

CWCB Bioengineering Manual and Restoration Matrix



Photo courtesy of R. Mandel

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Photo courtesy of J. Giordanengo
CWCB Bioengineering Manual for Colorado 2016

2013 Front Range floods were catastrophic



LIVING STREAMBANKS

A Manual of Bioengineering Treatments for Colorado Streams

Submitted To: State of Colorado, Colorado Water Conservation Board
1313 Sherman St, Room 718
Denver, CO 80201

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COLORADO
Colorado Water
Conservation Board
Department of Natural Resources



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New CWCB Bioengineering Guide for Colorado

CWCB Bioengineering Manual for Colorado:

Bioengineering: The integration of living woody and herbaceous materials along with organic and inorganic materials to increase the strength and structure of soil

-J. Chris Hoag (1998)

Purpose of manual: To provide restoration practitioners with guidelines for planning, design, and construction of streambank protection optimized for the conditions specific to Colorado's watersheds



Photo courtesy of R. Mandel

2015 Roaring Fork Restoration Planting



Photo courtesy of R. Mandel

2016 EWP Deutscheig Restoration Planting

CWCB Bioengineering Manual for Colorado:

Intent of the Manual:

- **Provide guidelines for comprehensive restoration strategy**
- **Incorporate design elements that impart site stability**
- **Include recommendations that minimize risk during periods of vulnerability**
- **Increase understanding of how to properly apply bioengineering and revegetation techniques**

CWCB Bioengineering Manual for Colorado:

Intent of the Manual (continued):

- **Provide means to calibrate bioengineering to water & gravity**
- **Create searchable revegetation matrix for native riparian spp**

CWCB Searchable Revegetation Matrix:

- **Includes prioritized woody, forb, and graminoid species based on feedback to Southern Rockies Seed Network**
- **Incorporates 51 searchable parameters including nomenclature, county, hydrology/physiographic preference, morphology, and germination data**
- **Included within morphology are root parameters that allow better incorporation in bioengineering techniques**
- **Also includes germination protocols, average seed weights, storage recommendations, and implementation preferences**

CWCB Searchable Restoration Matrix:

Root parameters can be applied to:

- Annandale Erodibility Index (2006)

$$K = M_s * K_b * K_d * J_a$$

Where: M_s - mass strength; K_b - block size; K_d - discontinuity bond shear strength; and J_a - relative ground structure.

$$K_b = 1000D^3$$

- ◆ Block size = 1000 * root dimension³

CWCB Searchable Restoration Matrix:

Root parameters can be applied to:

- Waldron Model(1977), as modified by Wu, McKinnell, & Swanston (1979) (as described in Simon et al. 2006)
- The simple perpendicular model is based on the Coulomb equation:

$$S_r = \acute{c} + (\sigma - \mu) \tan \varphi'$$

Where: S_r = shear strength (kPa), \acute{C} = effective cohesion (kPa), σ = normal stress (kPa), μ = pore pressure (kPa), and φ' = angle of internal friction in degrees

CWCB Searchable Restoration Matrix:

Waldron Model(1977), as modified by Wu, McKinnell, & Swanston (continued):

- As such, the shear strength of the roots (ΔS) is calculated through use of the root tensile strength and the cross section of the roots relative to the area of the shear surface

$$\Delta S = T_r (A_R/A) 1.2$$

Where: T_r = root tensile strength (kPa), A_R/A = root area ratio (dimensionless), A = soil area (m^2), A_R = root area (m^2), and 1.2 = value that accounts for the angle of shear distortion and soil friction in degrees (Wu et al., 1979; Simon et al., 2006)

CWCB Searchable Restoration Matrix:

Opportunity:

- Incorporate Manning's n into the matrix
- Would be useful for:
 - ◆ H&H Modeling
 - ◆ Better understanding the cumulative effect of treatments
 - ◆ Long-term operation and maintenance planning
- Support formation of working group to further investigate

CWCB Searchable Restoration Matrix:

Revegetation Matrix and Manual will be downloadable from:

<http://cwcb.state.co.us/environment/watershed-protection-restoration/Pages/main.aspx>

or

<http://coloradoewp.com/guidelines-and-resources>