Developing Remediation Guidelines for Hydrocarbons in Subsoil at Alberta Green Zone Sites

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Technical Steering Committee

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- Steve Kullman – Husky Energy
- Shawn Willetts – ConocoPhillips Canada
- Dave Williams – Meridian Environmental Inc.
- Miles Tindal – Millennium EMS Solutions Ltd.

What is the Alberta Green Zone?

Why Green Zone Subsoil Guidelines?

- Existing Alberta PHC subsoil guidelines:
  - Based on PHC Canada-wide standards
  - Consider urban settings
- Green Zone:
  - Different considerations
  - Different subsoil guidelines appropriate:
    - Depth at which eco-contact pathway excluded
    - Management limits

Intended Application

- Forested Alberta Green Zone sites
- Public (ESRD controlled) land
- Remote locations
- Future subsoil disturbance unlikely

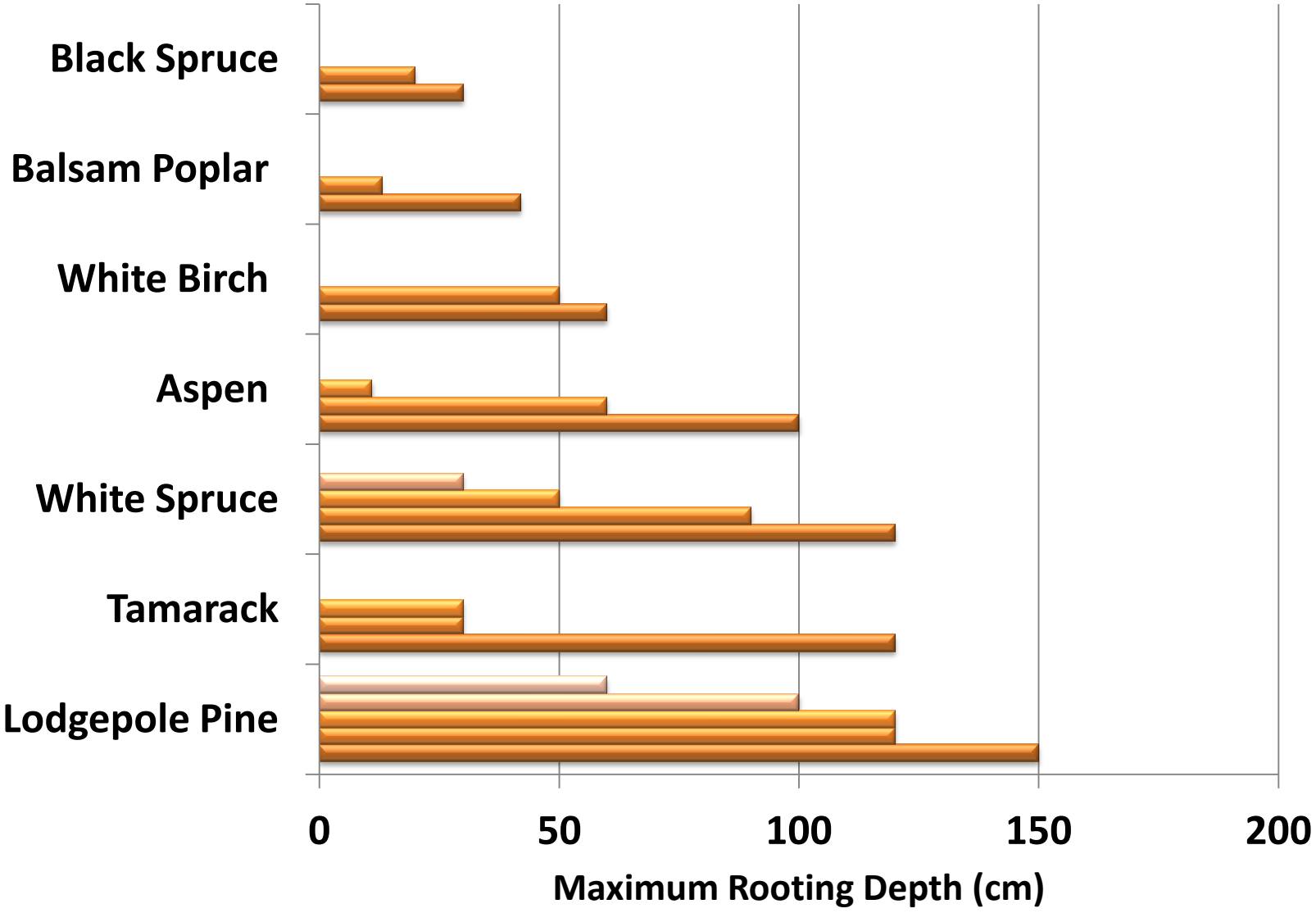
Project Overview

- Boreal Tree Rooting Zone
  - Literature study
  - Field verification
- Green Zone Management Limits
  - Identify relevant “pathways”
  - Laboratory investigation
  - Migration modelling
  - GZML value recommendations

Boreal Tree Rooting Zone

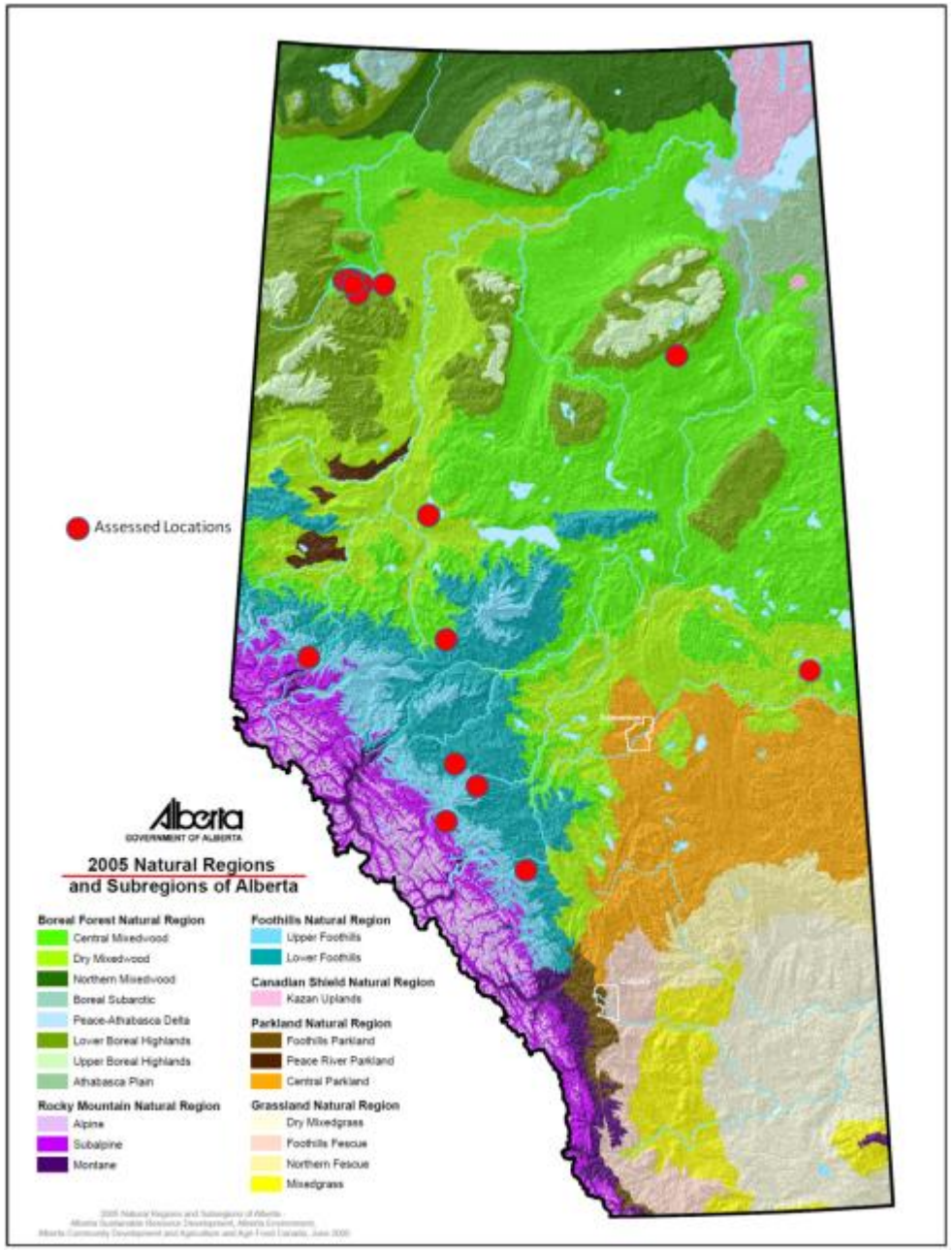
- Rationale:
  - Current 3m exclusion depth for eco-contact
- Literature review:
  - Max rooting depths for Alberta trees
- Field verification of rooting depth

Maximum Rooting Depth
Literature Data – Fine Soil

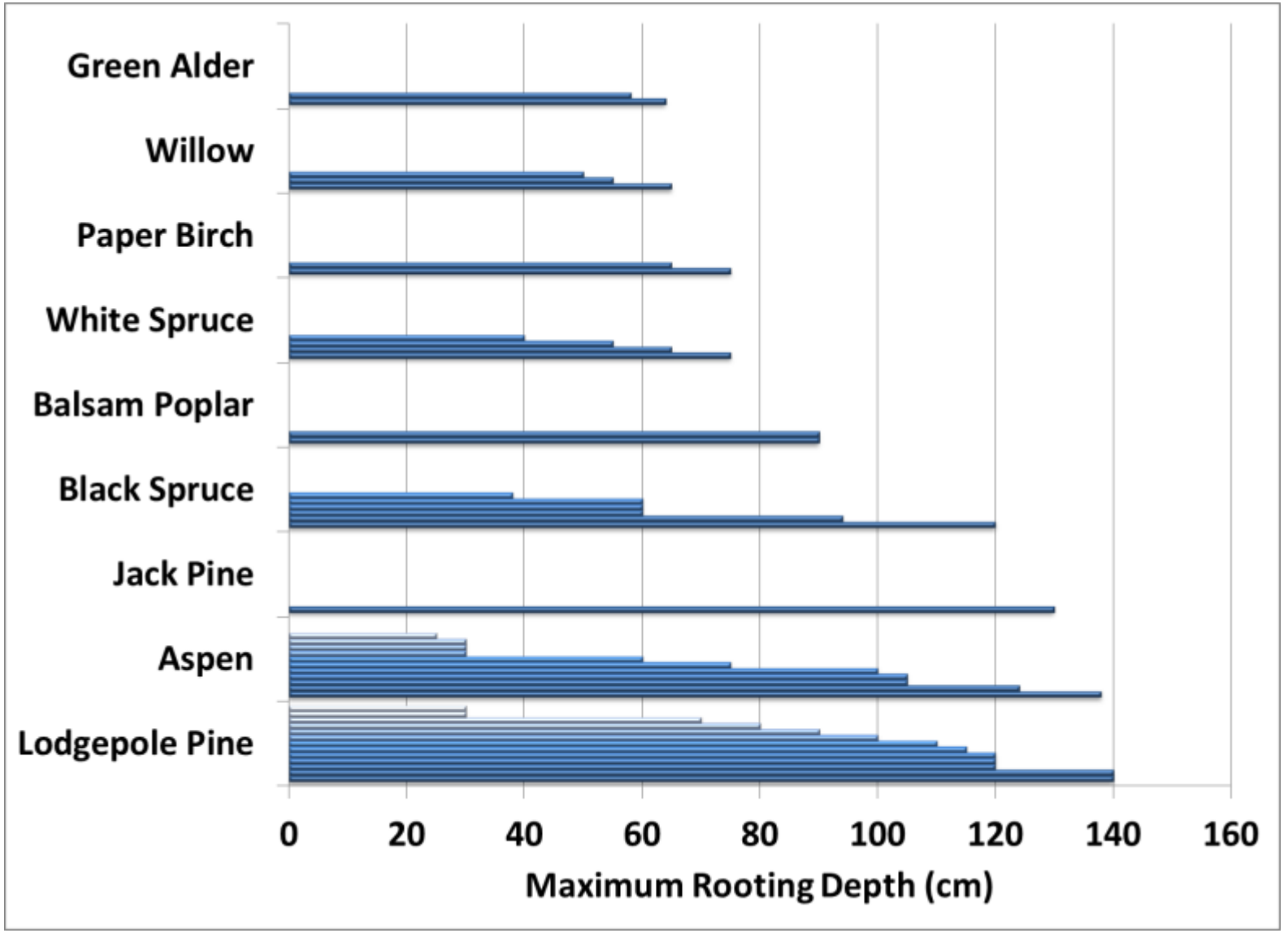


Field Verification

Field Verification Locations



Maximum Rooting Depth
Field Data – Fine Soil



Field Verification Results

- Fine soil sites assessed:
  - 16 sites
  - 44 trees
- Maximum rooting depth:
  - 1.5 m confirmed for fine soil
  - 3.0 m retained for coarse soil

Existing PHC Management Limits

- Existing PHC management limits:

	Value mg/kg	Limiting Consideration
F1	**700/800**	Mobile free phase formation
F2	**1,000**	Inhalation exposure – worker in trench
F3	**2,500/3,500/5,000**	"Technological factors"
F4	**10,000**	Professional/regulatory judgement

  - From PHC Canada-Wide Standard (2008)
  - Based on very limited dataset
  - Limited applicability to Green Zone

GZML - Scope

- No attempt to update MLs for:
  - F1 – high mobility, flammability etc
  - F4 – rarely drives site remediation
- Fractions selected for GZML research:
  - F2
  - F3

Green Zone Management Limits (GZMLs)

- Considerations to be assessed for GZ:
  - Modelling Studies
    - Upwards migration
  - Laboratory Studies:
    - Mobile free phase formation
    - Fire/explosion hazard
    - Hydrophobicity

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Residual Saturation Methods

- Experimental Variables
  - Coarse and Fine textured soils
  - 2 soil moisture contents – dry and FC
  - F2 and F3 petroleum hydrocarbons

Experimental Materials

Columns filled to 30 cm with coarse or fine soil

F2 and F3 PHC obtained through vacuum distillation

F2 PHC Residual Saturation

Columns saturating bottom up with Sudan IV red dyed F2 PHC

F3 PHC Residual Saturation

Columns saturating top down with Sudan IV red dyed F3 PHC

- Columns saturated
- Drained for a minimum of 7 days
- 0-15 cm and 15-30 cm samples collected

Hydrophobicity and Flammability

- Fine and coarse soil contaminated with 10 concentrations of F2 and F3 PHC
  - 0, 125, 250, 500, 1000, 2000, 4000, 8000, 16000, 32 000, 64 000
  - Molarity Ethanol Droplet (MED) test for hydrophobicity
  - Flammability with a direct flame

Results Summary

- Neither soil or PHC ignited with exposure to direct flame
- 64,000 mg/kg F2 PHC contamination did not cause hydrophobicity in coarse or fine textured soil
- Fine textured soils exhibited no hydrophobicity at 16,000 mg/kg F3 PHC and slight hydrophobicity at 32,000 mg/kg
- Coarse textured soil exhibited no hydrophobicity at 4,000 mg/kg F3 PHC and medium hydrophobicity at 8000 mg/kg

Results Summary

- Coarse Residual Saturation of F2 PHC
  - Dry soil retains substantially more PHC than wet soil (0-15 cm – 32,833 mg/kg vs 11,150 mg/kg)
  - 0-15 cm depth better representation of residual saturation
- Fine Residual Saturation of F2 PHC
  - Fine soil retains more PHC than coarse soil (DRY: 0-15 cm – 137,666 mg/kg vs 32,833 mg/kg) (WET: 0-15 cm – 15,253 mg/kg vs 11,150 kg/kg)
  - Fine wet columns showed similar trend as coarse – 0-15 cm depth well drained (0-15 cm – 15,253 mg/kg; 15-30 – 16,100 mg/kg)

Results Summary

- Coarse Residual Saturation of F3 PHC
  - Coarse treatment followed similar patterns with both F2 and F3 PHC contamination
  - Not as large of a difference between wet and dry soil with F3 PHC contamination
  - 0 -15 cm depth better representation of residual saturation
- Fine Residual Saturation of F3 PHC
  - More difficult to saturate with PHC
  - Awaiting analytical results

Summary – Rooting Depth

- Maximum rooting depth:
  - 1.5 m confirmed for fine soil
  - 3.0 m retained for coarse soil
- Potential for reduced exclusion depth for eco-contact pathway:
  - Under ESRD review

Preliminary ML Data (mg/kg)

	Mobile Free Phase	Hydro-phobicity	Flamm-ability	Upward Migration
F2 - Coarse	**9,000**	>64,000	no	no?
F2 - Fine	**10,000**	>64,000	no	no?
F3 - Coarse	28,000	**4,000-8,000**	no	no?
F3 - Fine	pending	16,000-32,000	no	no?

Next Steps

- Analyze remaining lab data as available
- Refine experimental dataset for limiting considerations
- Regulatory discussions