (TSS) and turbidity exiting the basin were averaged across all flow rates for each baffle configuration. The jute/coir baffle reduced TSS and turbidity substantially compared to the other basin configurations (fig. 5). This would be expected, since the jute/coir baffle reduced velocity and turbulence more effectively than the other baffle configurations (Thaxton et al., 2004). The silt fence was less effective in reducing TSS and turbidity, possibly due to localized currents generated by the weirs and overtopping. The triple layer of tree protection fence had slightly higher velocities than the jute/coir material, which may have been sufficient to reduce its effectiveness as well.

The jute/coir baffles captured the most sediment, although the capture rate was high for all of the tests at the relatively low sediment loading used (fig. 6). The jute/coir baffle was also observed to accumulate more soil at the point of peak accumulation on the intake side of the sampling grid compared to the other configurations. The jute/coir baffle accumulated some soil within the material itself (not quantified), while the silt fence and the tree protection fence materials did not appear to accumulate a measurable amount of sediment. The basin with the silt fence baffles installed captured less sediment than the open basin. It is important to stress, however, that the injection rates used in these experiments were very low compared to sediment inputs observed at actual field sites. Silt fence baffles have been used in certain locations in

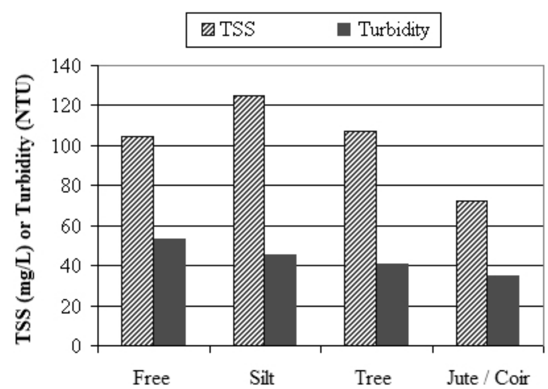

Figure 5. Total suspended solids (TSS) and turbidity obtained at the pond outlet.

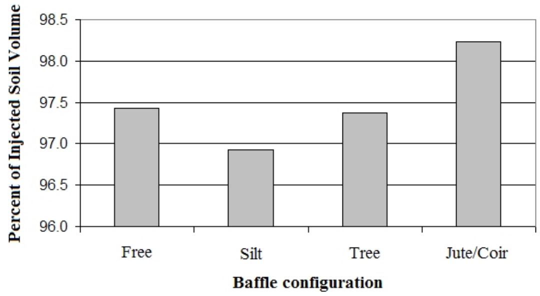

Figure 6. The percent of injected soil captured per baffle configuration.

North Carolina, and they appear to retain substantially more sediment than open basins. It was impractical to add sediment at field rates in this experimental basin because of the large volumes of soil needed as well as the difficulty in removing and disposing of the deposited sediment.

The representative $D_{50,i}$ obtained from equation 2 was averaged transversely at each of the four longitudinal (x−) grid soil sampling positions to yield a representative grain size distribution as a function of pond length, D_{50x} (fig. 7). Also included is the $D_{50,i}$ for the point of peak accumulation near the intake. Compared to the free flow size distribution, all three baffles were capturing smaller particles after the first baffle. The median captured grain size (D_{50}) at the x-grid position nearest the outlet (x = 4), averaged over the transverse grid positions, is the best indicator of the smallest grain size captured, since it is nearest the outlet and also was the most quiescent. The jute/coir baffle again performed the best in this measurement, capturing the smallest grain size of all baffles with a median of less than half that of the free flow (fig. 7).

The particle size distribution was relatively unchanged from inlet to outlet in the free flow condition (fig. 8). A higher percentage of the captured sediment was silt for the baffled configurations. Since the amount of sediment captured ranged tightly between 96.5% and 98.5% of injected sediment over all configurations, the baffled configurations captured more silt than free flow. However, there was no noticeable improvement in the capture of clay due to the baffles. The jute/coir baffle registered the greatest increase in captured silt. At the last sampling point before the outlet, the sediment in the jute/coir configuration was 75% silt and clay, while it was only 35% silt and clay for the free flow test.

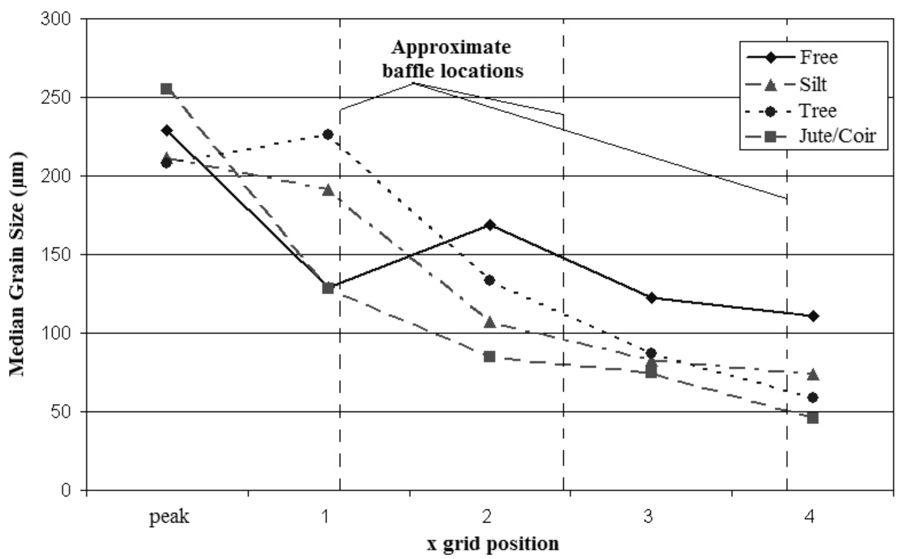

Figure 7. The D_{50} averaged transversely for each configuration along the pond length, which indicates grain size distributions only.

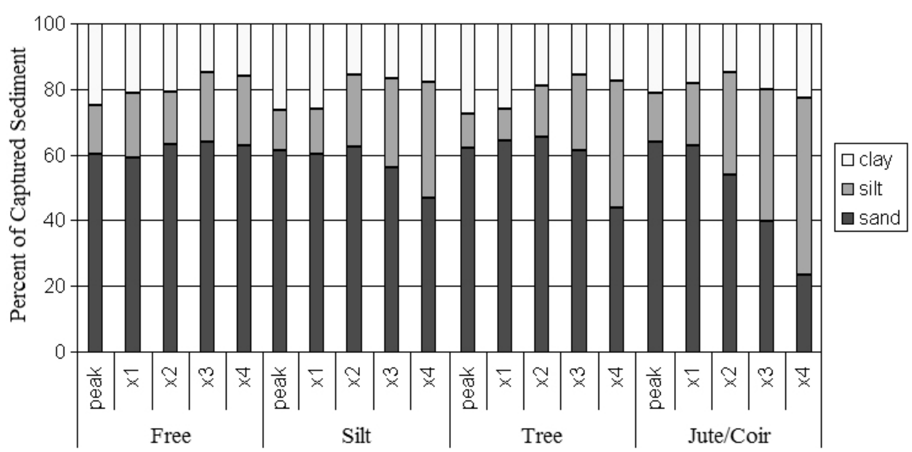

Figure 8. Particle size distribution by configuration as a percent of captured sediment averaged transversely for each x-grid position.

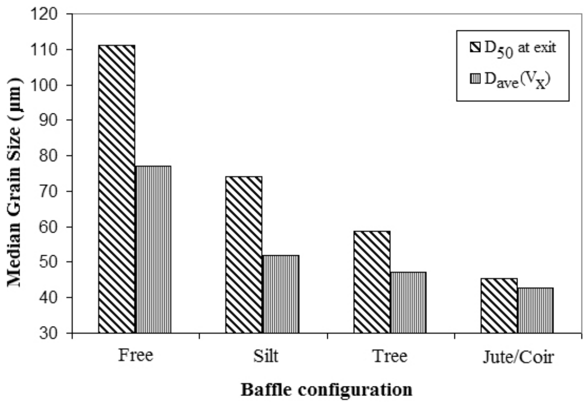

Figure 9. The projected median grain capture diameter, $D_{ave}(V_x)$ (based on Stoke's settling and the measured flow velocities), compared to the D_{50} computed from the soil samples at the x-grid location nearest the outlet.

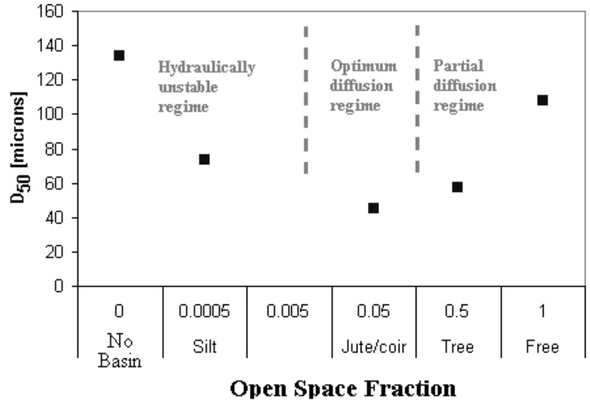

Figure 10. The measured median grain size of captured sediment versus measured baffle OSF, an indicator of baffle hydraulic permeability.

RESULTS ANALYSIS

The transverse-averaged D_{50} at the x-grid position nearest the exit compares well to the projected median captured grain size $D_{ave}(V_x)$ for the jute/coir baffle (fig. 9). The longitudinal component of the flow velocity, averaged over all grid locations, is progressively more representative of the actual flow for the free flow, silt fence baffle, tree protection fence, and jute/coir flow cases, respectively. This result corresponds to that suggested by the transverse variances in mean flow velocity and vertical velocity analysis (Thaxton et al., 2004): the flow with jute/coir baffles is much closer to calculated flow assuming full involvement of the basin cross-section, indicating optimal distribution of flow compared to the other configurations tested.

The permeability of each baffle, as indicated by the OSF measurements summarized in figure 10, was compared to the measured median captured sediment grain size (D_{50}) to determine if there was an "optimal" baffle permeability. The results suggest a pattern in which the minimum captured median particle size is achieved for the jute/coir baffle permeability, and it rises with greater or lesser permeabilities (fig. 10). This comparison allows the OSF spectrum to be divided into three functional regimes: (1) hydraulically unstable regime, indicative of low permeability that leads to overtopping and turbulent resuspension, (2) optimum diffusion regime, which diffuses incoming energy across the full width and depth of the pond without introducing turbulence, and (3) partial diffusion regime, which is less effective in reducing turbulence than optimum.

CONCLUSIONS

Sediment capture results from this study substantiated the hydrodynamic results presented by Thaxton et al. (2004), which showed that baffles, as compared to the standard, open sediment basin, reduced dead storage within the basin by transversely diffusing the inflow momentum and incorporating more of the basin volume in the sediment settling process. With the exception of the silt fence with weirs at moderate to high flow rates, the baffles markedly reduced the mean flow velocities, increasing residence times, and the velocity fluctuations that lead to turbulent resuspension. The more quiescent, distributed flow obtained from the jute/coir baffles resulted in the largest amount of sediment captured. In addition, the jute/coir baffles captured smaller particle sizes than the other baffle configurations. The silt fence with weirs and the tripled tree protection fence baffles had a negligible positive impact on the amount and size of the sediment captured in the basin compared to an open basin. The jute/coir baffle also had the greatest deposition in the first cell, which could be important in facilitating maintenance of sediment basins.

Analysis of the median captured grain size suggests that an optimal baffle permeability may exist, which, based on these baffles and limited test cases, ranges within 0.05 to 0.10 open space fraction. Higher baffle permeabilities may lead to marginally effective flow rate reduction and turbulent suppression, while low baffle permeabilities encourage hydraulic instabilities due to overtopping and baffle structure failure. While the jute/coir material was shown to be the optimal baffle among the three tested, other materials with similar permeabilities could be substituted with no substantial loss in efficiency. Further study would be required to determine if the optimum baffle permeability may be a function of flow rate, pond size and geometry, and/or baffle separation distance.

REFERENCES

Barfield, B. J., R. C. Warner, and C. T. Haan. 1983. *Applied Hydrology and Sedimentology for Disturbed Areas.* Stillwater, Okla.: Oklahoma Technical Press

Barrett, M. E., J. F. Malina, and R. J. Charbeneau. 1998. An evaluation of geotextiles for temporary sediment control. *Water Environ. Res.* 70(3): 283-290.

Chen, C. 1975. Design of sediment retention basins. In *Proc. National Symposium of Urban Hydraulic Sediment Control*. Lexington, Ky.: University of Kentucky.

Clesceri, L. S., A. E. Greenberg, and A. D. Eaton, eds. 1998. *Standard Methods for the Examination of Water and Wastewater,* 2-57, 2-58. 20th ed. Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environmental Federation.

Edwards, C. L., R. D. Shannon, and A. R. Jarrett. 1999. Sedimentation basin retention efficiencies for sediment, nitrogen, and phosphorus from simulated agricultural runoff. *Trans. ASAE* 42(4): 403-409.

Fennessey, L. A. J., and A. R. Jarrett. 1997. Influence of principal spillway geometry and permanent pool depth on sediment retention of sedimentation basins. *Trans. ASAE* 40(1): 53-59.

Goldman, S. J., K. Jackson, and T. A. Bursztynsky. 1986. *Erosion and Sediment Control Handbook.* New York, N.Y.: McGraw-Hill.

Griffin, M. L., B. J. Barfield, and R. C. Warner. 1985. Laboratory studies of dead storage in sediment ponds. *Trans. ASAE* 28(3): 799-804.

Line, D. E., and N. M. White. 2001. Efficiencies of temporary sediment traps on two North Carolina construction sites. *Trans. ASAE* 44(5): 1207-1215.

Loch, R. J. 2001. Settling velocity - a new approach to assessing soil and sediment properties. *Computers and Electronics in Agric.* 31(3): 305-316.

McLaughlin, R. A. 2003. The potential for substantial improvements in sediment and turbidity control. In *Proc. 2nd Conf. Total Maximum Daily Load (TMDL) Environmental Regulations*, 262-272. St. Joseph, Mich.: ASAE.

Millen, J. A., A. R. Jarrett, and J. W. Faircloth. 1997. Experimental evaluation of sedimentation basin performance for alternative dewatering systems. *Trans. ASAE* 40(4): 1087-1095.

Mills, T. R., and M. L. Clar. 1976. Erosion and sediment control - Surface mining in the eastern U.S. EPA 615/2-76-006. Washington, D.C.: U.S. Environmental Protection Agency.

NC DENR. 1988. *Erosion and Sediment Control Planning and Design Manual*. Raleigh, N.C.: North Carolina Department of Environment and Natural Resources, Division of Land Resources.

Thaxton, C. S., J. Calantoni, and R. A. McLaughlin. 2004. Hydrodynamic assessment of various types of baffles in a sediment retention pond. *Trans. ASAE* 47(3): 741-749.

Ward, A. D., C. T. Haan, and B. J. Barfield. 1979. Prediction of sediment basin performance. *Trans. ASAE* 22(1): 126-136.

Ward, A. D., C. T. Haan, and B. J. Barfield. 1980. The design of sediment basins. *Trans. ASAE* 23(2): 351-356.