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# **Biotic Soil Technology for Sustainable Erosion Control and Revegetation**

**TRIECA Conference**

**March 21, 2018**

**Brampton, Ontario, Canada**

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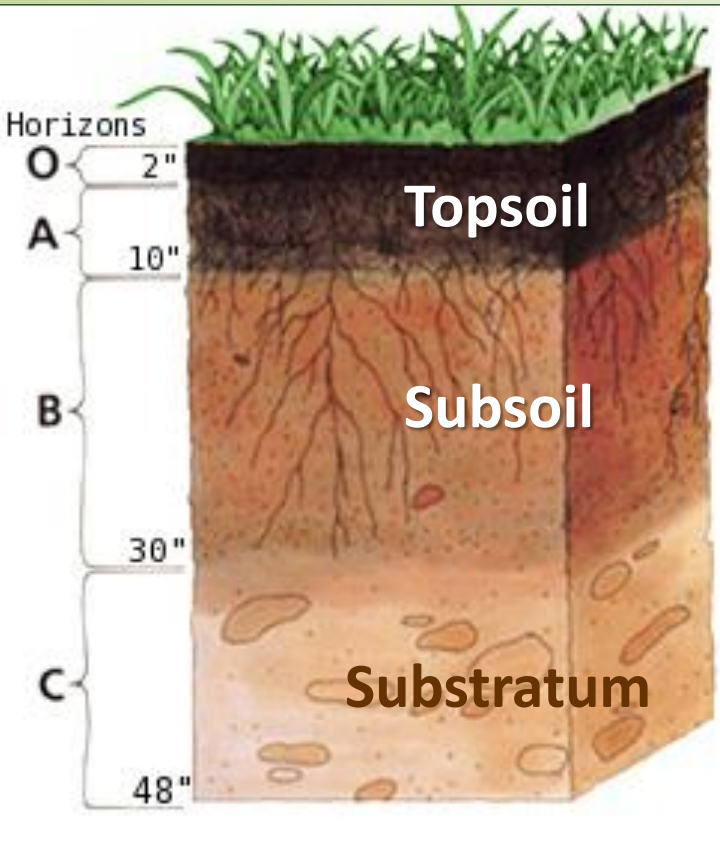
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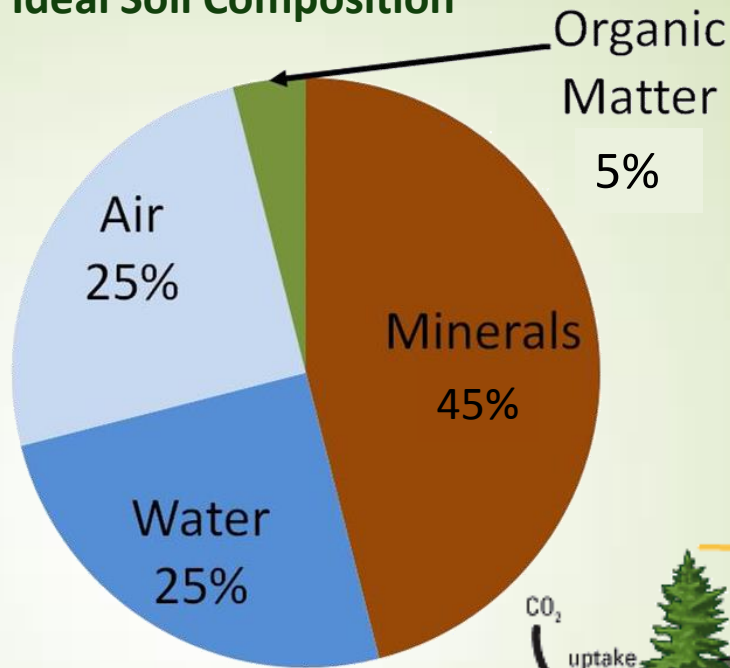
# Presentation Overview

- The need for topsoil and other agronomic assets to increase soil organic matter
- What is **Biotic Soil Technology (BST)**?
- What goes into BST materials, how do they work, and when/where to use them?
- Case Studies
- Discussion

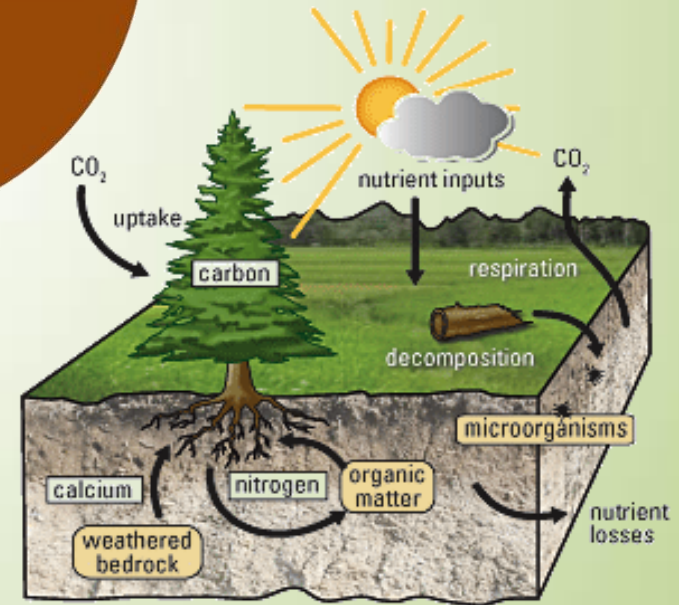
# Ideal Soil Profile & Nutrient Cycling



Ideal Soil Composition



## Carbon Sequestration



# **“Strive for 5%” Organic Matter**

- **Improves establishment and survival of vegetation**
- **Improves soil structure** to better accommodate drainage and increases water retention
- **Improves resistance to water and wind erosion**
  - Creation of pore spaces
  - Enhancement of soil aggregation (through microbial activity)
- **Reduces need for chemical based inputs**
  - Fertilizers, pesticides, herbicides and more
- **Improves rain/stormwater absorption and infiltration**
- **For every 1% increase in organic matter, water-holding capacity increases by 150,000 to 250,000 L/Ha** – depending on soil type (USDA NRCS 2013)

# How Do I Increase Organic Matter Content in My Soil?

- Topsoil
- Compost
- Peat Moss
- Wood chips, sawdust, straw, manure, biosolids, etc.
- **How about Biotic Soil Technology?**

# Biotic Soil Technology (BST)

- **Generic term** to describe **manufactured growth media** or “**engineered soils**” containing recycled biodegradable fibers, biostimulants, biological inoculants and other amendments
- Designed to promote **regeneration of denuded soils** and accelerate **sustainable vegetative establishment**
- Why **import “topsoil”** when **you can build a soil** in place?

# **Biotic Soil Technology (BST)**

**Descriptors or Categories** include:

- Biotic Soil Amendment (BSA)
- Biotic Soil Media (BSM)
- Engineered Soil Media (ESM)
- Hydraulic Growth Medium (HGM)
- Hydraulic Biotic Soil Amendment (HBSA)
- Organic Fiber Matrix (OFM)

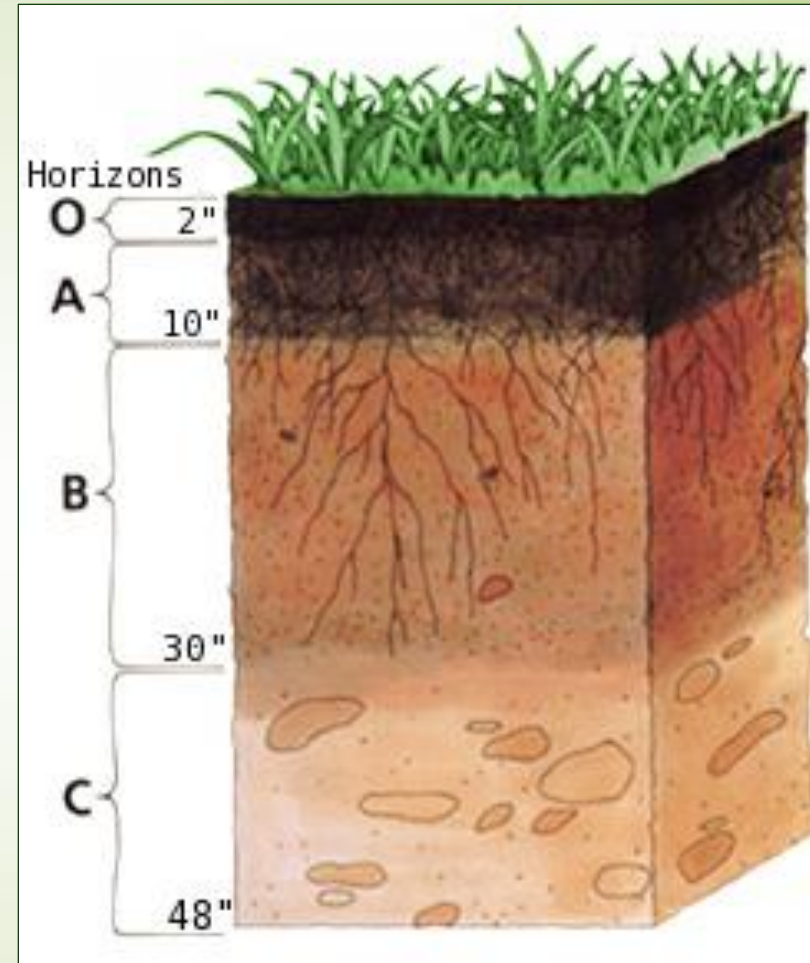


# Some Common BST Components

- **Bark and Wood, Straw, Flax, Fibers** – **phyto-sanitized** to provide organic matter, erosion resistance and high moisture retention **without weed seeds and pathogens**
- **Soil Building Components:**
  - **Porous Ceramics and Biochar** – stable, porous particles that demonstrate a high CEC, ability to hold water/nutrients & act as habitat (“coral reef”) for beneficial bacteria and fungi
  - **Beneficial Bacteria** – colonize “fresh” substrates and essential for soil processes, Nitrogen fixation, aggregation of soil particles, and maintenance of soil nutrients
  - **Endomycorrhizae** – symbiotic association of a **fungus** and plant roots to facilitate nutrient and water uptake that improves drought, disease and salinity resistance
  - **Humic Acid** – principal component of humic substances, which are the major organic constituents of soil (humus), peat and coal produced by biodegradation of dead organic matter
  - **Seaweed Extract (cytokinins)** – plant growth substances (phyto-hormones) that promote cell division or cytokinesis in plant roots and shoots
- **Cross-linked Polysaccharide Biopolymers/Flocculants** – increase water-holding capacity, viscosity, bond strength, and **“shoot-ability”** of the media matrix

# How Do BST Work to Build Soils?

- BST improves soil **chemistry** – which later improves soil **structure/texture** with **increased organic matter and biological activity** combined with plant establishment and subsequent nutrient cycling.
- Helps O & A horizons to regenerate faster by creating a **“revegetation platform”**.
- While the soil chemistry is improving, the media provides a **more ideal growing environment**.
- Provides rapid growth establishment and sustains long-term vegetation.





# Five Weeks After BST Installation Developing an “Engineered O Horizon”



05.07.2015 22:16



# BST Soil Development



O  
A  
B



Full Development of O and A Horizons

# Typical BST Application Rates

% Organic Matter	lb/ac	kg/ha
< 0.75	5,000	5,600
$\geq 0.75$ to <1.5	4,500	5,040
$\geq 1.5$ to <2.0	4,000	4,480
$\geq 2.0$ to <5.0	3,500	3,920

- Always conduct a soil test to determine agronomic needs.
- Soils with organic matter >5% typically do not require BST.
- Depending on the test results, it is typically advisable to apply fertilizer, pH neutralizers and/or additional biostimulants with BST.

# BST Advantages

- **Engineered and manufactured under highly controlled conditions** to ensure consistency in each and every bale of material provided.
- The material **can be placed faster** and more uniformly through **standard hydraulic seeding/mulching equipment** with no dust or potential for wind erosion.
- **Seed, fertilizer and other soil amendments** may be **applied in the same hydraulic slurry saving time and improving worker safety** due to less exposure to jobsite hazards or traffic.
- May be **applied in wet or freezing temperatures** and **require minimal soil preparation**.
- Designed to **complement** and **bond with hydraulically-applied erosion control products**.

# Mixing and Application

- **Pre-packaged bales** mixed with water, seed, fertilizer, amendments and other components
- **Applied below** hydraulically-applied or rolled erosion control products, blown straw or **even sod**
- **Complements performance** of hydraulically-applied erosion control products such as Flexible Growth Medium



Quick and Easy Loading



Consistent Slurry



Smooth Shooting



**Canoe Journeys  
Nisqually Tribe  
Olympia, WA**



**Convenient application of Biotic Soil Media,  
biostimulant, seed, and fertilizer in one pass  
< 4 tank loads/ha with 3,000 gallon machine**



# Norway House Baseball Diamond Project

Norway House, Manitoba

53.9821° N, 97.8329° W



# Baseball Diamond Renovation

## Norway House, Manitoba

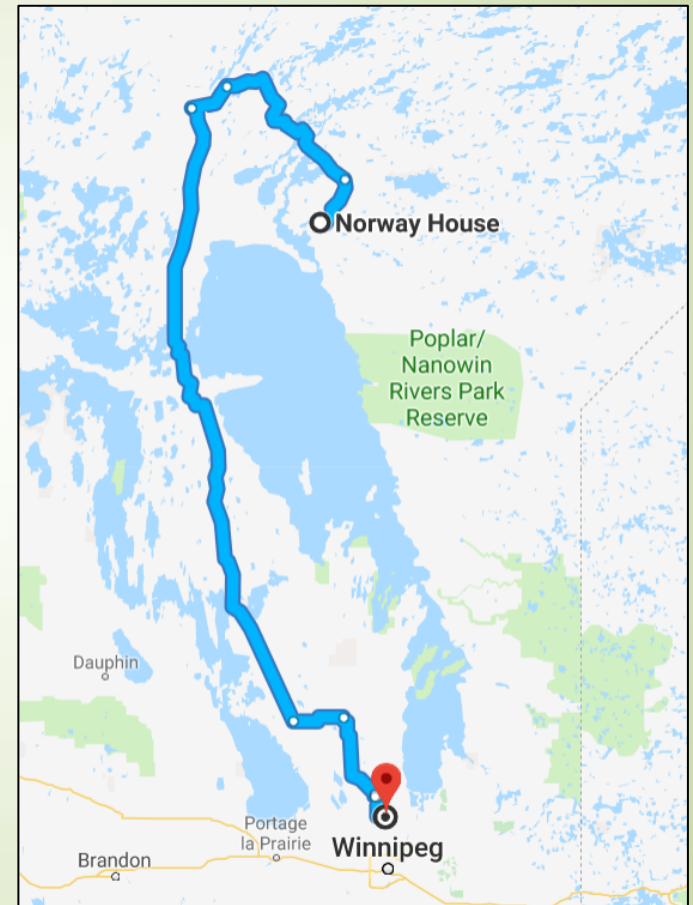
- Specifications called for:
  - Kentucky Bluegrass/Fescue blended sod
  - 10 cm of topsoil below sod over existing substrate
- Very short growing season with full establishment required for following season



# Baseball Diamond Renovation

## Norway House, Manitoba

- Nearest Topsoil and Sod Source – Winnipeg 796 km
- Hauling costs for both materials were extreme
  - Blended “Topsoil” near site was being considered
- BST was proposed as an alternative to “Topsoil”
  - Soil Sampling/Testing Initiated



# Blended “Soil” Option



Blend “Soils” and/or Compost to Create...



“Manufactured” Soils

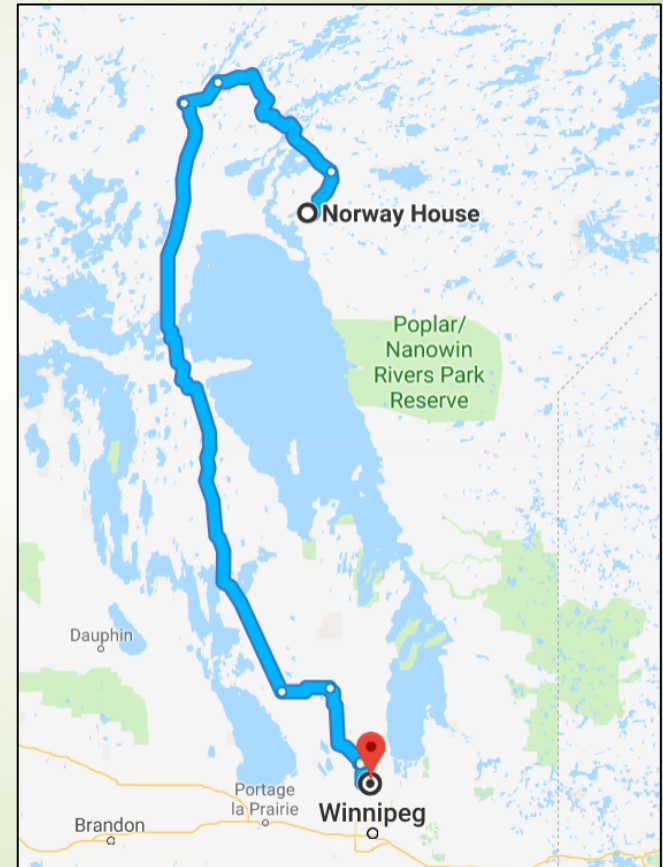




# Baseball Diamond Renovation

## Norway House, Manitoba

- Other Potential Costs:
  - Removal of existing substrate before topsoil application to reach final grade
  - Labor costs
  - Speed of Installation
  - Maintenance



# Soil Test – June 6, 2016

Sample (#)	Aqua-pHix™ (gal/acre)	NeutraLime™ <sup>3</sup> (lb/acre)	JumpStart™ (gal/acre)	BioPrime™ (lb/acre)	Soluble Gypsum (lb/acre)	ProGanics™ BSM (lb/acre)
1	10	0	3.75	120	---	4500
2	10	0	5	160	---	5000

## SOIL ANALYSIS RESULTS

Sample (#)	Texture (USDA)	Sand (%)	Silt (%)	Clay (%)	Soil pH (6.3 - 7.3)	TDS <sup>1</sup> (ppm) (< 256)	SAR <sup>2</sup> (< 2)	Organic Matter (%) (3 - 5%)	CEC % Sodium <sup>4</sup> (%) (< 2%)
1	Clay	29.2	20	50.8	8.1	371.2	0.63	1.3	0.6
2	Sand	95.2	0.01	4.8	8.5	134.4	0.4	0.3	0.3

# Typical BST Application Rates

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< 0.75	5,000	5,600
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- Always conduct a soil test to determine agronomic needs.
- Soils with organic matter >5% typically do not require BST.
- Depending on the test results, it is typically advisable to apply fertilizer, pH neutralizers and/or additional biostimulants with BST.

# Installation Completed July 1, 2016

- BST – 5,600 kg/ha
- 18-24-12 Fertilizer
- Gypsum Supplement
- Sod – Kentucky Bluegrass/ Fescue Blend





# Placement of Sod over BST



# Outstanding Results

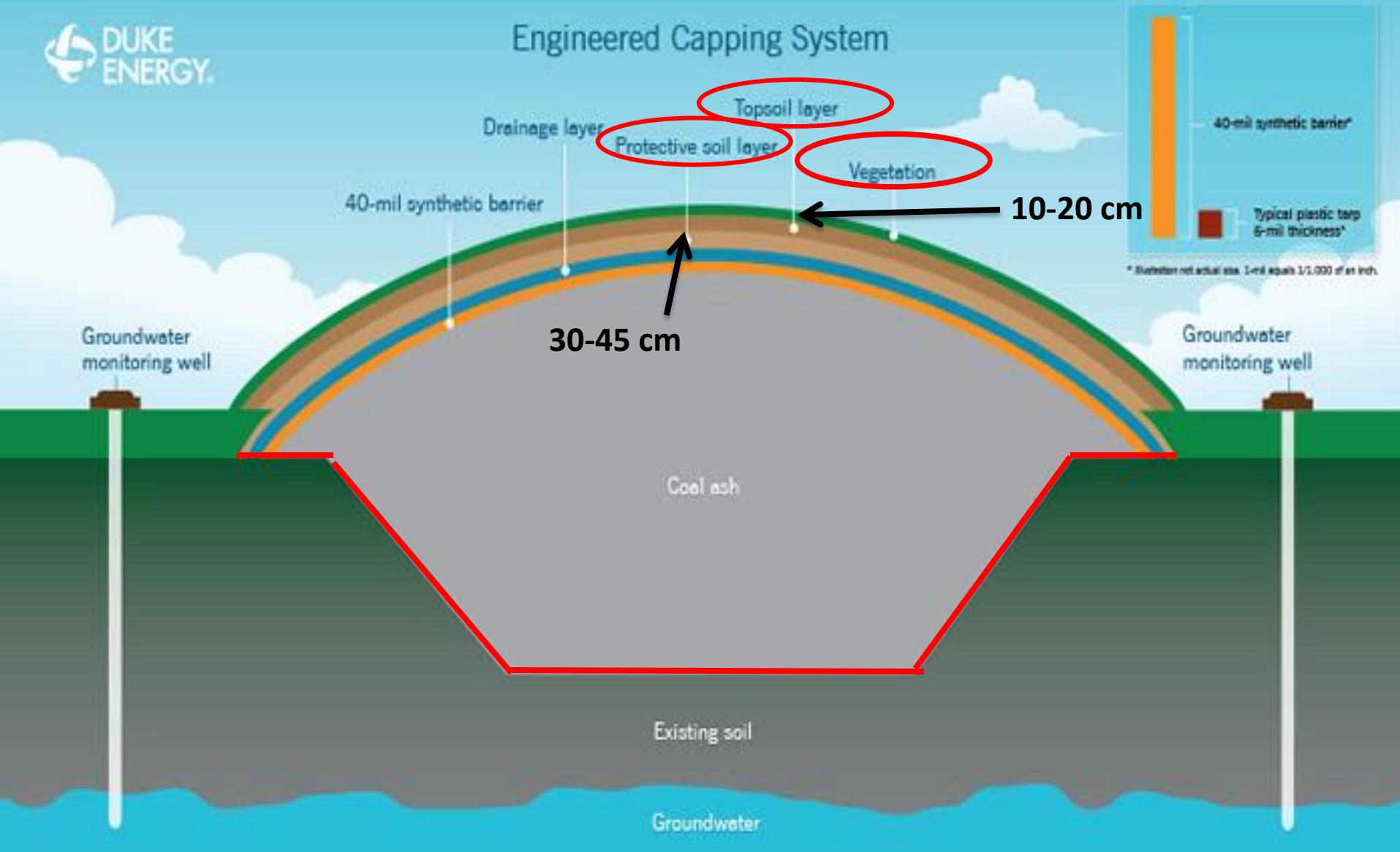
- Field received heavy use starting in April 2017, performing well and thriving after 12 months
- Great root development into native soil layers



# Coal Ash Closure Capping System



## Engineered Capping System



# Cover System Comparison (10 hectares)

- Topsoil costs at 150 mm specified depth:
  - \$13.00 m<sup>3</sup> delivered for 1,500 m<sup>3</sup>/ha
  - \$10.00 m<sup>3</sup> to spread 100 truckloads of soil/ha
  - ~ \$35,300/ha
- BST costs:
  - ~ \$19,000/ha applied w/ seed/fertilizer/amendments
- Total Cost savings ~ \$160,300 = 54%  
And a Dramatic decrease in installation time!



# BST Application on Cover System





# Flexible Growth Medium “Cap”





**Three Weeks Later!**





# BST Provides Solution at “Lunar” Quebec site

Thetford Mines, Quebec





# August 2016







**Rebuilding a deficient substrate**



# September 2016



# Fall 2017





# Central America Copper Mine

## Site Conditions:

- Tropical with rolling terrain
- Precipitation typically abundant and very heavy rainfall can occur during wet season
  - 2014 ~ 6 m (236 in)
  - 2015 ~ 4.35 m (170 in)
  - 2016 (through August) ~ 3.5 m (138 in)
- Erosion potential – very high
- Wet season typically 8 months – May through December
- “Dry” season – January through April, but rain can occur at any time

A photograph of a steep, rocky slope covered in dark grey and black debris. The slope is composed of numerous small, angular rocks and larger boulders. At the top of the slope, there are some green trees and vegetation. The sky is overcast with grey clouds. In the foreground, there is a dirt path or road that runs along the base of the slope.

# **Rock Debris Slope**

## **September 16, 2015**



# BST Application September 16, 2015



# FGM Application

## September 16, 2015





**Two Months Later**  
**November 18, 2015**





# March 2016 – Degraded Mine Site Southeastern US



**Erosion over 10 year period**



**3 failed reclamation attempts**

# April 25, 2016



**Per soil test recommendations installed:**

- **5,600 kg/ha of BST**
- **3,920 kg/ha of HP-FGM**
- **Fast-Acting Lime**
- **Slow-Release and Fast-Acting Biostimulant additives**

**Slopes were cat tracked to:**

- **Increase soil roughness**
- **Reduce erosion potential**
- **Create pockets for germination**





# April 25, 2016



**Installation of Flexible Growth  
Medium over brown BST**



# April 25, 2016



**Drone shot of applications  
over 2 hectare site**

- **Adjacent photo show site after Tropical Storm Colin dumped 150 mm of rain on June 5-6**
- **Site showed no soil loss into lake**
- **Engineer/Owner pleased with results**





# June 2016



- **Very rapid grow in after Tropical Storm Colin**
- **Cover crop gave way to permanent seed mix**





# Mine Reclamation Complete

## October 2016

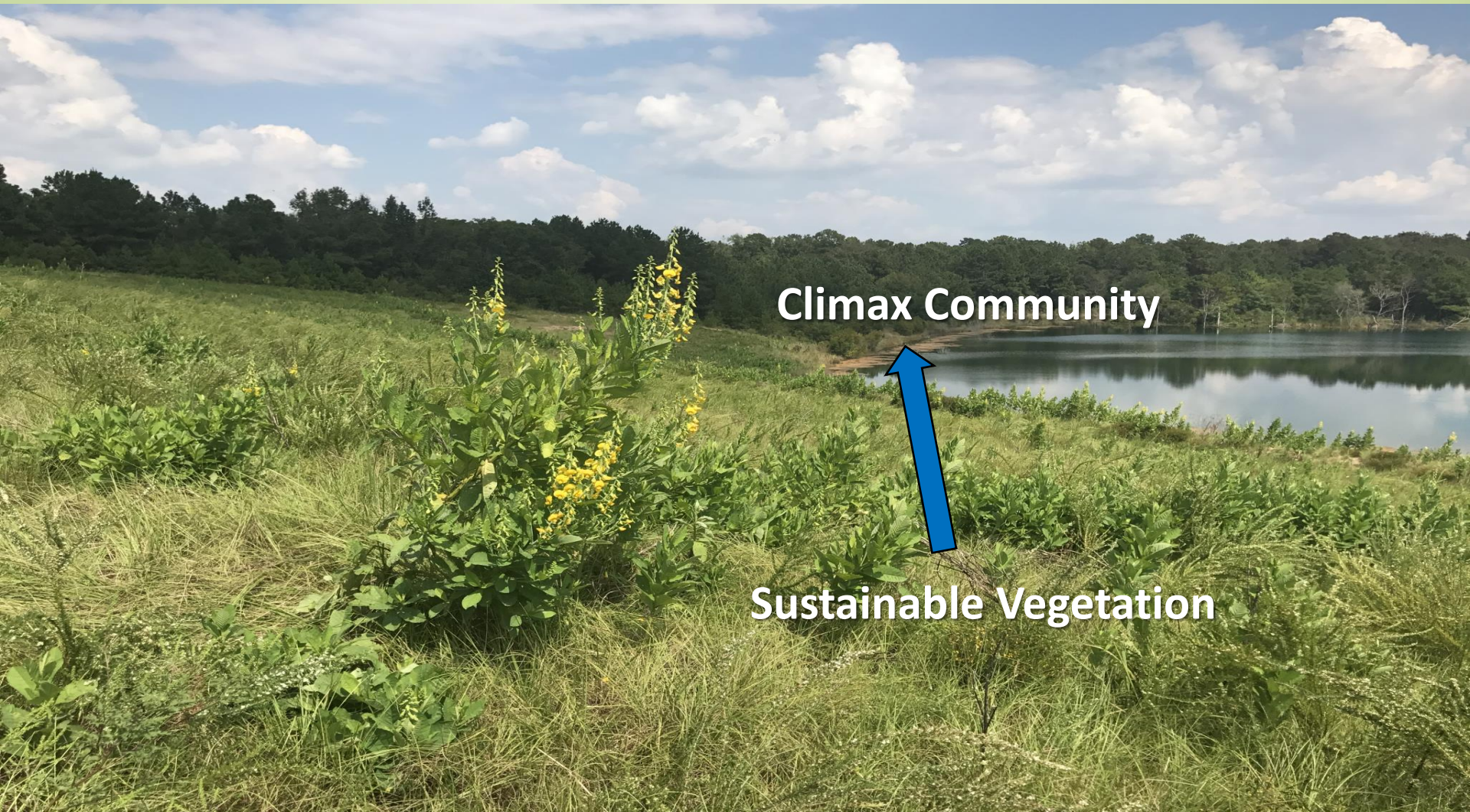


### Project Summary

- Initiated/completed final design Jan/Feb 2016
- Completed grading & re-contouring and application by end of April 2016
- Site inspection mid-August 2016 by regulatory agency
- Completed reclamation release on September 1, 2016
- < 6 months from time of construction until release



# Follow Up – September 2017



Climax Community

Sustainable Vegetation

# Mine Site Soil Test Results

## December, 2015

### Sandy Clay Loam

- Organic Matter – 0.4%
- pH – 5.0

## December, 2017

### Sandy Clay Loam

- Organic Matter – 2.0%
- pH – 5.3

# Soil Respiration

Condition	Average C-CO <sub>2</sub> (ppm)/100g/day	% Increase in Soil Respiration
Untreated Soil	17.4	n/a
BST Treated Soil	47.1	271%

- Significant increase in soil respiration with BST treated soil compared to untreated area after 18 months
- Indicator BST treated soil is improving soil health



# Bacteria/Fungal Counts

Condition	Bacteria (cells/g soil)	% Increase in Bacteria	Fungal (cells/g soil)	% Increase in Fungi
Untreated Soil	6.7E+09		1.1E+07	
BST Treated Soil	2.3E+10	345%	1.6E+07	142%

- Significant increase in both bacteria and fungal counts in BST treated soil compared to untreated area after 18 months
- Indicator BST treated soil is improving soil health

# **“The Five Fundamentals”**



**Create Optimal Soil Conditions**



**Pick the Right Plant Species**



**Select the Correct Erosion Control Materials**



**Ensure Proper Installation**



**Inspection and Maintenance**



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