Leachability of Contaminated Soils

JOSH GIRVIN – SLR CONSULTING NEW ZEALAND LTD | SUSIE HUMPHREY – PATTLE DELAMORE PARTNERS LTD | MARTIN ROBERTSON – Z ENERGY LTD

solutions for your environment

Kei ō tātou Ringaringa te ānamata
The future is in our hands
27–30 MAY 2024
CLAUDELANDS, HAMILTON

Overview

Image credit: Gabriel Jimenez, Unsplash.com

- Waste Acceptance Criteria (WAC)
- Leachability of Contaminants in Soil
- Hydrocarbons in Soil

Waste Acceptance Criteria (WAC)

- Disposal facilities adopt different WAC as outlined in resource consents.
- Variable WAC in play – Class A and B, Oil Industry GLs, Class 1 to 5.
- Contaminant leachability inherent of landfill WAC.
- For clean fills, regional soil background levels important for assessing WAC.

Image credit: New Zealand Geographic

Contaminant Leachability – Testing Methods

Toxicity Characteristic Leaching Procedure (TCLP) (USEPA Test Method 1311)

- A test is designed to determine the mobility of both organic and inorganic contaminants present in wastes **(i.e. conditions at a disposal facility).**
- A weak acid, which mimics landfill leachate, is used to leach the contaminants from a sample of waste.

Synthetic Precipitation Leaching Procedure (SPLP) (USEPA Test Method 1312)

- A test is designed to determine the mobility of both organic and inorganic contaminants present in soils, under neutral conditions **(i.e. in-situ site conditions).**
- Reagent or Type 2 water (defined as water in which contaminants are not observed at or above the laboratory detection limits) is used to leach contaminants from a sample of soil.

Australian Standard Leaching Procedures (ASLP) (Australian Standard AS 4439)

- Similar to TCLP; aims to evaluate potential environmental impact of waste materials.

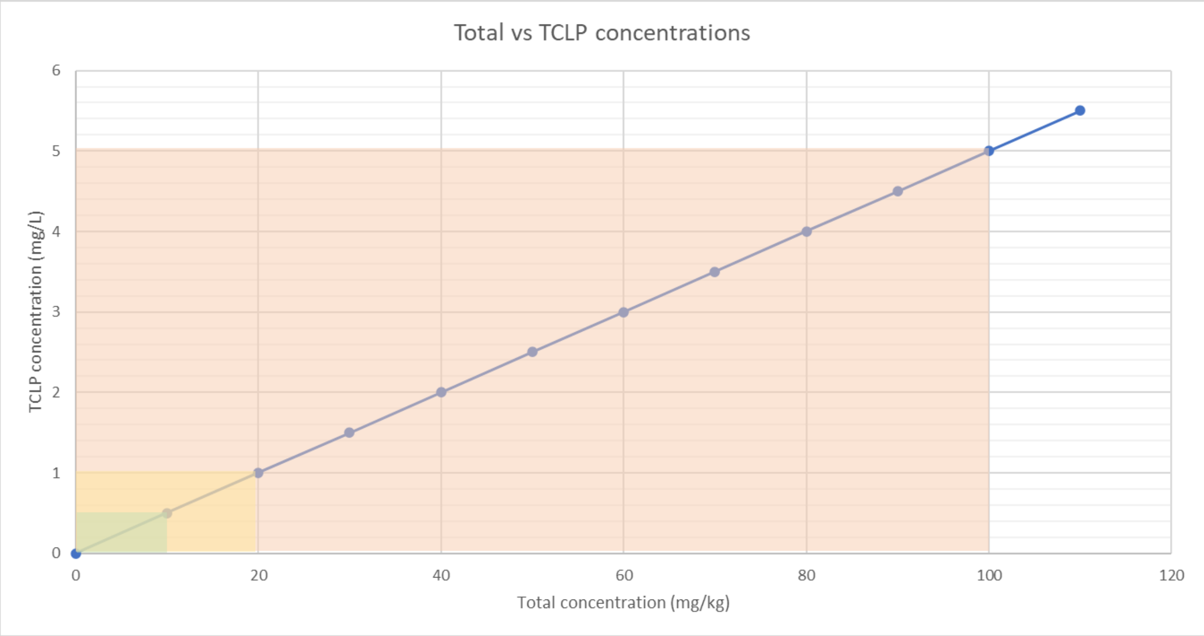
TCLP & SPLP Reference: WasteMINZ (2023) Technical Guidelines for Disposal to Land Revision 3.1.

The TCLP Rule of Thumb – Maths

What is the rule of thumb for conversion of totals contaminant concentration to TCLP results?

"derived by multiplying the ***<u>TCLP criteria by 20,</u>*** *based on the assumption that all the contaminant present in the waste is transferred to leachate (which is diluted 20-fold in the TCLP methodology). Where the concentration of the contaminant in the waste is below the screening level, there is no need to test for TCLP. Where the concentration of the contaminant in the waste exceeds the screening level, a TCLP test may show that the contaminant is sufficiently immobilised in the waste matrix to still meet the TCLP criteria"*

(MfE (2004) *Module 2: Hazardous Waste Guidelines Landfill Waste Acceptance Criteria and Landfill Classification*)



So, we would expect TCLP results to be (at least) 20x less than total metals...

SPLP vs Total Metals – Understanding On-Site Effects

Leachability varies.

However, all metals are not created equally, there are differences in:

- Solubility
- Mineralisation
- pH dependencies
- Eh-pH stability fields
- Clay mineralogy
- Organic carbon

Will metals leach to groundwater?

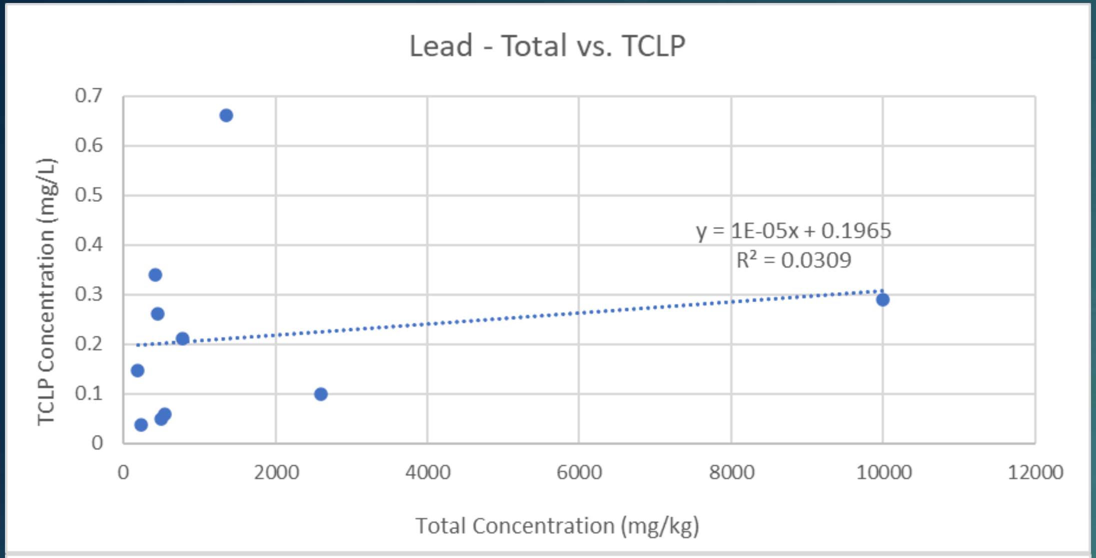
Can soil be managed on site?

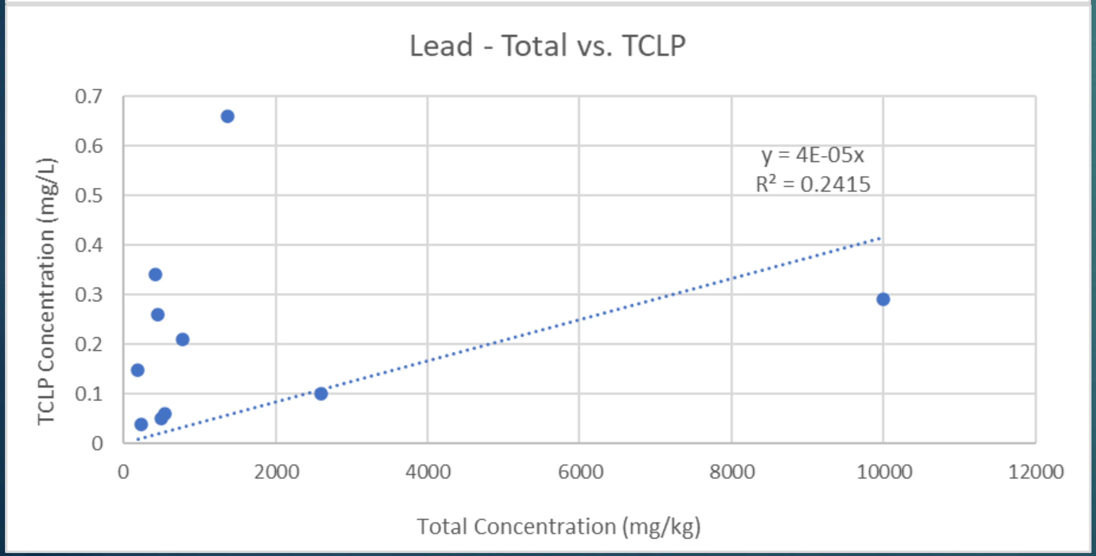
Would stormwater disposal with elevated metals concentrations contaminate groundwater?

TCLP vs Total Concentration

- Search of our own recent projects:
  - Total **67** data points over **three** different sites (**five** projects).
  - Terminal site, truck stop and former landfill.
  - TCLP:
    - 10 pairs for lead.
    - 14 pairs for zinc.
    - 5 pairs for nickel.
    - 1 pair for cadmium.

TCLP vs Total Concentration





TCLP / Totals criteria:

- Class 1 = 5 mg/L
- Class 2 (C&D) = 1 mg/L (20 mg/kg total)

- Class A = 100 mg/kg or 5 mg/kg
- Class B = 10 mg/kg or 0.5 m mg/kg

TCLP results

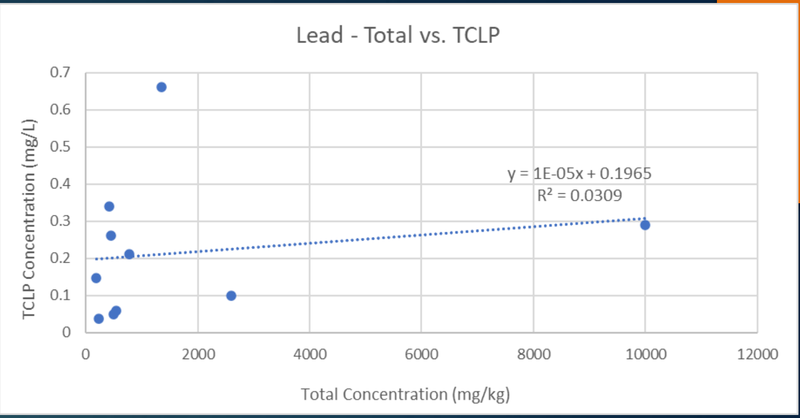
Ratio of total metals: TCLP

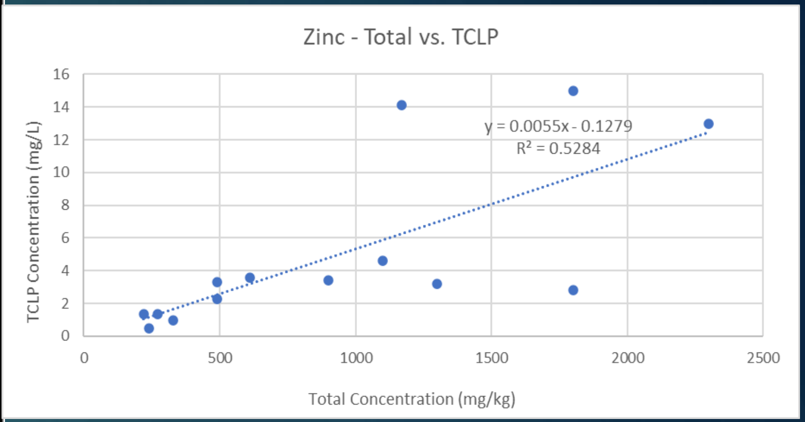
- Average lead 9571:1
- Average zinc 261:1
- Average nickel 974:1

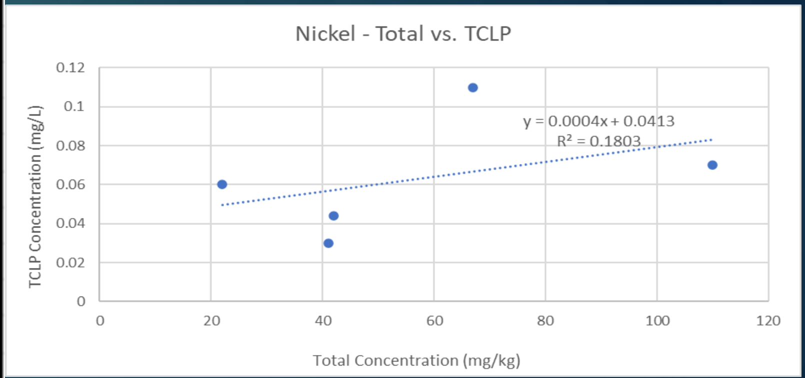
Suggests that TCLP data is conservative (20:1)

Needs larger data set to confirm patterns

	Total Contaminant Concentration in Soil (mg/kg)	Leachate Concentration from TCLP (mg/L)	Total / Leachate
Lead	540	0.059	9,153
	420	0.34	1,235
	450	0.26	1,731
	1360	0.66	2,061
	230	0.038	6,053
	189	0.147	1,286
	780	0.21	3,714
	2600	0.1	26,000
	500	0.05	10,000
	10000	0.29	34,483
Zinc	900	3.4	265
	610	3.6	169
	270	1.35	200
	2300	13	177
	240	0.51	471
	330	0.95	347
	220	1.33	165
	1170	14.1	83
	490	3.3	148
	490	2.3	213
	1800	15	120
	1800	2.8	643
	1100	4.6	239
	1300	3.2	406
Nickel	42	0.044	955
	67	0.11	609
	41	0.03	1,367
	22	0.06	367
	110	0.07	1,571
Cadmium	0.33	0.0024	138

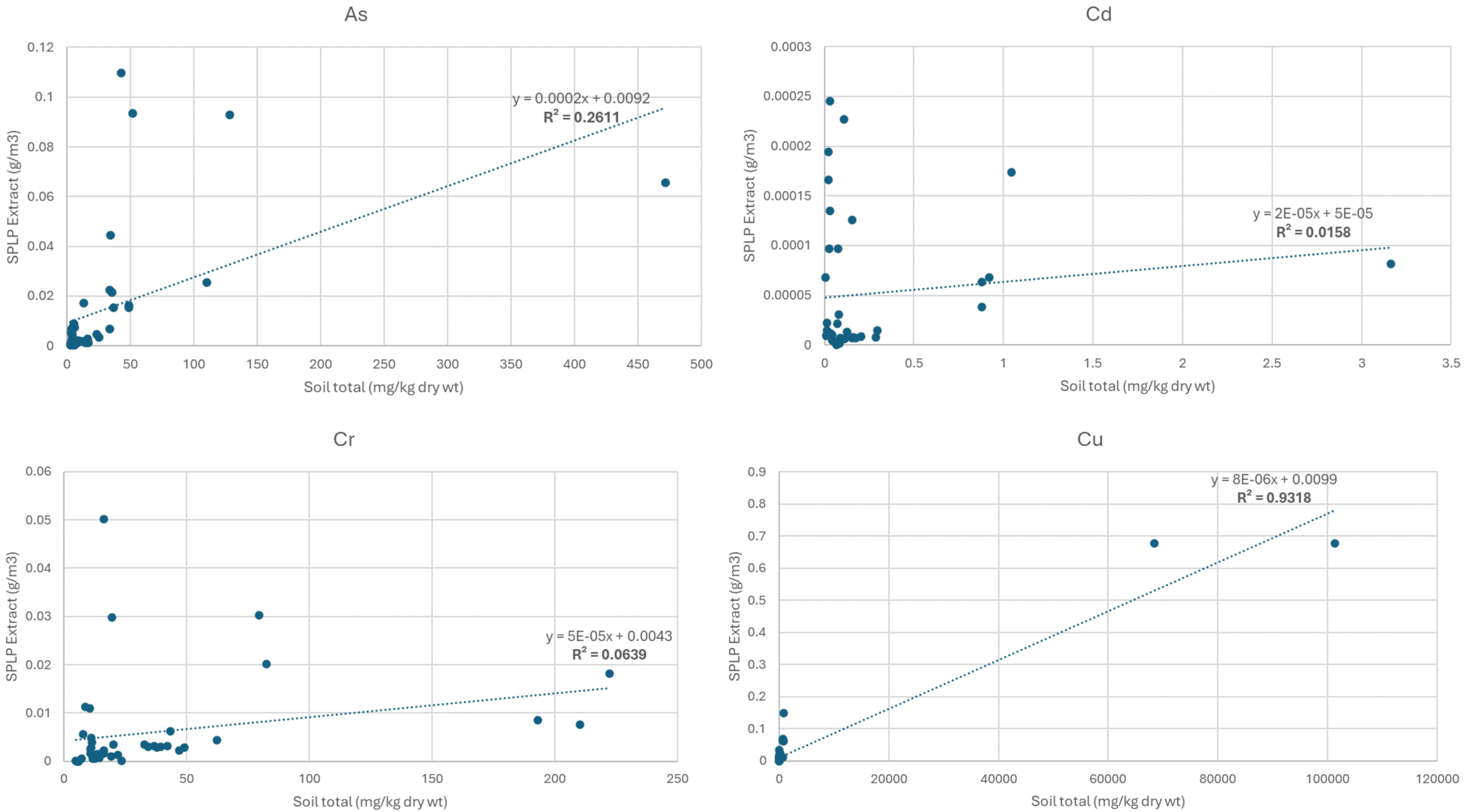


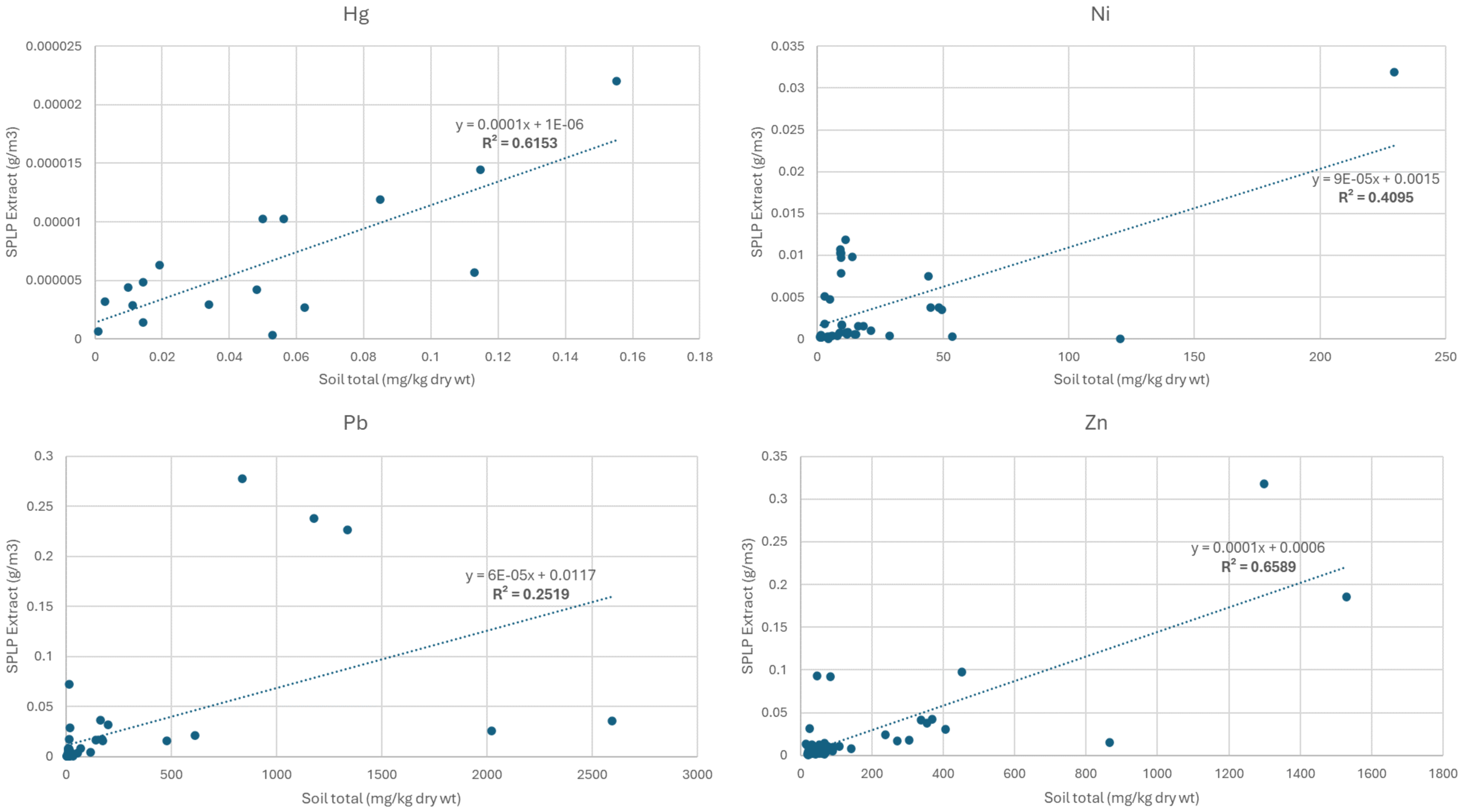




SPLP Data

- Request for total metals and SPLP metals data.
- Official Information Act request.
- 481 data points.
- Across 22 different projects/sites.
- Sites anonymized.
- Soil types etc. unknown.


As
y = 0.0002x + 0.0092
R^2 = 0.2611
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.12
0.1
0.08
0.06
0.04
0.02
0
0
50
100
150
200
250
300
350
400
450
500
Cd
y = 2E-05x + 5E-05
R^2 = 0.0158
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.0003
0.00025
0.0002
0.00015
0.0001
0.00005
0
0
0.5
1
1.5
2
2.5
3
3.5
Cr
y = 5E-05x + 0.0043
R^2 = 0.0639
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.06
0.05
0.04
0.03
0.02
0.01
0
0
50
100
150
200
250
Cu
y = 8E-06x + 0.0099
R^2 = 0.9318
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20000
40000
60000
80000
100000
120000

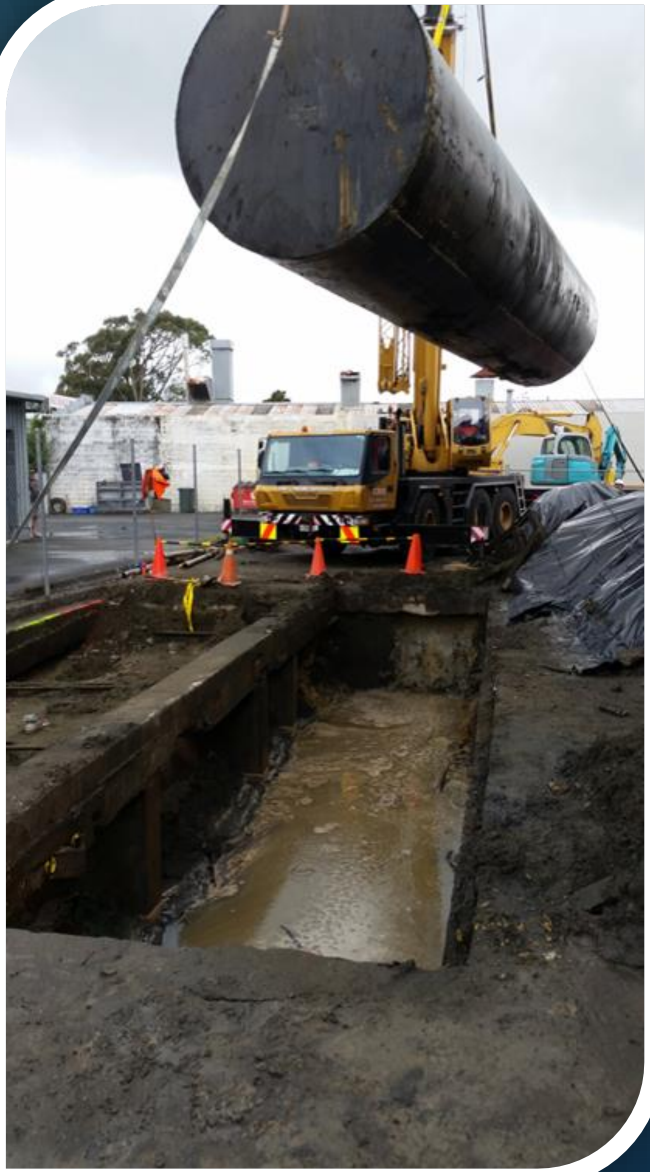

Hg
y = 0.0001x + 1E-06
R² = 0.6153
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.000025
0.00002
0.000015
0.00001
0.000005
0
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
Ni
y = 9E-05x + 0.0015
R² = 0.4095
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
50
100
150
200
250
Pb
y = 6E-05x + 0.0117
R² = 0.2519
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.3
0.25
0.2
0.15
0.1
0.05
0
0
500
1000
1500
2000
2500
3000
Zn
y = 0.0001x + 0.0006
R² = 0.6589
SPLP Extract (g/m3)
Soil total (mg/kg dry wt)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
200
400
600
800
1000
1200
1400
1600
1800

SPLP vs Total Concentration Plots – Highly Variable

Total metals	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
No. sample pairs	43	39	43	69	17	42	49	63
> (Old) Class A	3	0	3	8	0	1	13	11
<A but <(Old) Class B	17	1	34	35	0	9	23	49
< Class B	23	38	6	26	17	32	13	3
R^2	**0.2611**	**0.0158**	**0.0639**	**0.9318**	**0.6153**	**0.4095**	**0.2519**	**0.6589**
Mean total > SPLP	4,400	15,978	59,650	10,595	16,143	125,719	13,427	11,962

Hydrocarbons in Soil

- Petroleum sites often sealed with lots of UG infrastructure & operating workshops = accessibility & H&S implications.
- Limitations often mean cannot access for sampling to characterise soils for remediation and/or disposal.
- Becoming increasingly difficult to dispose of soil when undertaking these projects.



Hydrocarbons In Soil – Field Screening

Field measurements are a valid method for screening hydrocarbons in soil.

Field Screening for Hydrocarbons

Can you spot the hydrocarbon contamination?

Key field screening methods:

- Visual
- Olfactory
- Photoionisation Detector (PID)

What can we tell from visual observations and vapour concentration (PID) screening?

Field Screening – A Standardised Process

Screening using PID should adopt standard process:

- Sub-soil sample into sealed zip-lock bag (half soil / half air).
- Agitate to break up soil clumps – rest bag for 2 minutes.
- Puncture bag, record peak volatile organic compound (VOC) reading.

Validity of data subject to good QA/QC:

- Field personnel <u>trained</u> in use.
- PID calibrated & ambient air measurements collected at site.
- Unit kept out of rain and direct sunlight.
- Filter is clean & correct bulb in PID.

Field Screening – A Standardised Process

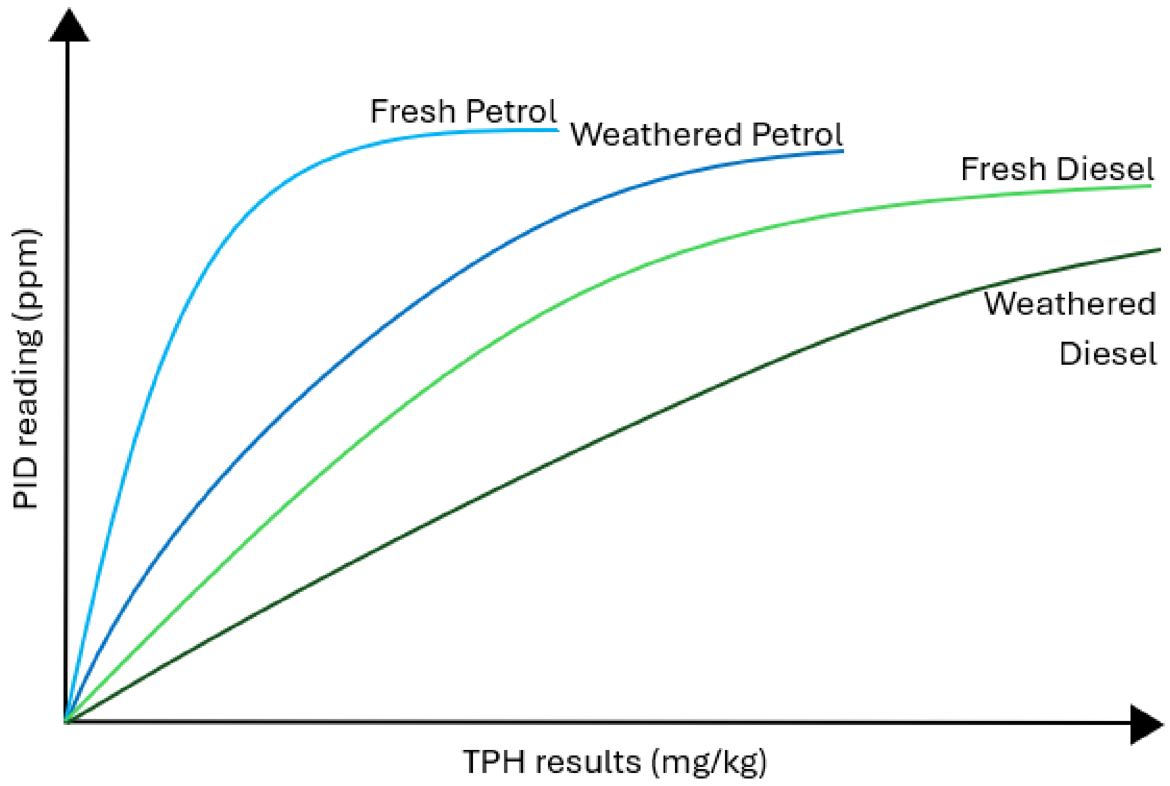
PID = solid tool for screening material for re-use onsite (with accompanying soil validation).

Can field observations be used to screen soil for landfill pre-approvals with provision of laboratory results post-receipt?

A Review of Field vs Laboratory Measures

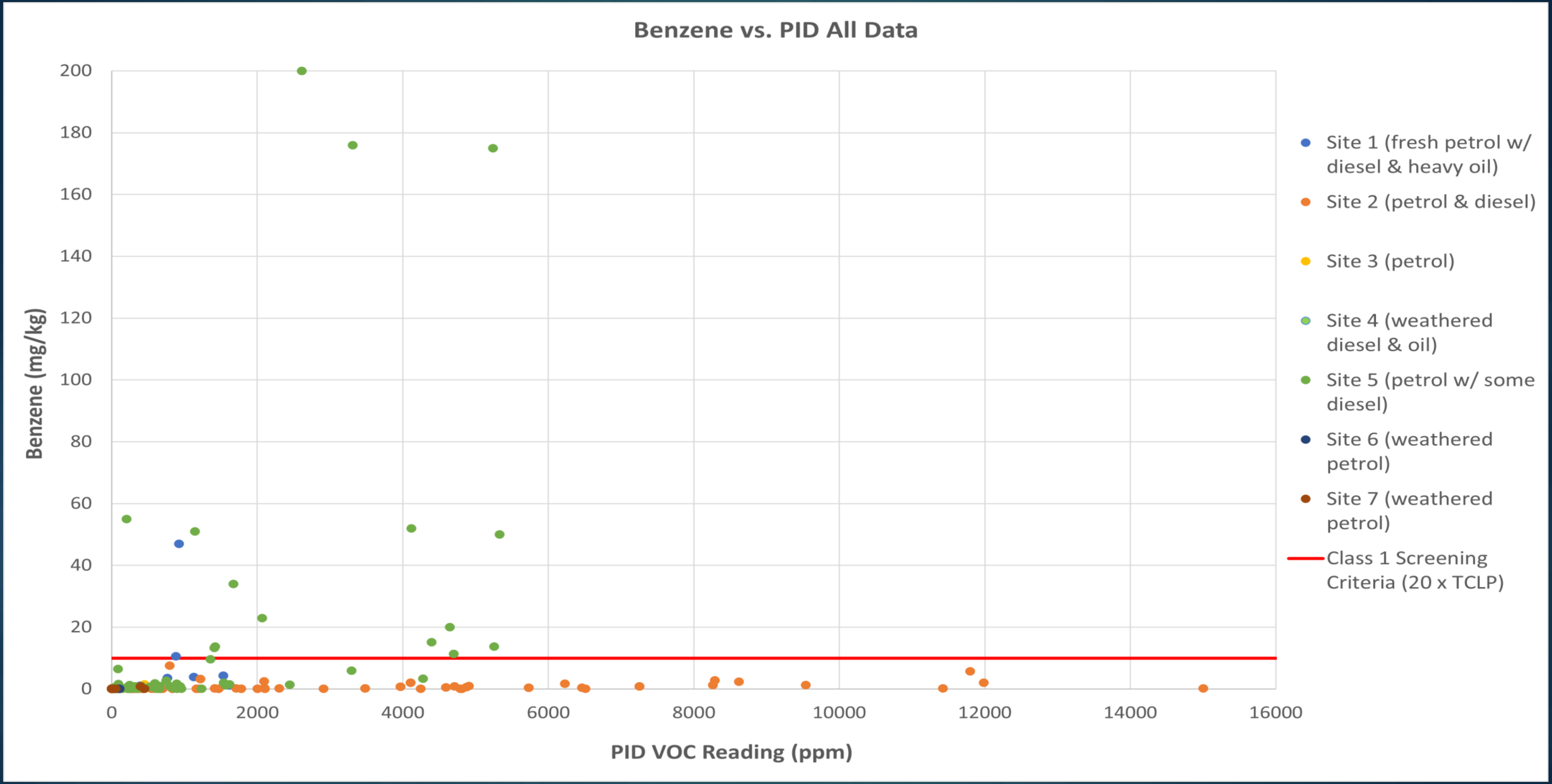
- Looked at soil sample data from various Z Energy sites in North Island.
- Compared laboratory results to PID data to assess how they compare to Class A/1 WAC.
- Data from multiple sites with different soil lithologies & different products (mostly petrol – some fresh, some weathered).

Theoretically....

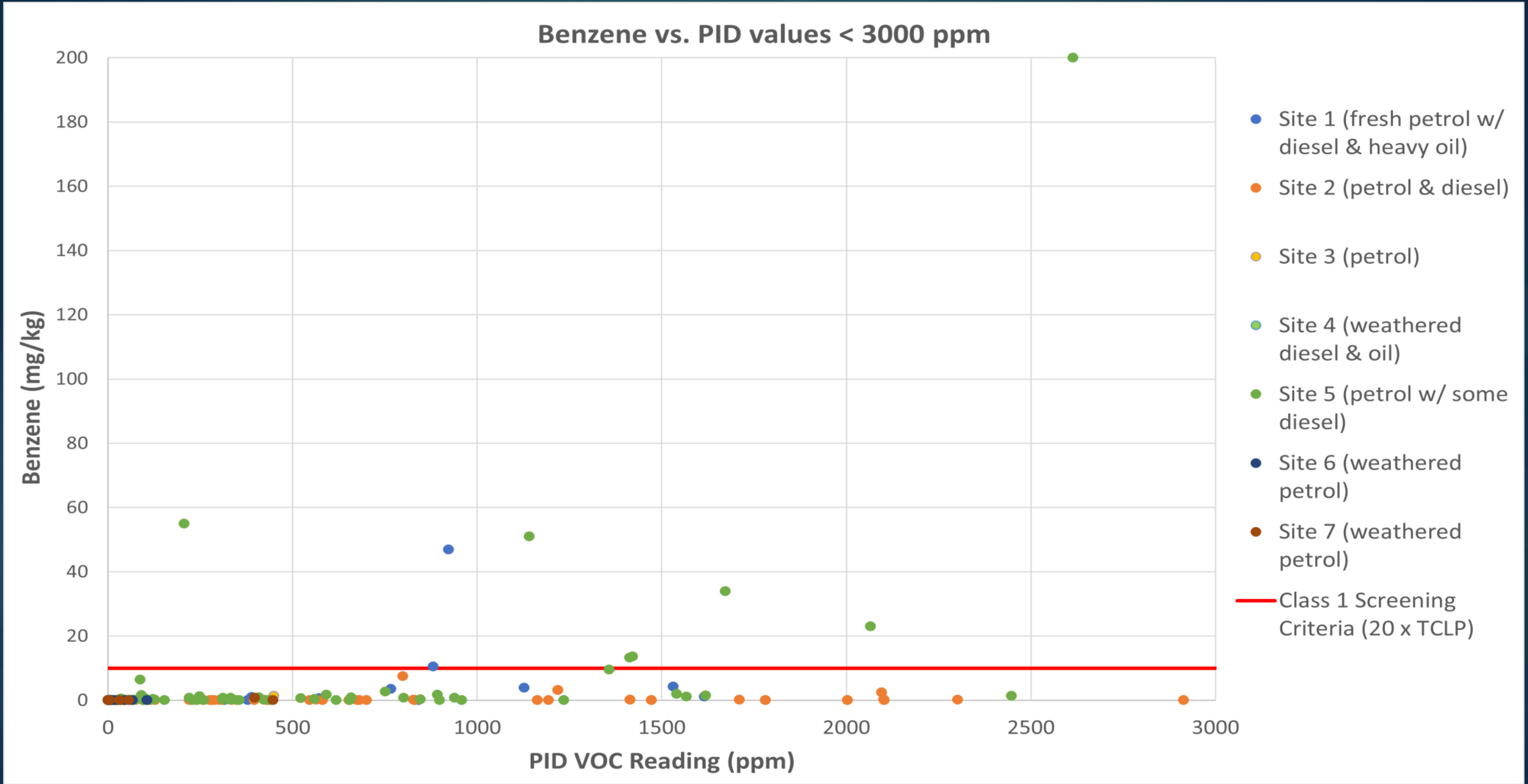


- If more volatiles (e.g. fresh petrol) – PID readings increase quickly compared to a weathered petrol or diesel.
- Theoretically, an asymptote is reached when vapour concentration saturates.
- Variables can impact trends e.g. soil lithology, moisture content, organic content etc.

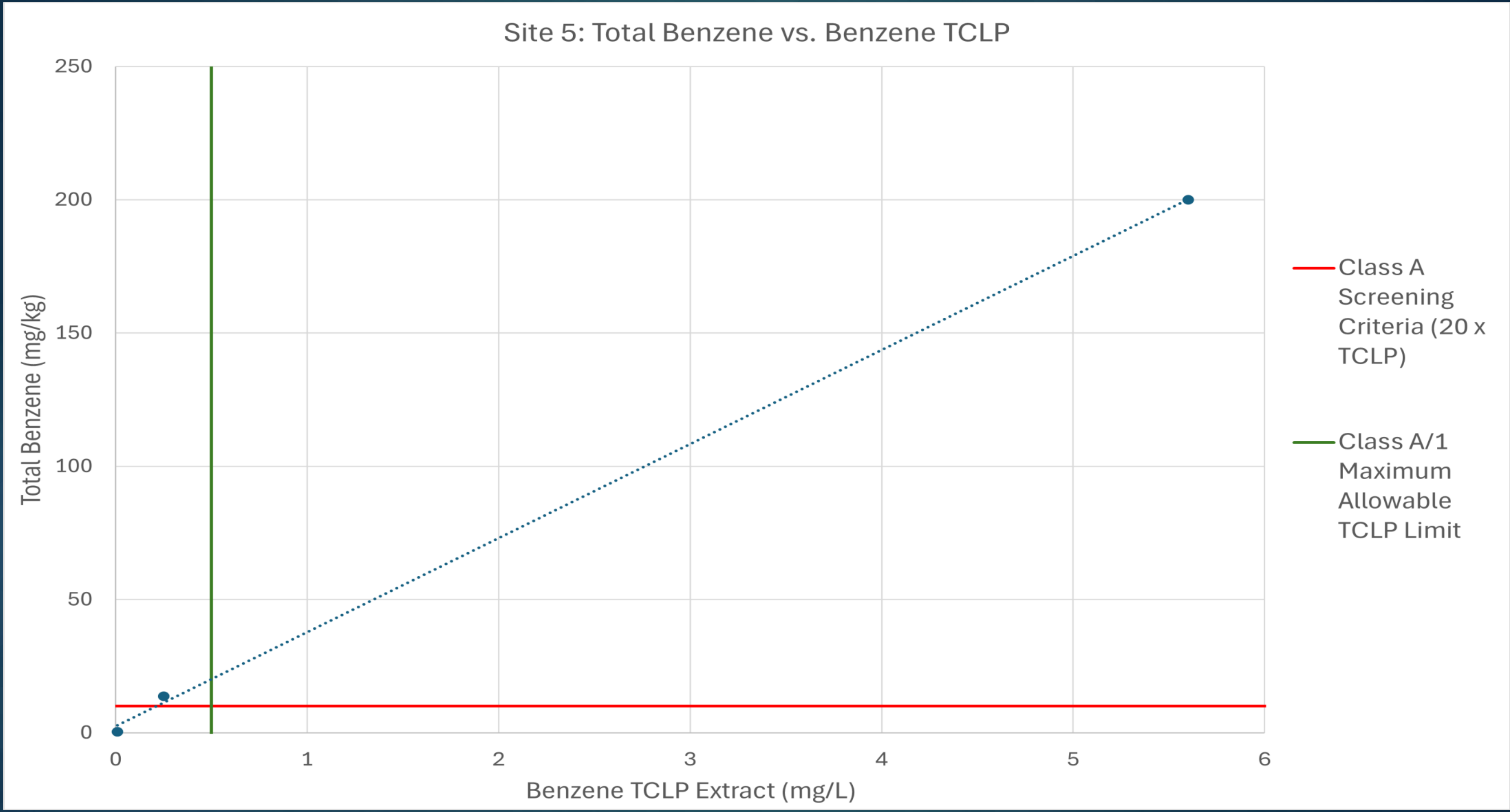
Benzene vs PID All Data



Benzene vs PID Values <3000 ppm



Site 5 – Total Benzene vs Benzene TCLP



Site 5 – BTEX Trends

- For sample with highest BTEX concentration submitted for TCLP analysis:
  - Total benzene: **200 mg/kg** vs Benzene TCLP: **5.6 mg/L** **– exceeding Class A/1 WAC** (0.5 mg/L).
  - Total TEX concentrations **exceeded** Class A screening criteria, however leachability concentrations were **compliant**:

Compounds	Concentration (mg/kg)	Class A Screening Criteria (mg/kg)	TCLP Concentration (mg/L)	Class A/1 TCLP Concentration (mg/L)
Toluene	5,600	2,000	69	100
Ethylbenzene	1,200	1,000	5.8	50
Total Xylenes	6,900	2,000	31.5	100

Where to from here?

Further investigative steps may include:

- Assessing sites with different fuel contamination (we looked at petrol).
- Assess TPH (different fuel types) vs PID to test volatilisation theory.
- Assess sites with different soil lithologies.
- Delve deeper into moisture content and influence of GW.
- Gather more TCLP testing data.
- Assess BTEX SPLP for in-situ soil management.