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Mining in the Alligator Rivers Region, northern Australia: Assessing potential and actual effects on ecosystem and human health

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supervising scientist

Mining in the Alligator Rivers Region, northern Australia: *Assessing potential and actual effects on ecosystem and human health*

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Jabiru NT Australia

Invited Paper presented by Rick van Dam at the 9th International Congress of Toxicology (ICT-IX)
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Powerpoint slides only

(NB: a manuscript on this presentation will be prepared and published in the journal *Toxicology*)

Mining in the Alligator Rivers Region, Northern Australia:

Assessing potential and actual effects on ecosystem and human health

Rick van Dam, Chris Humphrey & Paul Martin

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Department of the Environment and Heritage

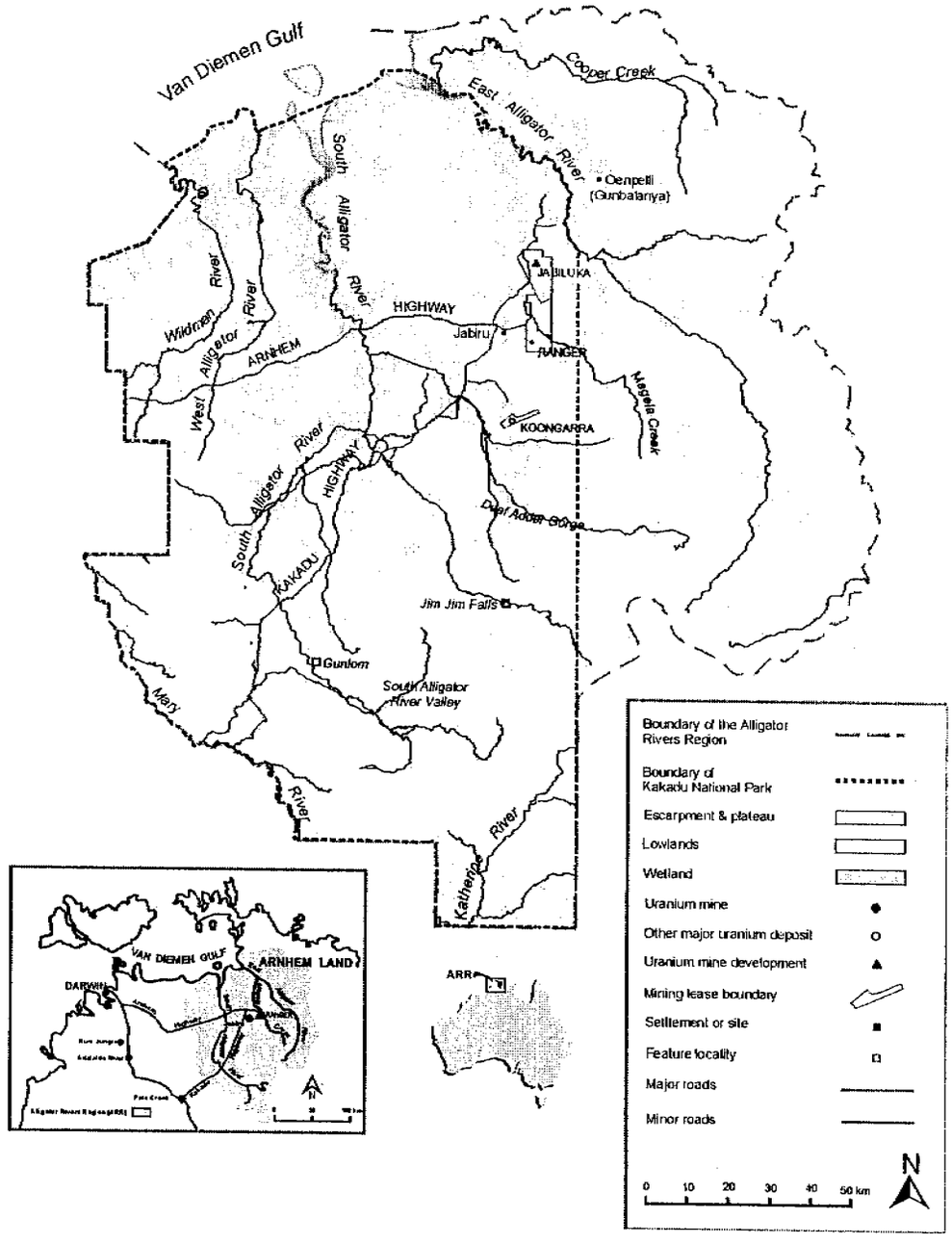
Outline

- **Background:** The ARR & Kakadu
  Mining and ERA Ranger Mine
- **Some Key Environmental Issues**
- **Environmental Protection:**
  Ecosystems
  Human Health
- **Summary**

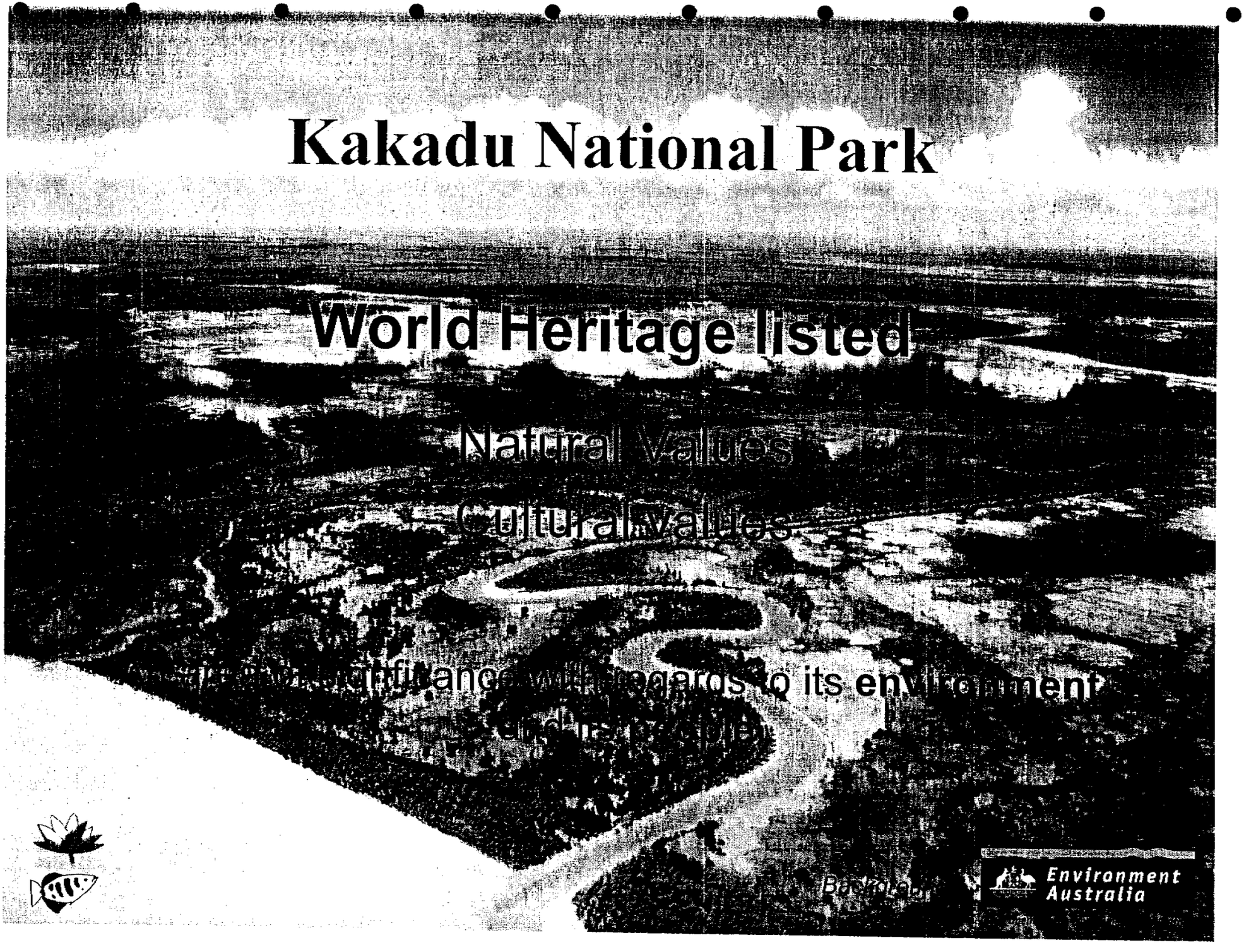
Environment Australia
Department of the Environment and Heritage

The Alligator Rivers Region (ARR) and Kakadu

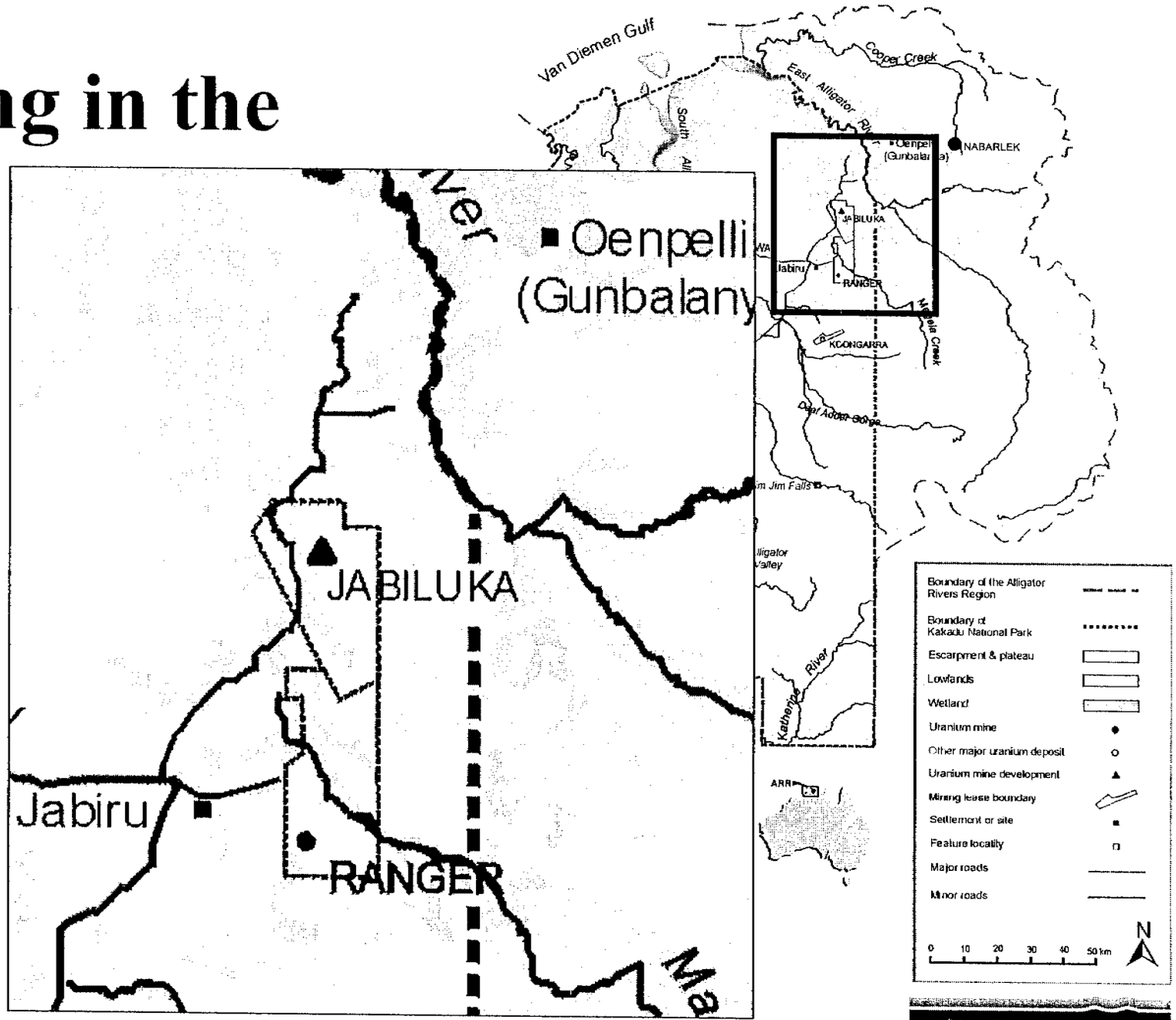
- ~30,000 km^2
- Wet-dry tropical climate
  (~1500 mm/yr rainfall: Nov-Mar)
- High conservation & ecological value
- Kakadu National Park



Environment Australia
Department of the Environment and Heritage


Kakadu National Park
World Heritage listed
Natural Values
Cultural Values
its environment
Environment Australia

Mining in the ARR



Background

Environment Australia

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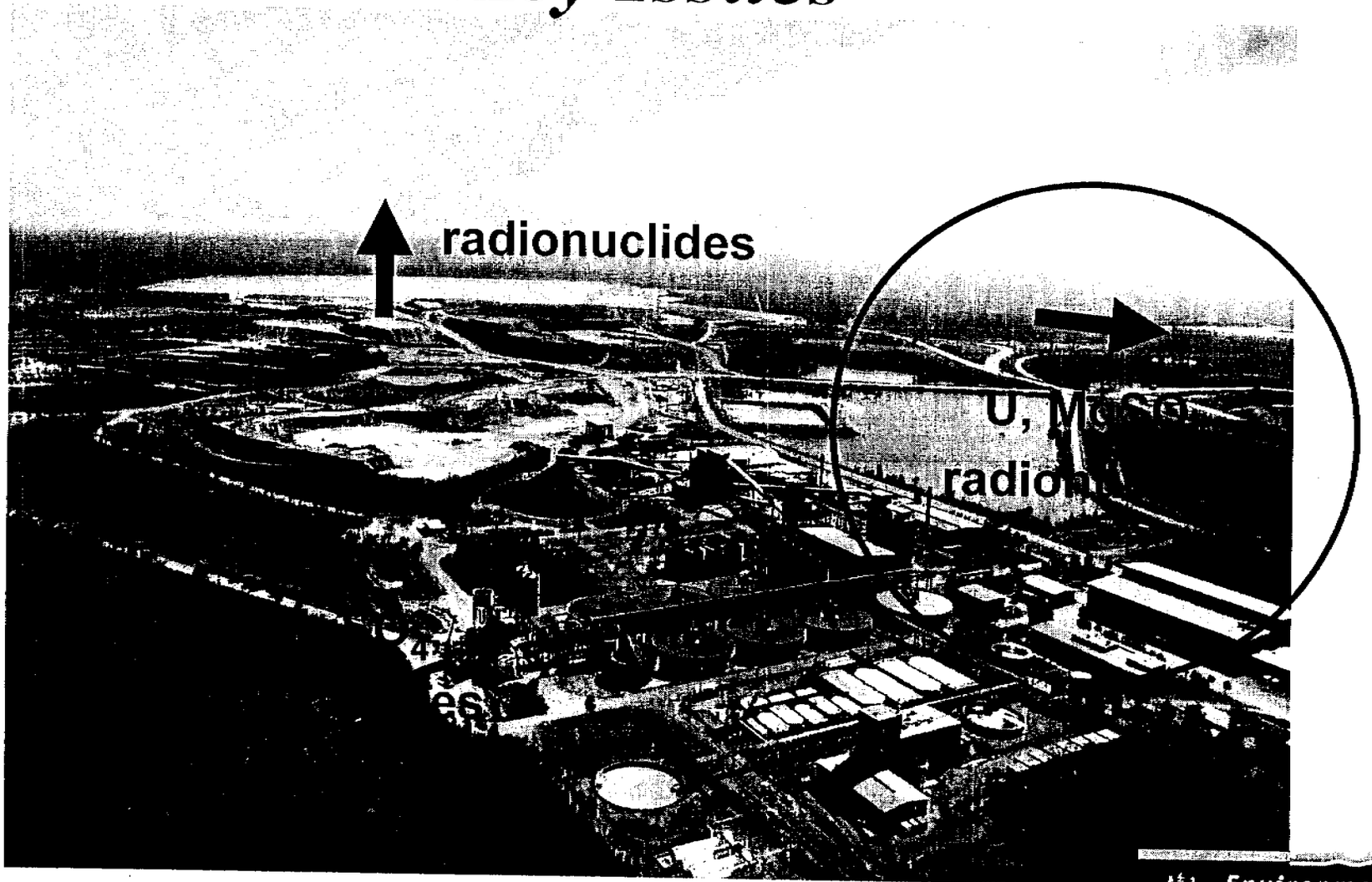
ERA Ranger Mine and Magela Ck

Key Issues



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Environmental Protection

- **Ecosystem Protection**
- Human Health Protection

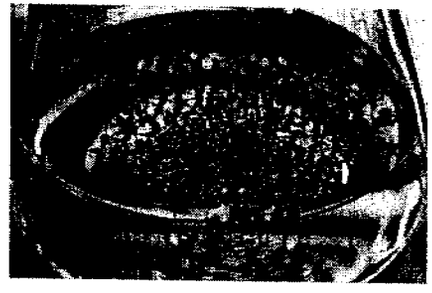
Ecosystem Protection

- Deriving toxicant trigger values/standards and wastewater release dilutions
- Early warning - *in situ* testing
- Longer-term monitoring - biological, chemical

Deriving Trigger Values & Release Dilutions

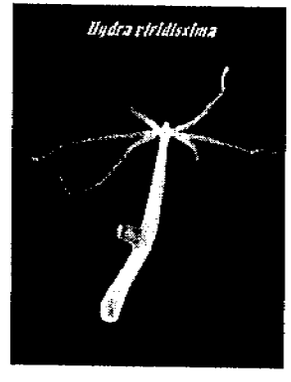
- Local aquatic species
- Uranium trigger value/standard
- Pre-release Toxicity Testing

Green alga (*Chlorella* sp.)
72 h cell density/population growth

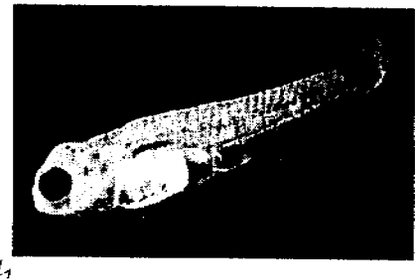


Duckweed (*Lemna aequinoctialis*)
96 h population growth

Freshwater cladoceran (*Moinodaphnia macleayi*)
3 Brood (5-6 day) reproduction



Green Hydra (*Hydra viridissima*)
96 h population growth



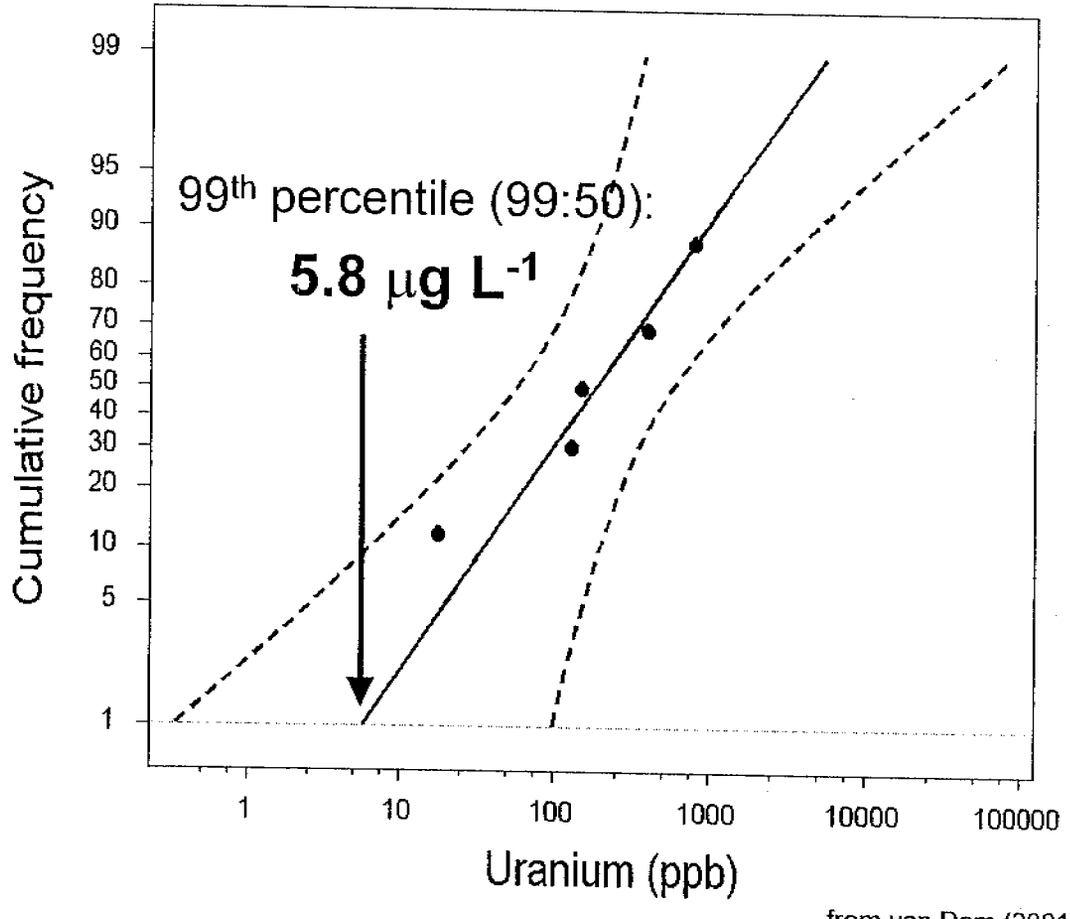
Purple-spotted gudgeon (*Mogurnda mogurnda*)
96 h sac-fry (larval) survival

Deriving Trigger Values & Release Dilutions

- Local aquatic species
- Uranium trigger value/standards
- Pre-release Toxicity Testing

U Trigger Value

- WQGs - statistical extrapolation approach (log-logistic)
- area of high conservation/ ecological value
- 99% protection level (High reliability)
- B'ground U: ~0.05 μg L^{-1}
  Drinking water g'line: 20 μg L^{-1}



from van Dam (2001)

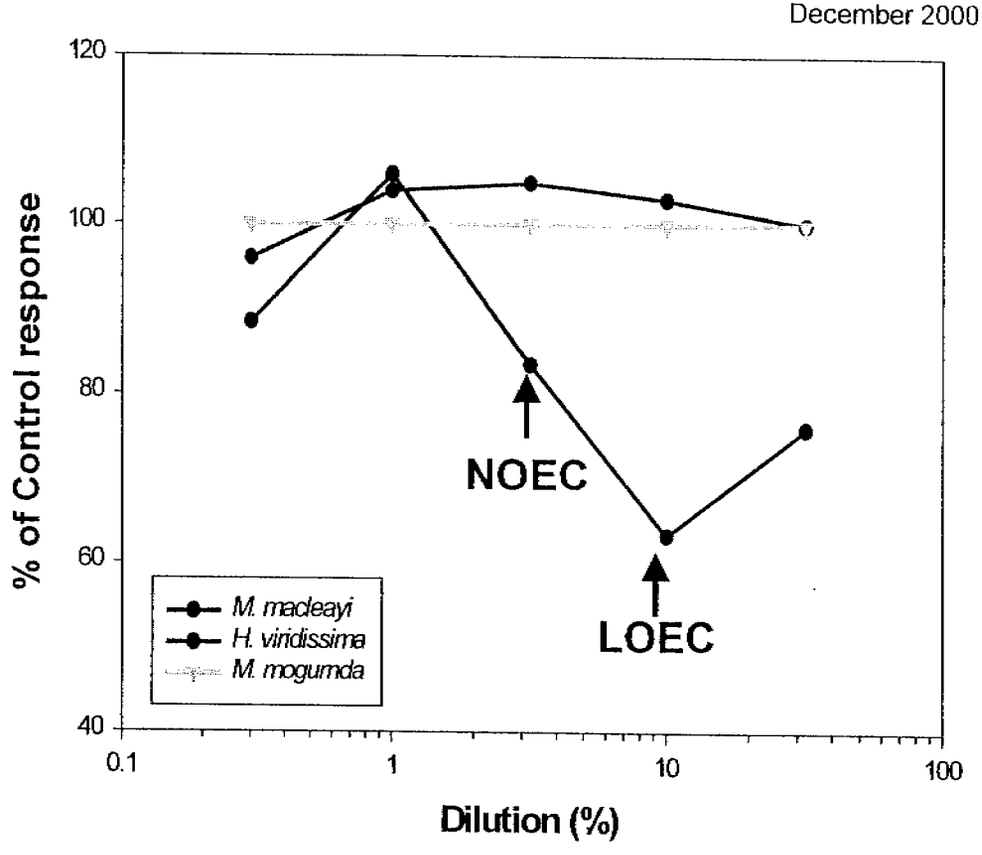
Deriving Trigger Values & Release Dilutions

- Local aquatic species
- Uranium trigger value/standard
- Pre-release Toxicity Testing

Pre-release toxicity testing - ERA Ranger Mine

- Runoff from minesite
  - pumped to Magela Ck during Wet season
- 3 species: *M. macleayi*
  H. viridissima
  M. mogurnda
- 'Safe' dilution (NOEC/10)

  3.2/10 = **0.32%**
  (~0.3 μg L^{-1} U)

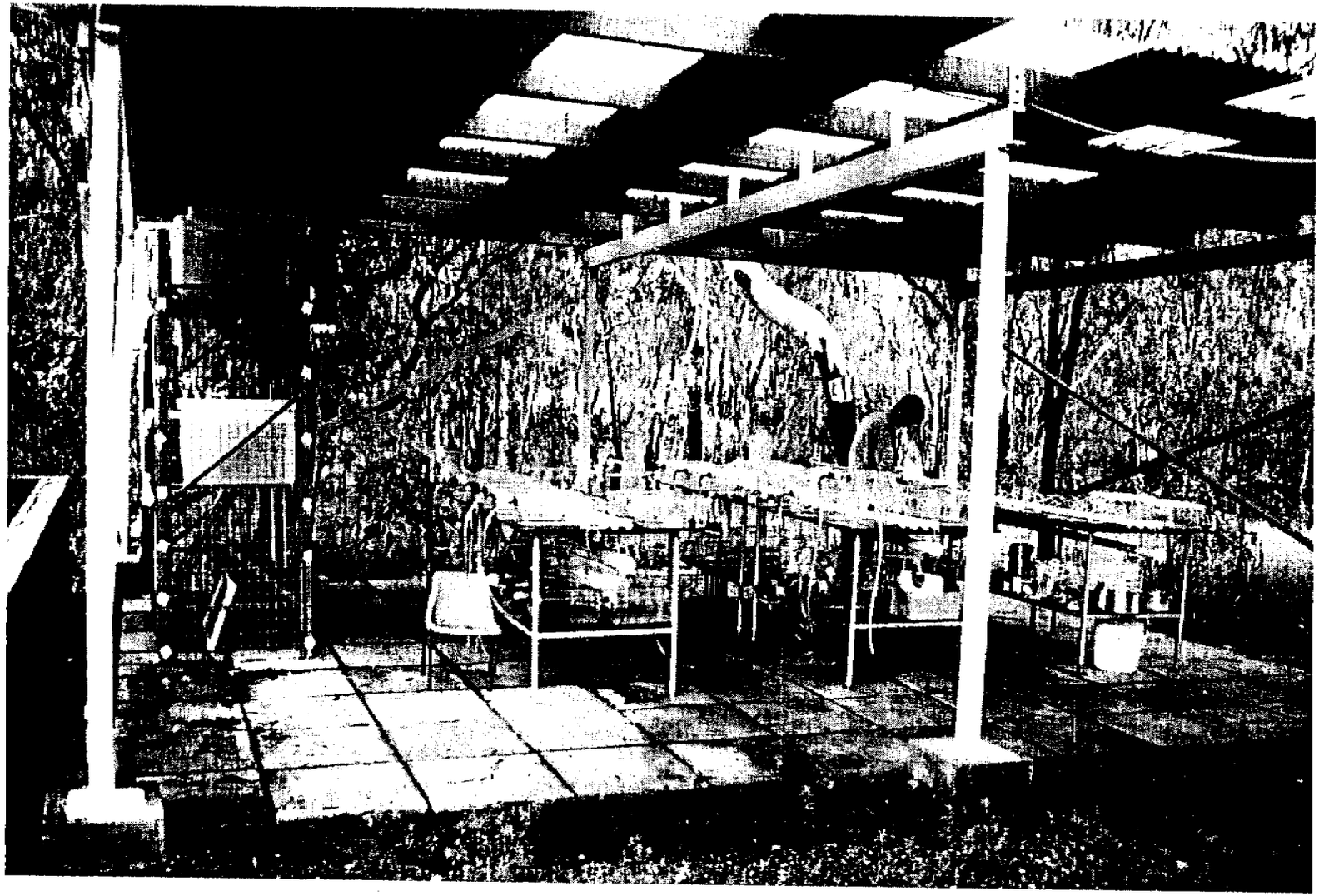


Data courtesy of ERA Ranger Mine

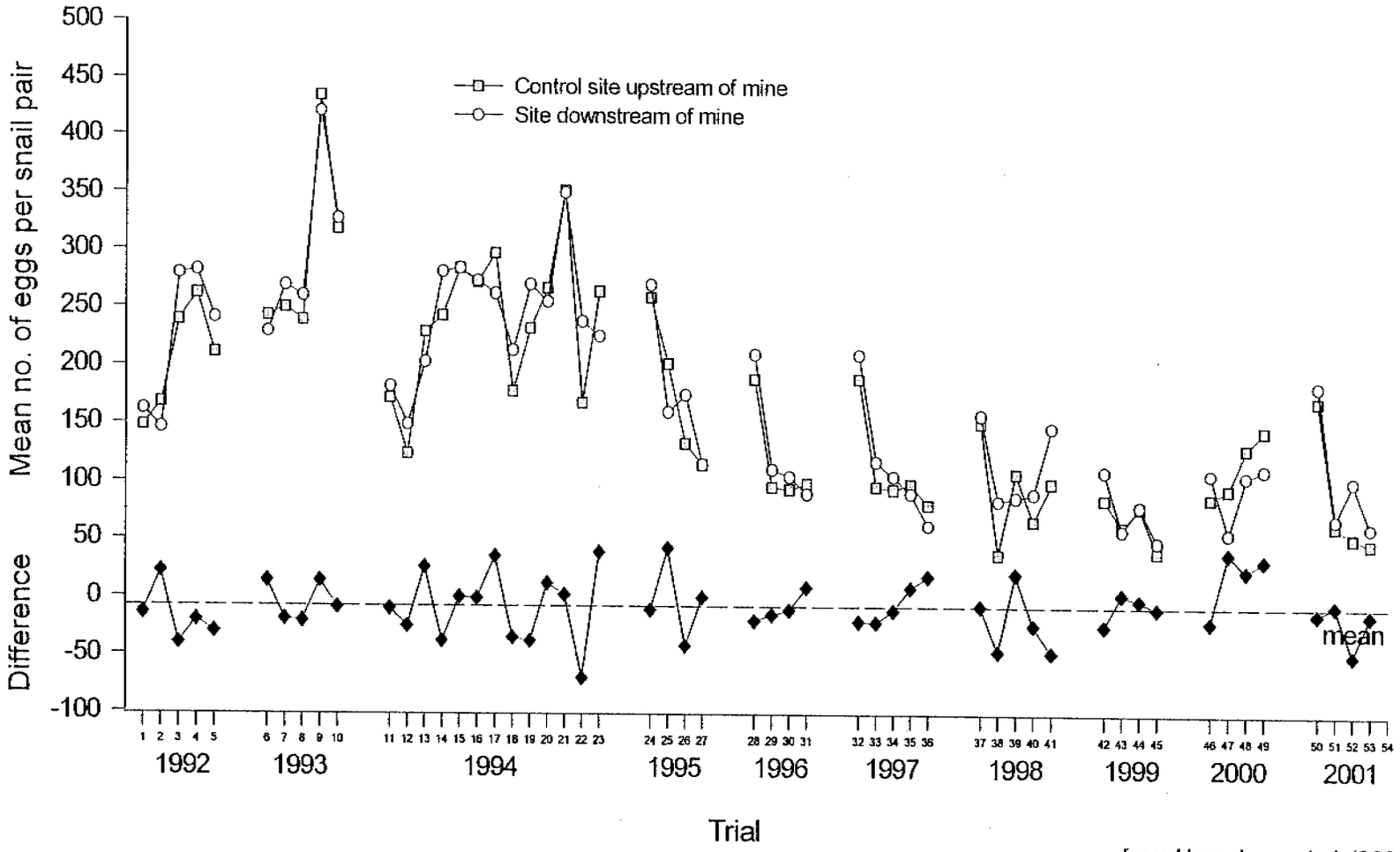
Early Warning - *in situ* Testing

- Early detection of possible adverse effects, important in area of high conservation value
- Local aquatic species
  - Black-striped rainbowfish (*Melanotaenia nigrans*)
  - Freshwater snail (*Amerianna cumingii*)
- Whole-organism responses over 4 day test duration during Wet season
- Time-series comparison of upstream versus downstream responses

in situ Testing - Creekside testing station



in situ Testing - *Amerianna cumingii* (egg production)



from Humphrey *et al.* (2001)

Longer-term Monitoring

- Macroinvertebrate community structure
- Fish community structure
- Chemical - surface water

bioaccumulation

Ecosystem protection
(fish, mussels)

Human health protection
(fish, mussels, turtle, fruits)

Environmental Protection

- Ecosystem Protection
- **Human Health Protection**

Human Health Protection

Radiological impact of mining on people

Major Pathways: Direct irradiation

Inhalation

Ingestion

bioaccumulation

Examples:

Dose prediction based on radionuclides in bushfoods

Impact assessment of past mining (South Alligator River Valley)

Radionuclides in traditional Aboriginal bushfoods

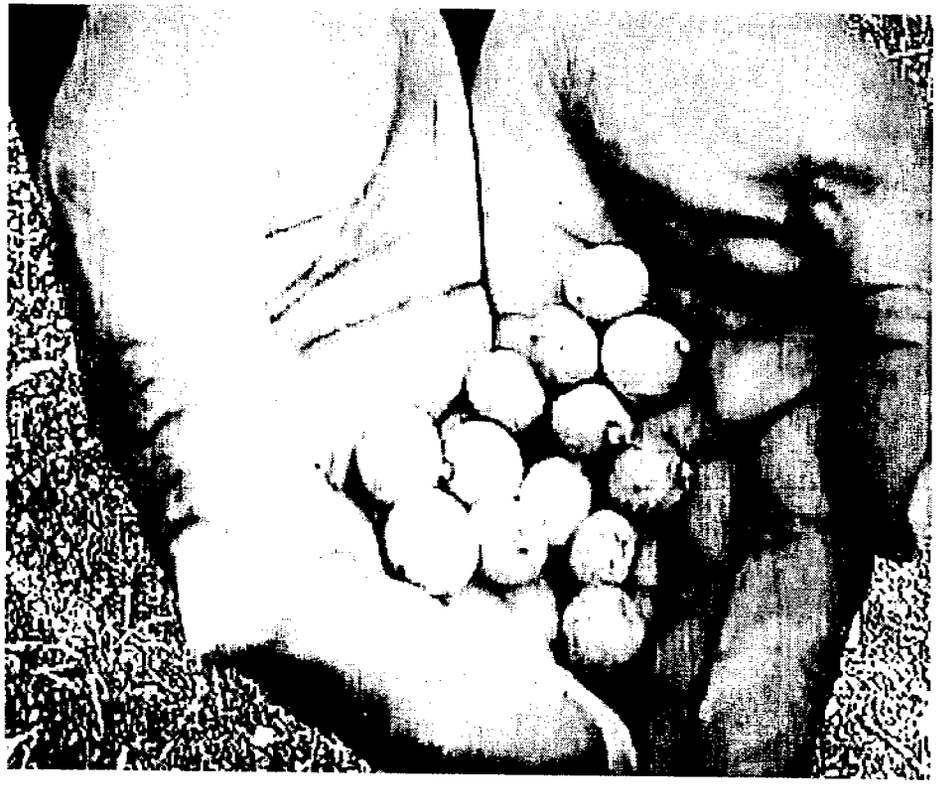
- Aboriginal people utilise >150 local flora and fauna species as food sources
- Potential radiological sources

  Aquatic: fish, freshwater crocodile, turtle, filesnake, shrimp, mussel

  Terrestrial: buffalo, pig, goanna, magpie goose, fruits, yams

- Radiological data collected and used to obtain local Concentration Factors (CFs) for prediction of dose to humans
- *Analytical methods:* alpha and gamma spectroscopy

Radionuclides in traditional Aboriginal bushfoods



Radionuclides in selected bushfoods from Magela Creek area

Bushfood	Ra-226 (Bq/kg)	CF	U-238 (Bq/kg)	CF
Green plum	17	0.06	0.6	0.003
Black plum	2	0.10	0.4	0.03
White apple	1.3	0.05	0.1	0.003
Bony bream	0.8	1200	0.2	250
Turtle - *Flesh*	0.2	250	0.01	28
Liver	1	460	0.09	180
Freshwater mussel		*19,000*		*100*

from Martin et al (1998) and Ryan & Martin (2001)

Radionuclides in traditional Aboriginal bushfoods

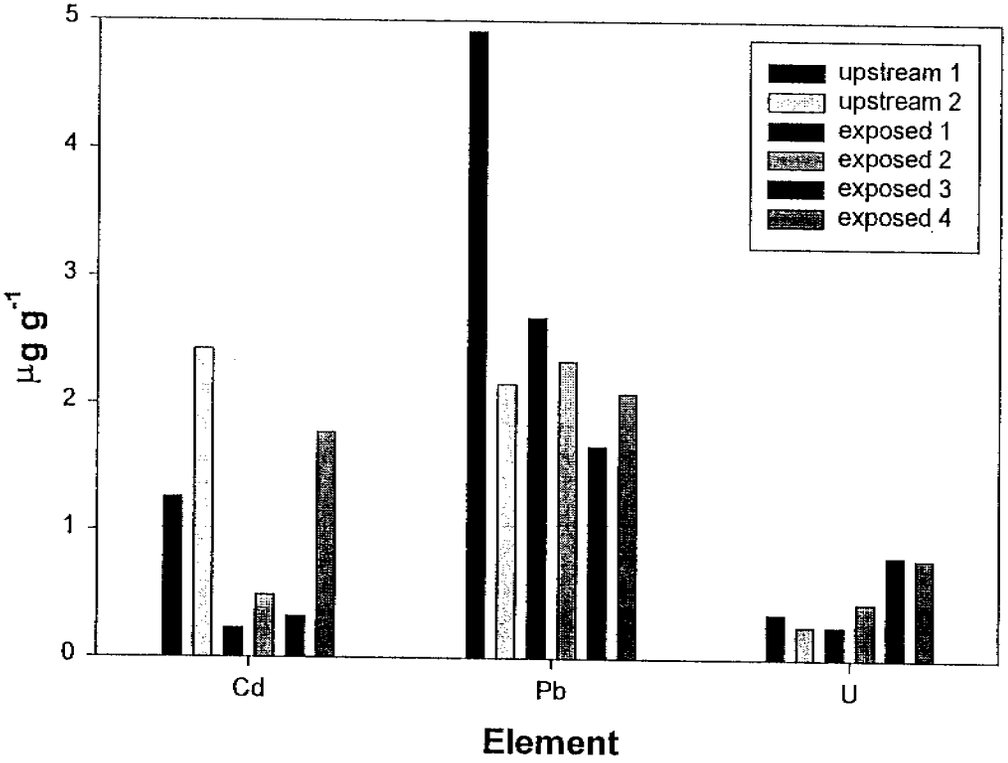
- Aquatic pathway is dominant during mine life phase
- Many locally-derived CFs different to 'default' CFs
- Hypothetical release of retention pond water from Ranger mine:
  - dose dominated by uptake from mussels, followed by fish
- Used to determine maximum water volume that can be released

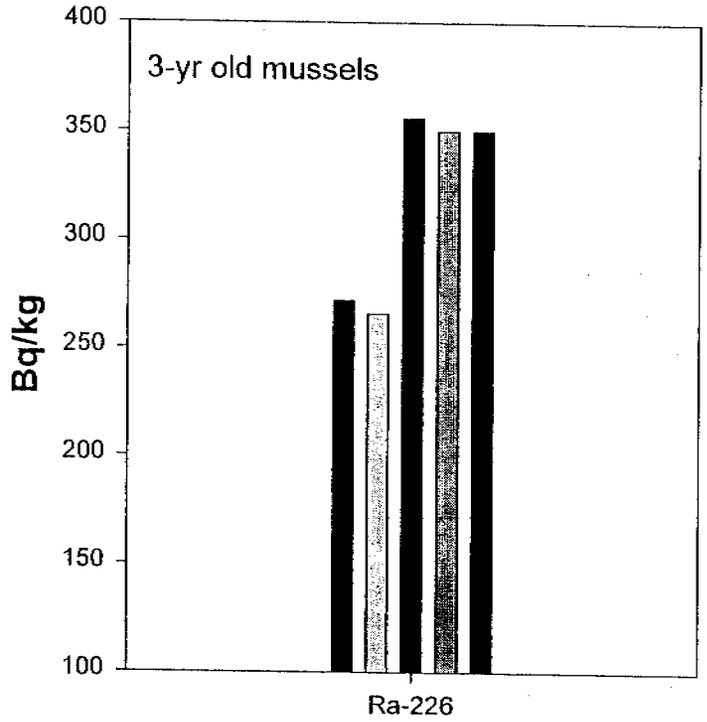
Mining in the South Alligator River Valley, ARR

- Sources of radionuclides from past mining
- Assessment of radiolological risk to people
  - safety of aquatic animals for human consumption
  - freshwater mussel (*Velesunio angasi*)

    Nov 2000: 177 mussels from 6 sites
- *Analytical methods:* alpha & gamma spectroscopy, ICP-MS

Metals and radionuclides in freshwater mussels (*Velesunio angasi*) from South Alligator River Valley





from Martin et al (2001)

Radiation dose estimate = 0.07 mSv y^{-1}

(Annual dose limit = 1 mSv - *all pathways*)

Summary

- Mining in the ARR - need to ensure protection of the environment and the people

- Four-tiered approach to ecosystem protection:

  - trigger value, pre-release, early warning (*in situ*), long-term monitoring

- Approach to human health protection spans all major pathways, including assessment of bioaccumulation of elements and radionuclides in bushfoods

- Holistic environmental program from which best-practice protocols have been developed and applied, and that are relevant at regional and national levels