Uranium in aquatic sediments; where are the guidelines ?

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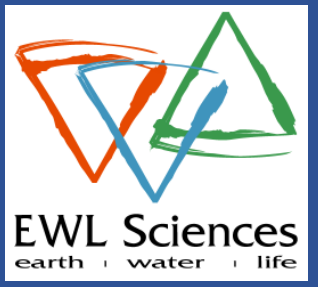


ERA

URAM 2009

IAEA

International symposium on uranium raw material for the nuclear fuel cycle

22 – 26 June 2009

Vienna, Austria

RIO TINTO

Overview

Sediment quality guidelines (U as toxicant)

- Framework approach
- Lack of U sediment quality guidelines

Biological effects data

- Approach
- Available Data
- Cost & Reality

Ranger uranium mine

- Planning for closure
- Sediment quality data

Conclusions/questions

- Global situation?
- Way forward?

Sediment quality framework – 1

< ISQG Low

> ISQG High

Total metals analysis
Grain size analysis

Below trigger value → Low risk

Between trigger value and upper guideline → Acid soluble metals analysis

Above upper guideline → Acid soluble metals analysis

Acid soluble metals analysis

Below trigger value → Low risk

Above upper guideline → Check against background concentrations

Check against background concentrations

Below trigger value → Low risk

Above trigger value → Examine factors controlling bioavailability
Acid volatile sulfides, pore waters, speciation

Examine factors controlling bioavailability
Acid volatile sulfides, pore waters, speciation

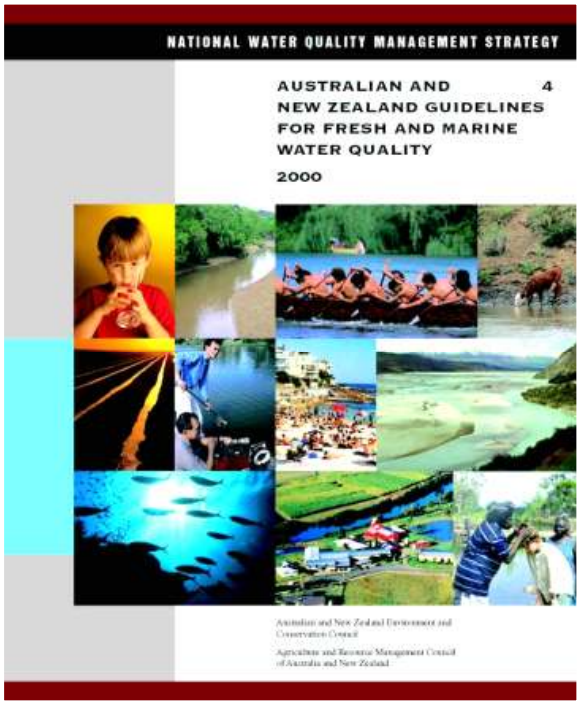
Below trigger value → Low risk

Above trigger value → Toxicity testing

Toxicity testing

Non-toxic → Low risk

Toxic → High risk



ISQG

based on NOAA 1999 ERL & ERM values

Screening level guidelines

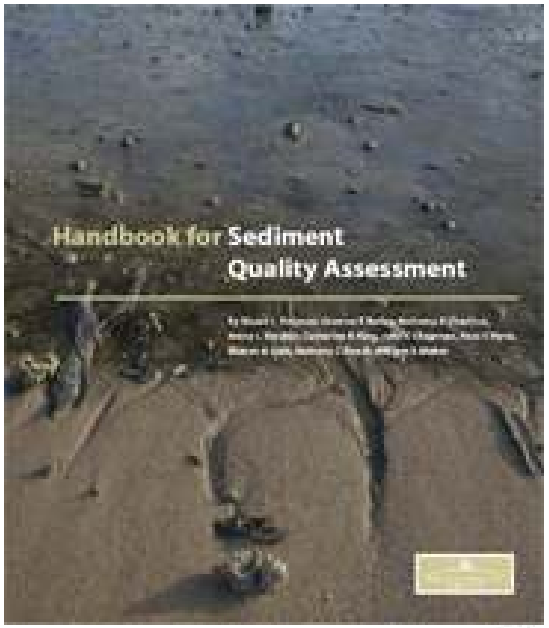
Table A1. Recommended sediment quality guidelines (ANZECC/ARMCANZ 2000)

Contaminant	ISQG-low (Trigger value)	ISQG-high
METALS (mg/kg dry wt)		
Antimony	2	25
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Mercury	0.15	1
Nickel	21	52
Silver	1	3.7
Zinc	200	410

No uranium guideline

Predicted No Effect Concentration 100 mg/kg Sheppard et al 2005
Canadian temperate species (Thompson et al 2002)

Sediment quality framework – 2



- Multiple lines of evidence (biological & chemical)
- Weight of evidence
  - qualitative (professional judgement)
  - semi-quantitative (ranking, scoring)
  - quantitative (statistical)

Resource intensive toxicity methods

Scientific debate over methods

Only do if [x] > SQG high

Site	Sediment Chemistry PAH-PCB-metal	Porewater Chemistry, TBT	AVS/ SEM	10-d Amphipod Survival - Avoidance	48-h Bivalve-Larvae Survival	20-d Polychaete Survival - Growth	Benthic Community Structure Abundance-diversity	Overall Assessment[a] Abs. risk	Overall Assessment[a] Rel. risk
Near-field sites									
1	2-1-2	1	2	2-1	1-1	1-2	3-3	3	3
2	1-1-3	1	1	1-1	2-3	1-1	ND	2	2
3	3-1-2	1	1	1-1	3-2	1-2	2-1	3	3
4	2-1-2	1	1	2-1	1-3	1-2	2-1	3	3
5	2-2-2	1	1	1-1	3-3	1-1	2-1	2	2
6	2-1-2	1	1	1-1	1-1	1-1	3-1	2	1
Far-field sites									
7	2-1-2	1	1	1-1	1-1	1-1	2-2	2	NA
8	1-1-2	ND	1	2-1	1-1	1-1	3-1	2	NA
9	2-1-2	1	1	1-1	1-1	1-1	1-1	1	NA

Biological effects data

Exposure pathways - which species?

Methods

- Chemical based models
- Species diversity/abundance across concentration gradient
  - Co-contaminants
- Transplants
  - Edge effects, solubility changes
- Spiked sediments
  - Compartmentalisation, controls
- Bioaccumulation / magnification
- Integr Environ Assess Manag. 2007 Jan ;3 (1): *Predicting metal toxicity in sediments: a critique of current approach*. Stuart L Simpson, Graeme E Batley

Resource intensive, Strict protocols

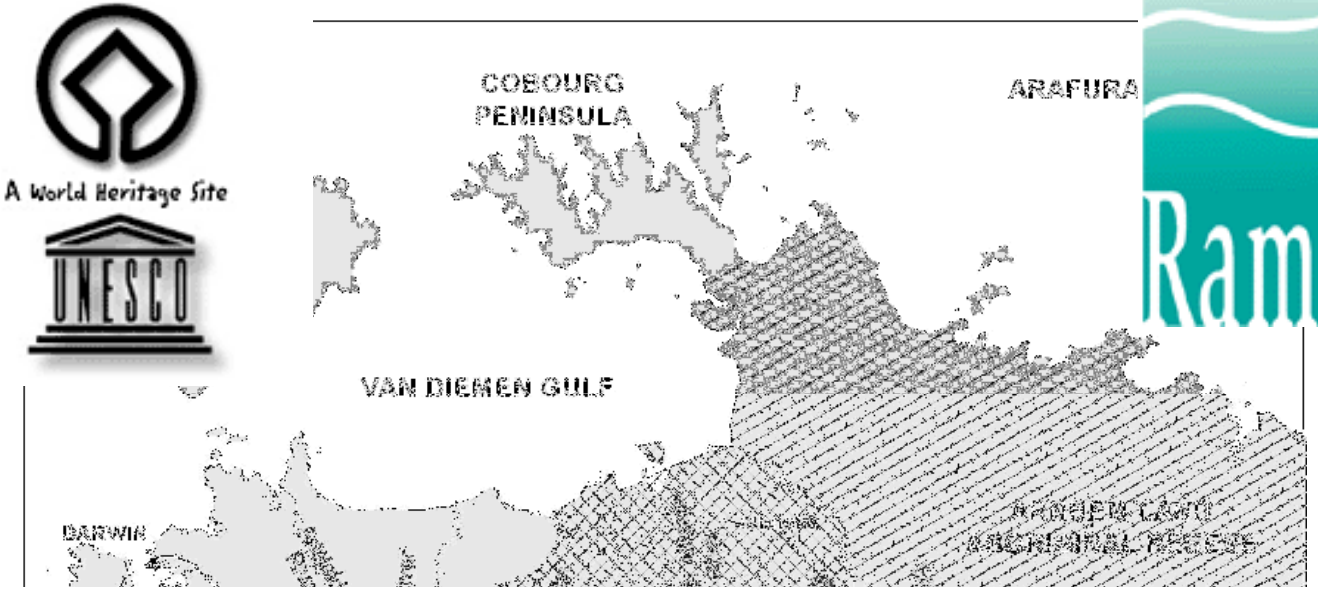
Broad understanding of limitations ?

Ranger Uranium Mine

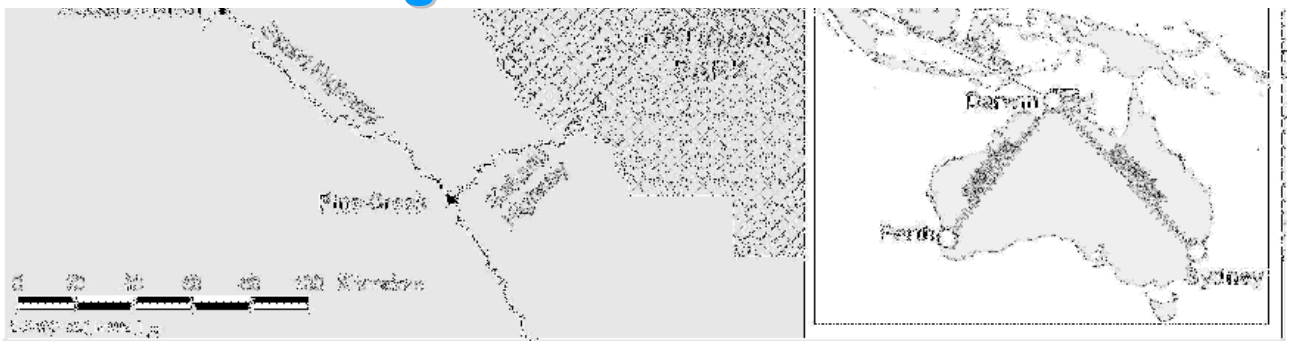
A World Heritage Site

UNESCO

Ramsar



ERA respectfully acknowledges the Mirarr, Traditional Owners of the land on which the Ranger Mine is situated.



Closure planning

Environmental Requirements

- Incorporate into Kakadu National Park
- Traditional owners

Criteria

- Land use & Radiation
- Ecosystems
- Water quality (sediments)

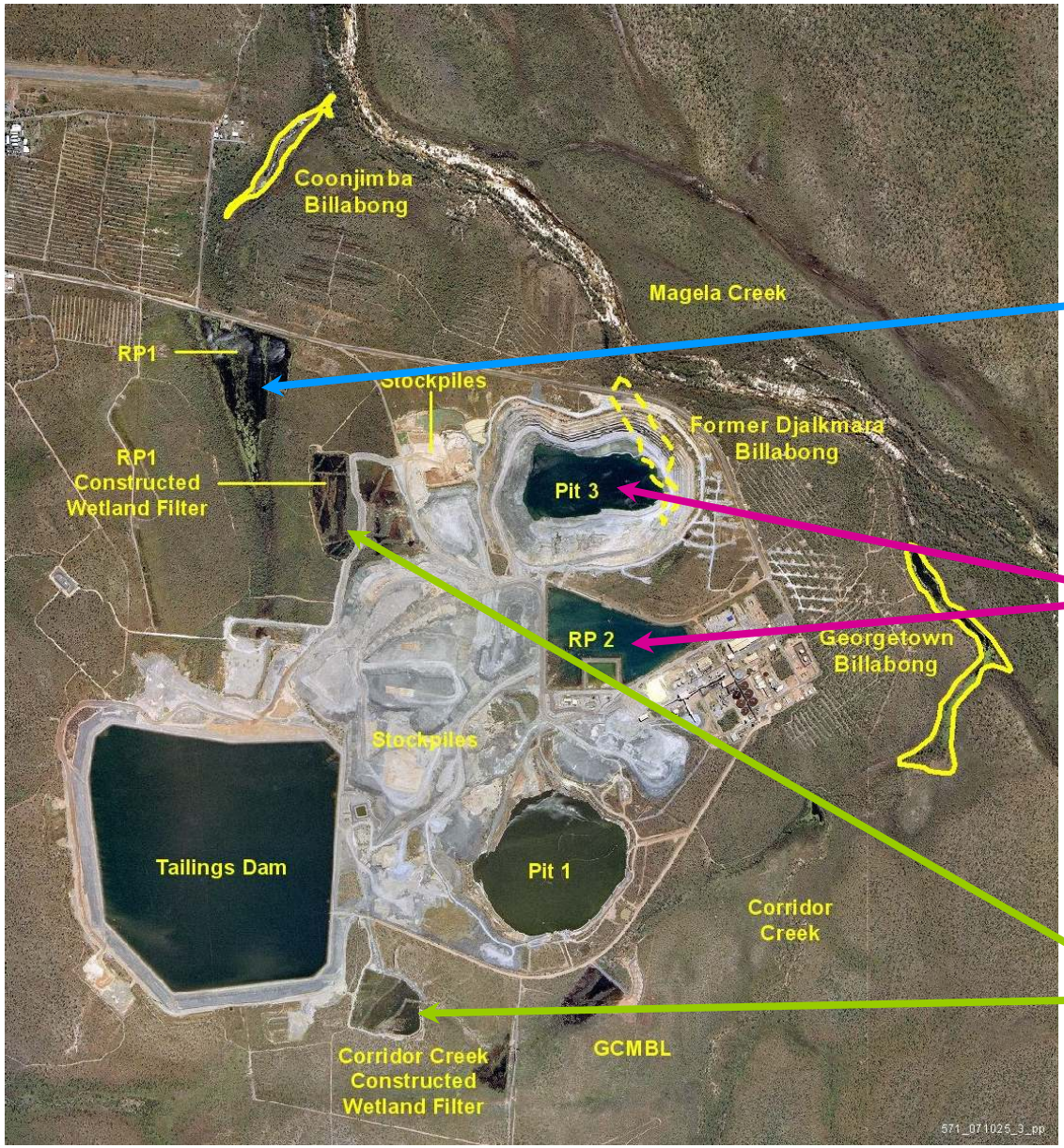
Radiation criteria

- Well established dose assessment practices and limits
- UNSCEAR, ICRP, IAEA, National bodies (ARPANSA)

Sediment toxicity ?

- *…low specific activity, uranium … has greater potential to cause chemical rather than radiological toxicity*
- *Methods problematic*

Waterbodies – operational phase



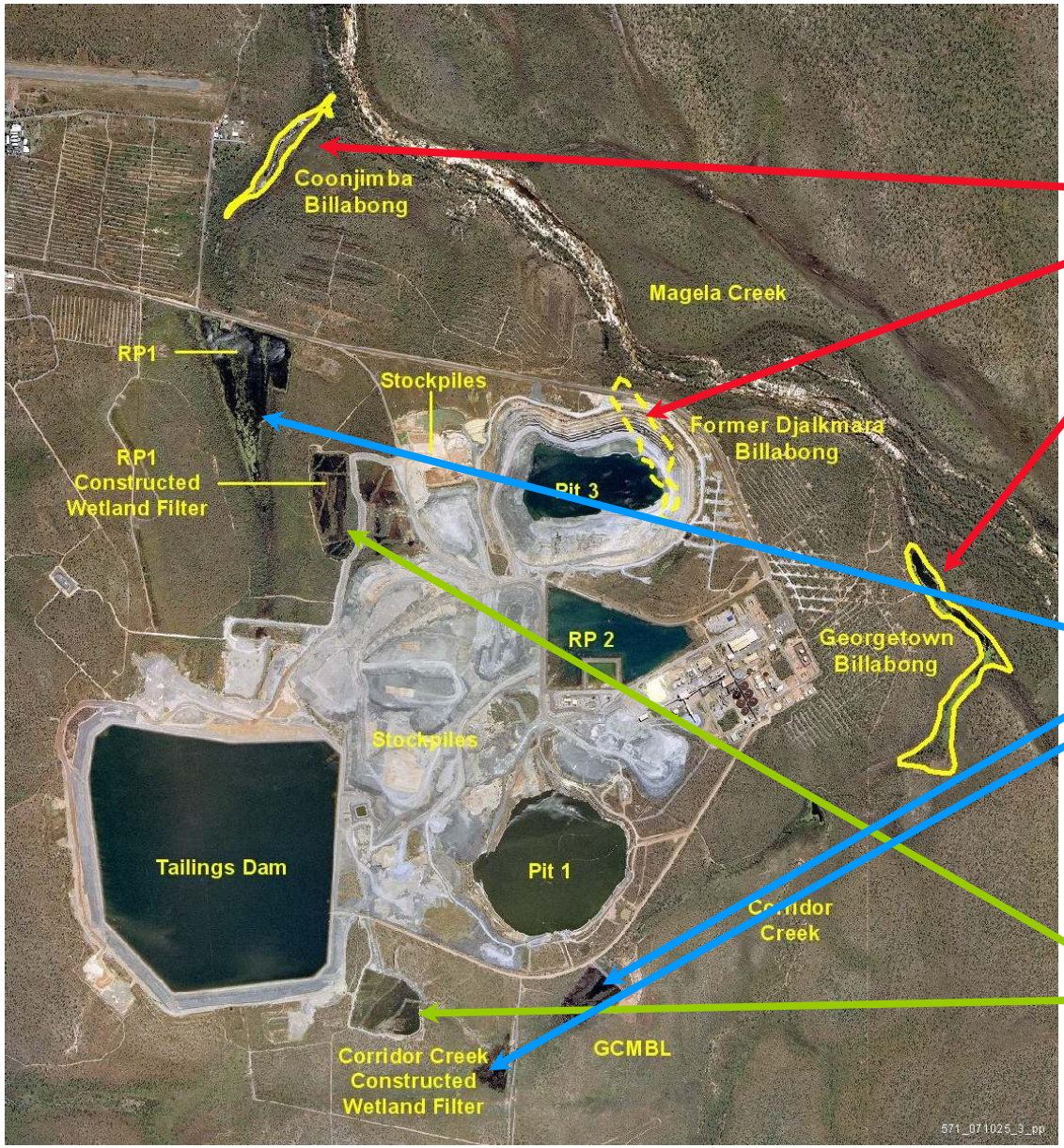
Passive release waters

Pond waters – treat & release

Constructed wetland filters

Biopolish U

Waterbodies – closure planning



Retain/reinstate billabongs

Reinstate creek line

Remove wetland filters




Sediment data

Spatial

- Onsite
- Off-site; control billabongs, Magela floodplain

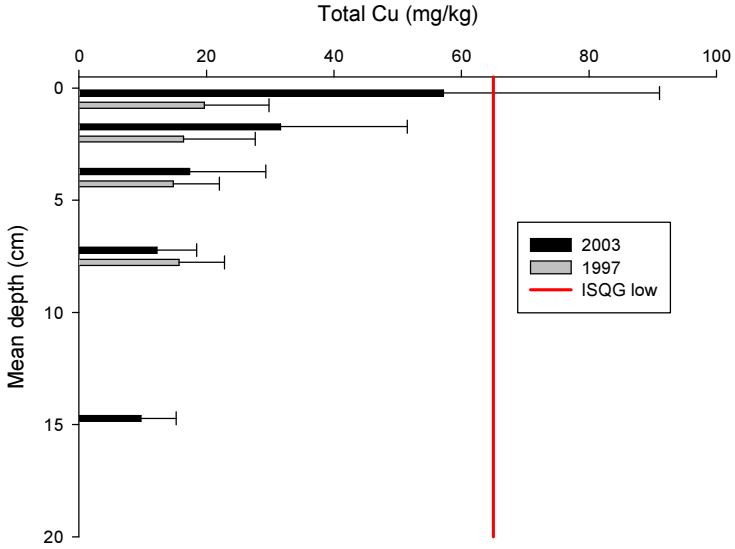
Temporal

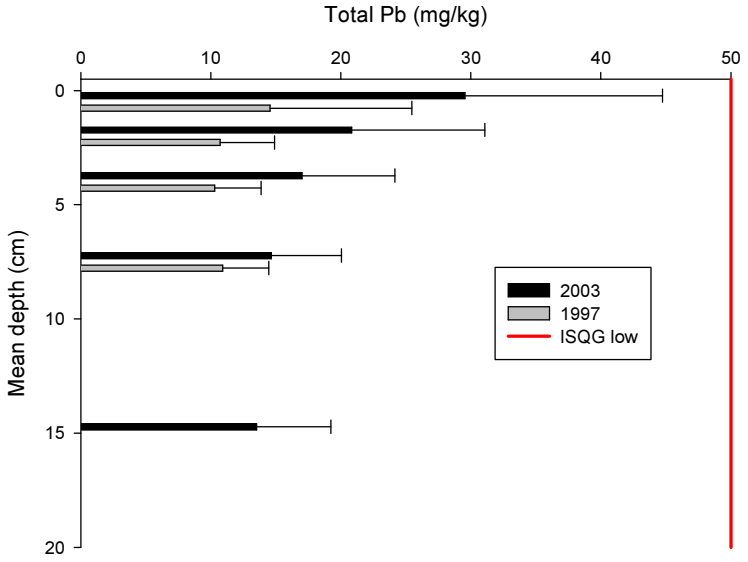
- Baseline
- >25 years specific research
  - phase associations, leachability, bioaccumulation, trophic transfer, attenuation capacity
- 20 years statutory prescribed monitoring
- Now project based monitoring

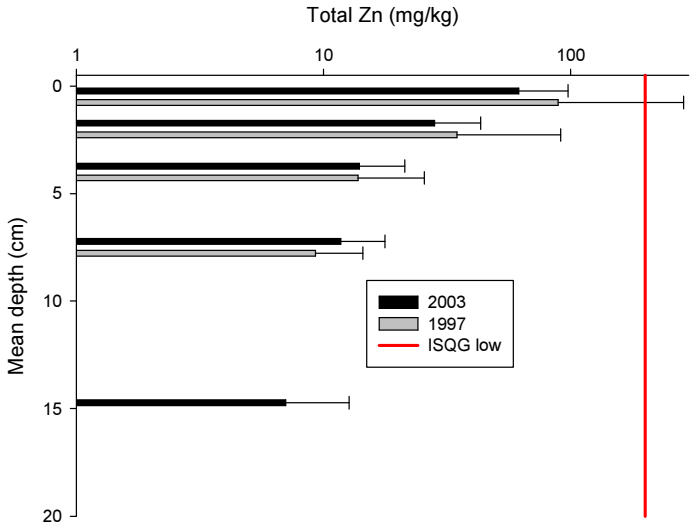
Methods

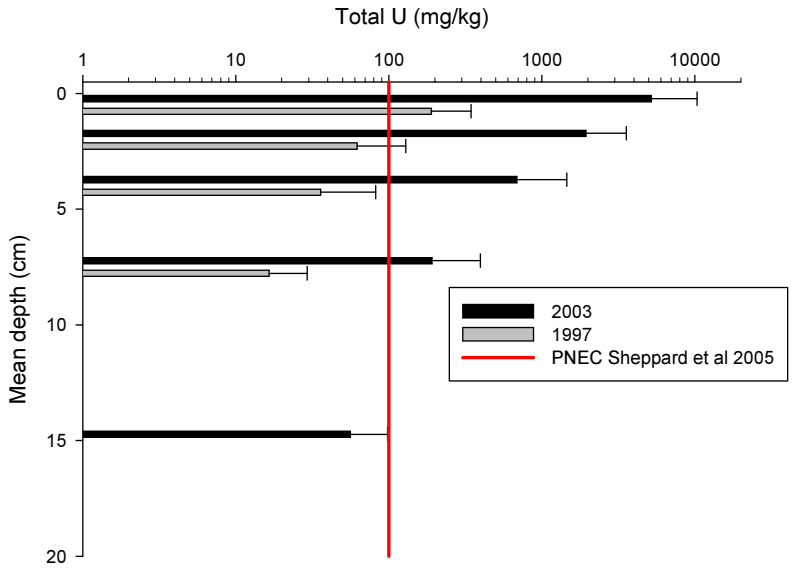
- Specific to research question in past
- Compatibility
- *Interpretation wrt "contaminated site" status*

Results – wetland filter

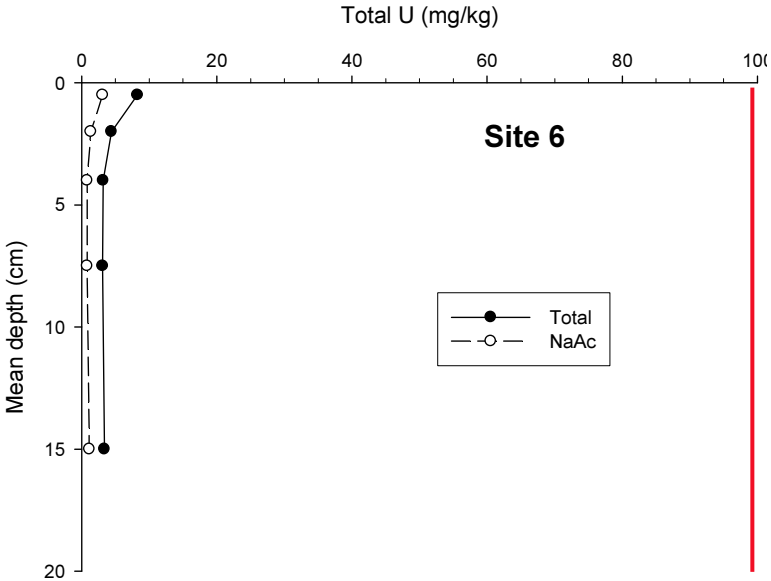


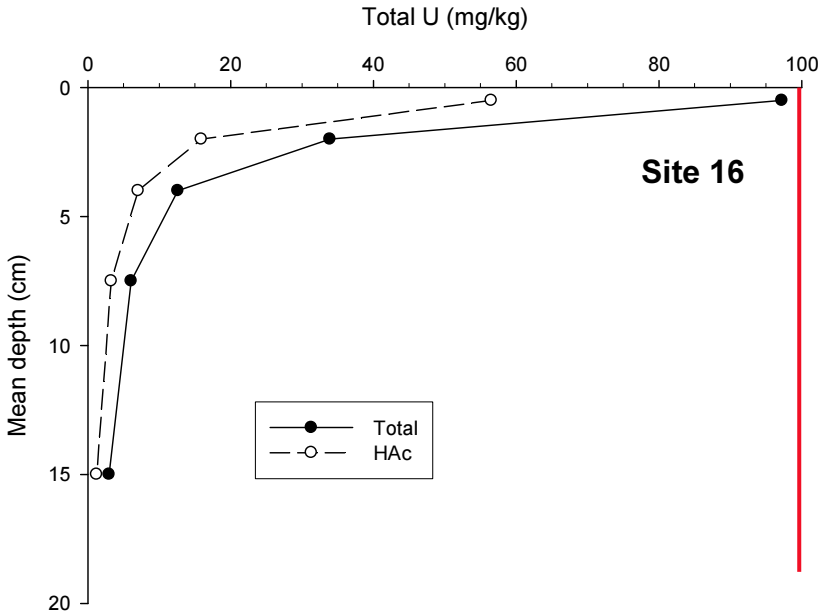


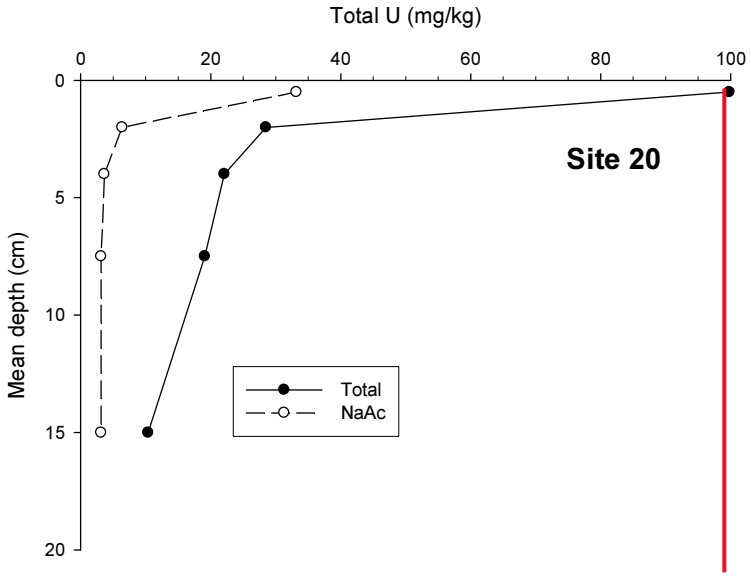




Results – retention pond







Variation across pond

Well below or at temperate PNEC value

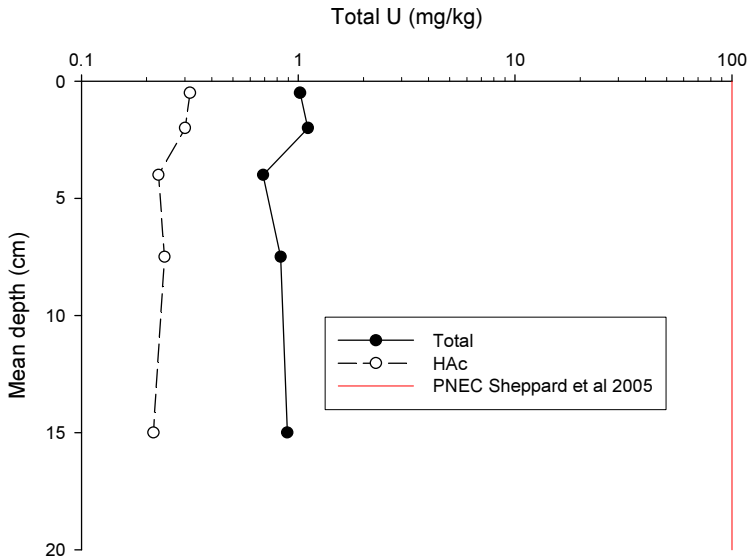
Change with depth

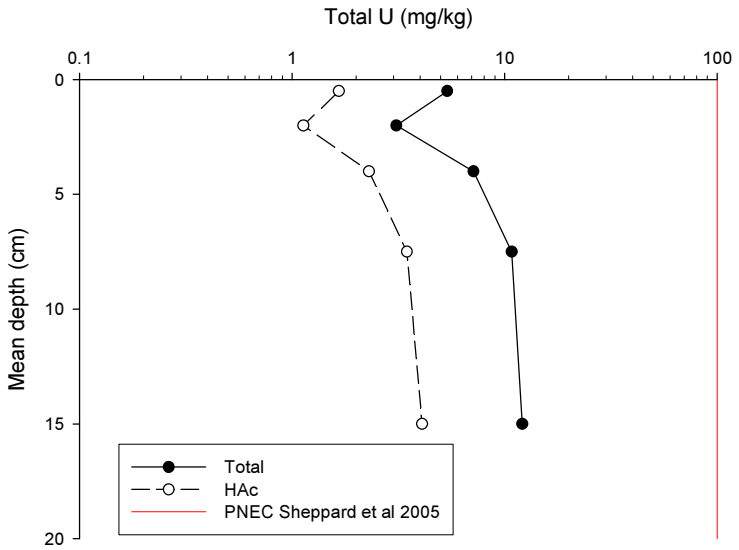
Variable availability

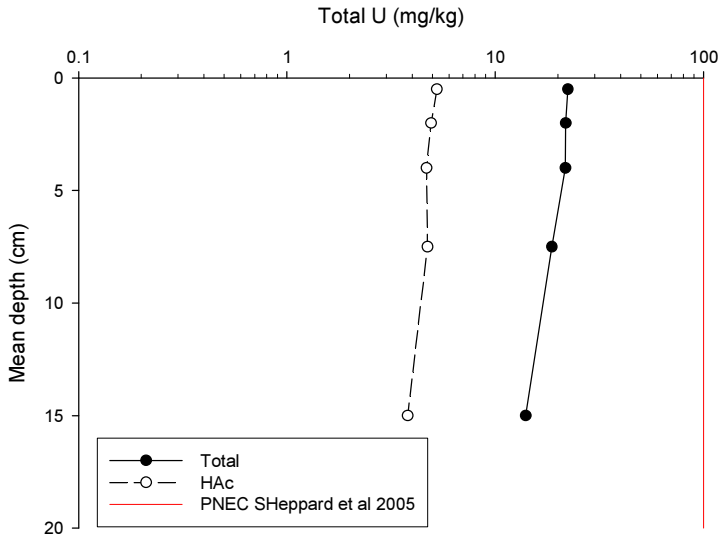
Creek line to be re-established

Cost of full scraping vs deriving site-specific SQG

Results – natural billabong







All well below temperate PNEC value

Surface & depth similar

Benthic community changes non-mining related

Spatial characterisation upstream creek-line planned

Issues, Lessons,

Lack of sediment characterisation accompanying past biological studies

- Cause – effect related to particular character

Standard basic suite of methods all studies regardless of aim

- Pore water, TOC, particle size, leachates

Lack of relevant/reliable toxicity data

- PNEC for temperate species
- Only 1 U *range finder* test on local species (Cu study)

Issues, Lessons, Further work

Lack of sediment characterisation accompanying past biological studies

- Cause – effect related to particular character

Standard basic suite of methods all studies regardless of aim

- Pore water, TOC, particle size, leachates

Lack of relevant/reliable toxicity data

- PNEC for temperate species
- Only 1 U *range finder* test on local species (Cu study)

Site specific guideline needed – method?

- Chemical models
- Bioaccumulation loads
- Field based sediment toxicity
- Laboratory based sediment toxicity
- Multiple lines of evidence

Global situation ?

Screening level guidelines exist for heavy metals & metalloids

- Pb, Zn, Cu, Cs, Cr, As
- Why not U ?

Distribution of biological effects data

- Most for temperate species
- Not matched to distribution of potential contamination
- # publications increasing

Implementation

- Specialist knowledge and agreed approaches
- Differing levels of regulation/scrutiny
- Regulator understanding in face of scientific debate
- Cost for junior players/developing nations to derive local SQG

Need for U guidelines to guide appropriate response

Soils situation?

Way forward

Global database ?

Review of information to derive regional screening guidelines ?

Who?

- WHO
- UNEP
- IAEA – toxic not radiological issue
- Industry coalition - global
- Facilitate or conduct

Recommendation for IAEA to request support/action from appropriate body

Thank you