

Development of a Reduced Analytical Suite of Upstream Oilfield Metals for Groundwater Monitoring

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Funding Acknowledgements

- PTAC/AUPRF 2013 Funding

Objective

- Routine groundwater monitoring at upstream sites: do we need to monitor all T1 metals?
- Rationale for which metals are likely to be associated with drilling and production.

Scope

- “Standard” upstream oil and gas wellsites
- Not large facilities (gas plants etc)
- Not thermal facilities
- Not facilities with specific issues of metals concerns

Tier 1 Groundwater Guidelines

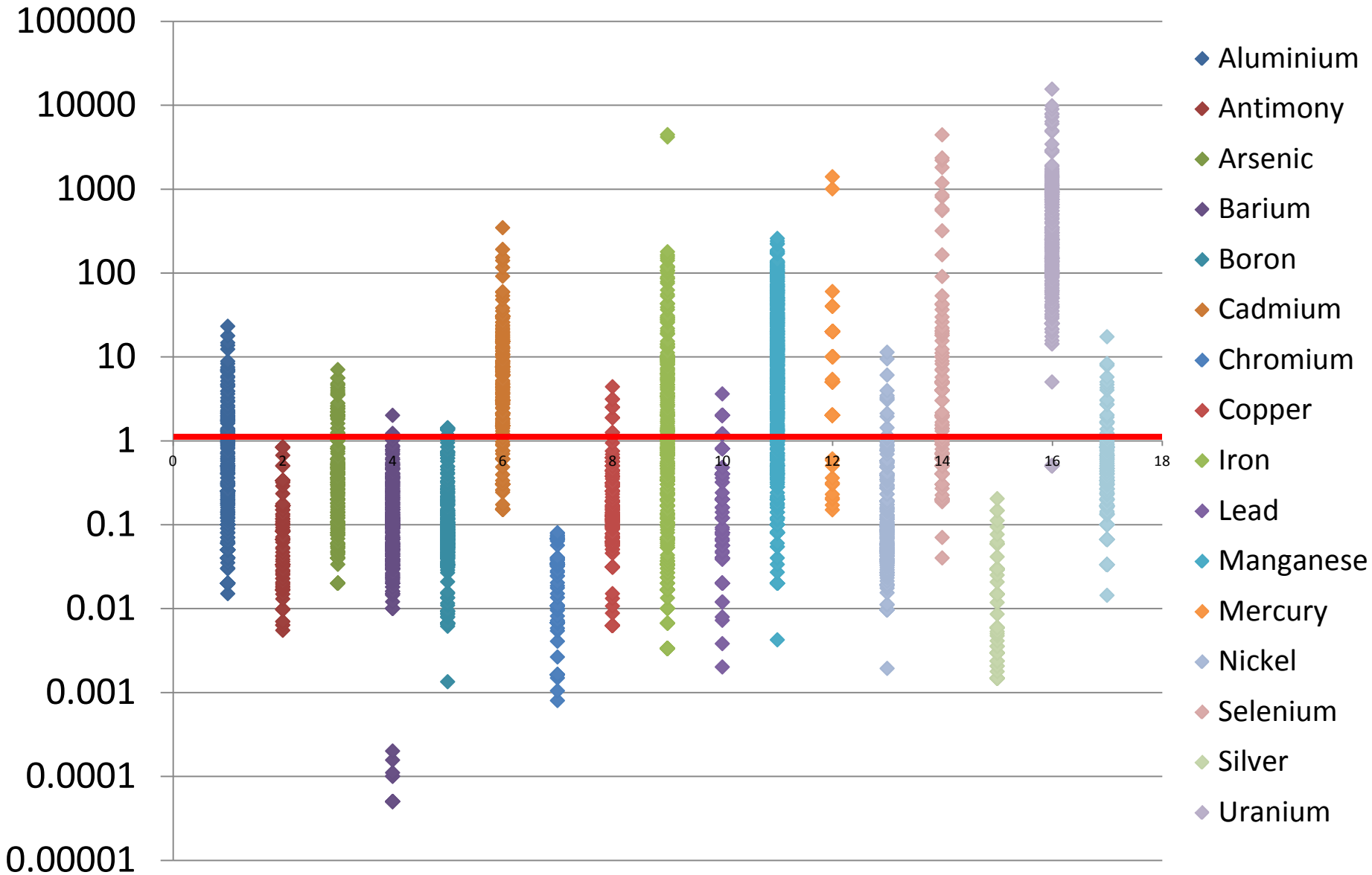
Metal	Guideline (mg/L)	Metal	Guideline (mg/L)
Aluminium	0.1	Lead	0.0025
Antimony	0.006	Manganese	0.05
Arsenic	0.005	Mercury	0.000005
Barium	1	Nickel	0.052
Boron	1.5	Selenium	0.001
Cadmium	0.000033	Silver	0.0034
Chromium	0.074	Uranium	0.02
Copper	0.016	Zinc	0.03
Iron	0.3		

Considerations

- Background concentrations for context
- Anaerobic biodegradation
- Drilling mud components
- Formation waters/produced water

Background Groundwater Metals

Relative to Tier 1



Anaerobic Biodegradation

- Iron and Manganese
 - Released during anaerobic biodegradation
 - Should be included

Drilling Mud Components

- Methodology:
 - Metals analysis for 314 mud components
 - Marquis Alliance
 - Compare:
 - Highest metal concentration with
 - Tier 1 soil remediation guideline
 - Screen based on ratio:
 - <1 – no concern
 - 1-10 – investigate more closely
 - >10 – should be included

Drilling Mud Tier 1 Ratios

Metal	Ratio	Metal	Ratio
Zinc	2,800	Antimony	3.2
Boron	970	Lead	1.5
Nickel	930	Silver	0.6
Copper	240	Uranium	0.4
Barium	26	Mercury	0.3
Chromium	21	Aluminium	No data
Selenium	16	Iron	No data
Cadmium	6.7	Manganese	No data
Arsenic	5.7		

“Ratio” is the maximum concentration in any drill mud component / Tier 1 soil remediation guideline

Mud Products With Highest Metals Concentrations

Metal	Product Type	Metal	Product Type
Zinc	Sulphide scavenger	Antimony	Lost circulation additive
Boron	Deflocculant	Lead	Drilling System
Nickel	Deflocculant	Silver	-
Copper	Deflocculant	Uranium	-
Barium	Weighting agent	Mercury	-
Chromium	Mica	Aluminium	No data
Selenium	Impurity in KCl	Iron	No data
Cadmium	Deflocculant	Manganese	No data
Arsenic	Lost circulation additive		

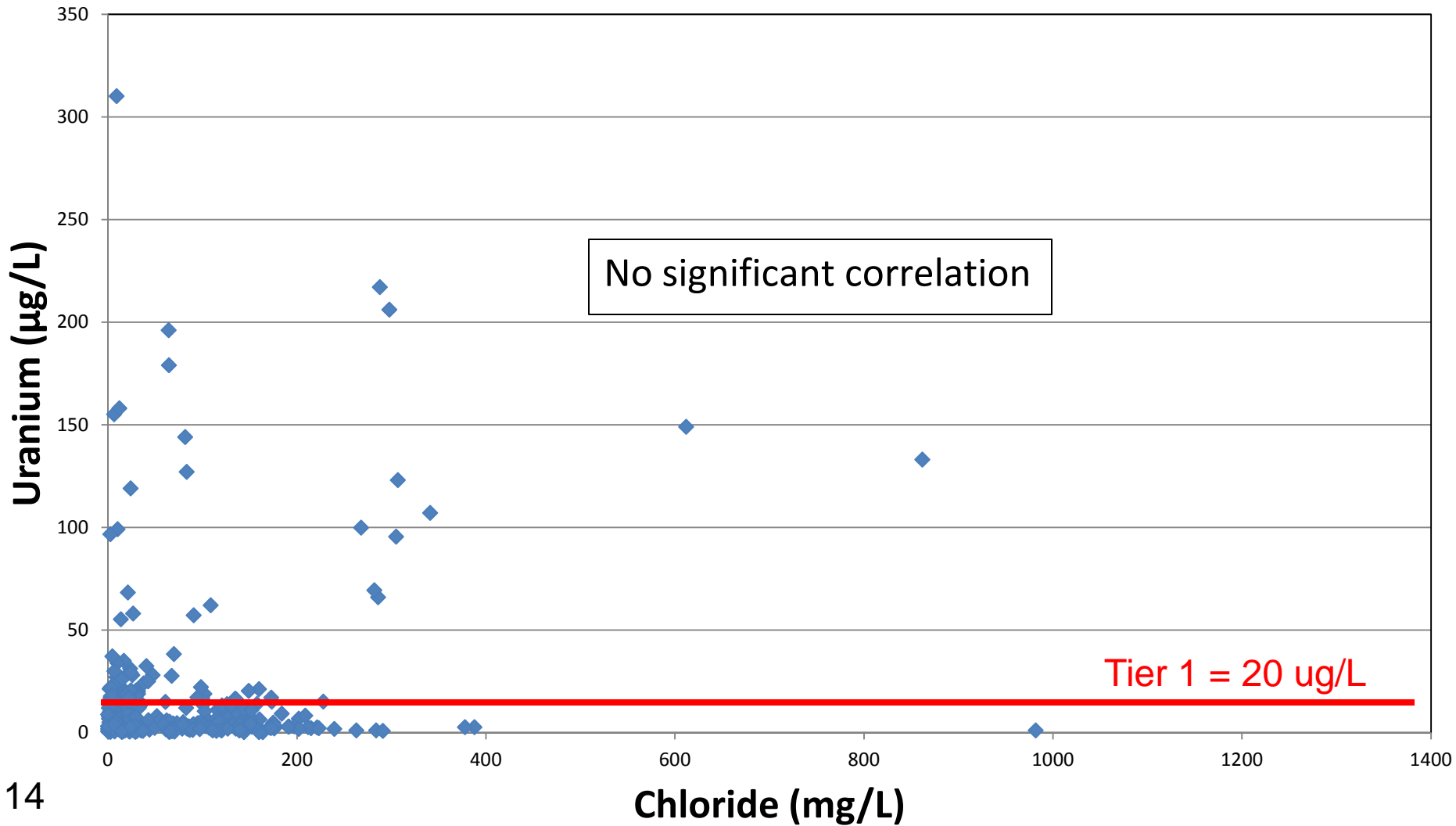
Drilling Mud - Conclusions

- Ag, U, Hg: not present in significant concs
- Cd, As, Sb, Pb: not a concern:
 - Highest concentration in a drill product <10x Tier 1
 - That product would only be used <10% of mud
- Zn, B, Ni, Cu, Ba, Cr, Se: potentially present in drill mud at significant concentrations
 - >10x Tier 1 soil concentration

Produced Water

- Formation water analysis?
- Groundwater data-mining approach:
 - Correlation between chloride and metal
 - Semi-quantitative approach on large database
 - Using chloride as tracer of produced water
 - Data with other contamination excluded

Example: Uranium vs. Chloride



Groundwater Impact from Produced Water?

Metal	Impact from PW?	Metal	Impact from PW?
Aluminium	No	Lead	No
Antimony	No	Manganese	No
Arsenic	No	Mercury	No
Barium	Possible	Nickel	No
Boron	No	Selenium	No
Cadmium	No	Silver	No
Chromium	No	Uranium	No
Copper	No	Zinc	No
Iron	No		

Recommended Metals to Sample in Groundwater at Upstream Wellsites

Metal	Rationale
Barium	Drilling Mud
Boron	Drilling Mud
Chromium	Drilling Mud
Copper	Drilling Mud
Iron	Biodegradation
Manganese	Biodegradation
Nickel	Drilling Mud
Selenium	Drilling Mud
Zinc	Drilling Mud

Tier 1 Groundwater Metals Unlikely at Upstream Wellsites

Metal	Rationale
Aluminium	Major component of Natural Soil
Antimony	Limited Maximum Conc. in Drill Mud
Arsenic	Limited Maximum Conc. in Drill Mud
Cadmium	Limited Maximum Conc. in Drill Mud
Lead	Limited Maximum Conc. in Drill Mud
Mercury	Low Concentration in Drill Mud
Silver	Low Concentration in Drill Mud
Uranium	Low Concentration in Drill Mud