# Risk-based environmental assessment for uranium mines – some Canadian and Australian experience

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# Environmental Protection

Environmental protection is a planned activity!

Environmental Impact Assessment:

- Establishment of environmental baseline
- Prediction of potential impacts
- Identification of mitigation measures (Design and operational control measures)
- Direction for monitoring program

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# Assessment of potential impacts

- Physical components
  - Surface water quality
  - Groundwater quality
  - Air quality
  - Water supply
  - Soil and Landscape (amenity)
- Biological/ecological components
  - Terrestrial flora and fauna
  - Aquatic flora and fauna
  - Public an occupational health
- Heritage and social characteristics
- Rehabilitation
- Economic components
  - Land use
  - Transportation
- Third party property impacts

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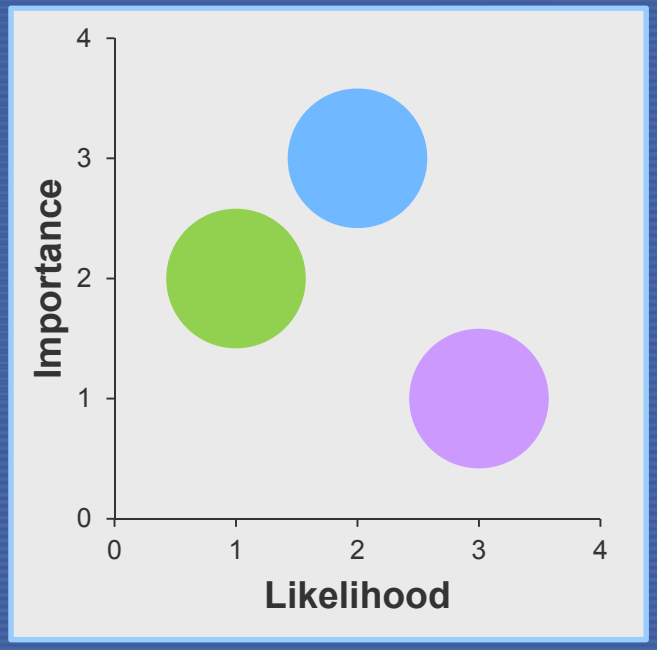
# Determining impacts – approaches

## Prescriptive

- Analysis of potential impacts related to established, set requirements

## Risk-based

- Analysis of impacts based on requirements but also the impacts' risk ranking

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# Environmental Risk Assessment (ERA)

- A process that evaluates the likelihood that adverse ecological effects may occur as a result of exposure to stressors

- Step 1: Hazard identification - LIKELIHOOD
- Step 2: Exposure assessment - IMPORTANCE
- Step 3: Risk characterization

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# Step 1: Hazard identification

LIKELIHOOD or PROBABILITY

- Determination of potential impacts
  - Likelihood of presence
  - Likelihood of adverse effect
  - Inclusions of low hazard stressors as needed
- Selection/identification of the criteria to be respected

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# 2: Exposure assessment

IMPORTANCE or CONSEQUENCE

- Usually relies on modelling to predict contaminant concentrations in media and resulting exposures or doses in biota
- May be a calculation of a numerical estimate of exposure or dose

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# Chemical and radionuclide assessment

| | CHEMICALS | RADIONUCLIDES |
|---|---|---|
| Exposure assessment | • Often considers bioavailability<br>• Only internal exposure | • Does not consider bioavailability<br>• Internal and external exposure |
| Dosimetry | Not needed | Needed |
| Effects assessment | • Effects related to concentrations or daily intakes<br>• Separate assessments for each chemical | • Effects related to dose<br>• Assessments for radiation type (not each radionuclide) |

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# Step 3: Risk characterization

- $\text{Risk quotient}(RQ) = \dfrac{\text{calculated exposure}}{\text{established limit}}$
- RQ > 1 = there is possible significant risk
  RQ < 1 = there is no significant risk
- Summarize and integrate information from the risk assessment to synthesize an overall conclusion about risk

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# The Risk-Based Approach to Environmental Assessment in Australia

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# The Risk-Based Approach to Environmental Assessment in Australia

- This has emerged over the last 2 decades
- Currently usually based around the Australian and New Zealand standard (AS4360:1999) for risk assessment
  - Potential impact events
  - Inherent risk levels (e.g. low, moderate) using a matrix approach
  - Design and operational control measures
  - Residual risk levels
  - Outcomes to be achieved
  - Outcomes measurement criteria
    - Leading to ‘compliance’ monitoring
  - Leading indicator criteria
    - Leading to ‘early warning’ monitoring

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# Environmental topics for consideration?

- Recent Australian examples:
  - Conversion of an open cut mine to underground in the monsoonal tropics
  - ISL and open pit mines in the temperate to sub-tropical deserts
- The details and priorities will differ, but a the first-pass some consideration should be of a long list of possibilities
- However, some may be dealt with informally if they are not relevant  or of very low risk

- Possible List of Topics
  - Water supply
  - Surface hydrology
  - Hydrogeology
  - Soil and Landscape (amenity)
  - Flora including weeds
  - Fauna, including farm or pastoral animals if relevant
  - Radiation management
  - Non-radioactive waste
  - Chemical/fuel management
  - Heritage and Community
  - Rehabilitation
  - Air quality
  - Third party property impacts (e.g. damage to fences, death of stock)
  - Plus…?
  - Plus…?

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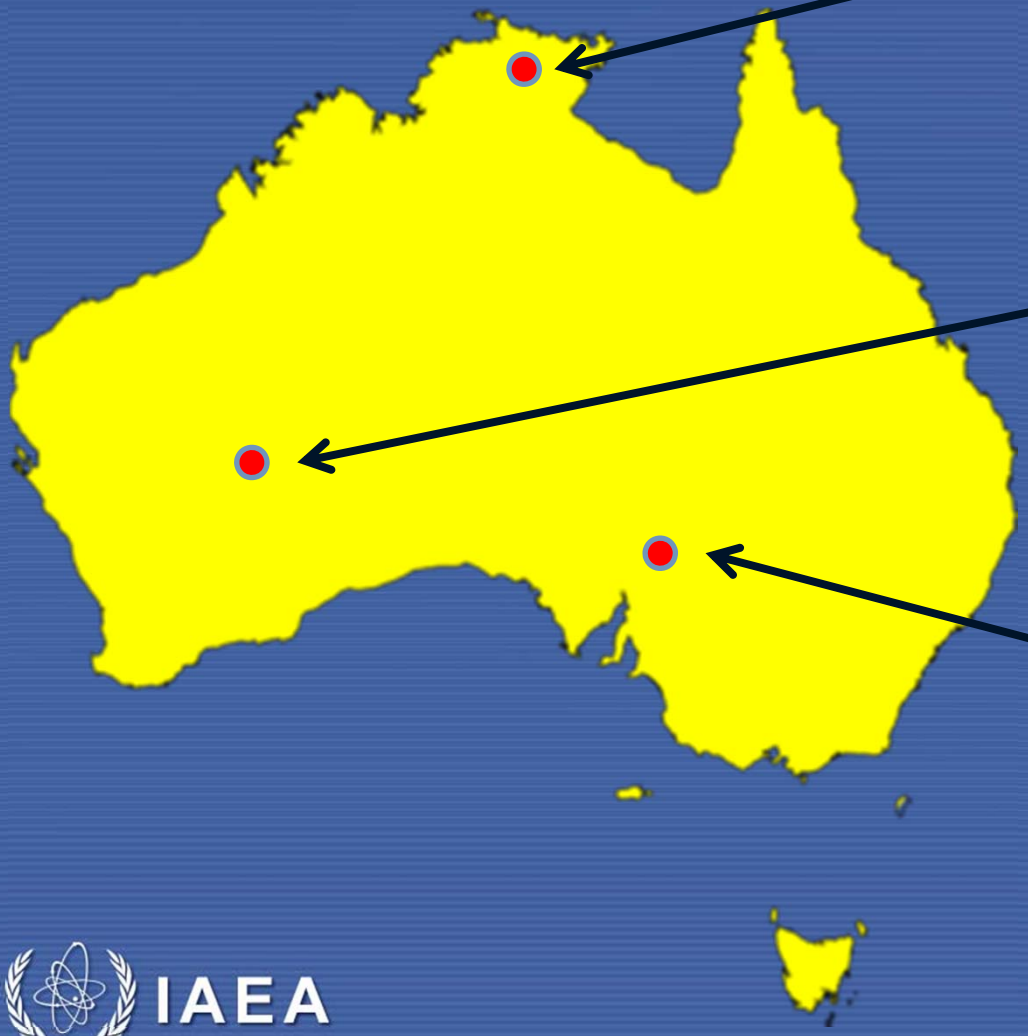
# Locations of Australian examples



- Ranger 3 Deeps

- Wiluna

- Beverley North

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# Example of risk assessment in practice Beverley North ISL U mine, 2010/11

- From 12 topics, 8 were identified for *formal* risk assessment

1. Soils – 4 impact events
2. Vegetation – 4 impact events
3. Surface Water – 2 impact events
4. Hydrogeology – 3 impact events
5. Fauna – 3 impact events
6. Air Quality – 1 impact event
7. Heritage – 1 impact event
8. Third Party Issues – 1 impact event
    - Note; this last topic was not in the initial list, it emerged in further discussions

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Source: Heathgate approval documents, 2010/11. This work may have been updated since, but is included here as an example of an approach early in a project proposal

# Example of risk assessment in practice Beverley North ISL U mine, 2010/11 (cont. 1)

- Each of the 19 identified (potential) impact events was subject to a more detailed risk assessment
- For each, the following were considered:
  - Inherent risk levels (e.g. low, moderate) using a matrix approach
  - Design and operational control measures
    - e.g. lining of ponds, inspections of ponds
  - Residual risk levels
    - The above steps are repeated until the residual risk is acceptable
  - Outcomes to be achieved
    - e.g. no compromise of other existing groundwater users in the region or pastoral use of [a named] aquifer
  - Note: radiation aspects were considered within each of these categories

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# Example of risk assessment in practice Beverley North ISL U mine, 2010/11 (cont. 2)

- Outcome to be achieved (example)
  - No introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of feral animals in the lease area compared to adjoining pastoral areas

- Outcome Measurement Criteria
  - Flora and fauna surveys demonstrate no new weeds or feral animals (due to mining activities) nor statistically significant increase in abundance of existing weed or pest species in the lease area compared to adjoining pastoral areas

→ For ***compliance***

- Leading Indicator Criteria

  -- Trends noted in annual vegetation and fauna monitoring

→ For ***early warning***

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# Example of risk assessment in practice
# Ranger Deeps U mine 2012

- An Environmental Risk workshop held with stakeholders 25-26 September 2012
- It was agreed by the participants of the workshop to brainstorm potential risks of the project as the initial identification process
- Areas included:
  - General project, Construction, Mine design, mining methods, ancillary facilities, processing, water management, workforce and contractors, power requirements, air quality and greenhouse gas emissions, radiation management, traffic management, rehabilitation and closure, land owners and external stakeholders
- At the end of the risk identification process, the group reviewed the risks identified against the risk scheme and identified and assessed two risks which were not identified during the brainstorming sessions.

Source: Appendix G of the Energy Resources of Australia referral of the project to the Commonwealth of Australia, 2012. This work may have been updated since, but is included here as an example of an approach early in a project proposal

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# Example of risk assessment in practice Ranger Deeps U mine 2012 (cont. 1)

Environmental components and mechanisms of interaction were identified. Environmental components were:

- Air quality
- Surface water flow
- Surface water quality
- Groundwater flow/quantity
- Groundwater quality
- Soil
- Landform
- Terrestrial and aquatic flora
- Terrestrial and aquatic fauna
- Health and safety
- Social/community
- Cultural heritage
- Noise and vibration
- Transportation
- Mineral resources
- Climatic/natural events

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# Example of risk assessment in practice Ranger Deeps U mine 2012 (cont. 2)

## Mechanisms of interaction included (2 examples):

| • Environmental component | • Mechanism of Project Interaction |
|---|---|
| 1. Air quality | 1. Greenhouse gas emissions; particulate (dust); gases/blasting fumes; increase in radiation; National Pollutant Inventory notifiable contaminants; odour |
| 2. Terrestrial and aquatic flora | 2. Habitat disturbance/removal; competition from weed species; direct/indirect disturbance to listed species affecting viability; fire |

The overall significance of the environment-related risks were assigned based on the combination of the consequence rating and the probability rating (matrix approach)

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# Example of risk assessment in practice Ranger Deeps U mine 2012 (cont. 3)

- The risk assessment found no ‘very high risks’
- 6 ‘high’ risks were identified:
  - 1 to do with cultural heritage
    - Intersection of discovery of an anthropological site with an impact on cultural significance
  - 4 to do with social/community;
    - Noise of vents and fans
    - Visual amenity of vents and fans
    - Communication issues; loss of richness of information sharing, loss of confidence (by landowners), and lack of respect for cultural values
    - Loss of public support due to perceived higher risks
  - 1 to do with transportation,
    - Increased traffic and the potential for spills of hazardous materials/waste causing environmental harm
- All other identified risks were ‘low’ (28) or ‘moderate’ (22) – this includes all ‘traditional’ environmental risks to fauna, flora, workers, water resources etc.

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# Example of risk assessment in practice
# Wiluna U Project 2011

- Proposed open-cut U project in an arid part of Western Australia
- Environmental Risk Assessments featured in approval documentation
- Principle: Environmental, social and economic factors should be taken into account… The environmental practices and procedures should be cost-effective and in proportion to the significance of the environmental risks and consequences being addressed.
- How addressed:  Toro carried out formal risk workshops. The outcomes of this work were used to establish an acceptable level of understanding of environmental risk and to allocate resources and effort to the management of all Project risks

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Source:  Toro Energy Ltd 2011 Environmental Review and Management Programme Parts 1 and 2. This work may have been updated since, but is included here as an example of an approach early in a project proposal

# Example of risk assessment in practice Wiluna U Project 2011 (cont.)

- Example; regarding possible dust generation, activities considered included:
  - Infrastructure construction
  - Mined materials handling (extraction, transport, stockpiling),
  - Haul road maintenance
  - Wind erosion
- For each events that could lead to dust generation greater than that predicted in the Management Plan assessment resulting in adverse impacts to nearby sensitive receivers
- For each a ***contingency plan*** was proposed

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# Environmental Risk Assessment in the Regulation of Uranium Mining & Milling in Canada

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# Role of Environmental Risk Assessment in the Regulation of Uranium Mining & Milling in Canada

- 1990s: Risk assessment was used in EIAs for new projects
- 2000: Nuclear Safety and Control Act (NSCA)
  - Make adequate provision for protection of environment & health, safety public
  - Prevent unreasonable risk, to environment, health and safety of the public
  - Regulations:
    - Take all reasonable precautions to protect environment .. control releases …
    - Environmental baseline characteristics
    - Description of releases and proposed measures to control releases
    - Proposed measures to prevent or mitigate the effects …
    - Environmental protection policies and programs
    - Effluent and environmental monitoring programs

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# How to Implement This New Expanded Environmental Mandate?

## Two Major Questions to Address:

- What is "Adequate Provision" to Protect and "Reasonable Risk"?
- What is/are the best "tool(s)" or approach to meeting this new environmental mandate?

## Decision:

- Environmental and Public Protection to be:
  - Recognizant of principles of Pollution Prevention or ALARA
  - Risk Based
- Core tool for risk based element is to be ERAs including both:
  - Ecological Risk Assessment and Human Health Risk Assessment

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# Use of ERA in Canada

- Early 2000: ERA adopted as tool for assessing impacts of new and existing projects, designing monitoring programs
- Mid 2000: Used by CNSC Staff to independently assess facility specific emerging issues
- Present day: Formally being incorporated into full life-cycle licensing and completions of standards and guidance

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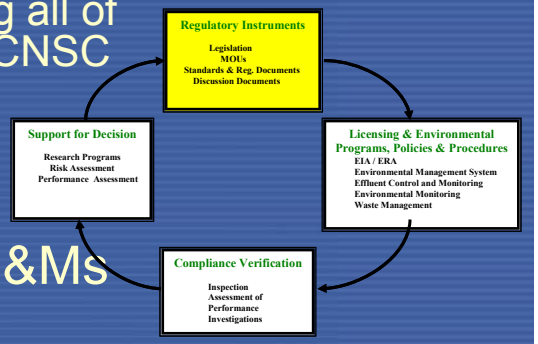
# Environmental Protection Instruments Standards and Regulatory Documents

**REGDOC 2.9.1 (2013):**

Environmental Protection Programs, Policies and Procedures: Present focus on EMS

- Environmental Regulatory Document under revision to bring all of these elements (EIA, ERA, EMS, & Monitoring) within one CNSC regulatory document.




**CSA N288.6 (2012):**

Environmental Risk Assessment at Class I and UM&Ms

**CSA N288.5 (2011):**

Effluent Monitoring Programs at Class I and UM&Ms

**CSA N288.4 (2010):**

Environmental Monitoring Programs at Class I and UM&Ms

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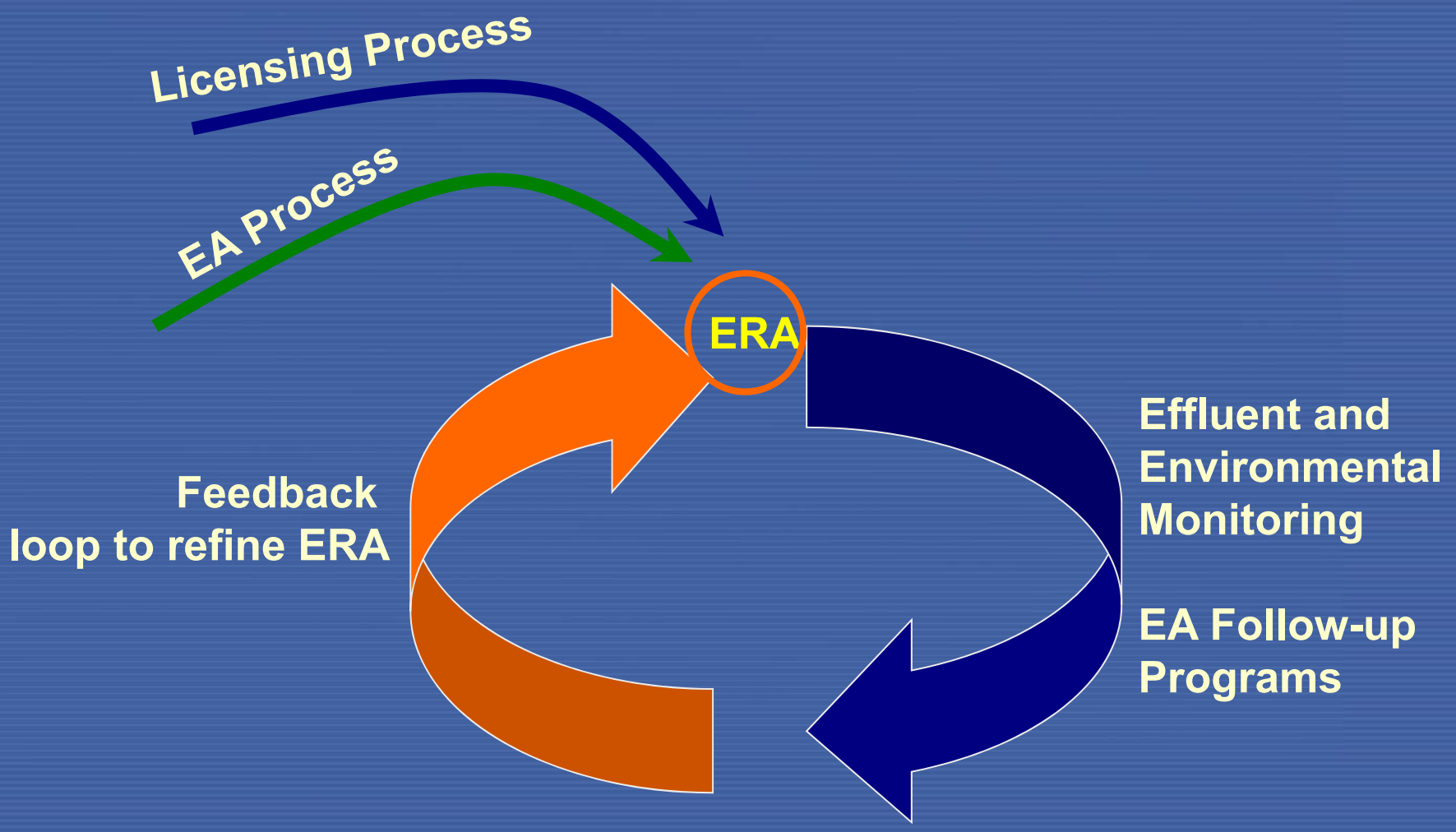
# Environmental Protection Framework

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# Case Study of ERA for Decision Making: Uranium, Molybdenum and Selenium

Monitoring programs indicated previously unpredicted concerns related to U, Mo, and Se.

## Uranium

- ERA completed by CNSC staff for PSL2 assessment
- Concluded releases of uranium from uranium mines and mills are CEPA toxic
- Appendix to Memorandum of Understanding with EC
- Risk management plan

## Molybdenum & Selenium

- CNSC staff completed site-specific ERA
- ERA submitted for external peer review
  - Nine recognised academic, gov't and industry researchers
- ERA submitted to Commission as supporting document for recommendation for treatment.

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# Case Study of ERA for Decision Making: Uranium, Molybdenum and Selenium (2)

## Decision Aiding Technique:

| Weight of Evidence | | | | |
|---|---|---|---|---|
| **Factors Under Consideration** | | **U** | **Mo** | **Se** |
| **Peer Reviewed Site-Specific Risk Assessment** | | | | |
| **Risk Assessment Conclusions** | Exceed guidelines for abiotic media | Yes | Yes | Yes |
| | Exceed guidelines for biotic media (e.g., tissues) | Yes | Yes | Yes |
| | Hazard Quotients >1 for multiple species at multiple trophic levels | Yes | Yes | Yes |
| | Spatial extent of hazard exceed local project area | Yes | Yes | Yes |
| | Potential for population level effect | Yes<br>BI | No | Yes<br>Fish |
| | Field evidence of cause-effect relationship on reproduction or mortality | Yes<br>BI | No | Yes<br>Fish |

# Case Study of ERA for Decision Making: Uranium, Molybdenum and Selenium (3)

| Risk Management Decision | | | | |
|---|---|---|---|---|
| **Adequate Precaution and Reasonable Risk?** | | **U** | **Mo** | **Se** |
| **CEPA Toxic** | | | | |
| Could the contaminant be classified as CEPA toxic? | | Yes | ? (No) | Yes |
| **Fisheries Act** | | | | |
| Possible deleterious substance? | | ? (No) | No | Yes |
| **Migratory Birds Act** | | | | |
| Possible deposition of a substance that is harmful to migratory birds … | | No | No | ? (Yes) |
| **Nuclear Safety and Control Act** | | | | |
| Control the release ...? Adequate Provision to Protect ...? | Is there an absence of control(s) specific to this contaminant? | Yes | Yes | Yes |
| | Pollution Prevention: Is there a readily available control considered to be BPT? | Yes | Yes | ? |
| Reasonable Risk? | Do measured abiotic and biotic effects exceed those predicted in original EA? | ? | Yes (?) | Yes (?) |
| | Should pre-cautionary principle be applied? | Yes | Yes | Yes |

# Case Study of ERA for Decision Making: Uranium, Molybdenum and Selenium (4)

## Risk Management Strategies

**Uranium**

- Field confirmed and available treatment technology considered BPT can substantially mitigate risk. Install treatment.

**Molybdenum**

- Theoretical risk but readily available treatment technology considered BPT can eliminate risk. Install treatment.

**Selenium**

- Field confirmed risk but difficult to treat to predicted levels of *de minimus* risk.
- Treatment to minimise releases with further monitoring to address uncertainty in risk and assess potential recovery.

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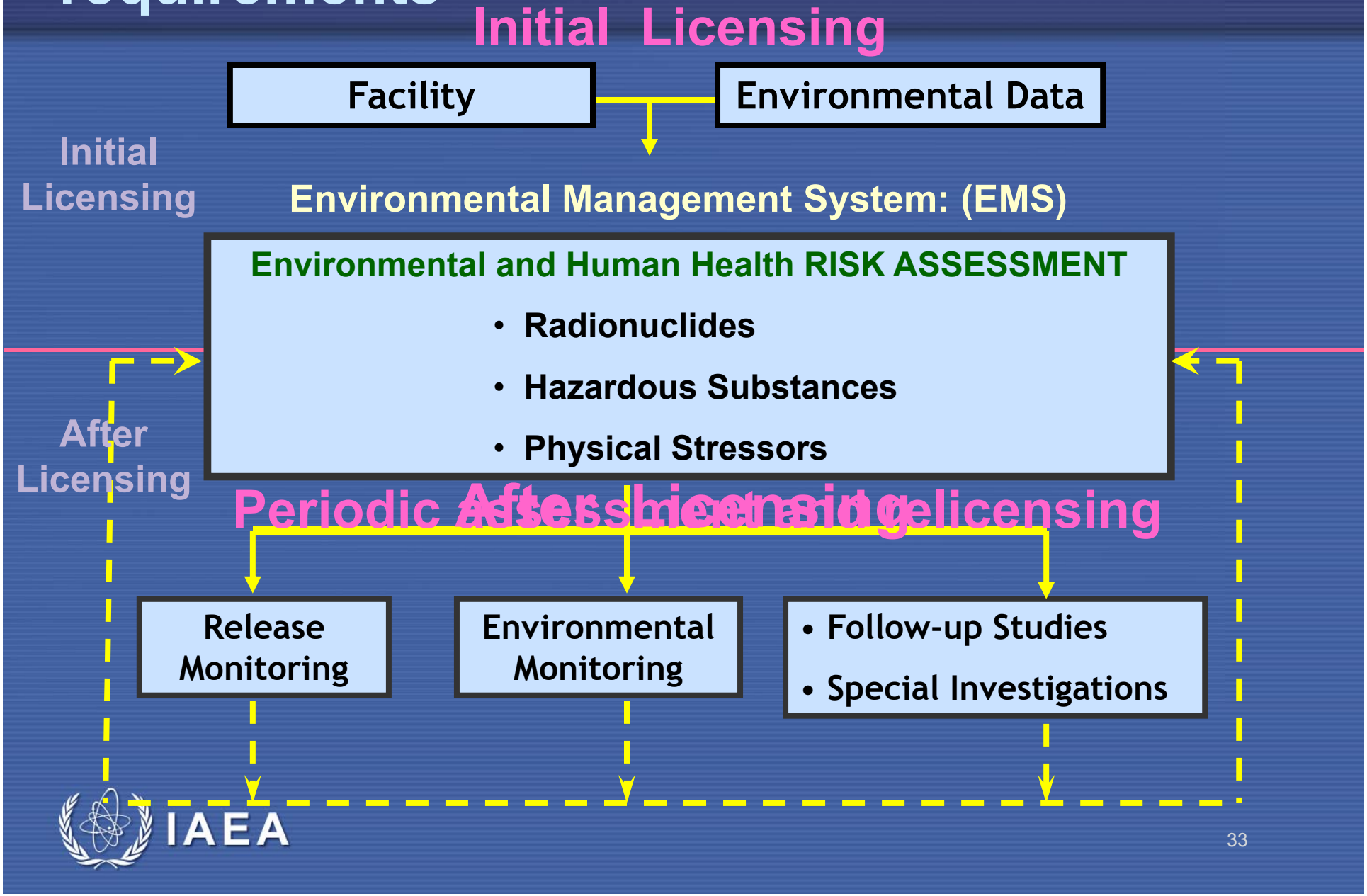
# ERA: Core tool for meeting environmental requirements



# Conclusions

1. ERA → useful tool to predict environmental performance
2. ERAs are site specific
3. Revisit, learn and adapt

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