Establishing Background Concentrations for Risk Management Purposes

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Clean Air, Safe Water, Healthy Land for Everyone

The Background Dilemma

- Health based versus background?
- Most regulatory programs allow for consideration of background concentrations
- How do we determine a defensible background concentration?
- With respect to AZ: What is the background scenario envisioned by the Soil Remediation Standards Rule?

Soil Remediation Standards Rule

Per AAC R18-7-204 Background remediation standards:

A. A person ***may elect to remediate to a background concentration*** for a contaminant.

B. A person who conducts a remediation to a background concentration for a contaminant shall establish the background concentration using all of the following factors:

1. Site-specific historical information concerning land use.
2. Site-specific sampling of soils ***unaffected by a release,*** *but having characteristics similar to those of the soils affected by the release.*
3. Statistical analysis of background concentration using the 95th percentile upper confidence limit.

Soil Remediation Standards Rule

- Characterization of the site must be completed before determining remediation standards to use.
- Soil Remediation Standards Rule describes the “what” but not the “how”

R18-7-204 states:

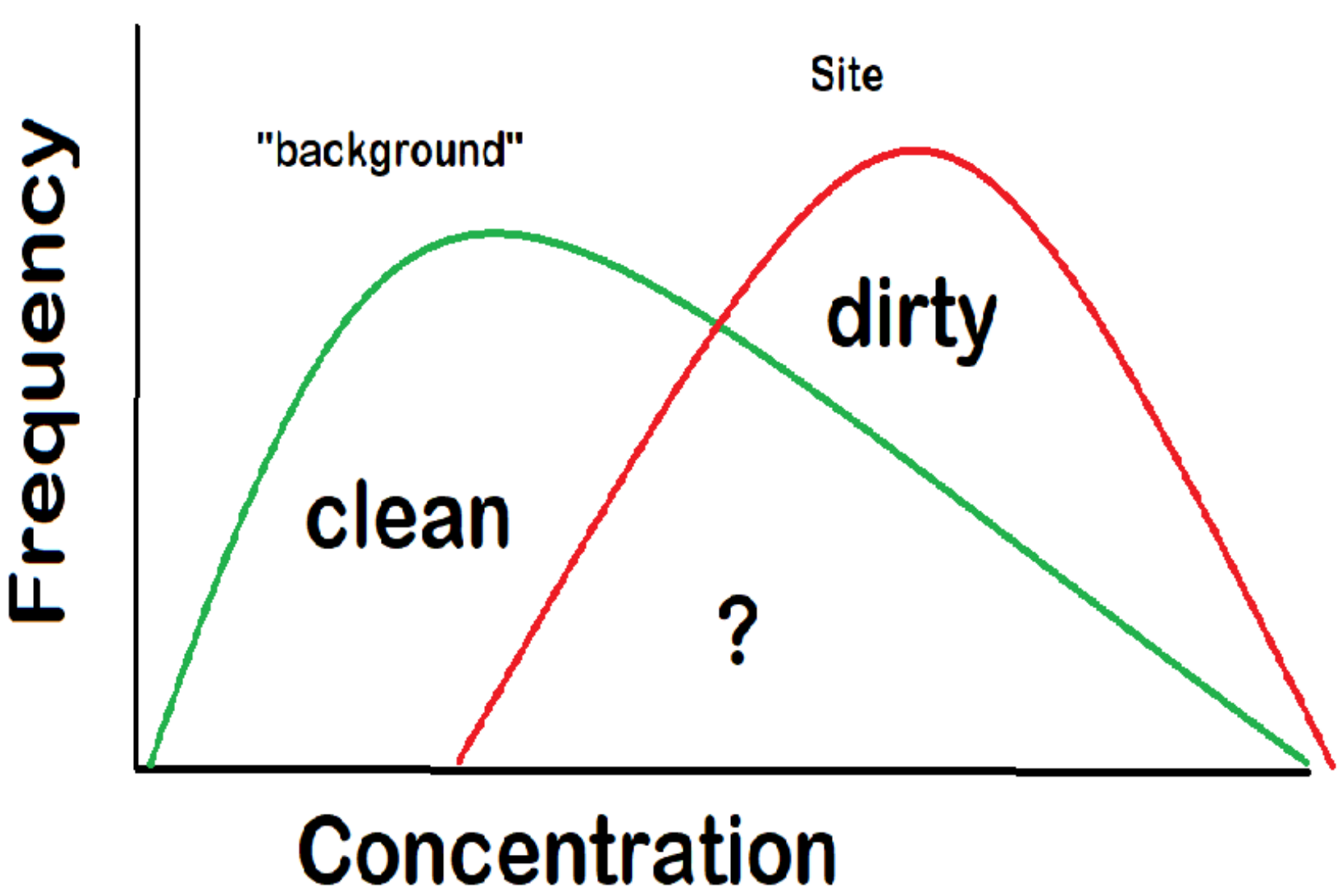
1. You must have knowledge of land use and site specific historical information
2. You must sample the contaminated as well as the uncontaminated areas and soil type must be identifiably similar
3. You must derive a background concentration using the 95th percentile Upper Confidence Level (UCL) of the background data set

How does one determine whether you have a reliable background data set in the first place?

Role of Background Analysis

- Differentiate concentrations representing a chemical release from concentrations representing background
- Identify site-specific chemicals of potential concern (COPCs) for evaluation in human health and ecological risk assessments
- Select appropriate cleanup and/or delineation levels

The Background Problem



The Question

How can we technically and defensibly differentiate between site-related releases and background conditions?

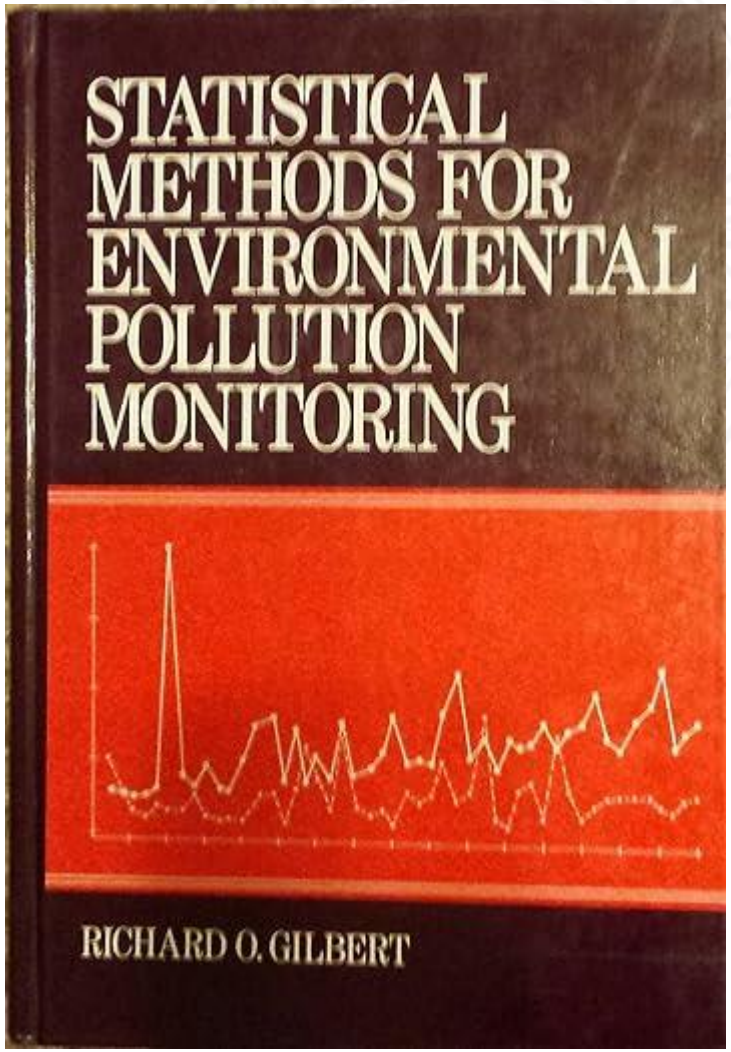
Basic Statistical Approach

1. Exploratory Data Analysis
   - Statistical summaries of the data
   - Simple plots of the data (side by side box plots, overlaid quantile plots)
   - Spatial plots of the data

2. Statistical tests to confirm what is “seen” in the data
   - Gilbert’s Toolbox
   - Multivariate options

Basic Statistical Approach

- In the 1990's Dr. Richard Gilbert and colleagues at Pacific Northwest Laboratories developed a set of statistical methods for data comparison that can be used to evaluate background.
- ADEQ's Voluntary Remediation Program has adopted Gilbert's methods for this purpose through a proprietary online software package developed by The Fehling Group and Neptune & Company
  - Online user interface
  - Conducts four statistical tests concurrently
  - Gilbert's Toolbox-GiSdT
- Output may be used in reports to support background decisions
    - Output = Editable text narrative, tables, and box plots
    - Able to add additional supporting narrative



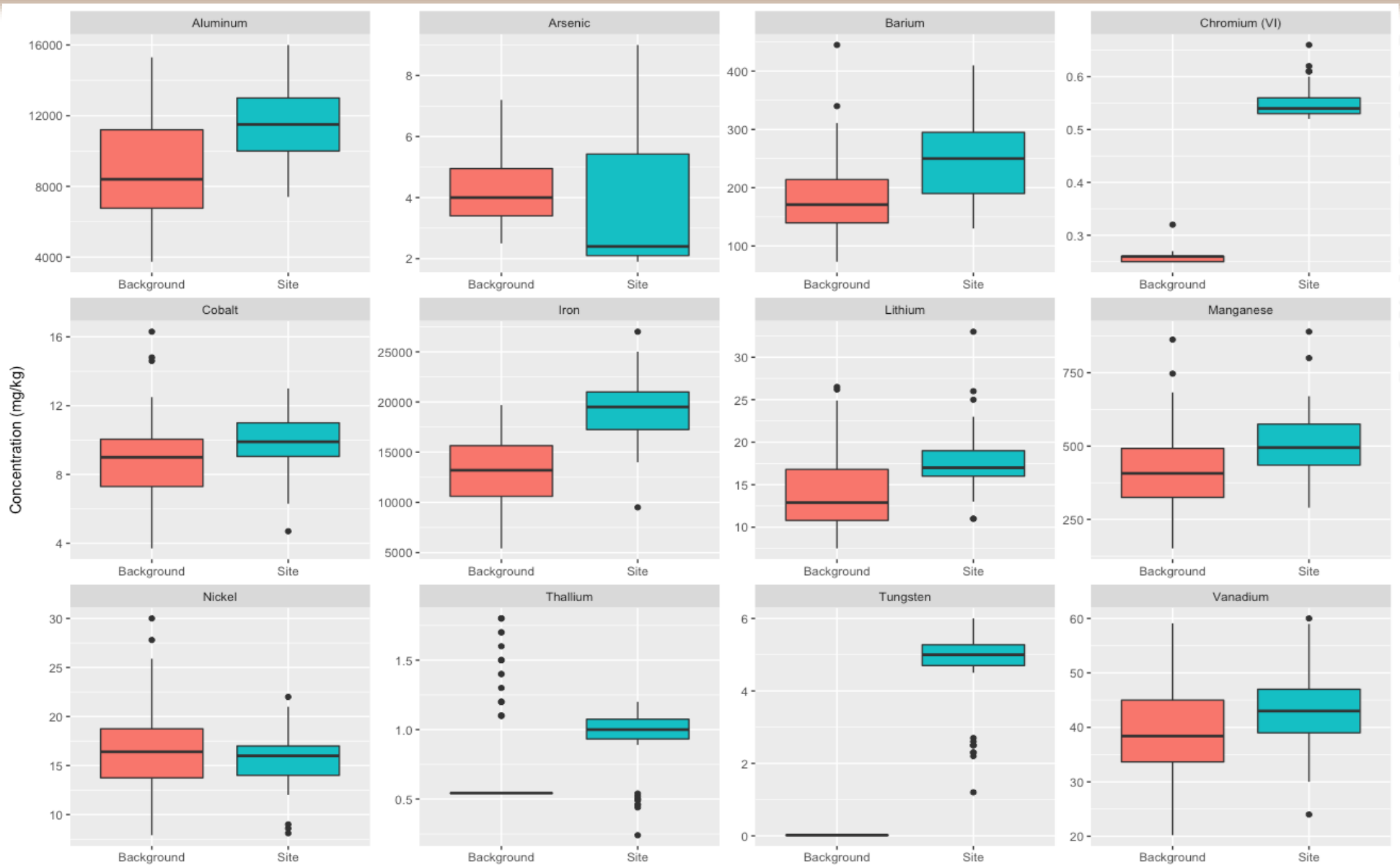
Gilbert's Toolbox

- *t*-test, Wilcoxon Rank Sum (WRS) test
  - Tests of central tendency
- Quantile test, Slippage test
  - Comparisons in the tails of the distributions
- If there are many non-detects another option is to compare the proportion of detects in site and background data
  - Requires that detection limits are essentially the same in both datasets
  - Not currently in the program

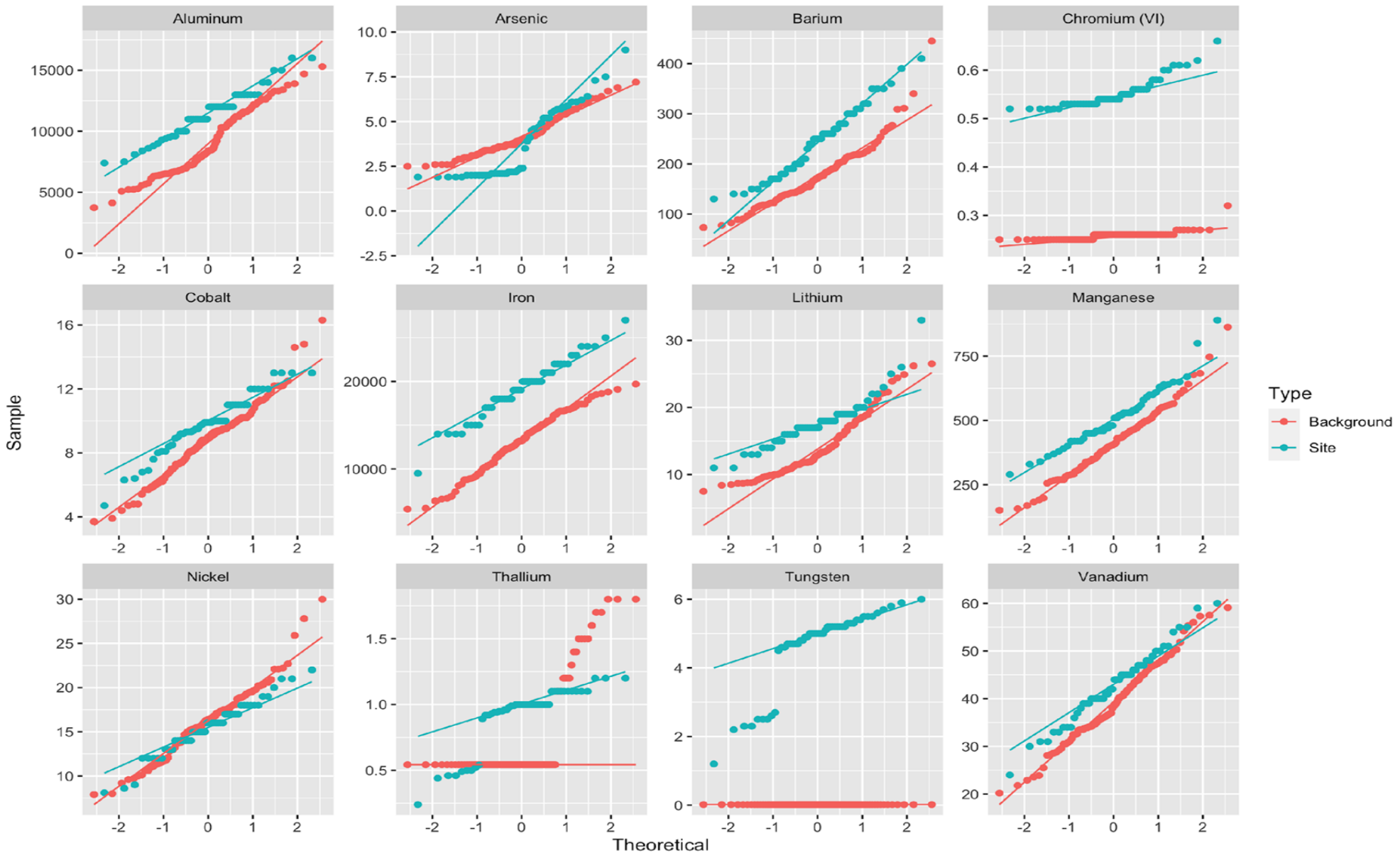
Example Data Set

		Detected Data								Non-Detected Data							
Chemical	N	Num Detect	Min Detect	25th Percentil	Median	Mean	75th Percentile	Max Detect	Standard Deviation	Num ND	Min ND	25th Percentil	Median	Mean	75th Percentil	Max ND	Std. Deviation
Aluminum	50	50	7400	10000	11500	11400	13000	16000	2050	---	---	---	---	---	---	---	---
Aluminum	95	95	3740	6765	8400	8990	11200	15300	2680								
Arsenic	50	24	3.5	4.675	5.55	5.55	6.1	9	1.22	26	1.9	2	2.1	2.08	2.175	2.4	0.144
Arsenic	95	95	2.5	3.4	4	4.21	4.95	7.2	1.1	---	---	---	---	---	---	---	---
Barium	50	50	130	190	250	245	295	410	70.1	---	---	---	---	---	---	---	---
Barium	95	95	73	139.5	171	177	214	445	59.1	---	---	---	---	---	---	---	---
Chromium (VI)	50	---	---	---	---	---	---	---	---	50	0.52	0.53	0.54	0.552	0.56	0.66	0.0311
Chromium (VI)	95	---	---	---	---	---	---	---	---	95	0.25	0.25	0.26	0.258	0.26	0.32	0.00867
Cobalt	50	50	4.7	9.05	9.9	9.83	11	13	1.83	---	---	---	---	---	---	---	---
Cobalt	95	95	3.7	7.3	9	8.78	10.05	16.3	2.31	---	---	---	---	---	---	---	---
Iron	50	50	9500	17250	19500	19100	21000	27000	3380	---	---	---	---	---	---	---	---
Iron	95	95	5410	10600	13200	13100	15650	19700	3410	---	---	---	---	---	---	---	---
Lithium	50	50	11	16	17	17.8	19	33	3.78	---	---	---	---	---	---	---	---
Lithium	95	95	7.5	10.8	12.9	14	16.8	26.5	4.44	---	---	---	---	---	---	---	---
Manganese	50	50	290	435	495	509	575	890	115	---	---	---	---	---	---	---	---
Manganese	95	95	151	325	407	415	492	863	130	---	---	---	---	---	---	---	---
Nickel	50	50	8.1	14	16	15.5	17	22	3	---	---	---	---	---	---	---	---
Nickel	95	95	7.9	13.75	16.4	16.2	18.75	30	4.02	---	---	---	---	---	---	---	---
Thallium	50	---	---	---	---	---	---	---	---	50	0.24	0.933	1	0.921	1.08	1.2	0.232
Thallium	95	21	1.1	1.2	1.4	1.41	1.6	1.8	0.256	74	0.543	0.543	0.543	0.543	0.543	0.543	0
Tungsten	50	---	---	---	---	---	---	---	---	50	1.2	4.7	5	4.63	5.28	6	1.16
Tungsten	95	---	---	---	---	---	---	---	---	95	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0
Vanadium	50	50	24	39	43	42.8	47	60	7.61	---	---	---	---	---	---	---	---
Vanadium	95	95	20.2	33.65	38.4	39.1	45	59.1	8.43	---	---	---	---	---	---	---	---

Gilbert's Toolbox Output



Gilbert's Toolbox Output



Gilbert's Toolbox Output

Analyte	Two-Sample t-test	Gehan Test	Quantile Test (0.75)	Quantile Test (0.90)	Slippage Test
Aluminum	8.51E-09	2.71E-07	6.48E-02	3.38E-01	1.17E-01
Arsenic	9.96E-01	9.89E-01	2.66E-01	1.61E-01	3.94E-02
Barium	4.80E-08	3.18E-08	9.25E-09	3.53E-03	1.00E+00
Chromium (VI)	1.01E-52	0.00E+00	1.00E+00	1.00E+00	*NA*
Cobalt	1.76E-03	1.25E-03	3.66E-02	5.65E-01	1.00E+00
Iron	2.55E-17	1.89E-15	1.25E-11	1.08E-06	1.63E-14
Lithium	2.47E-07	1.26E-07	3.66E-02	4.17E-01	3.45E-01
Manganese	1.02E-05	1.37E-05	1.76E-02	3.06E-02	3.45E-01
Nickel	9.03E-01	8.78E-01	9.95E-01	9.21E-01	1.00E+00
Thallium	8.83E-01	9.12E-04	9.98E-01	1.00E+00	1.00E+00
Tungsten	3.37E-32	0.00E+00	1.00E+00	1.00E+00	*NA*
Vanadium	4.56E-03	5.58E-03	1.99E-01	2.21E-01	3.45E-01

Issues That Can Arise

- **If Background concentrations are shown to be greater than Site concentrations, then background is not adequately characterized**
- **Statistical test results depend on sample size!**
- **Non-detect issues**
- **Analytical differences**
- **Geological differences or mixtures**

Summary

- Human health risk screening levels for some chemicals are within the range of background concentrations
- Clear need for accurately determining contamination versus background
- ADEQ has developed a robust statistical program for background:site comparisons
- Based upon Gilbert et al., environmental statistical test
  - Online user interface
  - Conducts 4 statistical tests
  - Output + EDA used to determine need for remedial action

Questions?

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