# Urban Erosion and Sediment Control Best Management Practice

## Definition and Nutrient and Sediment Reduction Efficiencies
## For use in calibration of the Chesapeake Bay Program's Phase 5.0 Watershed Model

The University of Maryland (UMD) is looking for reviewers' guidance in estimating total nitrogen (TN), total phosphorous (TP) and total suspended solids (TSS) efficiencies for urban erosion and sediment control. The efficiencies will be used by the Chesapeake Bay Program for calibration of its watershed model. Jurisdictions report implementation of the urban erosion and sediment control BMP for new construction projects on developing land.

Andy Baldwin at the UMD conducted a literature review and his findings follow. He stated that he is not comfortable recommending changes because of insufficient data but feels efficiencies should be adjust down. He recommends a reduction in current efficiencies because findings show that small particles (silts and clays) are probably not effectively removed via many BMPs and another study concluded that construction site BMPs are often not implemented correctly (or even at all). Using Andy's report and our best professional judgment, UMD project staff recommends the following efficiencies:

| | |
|---|---|
| TN | 25% |
| TP | 40% |
| TSS | 40% |

When providing guidance on TSS efficiencies keep in mind the watershed model does not separate course and fine grain sediments.

# Urban Erosion and Sediment Control Best Management Practice

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**For use in calibration of the Chesapeake Bay Program's Phase 5.0 Watershed Model**

**Recommendations for Formal Approval by the Nutrient Subcommittee's Tributary Strategy and Urban Stormwater Workgroups**

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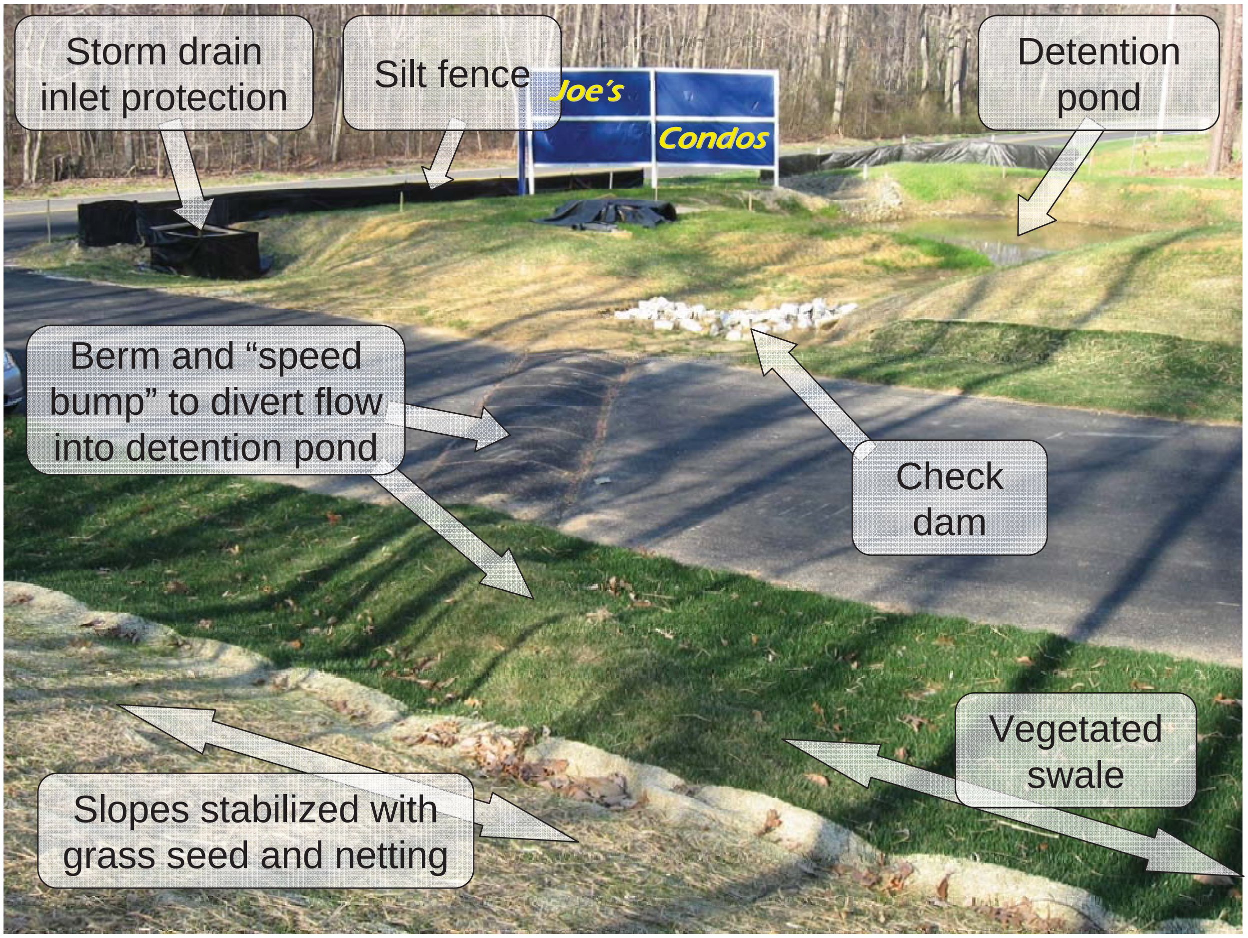
## Introduction

This document summarizes the recommended definition and nutrient and sediment reduction efficiencies for the Urban Erosion and Sediment Control Best Management Practice for review and final approval by the Tributary Strategy Workgroup and Urban Stormwater Workgroup. Included in these recommendations is a full accounting of the Chesapeake Bay Program's discussions on this BMP and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed.

## Photograph of BMP




*Several erosion and sediment control practices commonly used at land development or construction sites have been recently implemented at this Maryland residential development. Photograph by A.H. Baldwin.*

## Description/Definition

Development of land for industrial, commercial, or residential includes activities such as forest clearing and grading. The removal of vegetation and disturbance of soil from development and construction leave soil particles exposed and susceptible to erosion by wind and water. Nitrogen and phosphorus may also be transported from development sites via adsorption to eroded soil particles or dissolution in runoff from exposed areas. Erosion and sediment control practices protect water resources from sediment pollution and increases in runoff associated with land development activities. By retaining soil on-site, sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.

The goal of the erosion and sediment control practices evaluated in this document is the same as those of other BMPs designed to reduce transport of sediment and nutrients to aquatic downstream water bodies, such as wet ponds and constructed wetlands. Some of the technologies used to control erosion and sediment loss at development sites share the design and function of BMPs receiving runoff from existing developments (e.g. sediment detention ponds such as the one pictured above are the same as wet ponds, with the exception that one receives runoff from construction sites and the other from roads, buildings, or lawns). Another distinction from BMPs for existing developments is that typically a range of sediment and erosion control technologies and management practices is applied at a given development site (again as depicted in the photograph above). Furthermore, land development activities have the potential to generate much higher concentrations of sediment in runoff than do developed lands where vegetation has been established.

The water quality functions of erosion and sediment control BMPs result from diversion of surface runoff treatment areas (e.g. using terracing, berms, or swales), reducing water velocity (e.g., using check dams), filtration (e.g., by silt fences), and by removing suspended particle via settling or infiltration. Grasses are often planted on exposed soils, sometimes stabilized with nets or mats, to reduce erosion, and in swales to reduce velocity by increasing roughness of the surface. Nitrogen and phosphorus may be removed via settling of particulate forms and plant and microbial uptake. Phosphorus may also sorb to soil particles. Significant removal of nitrate is unlikely because the aerobic soil conditions are not favorable to microbial denitrification (an exception would be sediment ponds with permanent standing water). The combined effect of these types of BMPs are likely to promote infiltration, reduce runoff velocity, and store surface runoff water, attenuating flood peaks resulting from storms. This hydrologic function is considered a water quality function that helps to reduce stream channel incision, bank erosion, and loss of instream habitat structures that is typical of streams in urban areas with extensive watershed areas covered by impervious surfaces such as building, roads, and parking lots (Schueler 1994).

Erosion and sediment control BMPs provide little habitat value for organisms other than soil invertebrates

A number of definitions of various configurations of urban erosion and sediment control BMPs have been developed. Descriptions of these methods, abbreviated from USEPA (1993), include:

***Sediment Basins.*** Sediment basins, also known as silt basins, are engineered impoundment structures that allow sediment to settle out of the urban runoff. They are installed prior to full-scale grading and remain in place until the disturbed portions of the drainage area are fully stabilized. They are generally located at the low point of sites, away from construction traffic, where they will be able to trap sediment-laden runoff.

***Sediment Trap.*** Sediment traps are small impoundments that allow sediment to settle out of runoff water. Sediment traps are typically installed in a drainageway or other point of discharge from a disturbed area. Temporary diversions can be used to direct runoff to the sediment trap.

***Filter Fabric Fence [“silt fence”].*** Filter fabric fence is available from many manufacturers and in several mesh sizes. Sediment is filtered out as urban runoff flows through the fabric. Such fences should be used only where there is sheet flow (i.e., no concentrated flow).

***Straw Bale Barrier.*** A straw bale barrier is a row of anchored straw bales that detain and filter urban runoff. Straw bales are less effective than filter fabric, which can usually be used in place of straw bales. However, straw bales have been effectively used as temporary check dams in channels. As with filter fabric fences, straw bale barriers should be used only where there is sheet flow.

***Inlet Protection.*** Inlet protection consists of a barrier placed around a storm drain drop inlet, which traps sediment before it enters the storm sewer system. Filter fabric, straw bales, gravel, or sand bags are often used for inlet protection.

***Construction Entrance.*** A construction entrance is a pad of gravel over filter cloth located where traffic leaves a construction site. As vehicles drive over the gravel, mud, and sediment are collected from the vehicles' wheels and offsite transport of sediment is reduced.

***Vegetated Filter Strips.*** Vegetated filter strips are low-gradient vegetated areas that filter overland sheet flow. Runoff must be evenly distributed across the filter strip. Channelized flows decrease the effectiveness of filter strips.

Additional guidelines for effective sediment erosion control, again from USEPA (1993) include:

***Wind erosion controls.*** Wind erosion controls limit the movement of dust from disturbed soil surfaces and include many different practices. Wind barriers block air currents and are effective in controlling soil blowing. Many different materials can be used as wind barriers, including solid board fence, snow fences, and bales of hay.

***Earth dikes, perimeter dikes or swales, or diversions*** can be used to intercept and convey runoff above disturbed areas. These practices should be used to intercept flow from denuded areas or newly seeded areas to keep the disturbed areas from being eroded from the uphill runoff.

***Pipe slope drain.*** Also known as a pipe drop structure, this a temporary pipe placed from the top of a slope to the bottom of the slope to convey concentrated runoff down the slope without causing erosion (Delaware DNREC, 1989 in USEPA 1993).

***Benches, terraces, or ditches*** break up a slope by providing areas of low slope in the reverse direction. This keeps water from proceeding down the slope at increasing volume and velocity. Instead, the flow is directed to a suitable outlet, such as a sediment basin or trap.

***Retaining walls.*** Often retaining walls can be used to decrease the steepness of a slope. If the steepness of a slope is reduced, the runoff velocity is decreased and, therefore, the erosion potential is decreased.

***Linings for urban runoff conveyance channels.*** Often construction increases the velocity and volume of runoff, which causes erosion in newly constructed or existing urban runoff conveyance channels. If the runoff during or after construction will cause erosion in a channel, the channel should be lined or flow control BMPs installed. The first choice of lining should be grass or sod since this reduces runoff velocities and provides water quality benefits through filtration and infiltration. If the velocity in the channel would erode the grass or sod, then riprap, concrete, or gabions can be used.

***Check dams.*** Check dams are small, temporary dams constructed across a swale or channel (see photo above). They can be constructed using gravel or straw bales. They are used to reduce the velocity of concentrated flow and, therefore, to reduce the erosion in a swale or channel.

***Seeding, mulching/matting/netting, and sods.*** Seeding establishes a vegetative cover on disturbed areas. Seeding is very effective in controlling soil erosion once a dense vegetative cover has been established. However, often seeding and fertilizing do not produce as thick a vegetative cover as do seed and mulch or netting.  Mulching involves applying plant residues or other suitable materials on disturbed soil surfaces. Mulches/mats used include tacked straw, wood chips, and jute netting and are often covered by blankets or netting. The mulching/mats protect the disturbed area while the vegetation becomes established. Mulching and/or sodding may be necessary as slopes become moderate to steep, as soils become more erosive. Plastic mats should be avoided.

***Wildflower cover.*** Because of the hardy drought-resistant nature of wildflowers, they may be more beneficial as an erosion control practice than turf grass. While not as dense as turfgrass, wildflower thatches and associated grasses are expected to be as effective in erosion control and contaminant absorption. Only native wildflower mixes should be used.

## Efficiency

The removal efficiencies for urban erosion and sediment control BMPs used in the Chesapeake Bay watershed model are currently 33%, 50%, and 50% for nitrogen (N), phosphorus (P), and sediment, respectively. To evaluate the validity of these numbers, a review of peer-review and gray literature was conducted. Removal efficiencies found in the literature were summarized and used as a basis for validating or changing currently used efficiencies.

### *Literature Review and Data Analysis Methods*

Gray literature such as reports, web sites, and other information not subjected to the peer-review process was obtained through material already in hand, contacts with the Center for Watershed protection, references listed in refereed and gray literature already in hand, and web searches. Literature in peer-reviewed journals was identified using electronic databases such as ISI Web of Science. Literature was reviewed to find removal efficiency data for suspended solids (generally Total Suspended Solids, TSS), Total Nitrogen (TN), and Total Phosphorus (TP).

While the goal of this review is to develop or validate specific removal rating values, it is important to keep in mind that considerable variation exists between studies in methods for sample collection, chemical or physical analysis, experimental design, and data analysis. Even the calculation of removal efficiency, a seemingly straightforward concept, can be approached using at least four different methods (Strecker et al. 2001). The two primary methods are calculation of efficiency based on either 1) change in parameter concentration between inflow and outflow, or 2) percentage of mass of influent pollutants removed, which can result in markedly different efficiency removal efficiency values, even for the same data set. In many cases in this review, removal efficiencies were not reported, but influent and effluent concentration data (e.g., Event Mean Concentration, EMC) were presented that were used to calculate percent removal.

Recently, the concept of removal efficiencies itself has been questioned, and the use of "effluent quality," or the concentrations of pollutants in BMP effluent, has been recommended as a more robust measure of the effectiveness of BMPs for water quality improvement than removal efficiency values (Strecker 2001). A recent comprehensive review of the International BMP Database (BMP Database 2007), Rea and Traver (2005) report well-analyzed effluent concentration data for various BMPs, but present no removal efficiency values, indicating a shift in the state-of-the-art method for evaluating BMPs.

The literature found in this review was divided into two groups: a) studies of individual BMP project sites ("single-site" studies); and b) studies that reviewed or averaged performance for multiple sites or design ratings for particular BMPs based on multiple sites or professional judgment ("multi-site" studies). The studies of individual sites were analyzed separately from the multi-site studies because the latter typically relied on studies of some of the single sites. Single-site studies were limited to those that occurred in the eastern U.S., defined as those sites east of the Mississippi River. An exception was made for this review to include a study from Texas because of the scarcity of quantitative performance information on these BMPs. Some of the multi-site studies likely include some sites from elsewhere in the U.S., and possibly Canada.

Removal efficiencies were summarized in tabular format for single-site studies and multi-site studies. Summary statistics for removal efficiency, such as mean and standard deviation were calculated for multiple site studies, but not for individual site studies since only three single-site studies were found.

### *Results of Literature Review*

Little quantitative information was found on the removal efficiency of erosion and sediment control BMPs (Tables 1 and 2). This was surprising given 1. the widespread use of these BMPs throughout the US and elsewhere, and 2. the high concentrations of suspended sediment that can occur in runoff from exposed soils at land development sites relative to runoff from existing developments. No reports of any study that evaluated nitrogen were found, and only one study was found that examined phosphorus removal. All of the rest examined only suspended solids or effectiveness "in controlling erosion on construction sites", which was equated with solids removal even though the two parameters may not be identical.

The studies of individual sites showed a wide range of treatment effectiveness (Table 1). One study (Barrett et al. 1995; Barrett and Malina 2006) found 0% removal in field studies of silt fence effectiveness (range of -61% to 26%), which involved sampling water in the pond immediately upstream of the fence and in the effluent immediately downstream of the silt fence. This low removal rate was attributed to the small size of particles (silt and clay) that comprised the majority of suspended solids, which passed unfiltered through the fence. Most of the larger particles settled in the pond upgradient of the silt fence. In laboratory studies by the same authors, higher removal efficiencies were noted (68-90%), but again much of the removal settled out in the flume chamber upgradient of the fence; even flumes with no fence resulted in 34% removal. Studies of sediment traps at two North Carolina construction sites (Line and White 2001) found higher removal efficiencies of sediment (59-69%). This study also found the traps were not as effective in removing fine particles (silt and clay) as coarser particles (sand). This study also found phosphorus removal rates of 9-30%.

Twenty removal efficiency values were reported for multi-site studies on various sediment and erosion control BMPs (Table 2), even though these were reported in only two references (USEPA 1990 and 1993). These studies only included information on suspended solids or on "controlling erosion." Because little or no methological information was included in the references, it is not possible to determine if the studies are based on quantitative sampling and analysis or best professional judgment. Measures that rapidly establish dense grass vegetation or cover material on exposed soils (sods, seeding, mulch) appear to have removal efficiencies >75% (Table 2). Sediment traps and basins appear to have removal rates of 50-70%, while silt fences and straw bales appear somewhat more effective in these multi-site studies (but recall low removals by silt fences in the field described for single-site studies. The average removal of these multi-site studies is 78%, somewhat higher than would be that of the single-site studies (0, 64, and 79%).

In addition to quantitative measures of removal efficiency, one study performed a semi-quantitative assessment of 30 Michigan construction sites to evaluate the implementation of BMPs in accordance with guidelines developed by the Michigan Department of Environmental Quality (Kaufman 2000). This study concluded that "performance of erosion control measures was poor" because the BMPs were not implemented correctly in relation to the guidelines or were inappropriate for the topography, hydrology, and soil characteristics of the site. Specifically, the study found that slope stabilization BMPs (mulching, seeding, and staging, i.e. working on different areas at different times) were particularly poor performers, with water management BMPs (buffer strips, filter fences, and sediment basins) only slightly better. BMPs for stabilizing soils (grading, access roads, spoil piles) performed the best. The study concludes that developers are not following recommended BMP practices and/or the laws requiring BMPs at construction sites are not being enforced, reflecting "a failure to integrate science and policy." This study suggests that while sediment and erosion control BMPs may function effectively when properly installed, a majority of these BMPs may not be functioning effectively due to incorrect installation.

### *Recommended Removal Efficiencies for Model*

The current values used in the Chesapeake Bay model are not supported by the literature found in this review (although there is likely to be additional information in the gray literature that could not be obtained). No information was found for nitrogen removal, so the validity of the 30% removal efficiency currently in the model cannot be assessed. Only one study evaluated phosphorus removal, and the value reported (20%) suggest the currently used value of 50% is too high.

For suspended solids, the current value of 50% appears reasonable, although it is difficult to revise the number more specifically because the efficiency of different BMPs for sediment and erosion control varies widely and there have been few, if any studies of the combined effect of multiple BMPs on construction sites, even though that is the typical situation encountered in practice. Given the finding that small particles (silts and clays) are probably not effectively removed via many BMPs, increasing the number is not justified. Furthermore, the Michigan study's (Kaufman 2000) conclusion that construction site BMPs are often not implemented correctly (or even at all), if anything the 50% value should be reduced. However, insufficient data exist to warrant a reduction at this time.

As also noted previously in this review, Fifield (2002) states that there is little documentation of sediment-trapping systems for construction sites, and that conflicting opinions exist about the actual effectiveness of these systems. Fifield (2002) summarizes USEPA (1976) field studies, which noted that:

- Poor construction and maintenance were the most important factors leading to ineffective treatment;
- Predicted efficiency was higher than observed efficiency; and
- Cleaning out of sediment is necessary to maintain effectiveness.

The general concept of erosion and sediment control, according to Fifield (2002) is that properly designed, constructed, and maintained systems are always effective in trapping some sediment.

Changes in factors relating to soil, vegetation, topography, or hydrologic conditions may alter the effectiveness of erosion and sediment control BMPs for removal of suspended solids or nutrients. For example, longer detention times behind silt fences will in general tend to improve efficiency due to longer times for settling of particulates (Barrett and Malina 2006). Efficiency can also be affected by the geomorphology of the unit; designs that maximize the area of contact between water and soil, vegetation, or microbial surfaces should in general increase efficiency. Increased vegetation density and biomass in swales or buffers is also likely to improve efficiency because of greater roughness, nutrient uptake, and more microbial surface area. While microbial removal processes that affect nitrogen removal are sustainable indefinitely under relatively constant environmental conditions, soil surfaces may become phosphorus-saturated, and further phosphorus sorption is therefore not possible. Depending on the soil type and phosphorus loading rates, saturation may take many years, if it occurs at all. Capacity for sediment removal may also be impeded if high loading rates result in clogging or burial of vegetation. Additionally, high flow rates may lead to the formation of preferential flow pathways that reduce contact between water and microbes, soil, or vegetation. These and other variables may lead to changes in the efficiency of BMPs over time. Some processes may increase efficiency (e.g. development of vegetation) while other processes may simultaneously decrease efficiency (e.g. channel formation).

Climatic variables may also affect BMP performance over time, either positively or negatively. Periods of greater precipitation will likely result in shorter residence times, or even bypassing of the BMP due to high flow volumes, both of which will reduce performance. On the other hand, higher temperatures should increase metabolic rates, increasing growth of microbes and plants and facilitating greater transformation and uptake of nutrients. Global climate change may therefore affect performance by changing precipitation patterns and temperature in unpredictable ways. An additional factor is higher $CO_2$ concentrations, which may result in shifts toward species competitively favored under high atmospheric $CO_2$ levels. Changes in species composition may have some effect on performance, although effects are likely to be small unless there are large changes in stem density or biomass.

The few studies available suggest considerable variation in the performance of erosion and sediment control BMPs. Performance may vary over time, and in some cases high volume runoff events may bypass the system, resulting in little removal for large volumes of runoff. While some erosion and sediment control measures are temporary (e.g. silt fences), others are often left in place or modified into permanent structures (e.g., sediment traps and basins). Detention ponds should continue to function effectively for years without any significant maintenance other than mowing (which may not be critical for optimum performance). Periodic inspections should be performed to identify changes in hydrology, vegetation, or soils like those described above so that remedial measures can be taken in necessary. Development of channels or other evidence of erosion should be dealt with expeditiously, for example by diverting some portion of the runoff, installing rock berms, or otherwise decreasing flow velocities in the BMP.

While no studies have specifically evaluated how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, some general adverse effects to water quality are understood. If maintenance is neglected a BMP may become impaired, no longer providing its designed functions.

In addition, sediment accumulation is one maintenance concern that if not addressed may adversely affect BMP effectiveness. As sediment accumulates it decreases storage volume and detention time, bypassing the intended functions of the BMP and increasing discharge of nutrient and sediment rich stormwater (Livingston et al. 1997). Increased discharge will lead to decreased downstream channel stability, resulting in an increase of sediment loads and a reduction in available aquatic habitat. The consequences of increased stormwater discharges from sediment filled BMPs, are a reduction in the BMPs pollution removal efficiencies, and ultimately, increased ecological impairments. The uncertainty in how improper maintenance will adjust BMP efficiencies supports the recommendation to use a more conservative percent removal estimate.

## Statement of Conservatism

The level of uncertainty surrounding the recommended efficiency value for TSS is affected by, at a minimum, the number of studies available for a given parameter, the methods used to determine efficiency (e.g. number of replicates, analytical methods), the location of the studies, and the method used to calculate efficiency (e.g., load- vs. concentration-based). For the purposes of this review, the most-reported parameters in single- and multi-site studies was TSS, which is fortunate for developing recommendations for sediment efficiencies (only one study reported TP efficiency and none reported TN efficiency).

Given the numerous variables that may influence the performance of individual BMPs for erosion and sediment control, any single numerical removal efficiency will not apply to all situations. Because only a few studies were found, the reported studies do not incorporate a range of BMP designs of different ages across a wide geographic area. Therefore, there is considerable uncertainty in predicting the performance of actual BMPs across the Chesapeake Bay watershed. Furthermore, the degree to which BMPs are installed correctly in accordance with erosion control regulations across the Bay watershed is unknown. Using a confidence scale of low, medium-low, medium, medium-high, and high, I would rate the degree of confidence in the recommended values as low.

## Future Research Needs

As mentioned previously, the concept of "effluent quality" has been recommend over the use of removal efficiencies such as those that have been presented here and upon which the recommended values for the Chesapeake Bay model were based (Strecker et al. 2001). While the use of removal efficiencies in a modeling landscape or watershed transformation or removal or nutrients and sediments makes sense in theory, in practice problems arise due to the different methods used in calculating removal (e.g. load- vs. concentration-based) and small absolute changes in concentration or load resulting in large percentage changes, to name two examples. Furthermore, it is currently recognized (e.g., Kadlec and Knight 1996) that "natural" systems such as sediment ponds or grassy swales, are not capable of removal of pollutants below a certain "background" concentration, a phenomenon not often considered when removal efficiencies are used in modeling or design efforts. Adoption of an "effluent quality" approach however, recognizes that for a specific flow volume and above a certain minimum design size, most BMPs will remove pollutants to some constant background concentration, irregardless of additional increased in BMP area or volume. This approach could be applied in the Bay model by assigning the same effluent concentrations to BMPs of certain watershed:BMP size ratio. In addition to using effluent quality as a measure of BMP performance rather than removal efficiencies, Strecker et al. (2001) recommends using living resource restoration indicators, such as aquatic invertebrate sampling and habitat classification, in addition to calculating effectiveness by using chemical measures. These measures may not be applicable to systems such BMPs for erosion and sediment control, however.

Strecker et al (2001) recommend parameters that all studies should include, but are often missing. These include transferable measures of storage volume, surcharge detention volumes, stage/storage data, watershed characteristics, and land use information. Winer (2000) also recommends incorporating individual storm parameters, specifically bacteria, hydrocarbons, dissolved metals, as they correlate with human health, recreation and aquatic toxicity and are often not reported. Not only do many studies lack the aforementioned parameters, studies also make translation of available design parameters difficult. To ensure studies begin using these recommendations Strecker et al. state that the EPA require all federally funded projects that will evaluate BMP effectiveness employ standard methods they discuss, and in addition, that the EPA provide detailed guidance on data collection and sampling methods to improve data transferability (2001).

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Table 1. Summary of literature on the pollutant removal effectiveness (%) of single-site studies of urban erosion and sediment controls as Best Management Practices for urban and mixed open land uses. TSS = Total Suspended Solids, TN = Total Nitrogen, TP = Total Phosphorus. Calculation method: C = concentration-based; L = Load-based.

| System name | Type | Location | TSS | TN | TP | Calc. Method | Comments | Reference |
|---|---|---|---|---|---|---|---|---|
| Highway construction projects | Silt fences | Austin, TX vicinity | 0 | | | C | Median removal; range= -61% to 54%; SD=26%; Included even though West of Miss R due to low availability of rigorous studies | Barrett and Malina 2006; Barrett et al. 1995 |
| Laboratory tests | Silt fences | Austin, TX | 79 | | | C | Midpoint of range of 68-90%; much of removal due to settling in chamber or pond before reaching fence (34% removal with no fence); detention time more important than filtration capacity; Location not relevant for lab studies | Barrett and Malina 2006; Barrett et al. 1995 |
| Construction sites | Sediment traps | North Carolina | 64 | | 20 | NS | Midpoint of range | Line and White 2001 |

Table 2. Multi-site studies reporting removal efficiencies (%) for dry extended detention basins as Best Management Practices for urban and mixed open land uses. Calculation method: NS = not specified.

| Type | TSS | TN | TP | Calc. Method | Comments | Reference |
|---|---|---|---|---|---|---|
| Sod | 99 | | | NS | Average | References cited in USEPA 1993 Table 4-15 |
| Seed | 90 | | | NS | Average after vegetation establishment | References cited in USEPA 1993 Table 4-16 |
| Seed and mulch | 90 | | | NS | Average after vegetation establishment | References cited in USEPA 1993 Table 4-17 |
| Mulch (various) | 75 | | | NS | Midpoint of observed ranges | References cited in USEPA 1993 Table 4-18 |
| Terraces | 63 | | | NS | Midpoint of observed range | References cited in USEPA 1993 Table 4-19 |
| All erosion controls | 85 | | | NS | Average | Schueler 1990 in USEPA 1993 Table 4-15 |
| Sediment basin | 70 | | | NS | Average | References cited in USEPA 1993 Table 4-16 |
| Sediment trap | 60 | | | NS | Average | References cited in USEPA 1993 Table 4-17 |
| Filter fabric fence | 70 | | | NS | Average | References cited in USEPA 1993 Table 4-18 |
| Straw bale barrier | 70 | | | NS | Average | References cited in USEPA 1993 Table 4-19 |
| Vegetative filter strip | 70 | | | NS | Average | References cited in USEPA 1993 Table 4-20 |
| Seeding--permanent | 99 | | | NS | Effectiveness "in controlling erosion on construction sites" | USEPA 1990 |
| Seeding--temporary | 99 | | | NS | Effectiveness "in controlling erosion on construction sites" | USEPA 1990 |
| Mulching | 87 | | | NS | Midpoint of range; Effectiveness "in controlling erosion on construction sites" | USEPA 1990 |
| Sod stabilization | 99 | | | NS | Effectiveness "in controlling erosion on construction sites" | USEPA 1990 |
| Vegetative buffer strip | 87 | | | NS | Midpoint of range; Effectiveness "in controlling erosion on construction sites" | USEPA 1990 |
| Straw bale dike | 67 | | | NS | Removal of this percent of sediment in site runoff | USEPA 1990 |
| Silt fence | 97 | | | NS | Removal of this percent of sediment in site runoff | USEPA 1990 |
| Sediment trap | 46 | | | NS | Removal of this percent of sediment in site runoff | USEPA 1990 |
| Temporary sediment basin | 46 | | | NS | Removal of this percent of sediment in site runoff | USEPA 1990 |
| Average | 78 | | | | | |
| SD | 17 | | | | | |
| N | 20 | | | | | |
| Minimum | 46 | | | | | |
| Maximum | 99 | | | | | |