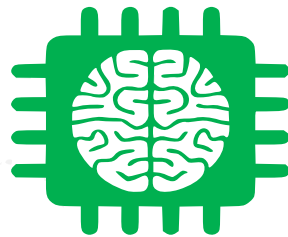


QUANTITATIVE FIELD SCREENING: HIGH RESOLUTION SITE CHARACTERIZATION WITH REFLECTANCE SPECTROSCOPY

MAAPER ANALYTICS INC.



Issue facing assessment and remediation work.....

- How much experience does it take to make accurate decisions with limited data?
- How long do people tend to stay in this industry?
- How much training for junior staff is affordable?

OUTLINE

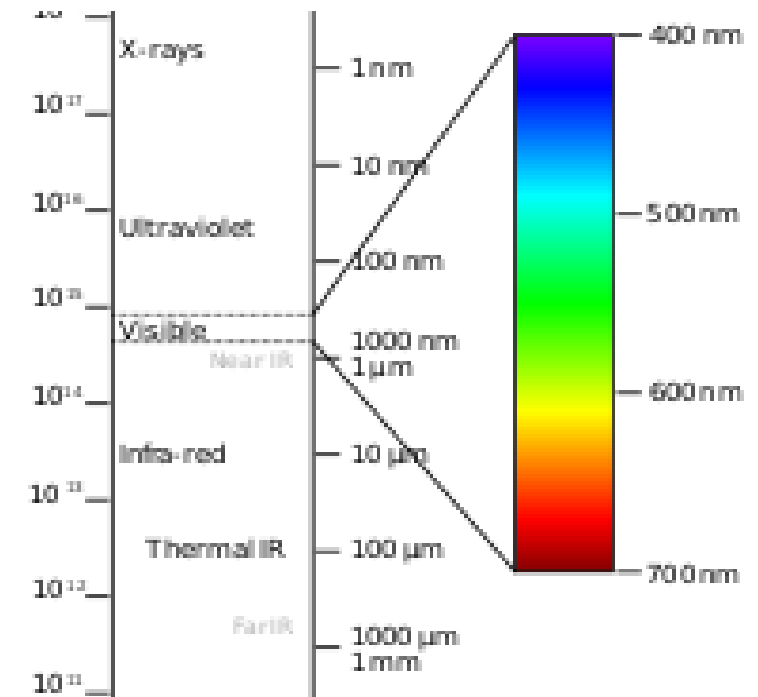
- Reflectance Spectroscopy
- Methods
- Results
- Challenges
- Conclusions





REFLECTANCE SPECTROSCOPY

- Different types of covalent bonds absorb different specific light wavelengths
- Majority of soil properties have spectral features in the short wave infrared portion of the electromagnetic spectrum





REFLECTANCE SPECTROSCOPY

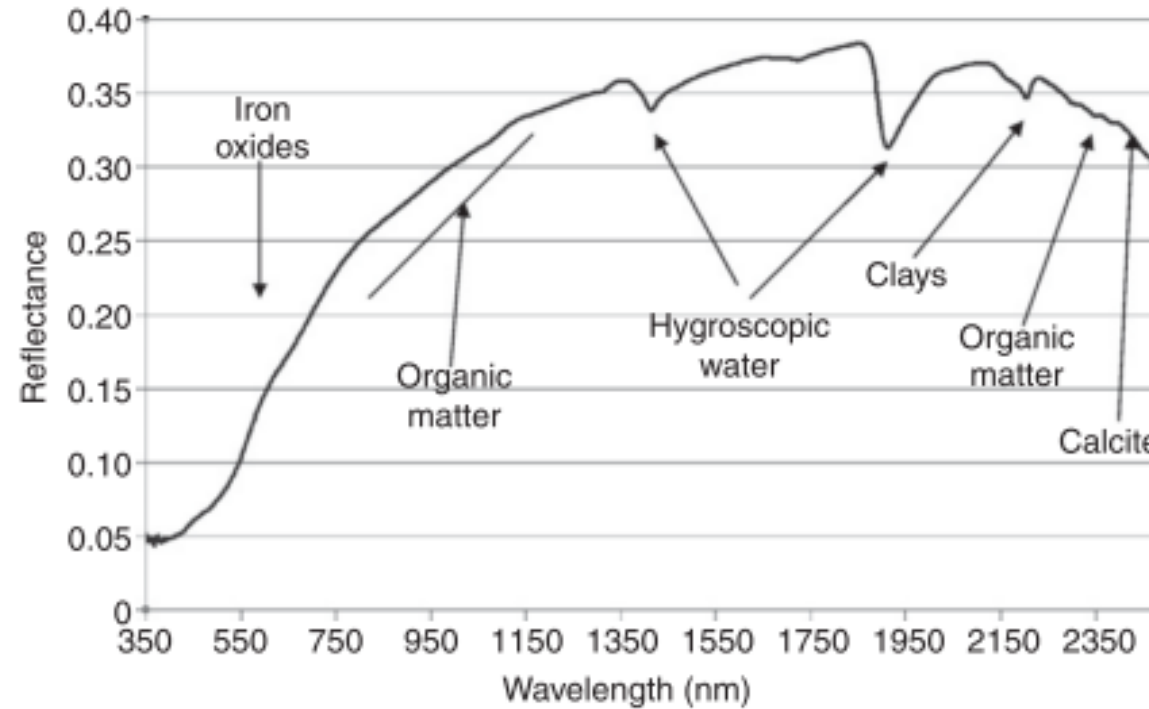


Figure 3 A soil spectra (Haploxeralf) that represents the major chromophors in soils (see text for more details).

Ben-Dor, E., R.G. Taylor, J. Hill, J. a M. Demattê, M.L. Whiting, S. Chabrilat, and S. Sommer. 2008. Imaging Spectrometry for Soil Applications. *Adv. Agron.* 97(07): 321–392.

METHODS

- Samples collected using conventional field methodologies
 - Using a drill rig or hand sampled depending on site
- Samples collected from each site were analyzed with reflectance spectroscopy and then sent to a third party analytical laboratory and analyzed using PHC CWS method

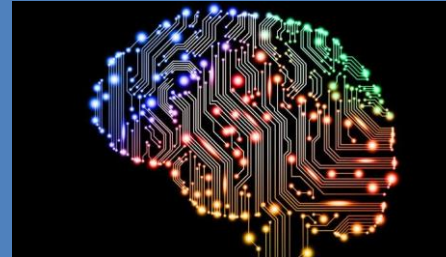


Methods

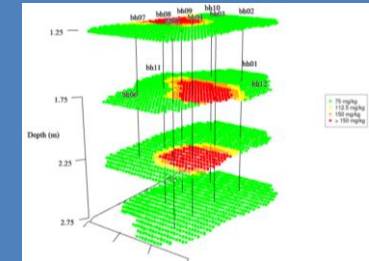
Near Infrared Reflectance Spectroscopy (NIRS)



Machine Learning and Advanced Data Analysis



Automated Visualization Data Products – delivered as HTML



Process in the Field

Set up scanner and allow for 30 min start up cycle and Calibrate by optimizing system to background signal and scanning Spectralon[®] reference panel



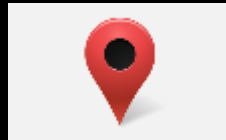
Scan calibration soil samples – supplied by Maapera – to confirm set up is correct



Collect Sample in typical industry practice and take sample to scanning set up (skinning is recommended)



Place contact probe with attached spacer that leaves 1 cm gap up to the sample



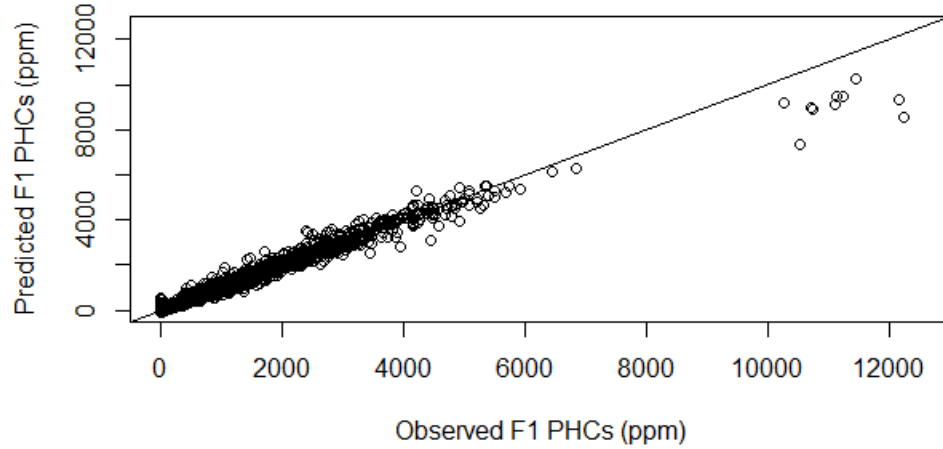
Entering location tag, comments and then press button on laptop to scan (2sec)



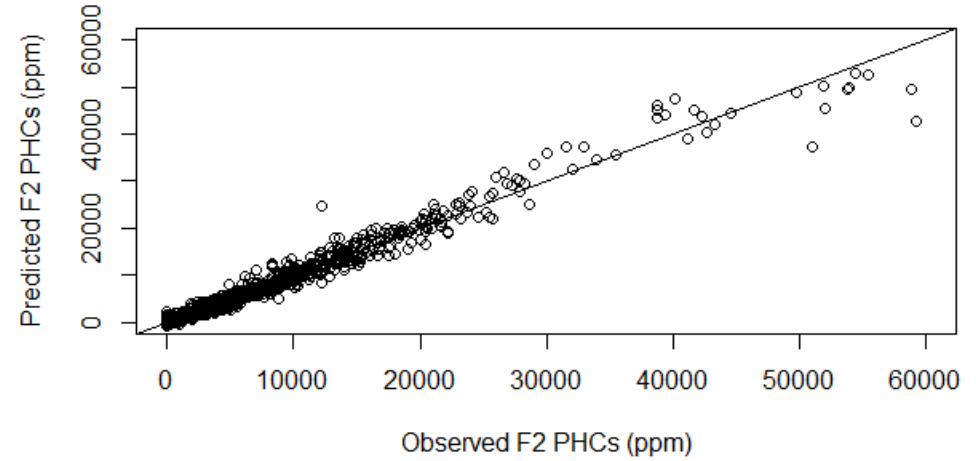
Analyze spectral data using machine learning algorithms

Overall Results

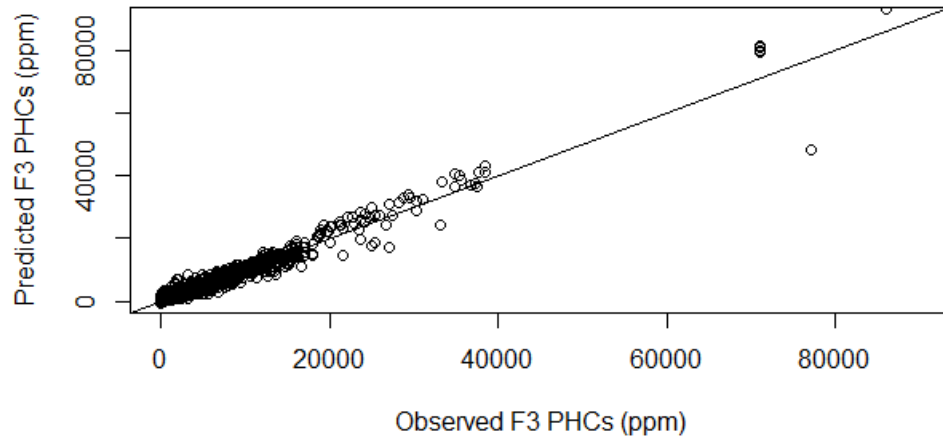
F1 Petroleum Hydrocarbons



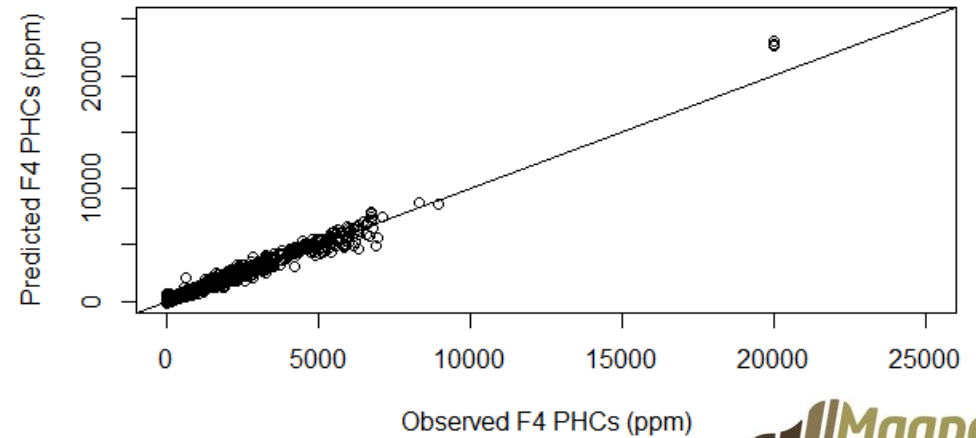
F2 Petroleum Hydrocarbons



F3 Petroleum Hydrocarbons



F4 Petroleum Hydrocarbons



Overall Results

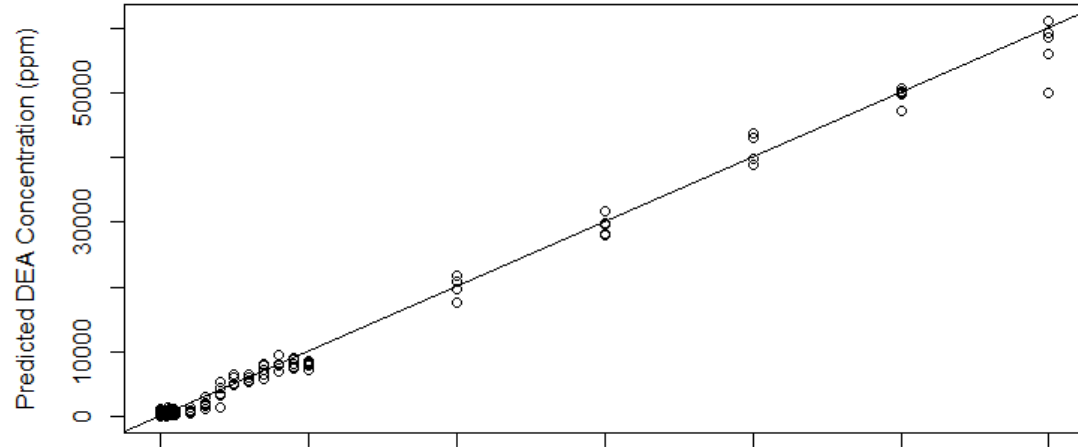
Table 1. Model Performance by Hydrocarbon Fraction for Build in Canada Innovation Program

PHC Fraction	R2	Ratio of Performance to Deviation ¹
F1	0.97	6.1
F2	0.98	7.0
F3	0.99	11.8
F4	0.98	8.5

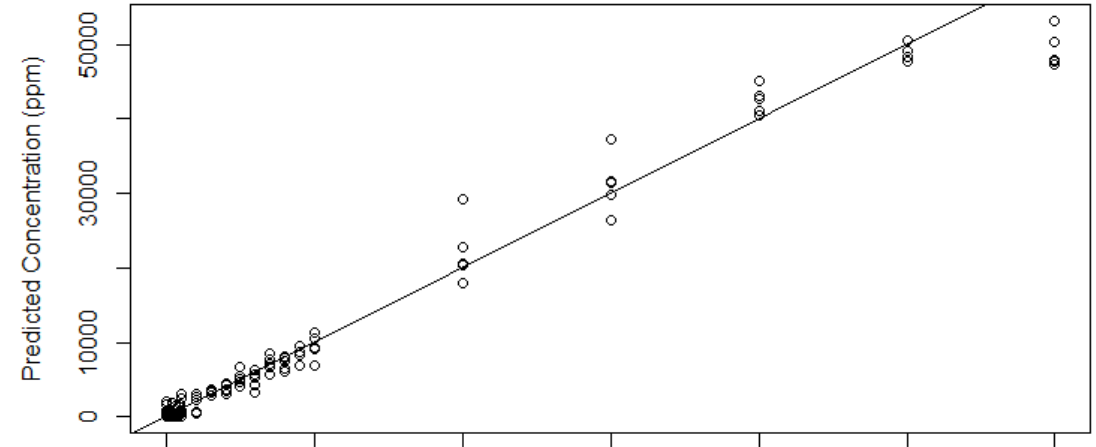
¹Values above 2 indicate good predictive capability

Additional Contaminants

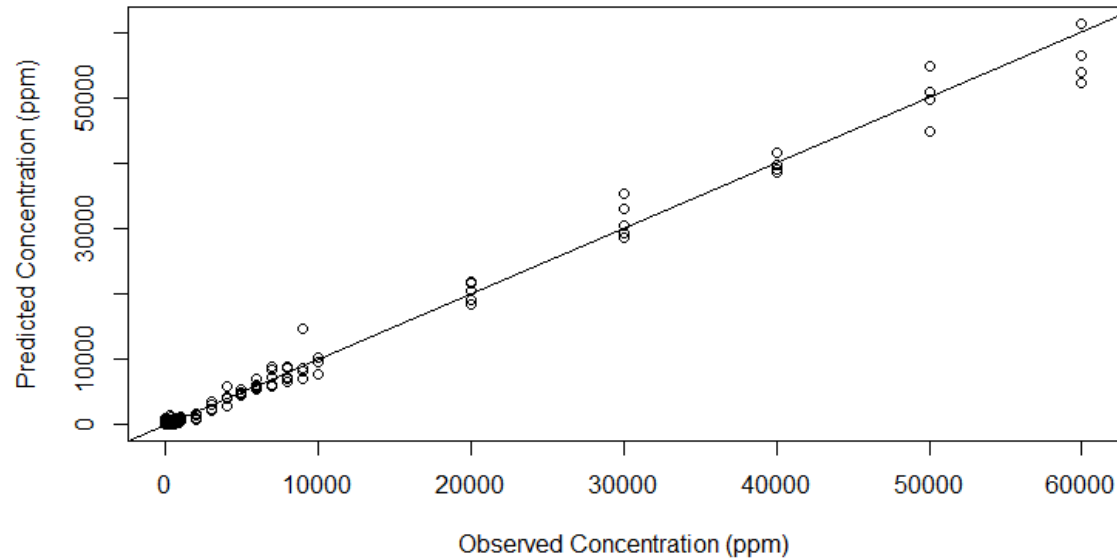
Amines



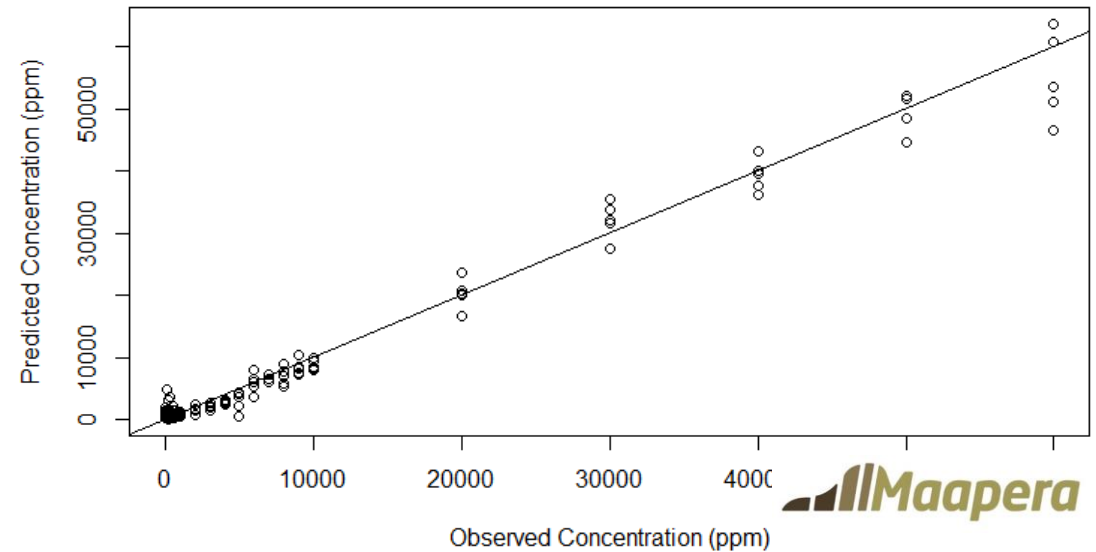
Glycols

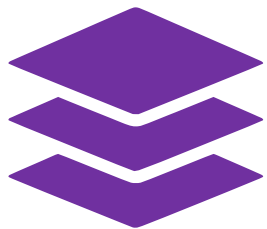


Sulfolane



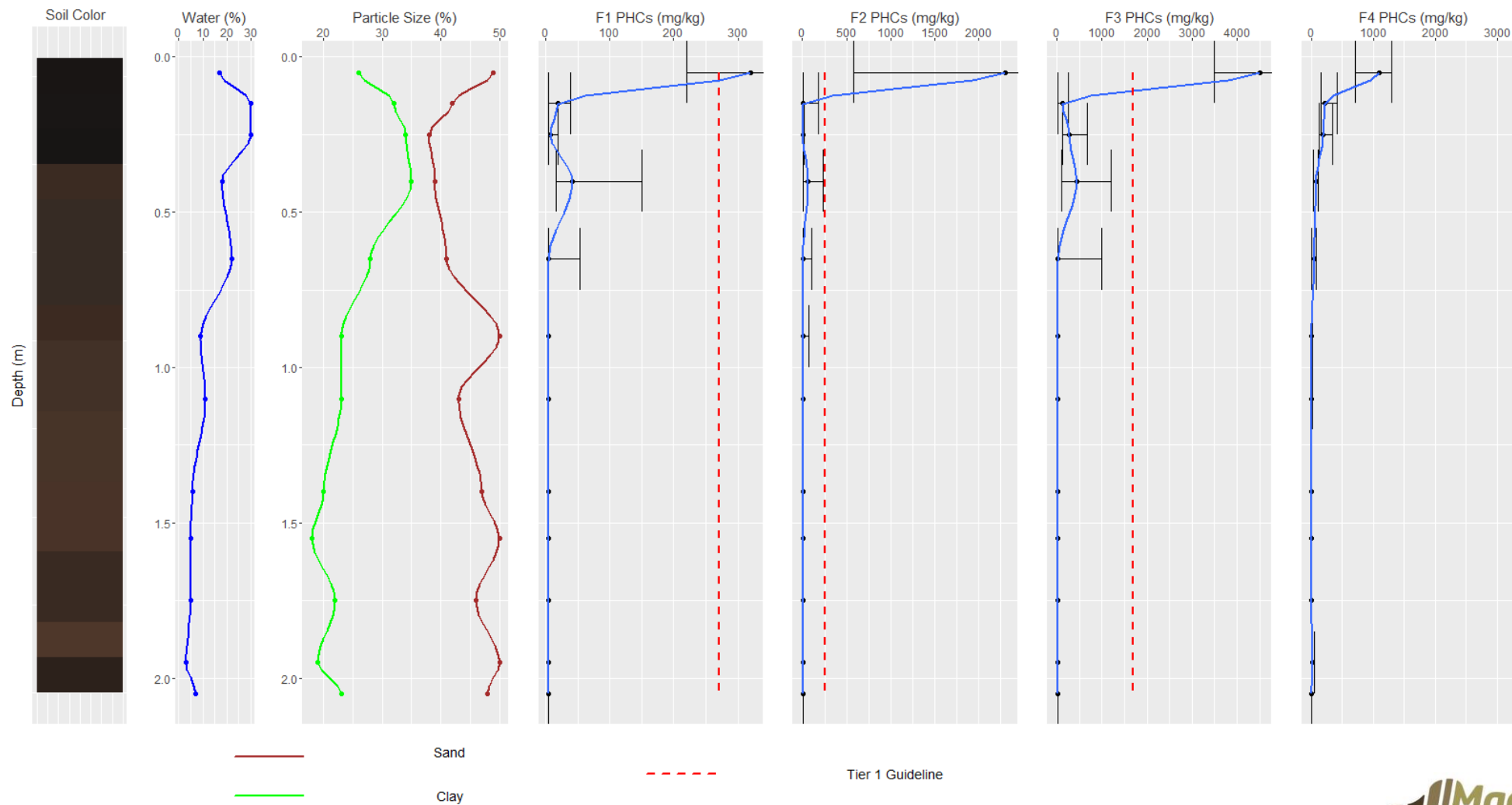
Methanol

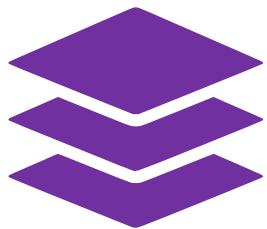




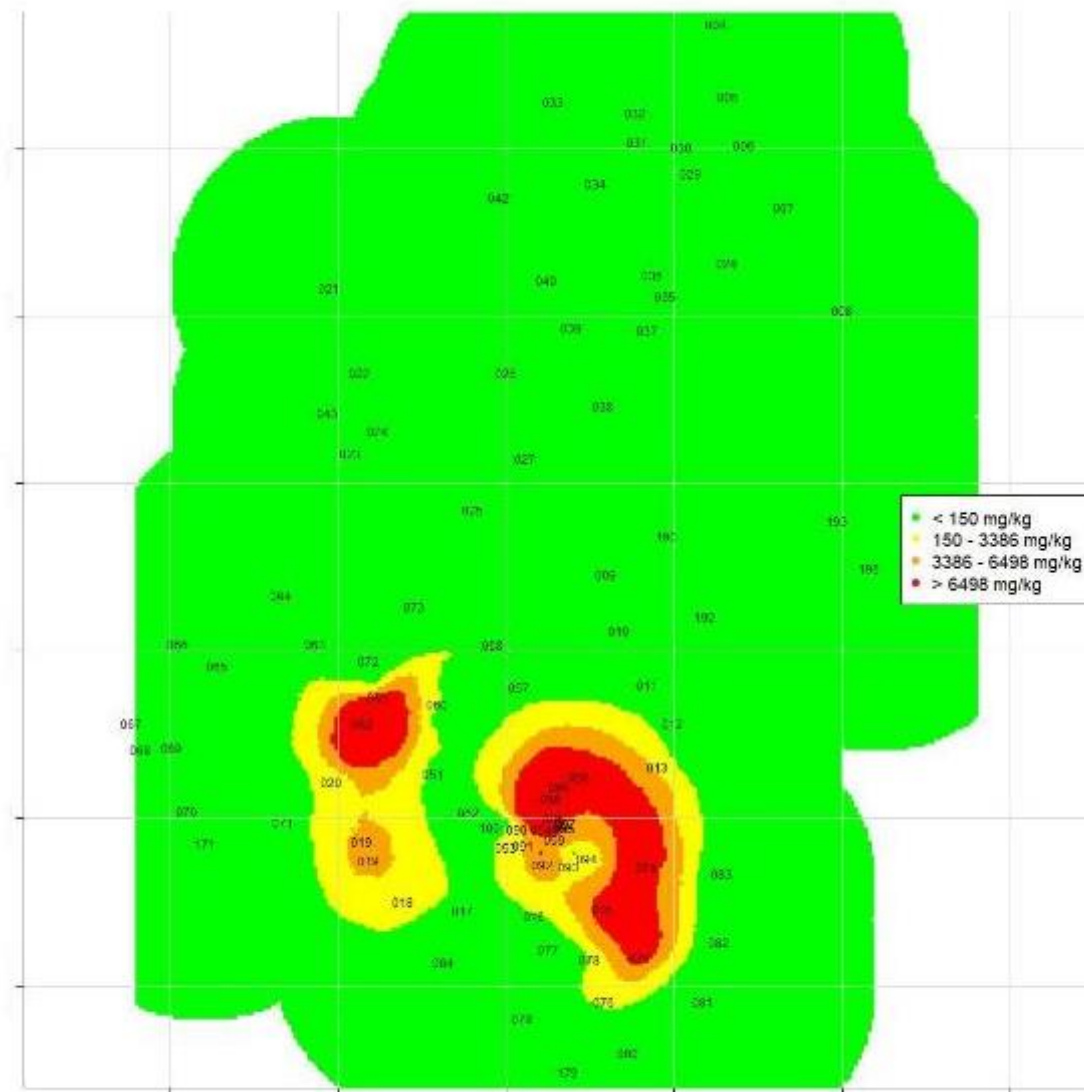
AUTOMATED VISUALIZATION

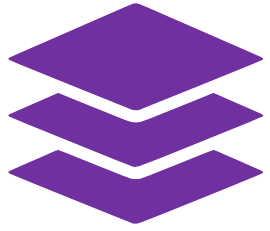
Borehole: BH007



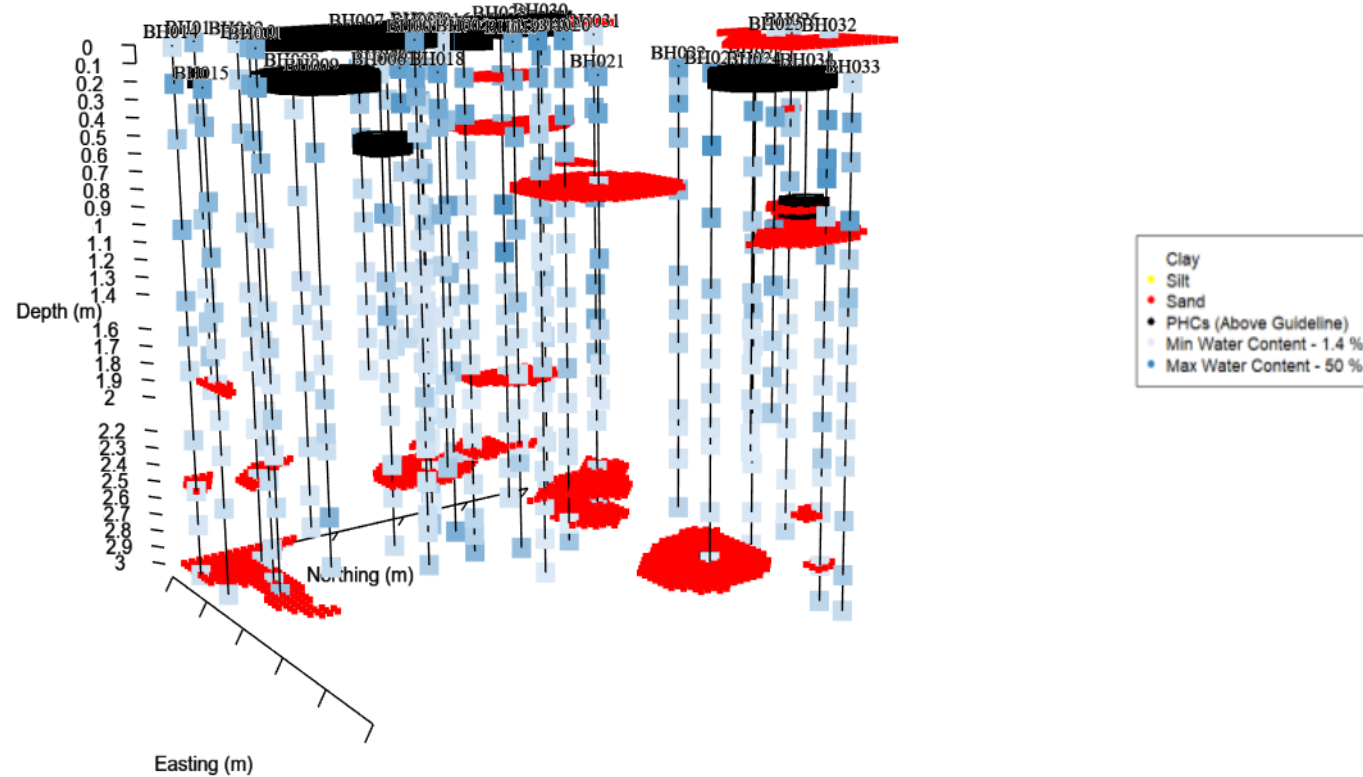


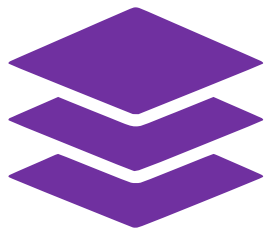
AUTOMATED VISUALIZATION



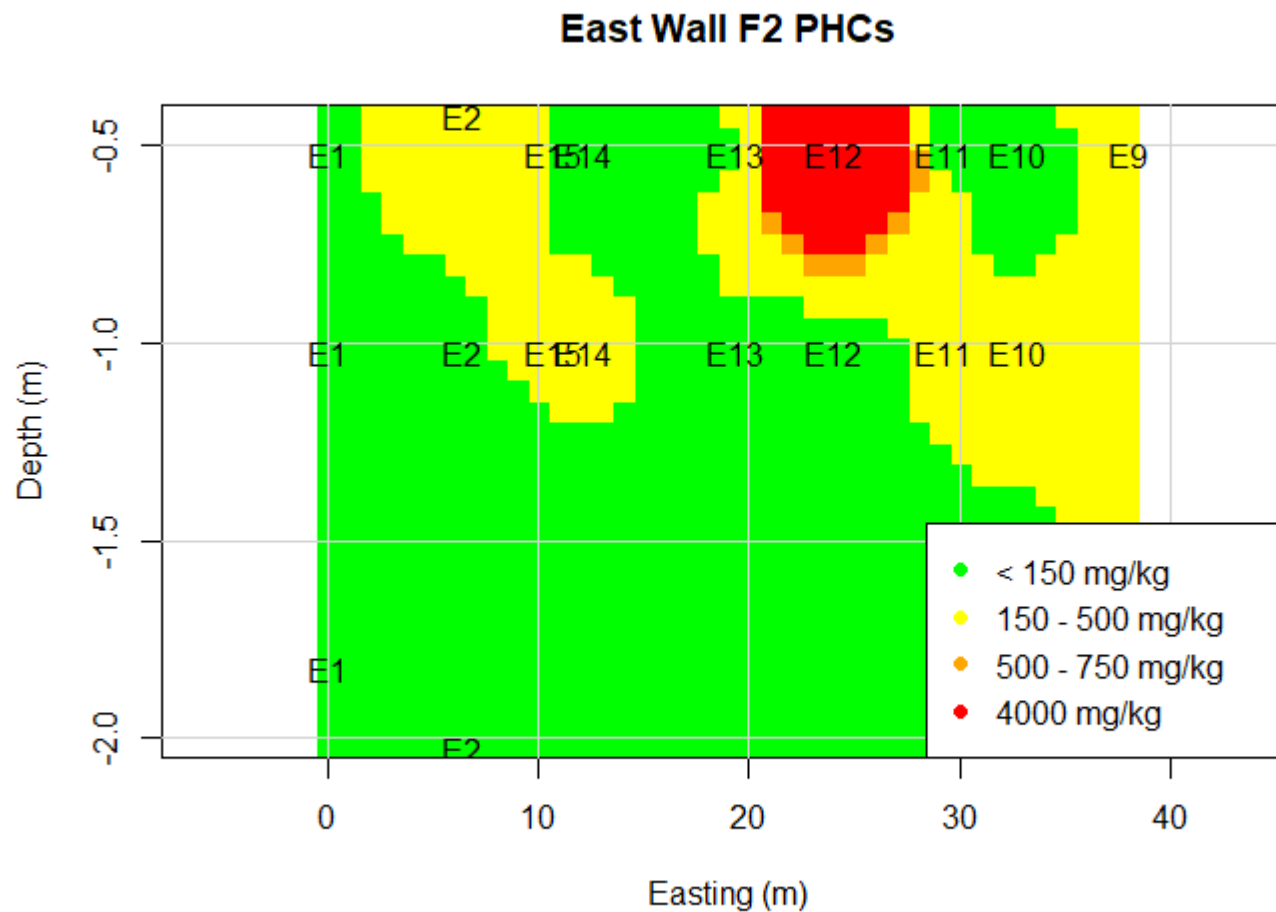


AUTOMATED VISUALIZATION

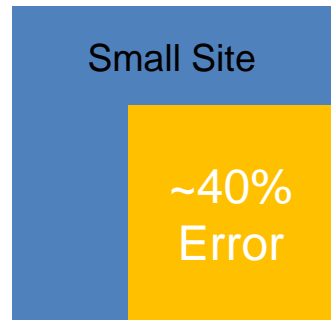




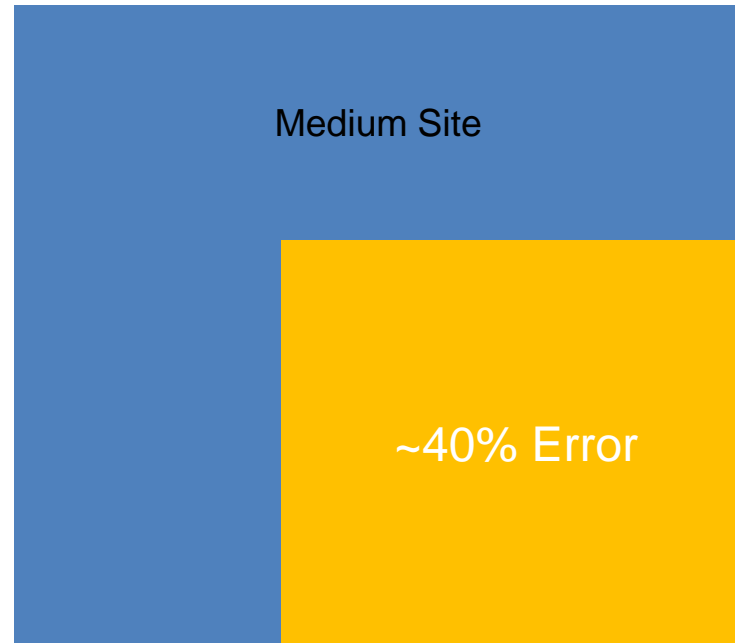
AUTOMATED VISUALIZATION



How much data do I really need?



- 8m x 8m x 2m deep
- 10 samples
- Error of +40%
- Confidence of 50%
- Does it matter.....
- **Cost of error \$3-4K**



- 20m x 20m x 3m deep
- 20 samples
- Error of +40%
- Confidence of 50%
- Does it matter.....
- **Cost of error \$50k - \$100k**



Less Than 10% Error

with

90% Confidence



**180-250 Samples
Required**

Conventional Methods to
do this are cost prohibitive.

Where do these numbers come from?

CCME Guidelines

- www.ccme.ca
- Guidance Manual for Environmental Site Characterization
- Sec. 5 & Appendix C

EPA Best Practice

- USEPA Guidance on Choosing a Sampling Design for Environmental Assessment
 - USEPA HRSC Optimization Results
- www.epa.gov

Maapera Models and Simulations to include cost parameters

- Simulated 100,000 random contaminated plumes
- Varied sampling intensity to obtain error
- Optimized cost of error based on sampling and remediation costs

CHALLENGES

- Sample management for volatiles – scanning the surface only so volatiles may be lost quickly
 - Break core open and scan quickly when concerned about F1 fraction
- Ice in samples
 - Ice cause different reflectance pattern, samples need to be above freezing
 - Currently working on solution for samples with ice
- Areas with very different soils from training library
 - Identified by QAQC system successfully
 - Correlation with lab samples required in this scenario for quantitative results

Failure of Current Practice

Table 1 **Failure Rate of AESRD Surface and Contamination Audits (GoA, 2010)**

Alberta Environment/SRD Surface Audits	2003 to 2011	9%
Alberta Environment/SRD Contamination Audits	2003 to 2011	28%

“Consultants should demand field screening equipment that is both accurate and precise as well”

Source: Polet M., Powter, C. 2012. Phase II Assessments and Phase III Remediation: A Brief History. RemTech Presentation.

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