The Icing on the Cake

Revegetation on the Flat Creek Iron Mountain Mine Superfund Site

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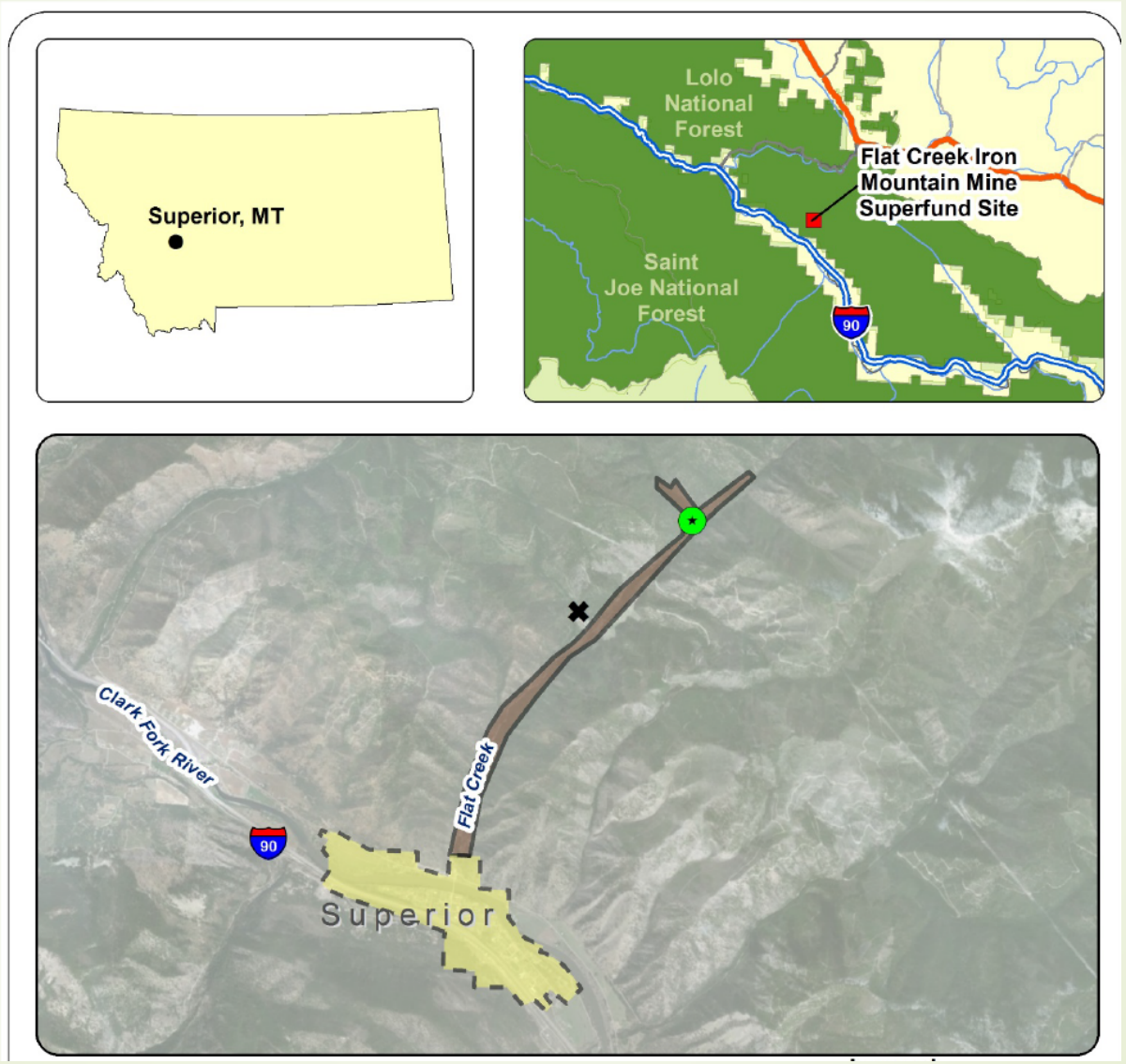
Today

- History of the Iron Mountain Mine Superfund Project
- Operating Unit 2 Revegetation
  - Goals
  - Process
  - Outcome
- Lessons Learned

Iron Mountain Mine



Iron Mountain Mine

- Silver, Gold, Lead, Copper and Zinc
- Operated from 1909 – 1930 and again 1947 – 1953
- All that remains
  - Tunnels
  - Tailings
  - Discharging Adit
  - Mill Remnants and other buildings

Iron Mountain Mine

- The issue begins

Iron Mountain Mine – Flash Forward

- Mine operations produced tailings and soils contaminated with heavy metals
- During operation tailings had been disposed of along Flat Creek (source of Superior's drinking water) using gravity drainage which washed tailings all the way to the Clark Fork River
- Mine waste was also used as fill in Superior
  - Yards
  - Roadways
  - School Track
  - Fairgrounds

Iron Mountain Mine – Flash Forward

- 2000 Forest Fire triggered a large runoff event furthering contamination
- EPA assessment 2001
- Listed on EPA National Priority List in 2009
- Site Divided into three Operating Units (OU's)
  - OU1 Town of Superior
  - ***OU2 Flat Creek Watershed***
  - OU3 Wood Gulch Mine Waste Repository

Iron Mountain Mine – Flash Forward

- Removal and remediation began in 2002 on OU1 due to results of assessment
- This removal continued off and on into 2012
- OU2 – Flat Creek Drainage was priority 2
- Cleanup of contamination completed in 2018
- We were called in prior to seeding of OU2 to consult on revegetation efforts.

Flat Creek OU2 Project – Contaminated soils removed where possible and remaining contamination capped with imported soils

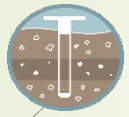
Flat Creek OU2 Restoration - Partners

- CDM Smith - Engineers
- ACF West - Distributors
- Profile Products – Consultant and Supplier
- Potter Frame Enterprises - Contractor

Flat Creek OU2 Project – Goals

- Stabilize new soils with vegetation
- Begin restoration of stream corridor to native condition

Flat Creek OU2 Restoration - Process



Create Optimal Soil Conditions

Pick the Right Plant Species

Select the Correct Erosion Control Material

Ensure Proper Installation

Follow-up Inspection and Maintenance Practices

Soil Test Results

Sample	% Organic Matter	Soil Respiration mg CO2/kg soil/week5	Sand %	Silt %	Clay %	Texture USDA
1	1.1	Not Tested	9.2	80.8	10	Silt
2	0.9	Not Tested	11.2	80.8	8	Silt
	(> 5%)	(> 1,000)	(20 - 60%)	Silt & Clay (40 - 80%)		

Sample	Soil pH6	Buffer Index	TDS7 ppm	Soluble Salts mmhos/cm	Sodium ppm	SAR8	g/cm3	oz/in3
1	8.2	7.5	192	0.3	16	0.53	1.26	0.73
2	8.2	7.5	204.8	0.32	16	0.67	1.19	0.69
	(6.3 - 7.3)		(<256)	(< 0.75)		(<2)		

Flat Creek OU2– Challenges

- Imported Soils
  - Low Organic Matter
  - High Silt Content
  - Moderately high pH

Prescription

- Biotic Soil Media (BSM) 3,500 lbs./acre
  - To address low Organic matter and biological activity
- BioAmendments and Organic Slow Release Fertilizer
  - Provides Nutrients, Mycorrhizae, Humic Acid, Beneficial Soil Bacteria and Cytokinins
- Custom Seed blend
  - 20% Slender Wheatgrass
  - 15% Bluebunch Wheatgrass
  - 10% Sandberg's Bluegrass
  - 20% Idaho Fescue
  - 20% Mountain Brome
  - 10% Streambank Wheatgrass
  - 5% Sterile Wheatgrass
- Engineered Fiber Matrix (EFM) 3,000 lbs./acre

BSM, Amendments, Fertilizer and Seed Application

Organic Matter & Biological Activity

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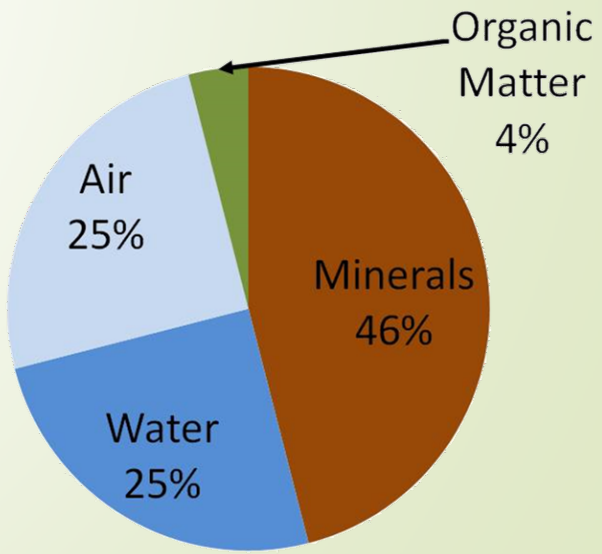
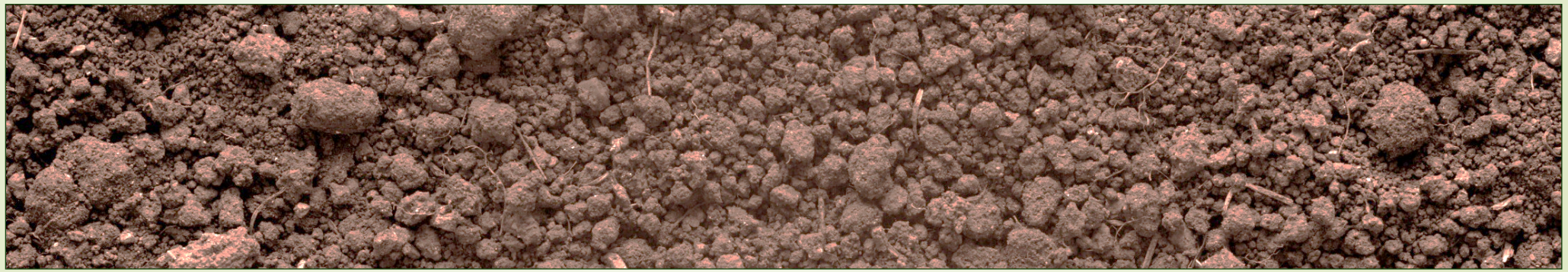
	(> 5%)	(> 1,000)	(20 - 60%)	Silt & Clay (40 - 80%)		

- Organic Matter (OM) is the foundation for all biological life in the soil
- Key words in the OM foundation is "Biological Life"
- Without biological life, the OM is not capable of building a solid foundation



Typical Biotic Media Composition

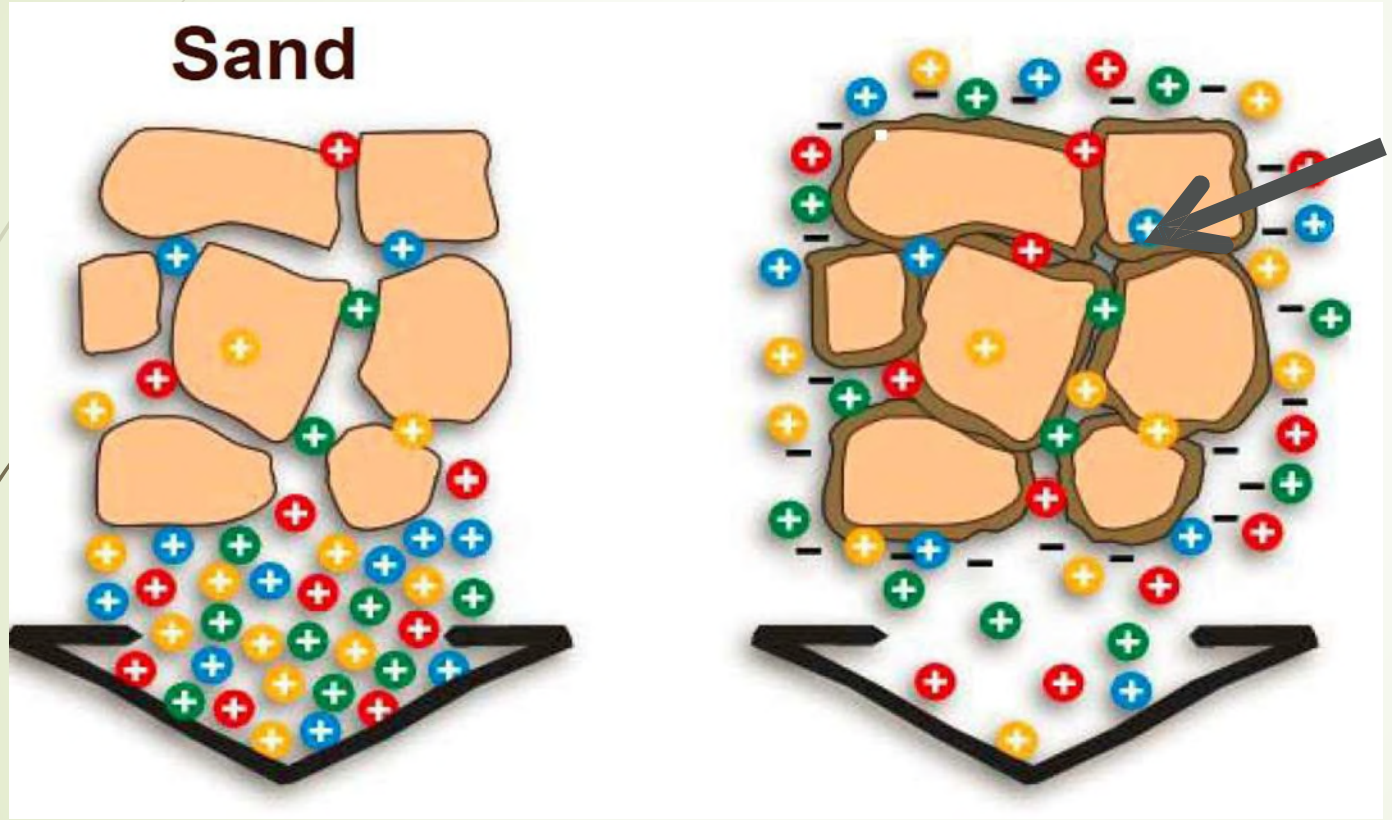
- **Bark and Wood Fibers** – provides organic matter, high moisture retention for fast germination
- **Biochar** – **Bio**logical **Char**coal derived from pyrolysis of wood sources – to create stable, porous particles that demonstrate a high Cation Exchange Capacity, a high ability to hold water and nutrients, and act as prime habitat for beneficial bacteria and fungi
- **Proprietary Formulation of Fast-Acting and Sustained Release Soil Building Components Containing Seaweed Extract, Humic Acid , Endo-mycorrhizae and beneficial bacteria** — grows vegetation quickly and have been proven under demanding conditions in a wide variety of environments over the planet



Humic Acid

- Helps break up clay and compacted soils
- Enhances soil water retention
- Improves root development and penetration through soil
- Improves transfer of macro & micronutrients
- Stimulates the development of micro-flora populations

Humic substances increase Cation Exchange Capacity (CEC)



Poor CEC
Low Humus

Good CEC
High Humus

Picture by *Michael Martin*

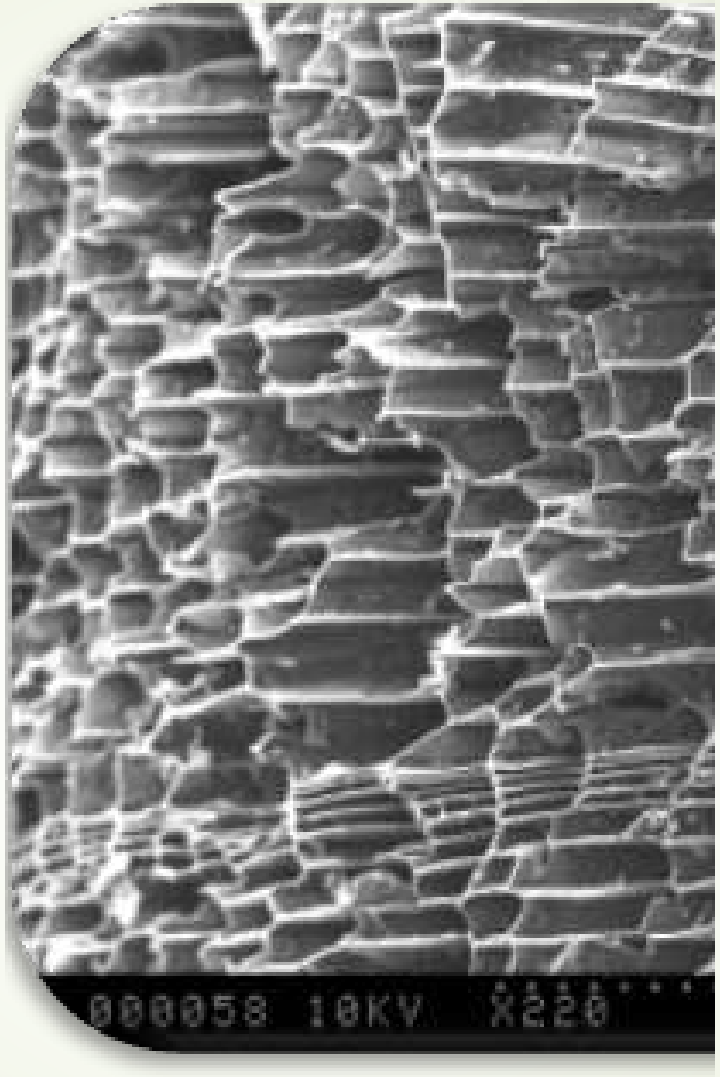
Seaweed Extract

- Contains plant hormones cytokinins, auxins and gibberellins
  - Promotes the development of roots and shoots
  - Leading to a healthier stand of vegetation
  - Greater resistance to stress
  - Improved seed germination
  - Increases fertility of soil and restores soil health

http://www.tipdisease.com/2015/04/kelp-ascophyllum-nodosum-overview.html

Biochar

- **Bio**logical **char**coal used for agricultural purposes
- Pyrolysis involves heating biomass, such as wood, in a low oxygen environment with temperatures ranging from 400° - 800° C.
- Amazingly large surface area of ~500 m^2 per gram
- High Cation Exchange Capacity (CEC)
- Biochar is extremely resistant to decomposition and remains in the soil hundreds to thousands of years



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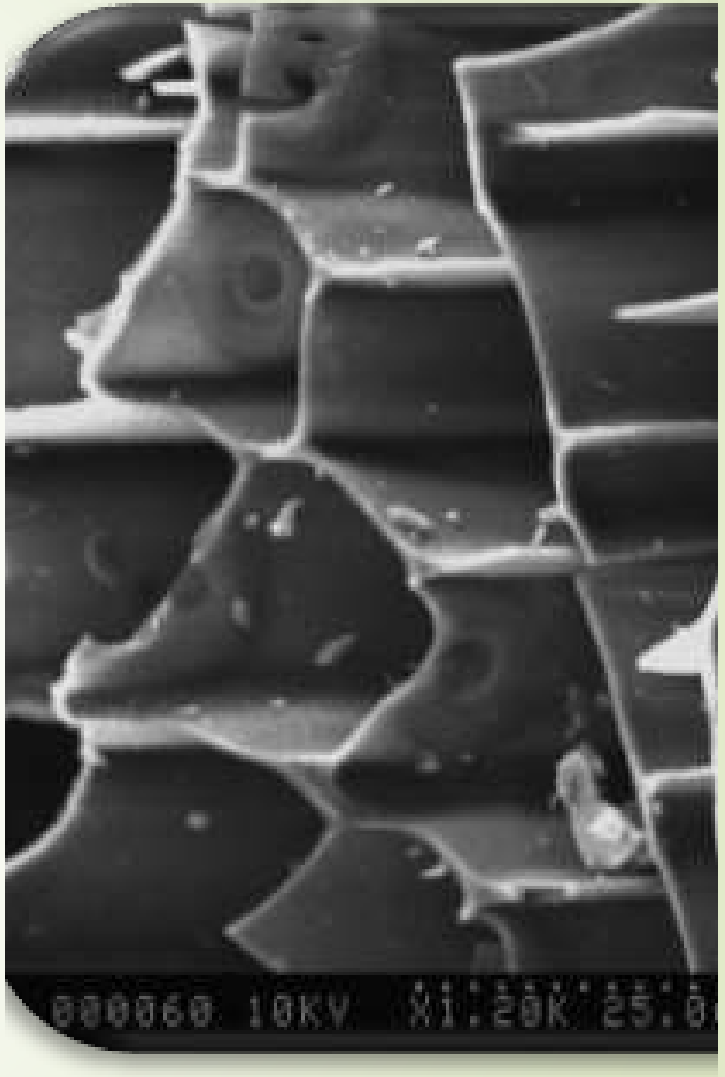

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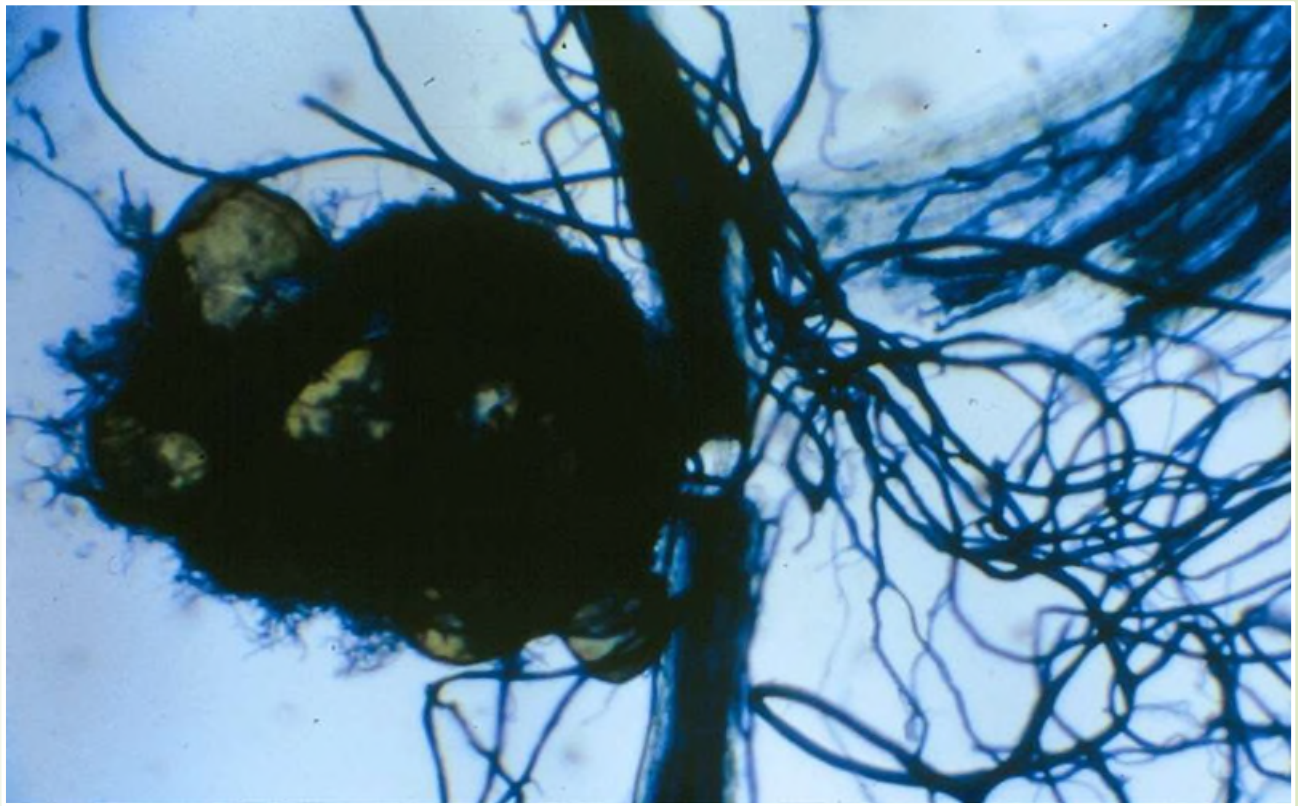
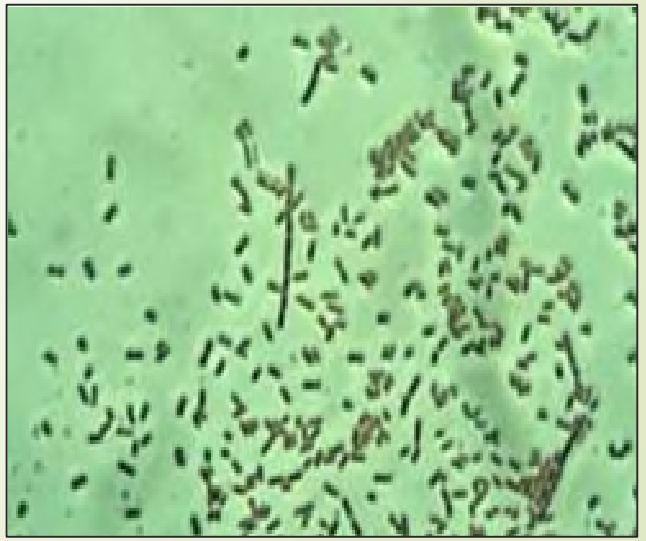
Biological Activity- Endomycorrhizae

- Forms a symbiotic relationship with the plant
  - Vegetation supplies food, carbohydrates, vitamins and amino acids
  - Fungi supplies water, macro & micro nutrients.



Biological Activity- Beneficial Bacteria

- Nitrogen Fixation
  - Some bacteria are able to source and solubilize a variety of nutrients, making them available for plant uptake
- Plant Hormone Production
  - Specialized strains can synthesize a variety of hormones that encourage plant development
- Prevention of Toxicity interference
  - Some synthesize metal binding molecules
- Reduced disease/pathogen presence
  - Synthesis of Antibiotics
  - Production of beneficial enzymes
    - Fungal cell wall degradation



How Does Biotic Media Build Healthy Soils?

- Short term — improves soil chemistry and water holding capacity. Promotes early vegetation establishment.

- Long Term —improves:

✓ Soil structure / texture

✓ Organic matter

✓ Biological activity - nutrient cycling

Soil Nutrients

Sample	Nitrate N ppm	Phosphorus ppm	Potassium ppm	Magnesium ppm	Calcium ppm	Sulfur ppm	Zinc ppm	Manganese ppm	Copper ppm	Iron ppm	Boron ppm
1	1	31	148	411	3434	6	3.2	5.1	1.1	38.5	0.2
2	1	30	149	407	3307	6	3.3	4.6	1.1	31.7	0.2
	(10 - 30)	IF pH ≤ 7.1 (20-40) IF pH > 7.1 (10-25)	(150 - 250)	(60 - 300)	(≥ 400)	(5 - 20)	(1.3 - 3.0)	(4.1 - 12.0)	(1.0 - 2.0)	(7.1 - 20.0)	(< 2.0)

- Macro Nutrients
  - Nitrogen – Supports Shoot Growth
  - Phosphorous – Supports Root Growth
  - Potassium – Supports overall plant health
- Micronutrients
  - Magnesium / Calcium / Sulfur
  - Many others

Soil Nutrients

	Crop Yield or Turf / Ornamental Code	Gypsum		Sulfur		N		P_2O_5		K_2O	
Sample		lb/ac	kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac	kg/ha
1	TURF	0	0	0	0	126.3	141.6	0.4	0.5	65.3	73.2
2	TURF	0	0	0	0	130.7	146.5	0.4	0.5	65.3	73.2

- More is not always better
  - Recommendations vary by species; these recommendations are for fine turf
  - Fine turf has higher needs than native species
  - High rates of nutrient availability can cause issues with native species
- Fertilizer type and timing are critical
  - Seeding timing
  - Ag based versus Slow release or Organic Fertilizer

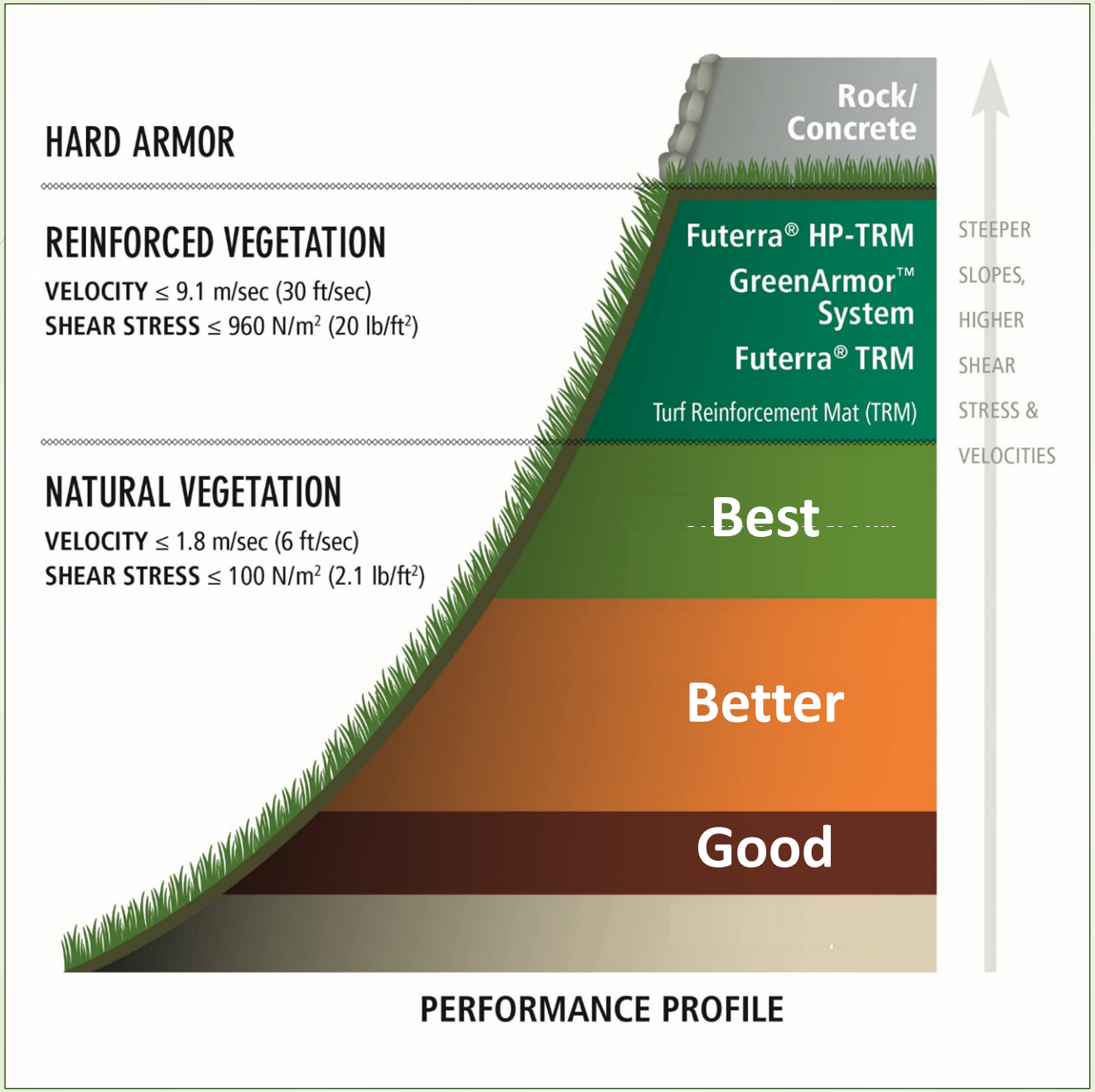
Alkaline Soils – Seed Selection

NATIVE GRASSES

ALKALI GRASS

Variety	Key Features	Growth Habit	Flood Tolerance	Drought Tolerance		Salt Tolerance	Soil pH	Soil Type	Approx. Seeds/lb	Canopy Mature Height
Alkaligrass (introduced) (Puccinellia distans)	- Introduced species - Very salt tolerant	Rhizomatous	Good	Good		High	Basic to Neutral	Moderately Fine, Moderately Coarse	1,200,000	12"-24"
Inland Saltgrass (Distichlis spicata)	- Useful salt-tolerant native grass - Nesting grounds for birds	Rhizomatous	Excellent	Poor		High	Saline to Alkaline	Moderately Fine to Medium	520,000	12"-24"

Protecting Stream, BSM and Seed with EFM



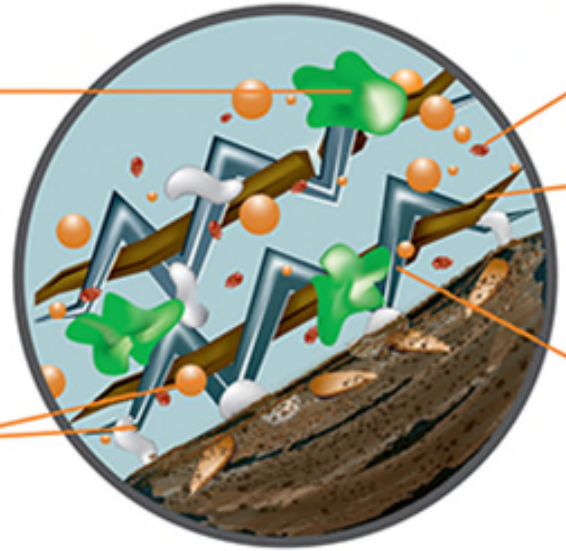
Increasing Erosion Potential

BETTER – HECP for moderate sites and conditions

Unique to this technology:
Proprietary Dispersion Granules:
Ensure the chemistry is thoroughly mixed and uniformly distributed

Effectively contribute to smooth, even shooting, which speeds application

100% non-toxic biopolymers and water absorbents further enhance performance



Advanced Micro-Pore particles optimize water and nutrient retention

100% recycled Thermally Refined® wood fibers that not only produce the highest coverage per pound, they are also phyto-sanitized, eliminating weed seeds and pathogens

100% biodegradable interlocking crimped fibers to help increase strength and matrix durability

Performance Comparison

Slope Gradient

Estimated Time to Establish Vegetation

Channel / Overland Flow Sites

Hydraulic Shear or Velocity

Soil Amendments, Tackifiers, and Mulch Amendment

Product	Erosion Control Effectiveness	Functional Longevity	Vegetation Establishment	Max Slope Gradient	Docs	
ET-FGM	≥ 99%	≤ 24 months	≥ 500%	≤ 0.25:1	CSI Specs Data Sheet Drawing	Learn More
HP-FGM	≥ 99%	≤ 18 months	≥ 800%	≤ 0.25:1	CSI Specs Data Sheet Drawing	Learn More
EFM	≥ 95%	≤ 12 months	≥ 600%	≤ 2:1	CSI Specs Data Sheet Drawing	Learn More
Wood with Tack	≥ 75%	≤ 3 months	≥ 250%	≤ 3:1	CSI Specs Data Sheet Drawing	Learn More

Protecting the Stream, BSM and Seed with EFM

Early Emergence at Four Months

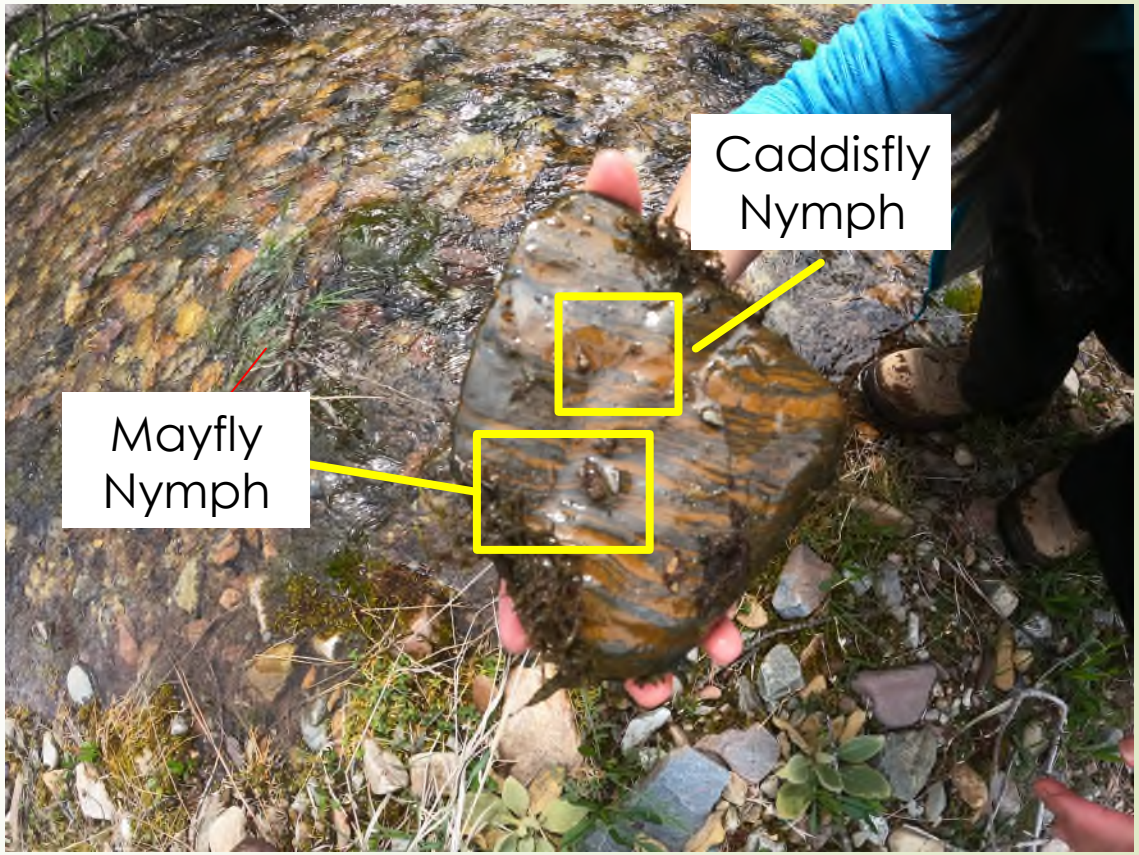
One year after installation – strong establishment of permanent seed blend


One year after
installation
Solid root development

Three years after installation Thriving vegetation

- Great establishment on very low organic matter soils
- BSM and EFM teamed to provide excellent erosion control on these highly erodible soils.

Stream Health



Best practices –
To get the *Icing on The Cake!*

- Test your soils and amend as needed
- Choose the correct seed blend
- Prepare the site correctly – decompact!
- Install properly with the correct HECP's
- Follow up visit to assess and correct any issues

Questions?

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