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Excess calcium and sulphate on peat-mineral mixes

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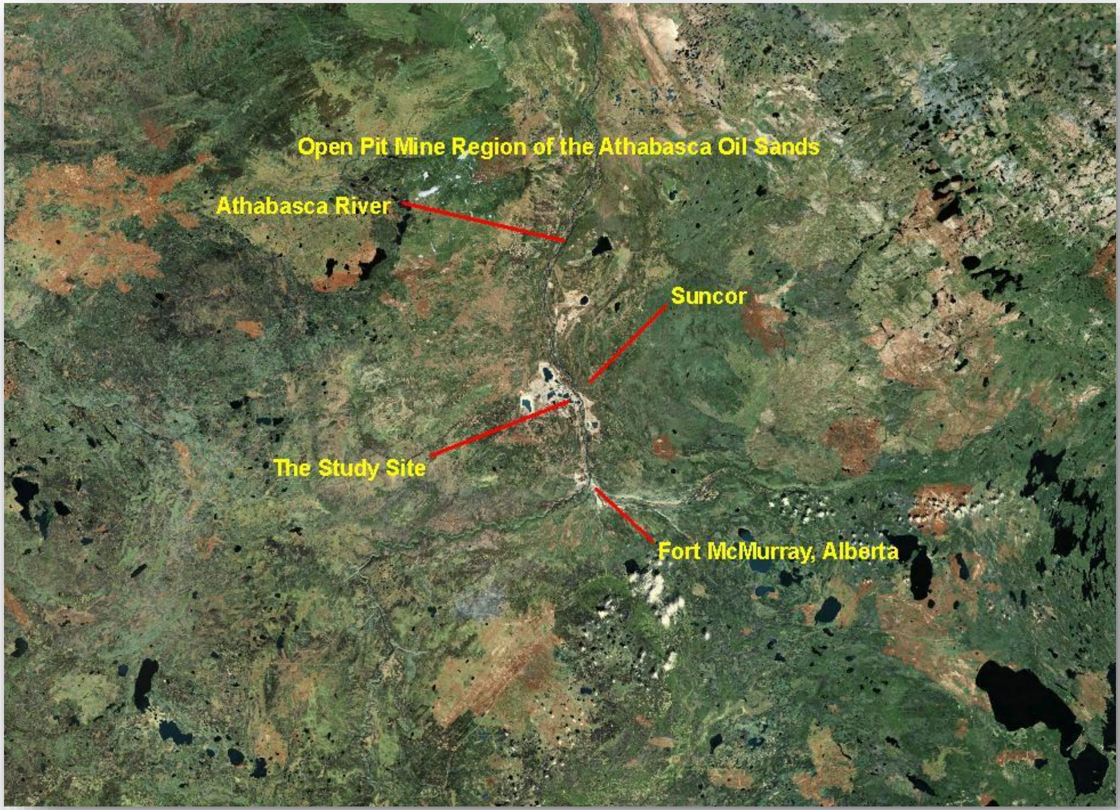
September 2018

Introduction – Project Location



The Study Site is located at the Suncor Oil Sands Project – in operation north of Fort McMurray since 1960s

Introduction – Peat-Mineral Mix

Peat-Mineral Mix:

- Over-stripping bog and fen peat into underlying glacial/post-glacial mineral substrate

Important for volume of reclamation stock in mineable Oil Sands region

Introduction – Peat-Mineral Mix

Spread over completed landscapes or stockpiled

Reclaimed landscapes include dry slopes of sandy tailings pond dykes

Introduction – Peat-Mineral Mix

The mineral substrate is incorporated into the organic component because:

- Improves moisture and nutrient retention of peat component

Fertility issues related to pH, Nitrogen and Phosphorus in peat-mineral mixes well documented

- Nitrogen deficiency: high C:N ratio, N leaching from peat-mineral mix
- Phosphorus deficiency: fixed by calcium in the alkaline environment

The Study Site

- Severely stunted growth and high mortality in west
- Intermediate growth in east
- Relatively normal maturation on central portion

The Study Site

Seeded to barley

- stabilizes against erosion
- poor competitor with pine

Lodgepole pine planted in 1992

- supplementary planting with Jack Pine in 1997

Objective

The objective was to determine the cause of the obvious pattern in lodgepole pine growth in distinct regions of the dyke.

Methods

Site history review and inspection of soils on site

- Revealed growth was associated with three distinct sources of reclamation soil

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Methods

Samples collected in each soil type:

- Forest Floor Moss / Upland Topsoil(FM)
- Shallow Fibric Peat Source (SF)
- Deep Mesic Peat Source (DM)

Coversoil samples analyzed for nutrients, reaction and salinity

Soil moisture tubes monitored through one growing season

Forest Floor Moss / Upland Topsoil (FM)

Tallest, least variable, low mortality, self-thinning

Thin crowns

Uniform ground cover of litter

Heterogeneous soil with evidence of LFH, Ae and Bm horizons

Shallow Fibric Peat Source (SF)

Variable growth, intermediate surviving density and stem height, thin crowns

Peatland origin soil – evidence of fibric peat

Soil roto-tilled into tailings sand

High coarse fragment content

Deep Mesic Peat Source (DM)

High mortality, visible stress, highly variable growth

Sparse ground cover

Peatland origin soil, moderately decomposed

Abundant shells of aquatic organisms

Results – Reaction and Salinity

Table 1 Peat-mineral amendment reaction and salinity[Z]

Amendment	pH	EC (dS m^{-1})	SAR	$CaCO_3$ (%)
DM	7.3 (0.0)[Y]a	2.3 (0.2)a	0.1 (0.0)c	9.1 (1.5)[W]a
SF	7.3 (0.1)a	0.8 (0.1)b	0.3 (0.0)b	3.8 (0.4)b
FM	6.7 (0.1)b	0.4 (0.0)c	0.5 (0.0)a	0.8 (0.1)c

[Z] As determined in October, 2005.

[Y] Values are averages (n = 9) with standard errors denoted by parentheses.

[W] Values are averages (n = 5) with standard errors denoted by parentheses.

a-c Different letters within a column represent significant differences (Fisher's LSD) among peat-mineral amendments ($p = 0.05$).

Results – Soluble Cations

Table 2 Peat-mineral amendment soluble cations and calcium ratios[Z]

Amendment	**Soluble Cations (mg kg^{-1} dry soil)**				**Ca/Mg Ratio[Y]**	**Ca/Total Cation Ratio[Y]**
	Ca	**K**	**Mg**	**Na**		
DM	430 (63)[W]a	7.0 (1.3)a	47 (9)a	8.9 (1.2)a	6.3 (0.6)a	0.83 (0.01)a
SF	63 (8)b	2.0 (0.4)b	16 (2)b	6.1 (0.4)b	2.4 (0.1)b	0.65 (0.01)b
FM	15 (2)b	1.6 (0.4)b	6 (1)b	4.3 (0.4)b	1.5 (0.0)b	0.50 (0.01)c

[Z] As determined in October, 2005 and corrected to dry soil.

[Y] Ratio calculated based on soluble cation concentrations converted to Meq 100g^{-1}.

[W] Values are averages (n = 9) with standard errors denoted by parentheses.

a-c Different letters within a column represent significant differences (Fisher's LSD) among peat-mineral amendments (p = 0.05).

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Results – Nutrient Status

Table 3 **Peat-mineral amendment available nutrient status and sulphate ratios[Z]**

Amendment	Available Nutrients (mg kg^{-1} dry soil)				NO3-N/SO4-S Ratio	SO4-S/Total Avail. Nutrient Ratio
	NO3-N	PO4-P	K	SO4-S		
DM	2.3 (0.4)[Y]ab	1.0 (0.0)b	24 (4)b	591 (125)a	0.01 (0.00)b	0.94 (0.01)a
SF	3.1 (0.4)a	2.9 (0.8)b	44 (8)a	19 (6)b	0.25 (0.05)a	0.27 (0.05)b
FM	1.7 (0.1)b	10.6 (2.6)a	16 (4)b	9 (1)b	0.21 (0.02)a	0.30 (0.05)b

[Z] As determined in October, 2005 and corrected to dry soil.

[Y] Values are averages (n = 9) with standard errors denoted by parentheses.

a,b Different letters within a column represent significant differences (Fisher's LSD) among peat-mineral amendments (p = 0.05).

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Results - Moisture

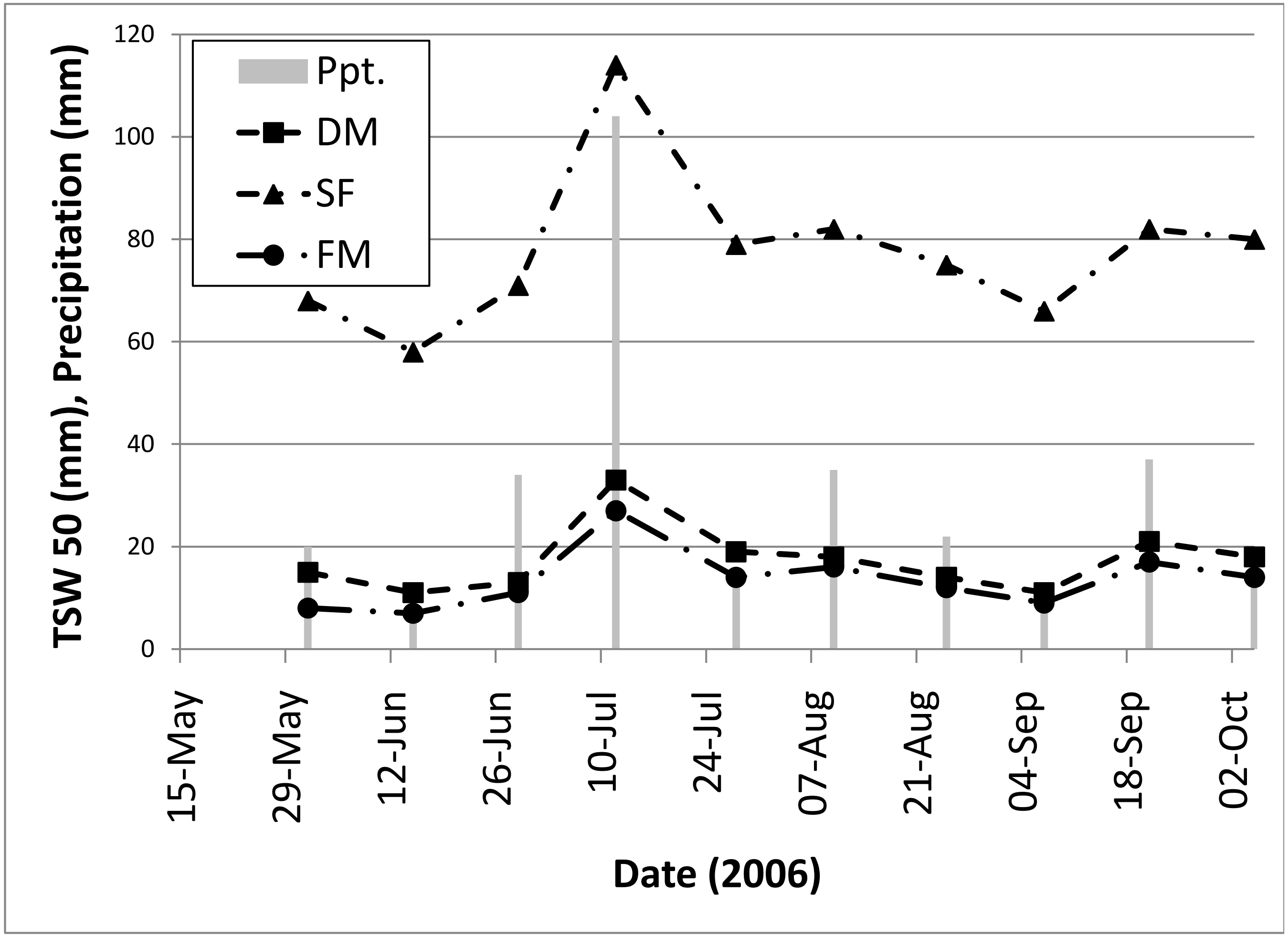

Figure 1 Total soil water to 50 cm (TSW 50) in the 2006 growing season for all treatments with diviners installed

Proposed Mechanism for Growth Pattern

Calcium, sulphate driven osmotic stress (salinity)

- DM > SF > FM

Phosphorus deficiency due to alkaline conditions and high soluble calcium

- DM <= SF < FM

Low N:S ratio reducing photosynthesis rate

- DM < FM <= SF

Overloading of calcium at soil-root interface

- DM > SF > FM

Overloading of sulphate at soil-root interface

- DM > FM >= SF

Learnings – The Study Site

Achieving reclamation objective unlikely on DM despite acceptable land capability classification

Success on DM depends on costly and uncertain amelioration of soil limiting factors

The FM soil shows pine maturation is possible on tailings pond dykes with minimal, but appropriate, amendment

Learnings

Avoid salvage of peat substrates containing marl layer

- Post-glacial, near-shore lacustrine sediments
- Identified by shells or inferred through soil chemistry
  - High $CaCO_{3\ eq}$, high soluble calcium and sulphate
    - Not obvious: Ca and S also released during peat decomposition
    - Peat naturally has slightly elevated $CaCO_{3\ eq}$
    - Calcareous till in region

Follow-up Research

Several studies now looking at reclamation success in the area.

Monitoring of pH change over time.

Contributors

The following people were key to the findings of this work:

John Hastie, Dr. Francis Salifu and Wayne Tedder provided technical direction during research compilation

Dr. David S. Chanasyk of the University of Alberta provided guidance during moisture data (and hydrophobicity) analysis, and helped design the field sampling program.

Thank you to **Golder Associates Ltd.** and **Suncor Energy Inc.** for providing funding and the research opportunity.

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