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## Phosphogypsum Reclamation in Alberta

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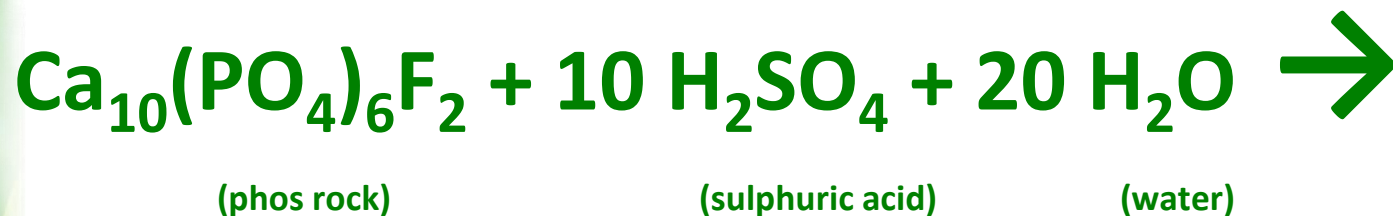
# What is phosphogypsum?



- Phosphogypsum (PG) is a by-product gypsum produced during the manufacture of phosphate fertilizer from phosphate rock



# Phosphate Fertilizer Production



- approximately 5 tonnes of gypsum are produced for every tonne of  $\text{P}_2\text{O}_5$  fertilizer manufactured

# Phosphogypsum



- worldwide, production of PG is estimated at 170 million tonnes per year
  - must be disposed of, stacked or used
  - stockpiles in Canada estimated at >100 million tonnes
  - stockpiles in U.S. > 8 billion tonnes
- 
- [Story of Phosphogypsum Video](#) on youtube





# Redwater PG Stacks



# Fort Saskatchewan PG stacks





# Phosphogypsum Properties



- phosphogypsum properties:
  - damp, silt-sized material
  - acidic
  - contains some trace components that were in the original rock
    - concentrations depend on the rock source
    - trace metals typically very low
    - small amounts of radium, therefore PG is considered a naturally occurring radioactive material

# Phosphogypsum Reuse



Is there anything we can do with the gypsum instead of just stacking it?

- **in other parts of the world, PG is widely used for agriculture, construction, road base, etc.**
- **Detailed risk assessments indicate that PG can be safely used for a variety of agricultural and industrial applications in Alberta**





# So why isn't PG being widely used?



- Economics compared to alternatives
- Transportation and handling issues
  - Low value bulk commodity
  - no standardized application method
  - no internal infrastructure for loading
- Volume of PG produced and low cost of storage
- Perception issues



- If we're not going to reuse all of the PG, we need a reclamation strategy
- Nominal base case reclamation plan in our operating approval is that the gypsum stacks would have to be covered with one meter of soil when closed



# Reclamation research



- partnered with the University of Alberta in 2005 to do research outlining the best way to close the gypsum stacks
- five students have already earned Master's degrees studying phosphogypsum reclamation
- We began by looking at the depth of soil cover





# Reclamation research



- results indicated that a soil capping depth of 8 to 15 cm is optimal for plant growth and minimizing water infiltration
  - in a dry year, thin soil layers actually grow better grass because plants root into the wetter gypsum
  - Increasing soil depths actually increase spring water infiltration and water penetration depth



Jackson, et al. 2011. Phosphogypsum Capping Depth Affects Revegetation and Hydrology in Western Canada. Vol. 40 No. 4, p. 1122-1129.

Christensen et al., 2013. In situ measurement of snowmelt infiltration under various topsoil cap thicknesses on a reclaimed site. Canadian Journal of Soil Science, 2013, 93(4): 497-510

# Reclamation research



- research progressed into whether incorporation of soil and PG is more effective for reclamation than the ‘barrier’ approach (embrace our phosphogypsum)
  - Greenhouse study shows that mixtures of PG and soil had healthier taller plants with greater biomass than PG or soil alone

Abou Rizk, Jenna, 2015. Potential Anthroposol development using phosphogypsum as a substrate with soil and organic amendments. MSc thesis, Dept. of Renewable Resources, University of Alberta

# Testing the Concept on a Field Scale while Reclaiming a Historical Pond





# Pond filled with phosphogypsum



# Filled pond was compacted and contoured





# And covered with top soil



164 loads of topsoil hauled and placed( $\approx 1970 \text{ m}^3$ )



# Deep Ripping



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# Reclamation research



- Seeded grass mixes in 2014
- Grew extremely well, but were grasses the right option?





# Tree Trial established in Summer 2015



- Partnered with the Canadian Forest Service and close to a thousand trees were planted in the north half of the former cooling pond
  - Two varieties of willow, two varieties of hybrid poplar planted in early June, 2015





# Willows in September 2015





# Willows in Sept 2016



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# Willows in September 2017





# What the willows will look like in a couple of more years.....





# Two varieties of Hybrid Poplars also planted in June 2015





# Poplars in Sept 2016



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# Poplars 2017





# Can grow many things in phosphogypsum...





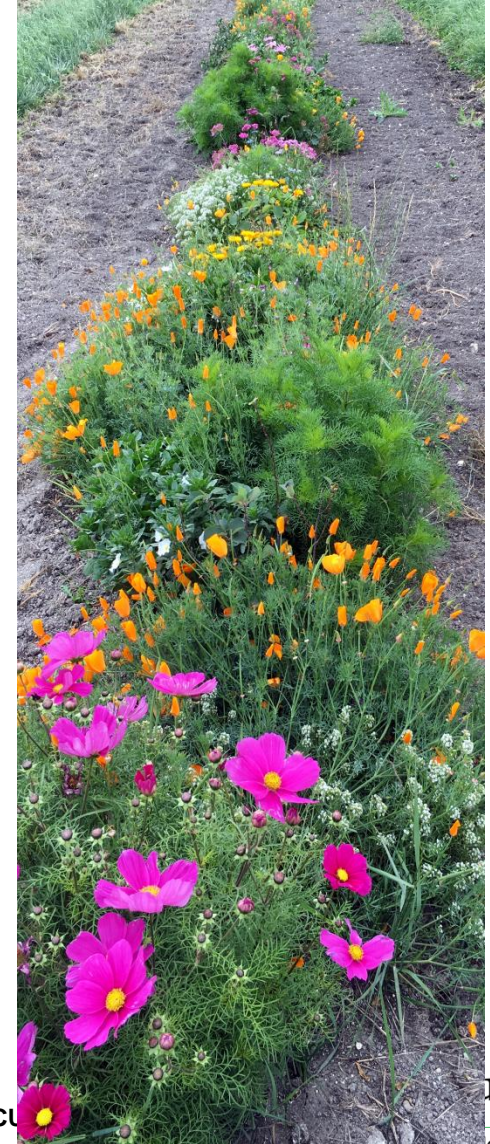
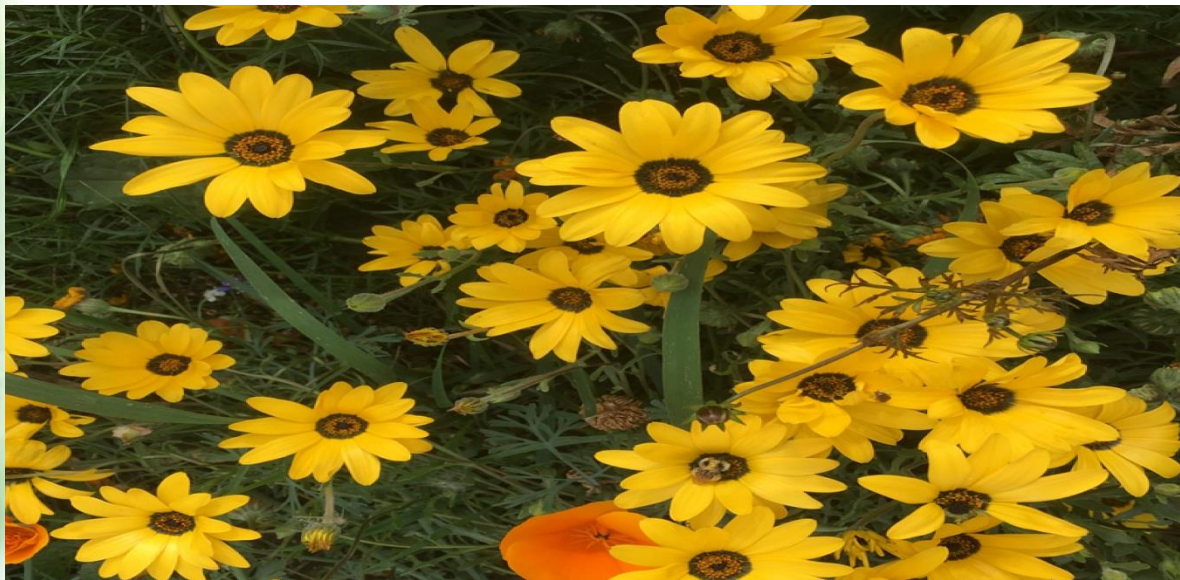
# potatoes.....



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# Wildflowers



cu



# Biggest Problem in Vegetation Establishment



2017-08-20 8:32:24 AM M 1/1 11°C



AGRIUM FNO

2017-08-14 8:41:40 PM M 1/1 21°C



AGRIUM FNO





# Afforestation for Gypsum Stack Reclamation



- Based on the success of the holding pond reclamation experiments, we started to close some of our historical gypsum stacks using what we learned on the large holding pond



# Afforestation of Gyp Stack #4 – June, 2016



- 1180 white spruce
- 12,500 willow
- 5875 hybrid poplar



# July 2016



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# Gyp Stack #4 in 2017



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# Hybrid Poplars grow rapidly



June 2017



September 2017





# Gypsum Stack #3 September 2015





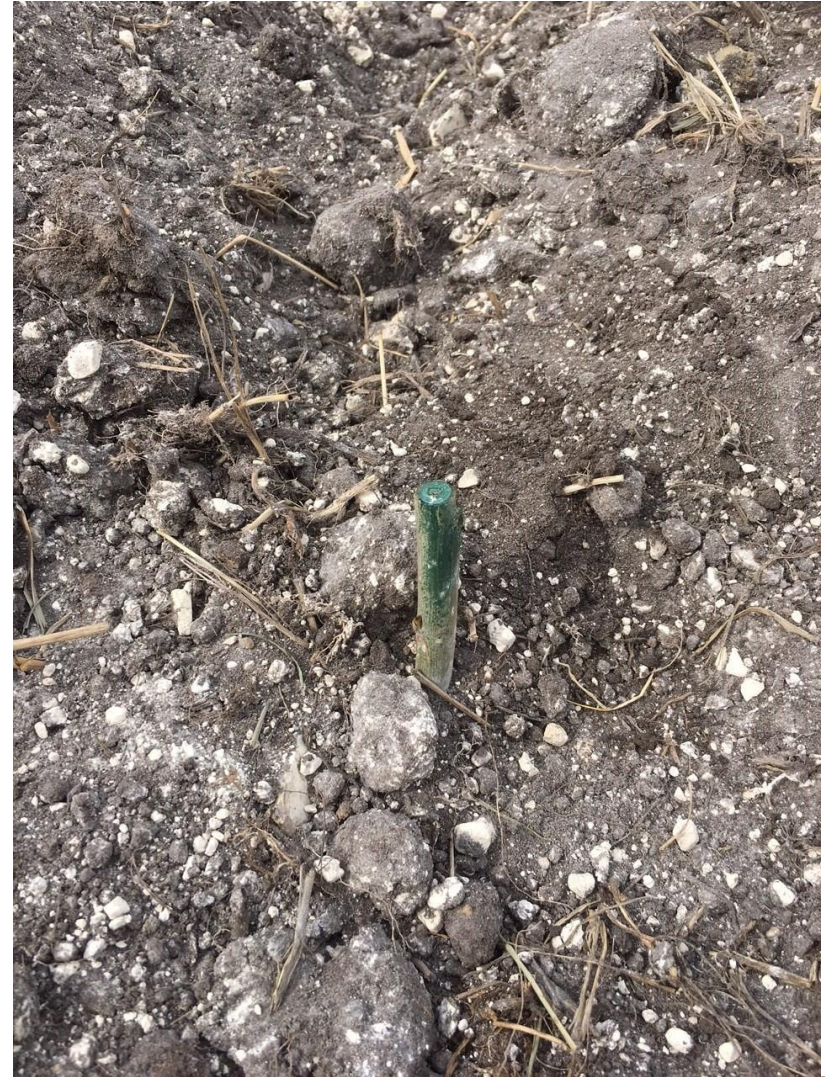
# Gypsum Stack #3 Afforestation – June 2017



11,000 hybrid poplar cuttings planted  
on 28 acres



# Poplar Cuttings





# Gypsum Stack #3 Sept 2017



# Benefits of Trees



- Trees are growing better on phosphogypsum than they would be on regular soil
- High yield afforestation plantations sequester carbon (approximately 30 t CO<sub>2</sub> e ha/year)
- Use a lot of water and nutrients so can be used to 'remediate' nutrient contaminated areas and prevent water infiltration into the stack
- Potential for use for green energy or wood chips
- Improved aesthetics and ecosystem diversity
- Reduced maintenance once established



# Plans for the future



- Continue joint research with University of Alberta and Canadian Forest Service
- Evaluate growth, yield, browse quality, carbon sequestration and fibre characteristics of woody species