



SOIL STERILANTS PROGRAM (SSP) – REMTECH

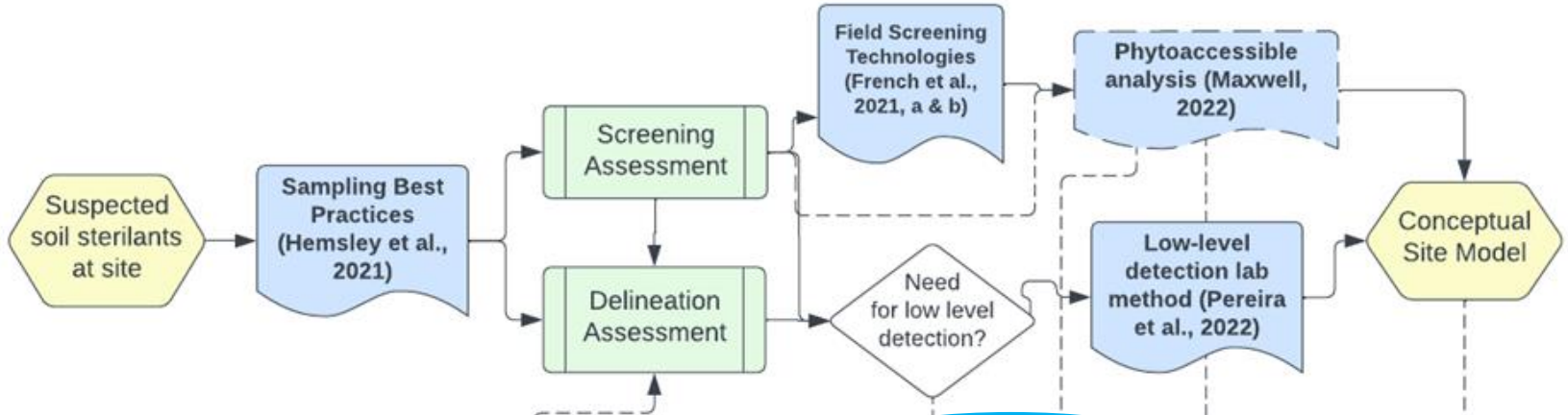
Risk Assessment for
Management of
Sterilant Impacted
Sites



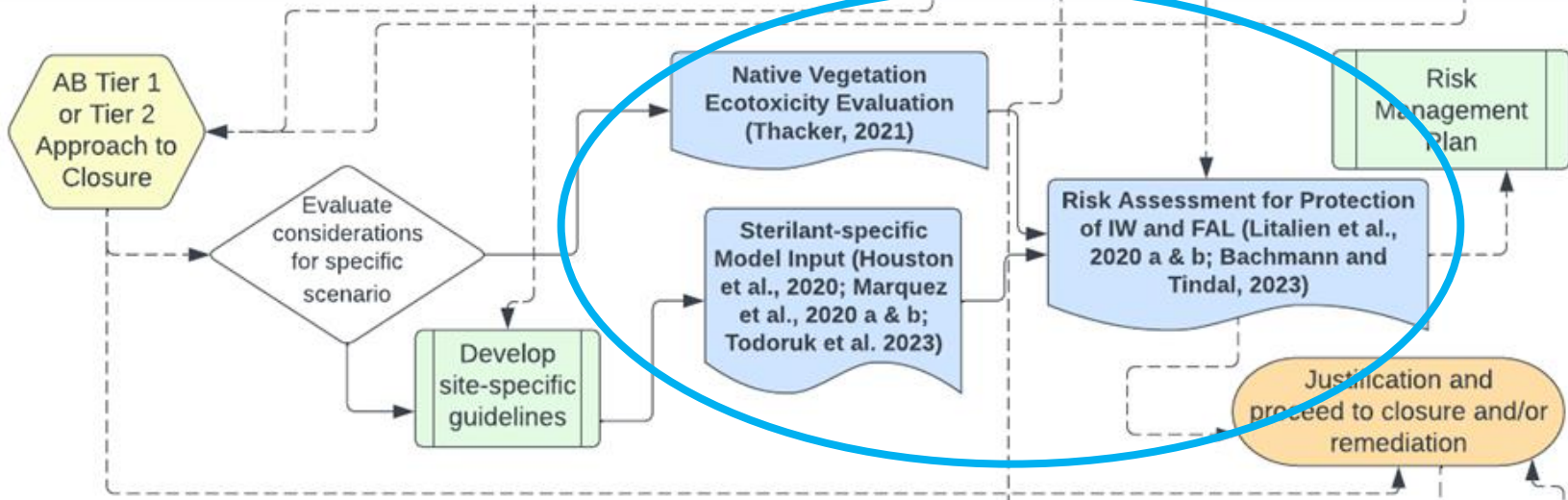
Cory Kartz

Millennium EMS Solutions Ltd

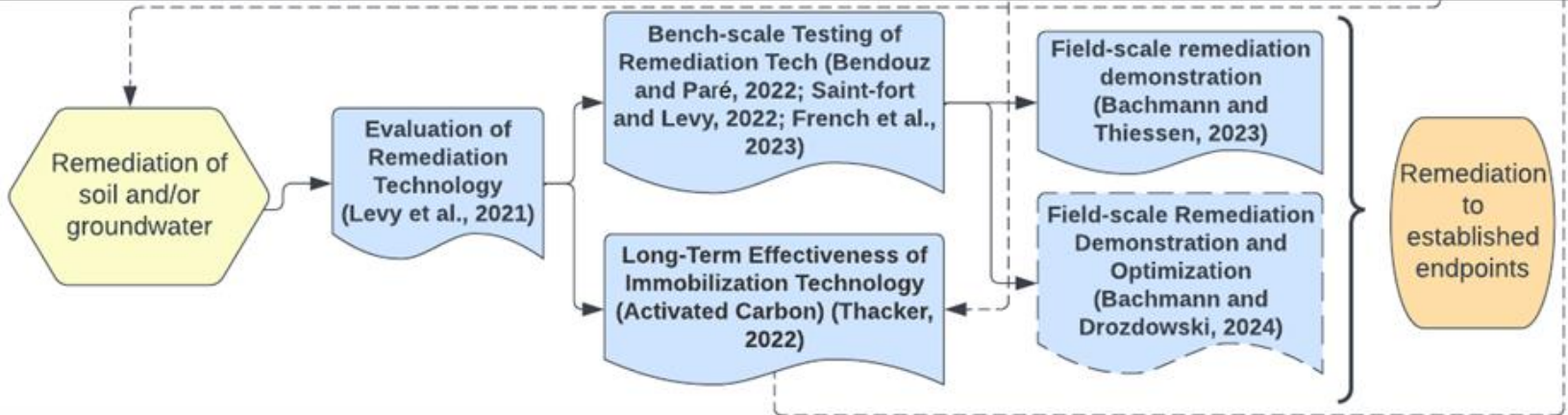
Identification and Delineation



Risk Assessment and Management



Remediation



- Objective was to establish **proven, technical and cost-effective** strategies and best practices for management of sites impacted by residual soil sterilants, with the goal of supporting regulatory site closure.
- 5 year program
 - Initiated in 2019
- Scope
 - Address challenges specific to AB
 - Applied research
 - Focus on Bromacil and Tebuthiuron
- Executed through a series of projects in:
 - Identification and Delineation
 - Risk Assessment and Management
 - Remediation

OBJECTIVE

- Review of risk models and model parameters to support improved risk assessment and risk management for bromacil and tebuthiuron with an Alberta context, specifically:
 - #1 Review of key chemical-specific parameters influencing fate and mobility in the subsurface with application to the irrigation water and freshwater aquatic life pathways
 - #2 Generation of new ecotoxicological data for native plant species for the ecological direct contact pathway

WHY A FOCUS ON THE IRRIGATION WATER (IW) AND
FRESHWATER AQUATIC LIFE (FAL) PATHWAYS?

TIER 1 SOIL GUIDELINES BY EXPOSURE PATHWAY - AGRICULTURAL LAND USE



	Bromacil		Tebuthiuron	
	Fine (mg/kg)	Coarse (mg/kg)	Fine (mg/kg)	Coarse (mg/kg)
Human Soil Contact	2,000	2,000	1,600	1,600
Drinking Water (DUA)	7	10	2.5	3.7
Livestock Water (LW)	2	2	0.12	0.11
Ecological Soil Contact	0.2	0.12	0.046	0.046
Freshwater Aquatic Life (FAL)	0.009	0.009	BDL	BDL
Irrigation Water (IW)	BDL	BDL	BDL	BDL

BDL = below detection limit – assessment by groundwater monitoring REQUIRED for Tier 1 soil guideline application

Overall Tier 1 guidelines in red

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EXPOSURE PATHWAYS

- Direct exposure pathways
 - Human direct contact pathway
 - Ecological direct contact pathway
- Indirect exposure pathways
 - Protection of freshwater aquatic life (FAL)
 - Protection of irrigation water (IW)
 - Protection of drinking water (DUA)
 - Protection of livestock water (LW)

CALCULATING GUIDELINES FOR **INDIRECT** EXPOSURE PATHWAYS



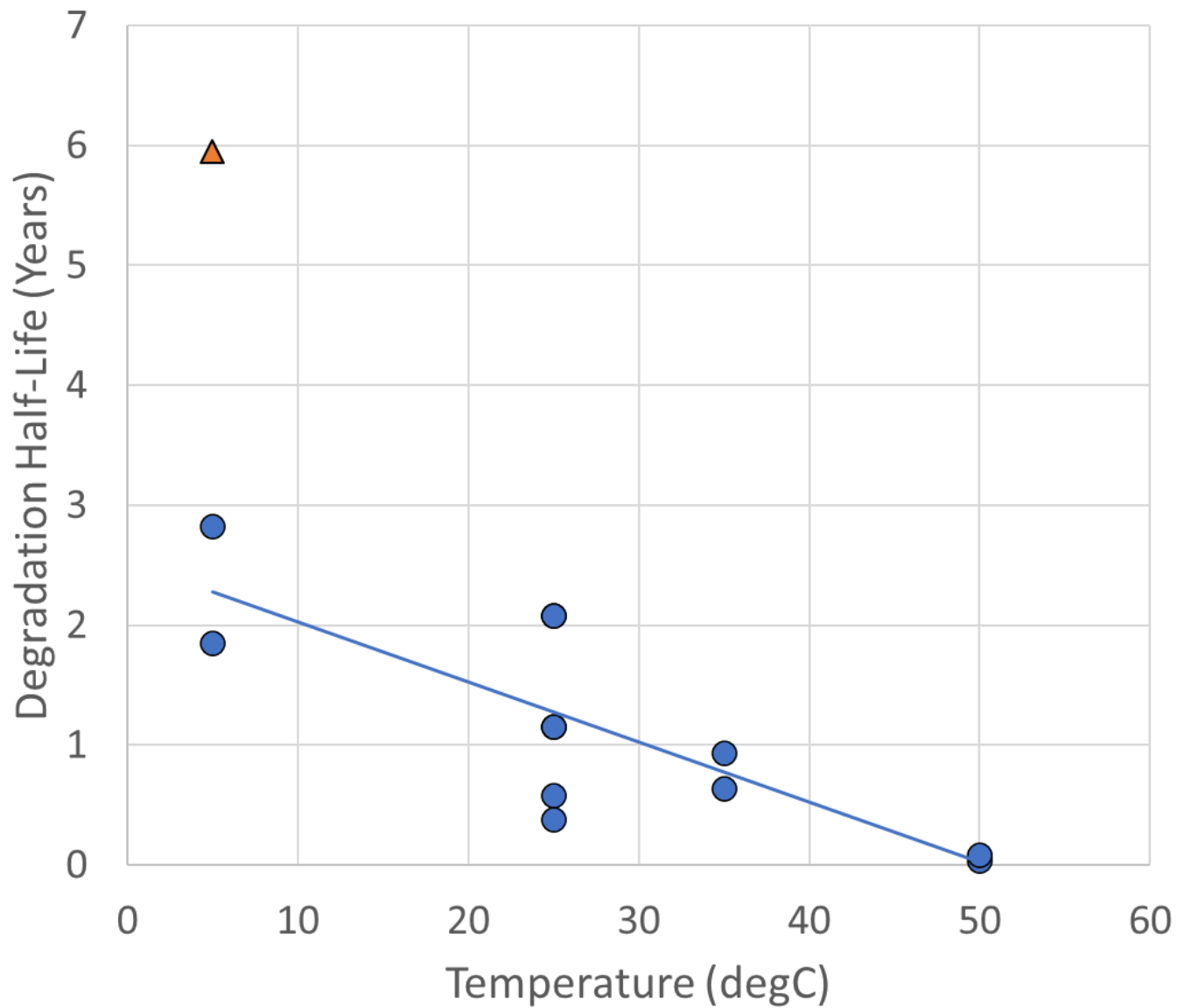
- Both the FAL and IW pathways are **indirect** exposure pathways
- Models (equations)
 - Standard Tier 1 models
 - Other models
- Parameters
 - Site (soil, groundwater, geometry) parameters
 - Tier 1 default value for fine and coarse soils
 - Chemical-specific parameters
 - Degradation half-life ($t_{1/2}$)
 - Sorption coefficient (K_{oc} or K_d)

CHEMICAL-SPECIFIC PARAMETER VALUES - EXISTING TIER 1 VALUES



Parameter	Unit	Bromacil	Tebuthiuron
Degradation half-life ($t_{1/2}$)	(years)	(no value)	(no value)
Sorption coefficient (K_{oc})	(ml/g)	66.6	23

Bromacil Degradation Half-Life vs Temperature



- Gerstl and Yaron (1983)
- SSP Data (2023)
- Linear (Gerstl and Yaron (1983))

ADSORPTION-DESORPTION INVESTIGATION

Measured parameters in the laboratory study conducted included Koc and soil-water partition coefficient (Kd) for bromacil and tebuthiuron in soils with variable texture and total organic carbon (TOC)

Results:

- Higher adsorption in fine versus coarse-grained soil
- Higher adsorption of bromacil than tebuthiuron under all conditions
- Higher TOC, fine -textured soil had greater adsorption than lower low TOC and coarse soils for both sterilants

Outcome: Need to isolate effects from different chemical and soil parameters –modification to Koc would involve Tier 2 SSRA

PRACTICAL APPLICATION



	Bromacil		Tebuthiuron	
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Overall Tier 1 guidelines in red

GROUNDWATER MONITORING TO SUPPORT RISK-BASED DECISION MAKING



- Groundwater monitoring strongly recommended:
 - Both bromacil and tebuthiuron
 - All land uses
- Groundwater monitoring should access reasonable worst-case location
- Groundwater below surface water guideline for aquatic life or irrigation:
 - Use as part of SSRA approach to establish absence of risk in the presence of soil quality >Tier 1
- Note that groundwater monitoring is REQUIRED for Tier 1 soil guideline application:
 - For any pathways noted as BDL in soil guideline tables
- Groundwater above surface water guidelines > Tier 2 approach recommended

FRESHWATER AQUATIC LIFE (FAL) – TIER 2 PATHWAY APPLICABILITY



- Formal Tier 2 pathway exclusion not available
- FAL pathway applicable in all land uses
- Other site-specific approaches to assess pathway relevance:
 - Transit time to water body
 - Tier 2 guideline recalculation

TIER 2 FAL APPLICABILITY - DISTANCE TRAVELLED IN 500 YEARS



	Bromacil		Tebuthiuron	
	Fine (m)	Coarse (m)	Fine (m)	Coarse (m)
Distance Travelled in 500 Years	500	5,000	700	8,000

These cut-off apply equally in all land uses

TIER 2 FAL APPLICABILITY - DISTANCE FOR FAL PATHWAY NOT TO BE LIMITING



Source Size (Width)	Distance to Surface Water			
	Bromacil		Tebuthiuron	
	Fine (m)	Coarse (m)	Fine (m)	Coarse (m)
10 m	410	360	590	950
20 m	(530)	720	(770)	1,900
30 m	(600)	1,100	(870)	2,800
50 m	(680)	1,800	(1,000)	4,400
100 m	(790)	3,100	(1,200)	6,500

These calculations are an example only based on:

- apply to natural area or agricultural land use
- Current Tier 1 ecological direct contact , different values would be calculated for industrial land use

Distances in parentheses are greater than the 500-year cutoffs in the previous slide

TIER 2 IRRIGATION WATER PATHWAY APPLICABILITY

LAND USE CONSIDERATIONS



- The irrigation water pathway applies only to agricultural land
- Tier 1 guidance indicates irrigation water can come from either:
 - An “irrigation use aquifer” (Section 2.3.5)
 - A dugout (Section C.5.2)
- Bromacil or tebuthiuron in groundwater in agricultural land use:
 - Will require Tier 2 SSRA, remediation or exposure control

RECOMMENDED BEST MANAGEMENT PRACTICES – FRESHWATER AQUATIC LIFE AND IRRIGATION WATER

- Always plan to assess groundwater when bromacil or tebuthiuron are present
- Compare worst case groundwater concentration to:
 - FAL surface water guideline
 - Irrigation water guideline
- Groundwater below guideline can be used in an SSRA approach to assess risk to corresponding pathways if the presence of a Tier 1 soil guideline exceedance
- Applicable guideline will then be the ecological soil contact guideline
- Groundwater above guidelines > Tier 2 approach recommended
- If Tier 2 approaches are not available or do not resolve the issue
 - SSRA, remediation or exposure control may be required

WHY A FOCUS ON THE ECOLOGICAL DIRECT CONTACT PATHWAY?

CHALLENGE

- Soil quality guidelines for sterilants in Alberta largely based on agronomic species
- Uncertainty regarding sensitivity of native species to soil sterilants

GOALS OF EXPERIMENT

- Evaluate the toxicity of bromacil and tebuthiuron to Alberta native species
- Develop potential alternatives for direct soil contact guidelines for the province



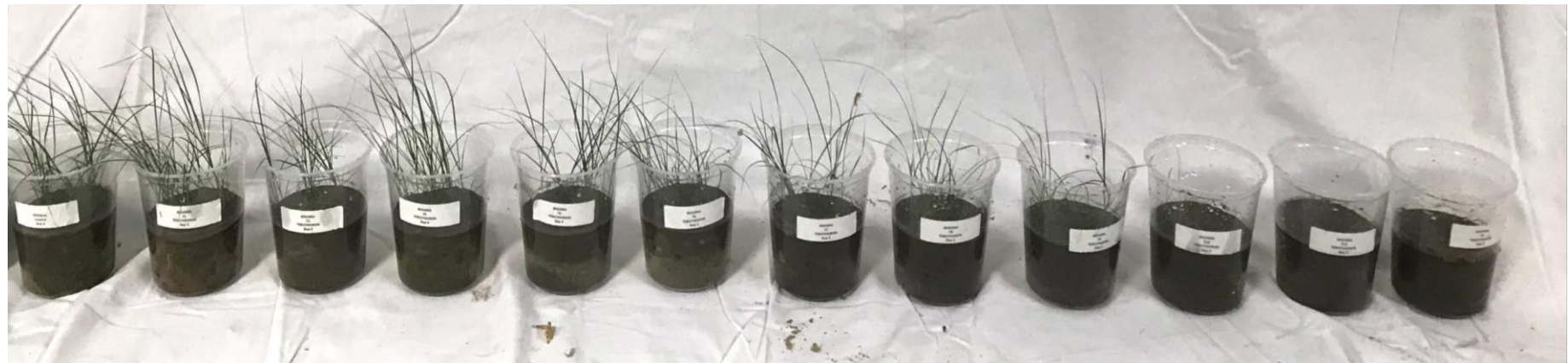
<https://www.country-guide.ca/crops/what-you-should-know-before-marketing-durum-wheat/>



<https://blog.cwf-fcf.org/index.php/en/pfra-community-pastures/>

EXPERIMENTAL DESIGN

- Followed an Environment Canada (2007) method
- **6-week** greenhouse experiment (fine textured soil and locally adapted seeds)
- Estimate Inhibition Concentrations for:
 - Emergence
 - Shoot length
 - Root length
 - Shoot weight
 - Root weight

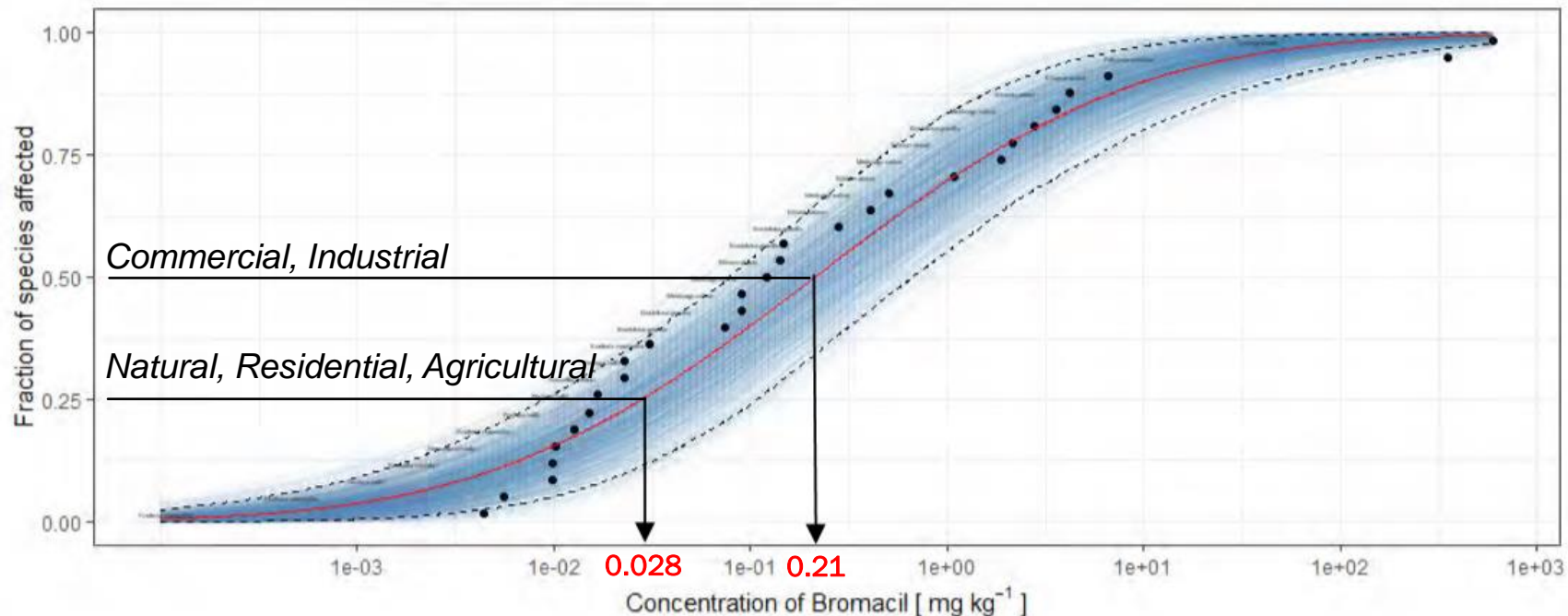


RESULTS – SOIL QUALITY GUIDELINE DEVELOPMENT

Work conducted by Millennium EMS Solutions Ltd. using current and historical data

- Species sensitivity distributions (IC_{25}) completed for:
 - All plants + invertebrates used for SQG

Species sensitivity distribution



CCME 2006
protocol for the
development of
soil quality
guidelines/eco-
contact pathway
guidelines

ALTERNATIVE SOIL QUALITY GUIDELINES



- Proposing alternative guidelines for the ecological direct soil contact pathway for fine textured soil
 - Species sensitivity distributions including new data on native species more sensitive to the effects of bromacil and tebuthiuron than species studied historically
 - Alternative guidelines more stringent than current Tier 1 Guidelines

	Tier 1 Guideline	Natural/Residential/Agricultural (25 th percentile of SSD)	Commercial/Industrial (50 th percentile of SSD)
Bromacil	Current Tier 1 (mg/kg)	0.20	0.49
	Revised ¹ (mg/kg)	0.028	0.21
Tebuthiuron	Current Tier 1 (mg/kg)	0.046	0.60
	Revised ¹ (mg/kg)	0.018	0.15

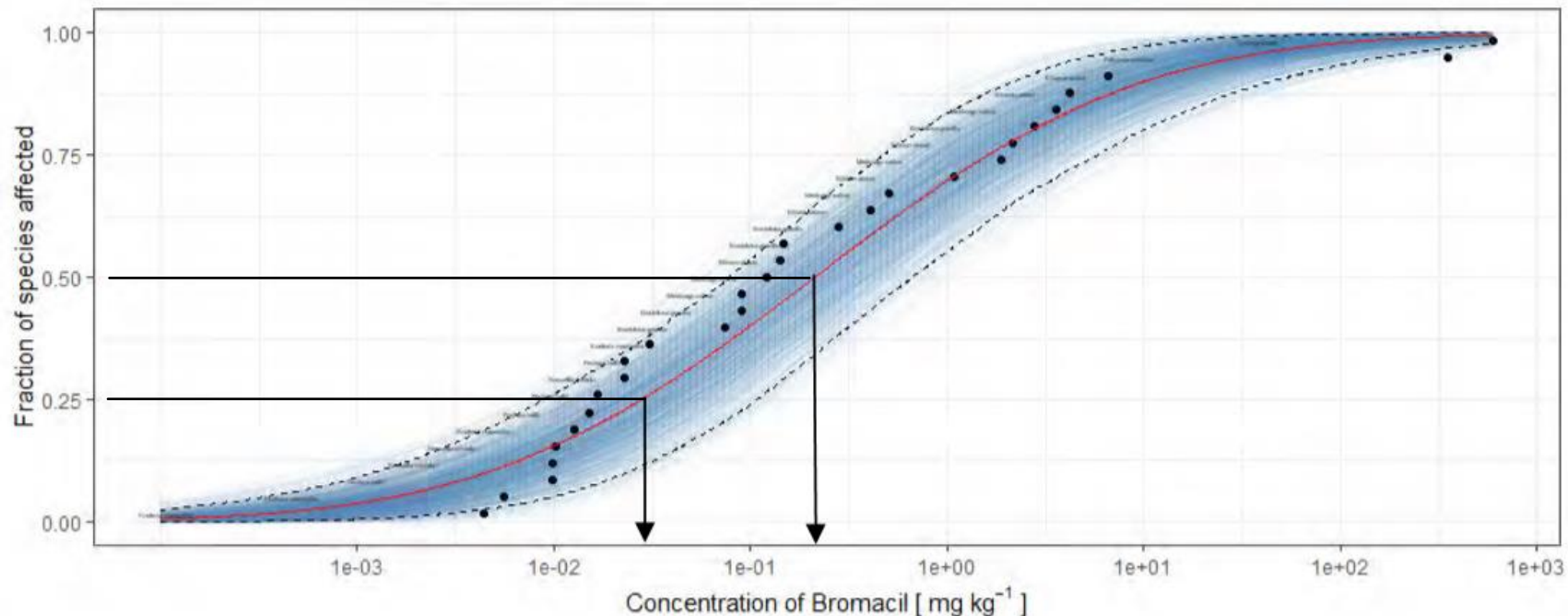
Table adapted from Litalien and Tindal (2021)

¹ Based on an expanded dataset which includes more native plant species than the current Tier 1 guidelines.

RESULTS – SOIL QUALITY GUIDELINE DEVELOPMENT

Work conducted by Millennium EMS Solutions Ltd. using current and historical data

- Species sensitivity distributions (IC_{25}) completed for:
 - All plants + invertebrates → Residential land use
 - Native plants + invertebrates → Natural land use
 - Agronomic plants + invertebrates → Agricultural land use



CCME 2006
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ALTERNATIVE SOIL QUALITY GUIDELINES



- Proposing alternative guidelines for the ecological direct soil contact pathway for fine textured soil
 - With the additional number of species, it may even be possible to look at individual guidelines for natural (*native plants/invert.*), residential (*native plants/crop plants/invert.*) and agriculture lands (*crop plants/invert.*)

	Tier 1 Guideline	Natural (25 th percentile of SSD)	Residential (25 th percentile of SSD)	Agricultural (25 th percentile of SSD)	Commercial/ Industrial (50 th percentile of SSD)
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	Revised (mg/kg)	0.023	0.018	0.018*	0.15

Table adapted from Litalien and Tindal (2021)

*insufficient number of datapoints are available for tebuthiuron based solely on crop plants and invertebrates (n=<10), therefore the SQG for the agricultural land use would need to be based on both native and agronomic species (i.e., residential land use)

RECOMMENDED BEST MANAGEMENT PRACTICES– ECOLOGICAL DIRECT CONTACT PATHWAY



- Additional data collection allowed to look at a more granular level to provide potential separate guidelines for different land uses, but more data is needed (soils, species etc.)
- We need to be more cognitive of the species present on site when comparing to existing SQG – agronomic or native species?
- Important to identify when a practitioner should consider a more conservative guideline to be protective of species present on site
- Potential application of Tier 2 SSRA on Natural Land Use sites



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XINGHUO MO
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