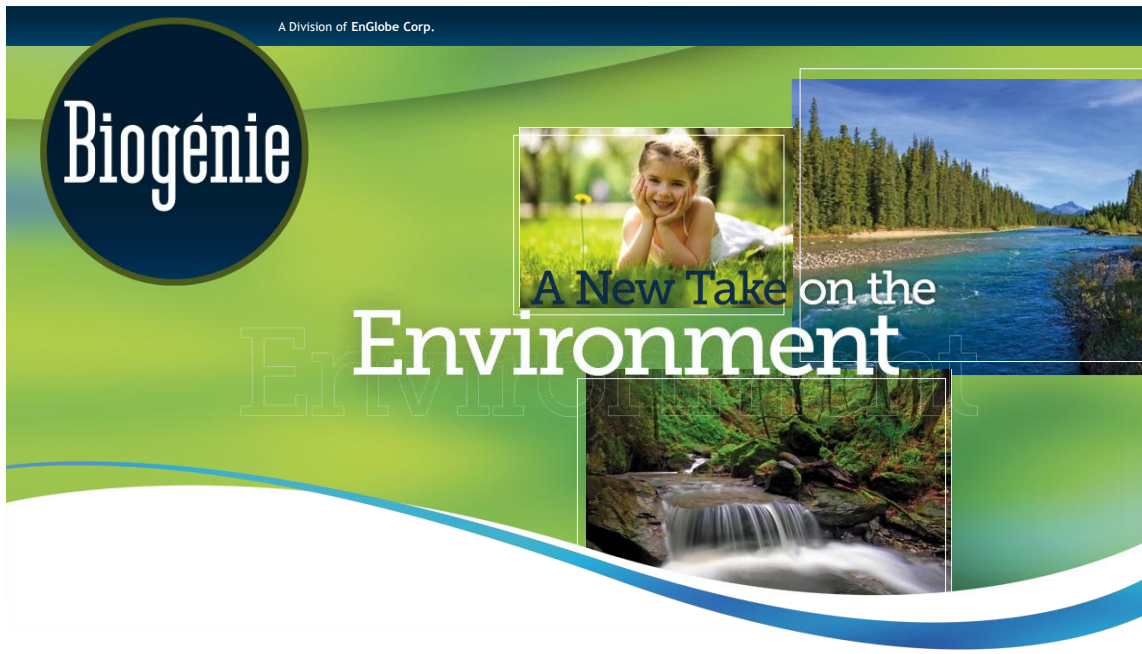

Efficient ex-situ salt-impacted soil remediation technology

October 19th , 2012

Presented by: Christian Bélanger, Vice President, Innovation and Development, EnGlobe Corp.

2012 remediation technologiesymposium Remtech Symposium, October 17-19, 2012, Banff, AB, Canada

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Salt-Impacted Soil: Current Solutions

- Passive remediation with calcium amendment (e.g.: weeping tile)
  - Slow (several years) and variable efficiency
  - Surface treatment approach with little control
  - Possibility of recontamination (upward capillary movement and off-site migration)
  - Ineffective for mixed contamination (PHC and salt)
- Off-site disposal
  - Limited by the distance to the landfill
  - Non-sustainable solution
- Electrokinetic
  - Still to be proven at full-scale (technico-economical efficiency)
- Phytoremediation
  - Not suitable for many salt-impacted sites
  - Long-term process that requires extended site monitoring

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Biogenie's Salt-Impacted Soil Treatment Process

- Based on Biopile technological platform
- Ex-situ Engineered Leaching Process
  - Engineered cation exchange process
- Single Technological Platform
  - Mixed contamination is sequentially treated on same treatment platform (Biopile switched to leaching pile)
- Based on a deep understanding of the contaminant, soil characteristics and involved physico-chemical phenomena
  - Assess applicability of the technology
  - Optimize leaching and avoid clay dispersion (clogging)
  - Design an optimized soil leaching technology

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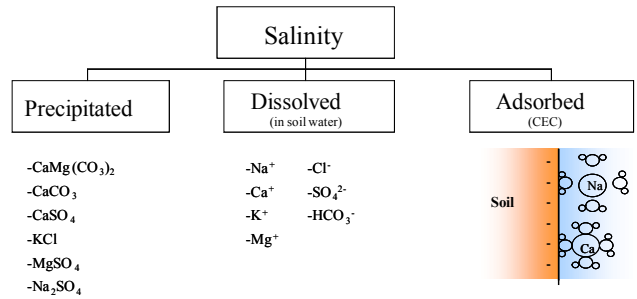
Salinity Characteristics

- The process solubilises precipitated ions and mobilizes dissolved ionic species (reduction of EC and chloride)
- Cation exchange reaction displaces adsorbed Na^+ from clay particles (reduction of SAR and ESP)



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Salt-Impacted Soil: Commercial Approach

- Understanding of site conditions and remediation objectives
- Potential of applying Subsoil Salinity Tool to optimize the volume of soil to be treated
- Recommendation of the most technical and economical efficient approach
- Implementation of the remedial approach
  - On-site treatment using Biogenie's engineered process
  - Off-site disposal, if required

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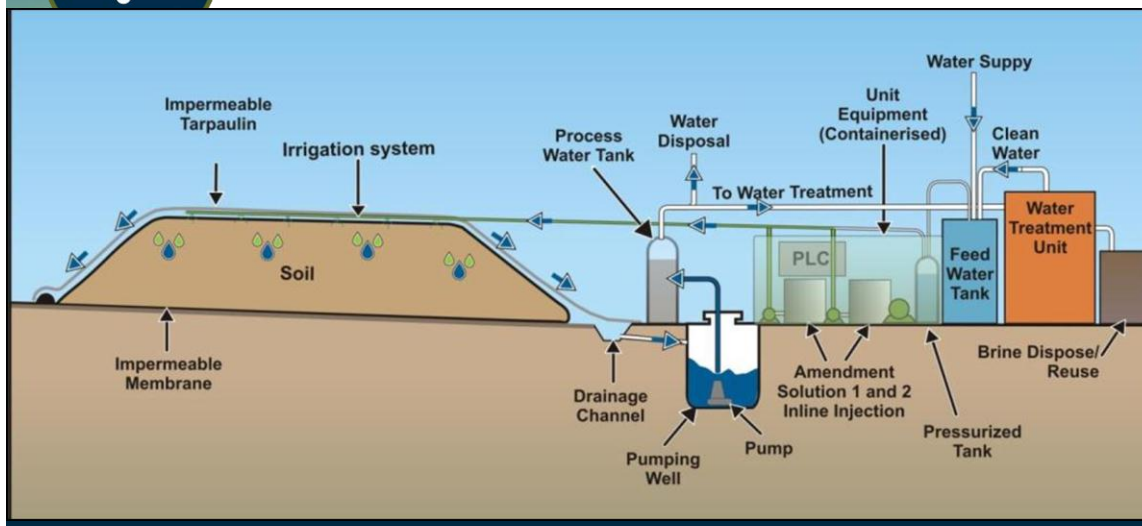
Biogenie's Salt-Impacted Soil Treatment Process



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Proprietary Know-how

- Biogenie has developed <u>proprietary</u>
  - Characterization protocols
  - Amendment mixes
  - Irrigation strategies
  - Process monitoring tools
- Patent application has been submitted (patent pending)

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Biogenie's Approach

ADVANTAGES

- Price competitive vs disposal to the landfill
  - As low as in the order of 50$/m^3 for the treatment process
  - No long distance transportation required, nor importation of backfill
- Increase safety by decreasing truck traffic for an on-site approach
- Reach site-specific objectives within a 1-year timeframe (typically 2 months)
- Eliminate the use of imported backfill
- Low energy requirement
- In line with sustainable development
- Applicable on remote sites
- Better control of treatment parameters

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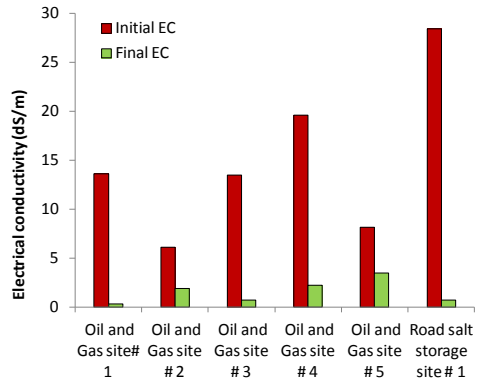
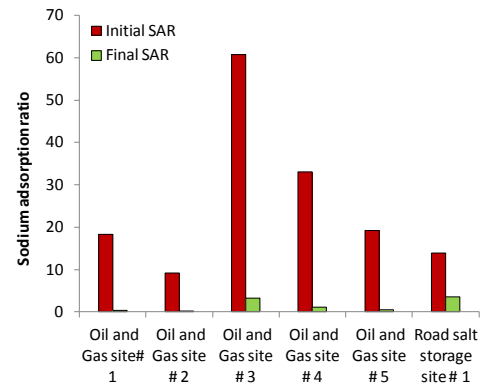
Treatability Studies - Typical Results

- Reduction of EC and SAR achieved during different projects
- Final EC and SAR values are related to soil texture and soil chemical characteristics rather than to initial salinity levels





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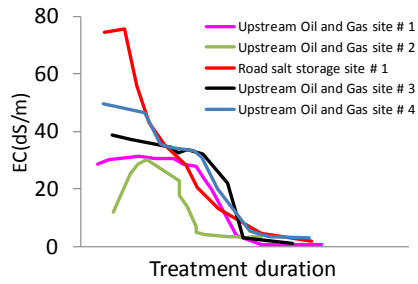
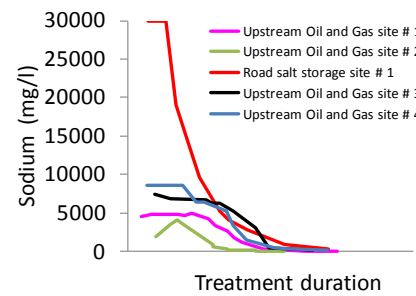
Treatability Studies – Leaching Kinetic

- Typical salt removal evolution during column trials as expressed by leachate electrical conductivity and sodium concentrations
- Reduction of EC and sodium display similar trend for different types of soil and degree of contamination
- Salt leaching kinetic is affected by soil texture, amendment dosage and initial EC and SAR values.





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Demonstration

- Soil Piling

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Demonstration

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Demonstration

- Demonstrations highly successful
  - EC, SAR and chloride reduction. Chloride mass balanced matched (from soil to water)
- Increased efficiency with improved irrigation system (#2)
- Ready for full scale implementation

Demonstration	Soil	Treatment strategy	Electrical conductivity (dS/m)			SAR			Chloride (mg/kg)			Initial soil rating*	Final soil rating*
			Initial	Final	Reduction	Initial	Final	Reduction	Initial	Final	Removal		
1	Upstream Oil and Gas site # 5	Irrigation system# 1	20,8	5,7	73%	13,5	3,8	72%	4755	834	82%	*Unsuitable*	*Poor (to background)*
2	Roadsalt storage site # 1	Irrigation system# 1	14,4	1,5	90%	27,9	3,6	87%	2700	184	93%	*Unsuitable*	*Good*
3	Roadsalt storage site # 1	Irrigation system# 2	15,5	0,7	95%	39,0	2,0	95%	3000	29	99%	*Unsuitable*	*Good*

* : Based on Alberta Tier 1 Soil and Groundwater Remediation Guidelines (AENV, 2010) for subsoil

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Optional process water treatment

- Demonstration: 10 m^3 of process water successfully treated using reverse osmosis
- Pre-treatment is required
- Treated water quality is good enough to be reused in the process
- Recovery ratio: up to 75%
- With such recovery, ratio water / soil (vol/vol) as low as 0.2

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Water Supply and Disposal Options

- Water supply options
  - Dugout
  - Surface water
  - On-site well
  - Municipal water
  - Imported on site
- Water disposal options
  - Sewer disposal
  - Well injection
  - Brine reuse
  - Treated water surface disposal / reuse

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Commercial implementation

- Under commercial implementation phase with several oil and gas clients
- Example of full scale implementation for an oil & gas client (proposal submitted)
  - Design and implementation of a 10,000 m^3 capacity treatment cell on a former gas plant as a semi-permanent soil treatment facility
  - Excavation and treatment of 10,000 m^3 of salt-impacted soil collected from a nearby well site
  - Treated soil stockpile for future backfilling purpose
  - Water supply and disposal from on-site wells (injection well already on-site)
  - Total potential volume to be treated of at least 75,000 m^3 (in-situ volume)
  - CAPEX cost as low as approx. 4-5 $ / m^3 (amortized on 75,000 m^3)
  - OPEX (process only) in the order of 50 $ / m^3

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Conclusions

- Biogenie as developed efficient ex-situ salt-impacted soil treatment process
- Process has demonstrated its technical, financial and regulatory efficiencies
- Patent application has been submitted (patent pending)
- Under full scale commercial implementation
- Semi-permanent or permanent soil treatment facility (STF) present the best advantage for the client
- Supported by a robust commercial and technical know-how of STFs operation
  - Biogenie's network of 22 STFs through Canada, France and UK, where more than 1.5 million tonnes of organic pollutant-impacted soil are decontaminated every year.
- R&D initiated to measure its implementation in an *in-situ* configuration

Question?