NRCREP - FW: Uranium Recovery GEIS

From: "Schutterle, Shelley (RTEA)" <Shelley.Schutterle@riotinto.com>
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Date: 10/08/2007 11:20 AM
Subject: FW: Uranium Recovery GEIS

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72FR 40344
387

Shelley

From: Schutterle, Shelley (RTEA)
Sent: Monday, October 08, 2007 8:56 AM
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Cc: 'Sweeney,Katie'; Lucas, John (RTEA); Paulson, Oscar (RTEA)
Subject: Uranium Recovery GEIS

This is being re-sent, without the "Confidentiality" statement included.

Attached please find Kennecott Uranium Company's comments on the Notice of Intent to Prepare a Generic Environmental Impact Statement for Uranium Milling Facilities.

Thank you,

Shelley Schutterle

Shelley Schutterle
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SUNSI Review Complete
Template = ADM-013

E-RIDS = ADM-03
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Mail Envelope Properties (470A46EF.A37 : 8 : 51767)

Subject:	Uranium Recovery GEIS
Creation Date	Mon, Oct 8, 2007 10:55 AM
From:	"Schutterle, Shelley (RTEA)" <Shelley.Schutterle@riotinto.com>
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Files	**Size**	**Date & Time**
MESSAGE	662	Monday, October 8, 2007 10:55 AM
TEXT.htm	5188	
ISL-GEIS-Scoping-Comments.PDF	1875985	
Mime.822	2576021	

Options

Expiration Date:	None
Priority:	Standard
ReplyRequested:	No
Return Notification:	None
Concealed Subject:	No
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8 October 2007

Uranium Recovery GEIS
Chief
Rules Review and Directives Branch
Mail Stop T–6D59
U.S. Nuclear Regulatory Commission
Washington, DC 20555–0001

VIA ELECTRONIC MAIL

Gentlemen:

Subject: Kennecott Uranium Company - Comments on the Notice of Intent to Prepare a Generic Environmental Impact Statement for Uranium Milling Facilities
Federal Register / Vol. 72, No. 141 / Tuesday, July 24, 2007 / Notices pages 40344 to 40346

Kennecott Uranium Company is a uranium recovery licensee located in Sweetwater County, Wyoming. It manages the Sweetwater Uranium Project which contains the last remaining conventional uranium mill in Wyoming. Kennecott Uranium Company has reviewed the Notice of Intent and has the following comments:

1. **The Generic Environmental Impact Statement (GEIS) Process**
   1.1. Kennecott Uranium Company believes that since direct use of Environmental Assessments (EAs) to permit in-situ uranium recovery facilities will no longer be allowed, the GEIS approach to environmental impact statements for proposed in-situ uranium recovery facilities is the next best alternative for the following reason:
      1.1.1. The in-situ uranium recovery process is similar from site to site regardless of the precise location of the recovery operations, thus a generic approach is wholly adequate and site specific environmental impact statements are not and should not be required of potential licensees. Kennecott Uranium Company does not agree with some commenters that this process is " *...a process to eliminate public review of individual NRC permit actions...* ". A GEIS does not eliminate opportunities for public review since the public will be afforded ample opportunity to comment on individual license applications. In addition, the GEIS process itself is open to public review and comment through the scoping meetings that have already been held and the opportunity to submit comments regarding the scope of the document.
   1.2. The Notice of Intent also states:
      1.2.1. The GEIS may also assess the potential environmental impacts of alternative methods of uranium recovery (including the conventional milling process).
      1.2.2. The GEIS for conventional uranium milling was prepared in 1980. There have been substantial regulatory changes since that time and Kennecott Uranium Company believes that the GEIS on conventional milling should be revised to reflect those changes.

2. **Assessment of the Potential Environmental Impacts of Alternative Methods of Uranium Recovery (Including the Conventional Milling Process)**
   2.1. Kennecott Uranium Company believes that an update to the 1980 GEIS on conventional milling should be included in this process and should incorporate the following items:
      2.1.1. NUREG-1620 - Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978
         2.1.1.1. This document dated June 2003 was prepared with the input of the uranium recovery industry and incorporates many of the changes since the publication of the 1980 GEIS on conventional uranium milling.

2.1.2. ***Staff Requirements Memoranda (SRM) for SECY-99-277 Concurrent Jurisdiction of Non-Radiological Hazards of Uranium Mill Tailings*** dated August 11, 2000:

2.1.2.1. This document stated, *"The Commission has determined that NRC has exclusive jurisdiction over both the radiological and non-radiological hazards of such material. The staff should ensure that all affected states are aware of this decision. "*

2.1.2.2. This determination should be unambiguously included in a revision to the 1980 GEIS on uranium milling.

2.1.2.3. This is documented in the Regulatory Issues Summary (RIS) 00-23 Recent Changes to Uranium Recovery Policy dated November 30, 2000 which states:

2.1.2.3.1. In 1980, the staff considered the issue of whether the Uranium Mill Tailings Radiation Control Act (UMTRCA) preempts a non-Agreement State's authority to regulate the non-radiological hazards associated with 11e.(2) byproduct material and concluded that it did not. The NRC concluded that NRC and the State both exercised this authority. As a result, the staff has followed the practice of sharing jurisdiction of the non-radiological hazards with States. In its 1998 white paper, the NMA questioned the 1980 staff interpretation of UMTRCA. The Commission, in the SRM for SECY-99-0277 determined that NRC has exclusive jurisdiction over both the radiological and non-radiological hazards of 11e.(2) byproduct material.

2.1.3. ***Staff Requirements Memoranda (SRM) for SECY-99-012 Use of Uranium Mill Tailings Impoundments for the Disposal of Waste Other than 11e.(2) Byproduct Material and Reviews of Applications to Process Material Other than Natural Uranium Ores*** dated July 26, 2000.

2.1.3.1. The conclusions of this document should be included in a revision of the 1980 GEIS on conventional uranium milling.

2.1.4. ***Regulatory Issues Summary (RIS) 00-23 Recent Changes to Uranium Recovery Policy*** dated November 30, 2000.

2.1.4.1. This document should be included as well since it includes the following new definition of ore developed subsequent to the publication of the 1980 GEIS on conventional milling which is as follows:

2.1.4.1.1. *Ore is a natural or native matter that may be mined and treated for the extraction of any of its constituents or any other matter from which source material is extracted in a licensed uranium or thorium mill.*

2.1.5. Conclusions of the ***Environmental Assessment for International Uranium (USA) Corporation's Uranium Mill Site White Mesa, San Juan County, Utah in Consideration of an Amendment to Source Material License SUA-1358 for the Receipt and Processing of the Molycorp Alternate Feed***

2.1.5.1. In this document the Nuclear Regulatory Commission staff *"...determined that the Molycorp material should be classified as "source material" ore and is, therefore excluded by definition as a solid and hazardous waste under the Resource Conservation and Recovery Act (RCRA) (see 40 CFR Part 261.4) NRC staff consulted with EPA region 8 staff who concurred with this interpretation. Secondly, the State of California (Radiological Health Branch) considers the material to be already classified as source material. There are two reasons for this conclusion: (1). The uranium content of the material in question i.e., 0.15% make this licensable source material and; (2) as an ore the material could be legitimately recycled by IUSA (International Uranium (USA) Corporation) which will process the material for its uranium content. Under EPA regulations source material is not considered a solid waste for purposes of RCRA. If the material is not a solid waste, it cannot be classified as a hazardous waste (see 40 CFR 261.4(a)). This is true even if the material contains a hazardous characteristic if the material is legitimately reclaimed."*

2.1.6. The National Mining Association's and the Fuel Cycle Facilities Forum's White Paper on Direct Disposal of Non-11e.(2) Byproduct Materials in Uranium Mill Tailings Impoundments

2.1.6.1. This document and its conclusions should be considered in the GEIS process.

2.1.7. ***The National Mining Association's (NMA's) Comments on the Environmental Protection Agency's (EPA's) Approaches to an Integrated Framework for Management and Disposal of Low-Activity Radioactive Waste: Request for Comment - Federal Register (FR) Vol. 68, No. 222 / Tuesday, November 18, 2003 / Proposed Rules pages 65120 to 65151***

2.1.7.1. This document and its conclusions should be considered in the GEIS process

2.1.8. ***Kennecott Uranium Company's Comments Regarding: Federal Register: July 7, 2006 Volume 71, Number 130 Pages 38675-38676 Request for Comments on the Nuclear Regulatory Commission's Low Level Radioactive Waste Program***

2.1.8.1. This document and its conclusions should be considered in the GEIS process.

2.1.9. 1996 Strategic Assessment and Rebaselining Initiative (SARI)

2.1.9.1. In its Strategic Assessment and Rebaselining Initiative (SARI), expanding the use of uranium tailings impoundments to allow disposal of wastes generated during decommissioning of nuclear facilities, along with 11e.(2) byproduct material, was considered when the document stated:

> *"Because several...sites [currently undergoing decommissioning] have large quantities of uranium and thorium contaminated waste with characteristics similar to those of mill tailings, it may be cost-effective to dispose of decommissioning waste at existing mill tailings sites...This cost is substantially less than disposal costs at licensed low-level waste disposal sites..."*

This conclusion should be included in the GEIS process.

3. Elimination of Dual Jurisdiction over In-Situ Uranium Recovery Wellfields

3.1. The issue of dual (State and Nuclear Regulatory Commission (NRC) jurisdiction over in-situ uranium recovery wellfields is an important one to Kennecott Uranium Company. Unnecessary, duplicative regulation should be eliminated and that the States (assuming that they possess a suitable program) should bear the primary responsibility for the regulation of in-situ uranium recovery wellfields.

3.2. On June 8, 2007, the Commission issued a Staff Requirements Memorandum (COMSECY-07-015) that stated in part, *"The staff should remain diligent in working with EPA and appropriate States to establish appropriate standards to protect public health and safety and the environment and at the same time reduce, and preferably eliminate, dual regulation."*

3.3. Kennecott Uranium Company agrees with the above statement and requests that the Commission as part of the GEIS process finally resolve the outstanding issues regarding dual jurisdiction over in-situ uranium recovery wellfields so that the States, provided that they possess suitable programs, can assume primary jurisdiction over in-situ uranium recovery wellfields with Commission oversight.

4. Environmental Impact Areas To Be Analyzed

4.1. *Public and Occupational Health*

4.1.1. Kennecott Uranium Company has the following comments regarding this impact area:

4.1.1.1. In-situ uranium recovery operations in Wyoming are reasonably distant from high population areas and are designed to greatly reduce health risks to the general public.

4.1.1.2. In-situ uranium recovery operations do not have associated ore stockpiles or tailings impoundments. That results in substantially reduced levels of airborne particulate radionuclides

4.1.1.3. Many in-situ uranium recovery operations use rotary vacuum dryers (e.g.; Mestena's Alta Mesa Project) that emit no airborne particulate uranium.

4.2. *Waste Management*

4.2.1. The radioactive wastes produced by in-situ uranium recovery operations are 11(e)2 byproduct material and are small in quantity in comparison with the volumes of tailings produced by uranium mills. These wastes can be placed for disposal in existing uranium mill tailings impoundments. Criterion 2 of !0 CFR Part 40 Appendix A states:

4.2.1.1. Criterion 2--To avoid proliferation of small waste disposal sites and thereby reduce perpetual surveillance obligations, byproduct material from in situ extraction operations, such as residues from solution evaporation or contaminated control processes, and wastes from small remote above ground extraction operations must be disposed of at existing large mill tailings disposal sites; unless, considering the nature of the wastes, such as their volume and specific activity, and the costs and environmental impacts of transporting the wastes to a large disposal site, such offsite disposal is demonstrated to be impracticable or the advantages of onsite burial clearly outweigh the benefits of reducing the perpetual surveillance obligations.

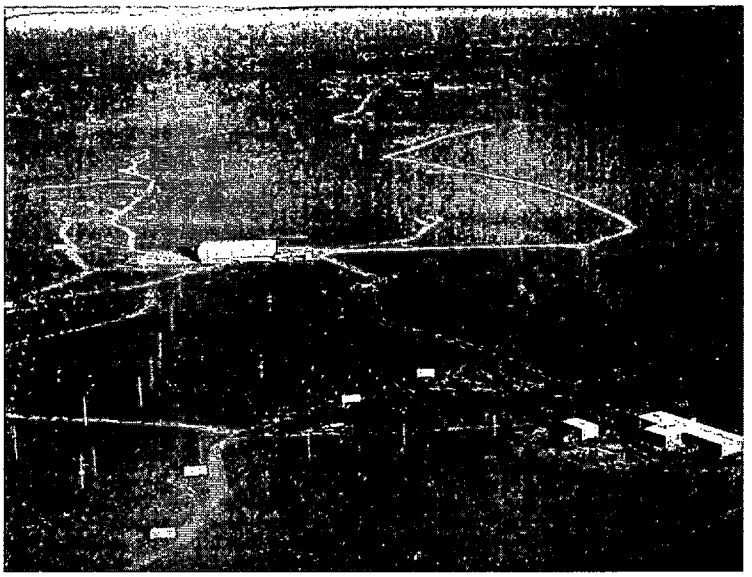
4.2.2. Should such capacity be unavailable uranium in-situ recovery operations should be allowed to join together to construct a common 11(e).2 disposal site that fully meets the requirements of 10 CFR Part 40 Appendix A.

4.3. *Land Use*

4.3.1. In-situ uranium recovery facilities are often located in areas that are remote. Land uses in these areas tend to be livestock grazing, oil and gas exploration and development and other similar uses.

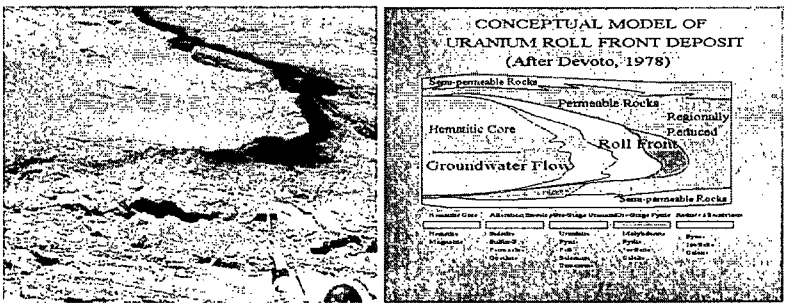
4.4. *Geology and Soils*

4.4.1. Uranium in-situ recovery operations tend to be located in areas of flat lying sedimentary rocks. Since the ground itself is not disturbed there is little disturbance of surface soils except for the construction of mud pits for drilling operations, foundations for buildings and roads. A wellfield at Power Resources, Inc.'s Highland Mine is shown below:



(Image courtesy of the Wyoming Mining Association's (WMA's) website)

4.4.2. The amount of surface disturbance is minimal. The actual leaching/extraction process is conducted underground. Most of the uranium is extracted from roll front deposits. An image of a typical roll front next to a diagram of one are shown below:



(Images courtesy of the Wyoming Mining Association's (WMA's) website)

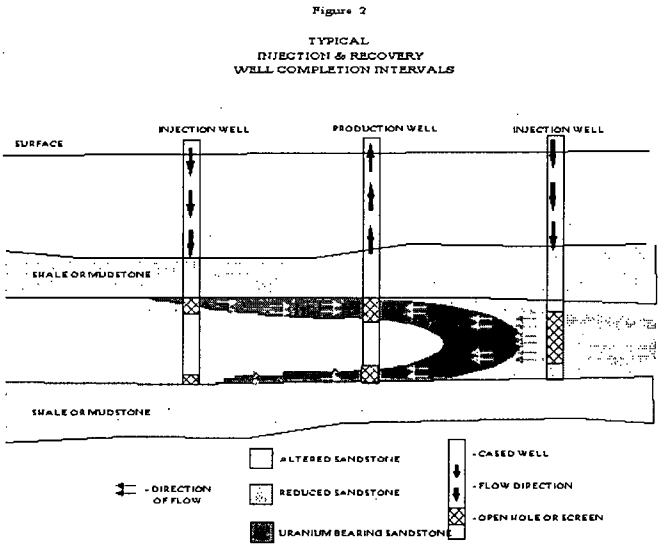
4.5. *Water Resources*

4.5.1. The single largest item regarding in-situ uranium recovery is water resources. In order to perform uranium in-situ mining the deposit must be in the saturated zone of an aquifer unless through extraordinary measures the unsaturated are is somehow grouted off from the unmineralized areas and artificially saturated/flooded. This alternative method for mining (by the in-situ method) naturally unsaturated deposits should be considered since given the current uranium price potential operators might consider it.

4.5.2. Uranium in-situ recovery operations are conducted within exempted portions of aquifers. Prior to operating, the operator must obtain an aquifer exemption for the portion of the aquifer in which the recovery operations are conducted from the Environmental Protection Agency (EPA) under 40 CFR

Part 144. The initial aquifer exemption application is submitted to the State under their applicable regulations and following State approval is then submitted by the State to the Environmental Protection Agency (EPA) for final approval. This layer of regulation is an important piece of regulatory oversight that assures that in-situ uranium recovery operations do not adversely impact groundwater.

4.5.3. As a general rule the process is conducted within the saturated zone of an aquifer between impermeable confining layers that reduce the potential for vertical movement of groundwater as shown in the diagram:



(Image courtesy of the Wyoming Mining Association's (WMA's) website)

4.5.4. The in-situ uranium recovery process does not result in the consumptive use of groundwater that occurs in open pit or underground uranium mining where large volumes of water are pumped out of an aquifer and discharged.

4.6. Kennecott Uranium Company also requests that the Commission as part of the GEIS process finally resolve the outstanding issues regarding dual jurisdiction over in-situ uranium recovery wellfields so that the States, provided that they possess suitable programs, can assume primary jurisdiction over in-situ uranium recovery wellfields with Commission oversight.

4.6.1. On June 8, 2007, the Commission issued a Staff Requirements Memorandum (COMSECY-07-015) that stated in part, "*The staff should remain diligent in working with EPA and appropriate States to establish appropriate standards to protect public health and safety and the environment and at the same time reduce, and preferably eliminate, dual regulation.*"

4.6.2. Kennecott Uranium Company agrees with the above statement and requests that the Commission as part of the GEIS process finally resolve the outstanding issues regarding dual jurisdiction over in-situ uranium recovery wellfields so that the States, provided that they possess suitable programs, can assume primary jurisdiction over in-situ uranium recovery wellfields with Commission oversight.

4.6.2.1. Under 10 CFR Part 40 depleted in-situ uranium recovery wellfields are not 11(e).2 byproduct material. The definition of 11(e).2 byproduct material (10 CFR 40.4) states:

4.6.2.1.1. *Byproduct Material means the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within this definition.*

4.6.2.1.2. Thus in regulating wellfields especially those in restoration, the States will not be regulating 11(e).2 byproduct material.

4.6.3. The use of bioremediation technologies as a better/more efficient means of achieving groundwater restoration should be addressed in the GEIS.

4.6.4. Groundwater restoration is an important issue in Wyoming. The following is a statement dated Friday, August 17, 2007, regarding groundwater restoration in Wyoming, by Mr. Rick Chancellor, Administrator of the Land Quality Division (LQD) of the Department of Environmental Quality (DEQ) that was included in an e-mail to Mr. Matt Grant, Assistant Director of the Wyoming Mining Association (WMA):

4.6.4.1. *"While uranium in situ recover operations have occurred in Wyoming for almost thirty years only a few well fields have been restored. However, the LQD has determined that those well fields have been restored to the pre-mining uses as required by the Wyoming Environmental Quality Act. The LQD is confident that the use of Best Practicable Technology as required in the Act will result in groundwater restoration and the protection of adjacent groundwater."*

4.6.4.2. Two (2) tables that accompanied the e-mail from Mr. Rick Chancellor are included in Appendix 2.

4.7. Ecology

4.7.1. The in-situ uranium recovery process is minimally intrusive with a small surface footprint causing little intrusion into the areas ecology.

4.8. *Air Quality*

4.8.1. In-situ uranium recovery operations have no ore pads or tailings impoundments so there is no associated windblown ore dust or tailings. Many use rotary vacuum dryers, which do not emit particulates. Thus air quality issues associated with in-situ uranium recovery operations are minimal.

4.9. *Noise*

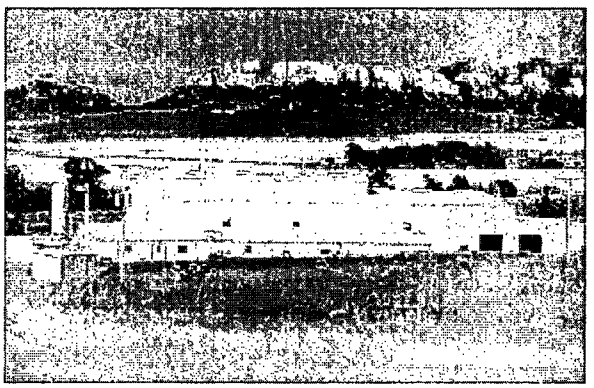
4.9.1. In-situ uranium recovery operations are quiet and located generally in remote areas so they present little associated noise problems. Possibly the greatest source of noise at such an operation are the drill rigs used to install the injection and recovery wells in the wellfield.

4.10. *Historical and Cultural Resources:*

4.10.1. Historical and cultural resources can occur in areas that have the potential for in-situ mining. This is a known issue in the Crownpoint, New Mexico area and in some areas of Wyoming where historic pioneer trails pass over or near potential resources.

4.11. *Visual and Scenic Resources:*

4.11.1. In-situ uranium recovery operations do not have major visual impacts. Cameco's Crow Butte Mine's plant building is shown below. It is one of the largest structures associated with in-situ uranium recovery and is not visually intrusive.



4.12. *Socioeconomics*

4.12.1. Uranium in-situ recovery operations are not large employers and will not have the impact that coal bed methane, and oil and gas development have already had in Wyoming in the last several years.

4.13. *Environmental Justice:*

4.13.1. The issue of environmental justice is particularly disturbing to the uranium mining and processing industry. Consideration of this issue implies that uranium recovery operators have a choice as to where they can locate their facilities. Uranium recovery operators are forced to locate their facilities where the extractable resource is located and have no choice in this matter. The uranium must be extracted where nature has placed it. As such operators must site their facilities where the resource is located. They do not site their facilities because any certain group of individuals resides in the

vicinity. The operator's siting decision is based on the location of the resource, which is determined by nature.

4.14. *Cumulative Effects:*

4.14.1. Cumulative effects can be an issue in Wyoming since some proposed in-situ uranium recovery operations may be located in areas already being used for oil and gas and/or coal bed methane development. The cumulative effects will however be minimal since new uranium recovery operations will not add substantial effects over and above those already present due to existing oil and gas operations and the oil and gas and coal bed methane operations are generally spread over a broad area and not highly concentrated.

Kennecott Uranium Company has also included Appendix 1 to this document that contains a brief description of uranium in-situ mining containing pictures and drawings that are useful in understanding the process.

Kennecott Uranium Company appreciates the opportunity to comment on this Notice of Intent. If you have any questions please do not hesitate to contact me.

Sincerely yours,

Oscar A Paulson

Oscar Paulson
Facility Supervisor

cc: Katie Sweeney - National Mining Association (NMA)

Appendix 1

Uranium In-Situ Recovery

In situ mining is a process by which uranium is extracted from porous and permeable host sands via well completed into these sands which serve as points of entry and exit for a lixiviant that is injected in some wells and recovered from others. During the lixiviants passage through the host sand from the injection well (point of entry) to the recovery well (point of removal/exit) it dissolves uranium out of the host sand via a chemical reaction involving oxidation.

Modern uranium extraction by in situ leaching is an environmentally benign process that involves minimal surface disturbance, minimal generation of solid wastes and two (2) simple chemicals, carbon dioxide and oxygen. The following companies at the following locations currently conduct uranium extraction by in situ leaching in the United States:

Company Name	Mine Name	Location
Cameco/Crow Butte Resources	Crow Butte Mine	Crawford, Nebraska
Cameco/Power Resources, Inc.	Smith Ranch/Highland Mine	Douglas, Wyoming
Mestena Uranium, Inc.	Alta Mesa Mine	Falfurrias, Texas
Uranium Resources, Inc	Vasquez Mine – Satellite Plant	Hebbronville, Texas
Uranium Resources, Inc	Kingsville Dome Plant	Kingsville, Texas

All of these operations consist of well fields from which the uranium is extracted, ion exchange plants in which the uranium is loaded onto ion exchange resins and elution/precipitation plants in which the uranium is stripped from the resin and precipitated as uranium oxide (yellowcake).

These facilities are operated under either a Nuclear Regulatory Commission (NRC) source material license in Nebraska and Wyoming, or an agreement state source material license in Texas. The operations are also operated under an Environmental Protection Agency aquifer (groundwater) exemption, underground injection control (UIC) permits and state issued permits to mine.

The Figure 1 below provides a flowsheet for the entire process based on the Smith Ranch Mine:

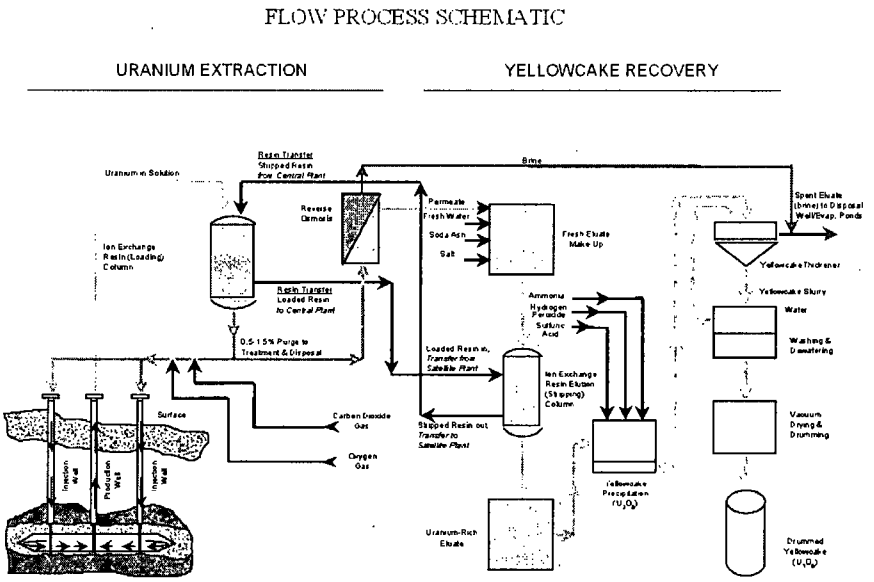


Figure 1 General Process Flowsheet – Smith Ranch Mine
(Image courtesy of the Wyoming Mining Association's (WMA's) website)

Process Description

The process is applied to deposits in porous and permeable sands and sandstones, generally to "roll front deposits. A photograph of a typical uranium roll front (Figure 2) compared with a conceptual model of one (Figure 3) is shown below:

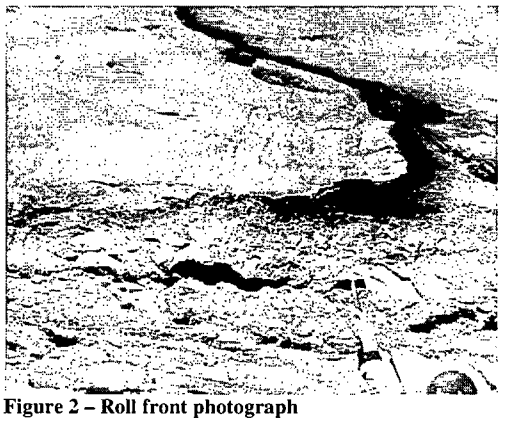


Figure 2 – Roll front photograph

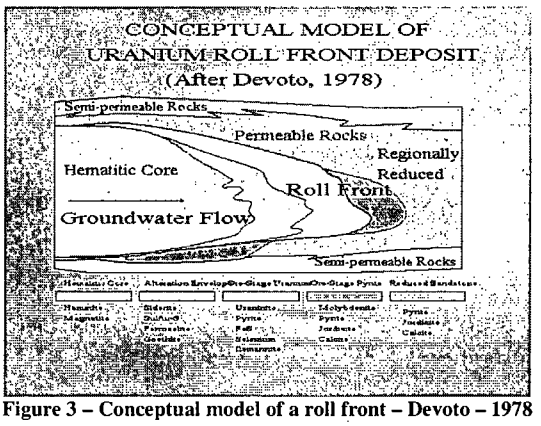


Figure 3 – Conceptual model of a roll front – Devoto – 1978

(Images courtesy of the Wyoming Mining Association's (WMA's) website)

A typical in-situ mineable uranium bearing reduced sand is shown in Figure 4 below:

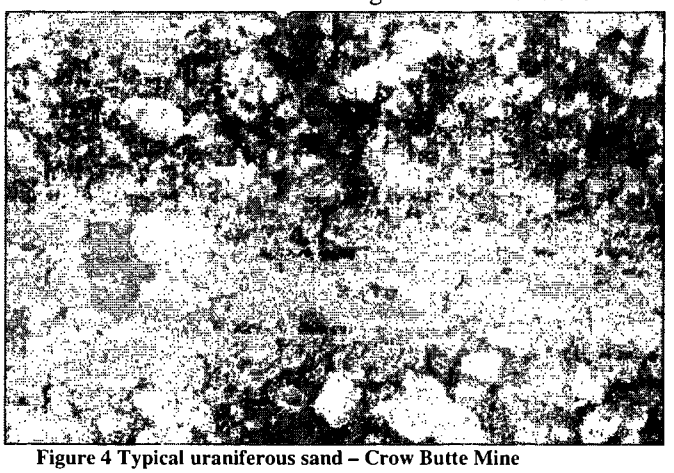


Figure 4 Typical uraniferous sand – Crow Butte Mine

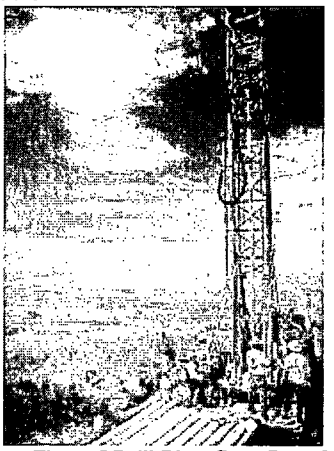
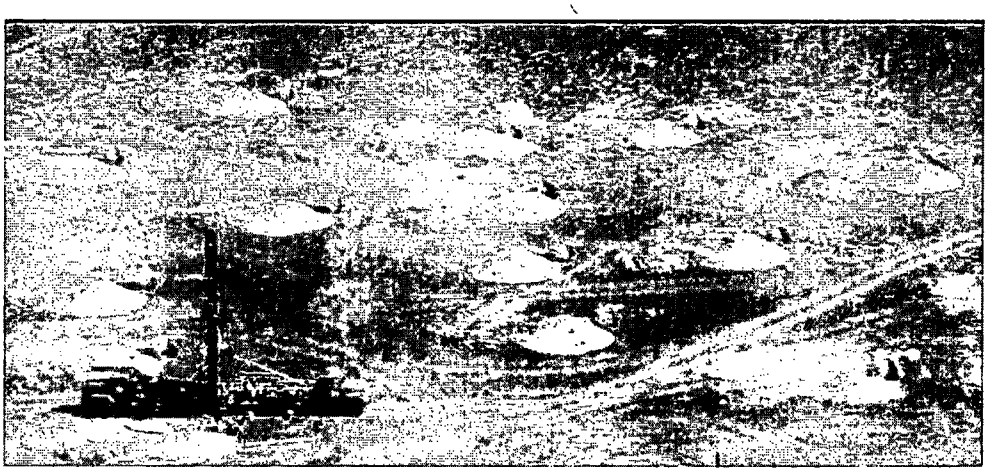


Figure 5 Drill Rig – Crow Butte Mine

(Images courtesy of the Wyoming Mining Association's (WMA's) website)



Wellfield Installation – Highland Mine – Wyoming

(Image courtesy of the Wyoming Mining Association's (WMA's) website)

The in situ leaching process begins with the completion of wells in the orebody using a large water well rig as shown above right in Figure 5.

A hole is drilled, geophysically logged and cased as is shown above. Most commonly the well is cased with PVC pipe. The area covered with wells is called a well field. The wells are screened (completed) just in the actual ore zone, which is determined by gamma logging of the borehole prior to casing. A diagram of a typical well completion used at the Smith Ranch Mine is shown below in Figure 6:

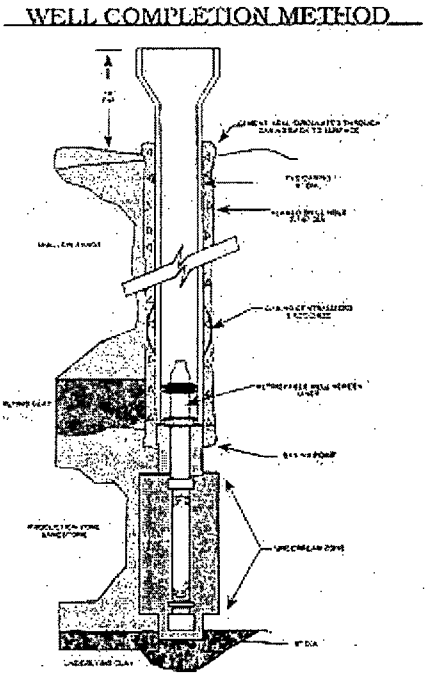
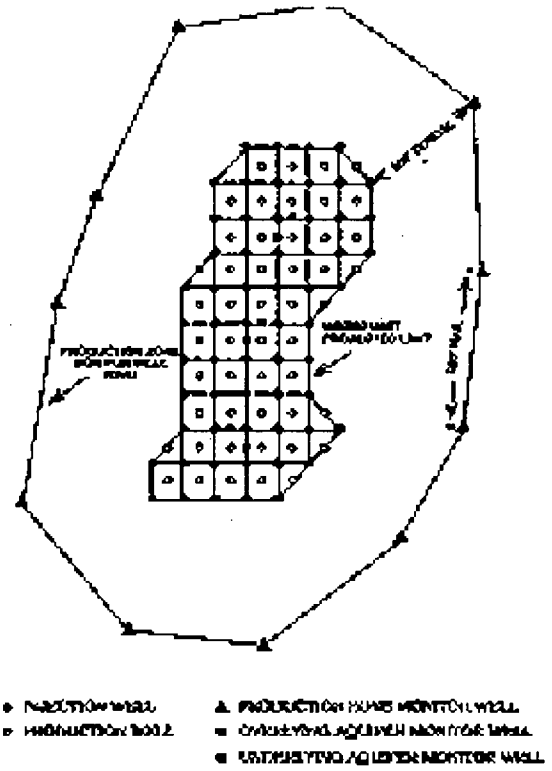


Figure 6 Typical Well completion
(Image courtesy of the Wyoming Mining Association's (WMA's) website)

This forces fluid injected into the well to only enter the ore zone and forces fluids pumped from the well to only originate from the ore zone. The wells are completed in varying patterns and at different depths, depending upon the shape and depth of the orebody. Generally, wells are approximately thirty (30) to fifty (50) feet apart. A typical well pattern from Power Resources, Inc.'s Smith Ranch Mine is shown below:

TYPICAL WELLFIELD DEVELOPMENT PATTERN
SMITH RANCH PROJECT



(Image courtesy of the Wyoming Mining Association's (WMA's) website)

Figure 7 below shows how in-situ uranium recovery wells are completed in a typical roll front deposit and Figure 8 shows how the sandstones are swept by the lixiviant to recover the uranium:

Figure 2

TYPICAL
INJECTION & RECOVERY
WELL COMPLETION INTERVALS

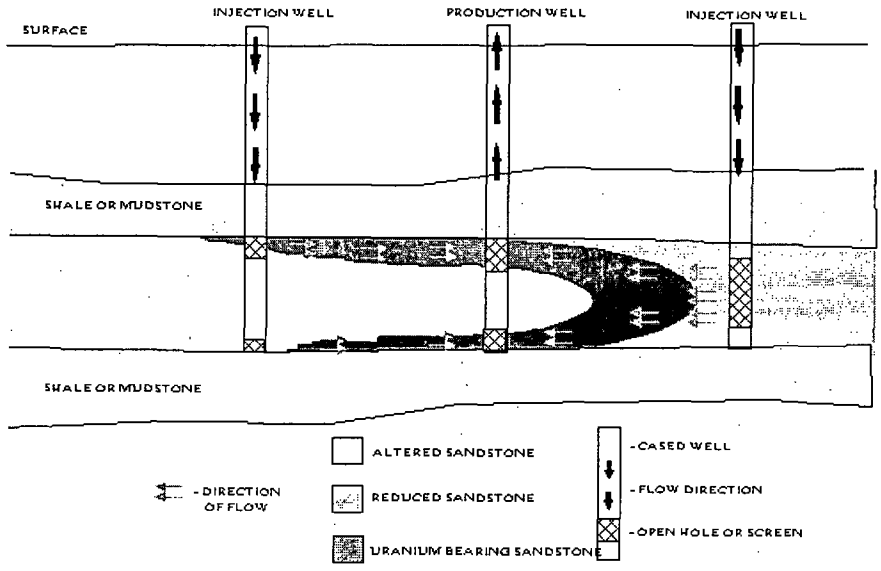
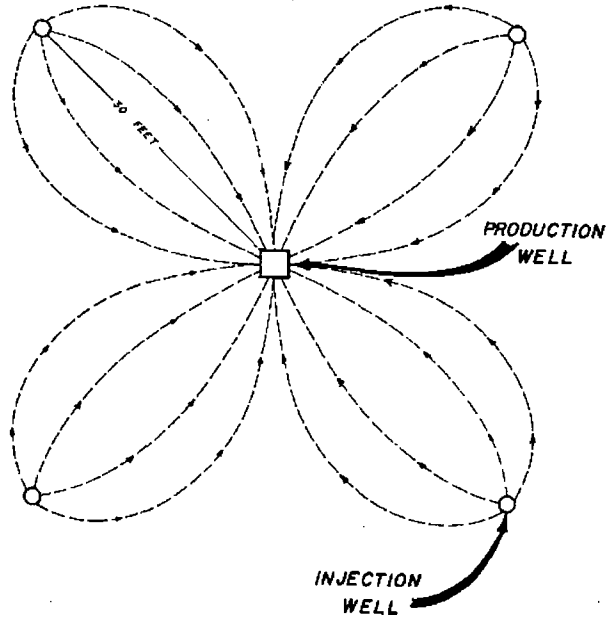


Figure 7 Injection and Recovery in a Rollfront
(Image courtesy of the Wyoming Mining Association's (WMA's) website)

Figure 11



Typical 5-spot well pattern.

Figure 8 Injection and Production Wells
(Image courtesy of the Wyoming Mining Association's (WMA's) website)

When the well field has been installed, the wells are piped up by connecting them to injection and production pipelines. Figures 9 and 10 below show a typical wellfield:

Mining begins when carbon dioxide (the complexing agent) and oxygen (the oxidant), which are both gasses, are added to groundwater removed from the aquifer. The fluid (groundwater with added carbon dioxide and oxygen) is now called lixiviant. The lixiviant is injected into the injection wells. The production wells are pumped to recover the lixiviant. As the lixiviant passes through the uranium bearing sands between the injection and production wells, the oxygen oxidizes the uranium in the formation while the carbon dioxide complexes it as soluble uranyl tricarbonate.

Figure 10 shows the general arrangement of in in-situ leach wellfield while Figure 9 is a photograph of a wellfield at the Highland Ranch Mine, near Douglas, Wyoming.

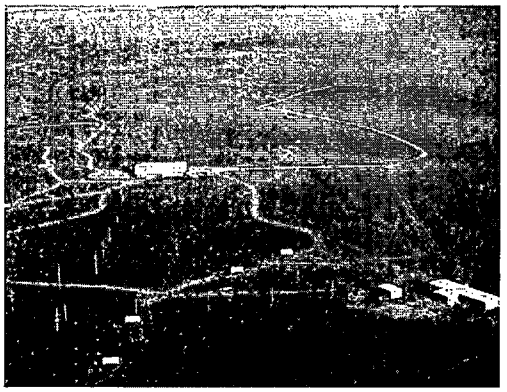


Figure 9 Wellfield – Highland Ranch

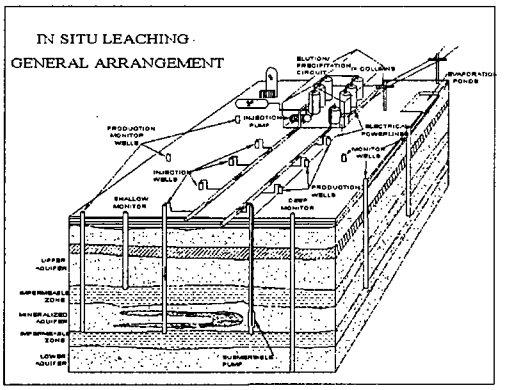


Figure 10 – Wellfield Diagram

(Images courtesy of the Wyoming Mining Association's (WMA's) website)

The uranium dissolves in the lixiviant and is carried to the production wells where the lixiviant is pumped to the surface via the downhole pumps installed in each production well. The lixiviant is pumped to an ion exchange plant which functions like a large water softener. Figure 11 is a photograph of an ion exchange plant while Figure 12 is a simplified flowsheet of a satellite recovery plant.

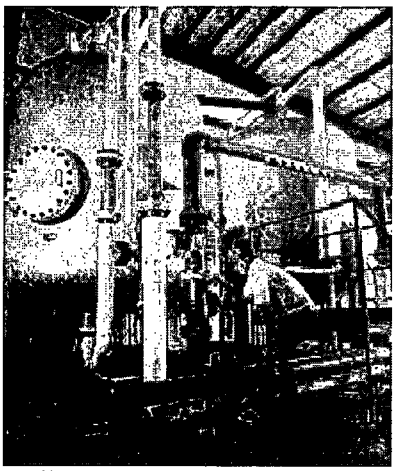


Figure 11 - Ion Exchange Columns – Crow Butte Mine

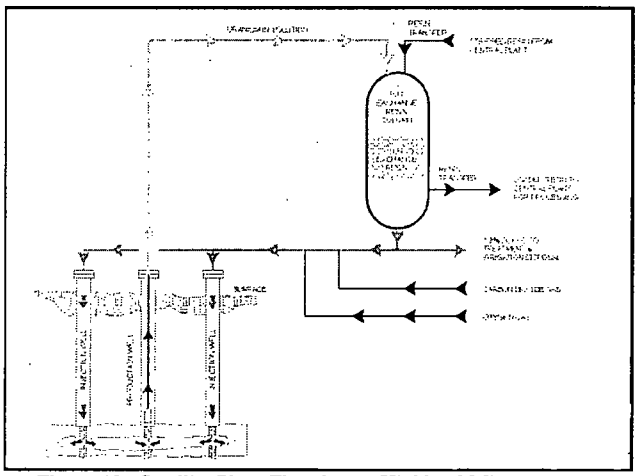


Figure 12 - Satellite Plant Flowsheet – Highland Mine

(Images courtesy of the Wyoming Mining Association's (WMA's) website)

This photograph is of ion exchange columns at Crow Butte Resource's Crow Butte Mine. A flow sheet for a satellite plant at Power Resources, Inc. Highland Mine is in Figure 12. This flowsheet describes how any downflow ion exchange columns operate. The lixiviant flows through beads of ion exchange resin contained in an ion exchange column (usually a sealed pressure vessel) which capture the uranium from the lixiviant.

Some times upflow columns are used in which the lixiviant flows up from the bottom of the column through the resin bed and out the top over weirs.

A stand alone ion exchange plant in or near a well field is known as a satellite plant. A satellite plant with a resin-hauling trailer is shown below in Figure 15.

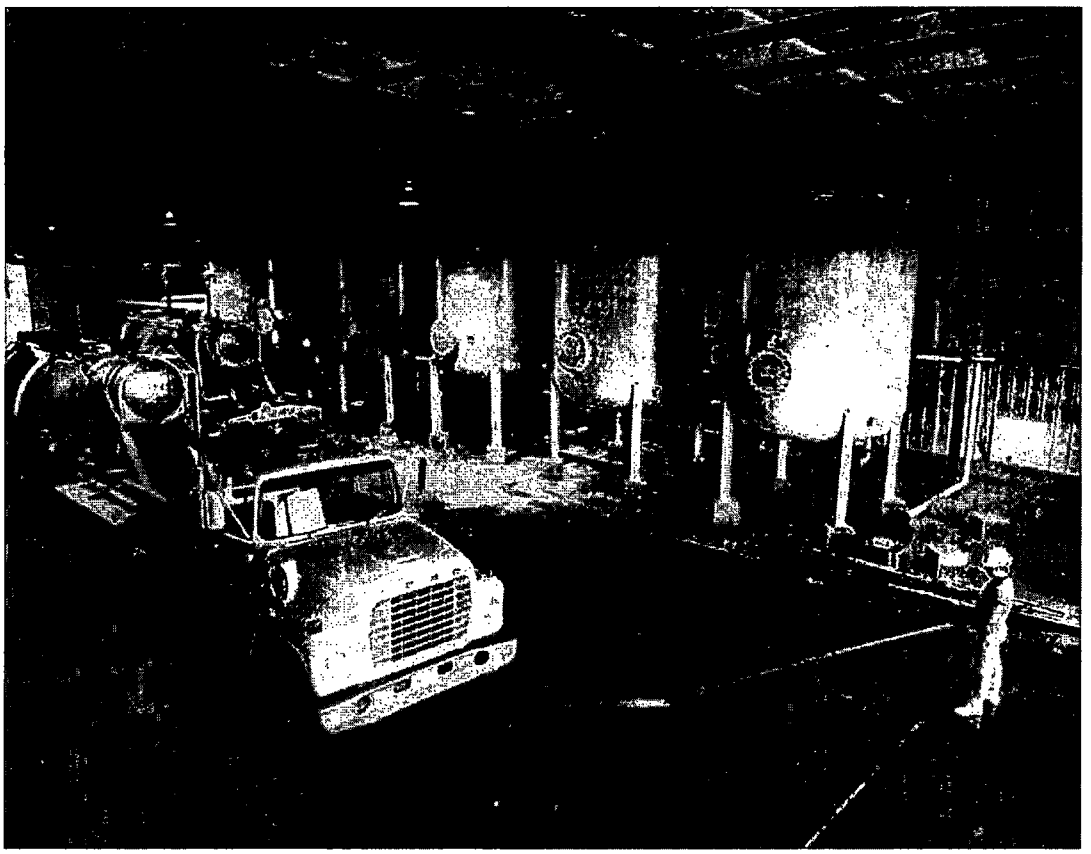


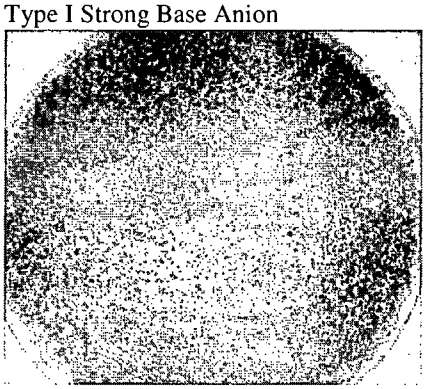
Figure 15 - Satellite Ion Exchange Columns with Resin Trailer – Highland Ranch Mine
(Image courtesy of the Wyoming Mining Association's (WMA's) website)

Any columns are usually filled with a strong base anion ion exchange resin such as Dow 21K. The properties of DOW 21 K are listed below:

DOWEX™ 21K 16/20 is a high efficiency, strong base anion exchange resin for mineral processing applications.

	Type	Matrix	Functional Group
Dow 21K	Type I Strong Base Anion	Styrene-DVB, Gel	Quaternary Amine

Resin Image:



Guaranteed Sales Specification	**Units**	**Cl^- Form**
Total Exchange Capacity, min.	eq/L	1.2
Particle Size Distribution		
% through 20 mesh, max.	%	10
% through 25 mesh, max.	%	2

Typical Physical and Chemical Properties	Units	Cl^- Form
Water Retention Capacity	%	50 - 58
Whole Uncracked Beads	%	90 - 100
Total Swelling ($Cl^- \rightarrow OH^-$), approx.	%	20
Particle Density, approx.	g/mL	1.08
Shipping Weight, approx.	g/L	690
Shipping Weight, approx.	lbs/ft^3	43

The above information on DOWEX 21K resin and image was taken from Dow's web site http://www.dow.com

The properties of Rohm and Haas's Amberlite IRA910U resin another type of uranium recovery resin are included below:

AMBERLITE™ IRA910U Cl Type 2, macroreticular, strong base anion exchanger with high capacity for uranium and excellent elution kinetics

Description:
Rohm and Haas AMBERLITE™ IRA910U Cl is a strongly basic, crosslinked, polystyrenic, type 2 macroreticular anion exchange resin for use in uranium recovery processes.

Used in:
- Chemical processing

Advantages:
- Excellent stability
- High capacity
- Excellent purification
- High yield

Properties:
Typical Properties
These properties are typical but do not constitute specifications.

Matrix	Macroreticular crosslinked polystyrene
Functional groups	$-N^{+}(CH_3)_2C_2H_4OH$
Physical form	Opaque beads
Ionic form as shipped	Chloride
Total exchange capacity [1]	$\geq$ 1.0 eq/L (Cl^- form)
Moisture holding capacity [1]	54 to 61 % (Cl^- form)
Shipping weight	700 g/L (43.7 lb/ft^3)
Harmonic mean size	0.700 - 0.900 mm
Uniformity coefficient	$\leq$ 1.50
Fines content [1]	< 0.710 mm : 5.0 % max
Coarse beads	> 1.180 mm : 4.0 % max
Maximum reversible swelling	Cl – OH: 15%

[1] Contractual value
Test methods available upon request

The above information on Rohm and Haas's Amberlite IRA910U resin was taken from Rhom and Haas's web site http://www.rohmhaas.com/wcm/

The ion exchange resin will capture approximately six (6) to eight (8) pounds of uranium per cubic foot of resin. Once loaded the resin must be eluted (stripped of its uranium content).

A process called elution removes the uranium loaded on the resin in the columns

- The resin is washed/eluted in place/inside of the columns with a four- (4) normal sodium chloride solution with sodium carbonate added to increase the pH to 9.0 to 9.4.

- The chloride exchanges for the uranium on the resin and the uranium enters the eluate solution. The resin is eluted in several stages using fresher and fresher eluant to insure good removal of the loaded uranium. Usually the resin must be eluted with at least four (4) to eight (8) bed volumes of eluate (depending upon whether the resin is air agitated during the elution process) in four (4) stages to assure complete elution.
- The elution reaction is as follows:
    - 4NaCl+3R-UO2(CO3)3 ----->Na4UO2(CO3)3+4[R-Cl]
    - Note: R means resin molarity

This process is often performed in a central plant in the case that wellfields have satellite plants and the loaded resin is hauled by truck to a central location for elution. A flowsheet for Power Resources, Inc.'s central plant at their Highland Mine is shown below in Figure 17.

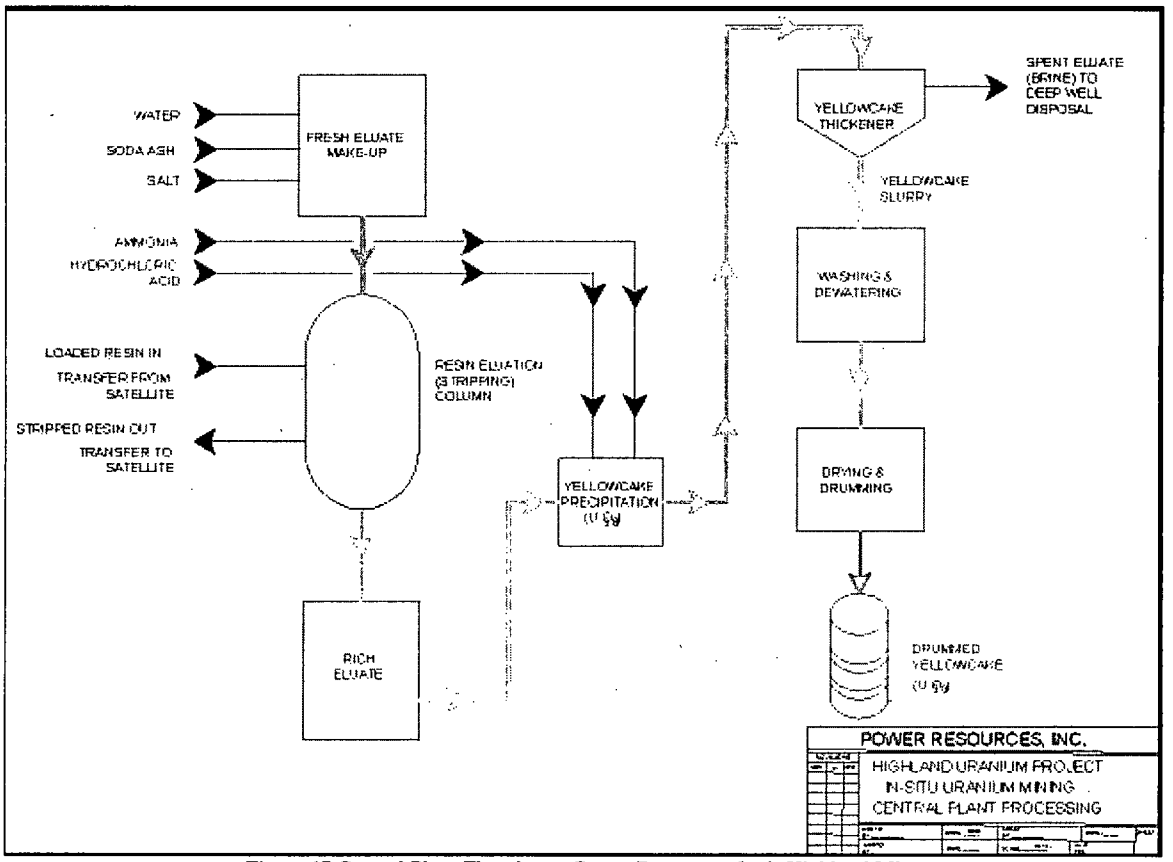


Figure 17 Central Plant Flowsheet – Power Resources, Inc's Highland Mine
(Image courtesy of the Wyoming Mining Association's (WMA's) website)

The uranium, now in a concentrated solution, called eluate is precipitated, usually with hydrochloric acid and hydrogen peroxide, but sometimes with ammonia and sulfuric acid. The maximally loaded (pregnant) eluate can be treated to precipitate the dissolved uranium by the following process:

- Hydrochloric acid is added to lower the pH.
- Concentrated (30% to 50%) hydrogen peroxide (H2O2) is added at a 0.15 moles H2O2 to one (1) mole U3O8
- A flocculent is added to settle the yellowcake.
- Precipitation is usually performed in a cone bottomed fiberglass tank
- The pH of the tank's contents is adjusted (raised) with caustic soda to at least four (4) if not five (5) or higher.
- The now settled yellowcake is decanted and pumped into either a thickener or belt filtered prior to drying or pumping into a slurry trailer for haulage to a drying facility.
- Belt filtering of yellowcake slurry is shown below

The uranium is precipitated as slurry called yellowcake shown in Figure 19 below. The yellowcake slurry is dried and barreled and shipped to a converter. Often the slurry is either centrifuged or filter pressed prior to drying to remove excess fluid as is shown in Figure 18 below.

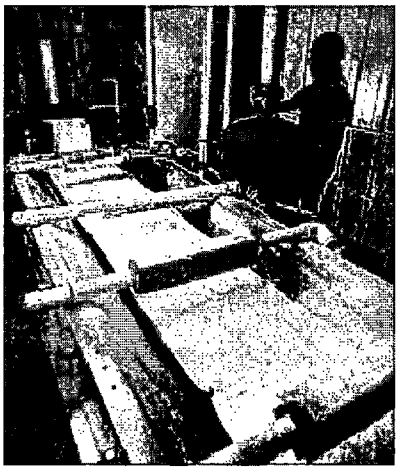


Figure 18 Yellowcake Slurry – Crow Butte Mine

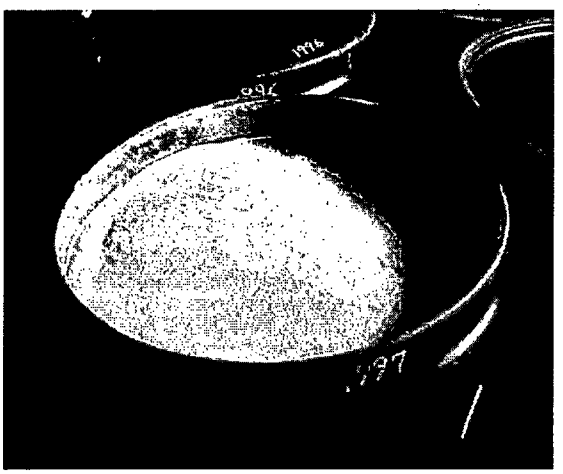


Figure 19 Dried Yellowcake Product – Cogema

(Images courtesy of the Wyoming Mining Association's (WMA's) website)

Drying is either accomplished with a multiple hearth roaster (Power Resources, Inc.'s Smith Ranch/Highland Mine or via a rotary vacuum dryer (Mestena Uranium, Inc's Alta Mesa Mine).

Once the uranium has been extracted from the aquifer, elevated quantities of uranium along with some other metals such as selenium, molybdenum and vanadium remain in the ground water. In addition, the total dissolved solids (TDS) content of the ground water may be elevated. The groundwater must be restored in accordance with the permit requirements and applicable State and Federal regulations. Ground water restoration can begin by first removing water from the aquifer and disposing of it by evaporation or disposal into a deep injection well which places the water into a deep brine laden formation. The water can then be further treated with reverse osmosis. Use of this process involves pumping volumes of water out of the aquifer, treating it by concentrating the contaminants into a small bleed stream, which is evaporated or injected into a disposal well, and reinjecting the purified water into the aquifer. In some cases, the aquifer water is treated with a reductant such as hydrogen sulfide to precipitate metals (uranium, selenium, arsenic, and molybdenum) in it. Bioremediation as a means of groundwater restoration is being considered in the industry. This groundwater remediation system would involve nutrients being injected in to wellfields to be restored and bacteria (native or introduced) metabolizing the nutrients and respiring on dissolved metals precipitating them. Groundwater restoration methods vary widely by operator.

Appendix 2

Major Ions	Baseline Average	Restoration Average	Class I Standards
Calcium (Ca)	49.51	86.4	
Magnesium (Mg)	10.18	17.7	
Sodium (Na)	57.21	43.5	
Potassium (K)	7.96	5.8	
Carbonate (CO3)	0.149	0.0	
Bicarbonate (HCO3)	206.48	344	
Sulfate (SO4)	117.27	64.7	250.0
Chloride (Cl)	5.33	12.7	250.0
Ammonium (NH4) as N	3.85	0.30	0.5
Nitrite (NO2) as N	0.01	0.1	1.0
Nitrate (NO3) as N	0.143	0.1	10.0
Fluoride (F)	0.215	0.16	4.0
Silica (SiO)	15.84	14.7	
Non-Metals			
Total Dissolved Solids (TDS)	350.28	386	500
Conductivity	563.98	672	
Alkalinity	170.62	282	
pH	8.12	7.1	6.5-8.5
Trace Metals			
Aluminum (Al)	<0.01	0.1	
Arsenic (As)	0.001	0.045	0.050
Barium (Ba)	<0.1	0.12	1.0
Boron (B)	<0.1	0.1	0.75
Cadmium (Cd)	<0.01	0.005	0.01
Chromium (Cr)	<0.05	0.05	0.05
Copper (Cu)	<0.01	0.01	1.00
Iron (Fe)	0.052	1.84	0.30
Lead (Pb)	<0.05	0.05	0.05
Manganese (Mn)	0.032	0.52	0.05
Mercury (Hg)	<0.001	<0.001	0.002
Molybdenum (Mo)	<0.1	0.1	
Nickel (Ni)	<0.05	0.05	
Selenium (Se)	0.001	0.010	0.01
Vanadium (V)	<0.10	0.1	
Zinc (Zn)	0.011	0.01	5.00
Radiometric			
Uranium (UNat)	0.062	2.40	
Radium 226 (Ra)	315.54	567	5

IRIGARAY DESIGNATED RESTORATION WELLS WATER QUALITY SUMMARY					
	Units 1-9 Baseline Minimum	Units 1-9 Baseline Maximum	Units 1-9 Baseline Mean	Units 1-9 Restoration Mean	Class I Standards
Major Ions mg/l:					
Ca	1.6	27.1	7.8	29.1	
Mg	0.02	9	0.9	7.0	
Na	95	248	125	188.0	
K	0.92	17.5	2.4	3.0	
CO3	0	96	13.2	0.8	
HC03	5	144	88.3	420.5	
SO4	136	504	188.1	133.1	250
Cl	5.3	15.1	11.3	42.0	250
NH4	0.05	1.88	0.3	8.8	0.5
NO2 (N)	0.1	1	0.4	0.1	1
NO3 (N)	0.2	1	0.9	0.1	10
F	0.11	0.68	0.29	0.1	4
SiO2	3.2	17.2	8.3	5.1	
TDS	308	784	404	629.7	500
Cond. (mmho/cm)	535	1343	658	1079.9	
Alk. (as CaC03)	67.8	232	104	348.8	
pH (units)	6.6	11	9	7.8	6.5-8.5
Trace Metals mg/l:					
Al	0.05	4.25	0.16	0.1	
As <	0.001	0.105	0.007	0.0	0.05
Ba <	0.01	0.12	0.06	0.1	1
B <	0.01	0.225	0.11	0.1	0.75
Cd <	0.002	0.013	0.005	0.0	0.01
Cr <	0.002	0.063	0.02	0.0	0.05
Cu <	0.002	0.04	0.011	0.0	1
Fe	0.019	11.8	0.477	0.1	0.3
Pb <	0.002	0.05	0.02	0.0	0.05
Mn <	0.005	0.19	0.014	0.2	0.05
Hg <	0.0002	0.001	0.0004	0.0	0.002
Mo <	0.02	0.1	0.06	0.1	
Ni <	0.01	0.2	0.1	0.0	
Se <	0.001	0.416	0.013	0.0	0.01
V <	0.05	0.55	0.07	0.1	
Zn	0.009	0.07	0.016	0.0	5
Radiometric pCi/l:					
U (mg/l)	0.0003	18.6	0.5162	2.0	
Ra 226	0	247.7	39.6	133.6	
Ra 226+/-				4.1	5