

Implementation of Site-specific Ecotoxicological Data for Estimating Risk and Deriving SSROs

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Presentation Overview

1 Background

2 Objectives & Challenges - Ecotoxicology

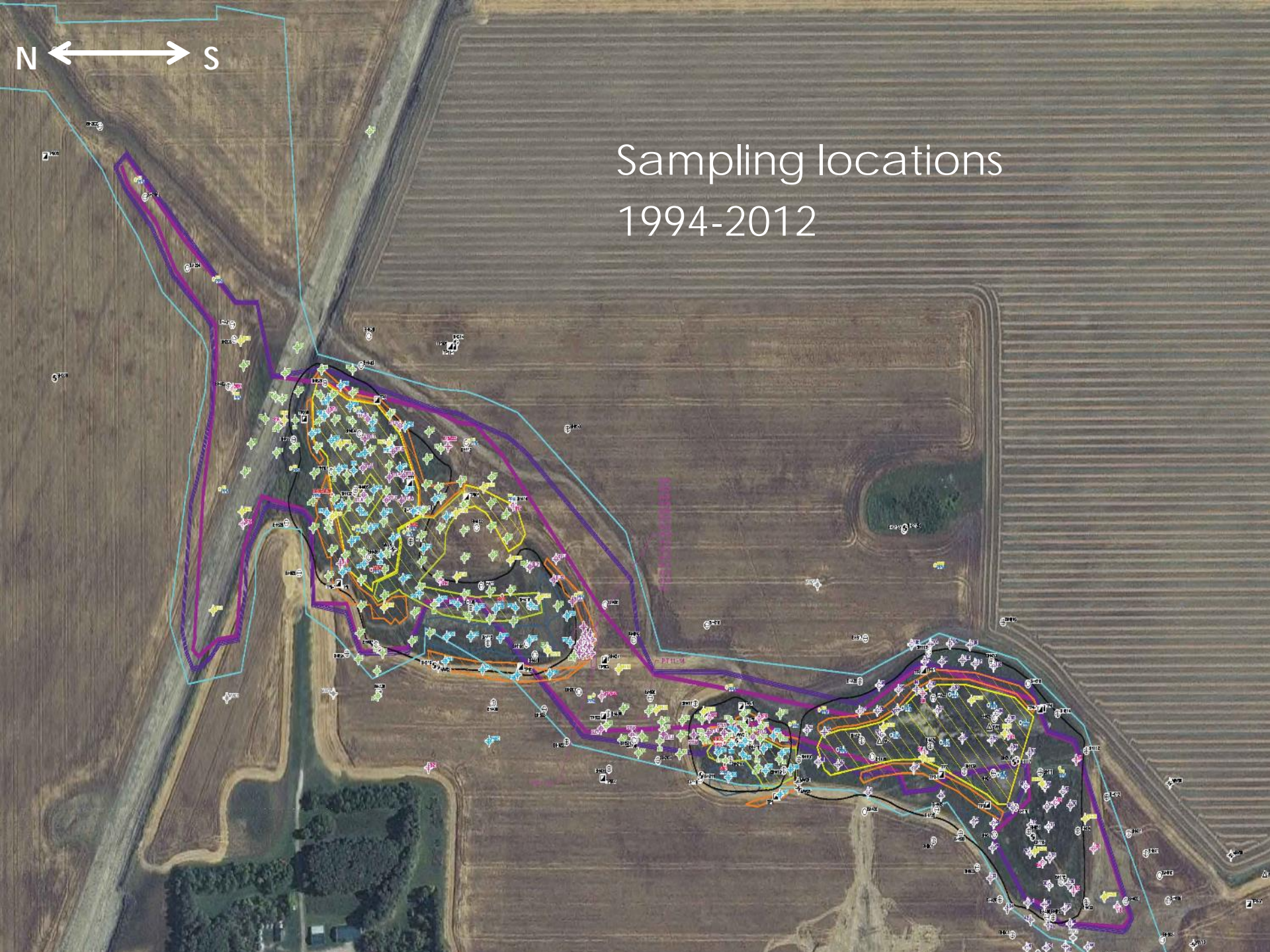
3 Test Methods and Results

4 Tier 2 Pass/Fail Criteria

5 Corroborating Evidence

1 Site History

- ~4,000 m³ crude oil inadvertently released covering ~15 ha of farmland (~3,000 m³ recovered)
- Cleanup and remedial activities have occurred since the release
- In 2008, an Environmental Site Assessment was completed and a remediation strategy developed and implemented
- One component of the strategy was to assess the risk associated with F3 residuals in stockpiled soils; therefore, an **ecotoxicity assessment** was commissioned



2 Objectives of Ecotoxicological Assessment

1. Determine if the soils comprising the stockpiles were acceptable for redistribution across the site as surface cover
2. To generate data required to derive a site-specific remedial objective for F3 residuals

3 Ecotoxicology Assessment (2011)

Test species:

Plants – Northern wheatgrass, Barley, Canola

Earthworms – *Eisenia andrei* (compost worm)

Arthropod – springtail (Collembola: *F. candida*)

Test soils (all fine-grained texture):

Reference Control Soil (TP11) – 73 mg F3/kg soil

Conductivity Control Soil (TP6-1) – 681 mg F3/kg soil

Site soil TP9-1 – 2300 mg F3/kg soil

Site soil TP4-1 – 3950 mg F3/kg soil

Site soil TP5-1 – 4667 mg F3/kg soil

Site soil TP2-1 – 7533 mg F3/kg soil

Artificial Soil – QA/QC

3 Experimental Design

Test Methods (chronic or definitive):

Environment Canada:

2004 – Report 1/RM/43 (worms)

2005 – Report 1/RM/45 (plants)

2007 – Report 1/RM/47 (springtails)

OECD 2004 (worms)



3 Experimental Design

Measurement Endpoints:

Plants: seedling emergence; shoot & root length;
shoot & root dry mass (14-21 d)

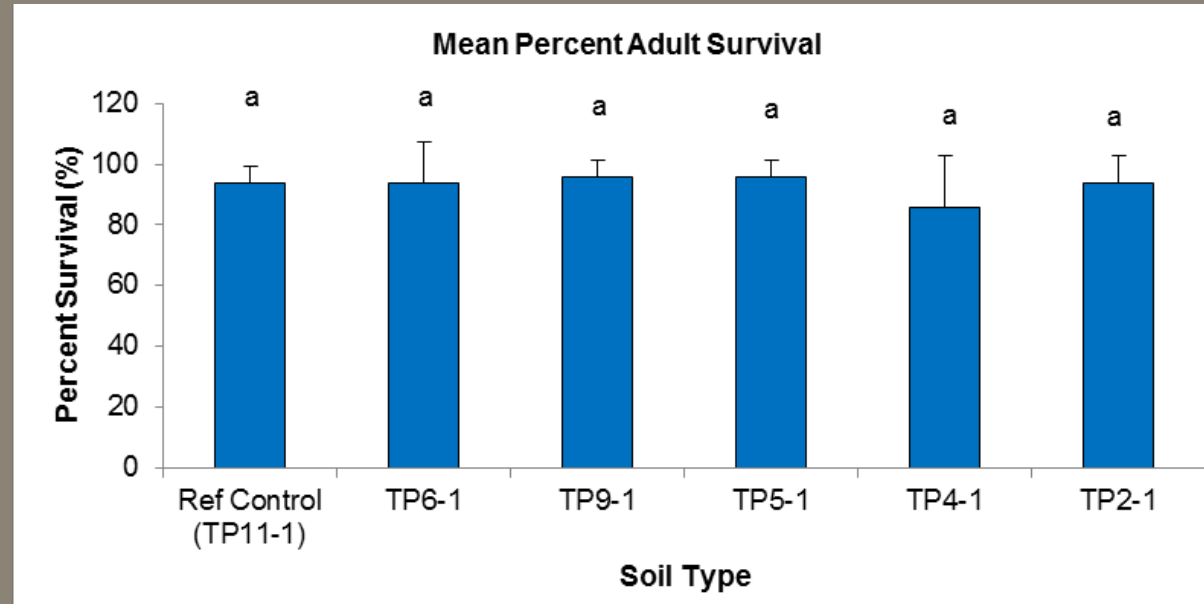
Worms: 35-d adult survival; 63-d progeny production;
progeny dry mass (EC, 2004)

Worms: 28-d adult survival; adult wet & dry mass;
56-d progeny production (OECD, 2004)

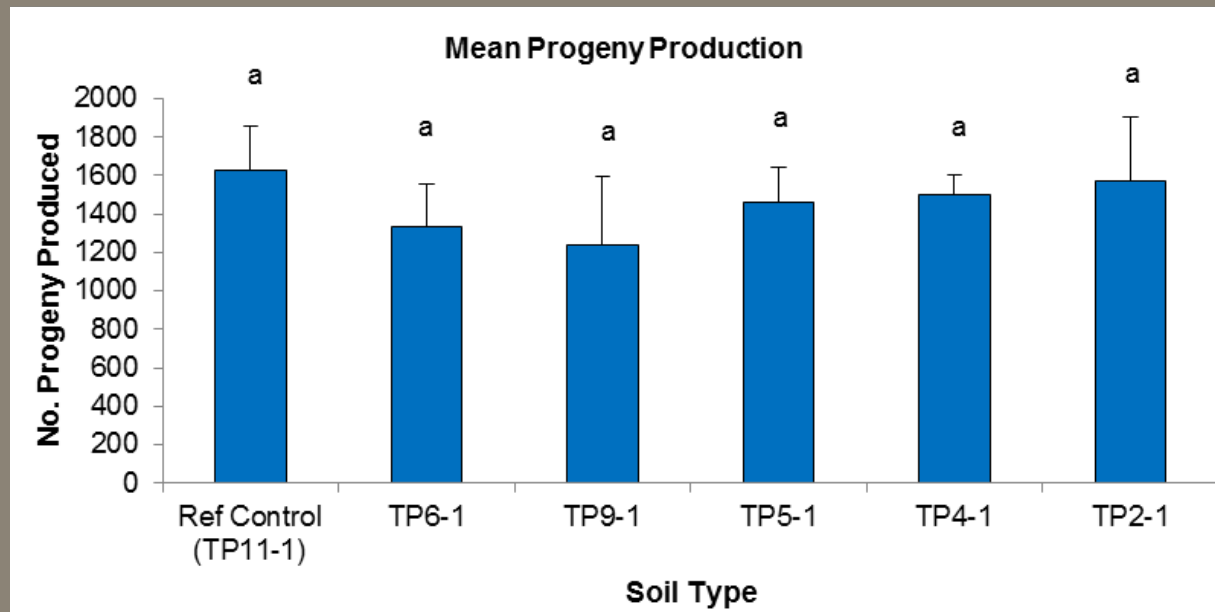
Springtail: 28-d adult survival; 28-d progeny production

3 Springtail Test Results

● No significant adverse effects for 28-d adult survival

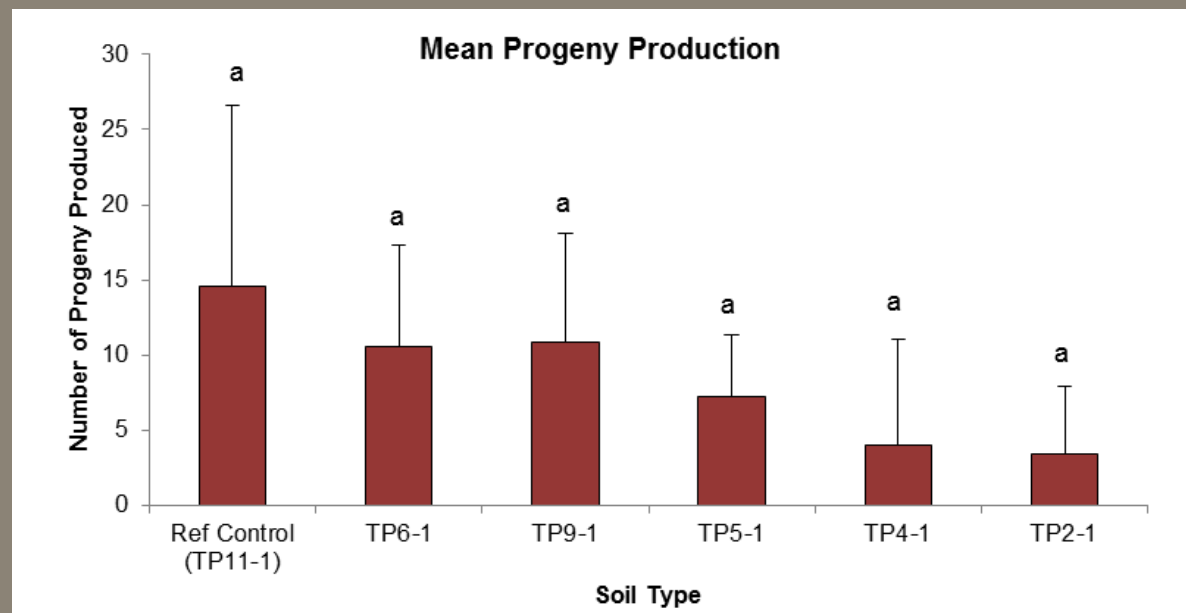
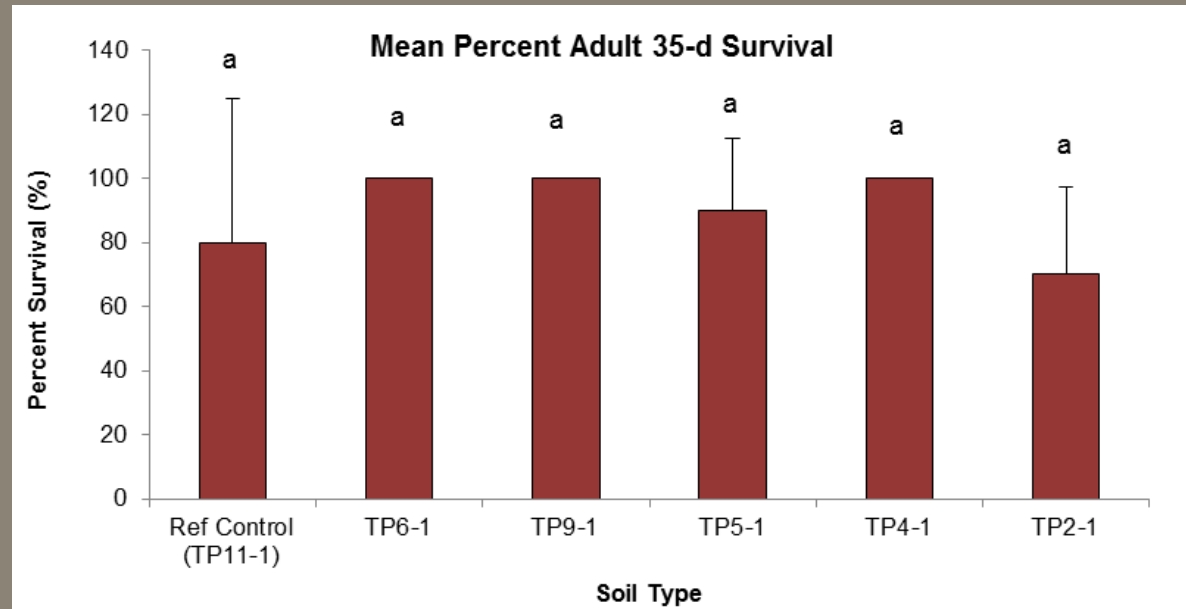


● No significant adverse effects for progeny production



3 Earthworm Test Results – EC

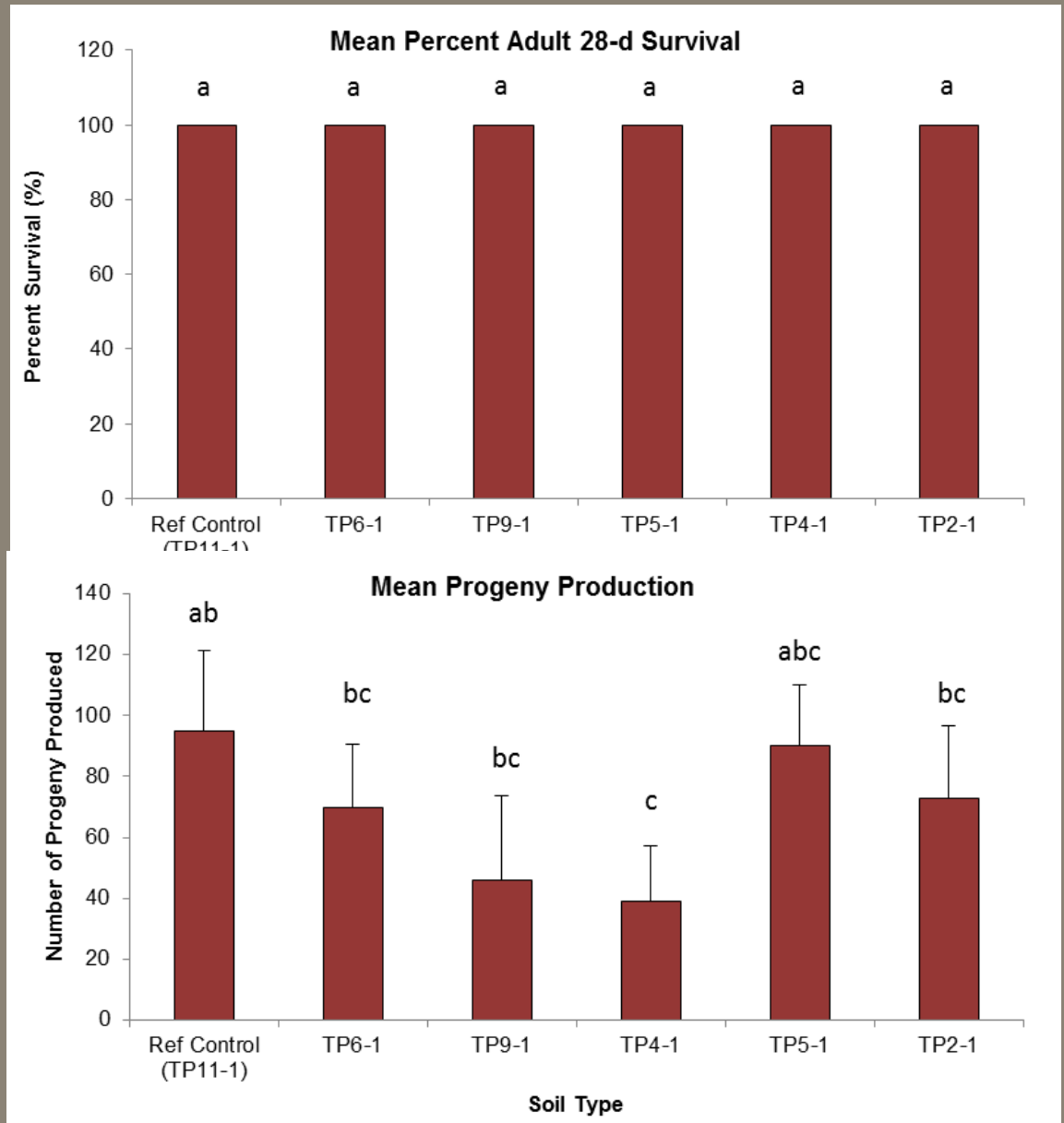
- Adult survival was not adversely affected
- Progeny production and progeny dry mass were unaffected
- Statistical power was lacking



3 Earthworm Test Results - OECD

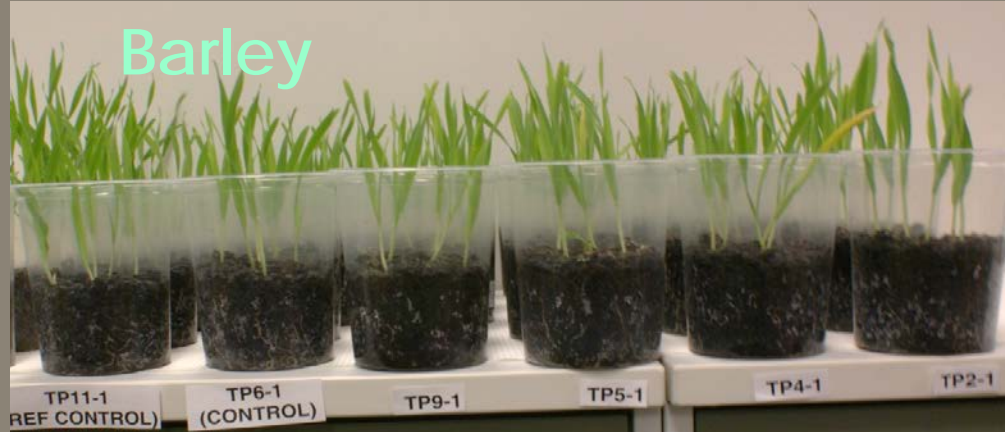
● Adult survival was not adversely affected

● Progeny production was reduced in one soil : TP4-1



3 Plants:

Barley



Canola



Northern wheatgrass



LEGEND

TP 11-1	–	79 mg F3/kg soil dry wt. (ref. control)
TP 6-1	–	681 mg F3/kg soil dry wt.
TP 9-1	–	2300 mg F3/kg soil dry wt.
TP 4-1	–	3950 mg F3/kg soil dry wt.
TP 5-1	–	4667 mg F3/kg soil dry wt.
TP 2-1	–	7533 mg F3/kg soil dry wt.

Conclusion:

- Plants generally grew better in soils with petroleum hydrocarbons present; when significant differences occurred, growth was enhanced;
- Only 1 of 15 endpoints indicated an adverse effect

Summary

- Plants grew well in soils with PHCs at concentrations as high as 7533 mg F3/kg
- Springtails were not adversely affected
- Earthworm adult survival and growth (wet/dry mass of adults) were not adversely affected
- Earthworm progeny production was significantly reduced by a site soil with a combination of F3 at 3,950 mg F3/kg soil dry wt. and conductivity of >3.35 dS/m
- Progeny unaffected by F3 concentrations of 4,667 and 7,533 mg/kg soil dry wt.

4 AB Tier 2 Pass/Fail Approach

Criteria for agricultural land uses and natural areas

- Statistical power must be sufficient to detect a difference of 25% or more
- When statistical differences are identified between reference and contaminated soils, the difference must be $\leq 25\%$ for at least 75% of the endpoints
- Test organism mortality must be no greater in the site soil than in the reference soil
- Invertebrate reproduction in the site soil must not be $< 50\%$ of that in the reference control soil
- No more than one endpoint per species may exceed a 25% difference between the site and reference soil
- Must be a minimum of 11 toxicity endpoints

Toxicity Test and Measurement Endpoints	Percent Difference from Reference Control (TP11-1)				
	TP6-1 681 mg/kg F3	TP9-1 2300 mg/kg F3	TP4-1 3950 mg/kg F3	TP5-1 4667 mg/kg F3	TP2-1 7533 mg/kg F3
Barley					
Emergence	0	0	-4	-4	-4
Shoot Length	-8	-4	-6	-6	-18
Root Length	-25	-27	-18	-43	-33
Shoot Dry Mass	-21	4	-16	-12	-22
Root Dry Mass	-39	-32	-35	-40	-32
Canola					
Emergence	8	12	8	4	8
Shoot Length	-19	-22	-39	-41	-61
Root Length	-9	-5	-15	-24	-21
Shoot Dry Mass	-69	-32	-96	-128	-155
Root Dry Mass	-83	-16	-84	-97	-128
Northern Wheatgrass					
Emergence	4	8	8	-8	4
Shoot Length	-14	7	2	-18	-5
Root Length	-27	-18	13	-7	4
Shoot Dry Mass	-43	16	-3	-8	-16
Root Dry Mass	-54	11	24	<u>28</u>	<u>31</u>
Eisenia andrei					
Adult Survival (d35)	-25	-25	-25	-13	13
Number of Juveniles Produced (d63)	<u>27 (26)¹</u>	<u>26 (50)¹</u>	<u>73 (59)¹</u>	<u>50 (5)¹</u>	<u>77 (23)¹</u>
Juvenile Dry Mass (d63)	-4	<u>32</u>	13	-200	9
Folsomia candida					
Adult Survival	0	-2	9	-2	0
Number of Juveniles Produced	18	24	8	10	3
Number of Endpoints	20	20	20	20	20
Number of Endpoints Adversely Affected	0	0	1 - Progeny Production	0	1

- Values in bold are significantly different from the reference control soil (TP11-1).
- Negative values indicate that the measurement was greater in the site soil than in the reference control (TP11-1).
- Underlined positive values represent a difference of > 25%.
- Values in brackets are the percent differences for the OECD earthworm test

4 Tier 2 Pass/Fail: Conclusions

- In the absence of elevated EC, F3 concentrations as high as 7533 mg/kg are demonstrably non-hazardous to earthworms and springtails
- PHC concentrations in the stockpile soils represent minimal risk for the crop rotation species (barley, wheat, and canola) frequently grown in this region

5 Corroborating Evidence



Photo 1: Cattail - senescent leaves; Prickly Sow Thistle in foreground



Photo 2: Brome Grass and Prickly SowThistle on stockpile



Photo 3: Earthworms present in soil from the site

Advantages

Ecotoxicology

- Demonstrated acceptable risk associated with PHC (F3) residuals in the stockpiled soils; SSRO = 7500 mgF3/kg
- ~8,000 tonnes of soil with $F3 > 7,500$ mg/kg were removed (management decisions supported by science)

Cost/Benefit

- Costs: 70K for testing + 30K for collection and analytical chemistry
- Benefit: ~4-5 M potential savings (excavation/disposal)
- Thousands of cubic meters of high-quality topsoil were conserved

Questions?

