Article 52

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Muddy Water In - Muddy Water Out?

Construction is considered the most damaging phase of the development cycle for streams and other aquatic resources. Many communities have responded to the many impacts caused by construction sites by enacting erosion and sediment control (ESC) ordinances. Typically, the ordinances require developers to submit a plan that contains measures to reduce soil erosion (erosion prevention) and practices to control sediments that have already eroded (sediment controls). In addition, the plan may restrict or require phasing of the clearing or grading needed to prepare a development site. Once an ESC plan is reviewed and approved by the local or state authority, the ordinance then requires the developer or contractor install and maintain specified measures and practices throughout the construction phase. A construction site may be inspected for compliance, and if found lacking, an inspector may issue a permit violation, stop-work order, fine or other measure to compel action.

Theory Collides with Reality

How well do these ESC programs work in the real world? Not very well, according to six recent surveys of local and state ESC experts and administrators. Consider these statistics:

- Paterson's (1994) investigation of 128 North Carolina construction sites revealed that 16% of the ESC practices prescribed in the plan were never installed. Of the ESC practices that were actually installed, 16% were not installed correctly and failed to perform. An additional 18% of ESC practices failed because of a lack of maintenance. Combining these three sources of failure together, Paterson found that half of all practices specified in the ESC plans were not implemented properly.
- Mitchell (1993) surveyed state highway erosion control experts, and reported that 30% of respondents noted that at least half of the ESC practices specified in highway ESC plans were never actually installed. While 83% of the respondents indicated that they required a preconstruction meeting with the contractor to discuss ESC plan implementation, only 29% scheduled a pre-wintering meeting. The state highway ESC experts cited five major problems in achieving better highway ESC control: lack of inspectors, weather, lack of contractor cooperation, lack of state leadership, and contractor ignorance (in rank order).
- North Carolina ESC surveys by Patterson *et al.* (1993) found that contractors actually spent only half the estimated cost to install the ESC controls outlined in their plan. In addition, local governments expended three to six times more effort reviewing plans than actually inspecting them. Despite the fact that a majority of ESC staff spent time in the office, they received very little training nor did they train contractors. Training comprised only one tenth of one percent of local ESC program budgets.
- According to a survey of 24 ESC local programs in Northeastern Illinois by conducted by Dreher and Mertz-Erwin (1991), less that 45% of ESC plan reviewers had received formal training in ESC techniques. In addition, while a slightly higher number of inspectors were trained in ESC techniques (55%), most training consisted of informal field mentoring by more experienced staff. The researchers also reported a wide range of inspection frequency. For example, 25% of communities only conducted inspections in response to citizen complaints, and 10% inspected construction sites less frequently than one time a month. More positively, half the Illinois programs reported construction site inspections were done weekly or on a more frequent basis.
- Corish's 1995 national survey of 40 local ESC programs documented poor plan implementation. For example, 67% of survey respondents indicated that ESC controls were inadequately maintained. Soils were not adequately stabilized within the prescribed time limit in 44% of ESC programs, and 56% of programs encountered chronic problems with inadequate temporary soil stabilization (grass or mulch cover).

Nearly half of the local program respondents noted that sensitive areas adjacent or within construction sites (such as stream buffers and wetlands) were inadequately protected from sediment or were actually cleared. Trees and forest areas "protected" under the plan were in fact not protected, according to 57% of respondents. Another 24% reported clearing frequently occurred well beyond the disturbed area specified in the plan. Lastly, 36% of the respondents to Corish's survey observed that steep slopes were improperly cleared, or were inadequately stabilized.

- A national survey of over 80 local ESC programs conducted by Brown and Caraco (1996) discovered that 10% of local ESC programs appear to exist only on paper, as they allocated no staff for either plan review or inspection. Staffing was a major constraint even for the established ESC programs in larger communities that processed in excess of 100 ESC permits each year. Over half of these larger ESC programs had less than two plan reviewers and three inspectors to administer their program, and these staff were often asked to perform other duties.

The lack of manpower reflects a chronic funding problem for many local ESC programs, as 75% reported complete dependence on unreliable revenue streams such as application fees or the local operating budget. Brown and Caraco (1996) further noted that a third of all programs surveyed did not require engineering plans, and one-fourth considered themselves a "non-regulatory" program.

Several surveys also noted that ESC practices rated by experts as "most effective" were seldom applied. Conversely, a number of ESC practices rated as "ineffective" still enjoy widespread use (Patterson, 1994; Brown and Caraco, 1996). The four most popular practices cited in a national survey were silt fences, stabilized construction entrances, storm drain inlet protection and temporary vegetative stabilization, all of which rank high in terms of installation and maintenance problems.

The actual sediment removal capability of many ESC practices appears to be fairly limited, with most practices achieving 50 to 85% total suspended solids (TSS) removal rates, according to recent field research. In contrast, sediment removal rates on the order of 95 to 99% are needed to achieve anything resembling a "clear water" discharge.

ESC practices are increasing the cost of development, with several sources estimating they now comprise from three to six percent of total development costs. While this investment would have been unthinkable a few decades ago, it is evident from the foregoing statistics that much of this money is not being well spent--practices are poorly or inappropriately installed, and very little is spent on maintaining them. It is therefore unsurprising that many in the development industry view ESC plans as **"muddy water in, muddy water out, and a lot of money in between."**

Taken together, the information presented here confirms that both the quality and implementation of ESC plans need to be greatly strengthened. In the remainder of this article, we explore practical factors that lead to poor design and implementation of ESC plans based on surveys and expert opinion of ESC professionals. Next, 10 elements that can improve performance are outlined in order to increase plan effectiveness. Finally, some practical recommendations are made to improve the capability of local ESC programs to produce better results in the field, given the reality that resources will always be scarce in most communities.

Why Do Erosion and Sediment Control Plans Fail to Perform in the Field?

Before ESC plans can be improved, it is important to understand the underlying reasons why they fail. In general, poor performance can be explained by two reasons. First, many ESC plans are poorly integrated with other stream protection efforts that occur during construction. Construction is potentially the most destructive stage in the entire development process: trees and topsoil are removed, soils are exposed to erosion, steep slopes are cut, natural topography and drainage are altered, wetlands are filled, and riparian areas are disturbed. Consequently, an ESC plan is about more than preventing sediment from leaving the site. It also sets forth how a stream will be protected during this critical stage of development. The plan should clearly outline where and how other stream protection measures are employed, such as wetland protection, forest conservation, stream buffers, and stormwater treatment practices. It is worth emphasizing that grading and ESC plans are usually the only plans that are routinely read by earthmoving contractors at a construction site. Consequently, any stream protection measure that is dependent or influenced by earthmoving activities - and most are - should be clearly marked on the plan.

Many communities fail to make this important link. As a result, their ESC programs are not integrated into an overall stream protection strategy. For example, only 35% of the local ESC programs considered wetland protection in the ESC plan approval process. An even smaller number (20%) reviewed ESC plans within a watershed or special protection framework (Ohrel, 1996). All too often, ESC plans tend to be developed in isolation from other stream protection plans prepared for the site: someone else designs the stormwater treatment practices, somebody else does the grading plan, while others assemble any wetland protection, forest conservation, stream buffers or other sensitive plans. Because these plans are usually submitted to different agencies and undergo a separate approval process, there is no apparent need to integrate them.

A quick glance through many state and local ESC manuals reveals a second major reason for poor ESC plans: they are based on “cookie cutter” manuals. Most ESC manuals consist of little more than a collection of a few dozen detailed standards and specifications for individual ESC practices. Very little guidance is given on how to combine ESC practices together into an effective plan. In particular, most ESC manuals provide very skimpy coverage about erosion prevention techniques, such as clearing restrictions, protecting the limits of disturbance, and construction phasing. Many of the standard details for ESC practices are outdated, or lack specific guidance on where and when a particular practice is appropriate. For example, Mitchell (1993) reviewed the contents of 49 state highway ESC manuals and found that 50% did not have detailed standards and specifications for 25 of the more common ESC practices. Few practices ever seem to be dropped from ESC manuals, even if monitoring data or maintenance experience prove them to be inadequate. At the same time, design enhancements that can sharply increase the effectiveness of a ESC practice are often recommended but not required. Faced with this choice, cost-conscious designers and contractors will generally only chose to install that which is absolutely required.

With ESC manuals offer relatively little practical guidance, the responsibility for developing a quality plan falls to the design engineer. ESC plans, however, are often among the last elements of a construction plan to be completed, and are usually delegated to junior engineers with little hands-on ESC experience or training. Often, the only resources available to them are the grading plan for the site, a few sample ESC plans and the local ESC manual. Given a tight timetable, a designer rarely has time to visit the site to become familiar with construction site conditions. Thus, it is not surprising that many ESC plans submitted to local agencies for review are of poor quality.

Local plan reviewers, in turn, often lack the time to fix mistakes, or may not have the field experience or specialized training needed to catch them. This leaves it up to the inspector to correct the mistakes at the construction site. At this point, the contractor who based his ESC cost estimate on the original plan, is extremely reluctant to make any changes that will increase costs.

Ten Elements of an Effective ESC Plan

How can the implementation of ESC plans be improved? To start, designers and plan reviewers should check their ESC plan to determine if it includes 10 critical elements as portrayed in Figure 1. These 10 elements were drafted in consultation with local and state ESC experts. They present a comprehensive and integrated approach for achieving stream protection requirements during construction. As a result, only four elements of the 10 actually involve better design and selection of ESC practices. Three ESC elements emphasize non-structural techniques for erosion prevention, while the last three involve management techniques to translate a plan into reality. The ten elements are as follows:

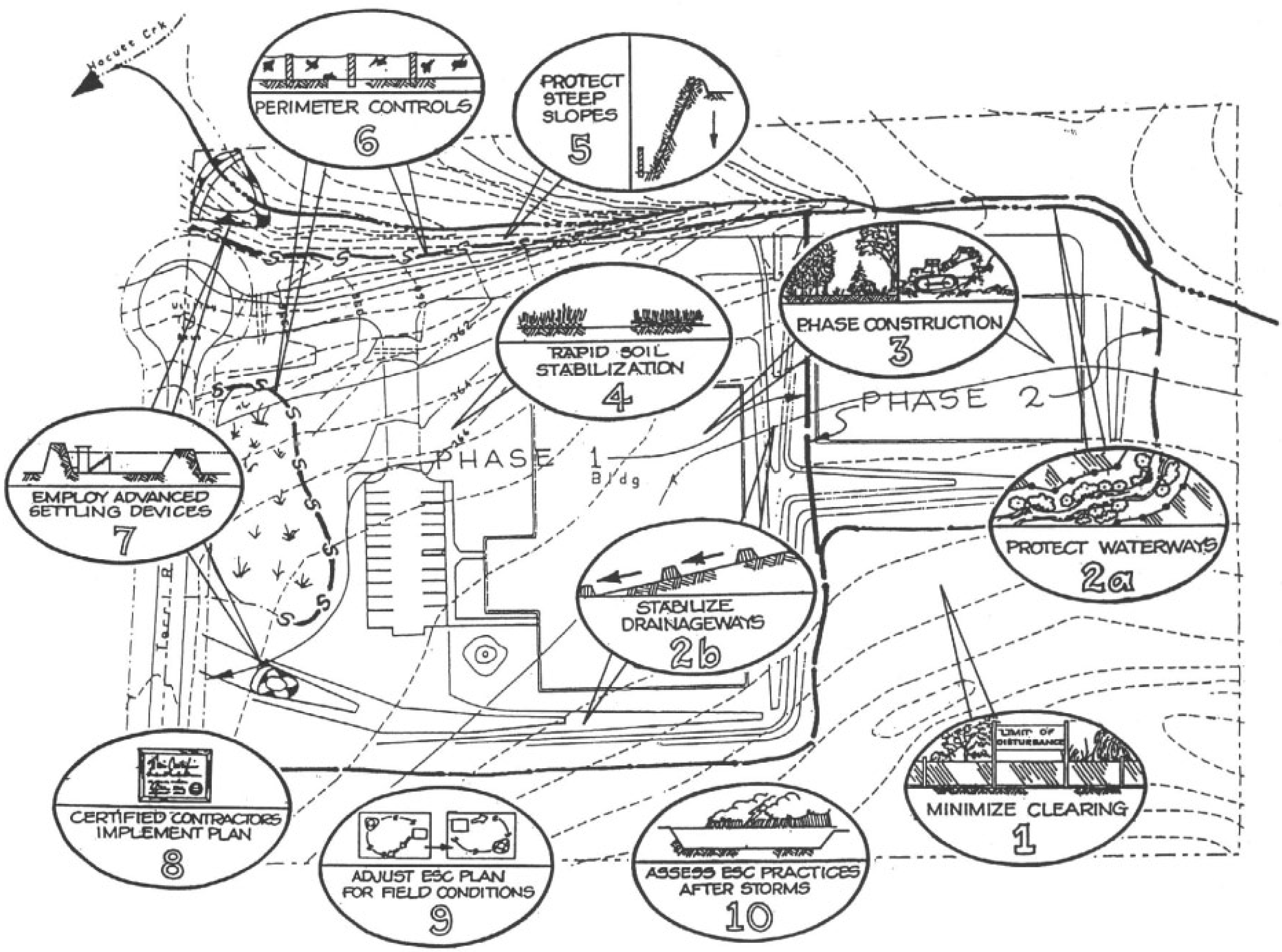
1. Minimize Needless Clearing and Grading
2. Protect Waterways and Stabilize Drainage Ways
3. Phase Construction to Limit Soil Exposure
4. Immediately Stabilize Exposed Soils
5. Protect Steep Slopes and Cuts
6. Install Perimeter Controls to Filter Sediments
7. Employ Advanced Sediment Settling Controls
8. Certify Contractors on ESC Plan Implementation
9. Adjust ESC Plan at Construction Site
10. Assess ESC Practices After Storms

1. Minimize Clearing and Grading

Clearing and grading should only be performed within the context of the overall stream protection strategy. Some portions of the development site should never be cleared and graded, or clearing in these areas should at least be sharply restricted. These areas include the following:

- Stream buffers
- Forest conservation areas
- Wetlands, springs and seeps
- Highly erodible soils
- Steep slopes
- Environmental features
- Stormwater infiltration areas

A site designer can go even further, however, and analyze the *entire* site to find other open spaces where clearing and/or grading can be avoided. Ideally, only those areas actually needed to build structures and provide access should be cleared. This technique, known as site fingerprinting, can sharply reduce earthwork and ESC control costs, by as much as $5,000 per acre (Schueler, 1995) and is critical for forest conservation. All “protected” areas should be delineated on construction drawings, and shown as the “limits of disturbance “ or LOD. The LOD must be clearly visible in the field, and posted by signage, staking, flagging or most preferably, fences (i.e., silt fence or temporary safety/snow fence). The limits and the purpose of the LOD should be clearly conveyed to site personnel and the construction foreman at a preconstruction meeting. In addition, paving and other subcontractors that



Every site designer and plan reviewer should analyze the construction site to see if it can achieve the ten critical elements of an effective ESC plan, as shown above. (Site plan courtesy of North Carolina Erosion and Sediment Control Manual.)

Figure 1: Ten Critical Elements of an Effective ESC Plan

will be working on the site during a later stage of construction should also be routinely notified about the LOD as they arrive.

2a. Protect Waterways

Streams and waterways are particularly susceptible to sedimentation, and a designer should always check to see if they are present at a site, and whether construction activities will occur near them. If so, no clearing is permitted adjacent to the waterway. As a secondary form of protection, a line of silt fence or earthen dike should be installed along the perimeter of the waterway buffer. If work is planned across or within the waterway, special crossings and diversion techniques are required (WRA, 1986 is an excellent reference in this regard).

2b. Stabilize Drainage Ways

Of equal importance, designers should carefully map the existing and future drainage patterns at the site, known as *drainage ways*. Not only are drainage ways the major route that eroded sediments take to reach streams and waterways, they also are prone to severe erosion due to the velocity of concentrated runoff that travels through them. Consequently, special ESC practices are applied to the drainage way, depending on their slope and length, and the disturbed areas that drain to them. An ideal drainage way serves as a grassed waterway, which may require sod, erosion control blankets or jute netting to prevent erosion during storms. In addition, checkdams may often be needed along the drainage way, using riprap, earth, dikes or silt fence. The storage provided behind checkdams can trap sediment, and is a useful backup when upstream portions of the drainage way begin to erode into a gully.

3. Phase Construction

Mass grading of larger construction sites should be avoided because it maximizes both the time and area that disturbed soils are exposed to rainfall and therefore subject to soil erosion. As an alternative, designers should consider “construction phasing” whereby only a portion of a construction site is disturbed at anyone time to complete the needed building in that phase. Other portions of the construction site are not cleared and graded until the construction of the earlier phase is nearly completed and its exposed soils have been stabilized.

Construction phasing is similar to “just-in-time manufacturing” in that earthmoving occurs only when it is absolutely needed. By breaking the construction site into smaller units, the disturbed area is sharply reduced. This is particularly critical for larger residential and commercial projects that may take one, two or even three years to finish. The potential reduction in sediment load from construction phasing can be very impressive. Claytor computes a 42% reduction in off-site sediment loads in a typical subdivision development scenario (article 54).

Phased construction requires careful planning. For example, each phase must be planned so that earthwork is balanced within it; i.e., the “cut” soil from one area matches the “fill” requirement elsewhere. Other key elements of construction phasing are described in article 54, and include provisions for temporary stockpiling and construction access, and performance criteria for triggering a new phase. In addition, the phases should correspond to existing or future drainage boundaries wherever possible. In general, construction phasing is most appropriate for larger construction sites (25 acres or more).

Lastly, it is important to note that construction phasing should not be confused with the construction sequence, which outlines the specific order of construction that the contractor must follow to complete a single phase. The construction sequence can also be a critical element of an ESC plan. For example, the construction sequence should clearly state that the first step of construction is a preconstruction meeting, that ESC controls must be installed prior to any clearing or grading, and disturbed areas must be stabilized within a prescribed time limit. In addition, the ESC designer should carefully evaluate the entire construction sequence to determine if additional ESC practices are needed. For example, the location of drainage ways are often altered as the construction sequence progresses, particularly after storm drains are installed. Consequently, additional ESC practices may be needed to accommodate the greater runoff and new discharge points that occur in later development stages.

4. Rapid Soil Stabilization

The objective at every construction site is to establish a grass or mulch cover within a minimum of two weeks after the soils are exposed. Given the germination time for grass, this means that hydroseeding must occur within two to five days after grading. In northern climates, a straw, bark or fiber mulch is needed to stabilize the soil during the winter months when grass does not grow, or grows poorly.

The value of soil stabilization cannot be overemphasized; research in Maryland has shown that it can reduce sediment concentrations by up to six times, compared to exposed soils without stabilization (Schueler and Lugbill, 1990). A review of over 20 field test plot studies of hydroseeding and various mulches on construction site soils indicates an average sediment reduction of about 80 to 90% (see article 55). ESC experts almost universally recommended mulching and seeding in the Brown and Caraco (1996) survey.

An effective ESC plan will clearly define time limits to establish grass and/or mulch cover, outline the rates and species of either cool-season or warm-season grasses to be hydroseeded (or type of mulch), and define the conditions under which the temporary cover must be reinforced (i.e, drought, severe erosion, poor germination etc.). In particular, a pre-winter meeting should be held at northern construction sites to assess whether the existing soil cover will be adequate throughout these demanding months. A good construction contract should also include a contingency line item for replacing temporary cover in the event that the cover does not take (drought, poor germination, weather, etc.). The last objective of the ESC plan is to permanently stabilize disturbed soils with vegetation at the conclusion of each phase of construction.

5. Protect Steep Slopes

Steep slopes are the most highly erodible surface of a construction site, and require special attention on the part of the designer. Steep slopes are variously defined, depending on local topography and the region of the country (with 15% or 6:1 h:v being fairly common). In addition, grading often creates engineered slopes on cut or fill of as much as 50% (2:1 h:v). Wherever possible, clearing and grading of existing steep slopes should be avoided altogether.

If clearing cannot be avoided, special techniques can be used to prevent upland runoff from flowing down a slope. Otherwise severe gullies quickly form, and the slope can fail. The best method involves diverting upland flow around the slope using an earthen dike or slope drain pipe. An upslope line of silt fence can also be used for this purpose, but only if it is adequately anchored, and contributing flow lengths are 50 feet or less, and a permanent drainage structure is installed to protect the slope.

Silt fencing at the toe of the slope should be applied with great care as high flow velocities and sediment movement downslope will quickly overload or knock the silt fence down. In addition, the performance of silt fence on the toe of slopes is rather low, ranging from 36% to 65% in two Oregon test plot studies (W&H Pacific, 1993). It may be advisable to use a scoop trap or super silt fence under these demanding field conditions. For a description of these techniques, see article 56.

Temporary seeding or mulch, by themselves, may not be effective in preventing erosion on the exposed soils of the slope (Harding, 1990). Additional stabilization methods may be needed such as erosion control blankets and mulch binders. Alternatively, the mulch application rate can be increased. In some cases, steep slopes can be protected in the winter months using plastic sheeting that is suitably anchored (e.g., temporary soil stockpiles).

6. Perimeter Controls

Perimeter controls are established at the edge of a construction site to retain or filter concentrated runoff from relatively short distances before it leaves the site. The two most common perimeter control options are silt fences and earth dikes. Other options are available, including using sidewalk gravel as a perimeter filter on very small and flat areas (Portland BES, 1994).

When properly installed, located and maintained, silt fences are moderately effective in filtering sediment, with reported removal rates ranging from 75 to 86% (Goldman *et al.,* 1986). A majority of the ESC experts, however, report chronic problems in maintaining silt fences (Brown and Caraco, 1996; Paterson, 1994). A field assessment of over 100 silt fences in North Carolina indicated that 42% of all site fences were improperly installed and 66% were inadequately maintained (Paterson, 1994). The correct placement of silt fences is discussed in detail in article 56.

The use of straw bale dikes as a perimeter control is not recommended for most communities, except in special circumstances. Only 27% of ESC experts rated the straw bale as an effective ESC practice, although its use was still allowed in half of the communities surveyed (Brown and Caraco, 1996).

Earth dikes can also be employed as a perimeter control. For small sites, a compacted two foot tall dike is usually suitable, if it is hydroseeded. When larger dikes are employed it should be kept in mind that they will actually divert runoff to another portion of the site, usually to a downstream sediment traps or basin. Therefore, the designer should ensure they have a stabilized outlet, have capacity for the ten year storm event, and that channel created behind the dike is properly stabilized to prevent erosion. ESC experts typically report fewer maintenance problems with these earth dikes if they are properly engineered (Brown and Caraco, 1996).

7. Employ Advanced Settling Devices

Even when the best ESC practices are employed, construction sites will still discharge high concentrations of suspended sediments during large storms. Therefore, the ESC plan should include some kind of trap or basin to capture sediments, and allow time for them to settle out. These settling devices face an imposing performance challenge, as they must operate at a 95 to 99% efficiency to produce a non-turbid discharge. Recent field research, however, indicates that most sediment traps and basins have sediment removal capabilities only on the order of 70 to 90%. They also routinely discharge sediment at a concentration of several hundred mg/l (see article 57).

The limited trapping efficiency of sediment basins in the field appears to be caused by two major factors: the extreme difficulty in settling out fine-grained sediment particles in suspension (i.e, fine silts and clays) and the simplistic design of existing basins which does not produce ideal settling conditions over the range of storm events that can be expected at a construction site. Indeed, most sediment basins are nothing more than a hole in the ground.

To improve their trapping efficiency, sediment basins must be designed in a more sophisticated manner. These design features include greater wet or dry storage volume, perforated risers, better internal

Table 1: Stages of Construction When Plan Revisions Should be Considered (U.S. EPA, 1993)

Stage	Basis of Plan Changes
Preconstruction meeting	Plan impractical from the contractors' standpoint (e.g., not enough space for materials storage) Site visit confirms that the plan will not work based on other site characteristics
After clearing/ grading and sediment control installation	"As built" grading or sediment controls are different from the original plan
During construction of the drainage system	Hydrology changes may require new different ESC measures
During house construction	Importing materials and site preparation for home construction will alter the landscape
As needed based on routine inspection visits	Failing measures may need to be modified
After major storms	Major storm events reveal under- or poorly designed practices
Close of season	Depending on weather or season, stabilization may be different than on the original plan.

geometry, use of baffles, skimmers and other outlet devices, gentler side-slopes and multiple cell construction. A series of recent field and lab research studies has evaluated the effectiveness of these additional sediment basin design features (see article 58). In addition, the ESC plan should contain a detailed inspection and clean out schedule for the basin, along with procedures for converting the basin into a permanent stormwater management facility.

8. Certified Contractors Implement Plan

Plans don't stop sediments from eroding, contractors do. Therefore, the single most important element in ESC plan implementation is a trained and experienced contractor, as they are ultimately responsible for the proper installation and upkeep of ESC practices. In recognition of this fact, many communities now require that key on-site construction staff be certified to implement the ESC plan. For example, both Maryland and Delaware require that at least one person on any construction project be formally certified.

Certification is obtained by completing a mandatory State-sponsored ESC training course. The certified ESC contractor is trained on why ESC is so important in stream protection, how to read ESC plans, and the proper installation and upkeep of ESC practices controls. Typically, the certified contractor is the liaison with the local inspector, and keeps a maintenance and inspection log (see article 61).

Even if no formal certification program exists in a community, there are still several opportunities to train and educate construction personnel on how to implement the ESC plan. These include a mandatory preconstruction meeting, regular inspection visits, a pre-wintering meeting, and the final inspection upon completion of a phase or the entire project. For example, Paterson documented that a preconstruction meeting can increases ESC plan compliance by as much as 15% (see article 60).

An inspector should view every meeting and site inspection as an educational opportunity to provide insight into why ESC practices worked or failed, and what maintenance may be needed in the future. This last item is especially important, as many contractors may not realize that ESC practices require maintenance or repair from time to time. Given tight construction budgets and schedules, it is not surprising that many contractors wait until a local inspector tells them what needs to be fixed. Local governments that make a strong commitment to contractor education report that inspectors and contractors develop a more constructive and responsive partnership at the site.

9. Adjust ESC Plan for Field Conditions

Plans are usually the first casualty in any military engagement, and must be rapidly revised if the battle is to be won. ESC plans are not much different. An effective ESC plan is usually modified as it moves

Table 2: Maintenance Costs as Percentage of Installation Costs (U.S. EPA 1993)

ESC Practice	Annual Maintenance as % of Installation Cost
Seeding	20%
Mulching	2%
Silt Fence	100%
Sediment Trap	20%
Sediment Basin	25%
Inlet Protection	60%

from the office to the construction site, because of discrepancies between planned and as-built grades, weather conditions, altered drainage, and unforseen construction requirements. The first opportunities to revise the ESC plan occur during the preconstruction meeting and the initial inspection of the installation of ESC practices. Table 1 highlights some of the more common revisions to the ESC plan that may be needed.

Regular inspections are needed to ensure that ESC plans are properly implemented, with an ideal frequency of a week or every two weeks. If this inspection frequency is not possible given local staffing, then a community may wish to utilize independent private-sector inspectors to supplement the efforts of local ESC inspector (see articles 61 and 62).

10. Assess ESC Practices After Storms

After a storm passes, it is very clear whether or not an ESC plan actually "worked" at the construction site. If the storm was unusually large or intense, it is very likely that many ESC practices will need repair, clean out or reinforcement. For example, hydroseeding may wash away, silt fences over-top, earth dikes blow out, sediment basins fill up or gullies form. Therefore, the last element of an effective ESC plan is a rapid response after a storm to assess the damage to ESC practices and quickly correct it.

The dynamic conditions at a construction site make maintenance of ESC practices critical. Some contractors will wait until an inspector threatens them with an enforcement action. The underlying reason for their reluctance is financial: most construction contracts include ESC as a single lump sum installation item in the bid estimate. More often than not, contractors "low ball" the ESC item to be competitive in the overall bid. Thus, they often balk at incurring the "extra" cost to maintain or repair ESC practices because it decreases their profit margin on a job. To avoid these problems, a good construction contract will also include a contingency line item for maintaining and repairing ESC practices. Some estimates of the expected cost of maintaining selected ESC practices as a percent of the total cost of installing the practice can be found in Table 2.

Other maintenance requirements in the ESC plan include the designation of an on-site (certified) contractor responsible for maintenance, a minimum maintenance schedule, and a periodic self-inspection of the limits of disturbance.

How Can Local Communities Foster Better ESC Control?

Over 90% of local ESC programs are administered by municipal agencies or soil conservation districts (Brown and Caraco, 1996). According to the same survey, 60% of local ESC programs were mandated by state laws that provided no funding to support local implementation. Local ESC agencies are chronically strapped for funds, and over 75% rely on local property taxes or application fees as their sole source of revenue. ESC programs must routinely compete with any other unmet spending priorities within a community— and they often lose. Without a dedicated funding source, it is doubtful whether many communities can ever afford the full complement of inspectors and plan reviewers they probably need. Given shoestring budgets faced by so many local ESC programs, how can they realistically improve the performance of ESC plans?

When resources are limited, the only means to become more productive is to dramatically improve how existing ESC program resources are managed. With this in mind, we present 10 modest management tips to get more results with fewer resources.

1. *Leadership.* According to Shaver (1996), the best ESC programs in the country share a common feature: committed local leadership. Key characteristics of effective leaders include a strong belief that ESC is a critical element of local environmental protection, a tireless commitment to educate designers, contrac-

tors, and the public about the need for better erosion and sediment control, and a willingness to try new approaches and techniques to continually improve the quality of the ESC program.

2. *Re-deploy existing staff from the office to the field or the training room.* Plan reviewers can be assigned more time at construction sites to get better feedback on the ESC plans they review, and to increase inspection frequency. In addition, training and education should become an integral element of the job description of both inspectors and plan reviewers, with as much as 10% of their time assigned to contractor training or public outreach.

3. *Cross train local development review and inspection staff.* An effective management approach involves cross training in stream protection for all local development review and inspection staff. The cross training provides ESC reviewers and inspectors with an understanding of important stream protection concerns at the site, such as forest conservation, stream buffer, wetland and stormwater management. At the same time, non-ESC staff are able to spot and refer ESC problems when they visit the site, and integrate ESC concerns in their plan review efforts.

4. *Submit erosion prevention elements for early planning review.* Amend the development preview process to require early review of the erosion prevention elements of the ESC plan (minimize clearing and grading, protect waterways, and construction phasing). Review of these elements should be closely coordinate with early site plan concepts. In some cases, review of erosion prevention elements can be shifted from the ESC permitting agency to the local planning agency.

5. *Prioritize inspections based on erosion risk.* Use a simple spreadsheet model to schedule inspections more frequently for the construction sites most vulnerable to erosion (Brown and Caraco, 1996). Vulnerability is based on such factors as site area, slope, erodible soils, and proximity to waterways. Even if staff resources are spread too thin to inspect all sites, this approach ensures that the most likely problem sites will get the attention they need.

6. *Require designer to certify initial installation of ESC practices.* The inspection process should be amended so that the ESC plan designer must visit the site to certify that the ESC practices called for in the plan were correctly installed at the construction site (adjusting for any changes that may have been made at the preconstruction meeting). This simple requirement accomplishes two things. First, it is a useful enforcement mechanism to ensure that all ESC practices are actually installed correctly. Second, it is also a great learning opportunity for ESC plan designers, as they can see how their plan works under the demanding conditions of a construction site.

7. *Invest in contractor certification and private inspector programs.* The ESC workforce can be quickly multiplied when a community invests in a contractor certification or private inspector program. The Delaware model is described in detail in Horner *et al*. (1994), and in article 85.

8. *Use public-sector construction projects to demonstrate effective ESC controls.* Local governments are a source of a lot of construction projects— new schools, roads, and other infrastructure. Needless to say, ESC practices on public-sector projects should always be first class, so they can be used as demonstration sites for contractor training and tangible evidence of local commitment to ESC. In addition, public sector construction documents should include contingency items and other contractual provisions that allow contractors to recover the full cost of maintaining ESC practices.

9. *Enlist the talents of developers and engineering consultants in the ESC programs.* Both groups provide useful input on how ESC practices can be applied more cost-effectively or how the plan review process can be streamlined. Many communities have found that advisory group is very helpful in developing a constructive partnership for improving ESC plans.

10. *"Reinvent" the local ESC manual.* A productive task to assign to the advisory group is to revisit the current ESC manual and local training materials. This will improve the quality of ESC plans and the overall performance of ESC measures installed at construction sites.

If these measures are taken, the murky mixture that usually leaves construction sites will be considerably less sediment laden. ESC plans will never produce 100% sediment-free runoff, but the dollars communities spend can be put to best use when erosion prevention and sediment control practices are applied with greater care, vigor and ingenuity.

References

Brown, W., and D. Caraco. 1996. *Task 2 Technical Memorandum: Innovative and Effective Erosion and Sediment Control Practices for Small Sites*. Center for Watershed Protection. Silver Spring, MD. 37 pp.

Corish, K.A., 1995. *Clearing and Grading Strategies for Urban Watersheds, Final Review Draft.* Metropolitan Washington Council of Governments, Washington, D.C. 66 pp.

Dreher, D.W., and L. Mertz-Erwin. 1991. *Effectiveness of Urban Soil Erosion and Sediment Control Programs in Northeastern Illinois.* Northeastern Illinois Planning Commission. Chicago, IL. 23 pp.

Goldman, S., *et al*. 1986. *Erosion and Sediment Control Handbook* McGraw-Hill. New York. 443 pp.

Harding, M.V. 1990. "Erosion Control Effectiveness: Comparative Studies of Alternative Mulching Techniques." In: E*nvironmental Restoration: Science and Strategies for Restoring the Earth*. Island Press. Covello, CA 149-156.

Horner, R., J. Skupien, E. Livingston and E. Shaver. 1994. *Fundamentals of Urban Runoff Management.* Appendices A and B. Terrene Institute. Alexandria, VA. 302 pp.

Mitchell, G. 1993. *Assessment of Erosion/ Sediment Control in Highway Construction Project. Ohio University Center for Geotechnical and Environmental Research*. Final Report to Ohio Department of Transportation. FWHA/ OH-93/ 011. Columbus, OH. 200 pp.

Ohrel, R.L. 1996. *Technical Memorandum: Survey of Local Erosion and Sediment Control Programs.* Center for Watershed Protection. Silver Spring, MD. 25 pp.

Paterson, R. G. *et al*. 1993. "Costs and Benefits of Erosion and Sediment Control: the North Carolina Experience." *Environmental Management* 17(2):167-178.

Paterson, R.G. 1994. "Construction Practices: The Good, the Bad and the Ugly." *Watershed Protection Techniques* 1(3): 95-99.

Portland Bureau of Environmental Services (BES). 1994. *Erosion Prevention and Sediment Control Plans - Technical Guidance Handbook.* Portland, OR. 40 pp.

Schueler, T., and J. Lugbill. 1995. *Site Planning for Urban Stream Protection*. Center for Watershed Protection. Metropolitan c\Council of Governments. Silver Spring, MD. 222 pp.

Schueler, T., and J. Lugbill. 1990. *Performance of Current Sediment Control Measures at Maryland Construction Sites*. Metropolitan Washington Council of Governments. Washington, D.C. 90 pp.

Shaver, E. Personal Communiation. September 26, 1996. *Delaware Department of Natural Resources and Environmental Control.* Dover, DE.

U.S. EPA. 1993. *Guidance for Specifying Management Measures for Nonpoint Pollution in Coastal Waters*. EPA 840-B-92-002. Washington, D.C. 740 pp.

Water Resources *Administration (WRA). 1986.* Maryland's Guidelines to Waterway Construction. Department of Natural Resources. State of Maryland, Annapolis, MD. 56 pp.

W&H Pacific and CH2M-Hill. 1993. *Demonstration Project Using Yard Debris Compost for Erosion Control*. Portland Metropolitan Service District. Portland, OR. 90 pp.