



# SIRCA

Sustainable In-Situ Remediation  
Co-operative Alliance

## *Effects Driven Assessment and Management of Complex Operating Sites*

Results of Initial Field Investigation

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*Presenting Members*

wood.



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## Complex site

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What makes up a complex site?

- Long and complex industrial history
- Limited knowledge of potential contaminants
- Apparent inconsistent spatial distribution of chemical constituents across site
- Constituents form highly complex mixtures affecting subsurface soil and groundwater
- Chemical mixtures consist of parent compounds and break-down products
- Traditional analytical chemistry methods not effective
- No regulatory guidelines or toxicology information
- Subsurface conditions are difficult to assess



## Introduction

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## Managing a Complex Site

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### Typical Management Process

1. Identify areas of concern.
2. Identify contaminants of concern.
3. Assess concentrations of contaminants of concern.
4. Compare concentrations to Tier 1 guideline values.
5. Detailed assessment of contaminants of concern that exceed Tier 1 values.
6. Development management plan.

### Complex Management Process

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- ~~5. Detailed assessment of contaminants of concern that exceed Tier 1 values.~~
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## Areas of Concern

SENTAR

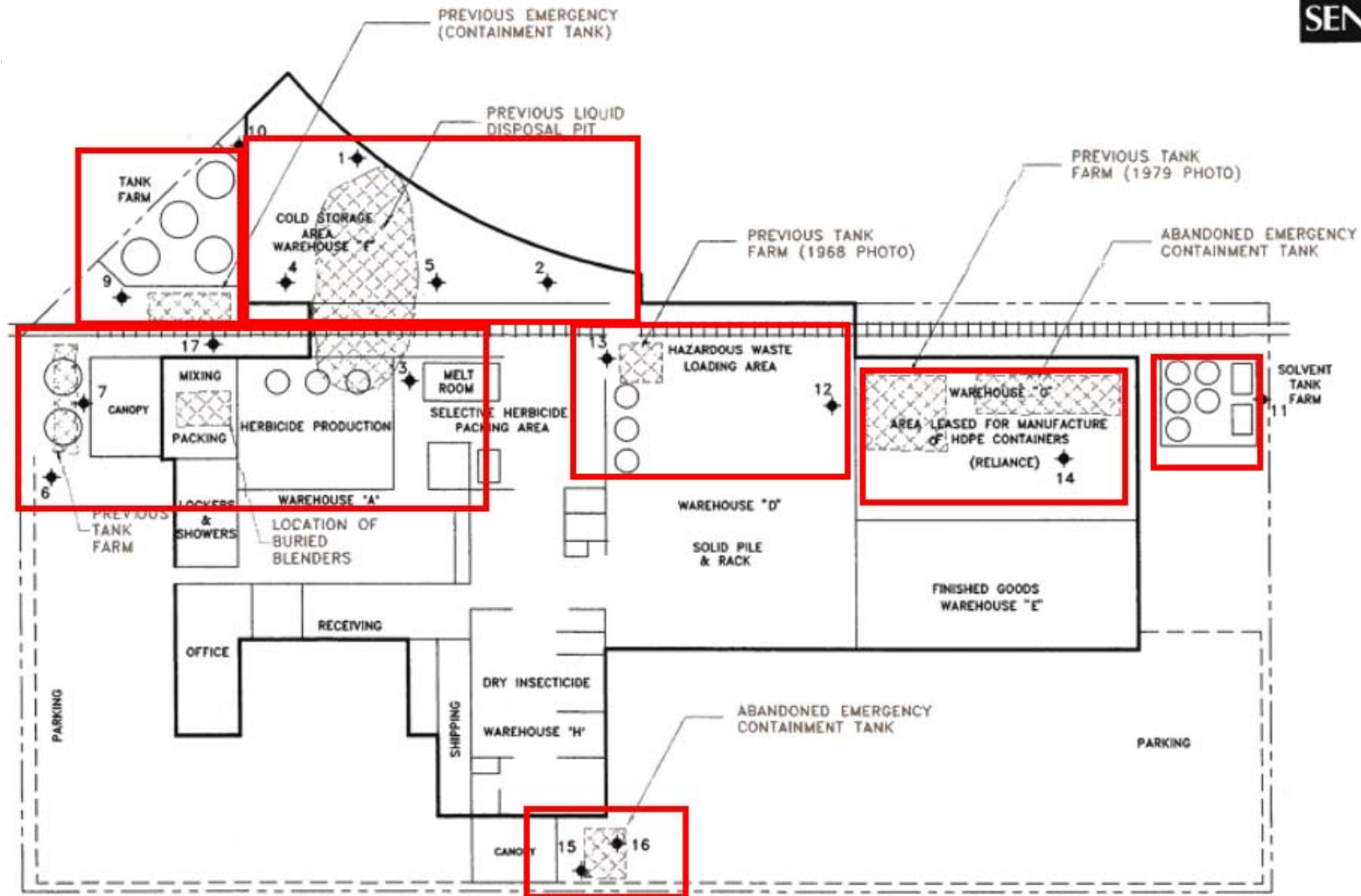


Figure D

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## Areas of Concern

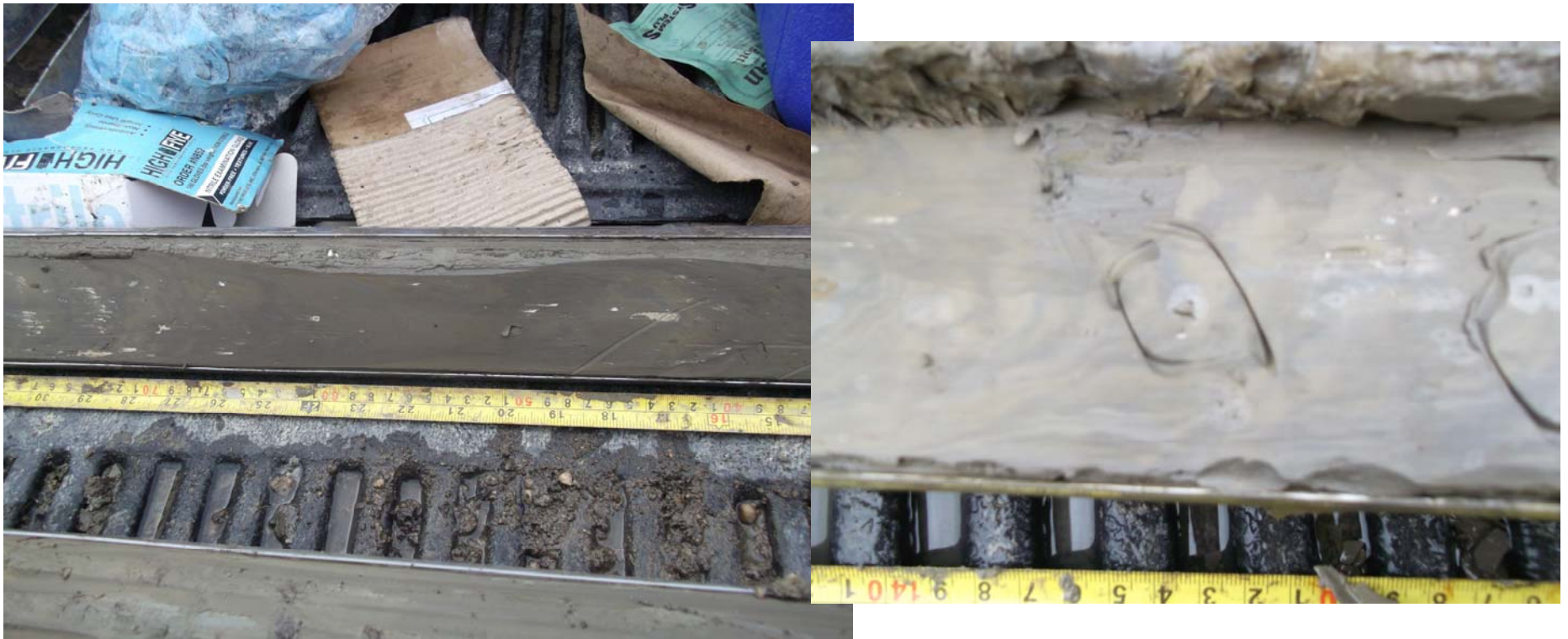


## Assessment work – 2010, 2012, 2013, 2015

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### 2012 Assessment Photos

- Clay soil cores with NAPL. TH7 4.5-6.1 m





## Assessment work – 2010, 2012, 2013, 2015

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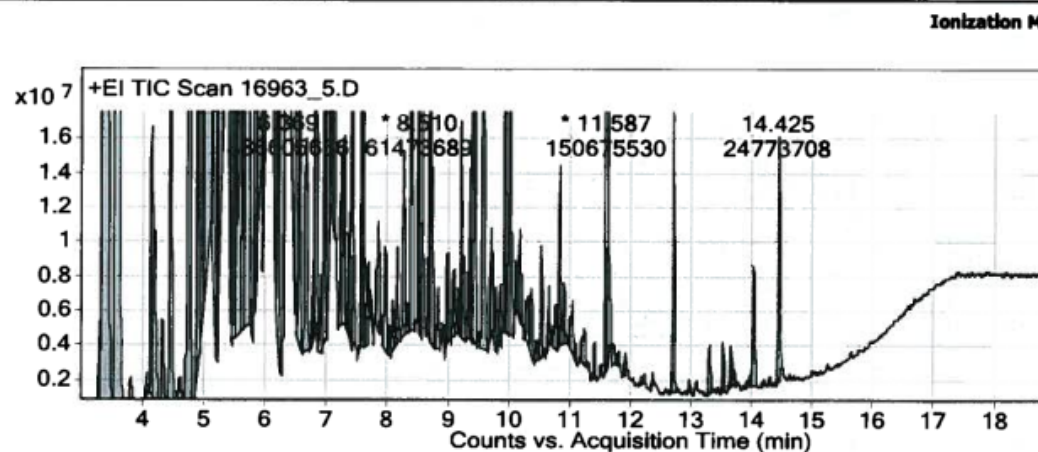
### 2013 Rail upgrade photos





# Initial qualitative analysis

Total Ion Chromatogram

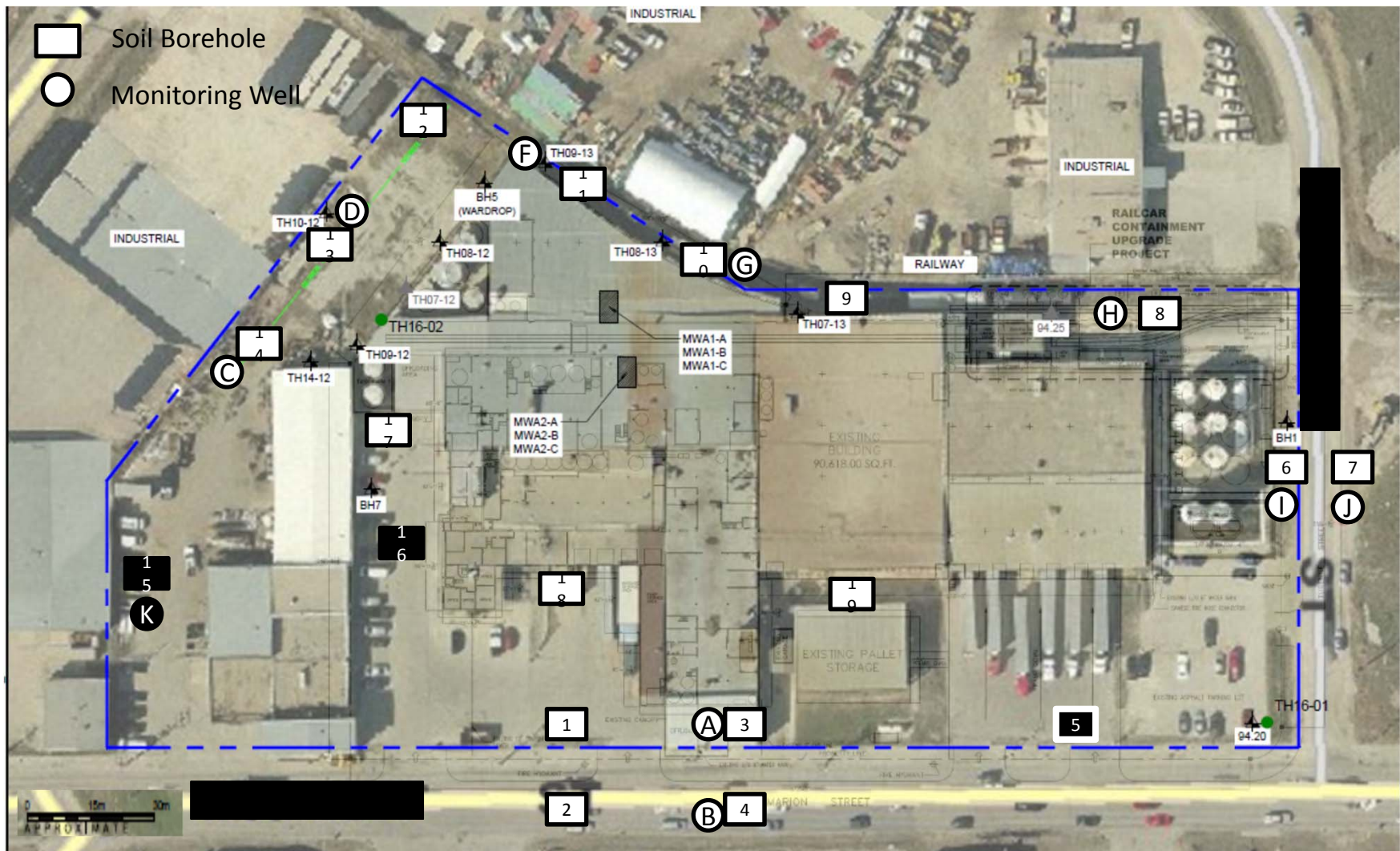


- 130 tentatively identified compounds
- 100 unidentified chemical formulations

Qualitative Analysis Report

Peak	RT	Area	Area %	Tentative Identity
22	5.488	33627077	0.32%	C11 compound
23	5.547	238875253	2.30%	C4 substituted benzene
24	5.635	595755586	5.74%	C4 substituted benzene
25	5.68	890666893	8.58%	C4 substituted benzene
26	5.815	47387068	0.46%	C5 substituted benzene
27	5.853	20046275	0.19%	unknown
28	5.886	428568748	4.13%	C4 unsaturated substituted benzene
29	5.957	16565463	0.16%	unknown
30	5.978	9752124	0.09%	unknown
31	6.006	309359384	2.98%	C4 substituted benzene + unknown
32	6.058	39008284	0.38%	C5 substituted benzene
33	6.1	12376851	0.12%	C5 substituted benzene
34	6.13	45663695	0.44%	C5 substituted benzene
35	6.19	94052116	0.91%	C5 substituted benzene
36	6.311	37175638	0.36%	Chlorophenol
37	6.369	886605656	8.54%	Naphthalene
38	6.42	177929069	1.71%	C5 substituted benzene
39	6.535	62846452	0.61%	C5 substituted benzene
40	6.658	35191516	0.34%	C5 substituted benzene
41	6.795	36992964	0.36%	C5 substituted benzene
42	6.806	19102503	0.18%	unknown
43	6.89	7243680	0.07%	unknown
44	6.949	51924635	0.50%	C2 substituted indane
45	7.03	79913947	0.77%	Chloromethylphenol
46	7.086	13522915	0.13%	C2 substituted indane
47	7.111	10455311	0.10%	unknown
48	7.229	22386078	0.22%	C5 substituted benzene
49	7.267	17973709	0.17%	unknown
50	7.347	9646700	0.09%	unknown
51	7.372	9627898	0.09%	unknown
52	7.405	35006080	0.34%	C1 substituted naphthalene
53	7.427	5580955	0.05%	unknown
54	7.568	17561702	0.17%	C1 substituted naphthalene + unknown
55	7.585	23988782	0.23%	C2 substituted tetrahydronaphthalene
56	7.626	7002218	0.07%	unknown
57	7.666	8845630	0.09%	C2 substituted tetrahydronaphthalene
58	7.813	2866090	0.03%	C2 substituted tetrahydronaphthalene + unknown
59	7.835	9545126	0.09%	C2 substituted tetrahydronaphthalene
60	7.95	12940854	0.12%	unknown
61	8.019	2813119	0.03%	unknown
62	8.072	7769057	0.07%	unknown
63	8.143	9193271	0.09%	Tetradecane
64	8.251	23477431	0.23%	C2 substituted tetrahydronaphthalene
65	8.316	2509156	0.02%	C2 substituted naphthalene
66	8.377	55142303	0.53%	C2 substituted naphthalene
67	8.51	61473689	0.59%	C2 substituted naphthalene
68	8.538	38608083	0.37%	C2 substituted naphthalene
69	8.565	7290602	0.07%	unknown
70	8.663	4933310	0.05%	C3 substituted tetrahydronaphthalene
71	8.685	27926176	0.27%	C2 substituted naphthalene
72	8.718	17070803	0.16%	C3 substituted tetrahydronaphthalene

## 2017 Assessment work





## Assessment work - 2017

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## Assessment work - 2017

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# What chemicals were present from the assessment process?

- A wide range of parent compounds are present.
- Innumerable metabolites are present.

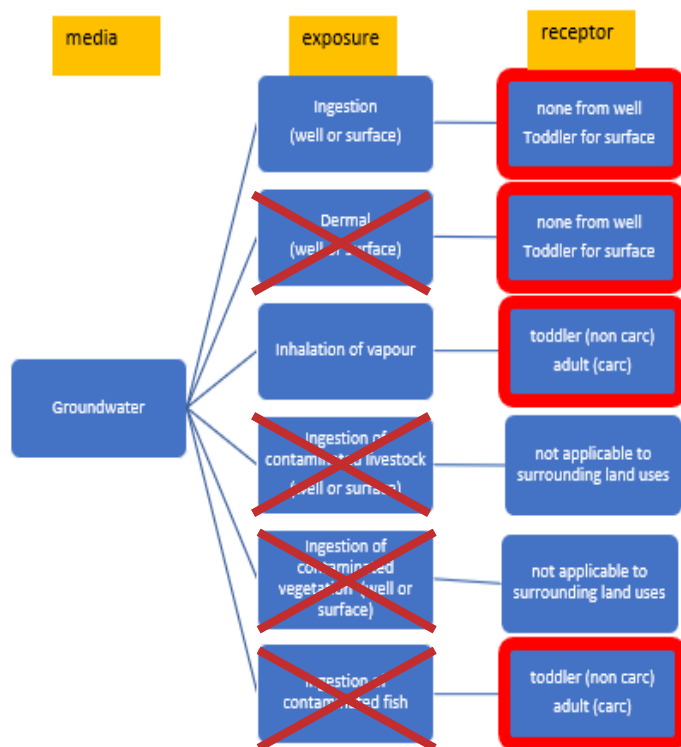
COPC	Media
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)*	GW
2,4,6-trichlorophenol	GW
2,4-D (2,4-dichlorophenoxyacetic acid)	S, GW
2,4-DB (4-(2,4-dichlorophenoxy)butyric acid)	S, GW
2,4-dichlorophenol	GW
2,4-DP (Dichlorprop)*	GW
2,6-dichlorophenol	GW
3,4-dichlorophenol	GW
Aldrin	GW
Bromacil	GW
Bromoxynil	S, GW
Chlordane	S
Chloroethane*	GW
Chloroform	S
Clpyralid*	S
DDD p,p	GW
DDE p,p	GW
DDT, o, p'	GW
DDT, p,p'	GW
Dicamba	GW
Dieldrin	GW
Dimethoate	GW
Endrin	GW
Fl	S
F1-BTEX	S

What exposure pathways are active?

MCPA	S, GW
MCP (mecoprop)*	GW
Metribuzin	GW
Phenol	GW
Solv Esso 100*	S, GW
Solv Esso 150*	S
Treflan (Trifluralin)	S, GW
Trilate/Trialate	GW
Xylene	S, GW

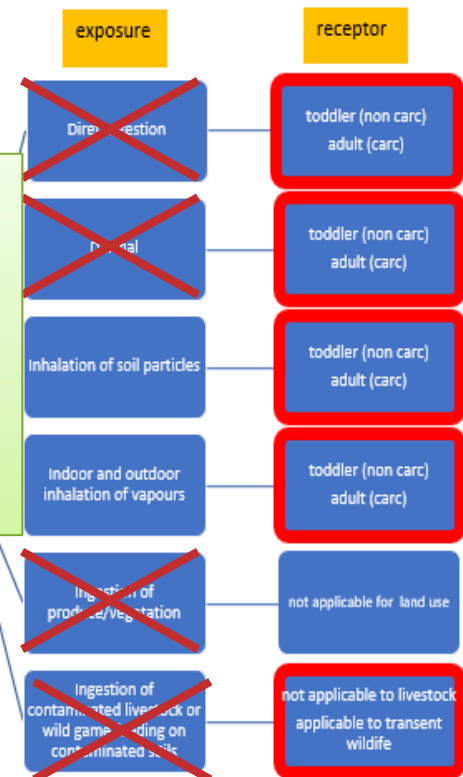
# Off Site and Future On Site Exposure Pathways

## Groundwater



Management Controls on Exposure Pathways

## Soil





## Complex Operating Site Assessment

# What is considered volatile?

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1. Vapour intrusion was only considered for compounds with a Henry's law constant greater than  $10^{-5}$  atm m<sup>3</sup> mol<sup>-1</sup>.
2. Many contaminants of potential concern were not present in US EPA Johnson and Ettinger model. Surrogates were picked
  - i.e Solv Esso 100, we picked hexane.
3. Dust inhalation was assessed for the inhalation and ingestion pathway (*many particles are captured in the upper respiratory tract and redirected to the digestive tract*).



## Contaminants of Potential Concern

### Initial Screen

COPC	Media
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)*	GW
2,4,6-trichlorophenol	GW
2,4-D (2,4-dichlorophenoxyacetic acid)	S, GW
2,4-DB (4-(2,4-dichlorophenoxy)butyric acid)	S, GW
2,4-dichlorophenol	GW
2,4-DP (Dichlorprop)*	GW
2,6-dichlorophenol	GW
3,4-dichlorophenol	GW
Aldrin	GW
Bromacil	GW
Bromoxynil	S, GW
Chlordane	S
Chloroethane*	GW
Chloroform	S
Clpyralid*	S
DDD p,p	GW
DDE p,p	GW
DDT, o, p'	GW
DDT, p,p'	GW
Dicamba	GW
Dieldrin	GW
Dimethoate	GW
Endrin	GW
F1	S
F1-BTEX	S
F2	S
F3*	GW
Heptachlor	GW
Indeno (1,2,3-cd)pyrene	GW
Lindane	S, GW
Malathion	GW
MCPA	S, GW
MCPP (mecoprop)*	GW
Metribuzin	GW
Phenol	GW
Solv Esso 100*	S, GW
Solv Esso 150*	S
Treflan (Trifluralin)	S, GW
Trilate/Trialate	GW
Xylene	S, GW

### After Paper Screening

COPC	Media
2,4-D (2,4-dichlorophenoxyacetic acid)	S, GW
2,4-DB (4-(2,4-dichlorophenoxy)butyric acid)	S, GW
2,4-dichlorophenol	GW
Benzene	GW
Chloroform	S
Dicamba	GW
DDE p,p	GW
DDT, p,p'	GW
Dimethoate	GW
Dieldrin	GW
Endosulfan	GW
Heptachlor	GW
Napthalene	GW
MCPA	S, GW
Xylene	S, GW

## Have we missed the big movers of risk?



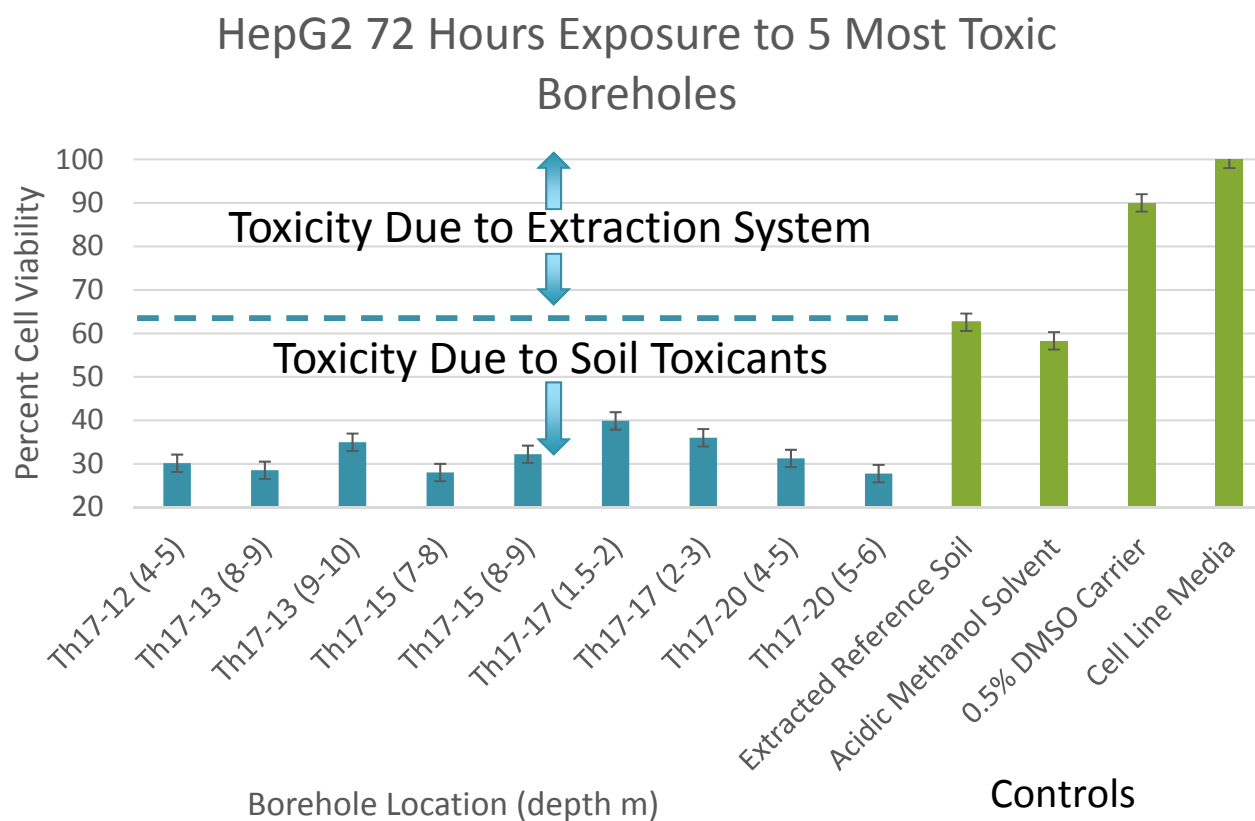
- Chemical results do not correspond with impact assessment team's visual recording and were often fragmentary.
- It is simply not possible to screen for all possible metabolites at all locations.
- We need to use in vitro assays.



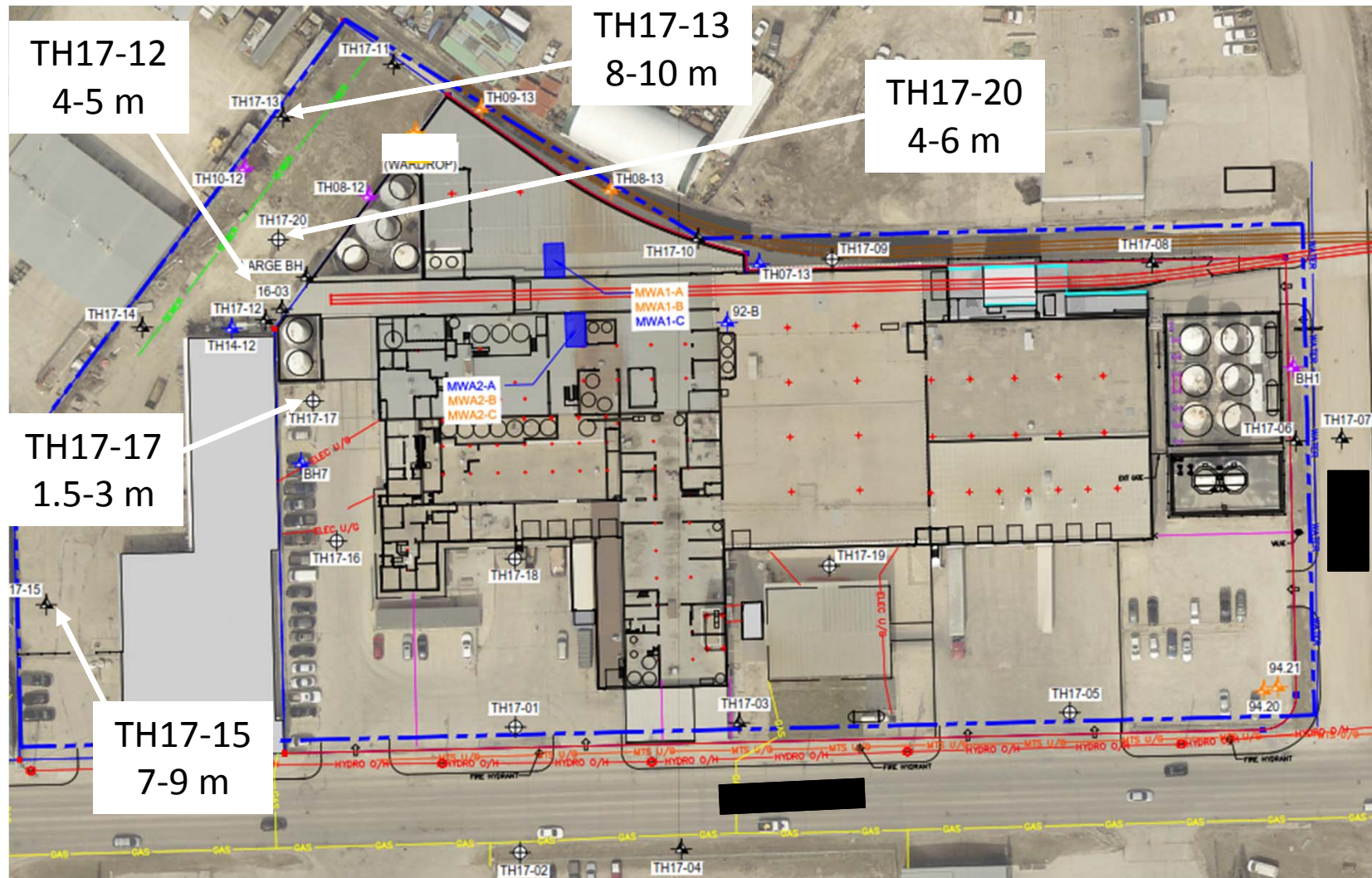


# How should we focus our hazard assessment?

Out of 42 chemicals of concern, 28 were known hepato-toxicants (liver). Thus, as an initial screen, we used liver cell lines to screen over 20 boreholes.

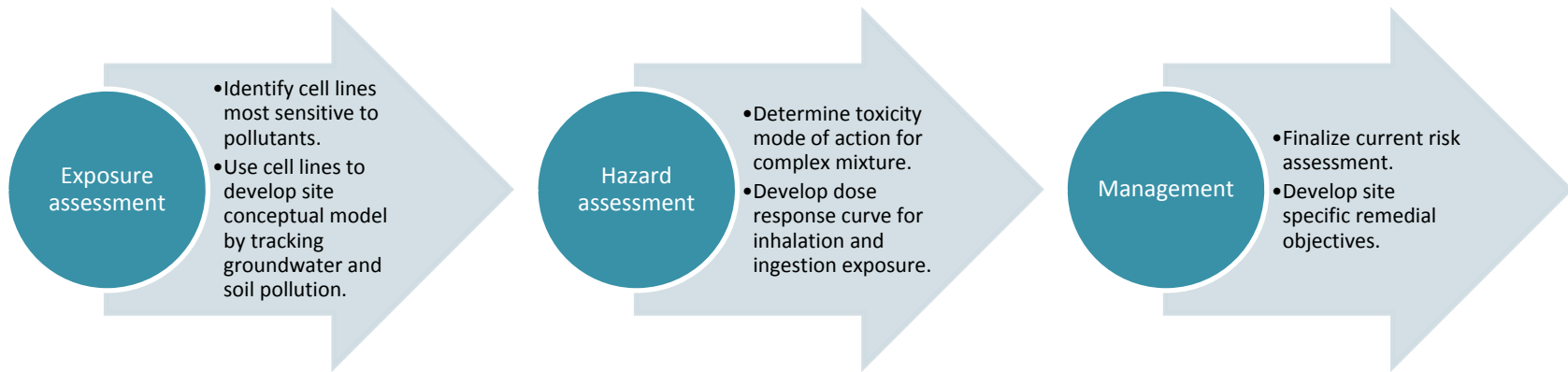


# Where are these boreholes on the site?



# Next steps (3 to 4 years)

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- Results to date identified that the primary risk exposure pathways of concern are vapour inhalation and groundwater.
- Areas of concern are not as spatially dispersed as initially assumed, but may be more localized. However, groundwater models still need additional work after cell lines are developed.

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## Acknowledgements



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**NSERC**  
**CRSNG**



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