RECENT DEVELOPMENTS IN URANIUM MINING AIR SAMPLING PROGRAMS IN THE UNITED STATES

BY
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Introduction and History

Commercial uranium mining operations in the United States, beginning in the post World War II era, were primarily open pit mining. Open pit mining was the primary extraction method until in-situ recovery (ISR) began in the State of Wyoming in 1961[1]. ISR is also known as in-situ leaching (ISL), or solution mining. It is a mining process utilized to recover minerals, such as uranium, through boreholes drilled into an ore bearing deposit, in-situ.

The USA uranium mining industry has experienced boom and bust cycles. The post World War II era activity in the uranium mining industry was fueled by the US Atomic Energy Commission's (AEC) desire to develop its nuclear program. Uranium mining projects in the 1950s, 1960s and 1970s were very active because they were driven by the growth of the U.S. nuclear defense program and the commercialization of nuclear power reactors for electrical production.[2]

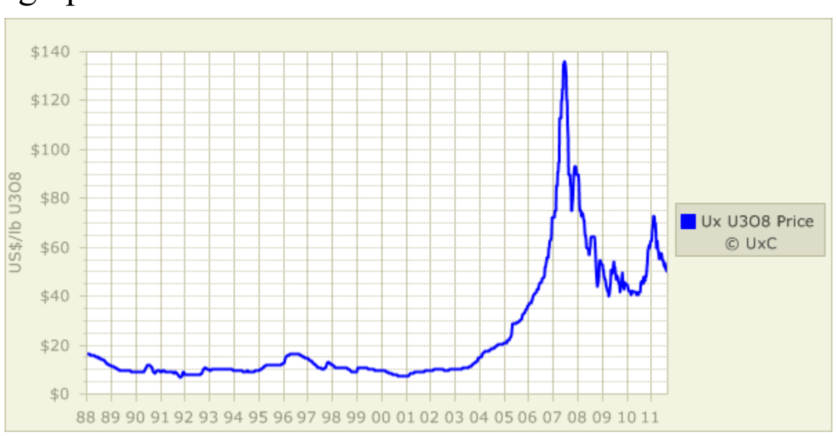
The Three Mile Island event in 1979 created a chilling effect on the future of commercial nuclear power in the USA and thus on the uranium mining industry due to the market decline in uranium ore prices. The Chernobyl incident in 1986 further depressed uranium ore prices until the 21st century when the political climate began to improve for the nuclear option. The most recent Fukushima incident in March of 2011 has also impacted the market price of uranium ore which had been rising since early in the most recent decade.

A listing of peak uranium ore pricing beginning in the 1980s and for various subsequent years is provided in graph below.[3]

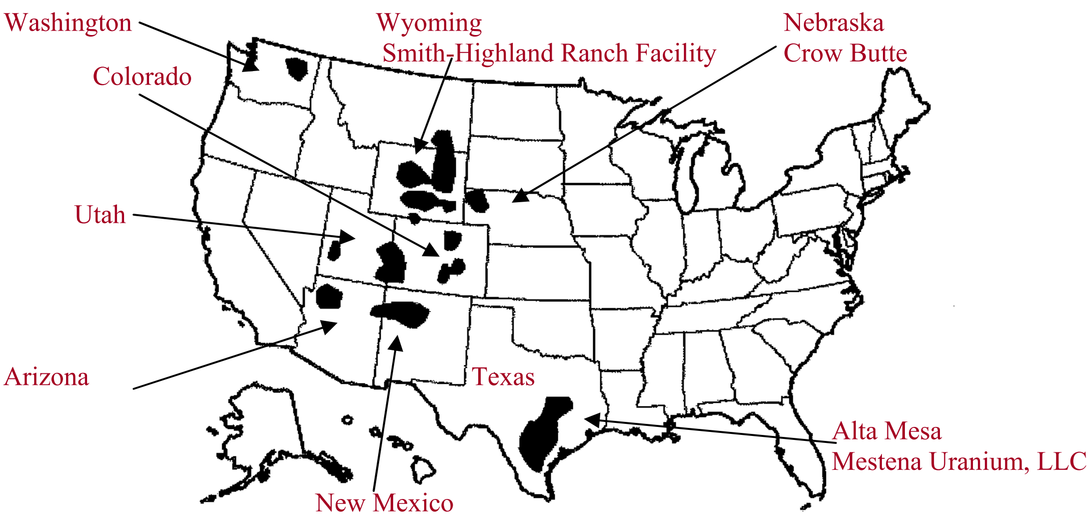
Table I

30 Years Uranium Peak Ore Prices
1981—2011

Year	USD/lb.—U_3O_8
1981	$32.90
1990	$12.55
2000	< $10.00
2001	$7.00
2007	$113.00
2011	$73.00



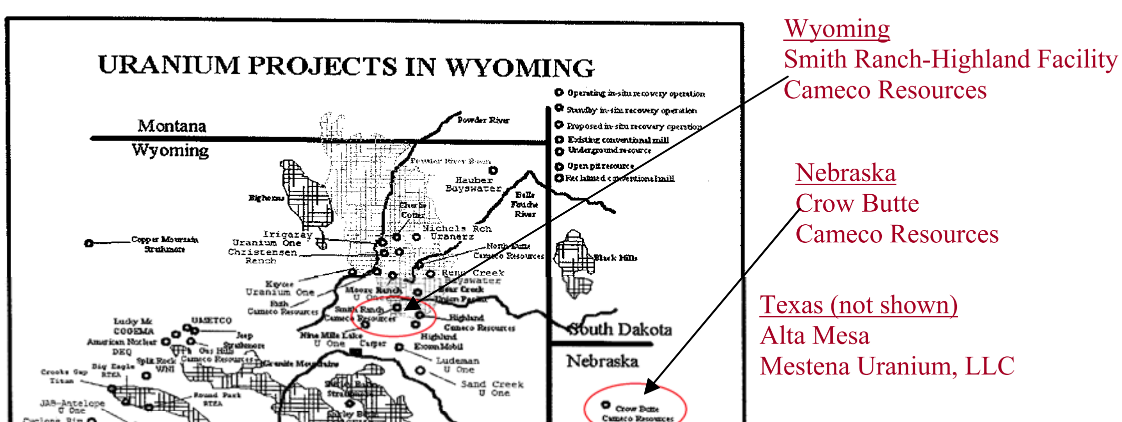
The major USA uranium reserves are located in the states of Texas, New Mexico, Arizona, Utah, Colorado and Wyoming. The EIA estimates that the uranium reserves recoverable through the ISR process to be approximately 446 million pounds of U_3O_8 at a price of $100.00 per pound. The USA ranks sixth in the world in total global reserves of uranium.[4]



Three ISR facilities currently operate in the United States. They are located in the states of Wyoming, Nebraska and Texas[1]. ISR uranium mining is currently still the predominant technique utilized for uranium mining operations in the United States.

Operational Uranium Projects in Wyoming and Nebraska

In-situ mining operations in Wyoming have resulted in Wyoming leading the USA in uranium production for the most recent 15 years. The Smith Ranch-Highland facility has been the largest ISR operation in the USA for the last decade.[1]



There is considerable pre-operational monitoring at various sites in Wyoming.

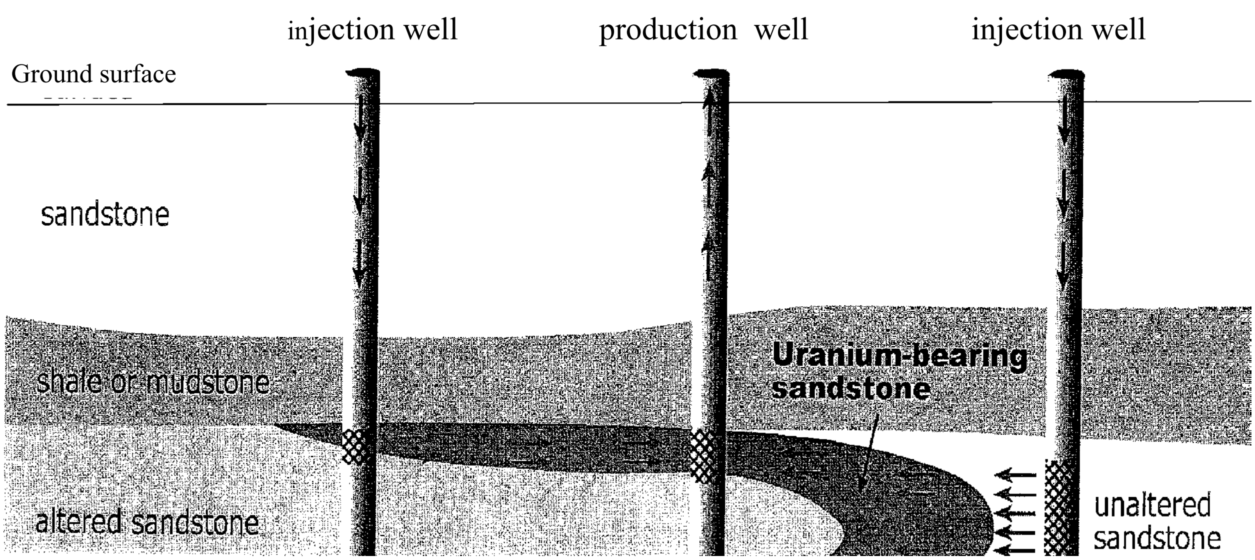
In-situ Recovery Process

The ISR process in the USA is utilized primarily where uranium is deposited in sandstone. This method of mining involves the injection of a water solution (usually groundwater) containing oxygen and carbon dioxide gas into the uranium bearing ore via injection wells which are cased.

The ISR process utilizes a closed groundwater system. Once a well field has yielded its full production, the groundwater within the depleted ore body is treated to meet regulatory standards.[1]

The O_2 and CO_2 enriched solution dissolves the uranium from the ore. The ore in solution is pumped to the surface via other cased recovery wells.

The dissolved uranium in solution is then removed in a water treatment plant utilizing ion exchange resin beds. Subsequently, the uranium is stripped from the resins, concentrated, precipitated, dewatered and dried.[5]



Typical IRS Well Field Design

The majority of the environmental impacts of ISR mining are primarily related to groundwater pollution of the production aquifer or surrounding aquifers.

Regulatory Oversite

The Nuclear Regulatory Commission (NRC) has regulatory authority in the United States over uranium source materials (uranium ores), by products (tailings and wastes) and enriched uranium.

State and local regulatory agencies may also have jurisdiction as it relates to groundwater and air quality based on environmental statutes or ordinances.

An Environmental Impact Statement (EIS) is usually developed by the NRC with the USEPA in an oversight role to ensure compliance with the National Environmental Policy Act (NEPA).

The NRC utilizes Regulatory Guide 4.14, Radiological Effluent and Environmental Monitoring at Uranium Mills as the vehicle to regulate the ISR pre-operational and operational monitoring programs. The NRC considers ISR facilities to be a milling operation.

Reg. Guide 4.14, Section 1 specifies the pre-operational monitoring program requirements. The pre-operational air sampling requirements are specified in subsection 1.1.1. Air Samples.

Table I

a) Continuous air sample at a minimum of three locations at or near the site boundary

b) If a residence or occupable structure exists within 10 Km of the site, a continuous outdoor air sample should be collected at or near the structure

c) At or near at least one structure where the predicted dose exceeds 5% of the standards in 40CFR Part 190.

d) A continuous air sample should be collected at a remote location that represents background (least prevalent wind direction)

Air particulate sampling and analysis requirements are as follows:

The typical duration of the sample collection activity is weekly.

Operational Monitoring requirements for air sampling are specified in section 2 of Reg. Guide 4.14. They are essentially identical to the pre-operational monitoring requirements.

Reg. Guide 4.14 Section 5 states the lower limit of detection for analysis of air samples other than stack samples should be as follows:

U-natural, Th230, Ra-226 in air - 3.7×10^{-6} Bq/m^3 (1×10^{-16} µCi/ml)
Pb210 - 9.25×10^{-5} Bq/m^3 (2×10^{-15} µCi/ml)

The typical analytical results for the particulate filter analysis are listed in the table below.

	NRC LLD Bq/m^3 (µCi/cc)	Airborne Concentrations Bq/m^3 (µCi/cc
PB-210	7.4×10^{-5} (2×10^{-15})	7.4×10^{-5} (2×10^{-15})
Natural U	3.7×10^{-6} (1×10^{-16})	ND to 1.48×10^{-5} (4×10^{-16})
Th-230	3.7×10^{-6} (1×10^{-16})	ND to 1.48×10^{-6} (4×10^{-17})
Ra-226	3.7×10^{-6} (1×10^{-16})	Non Detectable

ND = Non Detectable

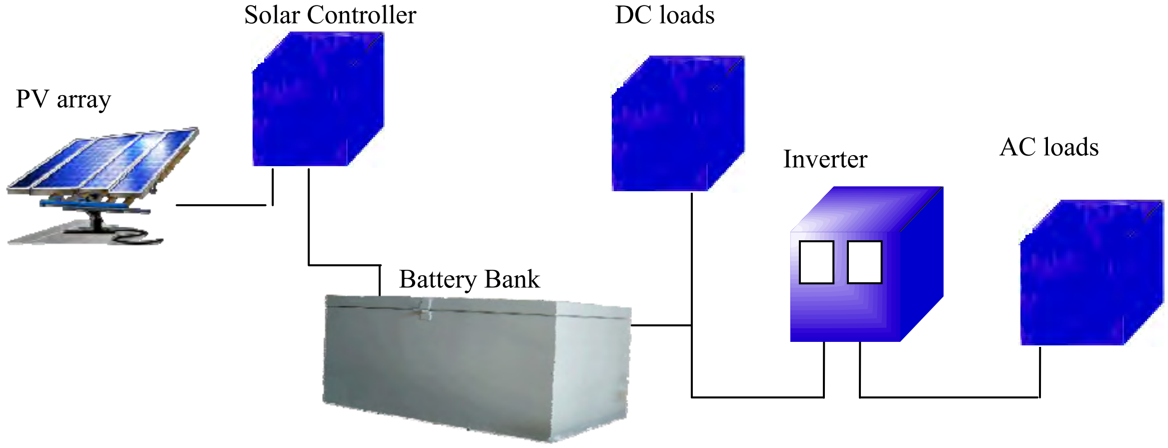
Typical Air Sampling Instrument Options

The majority of pre-operational ISR sites are located in remote locations where line power is not available. Therefore, the air sampling system design most probably will include either power generation from a renewable energy source, such as solar panels or a wind turbine. The alternative energy source charges batteries which in turn are utilized to power the air sampling system.

Typical Remote ISR Mining Environment in Wyoming
(July 2011; Near Jeffery City, Wyoming)

The electrical power stored in the batteries can be utilized to operate the air sampling system in one of two ways:

1) directly if the air sampler has a direct current (DC) motor or
2) Indirectly utilizing an inverter to convert the DC voltage from the batteries to AC voltage to operate an air sampler powered by an AC motor.



Electrical generators operable from natural gas, diesel fuel or gasoline are not generally chosen to operate AC power air sampling systems due to the noise and manpower requirements needed to maintain fuel available on a 24/7 basis.

Typical USA air monitoring stations utilized at ISR sites are illustrated below:

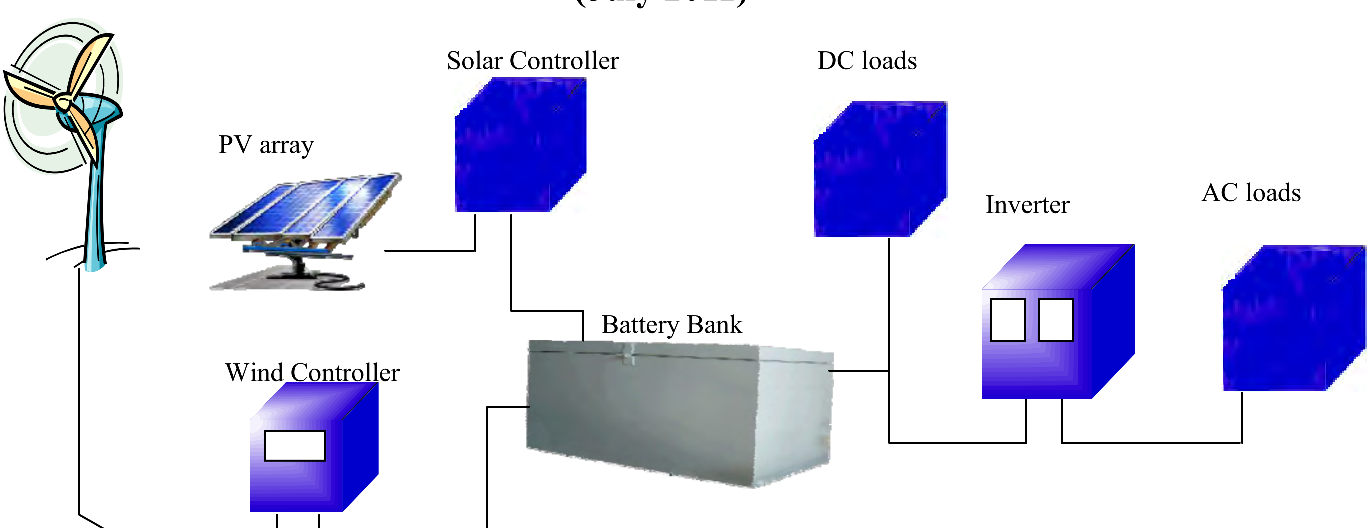
System with large external battery box (July 2011)

System with battery box inside Enclosure (July 2011)

Examples of solar powered air sampling station configurations illustrating the enclosure contents are provided below.

A hybrid system utilizing a wind turbine and solar panels is another option. A trailer mounted hybrid system is illustrated below.

Trailer Mounted Hybrid Solar/Wind Turbine Air Sampling System (July 2011)



Generally, when facility operation begins, line power becomes available at the ISR site. It may be possible if the air sampling stations are within reasonable distances of available power to have line power service brought to the station and operate standard AC continuous duty air samplers. Otherwise, a solar panel or wind turbine powered air sampling system is the preferred choice.

Several USA companies conducting pre-operational ISR sampling programs in Wyoming and Texas are utilizing brushed or brushless motor AC/DC air sampling instruments which can operate from either DC or AC voltage input. Models with either 12VDC or 24VDC are being utilized.

12VDC Brushless Motor System

24VDC Brushless Motor System

These AC/DC air sampling systems are available commercially in analog rotameter based systems or in advanced-technology designs utilizing microprocessor technology and state-of-the-art electronics. The hi-tech systems are often called "Smart Air Samplers".

These smart air sampling systems offer very desirable features which include;

1. Normalization of flow rates and accumulated sample volumes to a Reference Temperature (T) and Pressure (P)
2. RS232 communications port
3. Ability to automatically switch to a back up air sampler if the primary air sampler fails
4. Automatic volume totalization
5. Real-time data collection and storage options
6. Improved accuracy
7. Ability to operate and monitor the air sampling stations remotely, including performance of periodic sampling.

Regulatory Guide 4.14 in subsection 6.3, Quality of Results, requires implementing a program that ensures the quality of results and for keeping random and systematic uncertainties to a minimum. The use of smart air samplers enables compliance with this requirement an easy task. The inability of analog air samplers to normalize flow rates to standard conditions of T and P and to accumulate sample volumes accurately results in the smart air samplers being the best choice for demonstrating compliance with regulatory requirements.

Subsection 6.3 of Regulatory Guide 4.14 also requires that procedures should ensure that samples and measurements should be obtained in a uniform manner. The advanced-technology systems available on the market today which offer normalization of gas volumes clearly out perform the traditional analog air sampling systems in regards to uniformity of data collection when multiple air sampling sites are involved.

The quality of the air measurement data with smart air samplers can be comparable to the 95% confidence level of the radiochemistry analysis. Utilization of advanced-technology air sampling systems whether they be AC or DC powered instruments will definitely improve the quality of the data. The majority of the ISR uranium companies in the United States are utilizing smart air samplers to comply with Reg. Guide 4.14 requirements.

In the future, it can be expected that communication with remote air sampling sites will increase due to the operational demands of having near real-time information from monitoring systems.

Conclusion:

The remote air sampling regulatory requirements for ISR uranium mining projects, whether they are for pre-operation or operational air monitoring programs, can more easily be complied with utilizing advanced-technology air sampling instruments.

The microprocessor electronic and software features available in “Smart Air Samplers” can automate the majority of the air sampling process, including normalization of gas volumes to a reference temperature and pressure and provide the opportunity to control and monitor remote air sampling systems from a central location.

The smart air sampling instruments present the opportunity to communicate with remote air sampling stations for purposes of controlling and/or monitoring the progress of an air sampling event.

The opportunities available from the advanced technology instruments include periodic data transmission to a central location where computer data analysis and alarm condition notifications can be implemented.

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