Article 54

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Practical Tips for Construction Site Phasing

What is construction site phasing and why is it important? These questions are frequently asked by both developers and regulators seeking to implement erosion and sediment controls at construction sites. Construction phasing is different than construction sequencing. As most contractors and developers will tell you, construction sequencing is the standard practice of completing one portion or aspect of a project at a time, with site grading typically completed in a single step. In many circumstances, the time difference between building and actual building construction can take years. Table 1 illustrates a typical construction sequence for a single family residential subdivision.

Construction site *phasing* minimizes soil erosion through a somewhat more complex construction process. Only one portion of a site is disturbed at any one time to construct the infrastructure necessary to complete that phase. Subsequent phases are not started until earlier phases are substantially completed and exposed soils are mostly stabilized. This "just-in-time" construction practice can dramatically reduce disturbed soil exposure times and resulting erosion problems.

Despite the value of construction phasing, very few projects are successfully phased. Because many *sediment control* practices are at best 90% efficient in removing suspended solids, *erosion prevention* techniques that limit the erosion of sediments in the first place can have dramatic results in reducing sediment loss from construction sites (Corish, 1995). Uncontrolled urban construction sites can lose between 20 and 200 tons/acre of sediment per year (Dreher and Mertz-Erwin, 1991). Contrast this with an undisturbed meadow or forest, which loses less than one ton/acre of sediment per year. Clearly, a great reduction in sediment export is possible when clearing is reduced. As can be seen in Table 2, a carefully phased project can reduce sediment loss by more than 40% over a typical mass-graded site.

Construction phasing is only one of several *erosion prevention* techniques that can be used to reduce soil loss. Instead of relying on trapping already suspended solids, the phasing techniques rely on erosion prevention. Other erosion prevention strategies involve minimizing disturbed areas through various techniques such as fitting the de-

Table 1: Typical Construction Sequence of a Single Phase Residential Subdivision

1. Hold preconstruction meeting
2. Clear/grub areas necessary to construct ESC practices
3. Construct ESC practices
4. Construct stormwater management measures to be used for temporary ESC
5. Clear/grub remaining site areas
6. Grade site to rough grades
7. Construct utilities (water, sewer, storm drain, etc.)
8. Construct roads (paving, curb and gutter, sidewalks)
9. Construct housing (provide on-lot ESC practices)
10. Stabilize disturbed areas
11. Convert stormwater management measures to permanent functions
12. Remove ESC measures
13. Stabilize remaining disturbed areas

**Table 2: Sample 100-Acre Single Family Residential Development Project
Potential Sediment Loss for a Mass-Graded Project Versus a Phased Project**

Development Scenario - Conventional Project
100-acre site, mass-graded over a 6 month period.

Assumptions:
Good sediment control practices, successful vegetative stabilization of disturbed areas within 30 days of completion of grading. Approximately 3/4 of site exposed during 6 month grading operation, with 1 month stabilization period. 20 tons/year lost from construction site with sediment trapping effectiveness of 60% for sediment control devices

Sediment loss:
Exposure: 3/4 of 100 acres exposed over 7 months
Sediment loss: (.75) (100 ac)(20 tons/yr)(7/12 yr)(0.6) = 525 tons

Development Scenario - Phased Project
100-acre site, graded in 4 separate phases over a 6 month period, each phased exposed for one and a-half months.

Assumptions:
Good sediment control practices, successful vegetative stabilization of disturbed areas within 30 days of completion of grading. Each phase completely disturbed during 1½ month grading operation, with a one-month stabilization period. 20 tons/year lost from construction site with sediment trapping effectiveness of 60% for sediment control devices. One ton/year lost from undisturbed site, two tons/year lost from stabilized portions of site.

Exposure:	Sediment loss:
4 phases of 25 ac exposed over 2.5 month period	(4)(25 ac)(2.5/12 yr)(20 tons/yr)(0.6) = 250 tons
1 phase of 25 ac undisturbed for 4.5 months	(25 ac)(4.5/12 yr)(1 ton/yr) = 9.4 tons
1 phase of 25 ac undisturbed for 3 months	(25 ac)(3/12 yr)(1 ton/yr) = 6.3 tons
1 phase of 25 ac undisturbed for 1.5 months	(25 ac)(1.5/12 yr)(1 ton/yr) = 3.1 tons
1 phase of 25 ac completed for 4.5 months	(25 ac)(4.5/12 yr)(2 tons/yr) = 18.8 tons
1 phase of 25 ac completed for 3 months	(25 ac)(3/12 yr)(2 tons/yr) = 12.6 tons
1 phase of 25 ac completed for 1.5 months	(25 ac)(1.5/12 yr)(2 tons/yr) = 6.2 tons
	Total Sediment Loss: 306.4 tons

Result: Phasing results in a 42% reduction in sediment export compared to regular mass grading

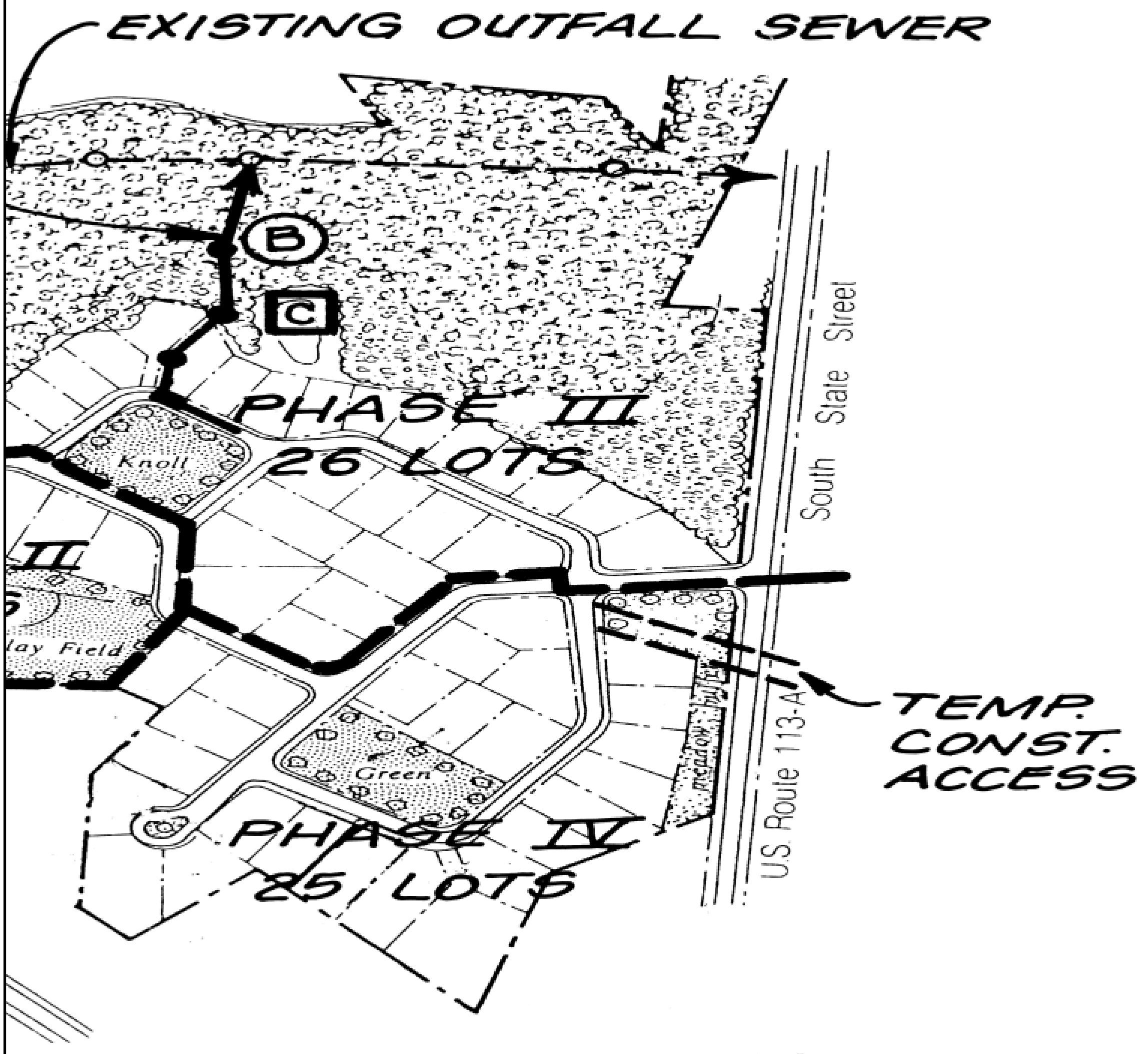
velopment to the topographic "lay of the land;" minimizing the development footprint by clearing only the land required for buildings, roads, and utilities; providing buffers from natural drainage systems and water bodies; and conserving or retaining existing forest cover. Immediate stabilization of disturbed areas by use of tackifiers, re-vegetative practices, mulching or stabilization blankets can also dramatically reduce soil loss caused by erosion.

Recent research consistently shows that erosion prevention techniques are among the most effective in reducing suspended solid concentrations leaving construction sites. Many erosion prevention methods can reduce sediment loads by as much as 90%, whereas sediment trapping devices often have lower removal efficiencies, particularly for fine-grained soils and clays (Brown and Caraco, 1996). The conclusion is obvious. Erosion prevention works. When it can be implemented in a cost effective manner, it is certainly worth pursuing. Clearly, construction phasing falls in this category.

Foundations of Successfully Phased Projects

Why is it so hard to get successfully phased projects implemented? The answer involves several practical problems in construction logistics, any one of which can doom a phased project to failure. First, phasing must be carefully planned at the early design stages of the development process. As most land planners will tell you, good planning is hard. It is

Figure 1: Typical Phasing Plan and Important Elements for A Single Family Residential Subdivision (Natural Lands Trust, 1996)



Construction phasing is a major ESC strategy for this large residential subdivision project. The site is subdivided into four distinct phases; clearing cannot proceed on a phase until the prior phase has been largely stabilized.

Notes:

1. Earthwork balances between each phase.
2. Phase I & II are sewered through outfall (A).
3. Water loops through project in phases starting at Rising Sun Road to South State Street
4. Stormwater management provided as follows:
   - Phase I - [A]
   - Phase II - [B]
   - Phase III & IV- [C]
5. Temporary construction access provided as shown.
6. Each phase consists of at least 19 lots. At least 50% of houses must be completed within a phase before construction on next phase can proceed.
7. Phase IV is uphill from Phase III. Utilize stormwater facility [C] as a temporary sediment basin until Phase IV is complete. Flush stormwater system through Phases III and IV.

difficult to think about construction phasing during the project layout stage. Why is this important to do early on? Because in order to construct a phased project that reduces soil loss, portions of the site that will be developed in the future must remain undisturbed. To do this, cut and fill quantities must balance by phase so that other site areas are not raided to either borrow or spoil dirt.

Other elements to consider during the planning stage include evaluating how stormwater will be conveyed and managed in each phase, whether water and sewer connections/extensions can be accommodated in a phased project and what happens to already completed downhill phases. It is also preferable to separate construction access from resident access to avoid conflicts between people living in earlier phases of the project and construction equipment working on later phases.

Obviously, the overall size of the project is a major factor in determining whether phasing can be successful. The results of a recent survey of more than 80 local ESC programs provide some insight into this issue. While approximately 45% of respondents used phasing, many reported that phasing was only appropriate for larger sites (i.e., greater than 25 acres). Only a few programs utilize phasing on projects smaller than five acres (Brown and Caraco, 1996). Table 3 provides a summary of the some of the key requirements for planning successful phased

Table 3: Some Keys to Planning Successfully Phased Projects

- Phasing plan is developed early in the project planning and design stage
- Natural features such as streams or drainage boundaries are considered in multiple phases
- Earth removal is balanced within each phase so cut soil from one area matches fill requirements elsewhere
- Size of project is conducive to phasing
- Phasing is not cost prohibitive

Table 4: Eleven Phasing Principles for Design Engineers and Plan Reviewers

1. Segregate temporary construction access in each phase from access for permanent residents.
2. Determine if site meets minimum "threshold" size (approximately 25 acres for ¼ acre single family residential projects).
3. Balance earthwork within each phase.
4. Carefully locate temporary stockpiles and staging areas to prevent additional soil disturbance.
5. Establish "trigger" for completion of each phase in order to start the next phase (e.g., # of houses completed in previous phase, or % of previous phase stabilized).
6. Accommodate water/sewer and other utility construction within each phase.
7. Incorporate road segments, temporary turn-arounds, and emergency access within each phase.
8. Address both temporary and permanent stormwater management in each phase.
9. Clearly identify sequence of construction of each phase and entire project on plan.
10. Identify key ESC elements to inspect in each phase (e.g., after installation of perimeter sediment controls).
11. Ensure that later upstream phases address potential impacts to already completed down stream phases of the construction site.

projects.

Figure 1 shows how phasing elements are considered in a construction project. One of the more important considerations for phased projects is the influence of market forces. Land developers often locate model homes in prominent locations that may or may not fit with the phasing plan. Furthermore, developers and homebuilders also want the flexibility to provide buyers with a variety of housing options and therefore are often hesitant to restrict construction to just one section. Another uncertainty is the size of individual sections and the construction rate of individual houses. The phasing plan must address these market forces and designate how many houses must be completed within a given section before allowing construction to begin on the next phase.

How much does phasing really cost? While watershed managers agree that phasing is a desirable erosion prevention technique, most also concede that phasing probably costs developers more money. The cost to a municipal agency of implementing an aggressive phasing program may also be higher. Permit review of phasing plans and construction site inspection costs will certainly be higher.

Obviously, limiting mass grading as an allowable construction technique will tend to increase earthwork costs—already one of the more expensive components of site development. Economies of scale may be undermined by project phasing. Costs may rise due to multiple visits with heavy earth moving equipment, increased storage requirements and equipment handling. How much more expense does phasing add to a typical construction project? The answer is that we don't really know because very little economic research has been done to answer this question.

Cahill and Horner (1992), however, contend that nonstructural, minimum disturbance techniques reduce the operation and maintenance costs substantially over structural practices. It does stand to reason that a carefully coordinated phased project can actually save developers money in reduced ESC practice maintenance costs and perhaps in reduced interest carrying costs. Because the entire project is not constructed at one time, only a fraction of the infrastructure installation and maintenance costs are incurred up-front. Developers make smaller construction loan payments for smaller components of construction, which can be paid off as home sales proceed. Furthermore, if the project takes several years to complete, then phasing may result in less re-grading due to erosion caused by slope failures.

Phasing can also be very hard to enforce. Incomplete or confusing phasing plans make permit compliance difficult. Inspectors can face difficulties caused by the several stages of development occurring at one time. For example, if mass-grading is occurring in one phase, simultaneously with drainage and road construction in another phase, and house construction in yet a third phase, it can be next to impossible for inspectors to enforce. One way to deal with this problem is to clearly specify in the phasing plan the allowable construction elements that can occur simultaneously. Table 4 presents a list of eleven "phasing principles" for plan reviewers and designers to consider when designing or reviewing phased projects.

How can more widespread use of phasing in construction site development be encouraged? Some communities are trying an enforcement approach, while others are looking for more voluntary measures. Prince George's County, Maryland, requires a phasing plan to be submitted with the erosion and sediment control plan. The phasing plan becomes part of the enforceable erosion and sediment control plan, and can be used to inspect compliance in the field. Some municipalities utilize clearing ordinances to limit total disturbed areas (Corish, 1995). Other municipalities are looking at incentives such as *faster review times*, or *more flexible permit conditions* to encourage developers to consider phased projects. One incentive which has not yet enjoyed widespread use, but may have a great deal of promise, is the use of economic incentives such as *reduced or waived permit fees or bonds* for projects with phased sections. Many jurisdictions already refund bonds for completed sections so this incentive may be a logical step.

What lessons can be learned about phasing? Construction site phasing provides a viable, practical technique to reduce sediment loads leaving construction sites. There are practical considerations that must be addressed to ensure that phasing works. It is difficult enough to get compliance on many aspects of a construction site, so good planning at the design stage coupled with an enforceable phasing plan is essential.

Little research has been done to assess the costs of phasing versus conventional construction costs, but obviously the larger the project, the easier it will be to implement successful phasing. Communities must strive to use a combination of enforcement measures and incentives to encourage wider use of this practice. Finally, we cannot forget to consider how market forces govern home sales. While the best phasing plans have strict provisions describing when certain elements of a project can begin and what must be accomplished first, they don't necessarily reflect the market pressures influencing developers. To accommodate market realities it may be wise to integrate a developer's sales strategy with the requirements of a phasing plan.

—RAC

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