ECOLOGICAL RISK ASSESSMENT

What is its Value in Risk Based Decision Making?

Andrew Botfield
James Cumming
Karen Ganza
David Allen
OVERVIEW

• What is ERA? – definition and history
• How can ERA help you? – applications
• ERA Methodology
  - Problem Identification
  - Receptor Identification
  - Exposure Assessment
  - Toxicity Assessment
  - Risk Characterisation
• Case Study – Windarra Nickel Project
WHAT IS ERA?

Scientifically understood process for evaluating ecological risks posed by a particular stressor/contaminant.

Risk assessed through the identification of contaminants, flowpaths, toxicities, and receptors.
Environmental Risk Assessment
- Stability
- Pollution/Seepage
- Health and Safety
- Closure Factors

Ecological Risk Assessment
- Contaminants
- Flow Paths
- Environmental Fate

Approval
Ecological risk associated with existing contamination issues.

Based upon NEPC 1999 methods.

MBS adopted process as a risk prediction tool.
HOW CAN ERA HELP YOU?

**Project Conception**
- Evaluation of design options/process scenarios.
- Technical supporting documentation for project approval documents.

**Project Operations**
- Design of monitoring programs.
- Guidance on controls required to meet environmental goals during production.
- Assessing various mine management options.

**Closure**
- Design of post-closure monitoring programs.
- Guidance for environmental controls during closure stages.
- Evaluation of different closure options.
APPLICATIONS OF ERA

Transport Routes

TSF Locations

Shipping Options
ERA METHODOLOGY

1. Problem Identification
2. Receptor Identification
3. Exposure Assessment
4. Toxicity Assessment
5. Risk Characterisation
1. **Problem Identification**

- Contaminated Waters
- Fuel Storage
- Product Transport
- TSF Seepage

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Footnote: Poseidon Nickel
2. Receptor Identification

Playa Lake Ecosystems
- Fringing woodland
- Halophyte communities
- Salt lake micro and macroinvertebrates

Ephemeral Creek Ecosystems
- Vegetation communities
- Livestock
- Rare and endangered flora and fauna
- Aquatic communities

Water Resources
- Pastoral station residents
- Town water supply
- Cattle
## 3. Exposure Assessment

<table>
<thead>
<tr>
<th>Medium</th>
<th>Flow Path</th>
<th>Exposure Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>Wind, airborne dust etc</td>
<td>Inhalation</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Palaeochannels, leaching, seepage etc</td>
<td>Ingestion, dermal contact</td>
</tr>
<tr>
<td>Surface Water</td>
<td>Creeks and lakes</td>
<td>Ingestion, dermal contact</td>
</tr>
<tr>
<td>Soil</td>
<td>Soil pore water, adsorption, capillary rise</td>
<td>Ingestion, dermal contact</td>
</tr>
</tbody>
</table>
CONCEPTUAL SITE MODEL (CSM)

Prevailing Wind Direction

Release Mechanism (volatization)

Release Mechanism (spillage)

Release Mechanism (leaching)

Exposure Route: Inhalation

Exposure Route: Water

Receptor (Cattle)

Receptor (Humans)

Exposure Point: Food Chain

Exposure Point: Water

Exposure Point: Food Chain

Exposure Point: Water

Environmental Medium (Air)

Environmental Medium (Soil)

Environmental Medium (Water Table)

Groundwater Flow

Exposure Point:

Water

Water

Water
4. TOXICITY ASSESSMENT

- Bioavailability
- Bioaccumulation
- Biomagnification
- Receptor Toxicity
### 5. Risk Characterisation

#### Likelihood

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Almost certain</td>
<td>Is expected to occur in most circumstances</td>
</tr>
<tr>
<td>Likely</td>
<td>Will probably occur in most circumstances</td>
</tr>
<tr>
<td>Possibly</td>
<td>Will probably occur in some circumstances</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Could occur at some time</td>
</tr>
<tr>
<td>Rare</td>
<td>May occur in only exceptional circumstances</td>
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</table>

#### Consequence Criteria

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
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<tbody>
<tr>
<td>Insignificant</td>
<td>No measurable environmental impact</td>
</tr>
<tr>
<td>Minor</td>
<td>Minor environmental impact in short term</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate environmental impact in short term</td>
</tr>
<tr>
<td>Major</td>
<td>Moderate environmental impact in long term</td>
</tr>
<tr>
<td>Severe</td>
<td>Irreparable damage</td>
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</table>

#### Likelihood vs Consequence

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Insignificant</th>
<th>Minor</th>
<th>Moderate</th>
<th>Major</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>HIGH</td>
<td>HIGH</td>
<td>VERY HIGH</td>
<td>EXTREME</td>
<td>EXTREME</td>
</tr>
<tr>
<td>Likely</td>
<td>MEDIUM</td>
<td>HIGH</td>
<td>HIGH</td>
<td>VERY HIGH</td>
<td>EXTREME</td>
</tr>
<tr>
<td>Possibly</td>
<td>LOW</td>
<td>MEDIUM</td>
<td>HIGH</td>
<td>HIGH</td>
<td>VERY HIGH</td>
</tr>
<tr>
<td>Unlikely</td>
<td>LOW</td>
<td>LOW</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
<td>HIGH</td>
</tr>
<tr>
<td>Rare</td>
<td>VERY LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>MEDIUM</td>
</tr>
</tbody>
</table>
Outcomes & Recommendations

- Understanding of ecological risk
- Informs appraisal of options
- Mitigation controls
- Monitoring requirements
- Do nothing
CASE STUDY – WINDARRA NICKEL PROJECT

• 260 km NNE Kalgoorlie
• Previously operated 1974 -1994
• Approvals for recommencement of:
  - Mount Windarra underground mine
  - Nickel concentrator
  - Gold Tailings Processing
  - Power generation
  - Borefield
  - Ancillary infrastructure
  - Village
• Approvals for Cerberus underground mine
• Approvals for use of South Windarra Pit
Problem Identification

Disposal of Tailings

Pit Lake

Impacts?!
KEY CONTAMINANTS OF CONCERN

Cyanide
- Free Cyanide
- Thiocyanate
- Cyanate
- Weak Dissociable (WAD) cyanide-metal complexes

Metals and Metalloids
- Arsenic
- Boron
- Cobalt
- Cadmium
- Copper
- Manganese
- Nickel
- Selenium
- Zinc

Inorganic Anions
- Nitrate
- Sulphate
RECEPTOR IDENTIFICATION

Human Receptors

Native Fauna/Avifauna

Livestock

Native Vegetation
EXPOSURE ASSESSMENT

- Volatilisation
- Retention and Accumulation
- Lateral Groundwater Seepage
FATE AND TRANSPORT OF CYANIDE

Atmosphere

Pit Lake Water

Hydrolysis to NO$_3^-$ + HCO$_3^-$

Oxidation to NO$_3^-$ + HCO$_3^-$ + SO$_4^{2-}$

Cyanate

HCN

WAD CN-Metal Complexes (mainly nickel cyanide)

CN ion

Adsorbed and Precipitated CN Complexed and Metal Species

Hydrolysis/Oxidation to NH$_3$/NO$_3^-$ + HCO$_3^-$/CO$_2$

KEY:
- Biological Pathways
- Physico-chemical Pathways

Free Cyanide Species
Intermediate Cyanide Species
Fate Species
**Where:** Discharge point & return process water  
**How:** Inhalation and dermal exposure to tailings & return process water

**Where:** Pit lake surface  
**How:** Inhalation, ingestion and dermal contact with lake water

**Where:** Stock bores down gradient of pit lake  
**How:** Ingestion of contaminated groundwater

**Where:** Down gradient of pit lake  
**How:** Root uptake of bioavailable contaminants in groundwater
CONCEPTUAL SITE MODEL

Source: InPit Lake

Contaminant: Cyanide, Sulphate, Nickel

Release Mechanism: Volatilisation, Seepage

Media: Air, Groundwater

Exposure Route: Inhalation, Ingestion, Dermal Contact, Root Uptake

Receptor: Humans, Fauna, Avifauna, Stock, Vegetation

Pathways addressed in ecological assessment.
• Non essential element in mammals.
• Readily absorbed and distributed through the body.
• No evidence for biomagnification or cycling.
• Rapidly detoxified by living organisms.

Cyanide

• Essential element.
• Respiratory and oral toxicant in high doses.
• Not accumulated in aquatic organisms or mammals.
• Evidence suggests accumulations decrease with increases in trophic level.

Nickel

• Not a significant threat unless present at very high concentrations.
• Recognised as an environmental stressor.
• No evidence to suggest bioaccumulation or biomagnification in the food chain.

Sulphate
# Risk Characterisation

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Contaminant</th>
<th>Transport Media</th>
<th>Reception Mechanism</th>
<th>Probability</th>
<th>Basis</th>
<th>Consequence</th>
<th>Basis</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock</td>
<td>Free Cyanide</td>
<td>Groundwater, south-west</td>
<td>Ingestion by stock</td>
<td>Rare</td>
<td>Unlikely to migrate to stock bores.</td>
<td>Insignificant</td>
<td>Will not be present in detectable concentrations in stock water</td>
<td>Very Low</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Volatilisation likely to restrict detectable concentrations within pit lake.</td>
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</tr>
<tr>
<td>Stock</td>
<td>Arsenic</td>
<td>Groundwater, south-west</td>
<td>Ingestion by stock</td>
<td>Rare</td>
<td>Migration of arsenic to stock bores highly unlikely.</td>
<td>Insignificant</td>
<td>Predicted to be below livestock drinking water guidelines</td>
<td>Very Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sufficient adsorption to soils.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tall mulga vegetated areas</td>
<td>Nickel</td>
<td>Groundwater, South-west</td>
<td>Root uptake</td>
<td>Unlikely</td>
<td>Migration of nickel to alluvial aquifers highly unlikely.</td>
<td>Insignificant</td>
<td>Concentrations unlikely to be much higher than background values</td>
<td>Low</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Sufficient adsorption to soils.</td>
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</tr>
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</table>
RESULTS

Total of 92 Risk Scenarios

- **0** VERY HIGH
- **0** HIGH
- **0** MEDIUM
- **46** LOW
- **46** VERY LOW
• Monitoring at pit lake and groundwater monitoring bores

• Setting site specific trigger values

• Use of hydrogen peroxide or ferric sulphate to reduce free cyanide
HOW THE POSEIDON ERA INFORMED DECISION MAKING

Framework
- For any further modelling and assessment of risks

Operation
- Provide set of practical measures

Approvals
- Provide evidence of assessing risks

Confidence
- Utilising pit lake for tailings disposal

Monitoring
- Provided set of requirements
CONCLUSIONS

• Invaluable predictive tool
• Identifies key risk issues
• Assesses complex biophysical processes
• Provides confidence to regulators
• Avoids unnecessary studies and monitoring
• Complements traditional environmental risk assessment