SECTION 3: STREAM COMPENSATION

3.0 STREAM COMPENSATION

"Stream Compensation" is a form of compensation whereby SCUs are used as currency for mitigating unavoidable impacts to streams. The amount of stream compensation required to mitigate for unavoidable impacts is equal to the total stream impacts, I_T, as calculated in Section 2 (Form 2-1). This section introduces methods for calculating an equivalent amount of stream compensation, also referred to as mitigation credits, for the amount of stream restoration being proposed.

3.1 PRESERVATION

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3.2 STREAM/ENHANCEMENT/STABILIZATION/ RESTORATION

Improvements to a stream include a wide range of activities aimed at enhancing, stabilizing, or restoring various stream functions. Some of these improvements require greater efforts and provide greater benefits than others. When these activities are proposed as mitigation for stream impacts, the amount of effort required and the resulting benefits from such activities must be taken into account when determining the amount of mitigation credit that should be awarded. The following presents a method for calculating the amount of credit given for various mitigation efforts aimed at enhancing, stabilizing, or restoring stream functions in a manner that provides a high degree of predictability in the regulatory process. However, regulatory authorities may modify the resulting determination during the permit review process.

The amount of mitigation credit achieved[1] by the construction of various types of improvements to a stream can be calculated by using the following equation:

$$S_R = RF_T \times L_R \qquad \text{Eqn. 3.2}$$

Where,

S_R = mitigation credits, in SCUs, achieved by enhancement, stabilization, or restoration of Reach *R*

RF_T = total Restoration Factor from Tables 3-2a, 3-2b, 3-2c

L_R = total length (in linear feet) of the improved reach

Details on the application of this equation are provided in the following sections.

3.2.1 RESTORATION FACTOR

Restoration Factors, RF, for various types of restoration activities are presented in Tables 3-2a, 3-2b, and 3-2c on page 101. Each table represents a different category of stream restoration that depicts different levels of required effort: Table 3-2a lists RF for projects involving only buffer restoration; Table 3-2b lists RF for projects associated with rural streams; and Table 3-2c lists RF for restoration efforts performed on urban/suburban streams.

[1] Assuming that appropriate design, monitoring, and maintenance activities are performed.

3.2.1 RESTORATION FACTOR (cont.)

Buffer restoration may be proposed by itself, in which case the corresponding RF in Table 3-2a would be used to calculate the entire mitigation credit. However, buffer restoration may also be proposed in addition to some of the other restoration efforts described in Tables 3-2b and 3-2c. For purposes of this manual, stream restoration factors are classified for either rural or urban/suburban. Streams qualify for urban/suburban restoration factors if the impervious area within the watershed exceeds 10%[2], otherwise rural restoration factors are applied .

In such cases, the RF values presented in Table 3-2a would simply be added to the RF value corresponding to the other restoration practice that is employed. RF values for amenities, as listed in Table 3-2a, will need to be determined during the permit process by the appropriate regulatory authorities on a case by case basis.

Examples of various types of restoration activities are provided in Section 3.4 on pages 110-114.

3.2.2 RESTORATION COMPENSATION SUMMARY WORKSHEET

Form 3-2, Restoration Compensation Summary Worksheet, is provided on page 102 to record information regarding any streams or reaches proposed for restoration, to calculate the mitigation credits achieved by each, and to summarize the total stream compensation calculated for those proposed restoration efforts.

[2] *Schueler, Tom. Urban Subwatershed Restoration Manual No. 1: An Integrated Framework to Restore Small Urban Watersheds Version 1.0. Center for Watershed Protection, 2004.*

TABLE 3-2a: BUFFER RESTORATION - RESTORATION FACTOR (RF)	
RF	**Restoration Description**
0.25	Fence installation (only applies if grazing threat)
0.75	Planting Trees and Shrubs in accordance with DEQ and COE specs.
1.25	Remove non-native species, deep-disk or plow, seed and plant native trees and shrubs.
*****	Amenities (trails, pedestrian bridges, etc)

*Consult Regulatory Agencies for RF determination of Restoration Amenities

TABLE 3-2b: RURAL STREAMS - RESTORATION FACTOR (RF)	
RF	**Restoration Description**
2.5	Bioengineered bank stabilization with regrading and toe protection and planting to Top of Bank on both banks (1.25 if only one bank)
3.0	Natural channel design without installation of grade control structures
3.5	Natural channel design with grade control structures

TABLE 3-2c: URBAN /SUBURBAN STREAMS - RESTORATION FACTOR (RF)	
RF	**Restoration Description**
4.5	Bioengineered bank stabilization with regrading and toe protection on both banks (2.25 if only one bank)
6.0	Natural channel design without installation of grade control structures
7.0	Natural channel design with grade control structures
8.5	Natural channel design with grade control structures and bed reinforcement

FORM 3-2: RESTORATION COMPENSATION SUMMARY WORKSHEET

Project # : ______________________ Date: ________________

Team : ______________________

Stream/Reach Name	Restoration Type	Drainage Area DA	RF_T	Length L_R	Restoration Credits $S_R = RF_T \times L_R$
		(acres)		*(feet)*	*(SCU)*

TOTAL RESTORATION (S_T) = ________

3.3 STREAM COMPENSATION CALCULATIONS

The amount of mitigation required due to unavoidable impacts is offset by the amount of stream compensation provided through stream preservation, and/or stream restoration. The total stream compensation calculated for preservation and restoration efforts can only be directly compared to the mitigation required for stream impacts if the preservation and/or restoration is provided on the same stream, or a stream of comparable size, to that of the impacted stream. Otherwise, a correlation factor, CF, must be applied to equate the mitigation efforts with the impacts.

If a correlation factor is required (refer to Section 3.3.1), the total stream compensation, C_T, is divided by the CF to determine the weighted total stream compensation, C_{WT}. Section 3.3.2 outlines the procedures for calculating C_{WT} and determining any additional mitigation, C_R, that is still required for the site based on the total impacts proposed.

3.3.1 CORRELATION FACTOR

Usually, improvements are proposed on a stream other than the stream being impacted. In such cases, it is likely that the stream with proposed improvements is a different size than the stream with proposed impacts. To compensate for this, a correlation factor is needed.

Studies have shown[3] that there is a correlation between stream drainage area and stream size (cross-sectional area, width, depth). Several studies have been or are currently being conducted in various physiographic provinces in Pennsylvania, Maryland, Virginia, and North Carolina to develop regional curves relating various stream parameters to drainage area. Published data for streams in the Piedmont physiographic province of Maryland[4], as well as currently un-published data for streams in the Piedmont, Coastal, and Mountain provinces in North Carolina[5], for instance, resulted in the following equations relating stream width to drainage area:

$\text{Width} = 14.78\ \text{DA}^{0.39}$	Piedmont Maryland
$\text{Width} = 11.89\ \text{DA}^{0.43}$	Piedmont North Carolina
$\text{Width} = 19.05\ \text{DA}^{0.37}$	Mountain North Carolina
$\text{Width} = 10.97\ \text{DA}^{0.36}$	Coastal North Carolina

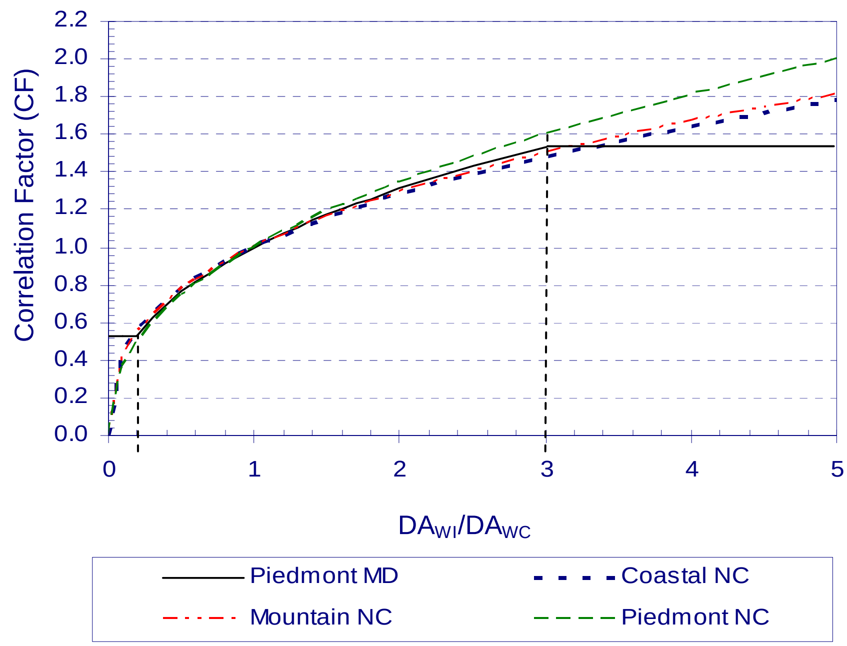
The CF developed in this methodology to account for the difference in stream size is based on the ratio of the impacted stream width to the width of the restored stream. Using any of the above equations, this ratio is reduced to the drainage area of the impacted stream divided by the drainage area of the restored stream raised to a power (i.e. the coefficient drops out). Presented graphically in Figure 3-1, it is evident that drainage area ratio curves based on any of the four regional curves are very similar.

[3] *Dave Rosgen, "Applied River Morphology", Second Edition, 1996.*

[4] *U.S. Fish and Wildlife Services, "Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Piedmont Hydrologic Region", March 2002.*

[5] *Regional curve data obtained from the North Carolina Stream Restoration Institute website, http://www.bae.ncsu.edu/programs/extension/wqg/sri/, presenting data from various researchers.*

FIGURE 3-1: STREAM SIZE CORRELATION FACTOR (CF)



Thus, current data suggests that the use of one curve will adequately represent the relationship between drainage area and stream size (width), regardless of the physiographic province. Therefore, the curve developed for the Piedmont streams in Maryland was selected as the representative correlation to be used in this Manual. The resulting equation for computing the CF for Virginia streams is:

$$CF_{\textit{Virginia streams}} = \begin{cases} 0.53, & \text{for } (DA_{WI}/DA_{WC}) < 0.2 \\ (DA_{WI}/DA_{WC})^{0.39}, & \text{for } 0.2 \le (DA_{WI}/DA_{WC}) \le 3.0 \\ 1.53, & \text{for } (DA_{WI}/DA_{WC}) > 3.0 \end{cases}$$

Note that for drainage area ratios (DA_{WI}/DA_{WC}) below 0.2 and above 3.0, constant values for CF are assumed to be 0.53 and 1.53, respectively, to provide reasonable CF values for either very small or very large drainage area ratios.

In the above equation, DA_{WI} is the weighted drainage area of all of the impacted streams. In a similar fashion, DA_{WC} is the weighted drainage area of the stream or streams for which the total stream compensation, C_T, will be provided. Forms 3-3a and 3-3b, are provided for calculating both DA_{WI} and DA_{WC}, respectively.

3.3.2 STREAM COMPENSATION CALCULATION PROCEDURE

Form 3-4, Stream Compensation Worksheet, is provided on page 106 to guide the User through calculating the total weighted stream compensation, C_{WT}, for the proposed preservation and restoration efforts, as well as calculating any remaining mitigation still required. The step-wise procedure is presented below:

STEP 1 → Use Form 3-1 to compute the proposed mitigation credits, P_T, achieved by the preservation of streams as presented in Section 3.1. Refer to Table 3-1 to determine appropriate preservation factors.

STEP 2 → Use Form 3-2 to compute the proposed mitigation credits, S_T, achieved by the restoration of streams as presented in Section 3.2. Determine the appropriate RF_T by utilizing Tables 3-2a, 3-2b, and 3-2c on page 101.

STEP 3 → Complete Forms 3-3a and 3-3b, Weighted Drainage Area Calculation Worksheet, to compute the weighted drainage area, DA_{WI}, for all impacted reaches and the weighted drainage area, DA_{WC}, for all preserved and restored streams used to provide compensation. Record the results in Section B of Form 3-4.

STEP 4 → Complete the Section A of Form 3-4, Stream Compensation Worksheet, to compute the total unweighted stream compensation, C_T, provided by preservation and restoration efforts. Next, complete Section C, by computing the correction factor, CF, the weighted total stream compensation, C_{WT}, and any additional mitigation that is still required, C_R.

STEP 5 → If additional compensation is necessary, repeat the above process with additional restoration measures until the compensation requirements are met.

Project #: ______________________ Date: ______________

FORM 3-3a: WEIGHTED DRAINAGE AREA FOR IMPACTED STREAMS (DA_{WI}) - CALCULATION WORKSHEET

Stream/Reach Name	Impact #	Length L_I	Drainage Area DA	DA * L_I
		(feet)	(acres)	(ft-ac)
	$\Sigma (L_I) =$			↓
			$\Sigma (DA * L_I) =$	

$$DA_{WI} = \frac{\Sigma (DA * L_I)}{\Sigma L_I} = \_\_\_\_\_\_\_\_\_\_ \text{ acres}$$

FORM 3-3b: WEIGHTED DRAINAGE AREA FOR STREAM COMPENSATION (DA_{WC}) - CALCULATION WORKSHEET

Stream/Reach Name	Restoration Type	Length [a] L_P or L_R	Drainage Area DA	DA* L
		(feet)	(acres)	(ft-ac)
	$\Sigma (L) =$			↓
			$\Sigma (DA * L) =$	

$$DA_{WC} = \frac{\Sigma (DA * L)}{\Sigma L} = \_\_\_\_\_\_\_\_\_\_ \text{ acres}$$

[a] Use applicable Length of Restoration or Length of Preservation

FORM 3-4: STREAM COMPENSATION WORKSHEET—VIRGINIA STREAMS

Project #: ______________________ Date: _______________

Stream Name: __________________ Reach: _______________

A Un-weighted Stream Compensation Total

Total Preservation Credits, P_T = __________ SCUs (Form 3-1)

Total Restoration Credits, S_T = __________ SCUs (Form 3-2)

Total Unweighted Compensation, C_T = _______ SCUs ($C_T = P_T + S_T$)

B Weighted Stream Compensation Total

Weighted Drainage Area for Impacted Streams, (DA_{WI})

DA_{WI} = _________ acres (Form 3-3a)

Weighted Drainage Area for Stream Compensation, (DA_{WC})

DA_{WC} = _________ acres (Form 3-3b)

$$CF = \begin{cases} 0.53, & \text{for } (DA_{WI}/DA_{WC}) < 0.2 \\ (DA_{WI}/DA_{WC})^{0.39}, & \text{for } 0.2 \le (DA_{WI}/DA_{WC}) \le 3.0 \\ 1.53, & \text{for } (DA_{WI}/DA_{WC}) > 3.0 \end{cases}$$

Virginia streams

CF = _________

Total Weighted Compensation, $C_{WT} = C_T / CF$ = _________ SCUs

C Compensation Requirements

Compensation Required, I_T = _________ SCUs (Form 2-2)

Compensation Provided, C_{WT} = _________ SCUs (Form 3-4, Section B)

- If TOTAL Compensation Provided $\geq$ Compensation Required, Compensation Requirements are satisfied.
- If TOTAL Compensation Provided is < Compensation, additional Compensation is Required. Record below:

Additional SCUs Required _______ SCUs (if $C_{WT} - I_T < 0$)

Surplus SCUs Provided: _________ SCUs (if $C_{WT} - I_T > 0$)

3.4 EXAMPLES OF RESTORATION PRACTICES

Amenities: Pedestrian bridge placed across a rural stream.

RF=0.25: Livestock exclusion fence placed along the stream to protect the streambanks and riparian vegetation.

RF = 0.75: Northern Virginia, Planting riparian corridor in accordance with DEQ & COE specifications.

RF = 1.25: Northern Virginia, Installation of livestock fencing and removal of non-native species, deep-disked, seeded and planted native trees and shrubs.

RF = 2.00: Northern Virginia, Rural stream with both banks stabilized utilizing bioengineering techniques. Coir logs are present along the toe of both banks.

RF = 2.25: Northern Virginia, Urban/suburban stream utilizing bio-engineering techniques on one bank. The left bank was regraded with biologs placed at the toe of the slope and the bank was re-planted with native vegetation.

RF = 2.25: Northern Virginia, Urban/suburban stream utilizing bio-engineering techniques on one bank. The right bank was regraded with biologs placed at the toe of the slope and the bank was re-planted with native vegetation. Left bank has one segment of imbricated stone to save trees.

RF = 3.00: Central Pennsylvania, Rural stream restored utilizing Natural Channel Design techniques without grade control structures.

RF = 3.50: Western Maryland, Rural stream restored utilizing Natural Channel Design techniques and grade control structures.

RF = 4.50: Central Virginia, Urban/suburban stream relocated and restored utilizing bioengineering techniques.

RF = 6.00: Northern Virginia, Urban/suburban stream restored utilizing Natural Channel Design techniques and no grade control structures.

RF = 7.00: Northern Virginia, Urban/suburban stream restored utilizing Natural Channel Design techniques and grade control structures.

RF = 8.50: Central Virginia, Urban/suburban stream relocated and restored utilizing Natural Channel Design techniques, bed reinforcement, and grade control structures.

RF = 8.50: Northern Virginia, Urban/suburban stream restored utilizing Natural Channel Design techniques, bed reinforcement, and grade control structures.

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