

Appendix H – Compliance with the C-Factor Stabilization Criteria

Background

Part 2.2.2 of this permit requires that you stabilize exposed portions of your site if construction activities in these areas will be suspended either permanently or for a minimum length of time (i.e., either 14 days, or 7 days depending on the project site). The permit further requires that, in order to be considered stabilized, you must use stabilization cover methods that have been proven to be effective at minimizing soil loss after their application. These requirements are based on extensive studies, using approved research protocols (ASTM 6459), on the erosion control effectiveness of commonly-used cover methods. These studies rate each type of cover method according to its erosion control effectiveness, or "C-factor" (Cover management factor (C)). The derivation of the C-factor is the Revised Universal Soil Loss Equation (RUSLE), a regression formula which computes the average annual erosion from an acre of land, accordingly:

$$A \text{ (tons of sediment per acre per year)} = R * K * S * L * C * P$$

Where the six contributing factors are:

1. Rainfall-runoff erosivity factor (R)
2. Soil erodibility factor (K)
3. Slope-length factors (S and L)
4. Cover management factor (C)
5. Support practice factor (P)

Through these C-factor studies, it has been shown that the higher the C-factor, the greater the amount of soil will be discharged from a construction site during rainfall events. For example, most earthmoving activities result in a denuded surface condition associated with a C-factor value between 0.9 and 1.2. Part 2.2.2 of this permit requires you to install surface covers that significantly lower the site C-factor value in order to minimize soil erosion. In Part 2.2.2.a of this permit, the maximum C-factor values for cover methods used for *temporary stabilization* (using vegetative or non-vegetative covers) are 0.1 for slopes less than 15 percent, and 0.3 for slopes 15 percent or greater. In comparison, cover methods used for *final stabilization* are to have a C-Factor value of less than 0.05 (vegetative or non-vegetative).

Use of Appendix H

For your assistance in complying with the Part 2.2.2 requirements, Table H-1 (see below) includes a compilation of published C-factor values for commonly-used stabilization cover methods. See Table H-1. Table H-1 is provided to you as a guide for you to utilize in selecting and applying appropriate covers with proven C-factor values. Table H-1 is intended to provide a good starting point for permittees needing to identify covers and cover material most appropriate for their location. The cover types referenced in Table H-1 are not exhaustive, and there are a variety of commercially-available stabilization covers that are not specifically listed in the table, either because they employ a combination of the types in Table H-1, or sufficient studies were not available for those cover types prior to the publication of this permit. In compiling Table H-1, EPA attempted to provide the range of probable C-factor values for the major cover types (e.g., erosion control blankets, straw, mulches, etc.), enabling the permittee to rapidly focus on the type(s) of covers that meets the Part 2.2.2 cover criteria.

In choosing the stabilization cover types for your site, you may elect to use any of the cover types that fit the description of the practices specifically listed in Table H-1, or you may use other commercially available methods that have been shown, using tests conducted consistent with accepted industry testing standards (e.g., ASTM 6459), to result in C-factors that are equal to or less than the required values. Regardless of the type of stabilization cover you choose, it not only must meet the required C-factor criteria, but you must also make sure that your application of the vegetative or non-vegetative cover to your site is consistent with the site conditions and application rates used during testing conditions. The values provided in Table H-1 indicate the performance under strict laboratory conditions. Cover materials will only perform to reported levels if they are carefully installed and maintained at the construction site in such a way that roughly parallels the site conditions and application rates used in laboratory conditions to achieve the C-factor values that meet the permit's criteria.

For example, if you need to temporarily stabilize your site to meet the required 0.1 C-factor criterion, and you choose to use straw that is anchored with netting, you will need to make sure that the straw and netting is applied on parts of your site that have slopes of less than 15 percent, and applied so that 92 percent of the exposed soil is covered or that you have applied the straw at a rate of 2 tons dry wt/ac. You may determine that a different application rate will meet the 0.1 C-factor criterion, however, you will need to document the study you relied on for this determination.

In some cases, the range of C-factor values reported in literature for a single cover type may suggest that in some cases the cover method will meet the required C-factor criterion, while other studies may yield C-factor values that fail to meet the criterion. In these cases, permittees can consider several options:

1. selecting another cover type;
2. performing site-specific analysis of conditions using state-of-practice methods, including computer programs such as RUSLE2 [NRCS, 2010];
3. contacting providers/manufactures for additional information; or
4. consulting references provided by State/local environmental and transportation agencies.

Note that the C-factor values in Table H-1 are generally higher for steep slopes than those reported for flatter slopes. This correlation serves as the basis for the two part C-factor criteria for temporary covers (i.e., a maximum temporary cover C-Factor of 0.1 for less than 15 percent slope and 0.3 for 15 percent or greater slope). The C-factor data available in current literature also indicates cover performance varies with construction site soil type, the overland flow path length, duration of use, and cover application rate. Accordingly, it is recommended that permittees utilize any available information on how these features affect performance when selecting stabilization covers and cover material.

For additional guidance regarding the use of Table H-1, refer to the section following the table, which provides a few case examples that illustrate proper use of the table and compliance with the C-factor criteria.

Table H-1. Reported RUSLE C-Factor Cover Values

Types of Cover Material/ Cover Condition	Reported C-Factor Values	Site Slope	Additional Technology Description	References
Physical Roughing of Bare Soil				
Surface roughening, disking, and tracking with and across contours	Greater than 0.3	< 5 percent		TRB, 1980
	Greater than 0.3	5 to 15 percent		
	Greater than 0.3	> 15 percent		
Straw/Fiber Freely Dispersed				
Straw/Fiber applied by hand or mechanical without anchoring	Less than 0.1	< 5 percent	2 tons dry wt/ac (92% cover)	Wischmeier and Smith, 1978
	See Note 1	5 to 15 percent		
	See Note 1	> 15 percent		
Straw/Fiber with Tackifier or Binder				
Straw/Fiber anchored with Tackifier (eg. Hydrophilic polymers and Guar Gum)	Less than 0.1	< 5 percent	2 tons dry wt/ac (92% cover)	Wischmeier and Smith, 1978; and EPA, 1979
	Less than 0.1	5 to 15 percent		
	Less than 0.3	> 15 percent		
Straw/fiber with Netting				
Straw/Fiber anchored with Netting	Less than 0.1	< 5 percent	2 tons dry wt/ac (92% cover)	Wischmeier and Smith, 1978; and EPA, 1979
	Less than 0.1	5 to 15 percent		
	Less than 0.3	> 15 percent		
Soil Stabilizers [See Note 2]				
Applying soil bonding agents such as the anionic form of polyacrylamide (PAM) directly to soil to minimize bare soil erosion.	Insufficient Data Available	< 5 percent	Dry and wet PAM applications include in C-Factor value range	StormwaterAuthority, 2010; and Filtrex 2010
	0.13 to 0.65	5 to 15 percent		
	0.13 to 0.65	< 15 percent		

Types of Cover Material/ Cover Condition	Reported C-Factor Values	Site Slope	Additional Technology Description	References
Hydromulch/Tackifier Combinations [See Notes 1 and 2]				
Mechanically applied fiber mulch with tackifier (e.g. Guar Gum or Latex-based)	From less than 0.1 to 0.4	< 5 percent	Between 0.5 and 2 tons/ac	ENCAP 2010; EPA 1979; and North America Green 2010
	From less than 0.1 to 0.4	5 to 15 percent		
	0.1 to 0.6	> 15 percent		
Hydromulch with Netting [See Notes 1 and 2]				
Mulch hydraulically applied upon previously installed netting.	From less than 0.1 to 0.4	< 5 percent	Between 0.5 and 2 tons/ac	ENCAP 2010; EPA 1979; and North America Green 2010
	From less than 0.1 to 0.4	5 to 15 percent		
	0.1 to 0.6	> 15 percent		
Rock Surface Covers				
1/4 to 1 1/2 inch crushed stone	Less than 0.05	< 5 percent	135 tons/acre or more	Wischmeier and Smith, 1978
	Less than 0.05	5 to 15 percent		
	Less than 0.05	> 15 percent		
Vegetative Surface Covers				
Mature crop (growth covers 75 to 96%)	Less than 0.05	< 5 percent		Wischmeier and Smith, 1978
	Less than 0.05	5 to 15 percent		
	Less than 0.05	> 15 percent		
Thin stalk grass (>60% density) w/mulch	Less than 0.05	< 5 percent		Wischmeier and Smith, 1978
	Less than 0.05	5 to 15 percent		
	Less than 0.05	> 15 percent		
Sod	Less than 0.05	< 5 percent		Wischmeier and Smith, 1978
	Less than 0.05	5 to 15 percent		
	Less than 0.05	> 15 percent		

Types of Cover Material/ Cover Condition	Reported C-Factor Values	Site Slope	Additional Technology Description	References
Netless Rolled Erosion Control Blankets (ECBs)				
ECBs are constructed of various degradable organic/synthetic fibers that are woven, glued or structurally bound with nettings or meshes. Open weave jute and woven coir (coconut husk) are examples.	Less than 0.1	< 5 percent	C-Factor range represents a range of blanket thickness and composition	Beltron Ind, 2010; and Filtrex 2010
	Less than 0.1	5 to 15 percent		
	From less than 0.05 to 0.5	> 15 percent		
Single-Net Erosion Control Blankets (ECBs)				
Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degradable, synthetic or natural fiber netting	Less than 0.1 [See Note 3]	< 5 percent	C-Factor range represents a range of blanket thickness and composition	KY BMP Manual; American Excelsior 2010; East Coast Erosion, 2010; and Filtrex 2010
	Less than 0.3 [See Note 3]	5 to 15 percent		
	From less than 0.3 to 0.6	> 15 percent		
Double-Net Erosion Control Blankets (ECBs)				
Processed degradable natural and/or polymer fibers mechanically bound together between two degradable, synthetic or natural fiber nettings.	Less than 0.1 [See Note 3]	< 5 percent	C-Factor range represents a range of blanket thickness and composition	KY BMP Manual; and Filtrex 2010
	Less than 0.3 [See Note 3]	5 to 15 percent		
	From less than 0.2 to 0.44	> 15 percent		

Specific Notes on Cover Materials:

[1] On steep slopes (> 15 percent) or where mulch is susceptible to movement by wind or water, the mulch material should be appropriately anchored.

[2] Many State Environmental and Transportation Agencies have developed guidelines relating features such as soil type and slope with a minimum application rate.

[3] Probable performance, see Manufacture for specifics.

General Notes:

Values above provide information for assessing erosion control products targeted at meeting EPA's minimum C-factor criteria for stabilization covers. The performance of a stabilization cover is to be considered independently of any additional protection provided by erosion and sediment controls such as silt fences and sediment basins.

Manufactures should be contacted to determine how their products perform with various soil types and slope lengths, and provide key installation information including the duration of use.

Case Examples

The following case examples are provided to illustrate how permittees should interpret the permit's stabilization requirements and how they may go about using Table H-1 or other available C-factor information to comply with the required criteria.

EXAMPLE 1: A large retail superstore is being developed within City XYZ on a square 6 acre site with relatively uniform soils. The construction activity will disturb 5 acres of the site. The site will be cleared, grubbed, and then graded at the very beginning of construction. The final grades for the acreage are as follows:

Average Slope	Project acreage disturbed
<5 percent	3 acres
>5 to 15 percent	1 acre
Greater than 15 percent	1 acre

The permittee plans to install temporary and permanent cover on disturbed portions of the site to achieve the required C-factor values.

Permittees should note that physically conditioning denuded soil surfaces (e.g., tracking with a compacting dozer) alone is insufficient to meet EPA's temporary and permanent C-factor criteria. As shown in Table H-1, the physical conditioning of bare soils result in C-factor values between 0.9 and 1.3; values too high to meet the criteria for stabilization. As a result, the permittee in this example must identify, install, and maintain vegetative or non-vegetative covers to meet the applicable stabilization criteria.

Consideration of temporary stabilization covers:

When selecting a temporary cover, the permittee needs to consider the stabilization requirements for areas of the site with slopes greater than 15 percent (i.e., 1 acre for this example) separately from the remaining site acreage that averages less than 15 percent (i.e., 4 acres). In accordance with Part 2.2.2.2.a.ii, the permittee must use one or a combination of practices that have been shown to achieve a level of stabilization that yields a C-factor value of no greater than 0.1 for slopes less than 15 percent, and no greater than 0.3 for slopes of 15 percent or greater.

As shown in Table H-1, there are several types of covers that can be employed at the example site, including Hydromulch, Erosion Control Blankets (ECBs), and Freely Dispersed Straw. By reviewing the individual C-factors listed in these cover types, the permittee can assess which cover type and application rate is most applicable to the site. A review of Table H-1 indicates the following options are available for temporary cover for a permittee seeking to use less expensive cover where plausible.

Site Conditions	Possible Cover Options	Timeframe
Acres with slope < 5 percent	<ul style="list-style-type: none"> • Freely dispersed straw • Hydromulch * • Straw/Fiber with Tackifier 	Immediately initiate stabilization where earth-disturbing activities have permanently or temporarily ceased, and will not resume for a period exceeding 14 calendar days. Complete stabilization within 7 calendar days of initiation.
Acres with slope between 5 and 15 percent	<ul style="list-style-type: none"> • Straw/fiber with netting • Hydromulch * • Hydromulch with Netting* • Straw/Fiber with Tackifier 	
Acres with slope > 15 percent	<ul style="list-style-type: none"> • Netless ECBs * • Single-Net ECBs * • Double-Net ECBs * • Hydromulch with Netting* • Sod ** • Rock Surface Cover ** 	Immediately initiate stabilization where earth-disturbing activities have permanently or temporarily ceased, and will not resume for a period exceeding 7 calendar days. Complete stabilization within 3 calendar days of initiation.

* Performance varies. Contact manufacturer for information on their product performance

** C-Factor values for these covers make them permanent covers.

As noted in Table H-1, the permittee should contact the manufacturer to determine how specific commercially available products perform with various soil types and slope lengths, and to obtain key installation information (e.g. the duration of use). For this construction site, a number of the possible cover materials will meet the temporary cover requirement, as shown in the table above; however, details about the application rate and the cover composition are needed to ensure the cover will have a C-Factor value that meets the required criteria. For instance, suppose the permittee chooses to use hydraulically applied mulch on top of previously installed netting, and the permittee is relying on any of the studies referenced in Table H-1 to support his/her belief that this cover will achieve the required C-factor criterion. The permittee, under this scenario, would be required to ensure that the application rate (e.g., between 0.5 and 2 tons/acre) for this particular installation of hydromulch at this site, as well as other site factors, such as slope length, must be consistent with the study conditions to be assured of complying with the stabilization criteria.

As indicated in the options table above, for the 4 acres of the permittee's disturbed land with slopes of 15 percent or less, temporary stabilization must be immediately initiated where earth-disturbing activities have permanently or temporarily ceased, and will not resume for a period exceeding 14 calendar days. For these areas, installation must be completed within seven (7) days after initial application. For the 1 acre of the permittee's disturbed land that has a slope of greater than 15 percent, temporary stabilization must be immediately initiated within 7 calendar days of the permanent or temporary cessation of earth-disturbing activities, and it must be completed within 3 calendar days of initiation.

As discussed in more detail below, two of the covers considered for slopes greater than 15 percent on the site (Sod and Rock Surface Cover) have C-factor values that are less than 0.05. As a result they meet the C-factor requirement for final stabilization. Therefore, if the permittee chooses, he/she could elect to install these covers shortly after steep cuts/fills are contoured, and thereby meet their stabilization requirements for both temporary and final stabilization.

Consideration of final stabilization covers:

When considering cover options for final stabilization, the permittee must recognize that regardless of land slope, the final cover material must be shown to perform at the required C-factor level of with a C-Factor value of 0.05 or less. Using Table H-1, the cover options available to the permittee are the following:

Site Conditions	Possible Cover Options	Completion Point
Acreage with slope < 5 percent	<ul style="list-style-type: none"> • Grass from planted seed • Sod • Rock Surface Cover 	Grass/Sod must provide a uniform vegetative cover with a density of 70 percent or more of the native background vegetative cover.
Acreage with slope between 5 and 15 percent		
Acreage with slope > 15 percent		Rock surface cover must provide a stable surface.

As shown in Table H-1, both vegetative and non-vegetative covers can meet the C-factor requirement. For this example, it would be possible to use only vegetative cover (grown with the assistance of fiber or straw mulch), or a combination of vegetative and non-vegetative cover. For acreage with steeper slopes (> 5 percent), final stabilization cover can be used in combination with an ECB or netting used to retain the temporary cover on the slope.

EXAMPLE 2: A large retail superstore is being developed within City XYZ on a 15 acre site with relatively uniform soils. The construction activity will disturb all 15 acres of the site, which will be cleared and grubbed. All of the site drainage discharges from a single point and construction is to begin in the summer of 2014.

The final grades for the acreage are as follows:

Average Slope	Project acreage disturbed
5 percent or less	14 acres
Greater than 15 percent	1 acre

Consideration of temporary stabilization covers:

If the permittee clears the whole 15 acre site and does not cease earth-moving activities until final cover or permanent structures are installed then no temporary cover need be applied. For example, a permanent structure can be a building and either a paved or gravel parking lot. Temporary cover is only needed for a portion of a site where the permittee temporarily ceases earth-disturbing activities.

The permittee must be aware that the average land slope establishes the temporary land cover C-Factor requirement and timeframe for action. In accordance with Part 2.2.2.2, the permittee must use one or a combination of practices that have been shown to achieve a level of stabilization that yields a C-factor value of no greater than 0.1 for slopes less than 15 percent, and no greater than 0.3 for slopes of 15 percent or greater. For 15 percent or less land slope, stabilization must be initiated where earth-disturbing activities have permanently or temporarily ceased, and will not resume for a period exceeding 14 calendar days. For greater than 15

percent, stabilization must be initiated where earth-disturbing activities have permanently or temporarily ceased, and will not resume for a period exceeding 7 calendar days.

A review of Table H-1 indicates the following options are available for temporary covers for a permittee.

Site Conditions	Possible Cover Options	Timeframe
Acreage with slope < 5 percent	<ul style="list-style-type: none"> Freely dispersed straw Hydromulch * Straw/Fiber with Tackifier 	Immediately initiate stabilization where earth-disturbing activities have permanently or temporarily ceased, and will not resume for a period exceeding 14 calendar days. Complete stabilization within 7 calendar days of initiation.
Acreage with slope > 15 percent	<ul style="list-style-type: none"> Netless ECBs * Single-Net ECBs * Double-Net ECBs * Hydromulch with Netting* Sod ** Rock Surface Cover ** 	Immediately initiate stabilization where earth-disturbing activities have permanently or temporarily ceased, and will not resume for a period exceeding 7 calendar days. Complete stabilization within 3 calendar days of initiation.

* Performance varies. Contact manufacturer for information on their product performance

** C-Factor values for these covers make them permanent covers.

Consideration of final stabilization covers:

Prior to terminating permit coverage for construction activities at this site, the permittee will be required to provide final stabilization for any areas that were disturbed and not covered by permanent structures. Regardless of the land slope on the site, in order to meet the final stabilization requirements in the permit, stabilization measures must be used that are shown to achieve a C-factor value of 0.05 or less. Using Table H-1, the final stabilization cover options available to the permittee are the following:

Site Conditions	Possible Cover Options	Completion Point
Acreage with slope < 5 percent	<ul style="list-style-type: none"> Grass from planted seed Sod Rock Surface Cover 	Grass/Sod must provide a uniform vegetative cover with a density of 70 percent or more of the native background vegetative cover.
Acreage with slope > 15 percent		Rock surface cover must provide a stable surface.

References:

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