# SECTION 4: RESTORATION PRACTICE GUIDELINES, MONITORING CRITERIA, & SUCCESS CRITERIA

# 4.0 INTRODUCTION - RESTORATION PRACTICES

The Restoration Factors (RF) presented in Section 3 includes categories of commonly used measures and practices in the field of stream restoration. The purpose of this Section is to provide a bit more guidance regarding the specifics of each measure - however, detailed design information is beyond the scope of this Manual and is therefore not presented.

## 4.1.1 FENCING (RF = 0.25)

In situations where cattle have unrestricted access to the stream, fencing can make a significant difference in the riparian and stream condition. Crossings with gates should be provided at a frequency of one crossing per 1,000 lf of stream. Each crossing requires 6 gates (two each to allow the cattle to cross and keep them out of the stream and buffer after crossing, and one to allow access to each side of the stream in both directions (total of 4) for maintenance equipment. Fencing and gates should be constructed in accordance with the latest Virginia Department of Transportation (VDOT) Road and Bridge Standards (as Revised on 7/04 at this printing) or an approved equal:

Fencing:

*Standard Fence Woven Wire Fabric*
*Standard FE- W1, W2, Page 502.02*

Gates:

*Standard Fence Gates*
*Standard FE- G, Page 502.05*

In addition, provisions for long-term maintenance must be addressed, both in terms of funding of repairs as well as the protection from damage through deed restrictions and/or restrictive covenants.

## 4.1.2 PLANTING OF TREES & SHRUBS (RF = 0.75)

This includes the addition of trees and shrubs in riparian areas without alteration of the existing soil and/or vegetation. To increase the likelihood of success, reduce temporal loss of functions and values, and as a means to out-compete invasive species, heavy planting densities of bare root seedlings, tubelings, and/or 1-gallon container

## 4.1.2 PLANTING OF TREES & SHRUBS (cont.)

grown stock (larger stock are always acceptable) should be provided through one of the following options:

Bare Root at 1,450/acre + 1-gallon container at 200/acre

*-or-*

Tubeling at 700/acre + 1-gallon container at 200/acre

*-or-*

1-gallon container at 680/acre

The more diverse the woody species provided, the better. Ideally, at least five (5) species, including mass-producing are recommended. Tree tubes are not recommended as they may do more harm than good, particularly in a riparian area prone to overbank flows where they can be knocked over. A more natural riparian system will be achieved by planting at higher densities without tubes and letting the strong survive.

## 4.1.3 STREAM EDGE LIVE STAKING / TUBELING

Stream Edge Live Stake/Tubelings – In addition to riparian areas, planting of the stream edge is also required for this Restoration Factor. Plant live stakes and/or tubelings (tubelings required during live stake non-dormant periods) at a density of *one plant every 2-ft o.c.* Species can include one or all of the following; dogwood, willow, and/or alder.

### 4.1.4 SOIL PREPARATION PLUS PLANTING & SEEDING (RF = 1.25)

This restoration practice goes beyond simply planting and seeding as described in the previous section to include preparing the seedbed. The required steps include:

1. Spray the entire area to remove non-native species using Rodeo at a rate of 2.5 ounces per gallon of water and 1.5 ounces of Sidekick (surfactant). *Consult product directions and only apply in accordance with all federal, state, and local regulations*. While not every invasive plant will be removed with this treatment, it will provide a good basis to allow new plantings to effectively compete.
2. Next, the entire area must be deep disked or plowed to loosen compacted soil – this is a very important step to increase the survival rate of newly planted seed and vegetation.
3. The final step is to seed with a combination of erosion control grasses (annuals) and a diverse native seed mix of herbs, shrubs, and trees, and plant at a high density with native trees and shrubs, as detailed in Section 4.2. A sample seed mix can be found in Appendix C.

### 4.1.5 BIOENGINEERING FOR RURAL STREAMS (RF = 2.5 for both banks, 1.25 for one bank only)

This practice applies to rural streams where easy access and existing infrastructure are not problematic. Further, the primary concern is with bank (lateral) instability, not stream bed (vertical) instability, i.e. grade control is not required. Stability can be returned to the stream primarily with softer, bioengineering practices that do not involve changes to the existing pattern, plan, or profile of the stream. Specifications for the applicable types of practices are included in **Chapter 4, Sections 1 and 2** in the *Virginia Stream Restoration Guide*[1].

[1] *The Virginia Stream Restoration & Stabilization Best Management Practices Guide, Department of Conservation and Recreation, 2004.*

### 4.1.6 NATURAL CHANNEL DESIGN IN RURAL STREAM, NO GRADE CONTROL (RF = 3.0)

This practice is also applicable to rural streams with easy access and no existing infrastructure to avoid. However, more effort is required to return stability to the stream through the use of Natural Channel Design (NCD) techniques. Lateral stability is the primary concern, with some changes to the channel cross-section and/or pattern deemed necessary. The applicable elements of the 40 step process that defines the NCD methodology[2] are performed to establish the stable form of the stream. Structural bank stabilization and vegetative practices are employed as necessary to reinforce the restored channel configuration. Specifications for applicable practices are contained in the *Virginia Stream Restoration Guide*, **Chapter 4, Sections 1, 2, and 4**.

### 4.1.7 NATURAL CHANNEL DESIGN IN RURAL STREAM, WITH GRADE CONTROL (RF = 3.5)

Very similar to the previous section, but in this situation vertical stability is also a problem. As a result, more substantial structural elements may be necessary to establish grade control of the revised channel. Specifications for grade control elements are contained in the *Virginia Stream Restoration Guide*, **Chapter 4, Section 3**. Practices contained in other sections of the *Virginia Stream Restoration Guide* may also be employed in conjunction with the grade control elements

### 4.1.8 BIOENGINEERING FOR URBAN/SUBURBAN STREAMS (RF = 4.5 for both banks, 2.25 for one bank only)

Identical to Section 4.1.4, but in an urban/suburban setting where considerably more effort is necessary due to access issues, culverts, outfalls, bridges, and utilities. Significantly more surveying is required to locate property boundaries, trees, and infrastructure.

[2] *River Restoration and Natural Channel Design Course Manual, Dave Rosgen, Wildland Hydrology, 2004.*

### 4.1.9 NATURAL CHANNEL DESIGN IN URBAN/ SUBURBAN STREAM, NO GRADE CONTROL (RF = 6.0)

Identical to Section 4.1.5, but in an urban/suburban setting where considerably more effort is necessary due to access issues, culverts, outfalls, bridges, and utilities. Significantly more surveying is required to locate property boundaries, trees, and infrastructure**.**

### 4.1.10 NATURAL CHANNEL DESIGN IN URBAN/ SUBURBAN STREAM, WITH GRADE CONTROL (RF = 7.0)

Identical to Section 4.1.6, but in an urban/suburban setting where considerably more effort is necessary due to access issues, culverts, outfalls, bridges, and utilities. Significantly more surveying is required to locate property boundaries, trees, and infrastructure.

### 4.1.11 NATURAL CHANNEL DESIGN IN URBAN/ SUBURBAN STREAM, WITH GRADE CONTROL AND BED REINFORCEMENT (RF = 8.5)

This practice includes elements contained in section 4.1.9 above, but also requires reinforcement of the bed. This may be necessary in situations where incoming sediment supply is low, stormwater runoff is uncontrolled, and/or where site constraints limit the ability to design a channel (through changes in cross-section, plan, and/or profile) that will result in non-erosive velocities in the design storm event. Reinforcement may include importation of sufficiently large aggregate that will withstand anticipated design flows to placement of class I riprap with the voids packed with soil to provide a media for vegetation to take hold. Other methods may also be acceptable at the discretion of the Regulatory Agencies.

## 4.2 INTRODUCTION - SUCCESS & MONITORING CRITERIA

Given that the field of stream restoration deals with dynamic systems, establishment of a detailed Monitoring Program linked to clear Success Criteria will be important to ensure that success of the current project is achieved, as well as to provide invaluable data for future stream restoration projects. Details of a Success Criteria and Monitoring Program are provided in the following sections. Regulatory Agencies will modify these as necessary to cite the specific project requirements as needed to assure success. The Monitoring Program provided in this Manual tracks more elements than specifically contained in the Success Criteria so that additional performance data can be collected and analyzed for use in future enhancements of the stream Success Criteria.

## 4.3 SUCCESS CRITERIA

Criteria to measure the success of the restoration project are presented below.

### 4.3.1 REFORESTED BUFFER AREAS

1. Plant density of at least 400 living wood stems (including volunteers) per acre of trees and shrubs must be achieved by the end of the first growing season following planting and maintained through the end of the monitoring period or until canopy coverage is greater than 30%;
2. Herbaceous plant coverage of at least 60% must be achieved by the end of the first growing season, and at least 80% each monitoring year thereafter; and,
3. Woody plant coverage (from live-stakes, tublings, container grown material, and volunteers) along stream banks shall achieve a density of at least 5 linear foot per stem (lf/stem) by the end of the first growing season and for each monitoring year thereafter.

## 4.3.2 STREAM & RIPARIAN SYSTEM

1. Dimension - The analysis of each permanent cross section specified on the Stream Restoration Site Plans shall indicate that:
   a. The Width/Depth Ratio (defined as the width at bankfull divided by the mean riffle depth at bankfull) did not increase or decrease by an amount greater than 1.2 of the designed or the as-built cross-section.
   b. The bankfull Cross-Sectional Area did not increase or decrease by an amount greater than 20% of the designed or the as-built cross-section.
   c. The Bank Height Ratio (defined as the low bank height divided by the maximum riffle depth) did not increase or decrease by an amount greater than 0.2 of the designed or the as-built cross-section.
2. Pattern - The analysis of the plan-view survey of field measurements shall indicate that:
   a. The Sinuosity of the stream (defined as the stream length along the thalweg divided by the valley length) did not increase or decrease by an amount greater than 0.2 of the designed or the as-built pattern.
   b. The Radius of Curvature/Width ratio did not increase or decrease by an amount greater than 0.2 of the designed or as-built condition.
3. Profile - The analysis of the longitudinal profile shall indicate that the slope of the longitudinal profile did not increase or decrease by an amount greater than 0.3% of the designed or as-built slope.
4. Structures - The analysis of each instream structure shall indicate that:
   a. The angle of any rock vane, j-hook, or cross vane did not increase or decrease by an amount greater than 3 degrees from the as-built angle, and remains between 20 and 30 degrees from the streambank.
   b. The slope of any rock vane, j-hook, or cross vane did not increase or decrease by an amount greater than 2% from the as-built slope (i.e. if the design slope was 5%, then any slope from 3% to 7% would be acceptable) and remains between 2% and 7%.

## 4.4 MONITORING PROGRAM

Comparison with the above Success Criteria will be conducted through the Monitoring Program as described below (note that the monitoring periods may be shortened when Regulatory Agencies feel success is likely to be achieved in a shorter time frame based upon design and watershed characteristics):

### 4.4.1 REFORESTED BUFFER AREAS

1. Visual Description. Visual descriptions shall be provided with each monitoring report by one of the following means: (i) ground level photographs, taken facing north, south, east, and west, from stations located adjacent to each vegetation plot and hydrology monitoring station [permanent markers shall be established to ensure that the same locations (and view directions) are monitored in each monitoring period], or (ii) one color aerial photograph (8" x 10" or larger) depicting the entire site. An aerial photograph should be taken once the site has been graded, planted, and stabilized (preferably in the 3rd or 5th year following final grading).

2. Vegetation. Sample plots shall be located on a stratified random basis over areas of the site that are reforested riparian buffer areas in order to sample all habitat areas of constructed wetlands at locations adjacent to each photo location marker. The following numbers of samples will be required:

    - If the reforested site is < 5 acres, then a minimum of 3 plots/acre is necessary;
    - If the reforested site is > 5 acres but less than 20 acres, then a minimum of 2 plots/acre is necessary;
    - If the reforested site is > 20 acres, then a minimum of 1 plot/acre is necessary

    Each plot shall be of a size no less than a 30 foot radius for woody plants and a 3 foot diameter for herbaceous plants. Alternative sampling methods may be submitted for Agency review and approval. The vegetation data shall be collected in the July - November time period and shall include:

### 4.4.1 REFORESTED BUFFER AREAS (cont.)

a. Dominant vegetation species identification;

b. Coverage assessment;

c. Number of woody plant stems (total and #/acre); and,

d. Indicator status.

### 4.4.2 STREAM & RIPARIAN SYSTEM

1. Woody plant coverage (from live stakes, tubelings, container grown material, and volunteers) along stream banks shall be quantified by species and density (linear foot (lf) per stem along the stream bank edge).
2. Exposure of bank pins (with locations specified on the Stream Restoration Site Plan) shall be measured to provide an assessment of bank erosion in the restored reach.
3. Scour chains (with locations specified on the Stream Restoration Site Plans) shall be assessed to provide data on sediment movement in the stream bed.
4. Pebble counts and bar samples will be collected (with possible locations specified on the Stream Restoration Site Plans) and analyzed to document changes in streambed material particle size.
5. Each Stream Stabilization Structure shall be surveyed, photographed from a permanent monitoring post, or otherwise designated location, established in the first report, visually evaluated for stability, and a narrative statement provided as to whether or not specific Success Criteria have been violated.
6. To assess channel stability Success Criteria related to cross-sections, at least one cross section per 1,000 lf shall be provided (with permanent markers established the first time in locations specified in the Stream Restoration Site Plan) on a representative mix of riffles and pools at these same time periods.
7. A surveyed profile of the stream along its thalweg provided as soon as practicable after completion, and in years 1, 3, 5, and 10 and compared to the original

## 4.4.2 STREAM & RIPARIAN SYSTEM (cont.)

design to assess compliance with Success Criteria and to provide feedback for future stream restoration designs. The slope of the individual stream features (riffle, run, pool, glide) shall also be measured, as well as the specific stream pattern parameters.

1. Location of any riparian areas with excessive erosion that needs replanting or protection with rock or coir logs shall be identified.

2. Assessment of biological conditions (habitat) using the following methods, with the number of study reaches equal to the length (in feet) divided by 2,000, shall be provided pre-restoration, and then in years 1, 5, and 10:

   a. Biological Reconnaissance (BioRecon) or Problem Identification Survey, following the guidance established in the "Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers."[3]

   b. Calculation of the Virginia Stream Condition Index (VA-SCI) following the guidance established in "A Stream Condition Index for Virginia Non-Coastal Streams."[4]

3. Within one week after any storm event that exceeds the 2-year storm (either the 2 or 24-hour storms) for the jurisdiction in which the restoration is taking place, the subject stream reach shall be visually inspected for damages. Photographs and narrative shall be utilized to summarize performance and provided in the next monitoring report, or earlier if requested by the Regulatory Agencies.

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[3] *"Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers"* ,Barbour et al., 1999.

[4] *"A Stream Condition Index for Virginia Non-Coastal Streams"*, Burton and Gerritsen, 2003.

### 4.4.3 TIMING OF MONITORING ACTIVITIES

Monitoring activities shall occur during the growing season, and at least:

1. Prior to restoration activities, as soon as practicable after completion of restoration, and once during the 1st, 2nd, 3rd, 5th, 7th, and 10th growing seasons following completion of grading (note that field surveys will be conducted in years 1, 3, 5, and 10 and biological surveys in years 1, 5, and 10, in addition to the pre-restoration surveys);
2. Monitoring of woody vegetation for the first year or any year following planting shall take place between July and November;
3. If all Success Criteria have not been met in the 10th year, then a monitoring report shall be required for each consecutive year until two annual sequential reports indicate that all criteria have been successfully satisfied (i.e., that corrective actions were successful).
4. A final monitoring report (typically prepared the 10th growing season following completion of grading).

Monitoring may be terminated earlier at the discretion of the Regulatory Agencies. Reports to be submitted in accordance with specific permit guidelines for the project.

## NOTES:

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