Remediation and Closure of a Former Oilfield Land Treatment Facility using Alberta Environment Draft Tier 2 Eco-Contact Guidelines

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PRESENTATION OUTLINE

- Chronology
- Background
- Remediation
- Reclamation
- Closure Assessment
- Summary
- Acknowledgements

Plot 1 - May 2006

Chronology

The land treatment area (LTA) has been remediated, reclaimed, and closure sampling completed

- 1996 – Land treatment activities ceased
- 1997 – EBA hired to do a review of historical information and provide an approach for closure
- 1998 – Initial correspondence with Alberta Energy Resource Conservation Board (ERCB) and meetings with Alberta Environment (AENV)
- 1998 – Benchscale biotreatment and ecotoxicity testing
- 1998 to 2001 – Remediation of surface in layers progresses annually within budget and biotreatment time constraints

Chronology (Continued)

- 2001 – Subsurface remediation and confirmatory sampling
- 2002 to 2003 – Reclamation
- 2006 – Draft Environmental Summary Report of remediation and reclamation activities prepared and work plan for closure
- 2007 – Meeting with regional and policy AENV to discuss proposed closure approach and new guidelines
- 2007 to 2008 – Closure sampling, statistical evaluation, and ecotoxicity testing
- 2010 – Environmental Summary Report completed
- 2011 – Addendum completed

Land Use Description

- CCS owned quarter near Valleyview, Alberta
- Former LTA on a portion of the quarter zoned as Agricultural land by M.D. 16 (Greenview)
- Quarter also contains CCS waste process plant that is licensed by EUB and zoned industrial by M.D. 16 (Greenview)
- Adjacent land is primarily agricultural land use with some forested areas
- Quite a few oilfield leases on quarter and in surrounding area

Land Use – 2003 Aerial Photograph

Historical Summary of Land Treatment

- Original land treatment approval from AENV
- ERCB took over as lead regulator and issued a interim approval May 3, 1995
- Annual soil and groundwater monitoring were required as part of the interim approval
- Oily sludge materials from oilfield wastes were applied
  - Plot 1: waste was applied annually from 1988 to 1995
  - Plot 2: waste was applied only once in 1992
- Plots were both originally 8 hectares; however, Plot 2 area has been affected by other uses (oil wells, highway widening)

Historical Use

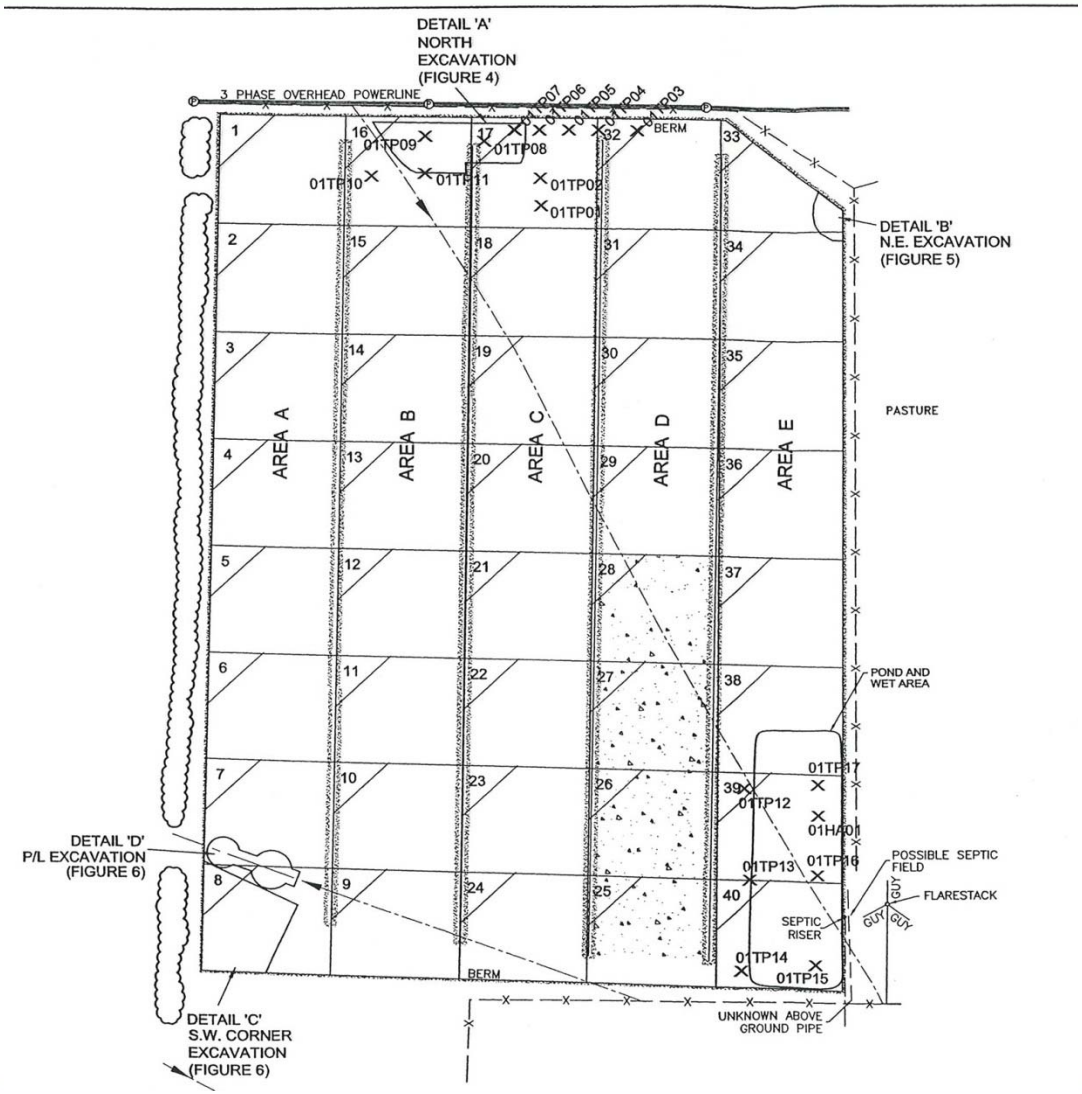
- Soils monitored in accordance with ERCB interim approval. For Plot 1:
  - Oil Content 1.44% to 6.99%,
  - pH < AENV 1994 Tier 1 (and in background soils)
  - EC ranged from 5.32 dS/m to 8.46 dS/m
  - SAR ranged from 4.5 to 7.5,
  - Select metals (boron, lead, zinc, barium, copper, and nickel) exceeded AENV 1994 Tier 1
  - Available ammonium nitrogen and phosphorous concentrations deficient for hydrocarbon biodegradation
  - Gamma radiation study in 1996 met NORM 1995 guidelines
- Soil in Plot 2 usually met 1994 Tier 1 or license conditions
- Groundwater monitored annually and met applicable guidelines

Approach for Remediation

Remedial Objectives, 1998

- To conserve the existing topsoil with oilfield wastes applied to them since topsoil is a valuable resource
  - All parties recognized that the treated topsoil will have concentrations of some metals, salts, and biotreated petroleum hydrocarbons (PHCs) above generic guidelines
- To biotreat the LTA as much as possible, then assess the remaining concentrations and use site-specific guidelines or risk assessment if necessary to address outstanding concerns
  - Since this approach was made, there has been changes in regulatory guidance for Closure, Tier 1 and Tier 2 Remediation Guidelines and Ecotoxicity testing

Approach for Remediation Monitoring



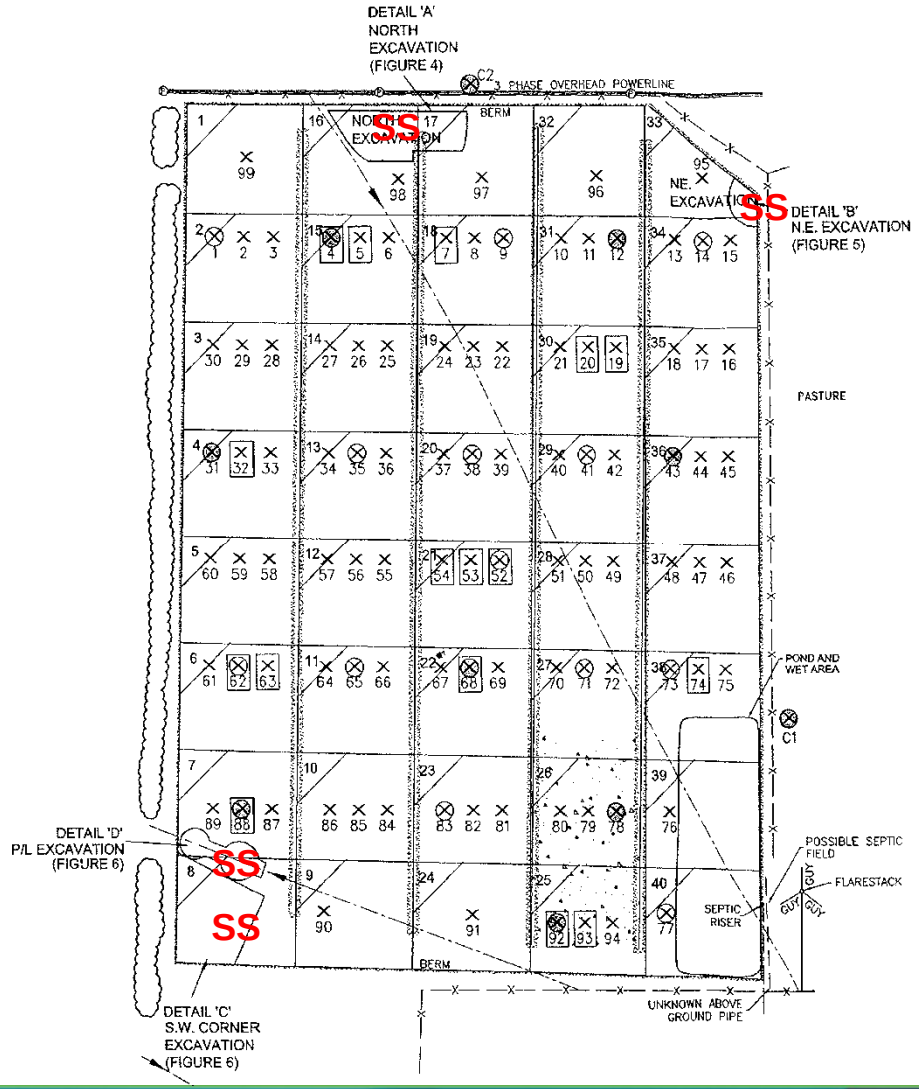
2001 Remediation Diagram

- **Soil biotreatment was maximized by regular tillage and nutrient additions**
- **Soil biotreatment monitored for physical and chemical characteristics annually on a grid basis**
- **Once a layer met the remedial objectives, it was stripped off and stored in berms on an area stripped to subsoil**

Post Remediation Results – Surface Material

- Land treated material meets 2001 Tier 1 Guidelines for all receptors and exposure pathways except for PHCs, EC (about 4 to 6 dS/m), sometimes either SAR or one of the previously identified metals or selenium or arsenic
- PHCs are residual (weathered and possibly aged) based on chromatogram and are primarily only F3 Fraction greater than Tier 1
- Surface soil materials are improved in terms of structure for plant growth and total organic carbon content
- Water repellency varies between low to severe

2001 Confirmatory Sampling



Pre-reclamation Assessment

- Additional inspections were completed at the final layer to ensure no pockets of deeper material existed.
- The diagram shows surface inspection locations (x) and SS subsurface excavation areas

Post Remediation Results – Subsurface

- Groundwater and subsurface soils meet 2001 AENV Guidelines for all potential contaminants of concern except occassionally where excavation was restricted due to pipelines
- Screens for PCBs, SVOCs, VOCs, and sterilants were completed and were non-detectable

Reclamation

- EBA recommended the site was ready for reclamation in 2002
- CCS hired a reclamation supervisor to supervise recontouring and backfilling where necessary, evenly spreading topsoil and seeding the plot to a hay seed mixture.

Plot 2 – May 2006

Closure Approach Update, 2007

- EBA presented a summary of the site history, background information and site assessment data, and proposed an approach for closure to AENV
- AENV agreed with the overall approach and indicated that if metals statistically meet the Tier 1 Guidelines and hydrocarbons pass the Tier 2 Direct Soil Contact, then this would fall under a Tier 2 Site-Specific Guidelines and not Tier 2 Risk Assessment so would not require their review.
- However, AENV noted that there is no process currently to approve Tier 2 for salt parameters within the rooting zone

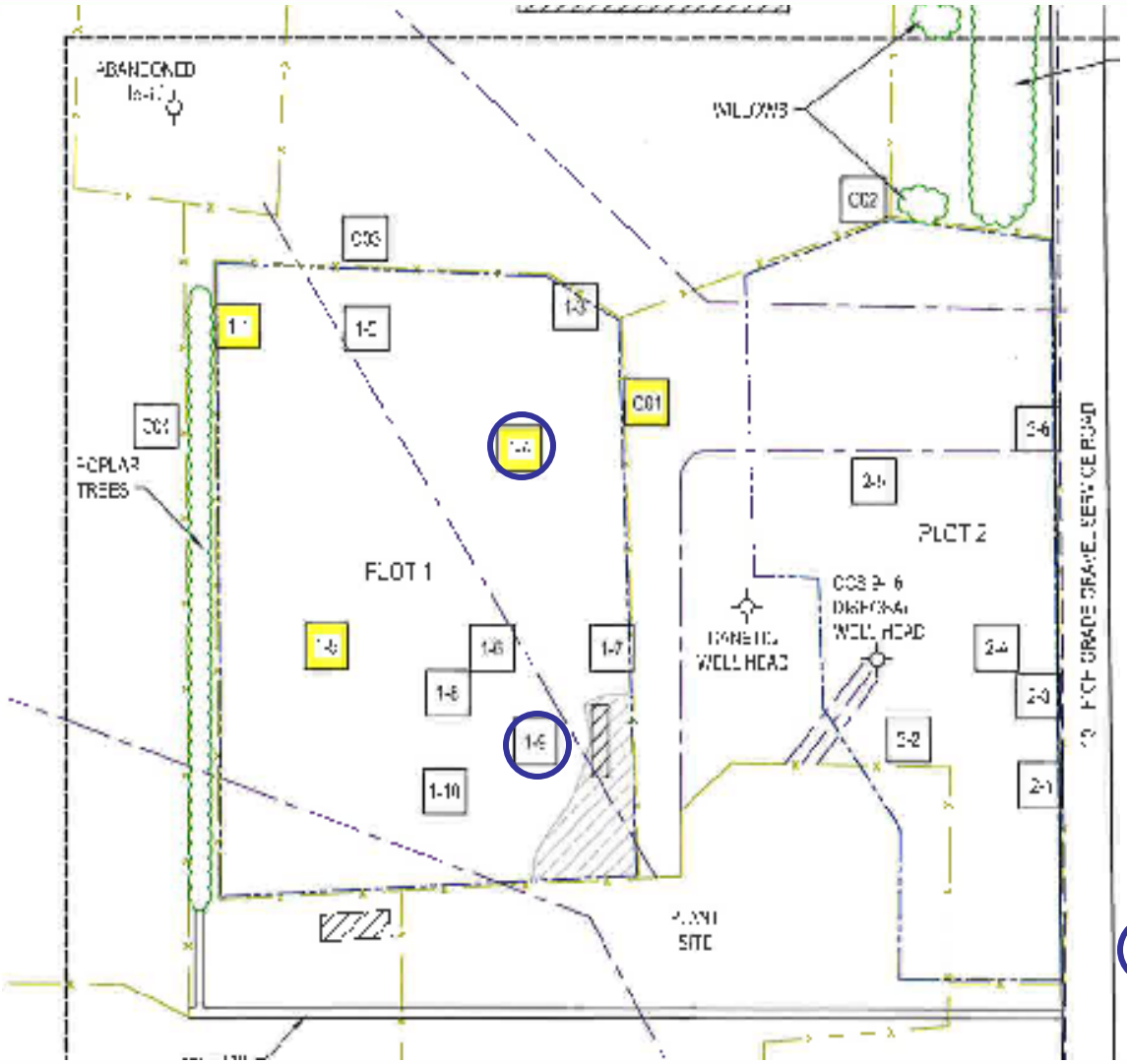
Closure Assessment

- Relied on similar strategy as used for the Wolf Lake Land Treatment Facility (reviewed and accepted by AENV Stony Plain Region in 2001), but updated to reflect “draft-for public comment” Tier 2 Eco-contact Guidelines Derivation Protocol” July 13, 2007
- Randomly selected locations were sampled and characterized for potential contaminants of concern (PCOC), physical characteristics, nutrients, water holding capacity, and cyclodextrin-extracted PHCs
- Sample 4 controls and randomly selected locations for Plot 1 and Plot 2 (10 and 6 locations, respectively)

Closure Assessment

- Chemical data was summarized statistically and the population distribution defined
- USEPA “Method of Attainment of Clean-up Standards” was used for evaluation of metals and EC
- Bulk samples were collected for ecotoxicity testing and characterized so that bulk samples representative of the upper 25th percentile of the population for PHCs could be determined
- Three bulk samples locations were selected for ecotoxicity testing based on chemical analysis results for PHCs and cyclodextrin-extracted PHCs and chromatogram interpretation

Bulk Sample Locations

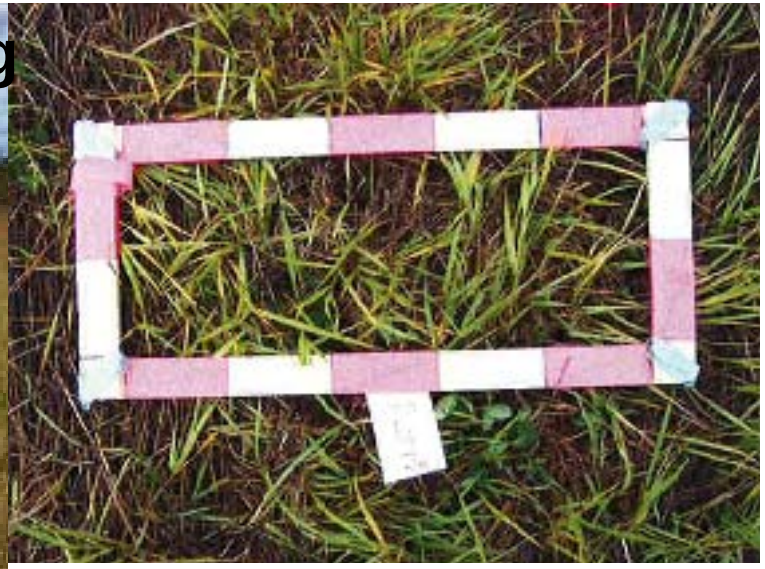


- 10 Randomly chosen locations within Plot 1
- 6 Randomly chosen locations within Plot 2
- 4 Controls
- After review of lab analysis, three Plot 2 treatment samples chosen as representing upper 25th percentile
- CO1 control chosen as most similar and both control site topsoil and an adjusted (for pH and EC) control site topsoil used for ecotoxicity testing
- Plot 1-4 found to be anomalous and replace with 1-6

Bulk Soil Sampling for Ecotoxicity Samples

Vegetation Assessment and Sampling

Control

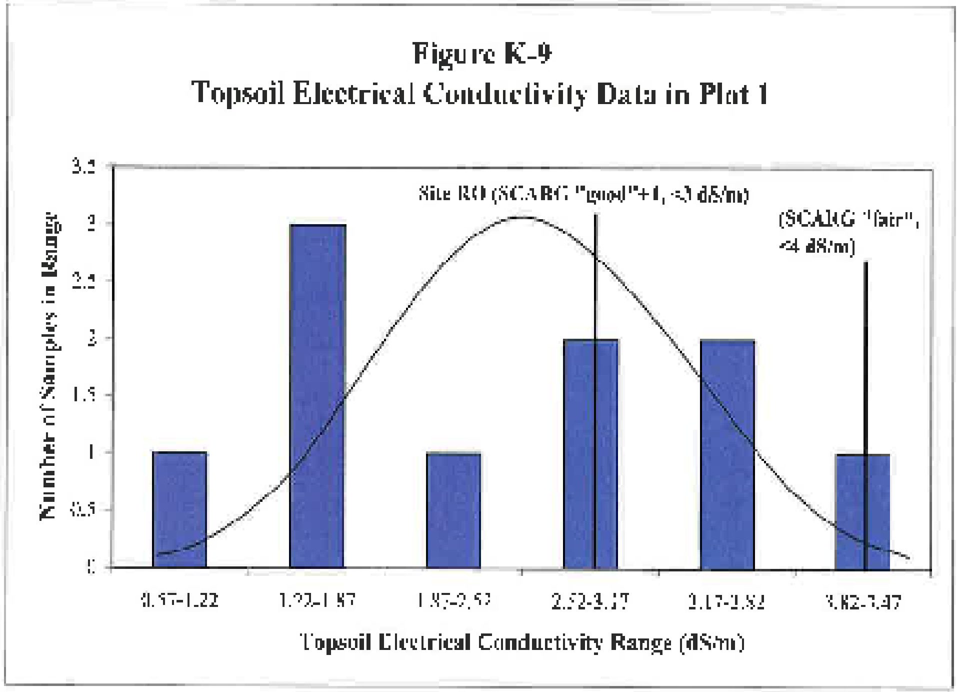


Plot 1-5

Plot 1-4

Soil Chemical Analysis Results, 2007

- All parameters analyzed (100% of samples) meet Tier 1 Guidelines for **native soils** underlying the land treatment material in Plot 1 and Plot 2
- All parameters analyzed meet Tier 1 Guidelines for **Plot 2 land treatment material** except PHC fraction F3, which exceeded for two of seven samples
- All parameters analyzed meet Tier 1 Guidelines for **Plot 1 land treatment material** (25 samples) except the following:
  - PHCs F3 and/or F4
  - Topsoil EC
  - Some metals (boron, copper, lead, zinc)
- Plot 1 zinc and copper statistically meet Tier 1 guidelines (80% of population with a 95% confidence)



Site Topsoil EC remediation objective (RO) is equal to SCARG [1] "good" rating plus 1 (= 3 dS/m +1).

30	% of population exceeding RO

Conclusion: Fail since 30% of population exceeds remediation objective.

10	% of population exceeding SCARG "fair" (4 dS/m)

Conclusion: Pass since 10% of population exceeds remediation objective.

Descriptive Statistics

Normal Distribution:	Yes	
Sample Size (n):	10	
Minimum:	0.89	dS/m
Mean ($\bar{x}$):	2.[illegible]53	dS/m
Median:	2.[illegible]65	dS/m
Maximum:	4.26	dS/m
Standard Deviation:	1.094	

Shapiro-Wilk W test[2,3]

H_0: population has Normal distribution

H_1: population does not have Normal distribution

Type I error (reject H_0 when it is true): α = 0.05

d =	10.7742	$= \sum (x_i - \bar{x})^2$
k =	5	= n/2, for n even
W =	0.9574	[illegible]
$W_{(0.05, 10)}$	0.842	[illegible]

Reject H_0 if $W < W_{\alpha}$

Cannot reject H_0, population assumed to be Normal

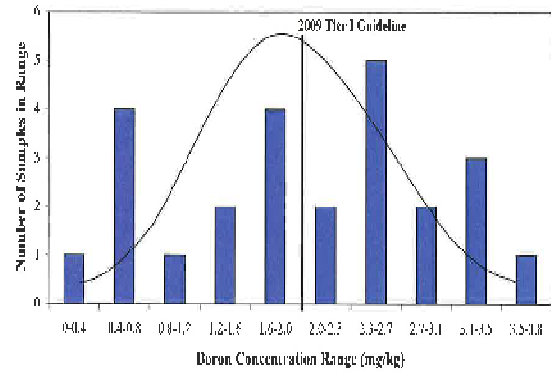
[1] Alberta Environment. 2001. *Soil Contamination Assessment and Remediation Guidelines*

[2] US EPA. 2006. *Data Quality Assessment: Statistical Methods for Practitioners (EPA QA/G-9S)*

[3] Richard O. Gilbert. 1987. *Statistical Methods for Environmental Pollution Monitoring*

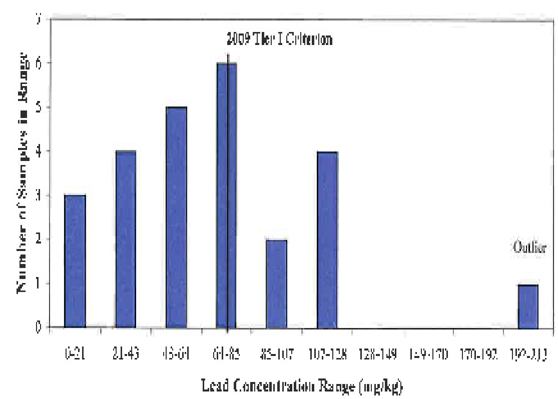
Boron

Figure K-5
Boron Data in Plot 1



Lead

Figure K-7
Lead Data in Plot 1



Further Study Approaches

- PHC F3 and/or F4 – use AENV 2007 Draft Guidelines for Setting Tier 2 for Eco-Contact
- Topsoil EC – allow to ameliorate naturally by leaching and then resample to show it meets Tier 1
- Boron – use saturated paste boron draft study being conducted through PTAC to set risk-based boron guidelines
- Lead – set site-specific lead guideline by adjusting limiting pathway of livestock soil and food ingestion

2010/2011Results

- Topsoil EC re-sampled and analyzed after 3 more years and now statistically meets the topsoil good category
- Saturated paste boron (more ecologically relevant for toxicity and risk-based) meets the draft guidelines presented through PTAC in 2007
- Further delineation at one of the bulk sample locations was completed to show it is anomalous (Plot 1-4) and an alternative bulk sample was used for ecotoxicity evaluation and the site passes for agricultural land use
- Lead – Calculated site-specific livestock soil and food ingestion pathway using land use, site characteristics and soil and vegetation lead concentrations and 100% of the samples meet the site-specific value

Ecotoxicity Evaluation

- Stantec in Guelph, Ontario conducted the Soil Ecotoxicity Testing
- Procedures followed Environment Canada standards and AENV draft (2007) Tier 2 Eco-contact Guidelines
- AENV Tier 2 Guidelines are based on a pass/fail analysis
- Acute and chronic testing were conducted
- Controls include control topsoil (site reference soils) an EC and pH adjusted control topsoil and a laboratory negative control (artificial control)

Ecotoxicity Evaluation

- Soil Invertebrates: springtail (*Folsomia candida*) and earthworm (*Eisenia andrei*)
- Plant species (based on current and potential land use relevance as well as species required by AENV draft guidelines) included four species, including 3 monocotyledonous and one dicotyledonous plants
  - Northern Wheatgrass (*Elymus laceolatus*)
  - Timothy (*Phleum pratense*)
  - Red Clover (*Trifolium pratense*)
  - Barley (H*ordeum vulgare)*
- The number of end points exceeded AENV minimum defined requirements

Ecotoxicity Evaluation

- Results were compared to both the control and the adjusted control
- Treatment soils from Plot1-1 and 1-5 had PHC F3 and F4 in the upper 25th percentile, Plot 1-6 was not in upper 25th percentile of PHC F3 but had second highest cyclodextrin F3






Ecotoxicity Findings

- Results were compared to Tier 2 Pass/Fail criteria for agricultural land use (most stringent)
- Results were also compared to various criteria requirements such as number of endpoints and allowable statistical difference from the control
- The site soils satisfy AENV Tier 2 criteria for the agricultural land-use scenario and; therefore, pass the Tier 2 assessment

Summary

- Land Treatment material generally meets the Tier 1 guidelines; however, Tier 2 or site-specific guidelines were needed for the following parameters
  - Use of AENV draft Tier 2 Guidelines for Eco-Soil Contact
  - Calculation of site specific guidelines for lead livestock soil ingestion pathway using site characteristics
  - Boron compared to draft saturated paste extract values from PTAC
- The project demonstrates the value of communication with the regulators for sites that are more complicated
- It also shows the value of a rigorous study design that tries to anticipate data complexities and shows how project updates may be necessary to address uncertainties

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Thank You!