FIVE FUNDAMENTALS FOR SUCCESSFUL LAND REHABILITATION

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Marc S. Theisen – M. Sc., CPESC, CPSWQ, CESSWI
Vice President – Business Dev. & Technical Services
Profile Products LLC
Presentation Overview

• The Five Fundamentals
• Integration via PS³ Software Program
• Successful Mining/Energy Case Histories
• Questions and Answers
Fundamental #1
Understand Your Substrate

- Texture/Type – sand, silt, or clay?
- pH – to determine soil acidity or alkalinity
- % Organic Matter and % Organic Acids
- Nitrogen, Phosphorus & Potassium (N, P, K)
- Electrical Conductivity (EC)
- Total Dissolved Salts (TDS)
- Cation Exchange Capacity (CEC)
- Sodium Adsorption Ratio (SAR)
- Excess metals and salts
Profile Soil Solutions Software

“In the Ground, On the Ground and By Your Side”

www.profileps3.com
Navigation – My Account

Use the following form to update your account information:

First Name: [temp]
Last Name: [temp]
Phone Number:
Email Address: [temp@temp.com]

Password Change:
Current Password:
New Password:
Repeat New Password:

Update

Update your contact information or change your password on the “My Account” page.
Check "yes" if you would like to obtain a soil testing input form to be able to perform a soil nutrient test for this project.
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Sample Description</th>
<th>Location of Sample</th>
<th>Lab Use Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Instructions / Guidance

Proper Sampling Equipment:
Equipment should be such that sampling depth can be monitored and controlled. A stainless steel sampling probe works the best, but is not required. Composite samples should be collected in a plastic bucket for thorough mixing. Metal buckets can contain traces of some micro-nutrients (particularly zinc), which can contaminate samples. Soil sample bags should be either plastic or plastic lined.

Sampling Procedures:
Determine which areas are to be sampled. Review the site, note significant changes in soil, such as color or texture. Each sample should consist of a composite of many sub-samples from like soils. Try to composite 10 to 15 sub-samples to create one representative sample. The volume of soil needed is roughly one 8 ounce cup (or approximately one pound). It is most important to “keep the sampling depth consistent”. Erosion Control projects should be sampled to a depth of 3 inches. If organic matter is on the surface, scrape away prior to sampling, usually no more than 1/2 to 1/4 surface layer. Insert each composite sample into a Ziploc bag and clearly mark the sample identification number (should be 01, 02 or 03) on each bag along with the matching input form report number using a permanent marker. Then place this bag inside another Ziploc bag and label the second bag identical to the first.

Paperwork and Shipping Instructions:
Please be sure all information is completed on the soil testing input form. Be sure to make a copy of the input form for your records. Prior to closing up the box, make sure that the soil sample bags are properly labeled, double bagged and correspond with the input sheet. Pack samples very tightly in a strong shipping box. Use packing material so the bag(s) will not shift in the box. Tape the box completely and affix a shipping label. If possible, collect and ship samples the same day.

For more than 3 samples on a project call Profile using the number provided above. Sample Description Example: loamy sand soil with organic matter Location of Sample Example: south facing 2H:1V slope above pond
Make a copy of the form for your records and then ship this form and samples to address shown on top of the form. Do not use this form more than once as each form has a tracking number!

Testing Packages: Diagnostic + Soluble Nutrients + Particle Size Analysis
Soil Test Results

* All soil tests were conducted by an independent, third-party laboratory.

<table>
<thead>
<tr>
<th>Project: 0111-00012</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>* Project Name: Nickel Mine</td>
<td></td>
</tr>
<tr>
<td>Project Number: 2</td>
<td></td>
</tr>
<tr>
<td>File #:</td>
<td></td>
</tr>
<tr>
<td>Location: New Caledonia</td>
<td></td>
</tr>
<tr>
<td>Notes:</td>
<td></td>
</tr>
</tbody>
</table>

Soil Sample Locations and Descriptions

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OMESDOM 3</td>
<td>COMPOSITE SOIL FOR SLOPE</td>
</tr>
</tbody>
</table>

Soil Analysis Results

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>Texture (USDA)</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Soil pH (6.3 - 7.3)</th>
<th>TDS&lt;sup&gt;1&lt;/sup&gt; (ppm)</th>
<th>SAR&lt;sup&gt;2&lt;/sup&gt; (&lt; 2)</th>
<th>Organic Matter (%)</th>
<th>CEC % Sodium&lt;sup&gt;4&lt;/sup&gt; (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sandy Loam</td>
<td>64</td>
<td>18</td>
<td>18</td>
<td>8.2</td>
<td>256</td>
<td>0.2</td>
<td>3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*Notes: 1. Total Dissolved Salts, 2. Sodium Absorption Ratio, 3. NutraLime is also available in a liquid form, please contact a Profile representative with questions. 4. Sodium at % Base Saturation Cation Exchange Capacity (CEC). 5. lb/acre associated with a 6-inch depth.
Agronomic Amendments

- Fertilizers
  - Quick release synthetic formulations
  - Slower release organic/natural formulations
- Soil Neutralizers
  - Raise or lower substrate pH
  - Lime, sulfur or acidifiers
- Organic Matter
  - Compost/manure/natural fibers
  - Biotic Soil Amendments
- Growth Stimulators & Enhancers
  - Achieve faster germination & establishment
  - Sustain long-term plant vitality
  - Typical ingredients include:
    - Humic and fulvic acids
    - Porous ceramics
    - Biochar
    - Bacterial or microbial cultures
    - Endo-Mycorrhizae
    - Seaweed extracts/cytokinins
#2 – Species Selection

- Where is project?
- Soil characteristics?
- Permanent or temporary vegetation?
- When will the installation occur - seasonality?
- Desired plant materials
  - Native, introduced, drought tolerant, palatable, warm or cool season, legumes, wildflowers, shrubs, trees, etc.
- What is the intended application?
  - Slope, channel, riverine, shoreline, levee, cover system, etc.
- Site characteristics – such as elevation, topography, aspect, climatic conditions
- Maintenance activities – irrigation, mowing, supplemental amendments or grazing?
### Project Information
- **Project ID:** 121982
- **Country:** United States
- **State:** Wisconsin
- **City:** Wausau
- **Is the vegetation intended to be permanent or temporary?** Permanent
- **What month(s) of year will the installation occur?** June
- **What is the intended application?** Slopes, slope stabilization and repairs, steepened slopes

### Site Characteristics
- **Elevation:** 750
- **Aspect:** South
- **Any Unique Concerns:** Rocky Slope

### Soil Conditions
- **Have you collected and submitted soil samples for a free soil test?** Yes
- **Has the site been previously treated with fertilizer, lime or other soil amendments?** Yes, Ag Lime Applied Last year
- **What is the soil texture?** Clay Loam
- **What is the soil pH?** 8.2
- **Any key agronomic problems or issues to consider i.e. low organic matter, toxic soils, etc.?** No

### Site Maintenance
- **Will the site be mowed or maintained?** Only a few times a year
- **Will the site be irrigated?** Yes
- **Will any livestock or wildlife be feeding on the vegetation and if so, what?** Yes, Cattle

### Species Information
- **Drought tolerant species**
- **Native vegetation**
- **Shrub species**
- **Turf grasses**
- **Cool season species only**
- **Warm season species only**
- **A blend of cool and warm season species**
- **A legume species that will provide added nitrogen**
- **A wildflower mix**
- **Other**

**How do you intend to apply the seed?** (This may affect the recommended seed rates.) For example, broadcasted rates are typically twice the rate of drilled seed.
- **Hydroseed**
Establishing vegetation requires balancing NATURAL VARIABLES and PRODUCT BENEFITS to create the best environment for growth and establishment.

"The Green Engineering Triangle"
Erosion Control Selection – Slopes

Universal Soil Loss Equation (MUSLE and RUSLE)

\[ A = R \times K \times LS \times C \times P \]

Where:

- **A** = computed soil loss/unit area/unit time for a given storm period and intensity
- **R** = rainfall factor
- **K** = soil erodibility factor
- **L** = slope length factor
- **S** = steepness factor
- **C** = vegetation or cover factor
- **P** = erosion control practice factor

C-Factor calculated as soil loss ratio of treated surface versus an untreated control surface ... 5 kg/100 kg = 0.05
Project Basics - Slopes

Add / Edit Slope

Slope Name: ____________________________

Functional Longevity: < 3 months

Supporting Practices Factor (P): Loose - Disked Flow Layer (1.0)

Soil Density (Y): 92 lb/ft³

Thawing Soils? □ Yes □ No

Soil Loss Limit (SLL): 0.01 in

Slope Length (SL): _________ ft

Slope Gradient (SG): _________ H:V

Slope Width (SW): _________ ft

Soil Type: _________

Expected Final Cover Type: _________

Rainfall Factor (R): 30.6

Required Growth Establishment Factor (Q): Standard

Tank Size: 1000 gal

Input the necessary information to determine the most appropriate Profile Products for your slope project.

Click Save and Calculate

As a reminder, click on any of the “?” to get more information.
Project Basics - Slopes

Product Selection

Acceptable HECPs
- CocoFlex (FS: >10)
- Flexterra (FS: >10)
- Hydro-Blanket (FS: 1)
- Profile BFM (FS: 1)

Acceptable ECBs
- Futerra Environet (FS: 1)

Acceptable TRMs
- GreenArmor 7010 (FS: >10)
- GreenArmor 7020 (FS: >10)
- GreenArmor 7520 ("S") (FS: >10)
- GreenArmor 7003 (FS: >10)

Notes
- FS = Factor of Safety

Click on any of the products to view more details as shown below for “Flexterra”

HECP Product Application:

Flexterra

Product C-Factor: 0.005
Factor of Safety: >10
Annual Soil Loss (with Product): 0.166 tons/acre, 0.001 in
Annual Soil Loss (without Product): 33.247 tons/acre, 0.1991 in

Functional Longevity: ≤18 months
Growth Establishment Factor: 800%
Suggested Application Rate: 3000 lbs/acre
Job Size: 1.148 acres
# of Tanks per Acre: 7.95
Estimated # of Bags: 73
# of Bags per Tank: 8
Total # of Tanks: 9.1

Click on “Documents” to see all Flexterra documents or “Printable Report” to view a printable summary report
Design Considerations – Channel Applications

Manning’s Equation for Permissible Velocity

\[ V = \frac{C}{n} \left( \frac{R}{S_f} \right)^{2/3} S_f^{1/2} \]

V = average velocity (ft/s, m/s)
C = 1.49 for U.S. Customary Units; = 1 for SI Units
n = manning’s roughness coefficient (dimensionless)
R = hydraulic radius (ft, m)
  = cross sectional area divided by wetted perimeter (A/P)
S_f = friction slope of channel (can be approximated as average bed slope for uniform flow conditions) (ft/ft, m/m)

US FHWA Hydraulic Engineering Circular #15 –
Design of Roadside Channels with Flexible Channel Liners
Design Considerations – Channel Applications

Permissible Shear Stress Equation

\[ \tau = \gamma dS_o \]

\( \tau \) = shear stress (lb/ft\(^2\), Pa)
\( \gamma \) = unit weight of water (62.4 lb/ft\(^3\), 9.80 KN/m\(^3\))
\( d \) = maximum flow depth (ft, m)
\( S_o \) = average bed slope (ft/ft, m/m)

US FHWA Hydraulic Engineering Circular #15 – Design of Roadside Channels with Flexible Channel Liners
Project Basics - Channels

Input the necessary information to determine the most appropriate Profile Products for your channel project.

Click Save and Calculate

As a reminder, click on any of the “?” to get more information.
Project Basics - Channels

### Product Selection

**TRMs**

- GreenArmor 7020 - FS: >10 (unvegetated), >10 (vegetated)
- GreenArmor 7520 (“S”) - FS: >10 (unvegetated), >10 (vegetated)
- GreenArmor 7010 - FS: >10 (unvegetated), >10 (vegetated)
- GreenArmor 7003 - FS: >10 (unvegetated), >10 (vegetated)
- Enkamat 7020 - FS: >10 (unvegetated), >10 (vegetated)
- Enkamat 7520 (“S”) - FS: >10 (unvegetated), >10 (vegetated)
- Enkamat 7010 - FS: 8.7 (unvegetated), >10 (vegetated)
- Enkamat 7003 - FS: 0 (unvegetated), >10 (vegetated)

**Notes**

- FS = Factor of Safety
- Products listed in red do not satisfy both the unvegetated and vegetated project conditions. It is recommended to select a product that satisfies both the unvegetated and vegetated project conditions.

### TRM Product Application:

**GreenArmor 7020**

- Unveg. Solved Depth, $du$: 1.12 ft
- Unveg. Product Roughness, $nu$: 0.015
- Unveg. Flowrate, $Q$: 99.95 ft$^3$/s
- Unveg. Velocity, $V$: 3.14 ft/s
- Maximum Unveg. Shear, TMU: 0.07 lb/ft$^2$
- Unveg. Factor of Safety, FSU: >10

<table>
<thead>
<tr>
<th>Vegetated Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veg. Solved Depth, $dv$:</td>
<td>3.28 ft</td>
</tr>
<tr>
<td>Veg. Product Roughness, $nv$:</td>
<td>0.099</td>
</tr>
<tr>
<td>Veg. Flowrate, $Q$:</td>
<td>99.99 ft$^3$/s</td>
</tr>
<tr>
<td>Veg. Velocity, $V$:</td>
<td>0.88 ft/s</td>
</tr>
<tr>
<td>Maximum Veg. Shear, TMV:</td>
<td>0.2 lb/ft$^2$</td>
</tr>
<tr>
<td>Veg. Factor of Safety, FSV:</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>

- Functional Longevity: >38 months
- Coverage Area +10%: 5832 yd$^2$

**Documents | Printable Report**

Click on “Documents” to see all GreenArmor 7020 documents or “Printable Report” to view a printable summary report.

Click on any of the products above to view more details as shown to the right for “GreenArmor 7020”
#4- Proper Installation

- Comprehensive and detailed construction specifications with plans/drawings
- Complete installation guidelines
- Tools or calculators to facilitate mixing ratios and/or application rates
- Experience...
- Site Specific Experience!
Mixing and Application Guidelines

Application Guide for Profile®
HP-FGM™ and ET-FGM™

Application / Loading Procedures

A. Thoroughly mix all components as directed. Manufacturer’s instructions and recommendations.

B. Use approved spray equipment and properly adjusted to assure 100% wet surface coverage. Flow rate and nozzle size should be adjusted based on the slope of the application area.

C. Fill 1/3 of mechanically agitated hopper with water. Turn pump on for 15 seconds and purge outlet and hopper. Turn pump off.

D. Park hopper on flat area and load low density materials first (i.e. seeds). **

E. Continue slowly filling tank with water while loading fiber matrix into tank.

F. Consult loading chart on the back to determine the number of bags to be added for desired area and application rate.

G. HP-FGM or ET-FGM should be oriented to the tank before water level reaches 75% of the top of tank.

H. Top off with water and mix until all fiber is fully broken apart and hydrated (minimum of 15 minutes — increase mixing time when applying at dilution levels). This is very important to fully activate the binding additives and to obtain proper viscosity.

I. Add fertilizers.

J. Shut off recirculation valve to minimize potential for air entrainment within the spray stream.

K. Sow down agitator and start spraying at a 50-degree fan tip nozzle.

L. Spray in opposing directions for maximum soil coverage.

** Do not add tackifiers or polymers.

Loading Chart for Profile’s HP-FGM and ET-FGM

<table>
<thead>
<tr>
<th>Tank Size (gpd)</th>
<th># of 50-lb Holes</th>
<th>2,500 lb/acre</th>
<th>3,000 lb/acre</th>
<th>4,000 lb/acre</th>
<th>5,000 lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>2</td>
<td>100</td>
<td>1,742</td>
<td>1,492</td>
<td>1,345</td>
</tr>
<tr>
<td>750</td>
<td>6</td>
<td>300</td>
<td>590</td>
<td>3,485</td>
<td>2,904</td>
</tr>
<tr>
<td>1,000</td>
<td>8</td>
<td>400</td>
<td>1,120</td>
<td>6,970</td>
<td>5,930</td>
</tr>
<tr>
<td>1,500</td>
<td>12</td>
<td>600</td>
<td>1,680</td>
<td>10,456</td>
<td>8,712</td>
</tr>
<tr>
<td>2,000</td>
<td>16</td>
<td>800</td>
<td>2,240</td>
<td>13,939</td>
<td>11,516</td>
</tr>
<tr>
<td>2,500</td>
<td>20</td>
<td>1,000</td>
<td>2,800</td>
<td>17,424</td>
<td>14,520</td>
</tr>
<tr>
<td>3,000</td>
<td>24</td>
<td>1,200</td>
<td>3,360</td>
<td>20,909</td>
<td>17,424</td>
</tr>
<tr>
<td>3,500</td>
<td>28</td>
<td>1,400</td>
<td>3,920</td>
<td>24,384</td>
<td>19,013</td>
</tr>
<tr>
<td>4,000</td>
<td>32</td>
<td>1,600</td>
<td>4,480</td>
<td>27,878</td>
<td>21,232</td>
</tr>
</tbody>
</table>

Additional Notes:

- For hose applications, 35 lb/100 gal is recommended.
- For dry applications, 30 lb/100 gal is recommended.
- Rough surfaces (rocky terrain, cat tracks, ripped soils, etc.) may require additional product to achieve 100% coverage.
- Be sure to allow for residual material in tank on subsequent applications.

Slope and Intermittent Rates

<table>
<thead>
<tr>
<th>Slope Condition</th>
<th>Product Category</th>
<th>Length (ft)</th>
<th>Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 1</td>
<td>HP-FGM</td>
<td>3000 lb/acre</td>
<td>3000 kg/ha</td>
</tr>
<tr>
<td>4 to 1</td>
<td>ET-FGM</td>
<td>3000 lb/acre</td>
<td>3000 kg/ha</td>
</tr>
<tr>
<td>4 to 1</td>
<td>Below 5' or TEM</td>
<td>4500 lb/acre</td>
<td>4500 kg/ha</td>
</tr>
<tr>
<td>4 to 1</td>
<td>As infl for TRM</td>
<td>5000 lb/acre</td>
<td>5000 kg/ha</td>
</tr>
</tbody>
</table>

*All slope intermittence limits are for product applications on a 3:1 hill slope. For application on steeper slopes, the slope interruptions limits may need to be decreased.

Use only approved and tested TMRs to create the GrowArmor System.
## Application Calculator

### Project and Conversion Information

<table>
<thead>
<tr>
<th>Calculation Name</th>
<th>Low pH area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select A Project</td>
<td>Matt's Example Project</td>
</tr>
<tr>
<td>Desired Units</td>
<td>U.S.</td>
</tr>
<tr>
<td>Project Area</td>
<td>37.000</td>
</tr>
<tr>
<td>Square Meter</td>
<td></td>
</tr>
<tr>
<td>Working Capacity</td>
<td>3000</td>
</tr>
<tr>
<td>Hydrotection Product</td>
<td>Flexterra</td>
</tr>
<tr>
<td>Mulch Application Rate</td>
<td>3500</td>
</tr>
<tr>
<td>Mulch Cost Per Unit (USD)</td>
<td>45.00</td>
</tr>
</tbody>
</table>

### Project Information

<table>
<thead>
<tr>
<th>Project Size</th>
<th>9.14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres</td>
<td>338.260.37</td>
</tr>
<tr>
<td>Square Feet</td>
<td></td>
</tr>
<tr>
<td>Working Capacity</td>
<td>3,000.00</td>
</tr>
<tr>
<td>Hydrotec Size</td>
<td>3,500</td>
</tr>
<tr>
<td>Gallons</td>
<td></td>
</tr>
<tr>
<td>Mulch Application Rate</td>
<td>26.67</td>
</tr>
<tr>
<td>Total Hydrotec Tanks</td>
<td>$36,845.74</td>
</tr>
</tbody>
</table>

### Mulch

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Total Amount Required</th>
<th>Total Units Required</th>
<th>Product / Tank Load</th>
<th>Cost Per Unit (USD)</th>
<th>Total Cost (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexterra</td>
<td>32,000.02</td>
<td>640.00</td>
<td>Bags</td>
<td>$45.00</td>
<td>$28,800.02</td>
</tr>
</tbody>
</table>

### Dry Amendments

<table>
<thead>
<tr>
<th>Product</th>
<th>Application Rate</th>
<th>Cost Per Unit (USD)</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioPrima</td>
<td>40</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Neutral Lime Dry</td>
<td>160</td>
<td>20.00</td>
<td></td>
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</tbody>
</table>

### Liquid Amendment

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Total Amount Required</th>
<th>Total Units Required</th>
<th>Product / Tank Load</th>
<th>Cost Per Unit (USD)</th>
<th>Total Cost (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JumpStart</td>
<td>91.43</td>
<td>36.57</td>
<td>Bottles</td>
<td>$100.00</td>
<td>$6,562.86</td>
</tr>
</tbody>
</table>

### Fertilizers / Seed / Other

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Application Rate</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>SlopeMaster Seed Mix</td>
<td>7 lb/1000 sq ft</td>
<td>Delete</td>
</tr>
</tbody>
</table>
#5 – Inspection and Maintenance

- Inspection by qualified professionals whose expectations are consistent with installer as well as owner and regulatory entity(s)
- Initial inspections to insure installations are in accordance with plans/specs with material quantities and activities fully documented
- Subsequent inspections conducted at predetermined time intervals and maintenance activities conducted after each significant precipitation or other potentially damaging weather event
Is Everyone on the Same Page?

General Installation for Slopes and Channels Used for Futerra 7003, 7010, 7020 and R45 Series

These suggestions represent generally accepted procedures for successful installation of Futerra Turf Reinforcement Mats (TRMs). These instructions may be modified, or rejected by the owner, engineer, contractor or their representative since they, not Profile, are responsible for planning and executing procedures appropriate to a specific application.

Futerra TRM is packaged in rolls that are easy to ship, store and install. No heavy equipment is needed for installation of matting: a roll can be handled by one or two workers.

1. Site Preparation: Whether slope or channel, the site must be shaped to the design specifications (grade geometry, density of soil, etc.) and then dressed to be free of soil clods, clumps, rocks, or vehicle imprint of any significant size that would prevent the Futerra TRM from lying flush to surface contours.

2. Anchor Trench: Anchor trenches are required to securely fasten the Futerra TRM to the ground surface. In channel applications, the initial anchor trench is installed at the beginning of the channel and intermediate check slots are spaced at approximately 7.6 m intervals downstream depending on flow conditions and whether you soil fill or not. Futerra TRM is installed into the bottom of the trench and fastened with pins spaced 0.9 meters apart. The anchor trench/intermediate check slots are then backfilled and compacted in a manner as to not damage the Futerra TRM.

   * In lieu of excavated check slots, a double row of pins (or a number 1 or 2 rebar pinned across the mat) may be used at 7.6 m intervals.

3. Futerra TRM Installation: Roll TRM down the slope or channel. The overlap between rolls is a minimum of 100 mm. The splice between roll ends is a minimum of 60 cm. Shingle the roll in the direction of water flow. Install pins down the center of each 2.44 meter wide mat staggering them between the outside pins with a spacing interval of 0.9 to 1.5 meters. Pins patterns will vary depending upon application, soil type, slope or channel slope, geometry, etc. A rule of thumb for estimating the amount of pins required for a project is:

   1H:1V to 2H:1V slopes
   4-5 pins per m²

   <3H:1V slopes
   3-4 pins per m²
Chrome mill tailings are acidic and contain no organics or nutrients.

Surface temperatures reach 63°C (145°F).
The Integrated Approach

- Prescriptive biological soil treatment hydraulically-applied at 8,000 kg/ha (7,142 lb/ac)
- Organic matter – composted manure
- Humic and fulvic acid
- Microbial cultures
- Slow release soft rock phosphate
- Lime applied at 2,240 kg/ha (2,000 lb/ac)
- Slope roughening to slow surface runoff, increase infiltration, and create pockets for germination and growth
The Integrated Approach

Transvaal Highveld Mixture
Prescriptive seed mix – “The Big Five”

• *Eragrostis tef* – “Teff“
• *Eragrostis curvula* – Weeping lovegrass/Oulandsgras
• *Digitaria eriantha* – Smutsfinger grass/Common Finger Grass
• *Chloris gayana* – Rhodes grass
• *Cynodon dactylon* – Bermuda or kweek grass
  and
• *Anthephora pubescens* – wool grass
• *Cencus ciliaris* – blue buffel grass/bloubuffelgras
Erosion Control Material

- Flexible Growth Medium
  - To resist heavy downpours
  - Facilitate growth establishment
  - Long dry season – functional longevity > 1 year
- Hydraulically-applied at 3,600 kg/ha (3,214 lb/ac) on 2H:1V slopes, 8 - 10 meters high
- Two-step application
  - Step one – amendments, seed mix and tracer
  - Step two – flexible growth medium from two directions
January 2012
3 weeks growth
June 2012
6 months later
February 2013
14 months later
Nickel Mill Slag
Remediation Project
Sudbury, Ontario, Canada
The Integrated Approach – Soil Test

- Slag – highly acidic, low in organic matter and nutrients
- 46 cm (18 in) clay cover specified
- 61,164 m$^3$ (80,000 yd$^3$) of clay
- Lime, synthetic fertilizer and biostimulants applied directly on clay cover
The Integrated Approach – Seed Mix

• Grasses – perennial ryegrass, Canada bluegrass, timothy, red top, hard fescue, creeping red fescue, meadow fescue, chewings fescue
• Legumes – alsike clover, red clover, white clover, birdsfoot trefoil
• Applied at 252 kg/ha (225 lb/ac)
Erosion Control Material

• Flexible Growth Medium
• Hydraulically-applied at 5,100 kg/ha (4,500 lb/ac) on 3H:1V slopes, 30 meters long
• Late fall dormant seeding
• Cat tracked (dozer walked) slopes
• Fiber filtration tubes for slope interruption
• Two-step application
  • Step one – amendments, seed mix and tracer
  • Step two – flexible growth medium from two directions
Sudbury, Ontario
October 2006
March 2009

Power Generation Site
Flexterra® HP-FGM, 20-20-20 fertilizer & agronomic formulations including NeutraLime™, JumpStart™ and BioPrime™
Coal Ash with 15 cm (6 in) Soil Cover

Slopesmaster™ Seed Mix
K 31 Tall Fescue
Red Top
Hulled Bermuda
Weeping Love Grass
Durana White Clover
Red Clover
Millet
July 2009
4 months later
16 months later – Sustainable Vegetation!
In Conclusion

• Five Fundamentals
  • Test the soil or substrate to understand your “foundation”
  • Pick plant materials compatible with project goals
  • Select cost effective erosion control measures
  • Insure proper installation
  • Coordinate Inspections & Maintenance to insure success

• Fundamentals must be integrated into a working process that entails proper planning and execution
Questions?
High Elevation Site
High Elevation Site
High Elevation Site