IAEA
International Atomic Energy Agency
Atoms for Peace and Development

In-Situ Leaching (ISL)

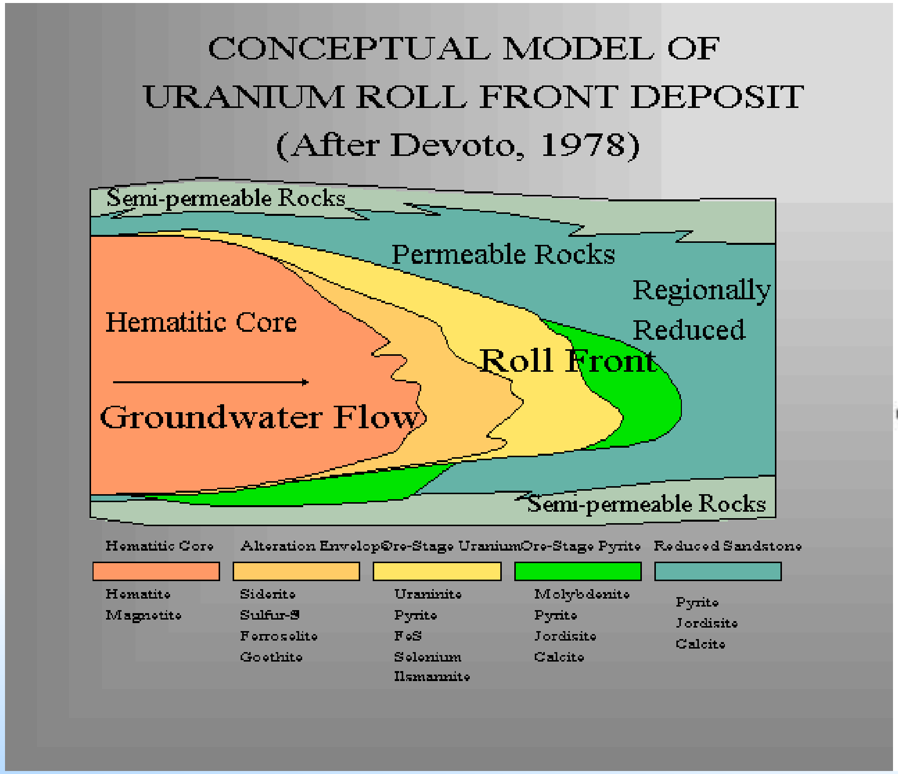
Training Package on Occupational Radiation Protection in Uranium Mining and Processing Industry

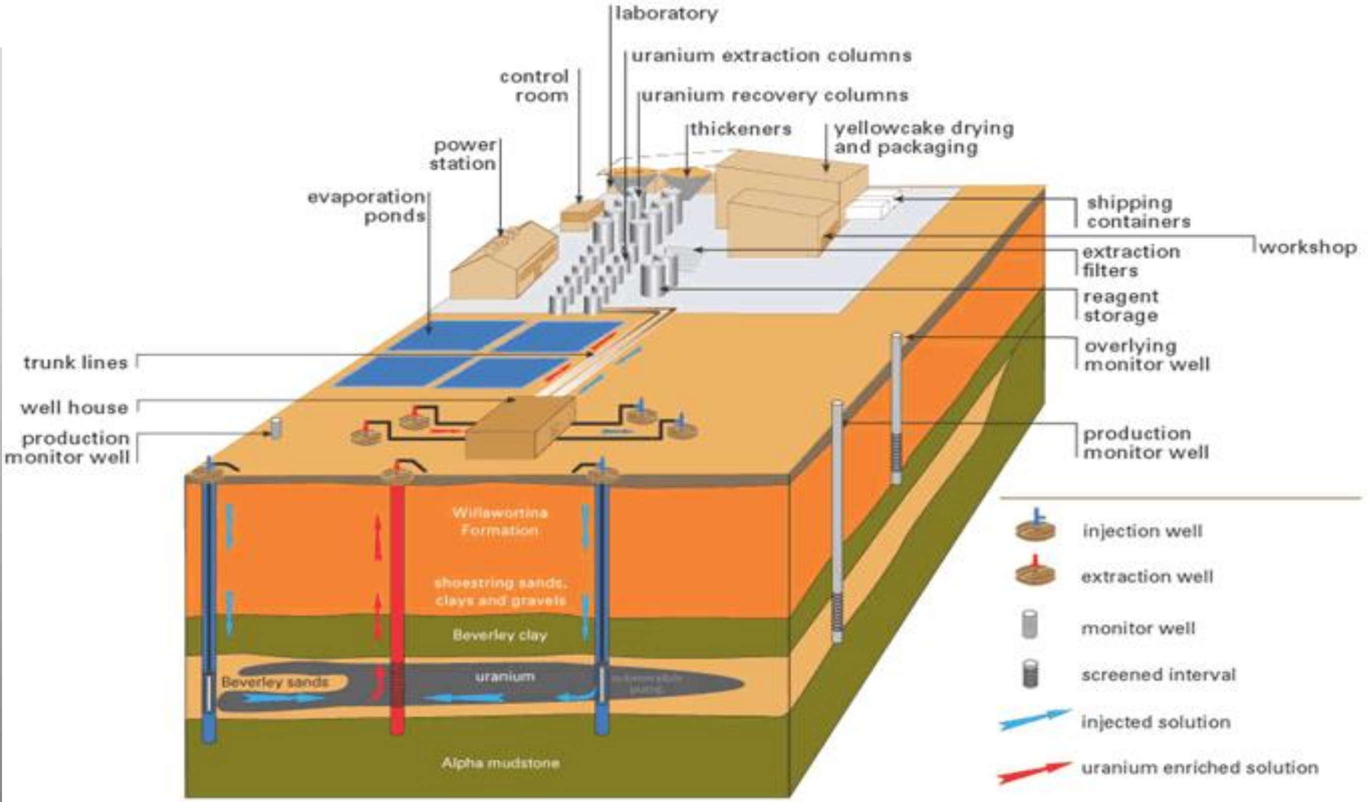
In-Situ Leaching Overview

- In-situ leaching (ISL) also known as in-situ recovery (ISR)
- ISL – 51% of word uranium production ;
- Kazakhstan, Australia, China, Russia, USA, Uzbekistan;
- Alkaline leaching – USA;
- Acidic leaching – Kazakhstan, Australia, Uzbekistan, China, Russia;
- Deposits depth 30-150 m in USA, up to 750 m in Kazakhstan;
- Other ISL methods are being developed;

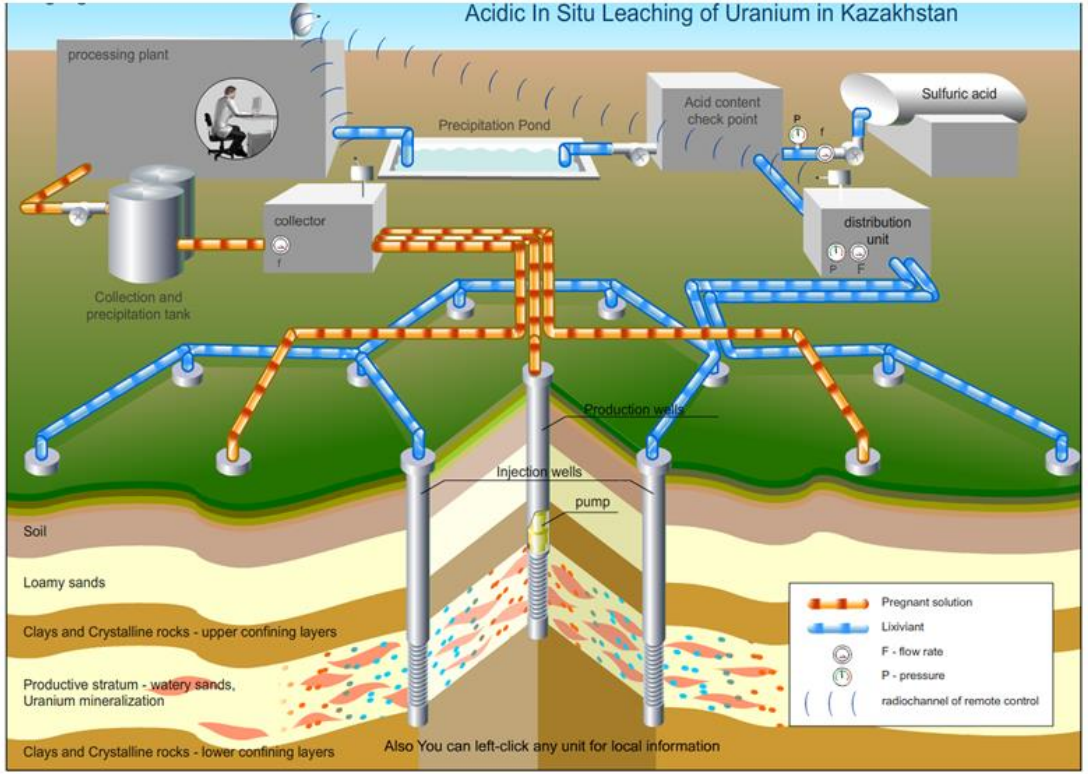
Process description

- An ISL operation consists of a wellfield with associated infrastructure to pump and extract lixiviant (alkaline or acidic solution) in and out of the mineralised zone; and a processing facility to extract the uranium from the lixiviant to produce the desired final uranium product.
- ISL currently accounts for most of uranium production in the world and is regarded as being a cost effective and environmentally acceptable method of uranium production.





Acidic In-Situ Leaching of Uranium – Kazakhstan



Kazatomprom is the world's largest producer of uranium, representing approximately 22% of total global uranium primary production in 2018. The Group benefits from the largest reserve base in the industry. Kazatomprom operates, through its subsidiaries, joint ventures and associates, 26 deposits grouped into 13 mining assets, all of which are located in Kazakhstan and mined using ISL technology. The uranium deposits in the Republic of Kaz akhstan are developed at the depth of up to 750 meters using environmentally safe and economically sound In-si tu Leaching Method.

ISL is a method of development of sandstone bedded infiltration type uranium deposits without use of mining by selective in-situ transfer of natural uranium ions in pregnant solution. The uranium-bearing ore remains underground as opposed to conventional methods (shafts and pits).

Development

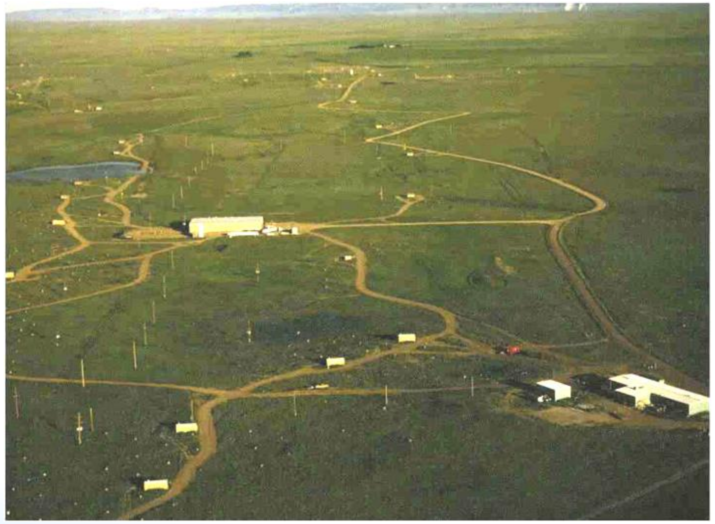
- Development is characterized by operations in the field to assess the uranium resource with drilling, geophysical researching and taking samples from wells.
- Occupational exposures during development are expected to be low due to the limited amount of radioactive material being handled and the usually low ore grades involved in most operations.
- Radiation protection aspects of development have often been ignored
- Current approach is to assess potential radiation hazards and doses through a prospective assessment and then implement an appropriate radiation protection program.
- Every case of mine development (exploration or trial mining) needs technical design including environmental impact assessment, industrial and radiation safety plans.

Design and operation

- The design and operation of an ISL mine and processing plant will depend on the nature of mineralisation of the ore body. This will determine whether an acidic or alkaline solution is used for extraction.
- Wellfield design is determined by local conditions such as permeability, thickness, deposit type, ore grade and distribution. Wellfields are designed either in spot patterns, with injection wells in the centre, or lines of wells alternating between injection and extraction.
- Approval of design best includes an environmental impact assessments and requirements of industrial and radiation safety.
- Compared to normal uranium mining methods, the processing plants for ISL mines are significantly smaller as they have no ore handling, crushing, grinding and recovery processes.
- Risk from Long Lived Radioactive Dust (LLRD) and radon progeny lower than other methods, however the design of the operation needs to include adequate ventilation systems at the plant (final product & process tanks).

South Australia

USA



Mining and Processing facilities in Kazakhstan

Wellfield

Plant

Well house

Operation center of plant

Principal Exposure Pathways

- External exposure (gamma) – medium
- External exposure (gamma) – high for operations with enhanced ^{226}Ra concentrations (scales, resins & residues)
- Inhalation of radon progeny – low (except for special areas where radon can degas & concentrate)
- Inhalation of LLRD – low
- Internal exposure via surface contamination – low

Determine the Exposure Pathways

For each stage assign a relative level for the importance of the exposure pathway

VH-very high, H-high, M-medium, L-low, VL-very low

Stage/Pathway	Gamma	Radon Progeny	LLRD*
Development			
Wellfield			
Extraction			
Drying			
Residue Management			
Storage end product			

* LLRD – Long Lived Radioactive Dust

Model Answer Exposure Pathways

Stage/Pathway	Gamma	Radon Progeny	LLRD*
Development	L	L	L
Wellfield	M	L (wet based)	L (wet based)
Extraction	M	L (wet based)	L (wet based)
Drying	M (packing)	L	VH (final product)
Residue Management	H (collect)	VL	L (wet based)
Storage end product	H	VL	VL

* LLRD – Long Lived Radioactive Dust

What Monitoring is Required

- **Gamma** – which groups need personal monitoring, can monitoring be optimised, do you need real-time assessments?
- **LLRD** – Sizing, solubility, respiratory protection factor, personal monitoring program for similar exposure groups (SEGs)?
- **Radon progeny** – monitoring methods, program to make dose assessment, is personal monitoring required, localised or default dose conversion factor (DCF)?
- **Contamination** – what are the critical areas, clearance for vehicles & equipment?

Develop a Monitoring Program – Model Answers

Stage/Pathway	Gamma	Radon Progeny	LLRD*
Development	P	Area	SEG
Wellfield	P	Area	SEG
Extraction	P	Area	SEG
Drying	P	Area	SEG/Area
Residue Management	SEG	Area	SEG
Storage end product	P	Area	SEG

* LLRD – Long Lived Radioactive Dust

Monitoring and dose assessment

- Each facility sets its own intervention limits for each exposure pathway (administrative internal limits)
- Measurement of gamma radiation at monitoring points;
- Measurement of radon progeny and LLRD
  - Accounting for the time of stay of workers in working area;
- Measurements for surface contamination;
- Dose assessment and search for ways to reduce of doses;
- If above the intervention limits search for causes and ways to reduce the radiation impact.

What Controls do you need for your mine?

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Controls

- Adequate ventilation in final product and areas where radon progeny can accumulate
- Wet based clean up of spills
- Isolate & contain residues
- Final product packing & storage isolated, ventilated & with restricted access

Key Messages

- The radiation protection program must be optimized for the ISL method.
- A successful radiation protection program is based on a detailed understanding of the technological infrastructure.
- Proper management of radioactive residues reduces radiation risks.

Guidance Questions

Q1:

- Where is the low impact of gamma exposure?

Q2:

- Where is the high impact of internal exposure?

Guidance Answers

A1:

- During development;
- On the wellfield;
- In the well house.

A2:

  - When we have poor ventilation in plant;
  - In the plant – ion exchange;
  - Final product purification, packing & storage.

Thank you!