THE TRIAD APPROACH

The Triad Approach to make contaminated sites cleanup projects better and more cost-effective.

Case: Complementary laboratory (ICP, etc) and field XRF analysis

Drs Ben Keet www.benkeet.com

Background Drs Ben Keet

Free University of Amsterdam : Physics & Hydrogeology

(theses: Isotope Hydrology + Hydrochemistry)

Work experience

- 5 years Ass. Lecturer Physics & Groundwater Models
- 5 years Shell Int'l : UK, Algeria, Gabon, Ecuador, London
- 20 years Geo & Hydro: New Zealand ('87-'91), Australia, US, Europe, back in New Zealand (from 2003)

Ø Proj. manager 2500 site assessments, 1500 remediations

Ø Design & manage : 400 in situ & biological remediation systems.

Ø Expert witness, 2nd opinion, accredited site auditor

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TRIAD ?? I’d rather go fishing ….

What is "TRIAD" ?

Simplified definition:

The Triad = an innovative decision-making tool

The Triad approach :

- Proactively exploits new characterization tools and treatment techniques,
- Uses interactive work strategies
- Provides better and cheaper results

Is used by innovative and successful contaminated site professionals.

Triad Message

- *Explicitly identify and manage uncertainties that could lead to decision errors*
- *Focus on: "sampling representativeness"*
- *Use new field & in-situ analysis methods to increase cost-effective sample representativeness*
- *Need to adapt work routines to include mechanisms that explicitly manage representativeness*

Triad Approach

Systematic Project Planning

Dynamic Work Plan Strategy

Real-time Measurement Technologies

Synthesizes practitioner experience, successes, and lessons-learned into an institutional framework

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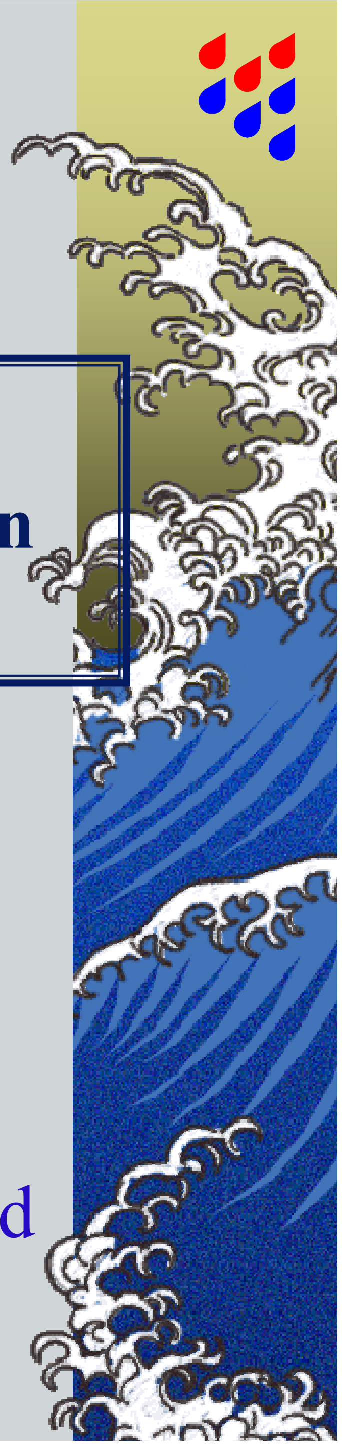
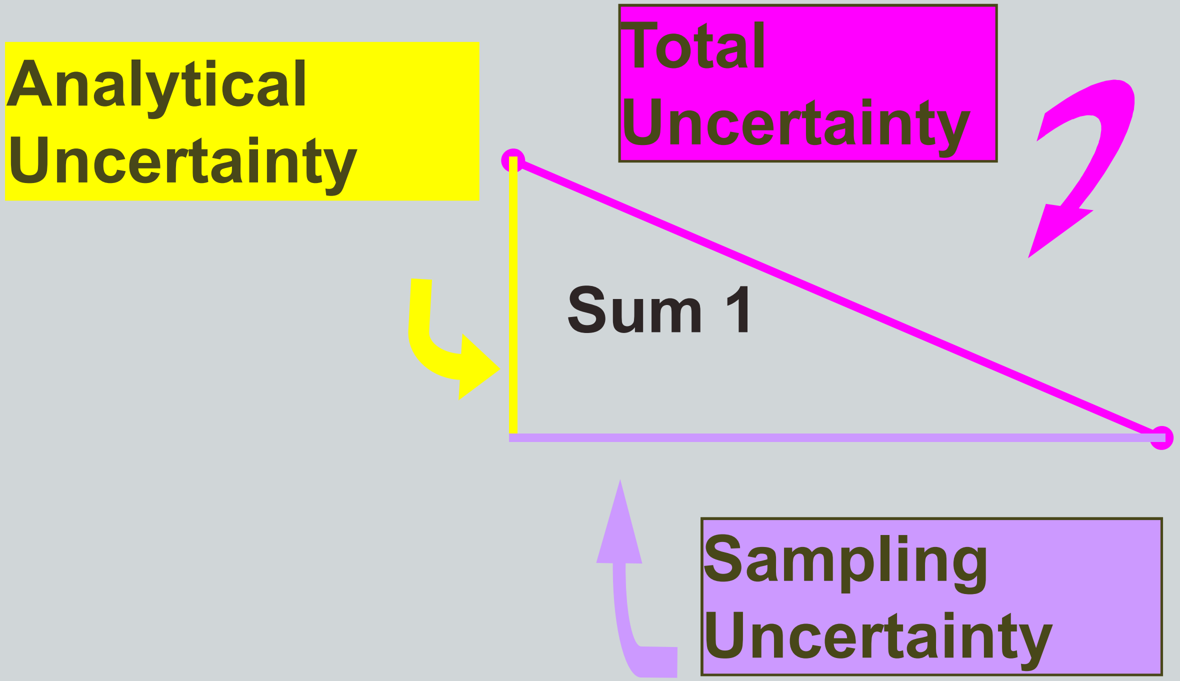


One of the aspects of Triad: adding of uncertainties

Uncertainties add according to $(a^2 + b^2 = c^2)$



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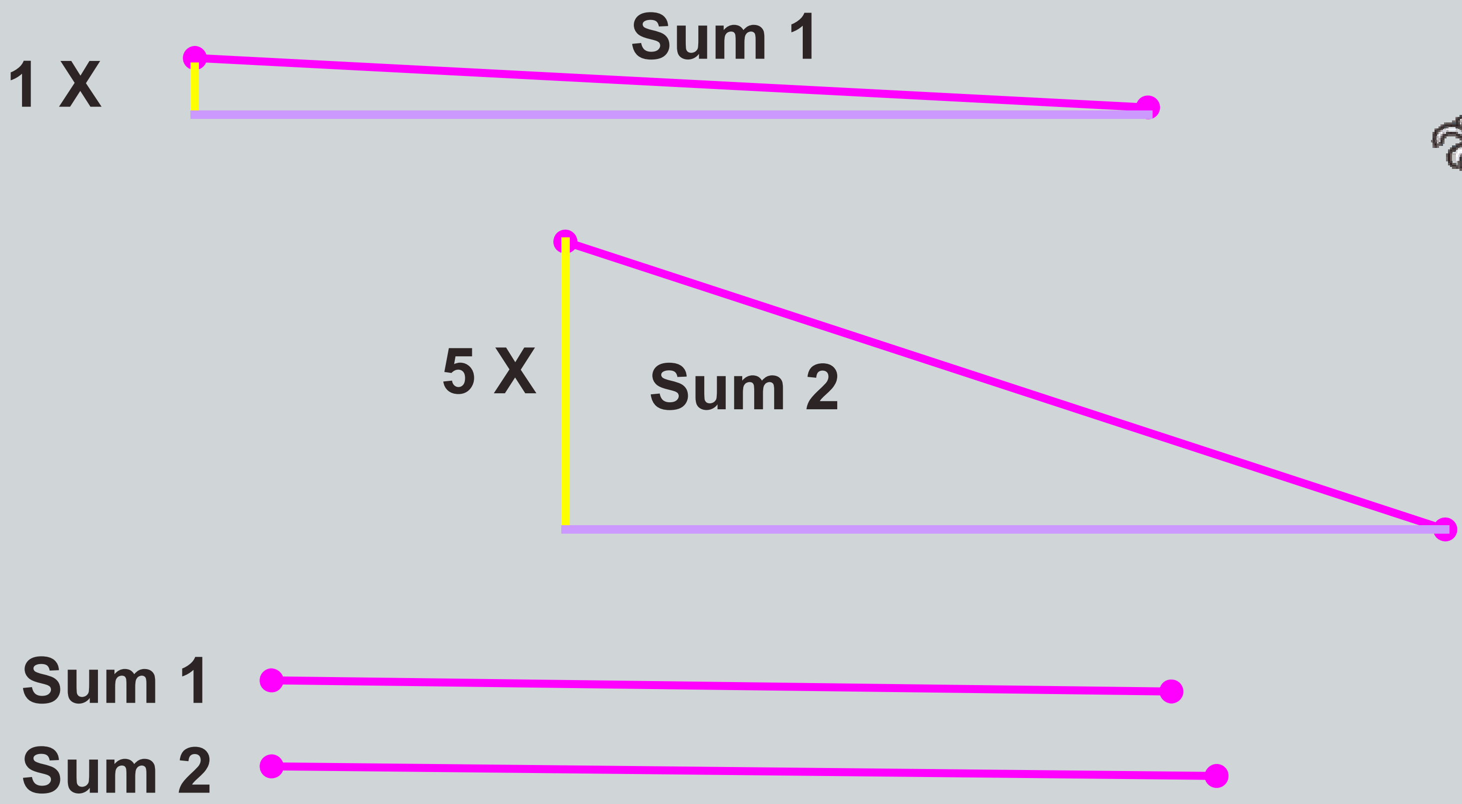
Effect of analytical uncertainty on total uncertainty



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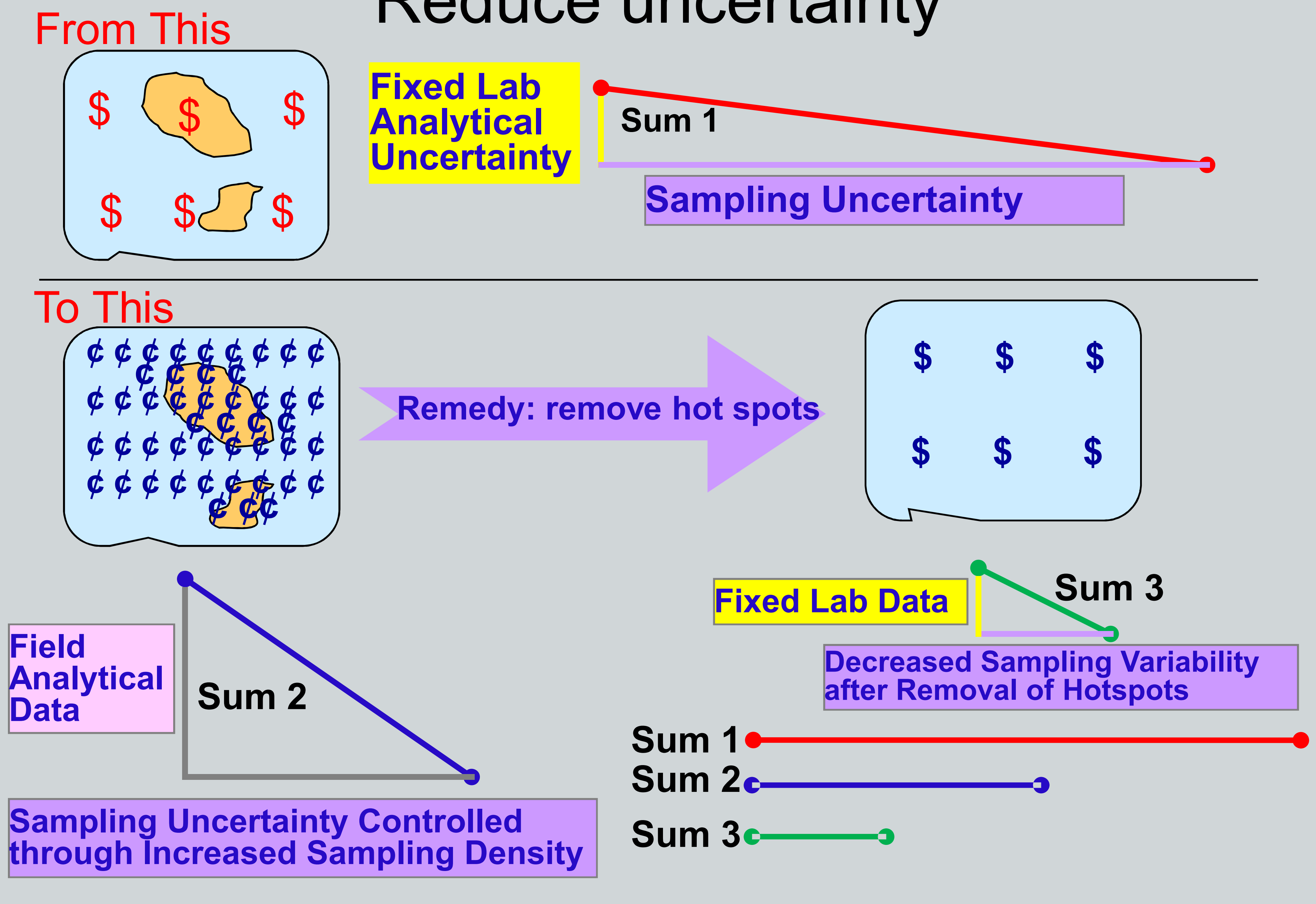
Reduce uncertainty

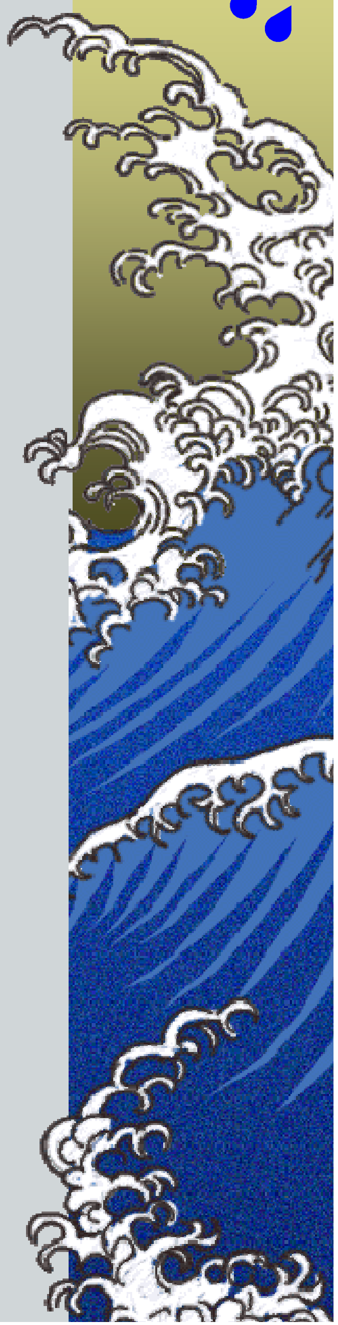


Misleading Terminology

Field Screening

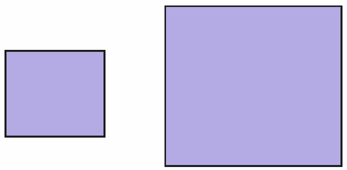
Misleading because…

- *Not all field methods are screening methods!*
- *Not all field produced data are screening quality data!*
- *Definitive analytical lab methods may produce screening quality data!*



Causes of Soil Sample Variability

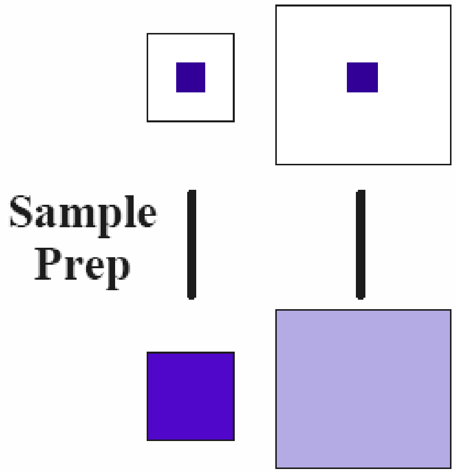
Regulatory and field practice assume the size/volume of a sample has no effect on analytical results.



The assumption doesn't hold under heterogeneity;

sample volume can determine the analytical result!

The Nugget Effect



Same contaminant mass… but different concentration results!!

Core of Triad:
Conceptual Site Model

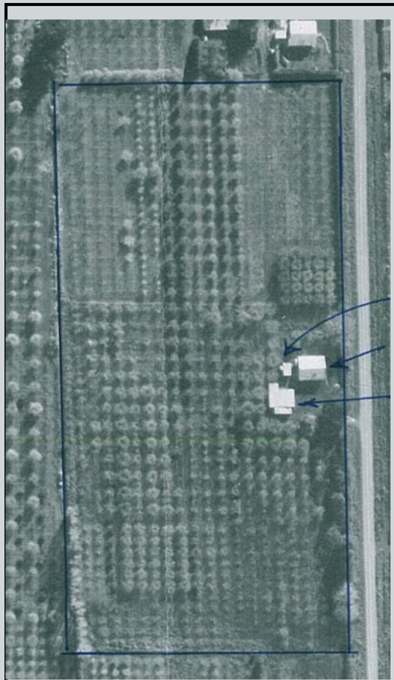
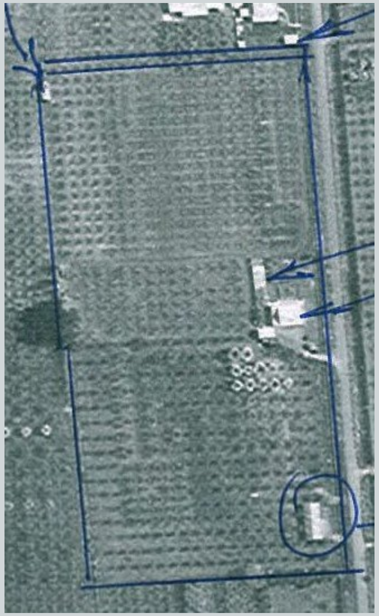
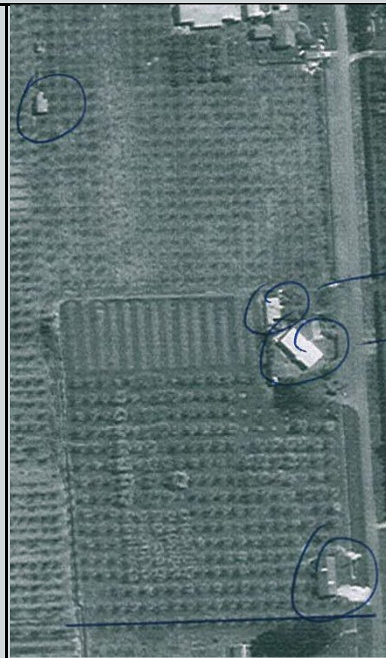
Development of Conceptual Site Model

- *Focusses investigation*
  - *Use current and historial site lay-out*
  - *Visualise the way operations were carried out*
  - *Use the 'Sherlock Holmes' method*
- *Reduces uncertainties*
  - *By increasing sample representativeness*
  - *Being able to make sound decisions*

Lyndhurst, Hastings

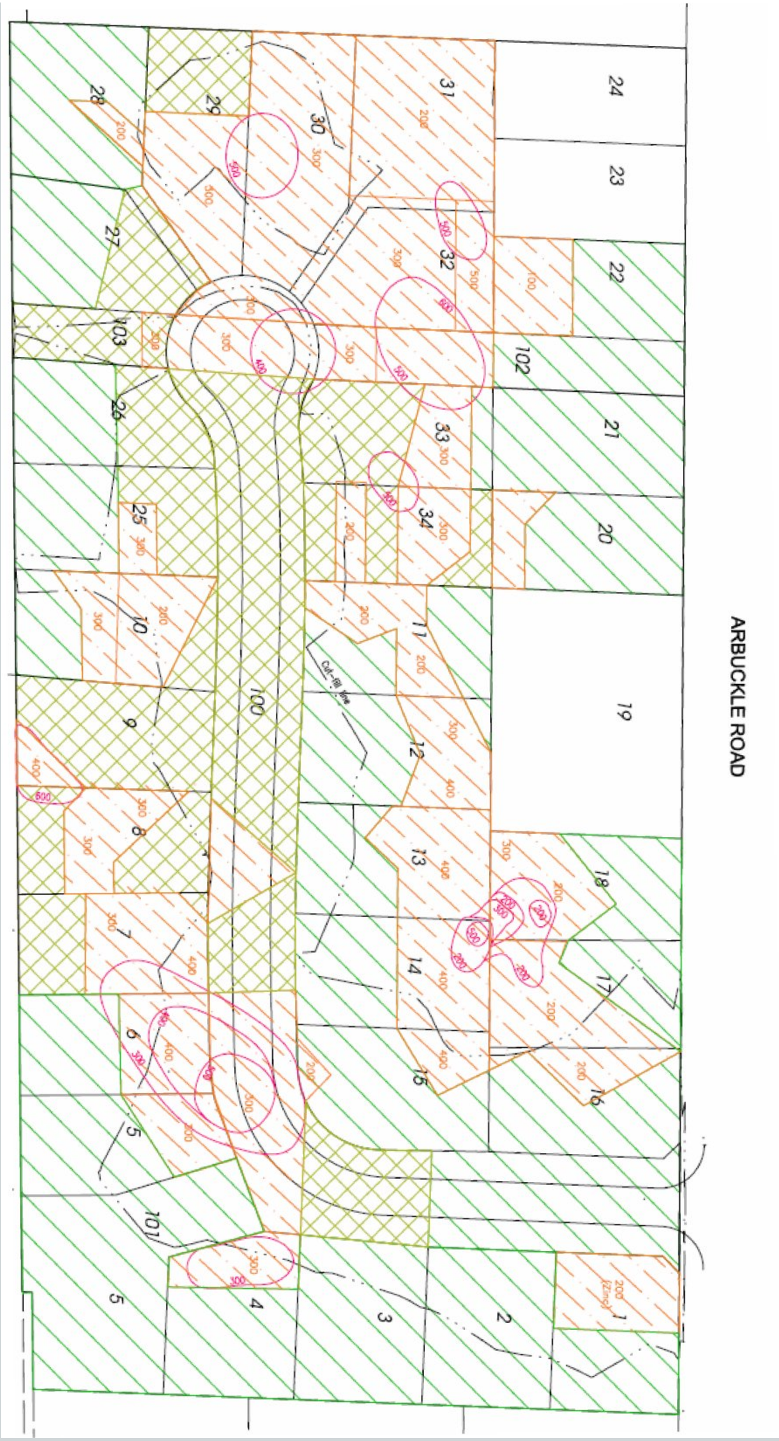
- *3 ha orchard*
- *Will be 34 lot subdivision*
- *Task:*
- *Assess, Remediate &Validate*

Past site lay-out

			
1935-47	60-ies	70-ies	1985

P = pear trees

S = shed



Result of Assessment:
6 x 6 meter grid
4 layers 100 – 150 mm

3,969 samples
5 x XRF analysed
using smart composites

Produced hotspot &
mix volumes map

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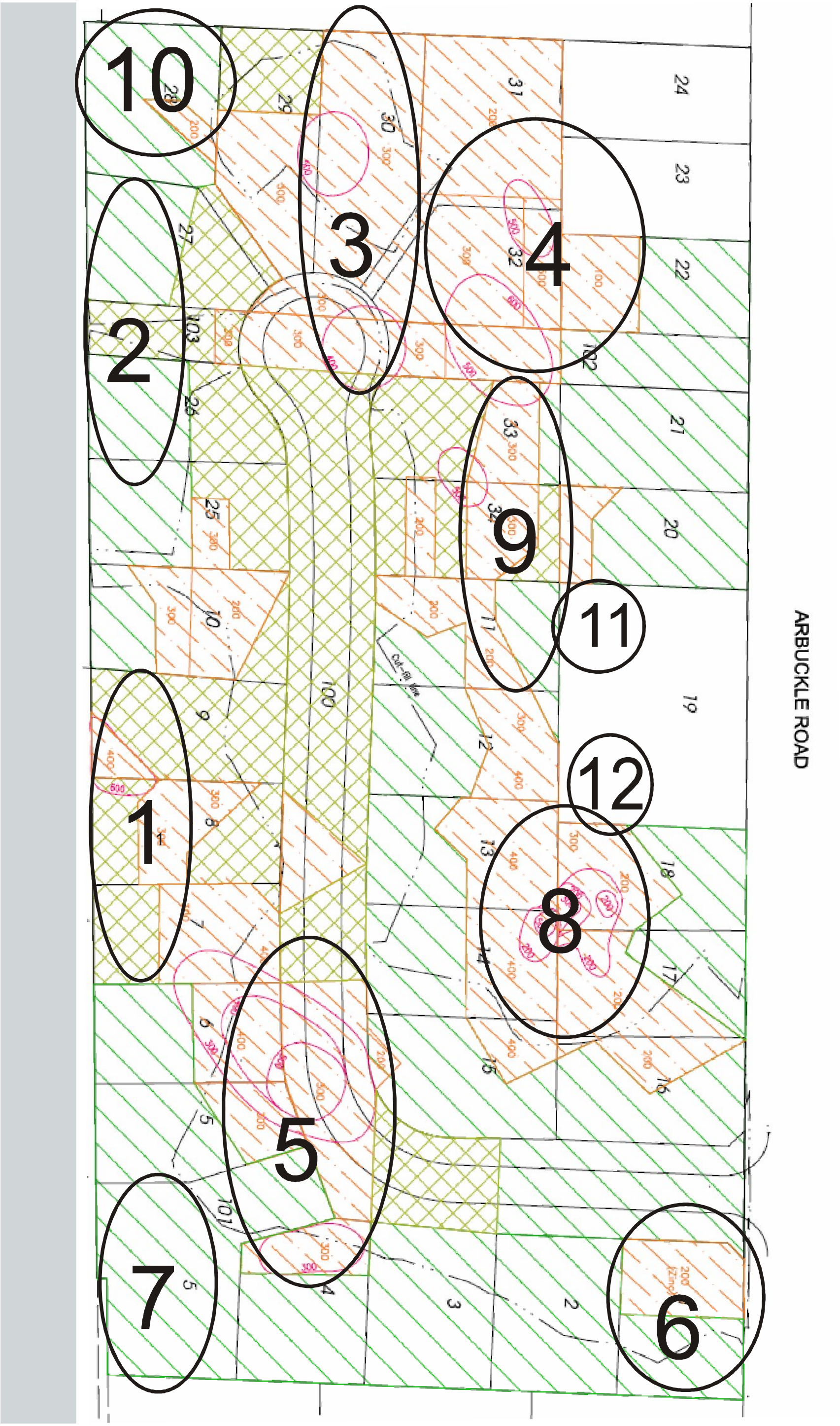
5 XRF analysis / sample bag

To avoid weeks of analysis, the number of analysis can be significantly reduced by 'using smart composites'

To refine the CSM we need

- *Quality control of field data →*
  (Laboratory analysis)
- *Compare and adjust if required*

- *Reduce uncertainty of analytes →*
  Laboratory screening for OCP, OP & ON
- *Identify additional hotspots*



Lab analysis

- As, Pb, Cu
-OP,ON, OCPs
(only DDT found)

- confirms XRF map
+ adds hotspot @ 12
(DDT)

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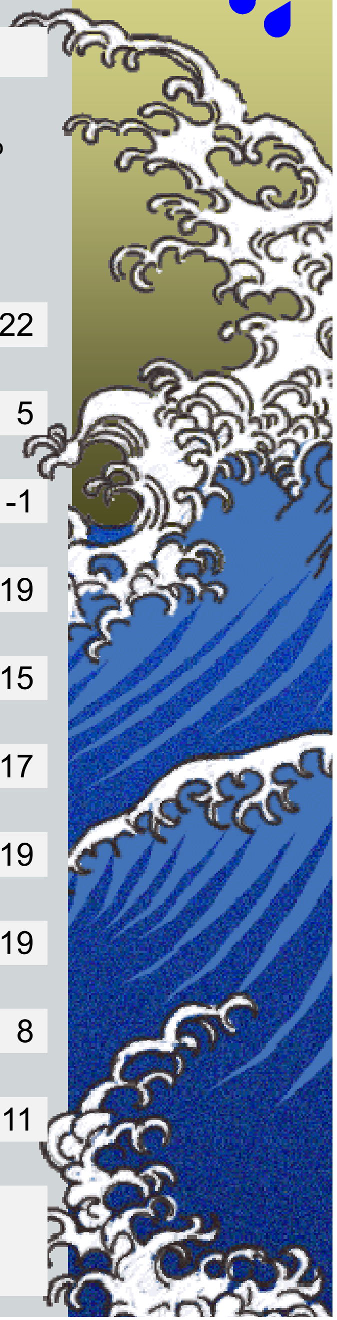
Sample number	XRF readings (mg/kg ww) Av xrf SMC Cu	Av xrf SMC Zn	Av xrf SMC Pb	Av xrf SMC As (corr)	% xrf <LOD	Laboratory results (mg/kg ww) CuTRI Cu	Δ%	ZnTRI Zn	Δ%	PbTRI Pb	Δ%	AsTRI As	Δ%
cs1	240	92	123	33	38	236	2	98	-6	133	-7	43	-22
cs2	107	85	78	25	8	119	-10	87	-3	77	1	24	5
cs3	127	85	215	69	20	132	-4	83	2	221	-3	70	-1
cs4	105	79	150	55	0	98	7	71	11	148	1	46	19
cs5	211	66	159	52	10	251	-16	66	0	199	-20	61	-15
cs6	218	275	53	14	88	176	24	454	-39	46	17	12	17
cs7	182	104	55	19	64	241	-25	123	-16	89	-38	23	-19
cs8	354	107	209	63	0	365	-3	100	7	214	-2	53	19
cs9	228	98	177	51	22	127	79	85	15	156	13	47	8
cs10	112	99	110	27	70	131	-14	111	-11	115	-4	30	-11
average % difference							**4**		**- 4**		**- 4**		**0**

(+ means the XRF reads higher than the lab result)



Remediation starts: hotspot removal

Remediation QC: XRF guidance

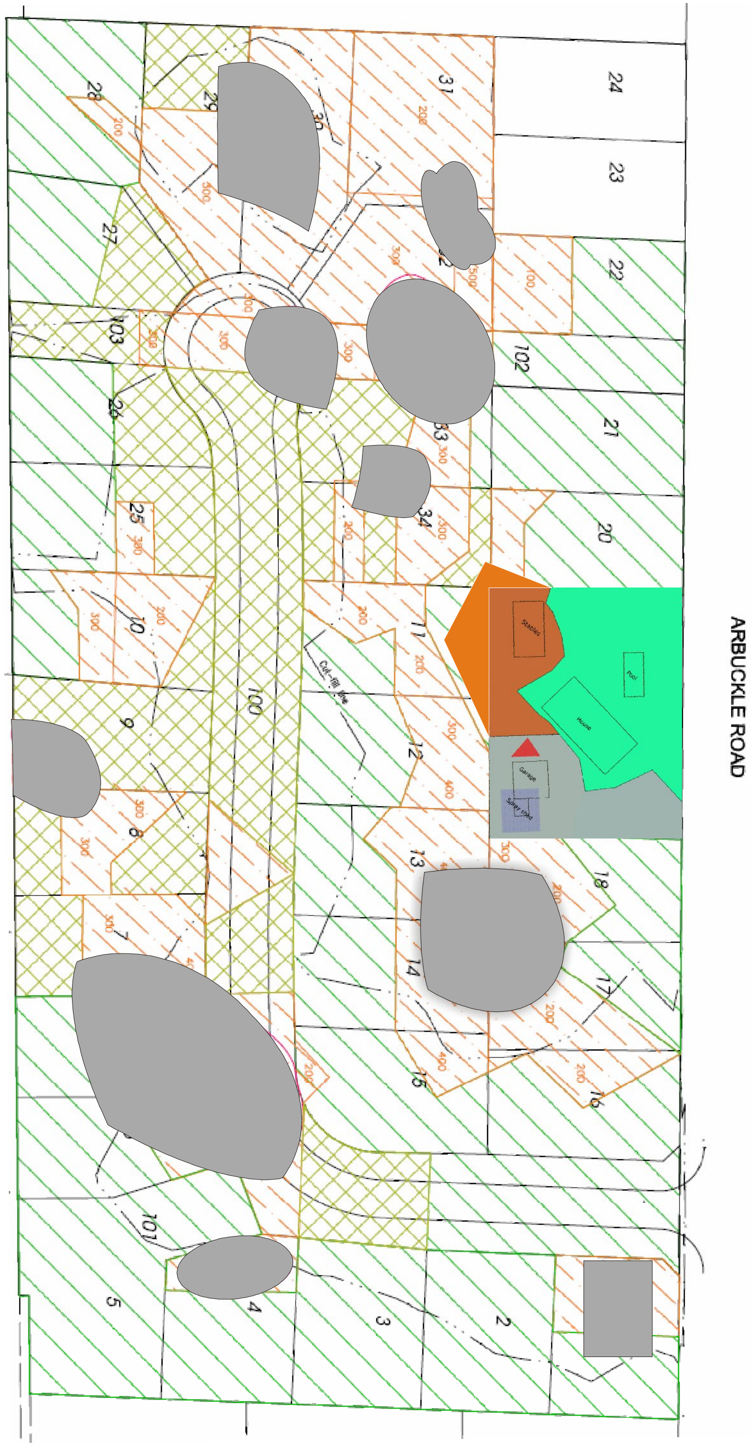
Then: Soil Mixing

QC of Mixing process: XRF analysis

Unexpected hotspots

Overall aim of QC of soil mixing process:

1. Obtain average levels below guideline levels
2. Ensure very limited number of peak concentrations
3. Avoid mixing in HOT spots as these can have huge effect on final average concentration



Conceptual Site Model (CSM v3.0)

after hotspot removal

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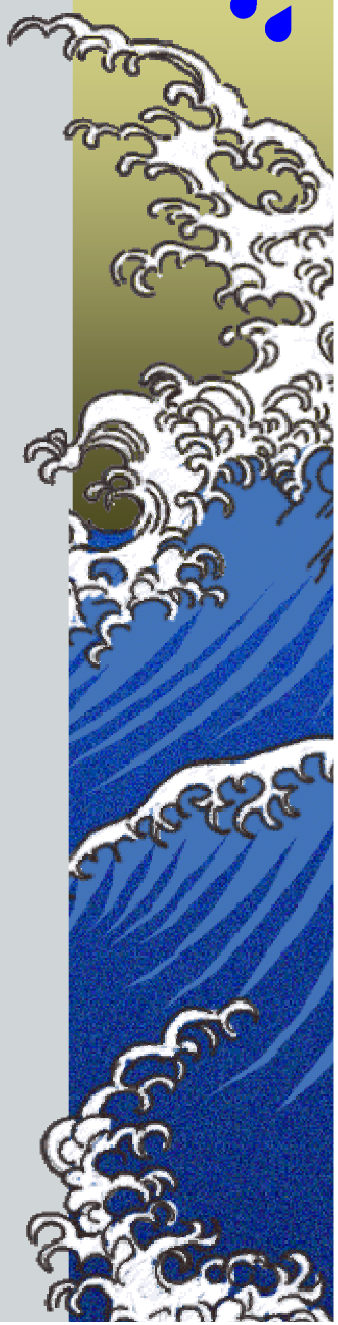

Validation

Combine
- field and
- laboratory analysis

Re-sample:
- Every lot
- Berms
- Reserves

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Triad Approach: Conclusions

- *A conceptual site model (CSM)evolves throughout all stages of the project*
- *Quality control (Lab) is important, however emphasis depends on project stage*
- *Field analysis increases representativeness and counters the variability in the sample*
- *Laboratory analysis manages analytical uncertainty: important during assessment and validation*

Questions ?

Calibration unit Bioremediation

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