INTRODUCTION TO URANIUM IN SITU RECOVERY TECHNOLOGY

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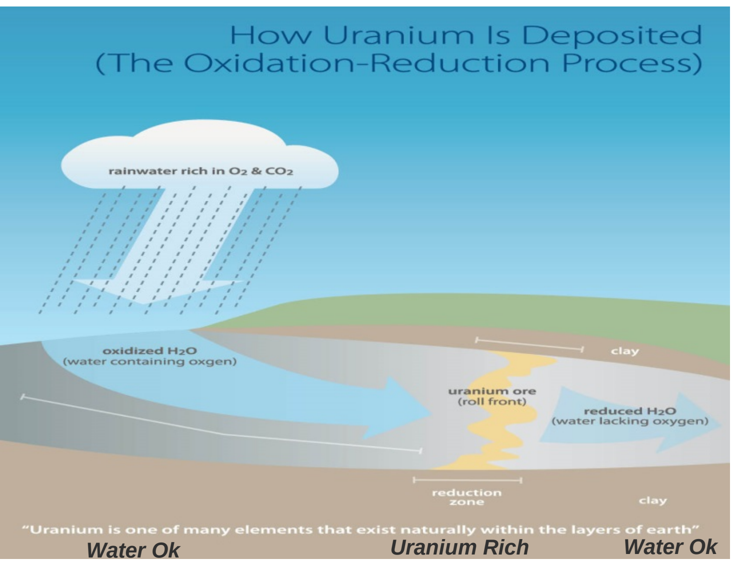
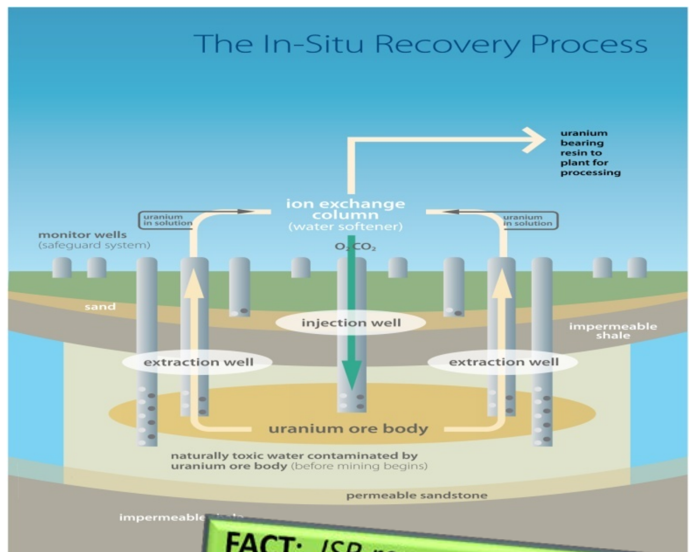
In-situ is a Latin word that that translates literally to "on site” or "in position". Unlike conventional mining methods where the uranium mineral and host rock are excavated together and the uranium is recovered on the surface, in situ recovery (ISR) technique removes the uranium while leaving the host rock in place. ISR utilizes wells to inject amended groundwater into the ore zone. This groundwater solution is commonly referred to as lixiviant. The lixiviant dissolves uranium as it is drawn through the uranium bearing host rock by a pump in a nearby production well which then sends the uranium rich water to the processing plant where the uranium is recovered. The water is then refortified and sent back to the ore zone through the injection wells to recover more uranium. The cycle continues until the desired uranium extraction is complete.

IN-SITU RECOVERY

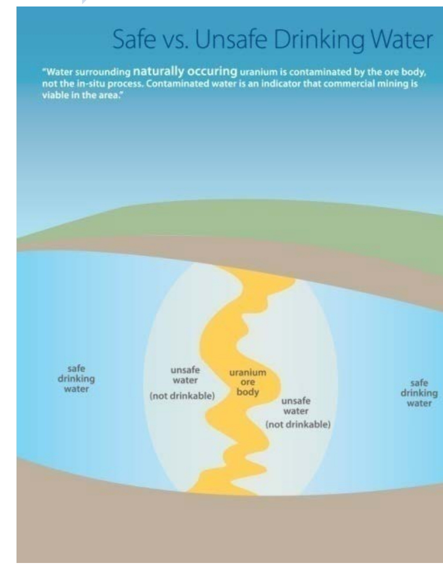
- Non-invasive mining process
- Uranium extracted by reversing the natural deposit process
- Existing groundwater fortified with oxygen leaches the uranium from sands
- Leached solution passed over ion exchange resin (much like in a domestic water softener) to recover uranium
- Groundwater restored to pre-mining state

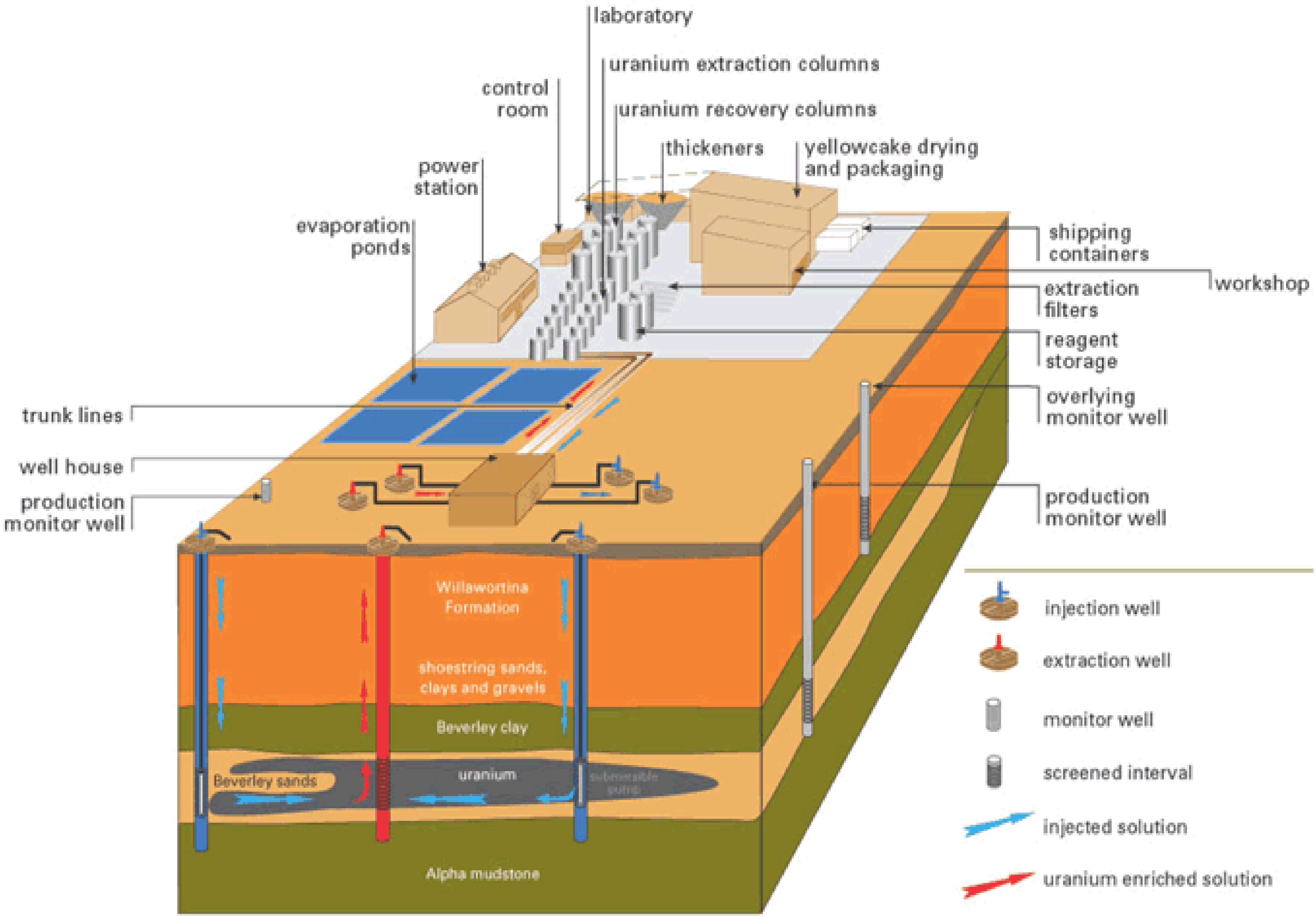


Water Ok | Uranium Rich Water | Water Ok



FACT: *ISR reverses the natural process which deposited the uranium in the first place.*





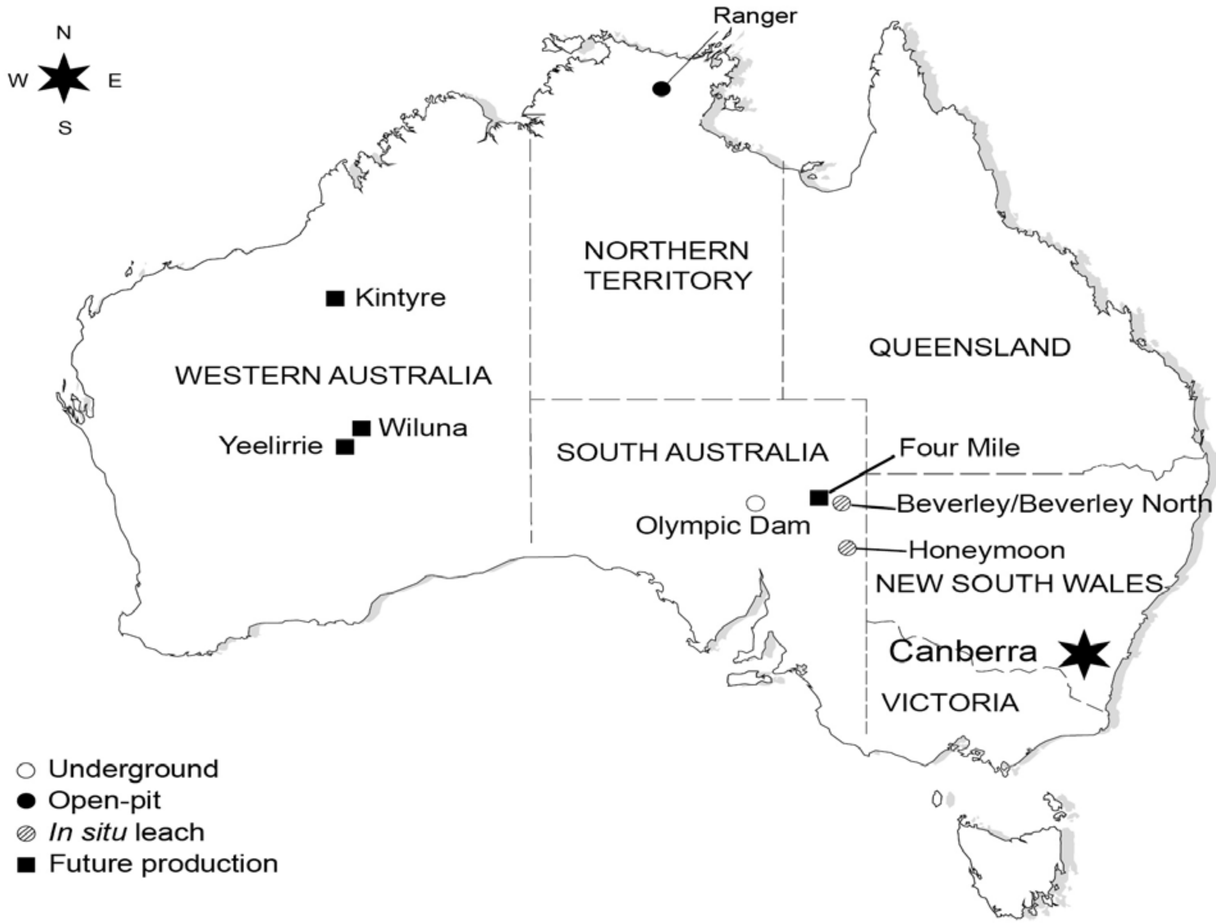
laboratory
uranium extraction columns
control room
uranium recovery columns
thickeners
yellowcake drying and packaging
power station
evaporation ponds
shipping containers
workshop
extraction filters
reagent storage
overlying monitor well
trunk lines
well house
production monitor well
production monitor well
Willawortina Formation
shoestring sands, clays and gravels
Beverley clay
Beverley sands
uranium
Alpha mudstone
injection well
extraction well
monitor well
screened interval
injected solution
uranium enriched solution

WELL FIELD AT THE BEVERLY ISR PROJECT, AUSTRALIA

ISR – 46% GLOBAL U PRODUCTION

- ISR results in significantly less surface disturbance. Mine pits, waste dumps, haul roads, and tailings ponds are not needed.
- Compared to conventional mining, ISR reduces the short- and long-term exposure to the general population to the extremely low levels of radioactivity because almost all of the source term (notably the radioactive decay products of U-238) remains underground in its natural location. ISR requires much less water than pit or underground mine dewatering, or conventional milling.
- Minimal use of heavy equipment, combined with the lack of haul roads, waste dumps, etc., result in virtually no air quality degradation at ISR sites.
- Following the initial construction activities fewer employees are needed at ISR sites, thereby reducing transportation and socioeconomic concerns.
- Aquifers are not excavated, but remain intact during and after ISR so after any required rehabilitation they remain available for future uses.
- Avoiding the creation of large excavations preserves the surrounding land for grazing or raising crops and other traditional uses.
- The technology of recirculating groundwater through the ion exchange facility reduces the amount of solids to a negligible quantity, and tailings ponds are not used, thereby eliminating a major groundwater pollution concern.

AUSTRALIA



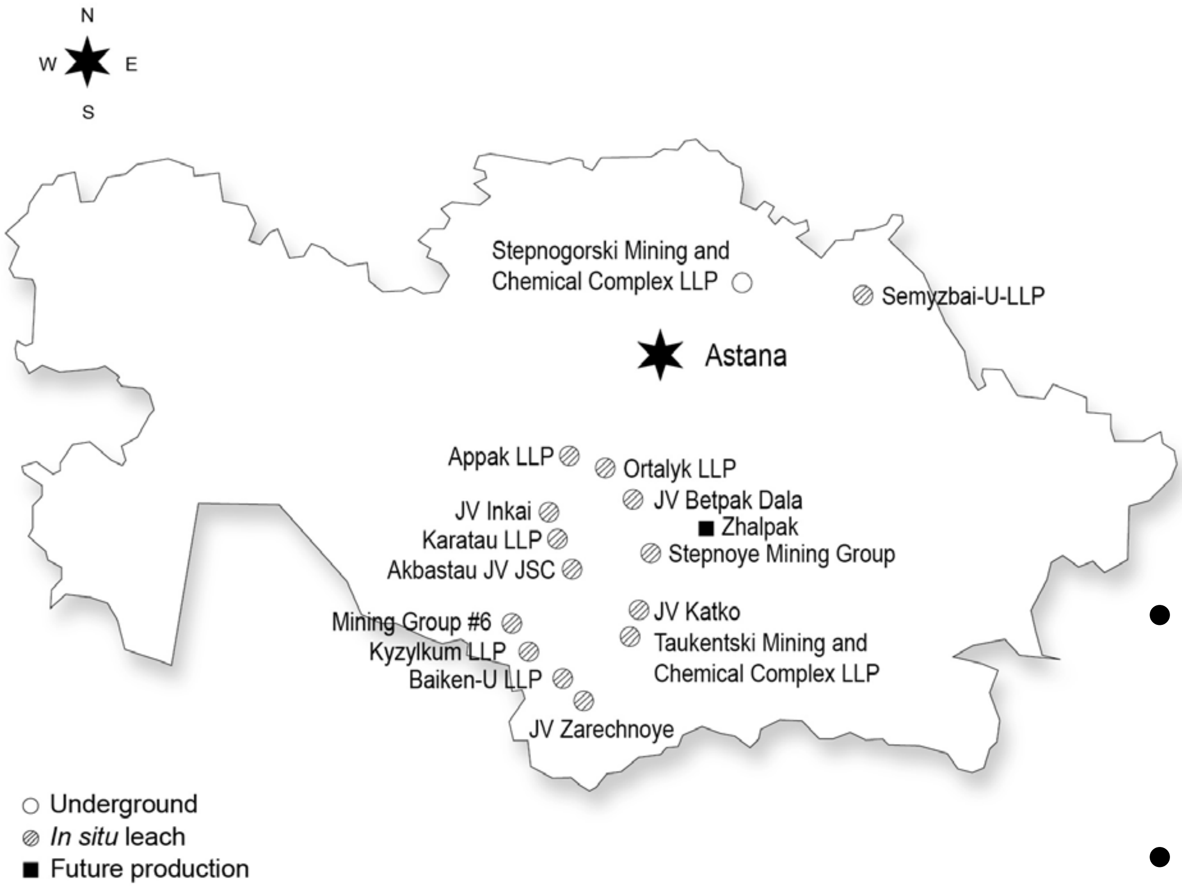
- Beverly 2.24 mm lb. U/yr., Acid, IX
- Four Mile 2.24 mm lb. U/yr., Acid, IX
- Honeymoon, Acid, SX

THE BEVERLY ISR PROCESS FACILITY

CHINA

- Historic production from granite and volcanic type deposits (conventional).
- ISR testing began in the 1990s.
- High carbonate in the ore has resulted in problems with sulfuric acid chemistry.
- Sodium bicarbonate testing has been conducted.

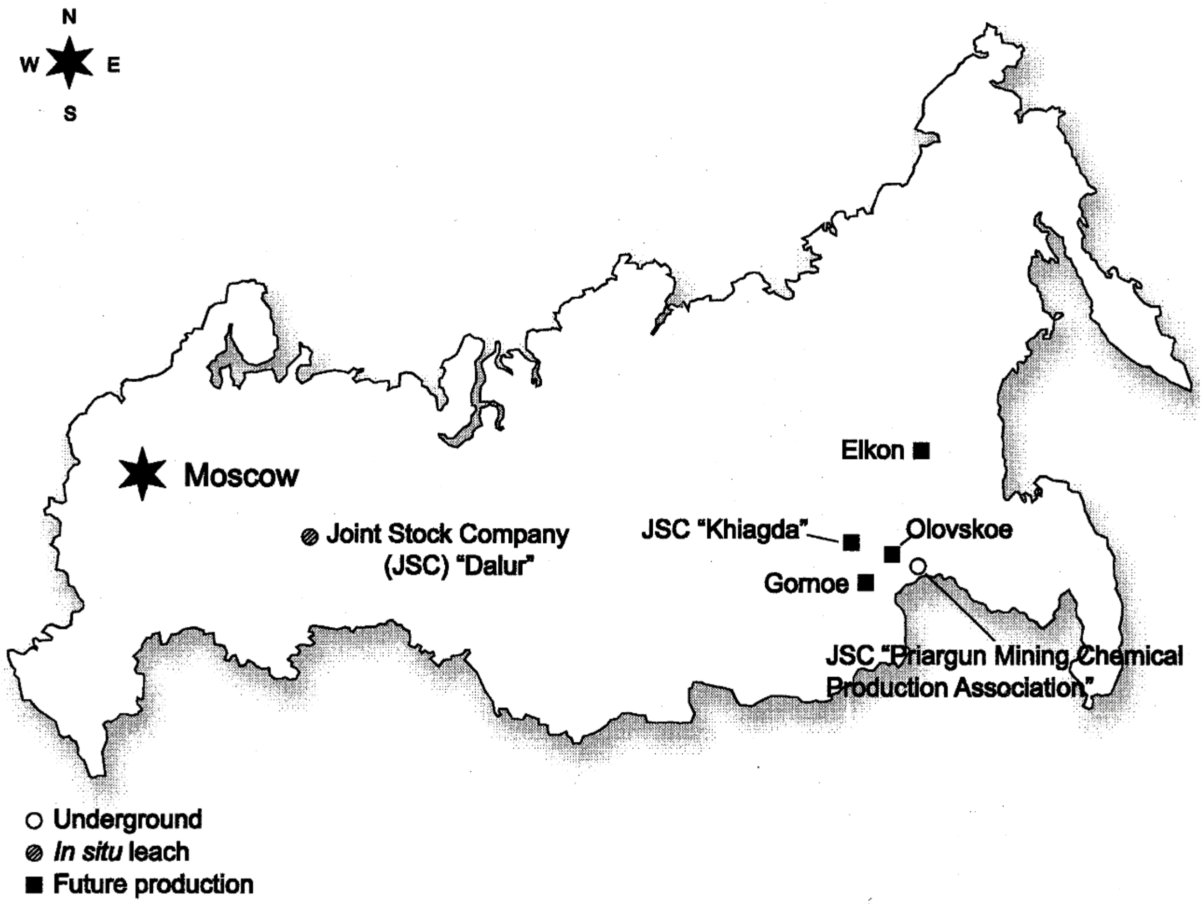
KAZAKHSTAN



- In 2009 Kazakhstan became the world's leading source of uranium, producing almost 28% then, 33% in 2010, 36% in 2011, 36.5% in 2012 and 38% in 2013, almost all using ISR methods.
- 2013 ISR production was about 50 mm lb. U.
- All acid leaching chemistry.

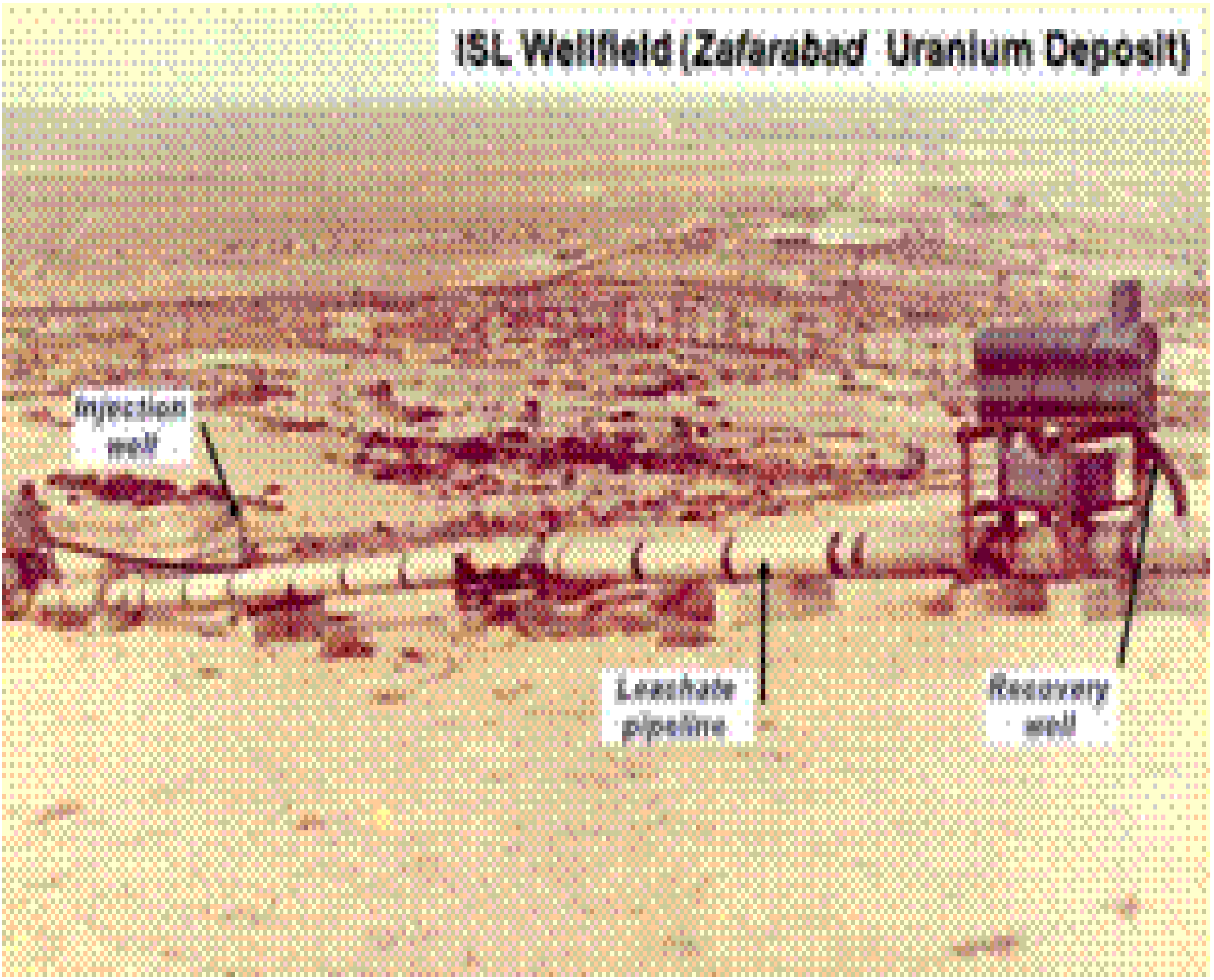
KHARASAN ISR PROCESSING FACILITY

RUSSIA



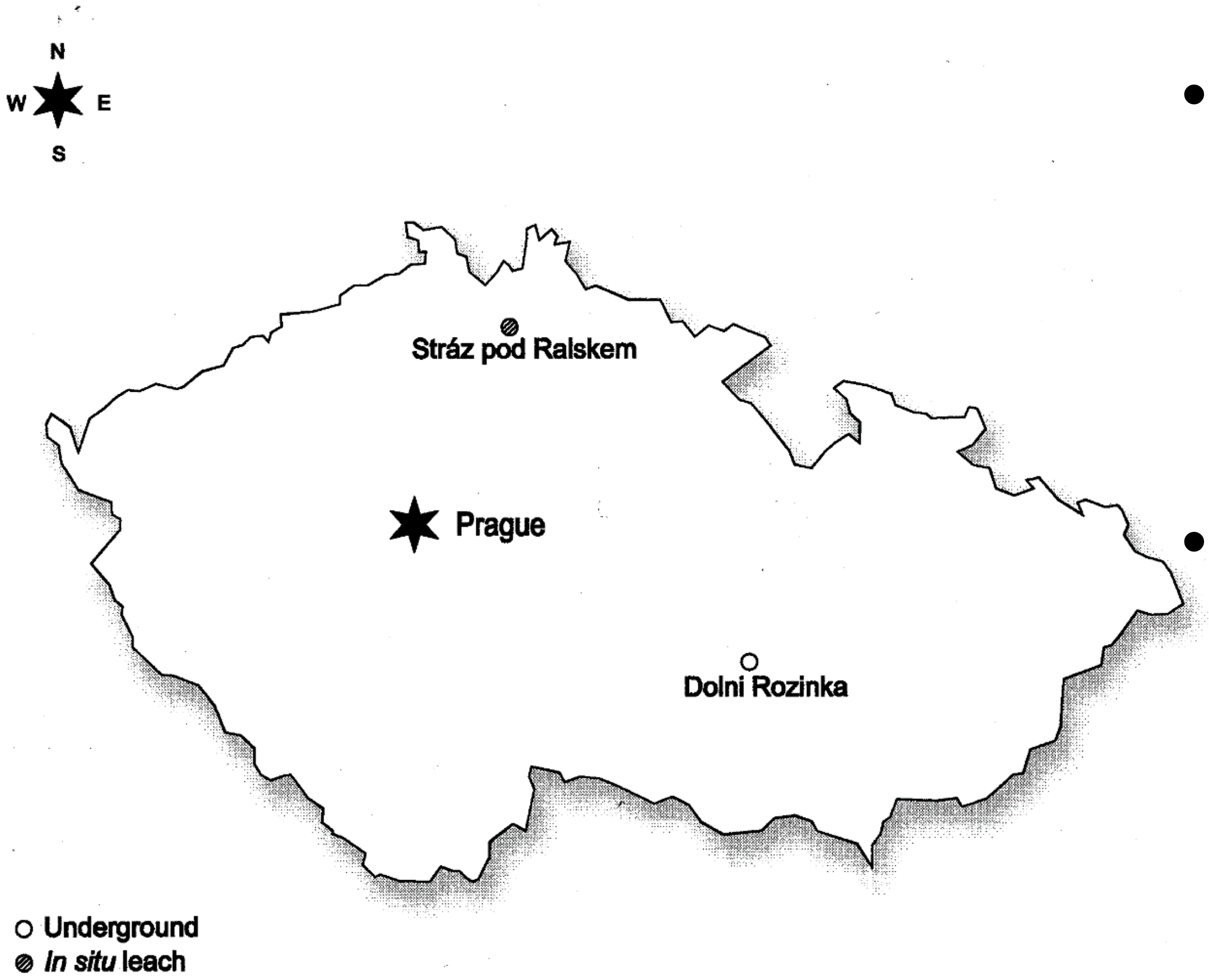
- Dalmatovskoe/ Khohlovskoe 1.28 mm lb./yr.
- Khiagdinskoye .73 mm lb./yr.
- Sulfuric acid leach chemistry.

UZBEKISTAN



- Northern district ~ 1.54-1.65 mm lb./yr. Since 1965.
- Eastern district ~ 2.2-2.65 mm lb./yr. Since 1977.
- Southern district 1.32-1.43 mm lb./yr.
- All sulfuric acid leach chemistry.
- Pilot projects under way. Problems reported with high carbonate content.

BULGARIA AND CZECHOSLOVAKIA



- Bulgaria .761 mm lb./yr. since 1961. 1992 uranium development closed. Sulfuric leach chemistry.
- Czechoslovakia/ Stratz 1.27 mm lb./year. Sulfuric, nitric, hydrofluoric acids and ammonia leach chemistry. Now closed.

INJECTION WELLS AT THE STRÁZ ISR PROJECT

GERMANY/UKRAINE

- Germany. Operation at Königstein near Dresden produced 39.69 mm lb. U. Sulfuric acid. Closed 1990.
- Ukraine. 1966 - 1983 ISR in the Devladovo of Sofiivela District, Drivipropetrovska Provence and Bratske of Mikolaivska Provence using sulfuric acid chemistry. Future plans call for ISR with alkaline chemistry.

UNITED STATES

State	Project	Mm lb./yr.
Nebraska	Crow Butte	.85
Wyoming	Smith Ranch/ Highland	4.6
	Willow Creek	1.1
	Lost Creek	1.6
	Hank/Nichols	1.5
	Moore Ranch	.45
Texas	Hobson/Palangana	.85
	Alta Mesa	.85

All using carbonate leaching chemistry

THE CROW BUTTE ISR PROJECT IN NEBRASKA

THE ALTA MESA ISR PROJECT IN TEXAS

THE PALANGANA/HOBSON SATELLITE IN TEXAS

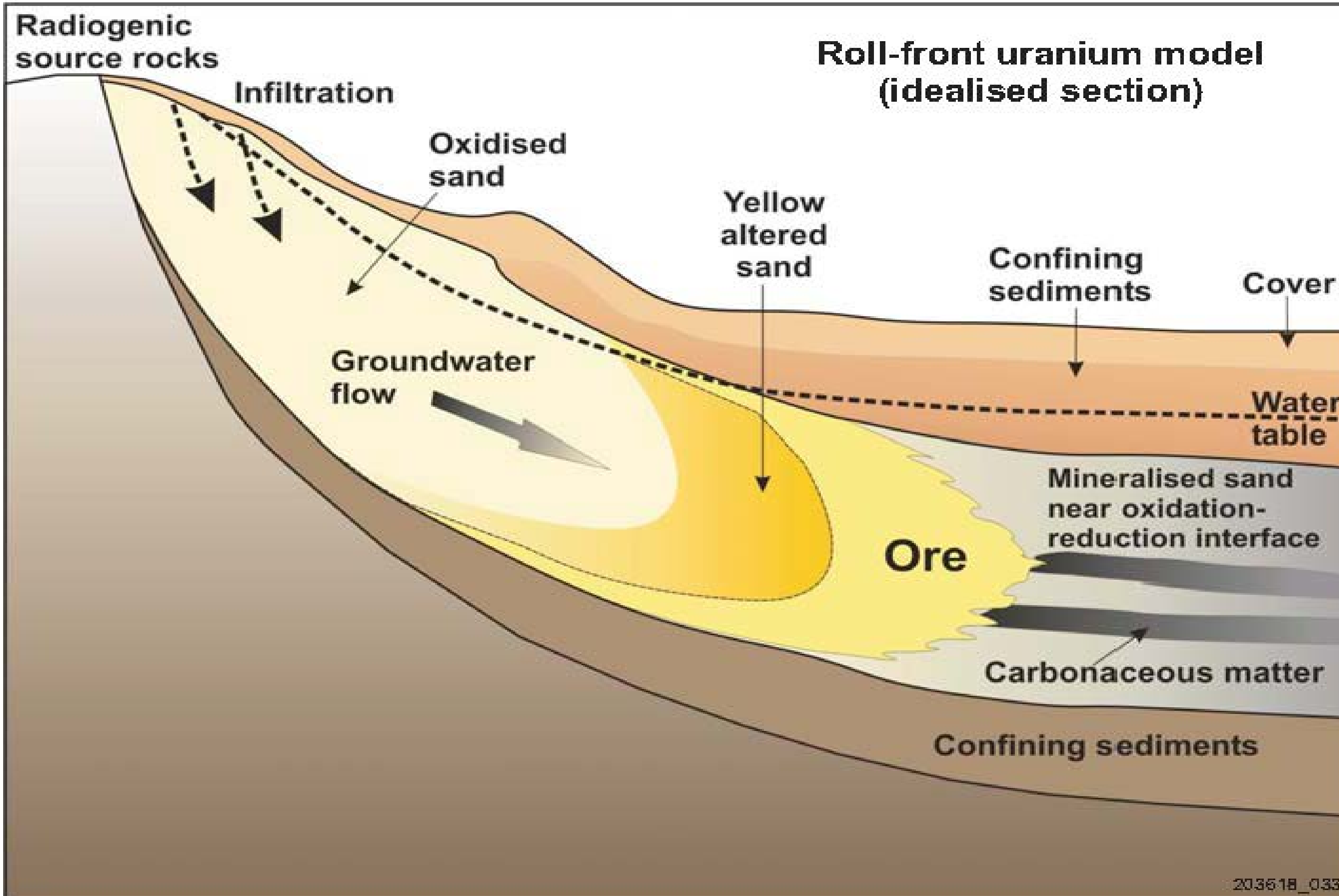
THE SMITH RANCH/HIGHLAND PROJECT IN WYOMING

THE NICHOLS RANCH PROJECT IN WYOMING

GEOLOGY AND HYDROGEOLOGIC CONDITIONS AND U DEPOSIT AMENABILITY

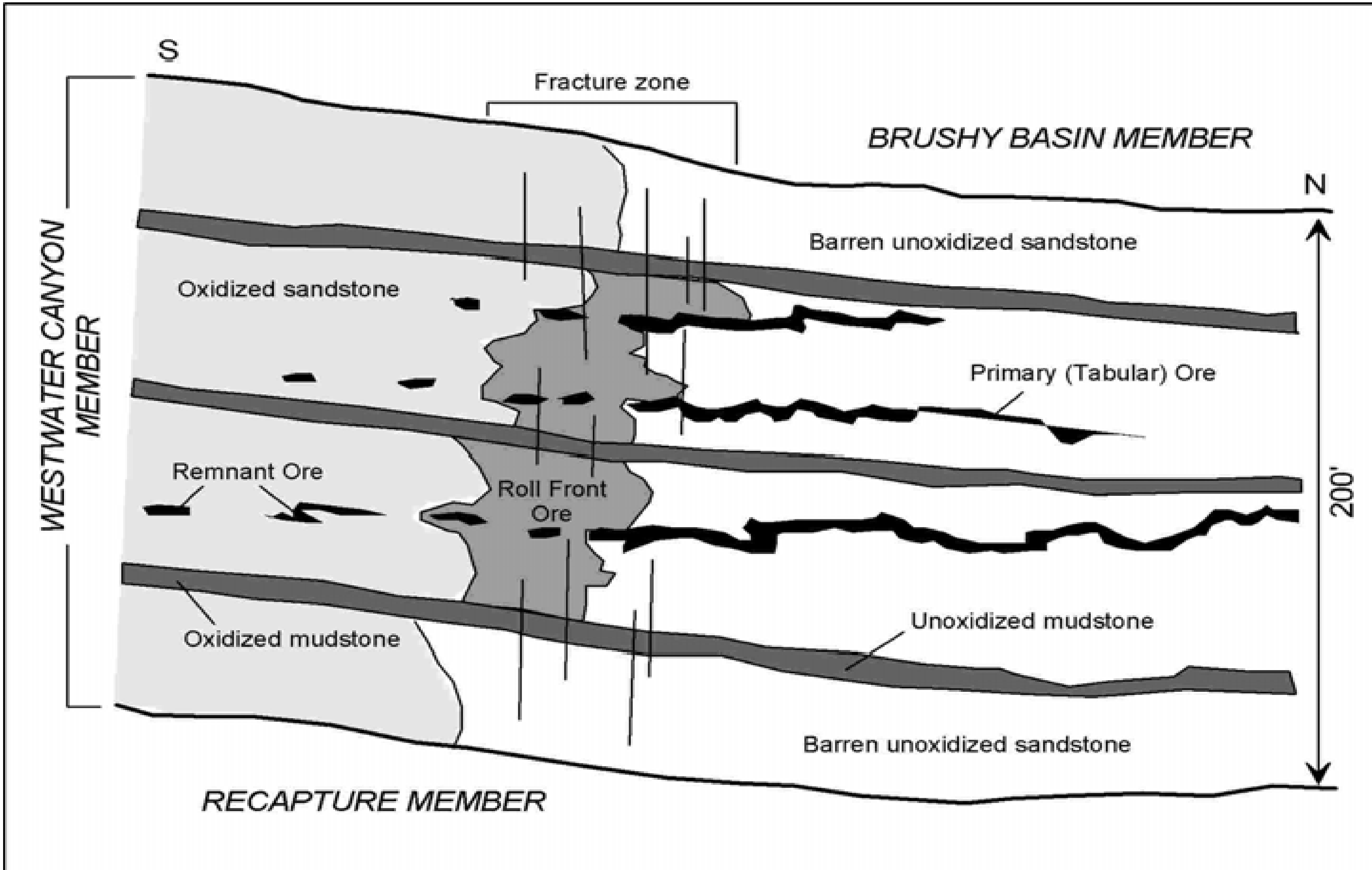
- Permeable sandstones.
- Uranium mineral is typically epigenetically redistributed and through a reduction-oxidation (REDOX) processes.
- Permeable conduit through which groundwater and hence the lixiviant can be circulated.
- Saturated or below the water table to allow for controlled circulation of the contained groundwater which is fortified with leaching reagents during the ISR activity.
- Preferred that the sandstone deposit be confined by strata of lesser permeability to facilitate containment of leaching solutions.

ROLL-FRONT TYPE DEPOSIT



PIT CUT ILLUSTRATING A CLASSICAL ROLL FRONT

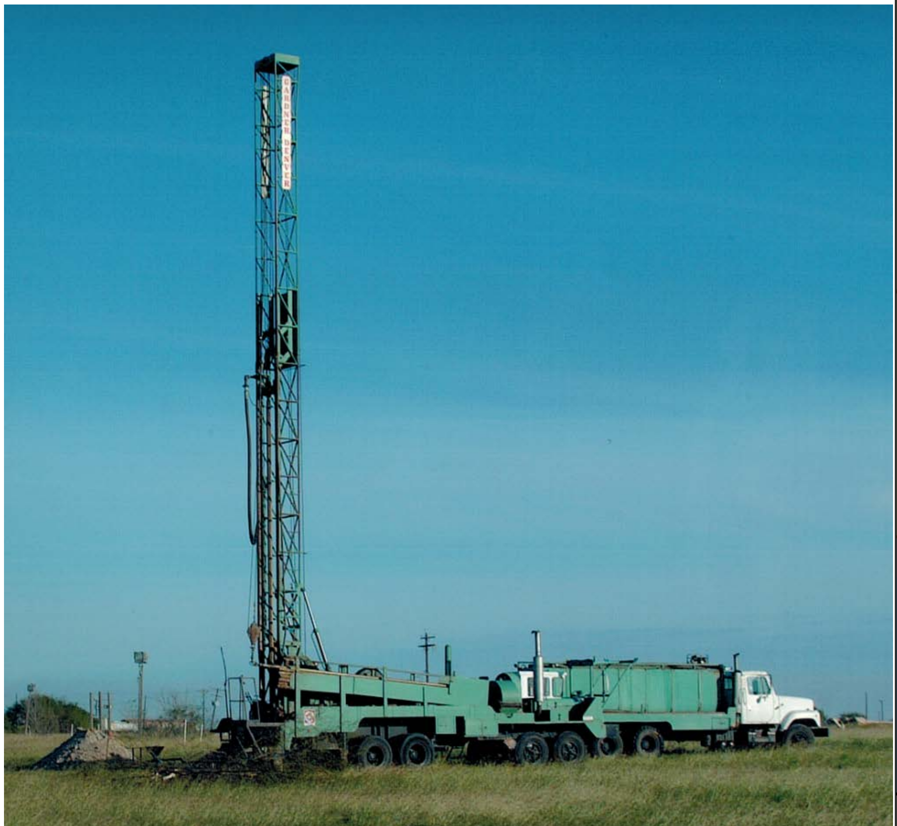
TABULAR DEPOSIT

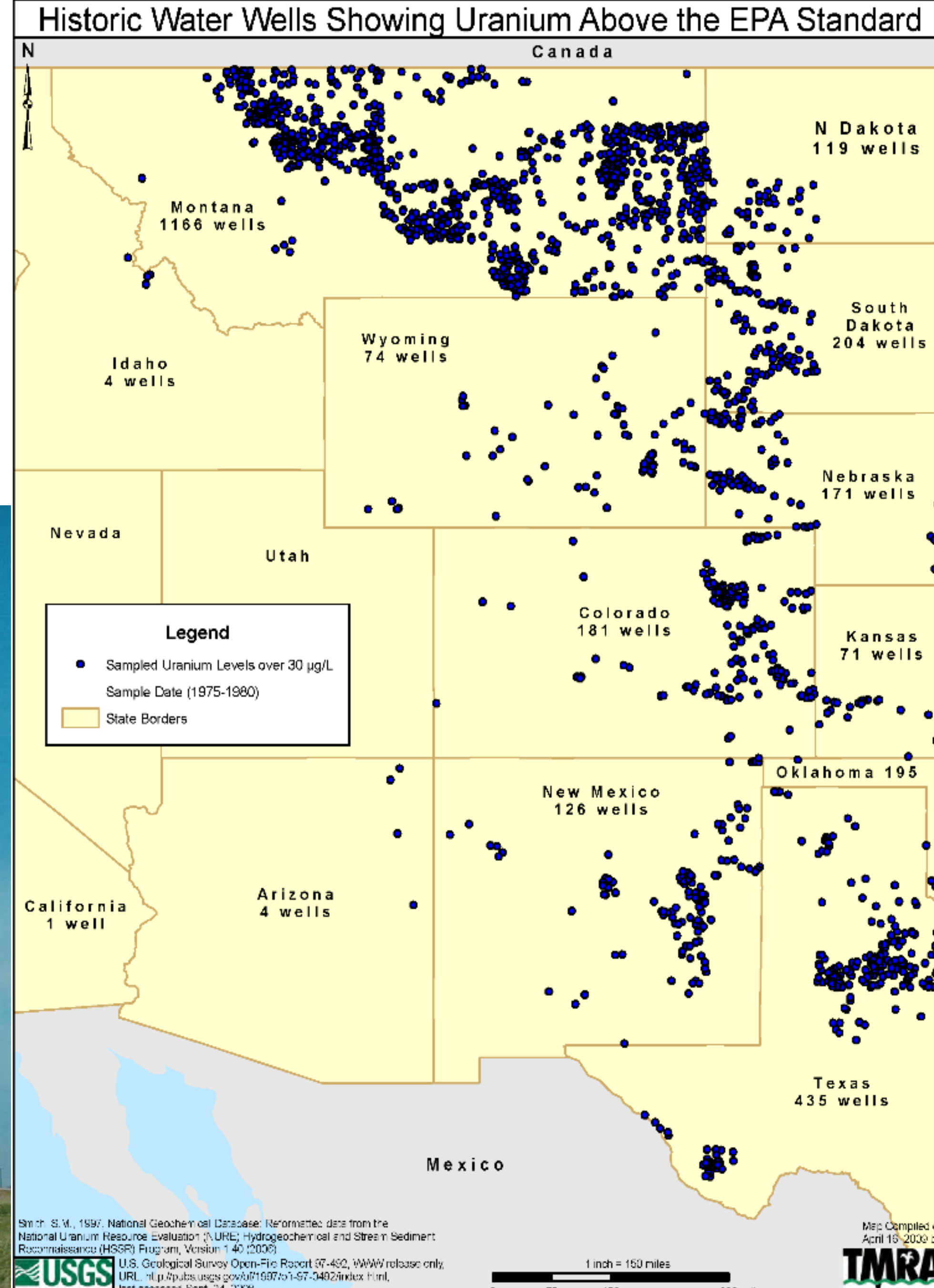


HYDROGEOLOGICAL CONDITIONS

- **Confinement** -Hydrogeologic geometry must prevent uranium-bearing fluids lixiviant from vertically migrating. Typically, low permeability layers such as shale or clay confine.
- **Ground Water Conditions -** Ground water is fundamental to ISR development because it is the fortified groundwater that forms the lixiviant and the quality of that water affect the lixiviant composition and other factors within the process. The salinity of groundwater is an important measure of quality. Where the salinity in an aquifer is low, water in the contiguous regional aquifer may be used for domestic purposes and groundwater restoration becomes a priority. This is generally the case in the U.S. where water quality contains relatively low TDS and groundwater restoration is required. In Kazakhstan and Australia, TDS values are high and the groundwater in aquifers is not considered suitable for domestic purposes. As such, in those jurisdiction groundwater restoration is not a priority. General water quality is also an important parameter when evaluating the process design. Salinity values will affect IX efficiency and other components of the water treatment process.
- Uranium and decay products such as radium (^{226}Ra) and radon (^{222}Rn), are uranium's natural decay products and are found in water near uranium deposits. They significantly affect the toxicity and hence the suitability of water for domestic purposes when they exceed federal drinking water limits. Radon may exceed 1,000,000 pCi/l in ground water in a mine unit.
- Uranium is a naturally occurring radioactive element. As such, radioactive decay of uranium into other elements is continuous. Anomalous levels of ^{226}Ra and ^{222}Rn decay products and gross alpha radiation in ground water means that elemental uranium must be close by in the host rock, so they, along with the U by itself, are commonly used by geologists as a uranium exploration screening tool by water well sampling.

EXPLORATION AND DELINEATION METHODS





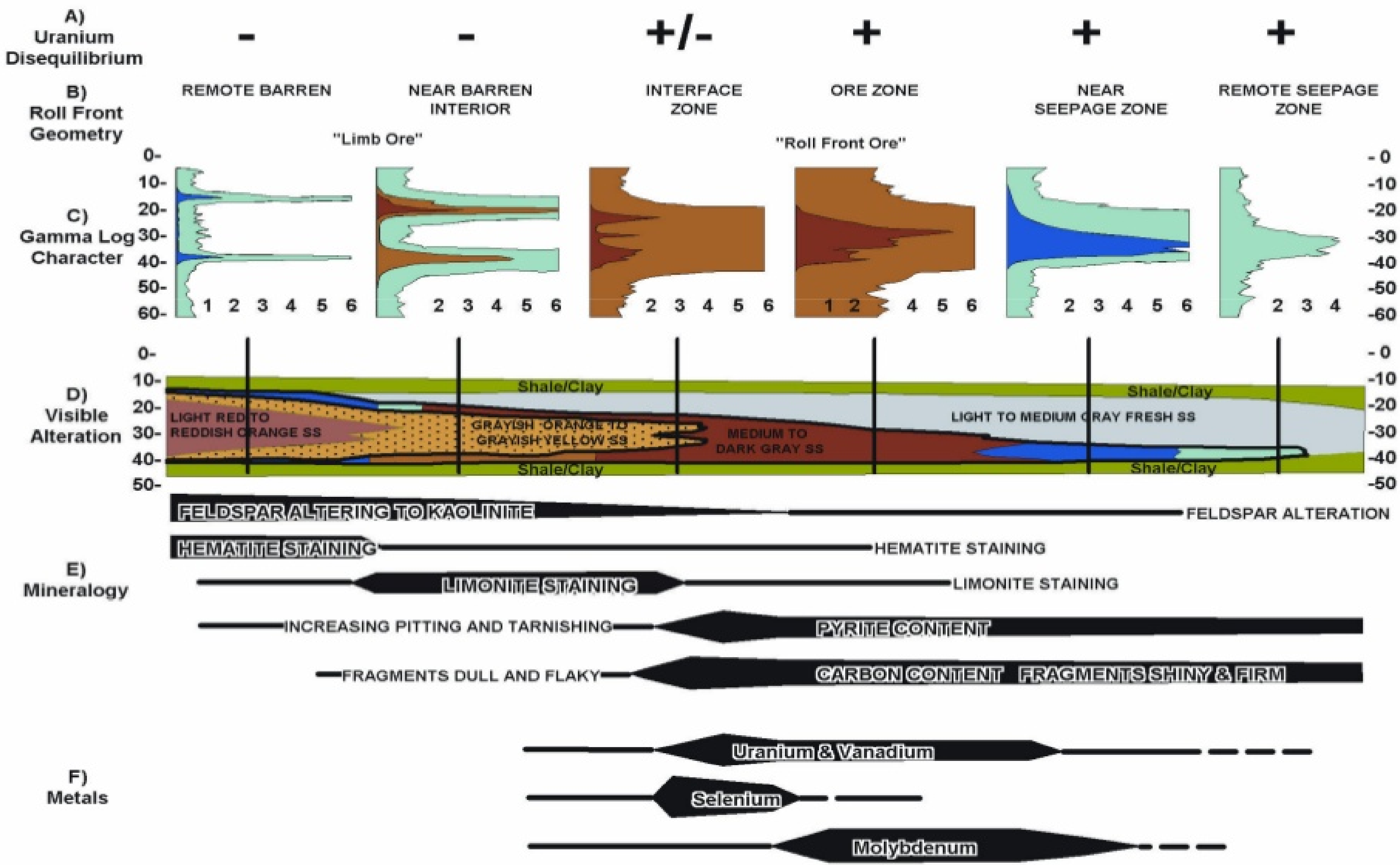
DRILL CUTTINGS IN 5 FT. INTERVALS ILLUSTRATING REDOX COLORATION. OXIDIZED AND REDUCED SAND SAMPLE

LOGGING

- Spontaneous potential
- Resistivity
- Gamma

PFN - Prompt neutron induced fission of U-235 results in epithermal and thermal neutrons. The resulting ratio is measured and used as a surrogate for uranium content.

Basic Roll-Front Characteristics

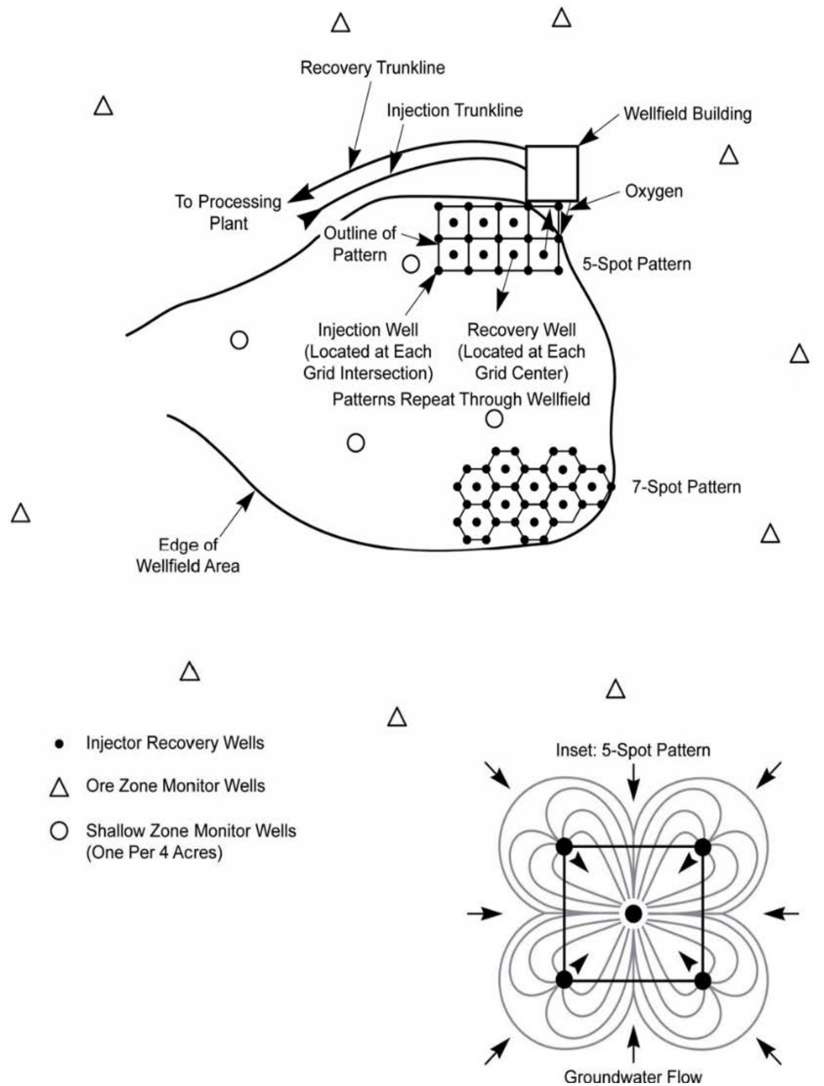


Adapted from Rubin, 1970; Harris and King, 1993; Ur-Energy, 2010

EXPLORATION DRILLING DRILL “FENCES” ARE APPARENT FROM THE BRUSH CLEARING PATTERNS

MINE AREA CONDITIONS & WELL FIELD DEVELOPMENT

- Site geology is continuously closely evaluated in conjunction with well field development to assure proper placement of monitor and production wells.
- Cross-sections, grade X thickness or “GT” contour maps, isopach maps of the overlying and underlying confining unit units, well completion reports, models and other information regarding the morphology of the uranium deposit.



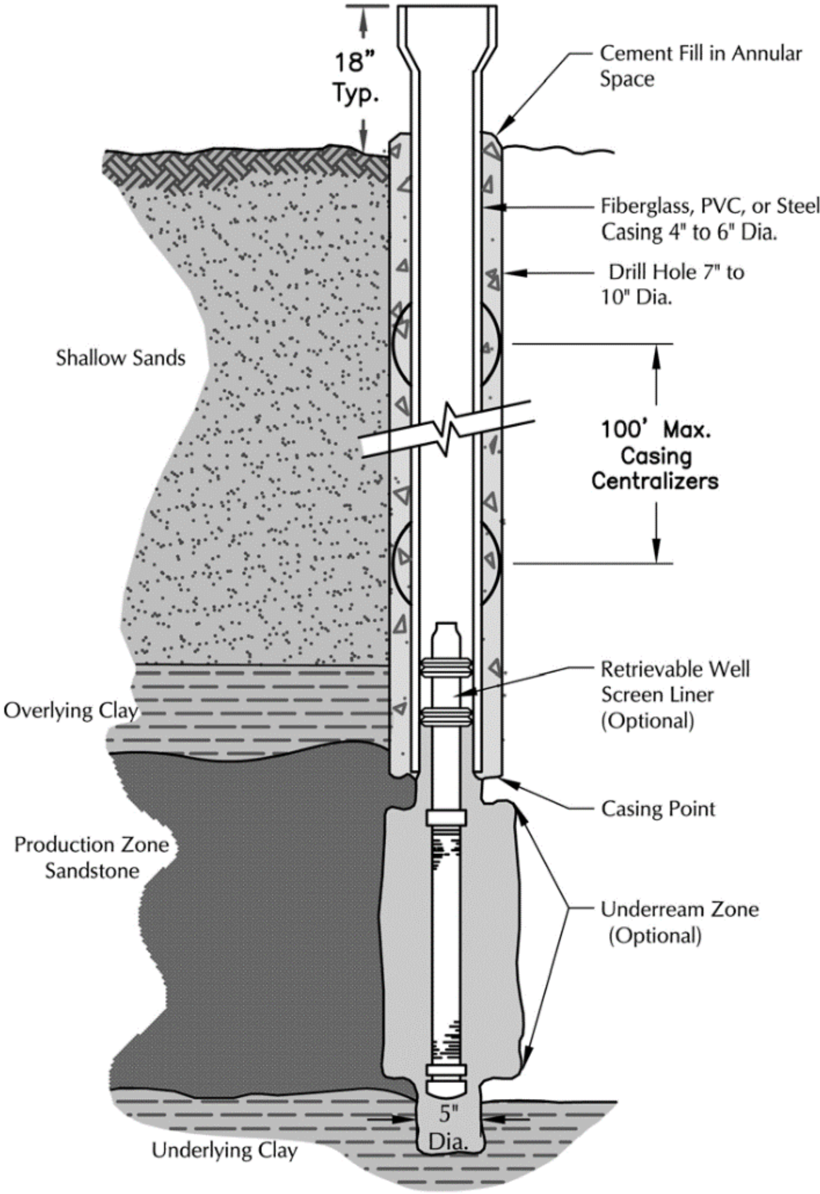
WELL DRILLING, INSTALLATION AND OPERATION

- **Layout and Patterns**
  - *Monitor wells*
  - *Injection Wells*
  - *Extraction Wells*
- **Construction and Installation**
  - *Logging.*
  - *Casing*.
  - *Cementing.*
  - *Completion.*
  - *Mechanical Integrity Testing.*

ENVIRONMENTAL EVALUATIONS

Alkalinity	Lead
Ammonium	Magnesium
Arsenic	Manganese
Bicarbonate	Mercury
Boron	Molybdenum
Cadmium	Nickel
Calcium	Nitrate
Carbonate	pH (s.u.)
Chloride	Potassium
Chromium	Radium-226 (pCi/l)
Copper	Radon -222 (pCi/l)
Conductivity (µmho/cm)	Selenium
Fluoride	Sulfate
Gross Alpha Radiation (pCi/l)	Uranium
Iron	Vanadium

- **Baseline Water Quality**
- **Operational Groundwater Monitoring**
- **Hydrological Characterization (Pump tests).**
- **Environmental Monitoring**

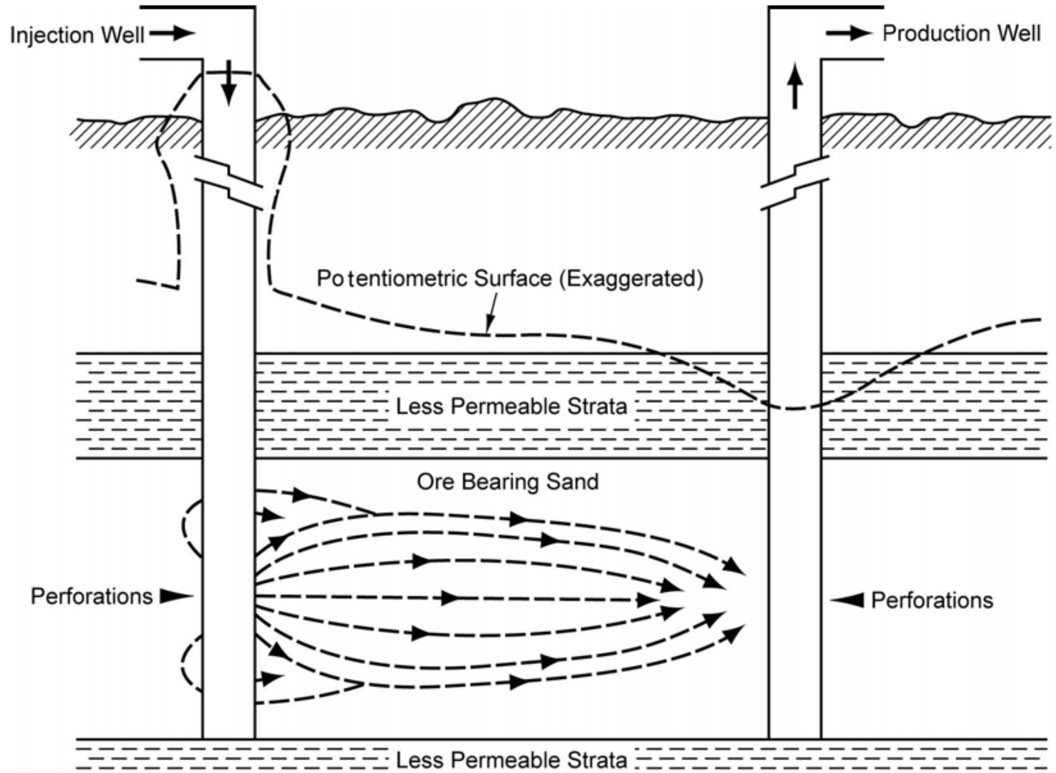


A completed ISR well at the Beverly ISR Facility, Australia. The drip pan and auto shut off switch is designed to catch potential leaks and drips from the well head to prevent soil contamination

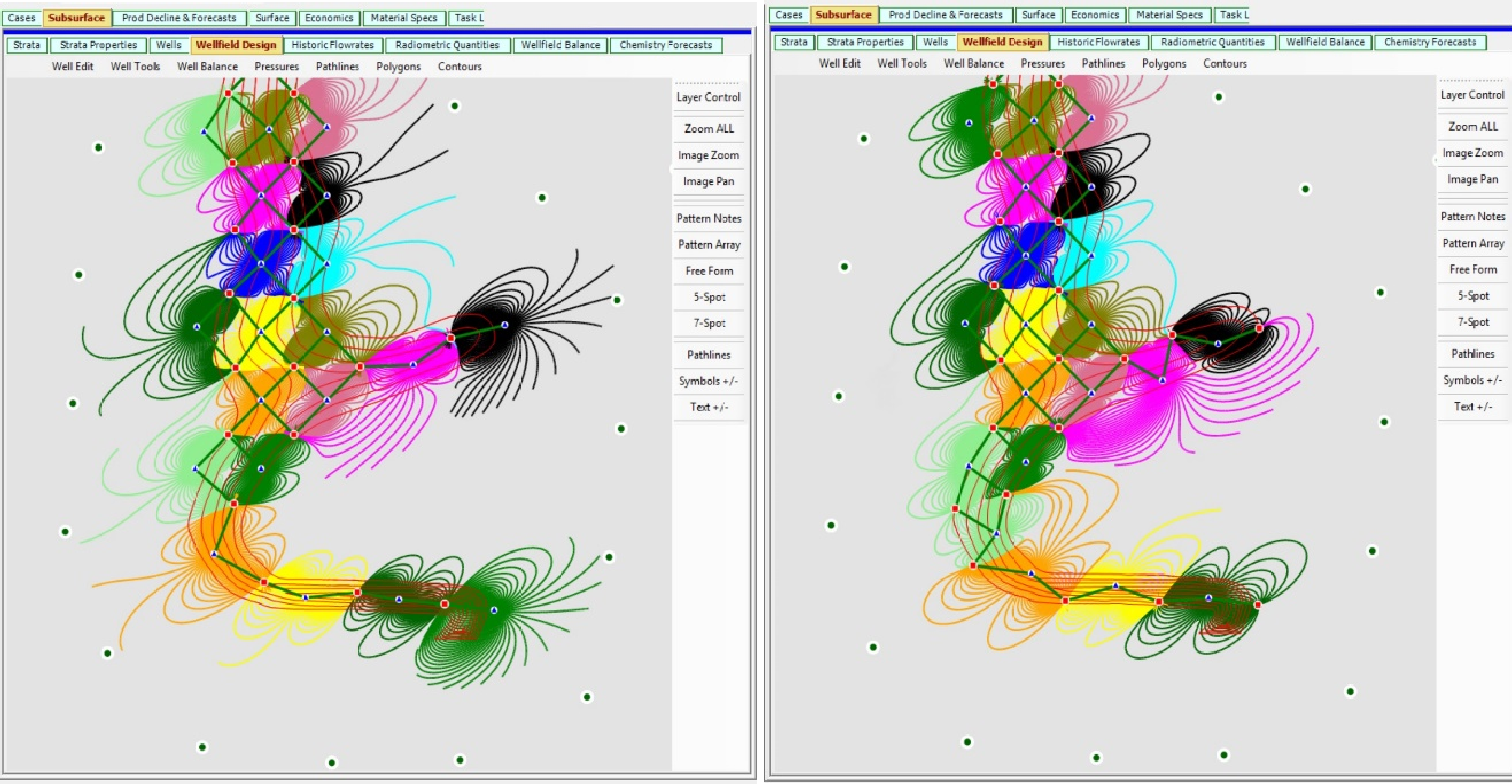
ISR WELL FIELD IN NORTHERN USA

WELLFIELD OPERATIONS

Production wells are operated at the maximum continuous flow rate achievable for a pattern. The primary consideration in determining maximum continuous flow rate is to assure the well field is collectively balanced. he Overall injection flow rates into the well fields is less than the total extraction flow rate by a “process bleed”, resulting in a hydraulic pressure sink which causes groundwater to migrate into the well field.



WELL FIELD PLANNING USING SUBSURFACE PATH LINES



Left: Original well field plan and flow balance resulting in excursions
Right: New well field plan with well reversals and flow re-balance
[Circles (monitor wells); Blue Triangles (injectors); Red Squares (extractors)]

WELL FIELD PIPING ON THE SURFACE IN TEXAS

HEADER SYSTEM ON THE SURFACE IN TEXAS

INDOOR WELLFIELD INSTRUMENTATION

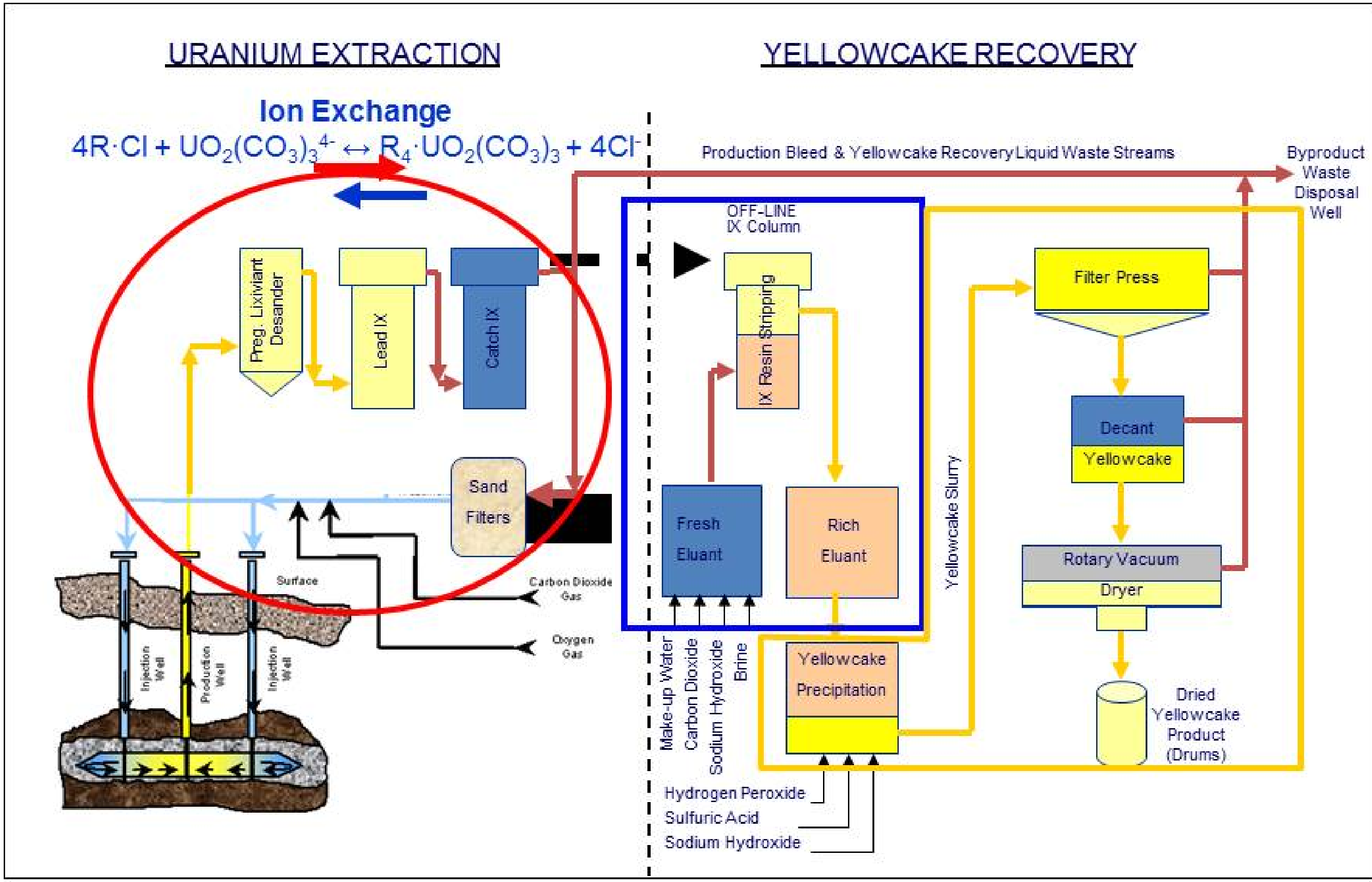
Contained header house at the Nichols Ranch ISR project in Wyoming

PIPE BURIAL IN WYOMING

WEATHERIZED WELLHEAD ENCLOSURES IN WYOMING

PROCESSES

The uranium extraction portion of the process may be conducted separate from the full process by remote IX



PROCESSING PLANT EQUIPMENT

Retention pond construction at the Beverly ISR facility, Australia

- Concrete curbed process pads
- Retention ponds
- Tankage - fiberglass or steel
- Piping - polyethylene, PVC, fiberglass, steel
- Weatherization equipment
- Drying system
- Liquid waste management equipment

LIXIVIANT TYPES (IAEA 2001)

Sulfuric acid storage at the Akdala ISR project in the South Kazakhstan Provence

ACID LEACHING CHEMISTRY

Leaching

- $UO_3 + H_2SO_4 \rightarrow UO_2SO_4 + H_2O$
- $UO_2SO_4 + SO_4 \leftrightarrow [UO_2\ (SO_4)_2]^{2-}$
- $[UO_2\ (SO_4)_2]^{2-} + SO_4{}^{2-} \leftrightarrow [UO_2(SO_4)_3]^{4-}$

IX

- $(R_4N^+)_2SO_4 + UO_2{}^{2+} + SO_4{}^{2-} = (R_4N^+)_2\ [UO_2(SO_4)_2]$
- $2(R_4N^+)_2SO_4 + UO_2{}^{2+} + SO_4{}^{2-} = (R_4N^+)_4\ [UO_2(SO_4)_3] + SO_4{}^{2-}$

or, if the anionic resin is in a non-sulfate form (e.g. in nitrate):

- $2(R_4N^+)NO_3 + UO_2{}^{2+} + 2SO_4{}^{2-} = (R_4N^+)_2\ [UO_2(SO_4)_2] + 2NO_3{}^-$
- $4(R_4N^+)NO_3 + UO_2{}^{2+} + 3SO_4{}^{2-} = (R_4N^+)_4\ [UO_2(SO_4)_3] + 4NO_3{}^-$

ALKALINE OR CARBONATE LEACHING CHEMISTRY

Leaching

- $2UO_2 + O_2 \rightarrow 2UO_3$
- $UO_3 + 2NaHCO_3 \rightarrow Na_2UO_2(CO_3)_2 + H_2O$

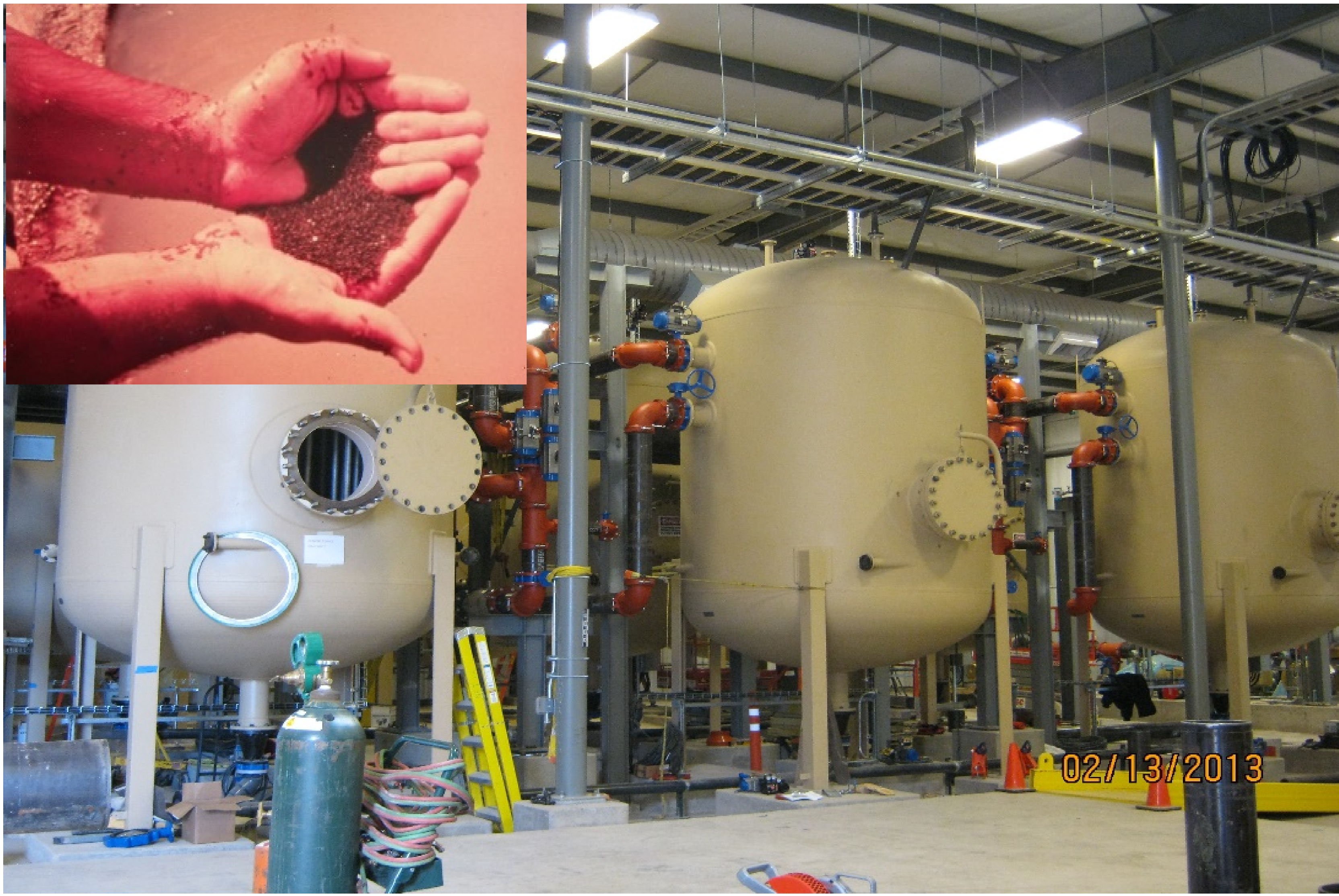
IX

- $Na_2UO_2(CO_3)_2 + 2RCl \rightarrow R_2UO_2(CO_3)_2 + 2NaCl$,

where R is a reacting site of the ion exchange resin

ION EXCHANGE COLUMNS AT THE NICHOLS RANCH ISR

INSERT SHOWS IX RESIN IN HAND



ELUTION AND PRECIPITATION

- In the alkaline lixiviant system, brine and soda ash solution are used to remove the uranium from the resin in a two-step process.

$$R_2UO_2(CO_3)_2 + 2NaCl + Na_2CO_3 \rightarrow Na_4UO_2(CO_3)_3 + 2RCl$$

- Next eluant rich in uranyl d-, and tri- carbonate is acidified using hydrochloric acid or sulfuric acid to destroy the uranyl carbonate complex as shown below.

<u>Hydrochloric Acid</u>

Na4UO2 (CO3)3 + 6HCl → UO2Cl2 + 4NaCl + 3CO2 + 3H2O

Na2UO2 (CO3)2 + 4HCl → UO2Cl2 + 2NaCl + 2CO2 + 2H2O

<u>Sulfuric Acid</u>

$$Na_4UO_2(CO_3)_3 + 3H_2SO_4 \rightarrow UO_2SO_4 + 2Na_2SO_4 + 3CO_2 + 3H_2O$$

$$Na_2UO_2(CO_3)_3 + 2H_2SO_4 \rightarrow UO_2SO_4 + Na_2SO_4 + 2CO_2 + 2H_2O$$

- Next hydrogen peroxide is added to oxidize the uranium even further and cause it to precipitate.

<u>Hydrochloric Acid:</u>

$$UO_2Cl_2 + H_2O_2 + xH_2O \rightarrow UO_4 \cdot xH_2O + 2HCl$$

<u>Sulfuric Acid:</u>

$$UO_2SO_4 + H_2O_2 + xH_2O \rightarrow UO_4 \cdot xH_2O + H_2SO_4$$

- Peroxide may be used to precipitate uranium using either alkaline or acid lixiviant system although there are other methods available to precipitate uranium in the acid system by decreasing pH. The crystalline uranyl peroxide slurry is allowed to settle. The yellowcake is further dewatered, washed with a clean water to remove impurities such as sorbed chloride, and dried.

INDOOR PROCESS FACILITY IN WYOMING

PLANT CONFIGURATIONS - CENTRAL PLANT/REMOTE IX

Central processing facility at the Inkai ISR project Kazakhstan

REMOTE ION EXCHANGE SATELLITE CONNECTED TO THE RESIN TRANSPORT AT THE NICHOLS RANCH PROJECT

RIX AND IMPROVED OPERATING EFFICIENCIES

Progressive increase of ionic constituents. In an alkaline groundwater lixiviant chemistry example:

Oxidation of iron sulfides – Fe (ppt) SO_4 ↑ pH ↓

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3\ [ppt] + 4\ H^+ + 2\ SO_4^{=}$$

Next the host rock with an abundance of calcium carbonate in its matrix experiences dissolution of calcium carbonate from lowered pH. The resulting calcium, bicarbonate and sulfate buildup is progressive and cumulative and becomes more detrimental as one mine unit's water is comingled into the next. In time saturation of calcium, carbonate and sulfate is reached that results in the precipitation of calcium carbonate and calcium sulfate onto the U coated sand grains, resulting in poor U recoveries.

Continuous IX also results in the buildup of sodium chloride in leaching solution resulting in lower IX efficiencies.

$$Na_2UO_2\ (CO_3)_2 + 2RCl \rightarrow R2\ UO_2(CO_3)_2 + 2NaCl$$

ROTARY VACUUM DRYER SHOWING BAG FILTER

LIQUID WASTE MANAGEMENT – RO, DISPOSAL WELLS, EVAPORATION

DISPOSAL WELL

AUTOMATION AND TELEMETRIES

Employee at central process plant central control panel

U.S. NUCLEAR REGULATORY COMMISSION

or Agreement State Agency

- **Primary Regulatory Authority.**
- **Implementing Regulations 40 C.F.R. Parts 20 & 40 under the Atomic Energy Act.**
- **Environmental Impact Statement.**
- **Certifies proper restoration and reclamation before a license may be terminated and financial security may be released.**

U.S. Environmental Protection Agency or Agreement State Agency

- Implementing Regulations 40 C.F.R. Part 146-148 under the Safe Drinking Water Act.

- For ISR operations to be legal USEPA must determine that the baseline water quality in the mine zone is not suitable for human consumption and exempt the water for future consideration as an underground source of drinking water.

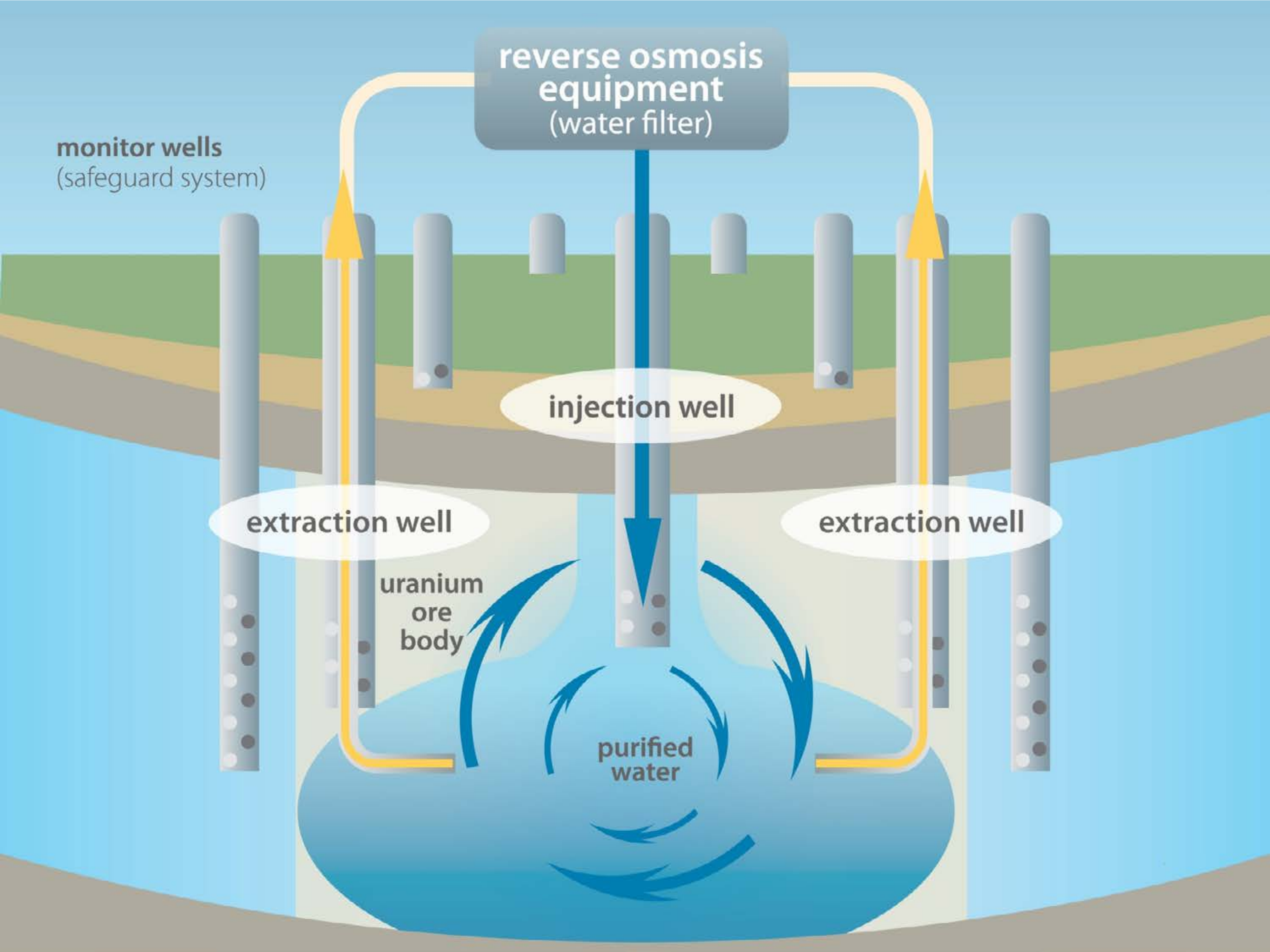
- USEPA sets safe water criteria for uranium, radium, radiation and many other hazardous and nonhazardous parameters in drinking water that are used to gauge water quality at ISR sites.

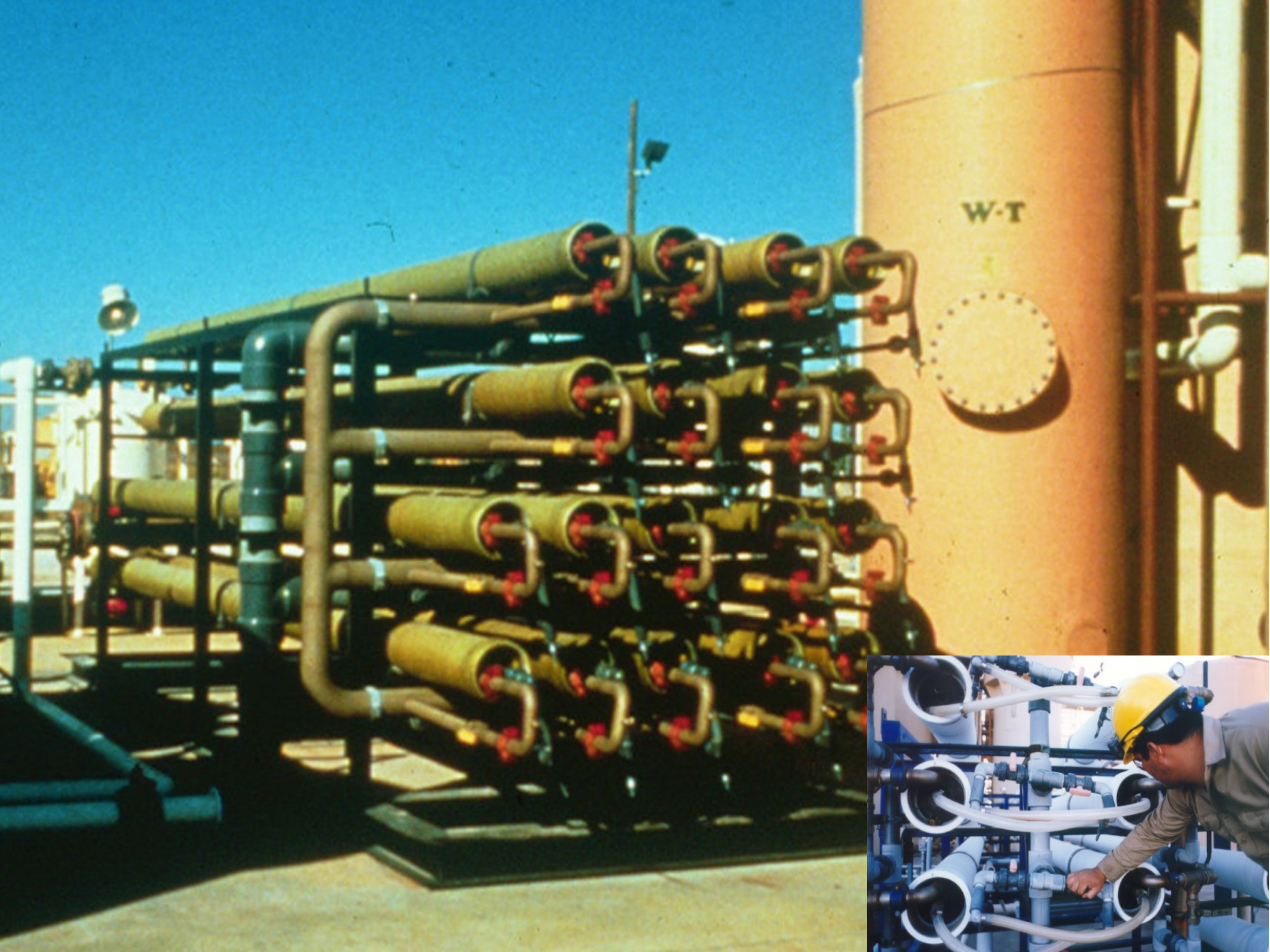
SURFACE RECLAMATION AND REVEGETATION

Surface reclamation of the Trevino ISR site in Texas. The top photo was taken during operations in 1982 and the bottom in 2010 after the facility was decommissioned and the surface reclaimed.

GROUND WATER RESTORATION AND WELL PLUGGING

- Restoration of the production zone may be achieved by a combination of groundwater sweep and R.O. The restoration of ground water at the ISR sites will have the benefit of a previously engineered array of injection and production wells that were initially installed in a configuration to maximize sweep efficiently throughout the uranium ore body, and maximize uranium recovery.
- With the R.O. techniques, injection and extraction operations continue at the facility except produced water is processed through a R.O. unit which produces a deionized fluid for reinjection. The injection solution passes through the pores of the aquifer formation and replaces the affected solutions which are pumped to the surface. The net effect is that the resulting interstitial ground water quality becomes consistent with, and in many cases better than pre-mining quality. The primary benefit of R.O. treatment is that a large fraction of the total water extracted is purified and reinjected resulting in less water consumption and less ground water drawdown in the area.
- Reducing agents may be added to the formation to help re-establish REDOX conditions.
- All wells is permanently plugged and abandoned with an approved grout medium upon completion of ground water restoration


reverse osmosis
equipment
(water filter)
monitor wells
(safeguard system)
injection well
extraction well
extraction well
uranium
ore
body
purified
water


W-T

HISTORIC DATA AT TECQ. 28 ISR PROJECTS, 50 PAs

U & Ra POST RESTORATION RESULTS

Avg. Uranium 50 PAs (MUs)				Avg. Radium 50 PAs (MUs)			
Baseline Average	Post Stability Average	Δ	MCL	Baseline Average	Post Stability Average	Δ	MCL
0.45 mg/l	**1.13 mg/l**	**0.68 mg/l**	**0.03** Δ **mg/l**	**124 pCi/l**	**128 pCi/l**	**4 pCi/l**	**5 pCi/l**

Gallons to achieve restoration in 33 out of 50 of these PAs (MUs) – 11,400,000,000

INCREASE TRACE ELEMENTS/SALINITY
Oxidation, pH↓ and Ion Exchange

Oxidation of iron sulfides – Fe (ppt) $SO_4\uparrow$ pH ↓

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3\ [ppt] + 4\ H^+ + 2\ SO_4^{=}$$

Oxidation of ferroselite – Fe (ppt) Se ↑ pH ↓

$$FeSe_2 + 11/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3\ [ppt] + 4\ H^+ + 2\ SeO_3^{=}$$

Oxidation of molybdenum sulfide – Mo ↑ S ↑ pH ↓

$$2\ MoS_2 + 9/2\ O_2 + 2\ H_2O \rightarrow Mo_2O_5 + 4\ H^+ + 2\ S_2O_3^{=}$$

Thiosulfate

Dissolution of calcium carbonate from lowered pH caused by oxidation of one mole of FeS_2 – $CaSO_4$ (ppt) $HCO_3\uparrow$ pH ↑
[Ca ↑ further lowers $CaSO_4$ & HCO_3 solubility]

$$2\ H_2SO_4 + 4\ CaCO_3 + 4NaCl \rightarrow 4NaHCO_3 + 2\ CaSO_4\ [ppt] + 2\ Ca^{++} + 2\ Cl^-$$

Ion Exchange

Na2UO2(CO3)2 + 2RCl → R2 UO2(CO3)2 + 2NaCl

TRACE ELEMENTS LINGER

Oxidation of iron sulfides – Fe (ppt) SO_4 ↑ pH ↓

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3\ [ppt] + 4\ H^+ + 2\ SO_4^{=}$$

Oxidation of ferroselite – Fe (ppt) Se ↑ pH ↓

$$FeSe_2 + 11/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3\ [ppt] + 4\ H^+ + 2\ SeO_3^{=}$$

Oxidation of molybdenum sulfide – Mo ↑ S ↑ pH ↓

$$2\ MoS_2 + 9/2\ O_2 + 2\ H_2O \rightarrow Mo_2O_5 + 4\ H^+ + 2\ \underset{\text{Thiosulfate}}{S_2O_3^{=}}$$

U6 remains

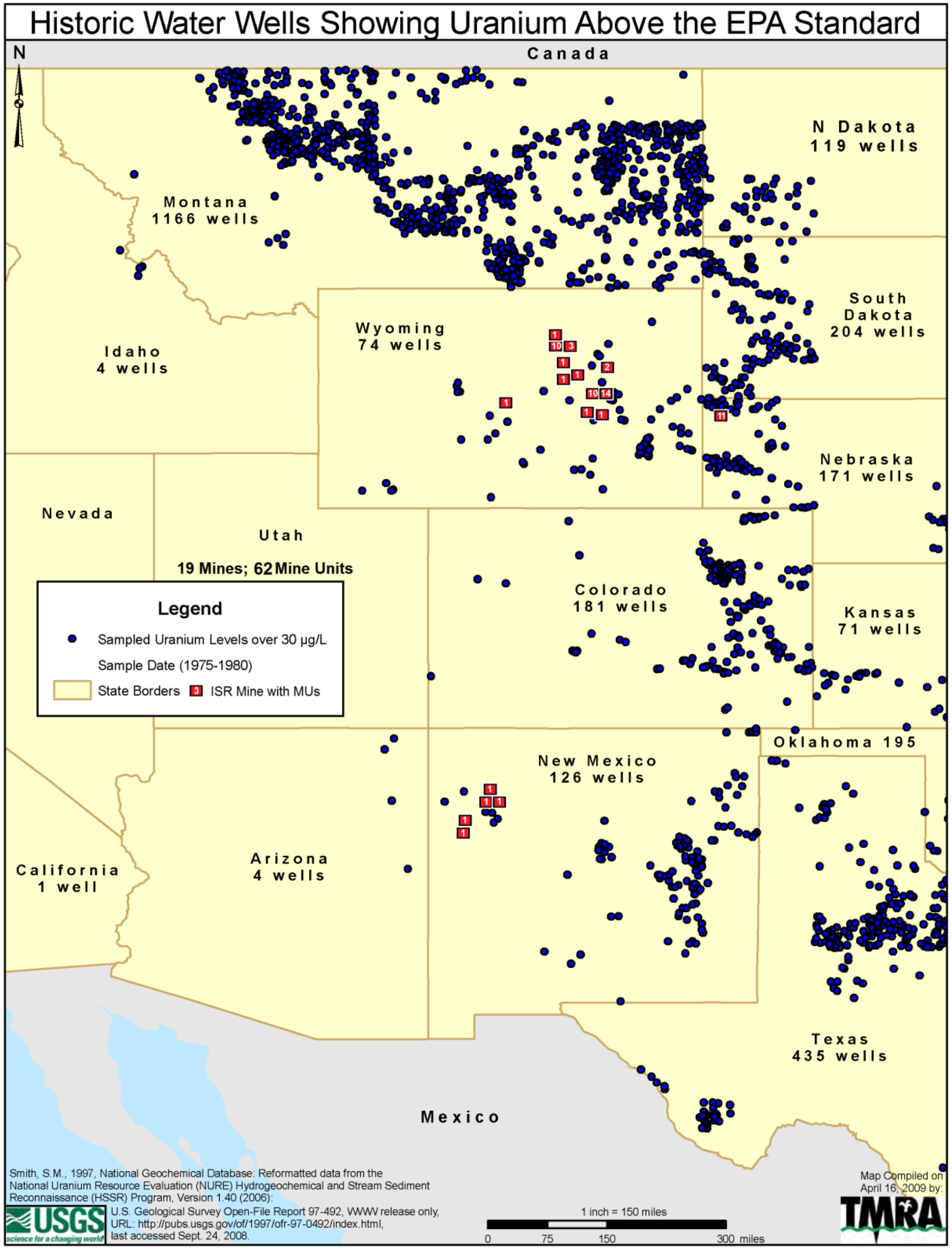
$$2UO_2 + O_2 \rightarrow 2UO_3$$

$$UO_3 + 2NaHCO_3 \rightarrow Na_2UO_2(CO_3)_2 + H_2O$$

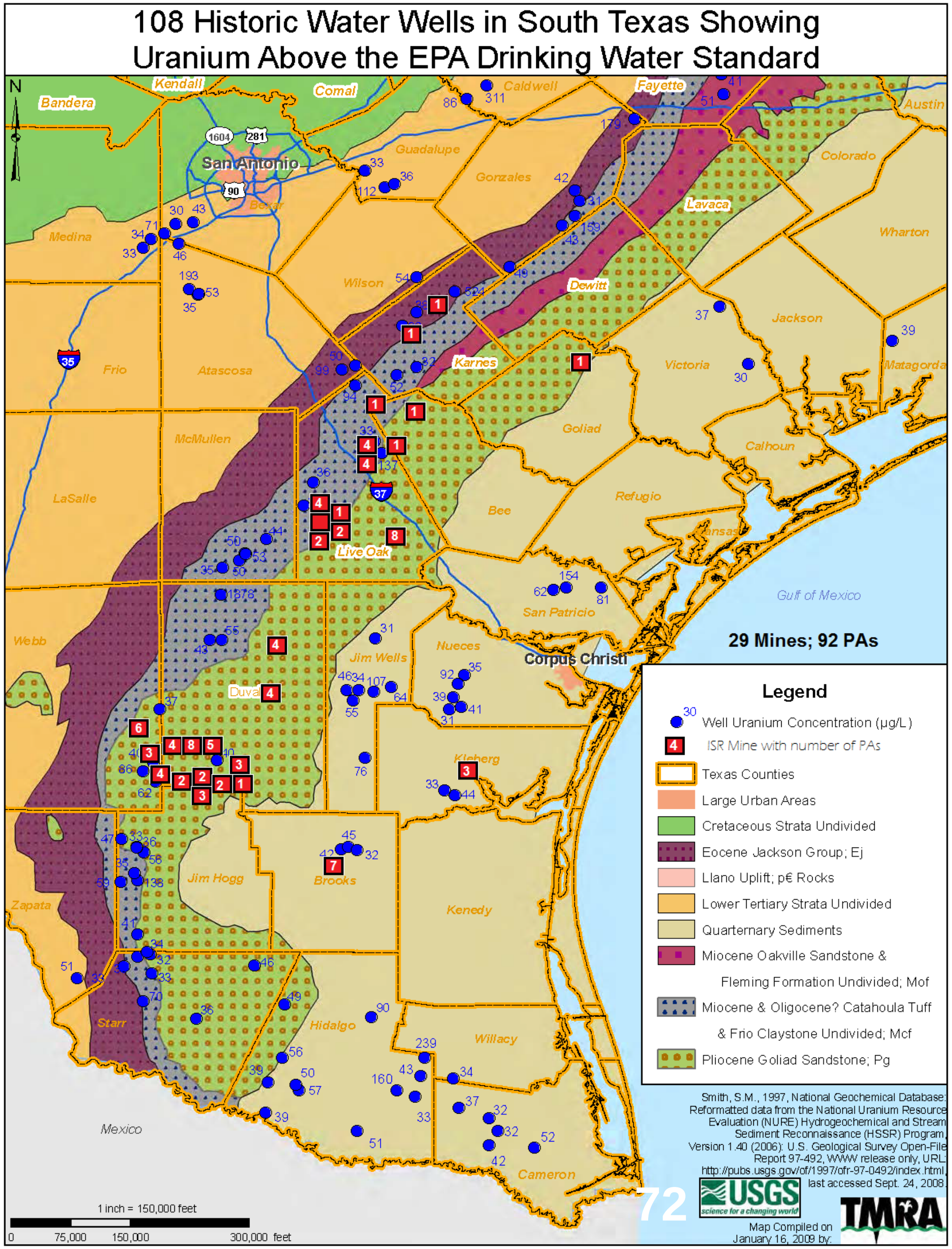
URANIUM - A NATURALLY OCCURRING RADIOACTIVE ELEMENT

- Geoscientists have historically sampled and analyzed groundwater for uranium from existing springs and wells as a exploration method.
- In 1973 the Atomic Energy Commission initiated the National Uranium Resource Evaluation (NURE) program to identify uranium resources in the United States.
- NURE investigators systematically sampled and analyzed groundwater across the United States to determine the presence and levels of uranium.
- Analysis of the NURE data shows where uranium is found above EPA's MCLs in aquifers in the US.

NURE West w/ISRs……



NURE Texas w/ISRs…….



AQUIFER EXEMPTION - 40CFR146.4

A aquifer or portion thereof which meets the criteria for an “underground source of drinking water” may be determined to be an exempted aquifer if:

(a) It does not currently serve as a source of drinking water; and
(b) It cannot now and will not in the future serve as a source of drinking water because:

(1) It is mineral, hydrocarbon or geothermal energy producing, or can be demonstrated as part of a permit application… that considering their quantity and location are expected to be commercially producible….
(3) It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption…

BACKGROUND SAMPLING PROTOCOL

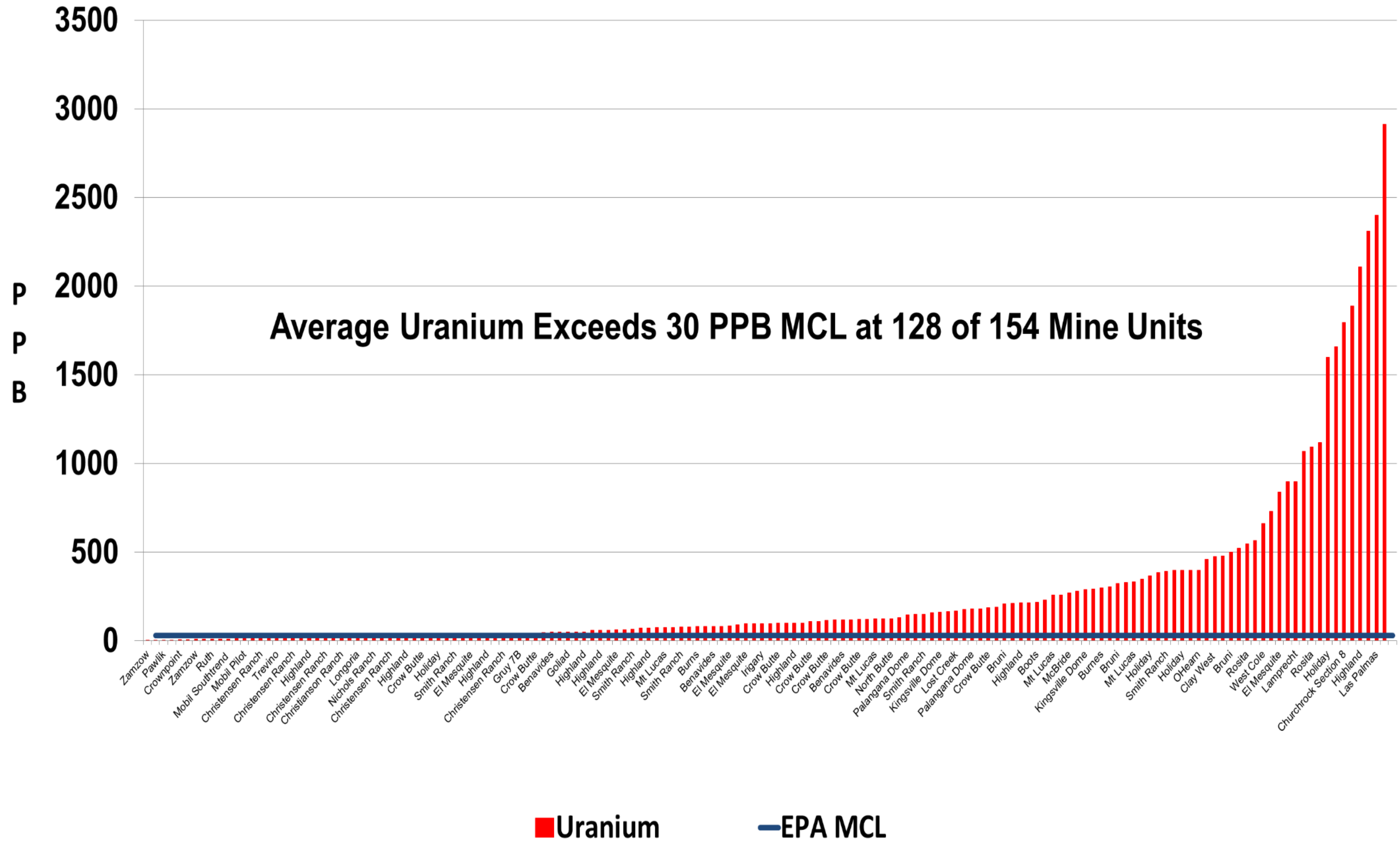
- **Baseline wells are completed in the mineralized sand within the production area or mine unit.**
- **Generally regulatory agencies require at least of five baseline wells or one baseline well for every four acres of production area which ever is more.**
- **ISR operators often obtain more samples than are required by regulatory agencies.**
- **Many operators take multiple (seasonal) samples per well.**
- **Samples are collected, preserved and controlled according to accepted methods using outside labs.**
- **Data from these multiple baseline wells samples are averaged for each production area or mine unit to establish background for restoration purposes.**

BACKGROUND SUMMARIES COMPILED

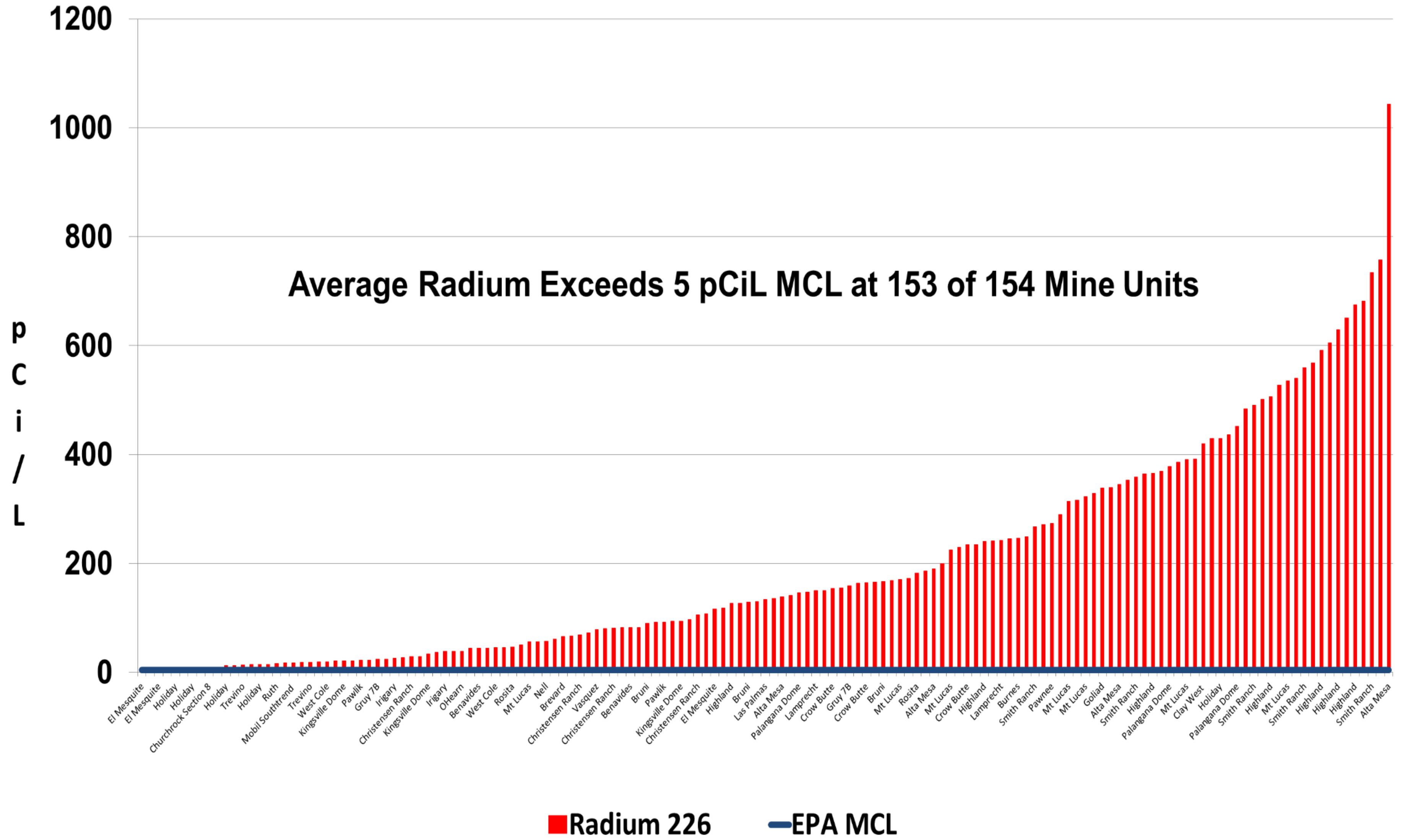
4 States, 48 ISRs, 154 PAs or MUs

PRE-MINING URANIUM AND U RELATED ELEMENTS IN ISL WELLFIELDS			
(highlighted where the drinking MCL is exceeded)			
State:	Wyoming		
Mine:	Nichols Ranch		
Wellfield Designation:	PA#1		
Number of Wells Sampled:	52 (PA#1)		
PRODUCTION AREA BASELINE WELLS			
Element	High Value	Average	MCL
Uranium (ug/l)	136	31.7	30
Radium (pCi/l)	254	56.4	5
Radon (pCi/l)	N/A	N/A	300
G. Alpha Radiation (pCi/l)	1080	239	15
G. Beta Radiation (pCi/l)	706	170	50
MONITOR WELL RING			
Element	High Value	Average	MCL
Uranium (ug/l)	34.4	12.9	30
Radium (pCi/l)	12.1	1.09	5
Radon (pCi/l)	N/A	N/A	300
G. Alpha Radiation (pCi/l)	90.2	21.05	15
G. Beta Radiation (pCi/l)	80.1	8.33	50
Source: Uranerz			

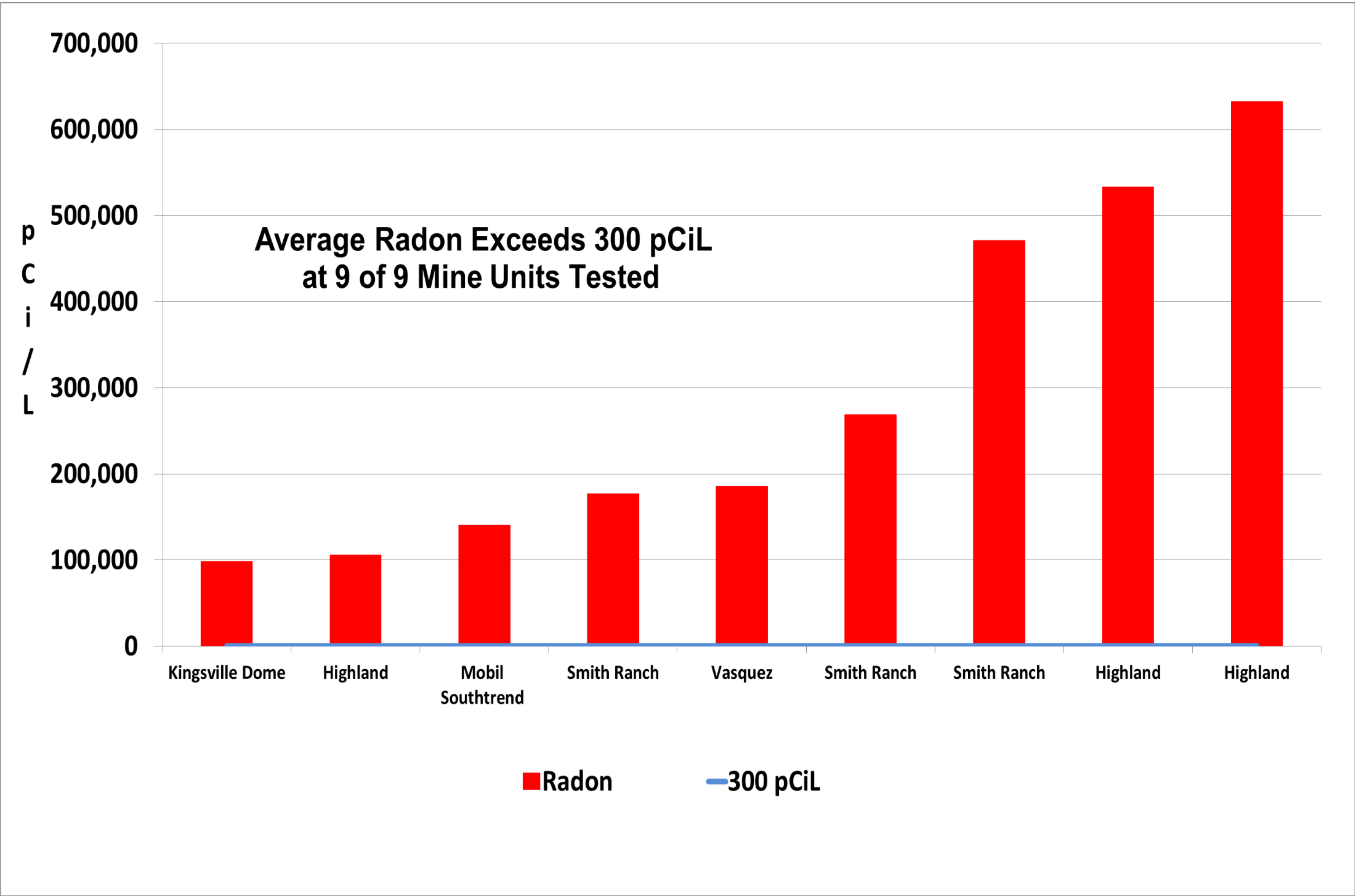
BACKGROUND URANIUM AT ISRs



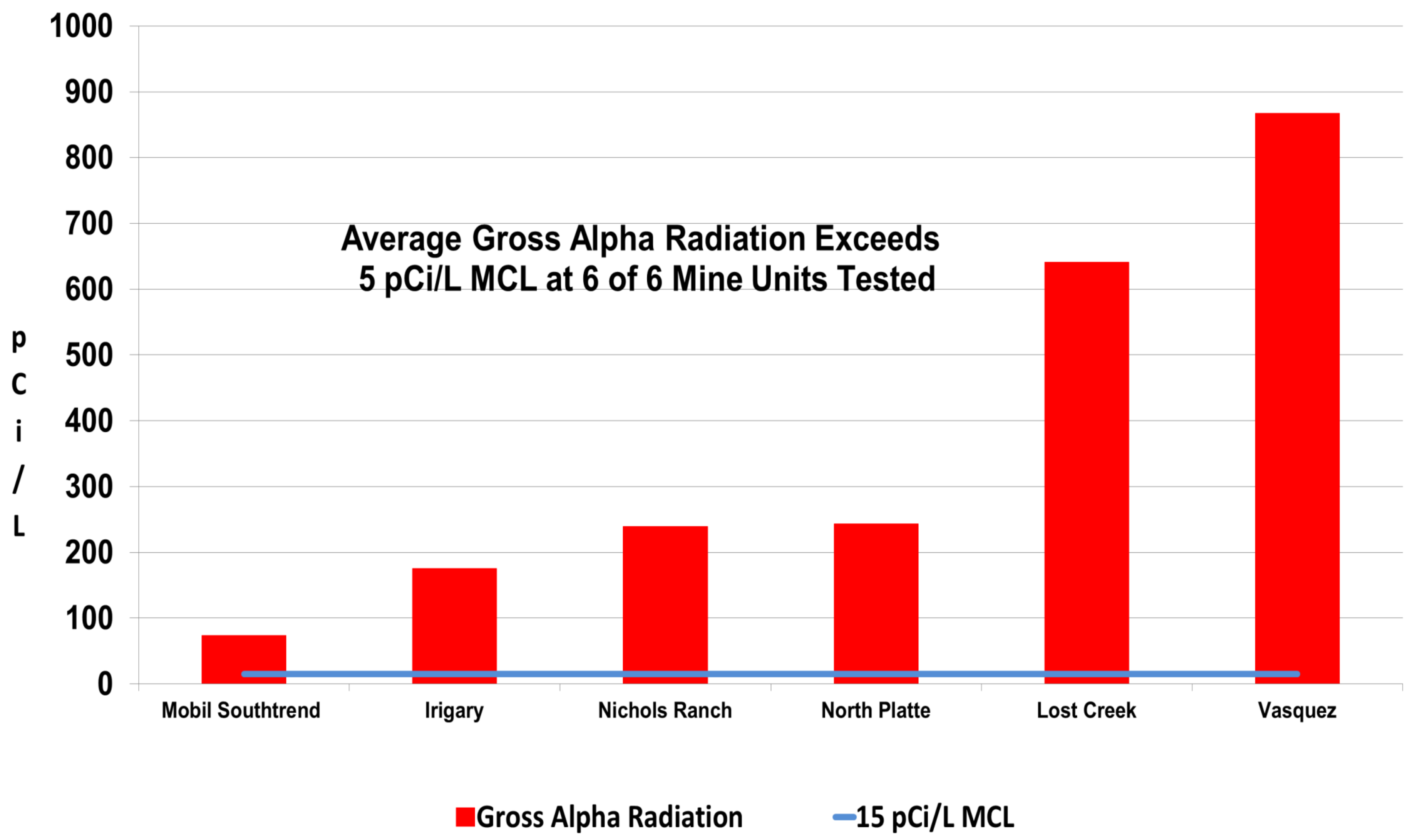
BACKGROUND RA-226 AT ISRs



BACKGROUND RN-222 AT ISRs



BACKGROUND GROSS ALPHA AT ISRs



ISR COMPILATION SUMMARY

- Data compiled from 4 states, 48 mines 154 mine units show that none meet MCLs for uranium and/or radium-226 together.
- Average uranium exceeds 30 µg/L MCL in 128 of 150 mine units or by 85.3 %.
- Average radium-226 exceeds 5 pCi/L MCL in 149 of 150 mine units or by 99.4 %.
- Average radon-222 exceeds 300 pCi/L in 9 of 9 mine units or by 100 %.
- Average gross α radiation exceeds 15 pCi/L MCL in 6 of 6 mine units or by 100 %.
- Average gross β radiation exceeds 50 pCi/L in 6 of 6 mine units or by 100 %.

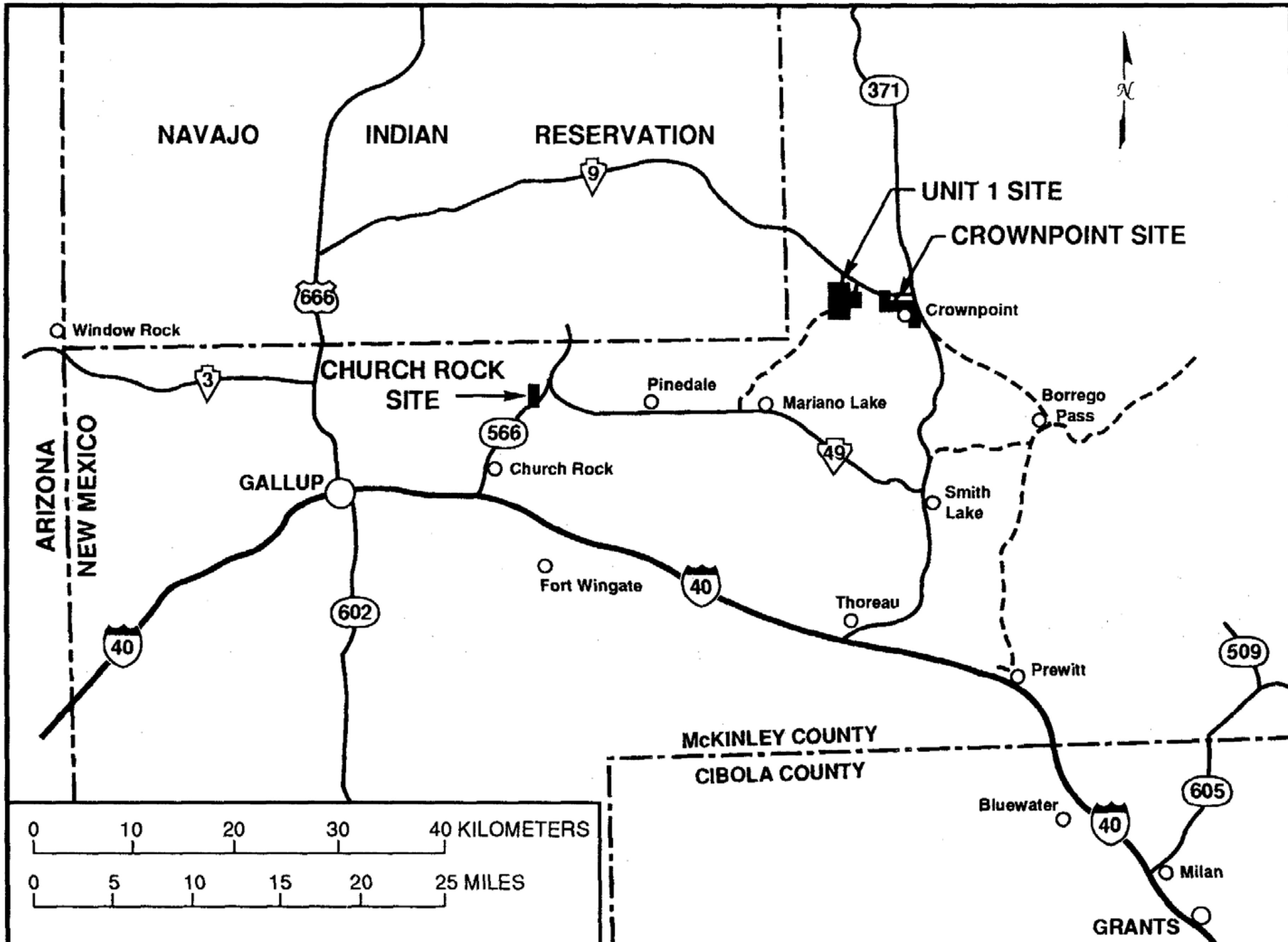
NUREG–1508
BLM NM–010–93–02
BIA EIS–92–001

Final
Environmental Impact Statement
to Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico

Docket No. 40–8968
Hydro Resources, Inc.

Manuscript Completed: February 1997
Date Published: February 1997

Division of Waste Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555–0001



NAVAJO
INDIAN
RESERVATION
371
9
UNIT 1 SITE
CROWNPOINT SITE
Crownpoint
666
Window Rock
CHURCH ROCK
SITE
3
Pinedale
Mariano Lake
Borrego
Pass
566
49
ARIZONA
NEW MEXICO
Church Rock
GALLUP
Smith
Lake
Fort Wingate
40
Thoreau
602
40
509
Prewitt
McKINLEY COUNTY
CIBOLA COUNTY
605
Bluewater
40
Milan
GRANTS
0
10
20
30
40 KILOMETERS
0
5
10
15
20
25 MILES

Table 3.19. Church Rock site water quality data,[a] Westwater Canyon aquifer

Parameter	Mean (mg/L)	Maximum (mg/L)	Minimum (mg/L)	EPA (and NNEPA) drinking water standard
Calcium	2.775	5.8	1.5	
Magnesium	0.235	0.81	0.07	
Sodium	129.75	148.0	114.0	
Potassium	2.46	6.6	0.85	
Carbonate	28.75	80.0	0.0	
Bicarbonate	246.25	331.0	185.0	
Sulfate	37.0	46.0	32.0	250.0
Chloride	6.15	12.0	2.8	250.0
TDS	369.75	435.0	322.0	500.0
Uranium	1.8	10.9	0.002	**0.03**
Radium-226[d]	10.225	26.0	1.1	5.0

[a]*Source*: HRI 1996b.
[b]μmhos/cm.
[c]Units.
[d]pCi/L.

Modified from NUREG-1508

Table 3.13. Crownpoint site water quality data,[a] Westwater Canyon aquifer

Parameter	Mean (mg/L)	Maximum (mg/L)	Minimum (mg/L)	EPA (and NNEPA) drinking water standard
Calcium	2.68	7.8	0.07	
Magnesium	0.44	2.5	0.0	
Sodium	120.3	184.0	97.0	
Potassium	10.58	56.0	1.5	
Carbonate	26.42	127.0	0.0	
Bicarbonate	201.22	260.0	54.0	
Sulfate	54.9	177.0	19.0	250.0
Chloride	10.9	54.0	1.8	250.0
TDS	367.8	666.0	318.0	500.0
Uranium	0.001	0.021	0.0	**0.03**
Radium-226[d]	65.85	806.0	0.1	5.0

[a]Values obtained from Wells CP-3, CP-5, CP-6, CP-7, CP-9, and well CP-2 (for parameters from arsenic to radium-226, (*Source:* HRI 1992b).

[b]μmhos/cm.

[c]Units.

[d]pCi/L.

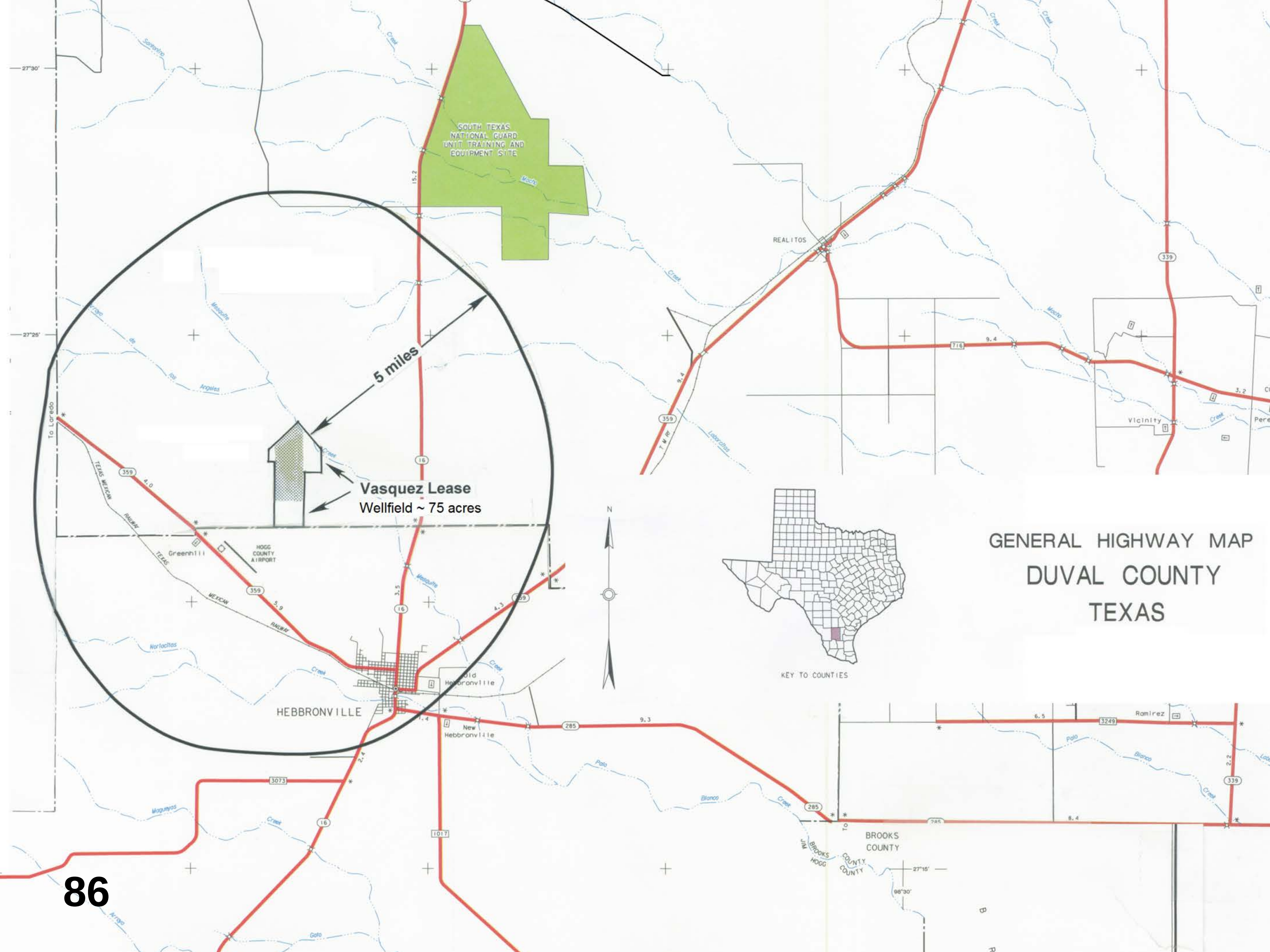
Modified from NUREG-1508

Table 3.16. Unit 1 site water quality data,[a] Westwater Canyon aquifer

Parameter	Mean (mg/L)	Maximum (mg/L)	Minimum (mg/L)	EPA (and NNEPA) drinking water standard
Calcium	3.75	18.0	1.1	
Magnesium	0.145	9.2	0.0	
Sodium	113.0	1100.0	82.0	
Potassium	1.95	12.0	0.7	
Carbonate	12.0	120.0	0.0	
Bicarbonate	206.0	270.0	89.0	
Sulfate	35.5	220.0	20.0	250.0
Chloride	5.5	41.0	<3.0	250.0
TDS	285.0	590.0	0.0	500.0
Uranium	2.0	2.7	0.68	**0.03**
Radium-226[d]	10.3	200.0	0.0	5.0
Gross alpha[d]	42.0	610.0	0.0	**15.0**
Gross beta[d]	43.0	510.0	0.0	
Radon[d]	81699.0	1100000.0	22.0	

[a] *Source*: HRI 1992b.
[b] μmhos/cm.
[c] Units.
[d] pCi/L.

Modified from NUREG-1508

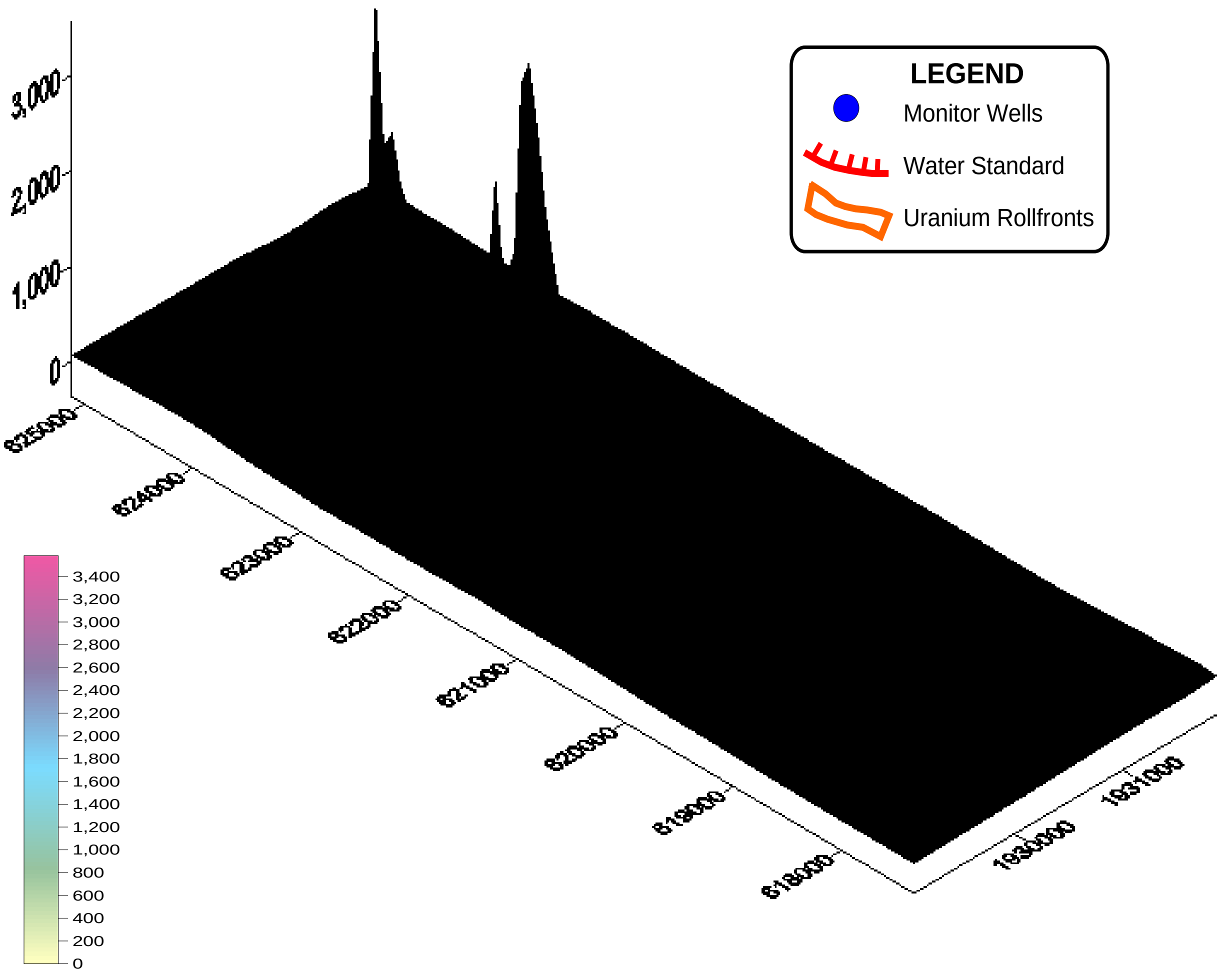


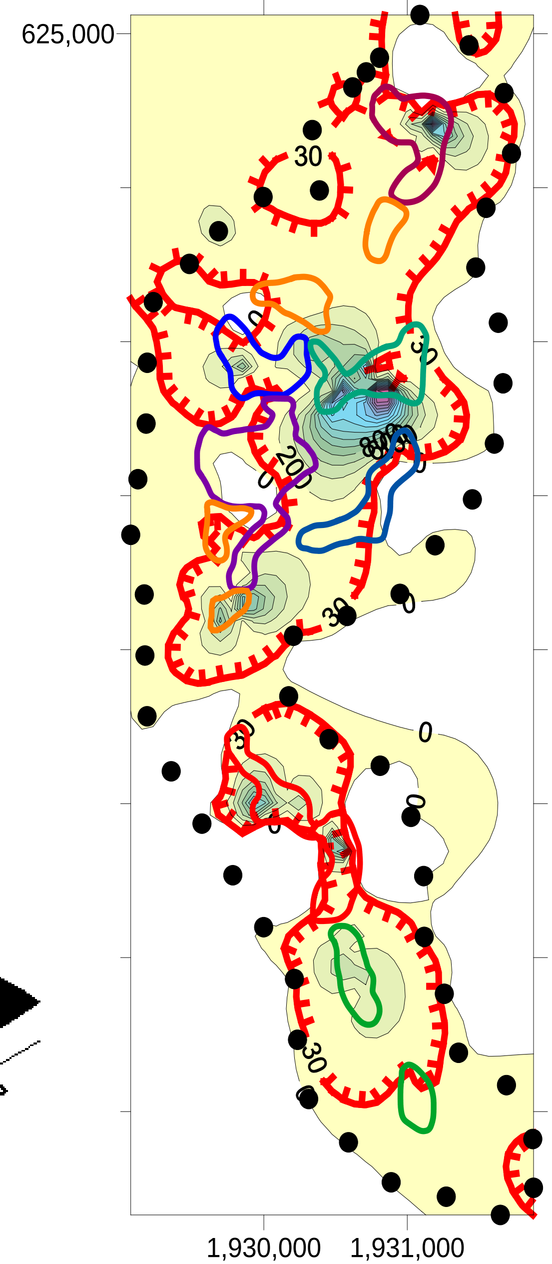
5 miles
Vasquez Lease
Wellfield ~ 75 acres
SOUTH TEXAS NATIONAL GUARD UNIT TRAINING AND EQUIPMENT SITE
REALITOS
HOGG COUNTY AIRPORT
Greenhill
HEBBRONVILLE
Old Hebbronville
New Hebbronville
Vicinity
Ramirez
BROOKS COUNTY
JIM HOGG COUNTY
BROOKS COUNTY
TEXAS MEXICAN RAILWAY
To Laredo
KEY TO COUNTIES
GENERAL HIGHWAY MAP
DUVAL COUNTY
TEXAS

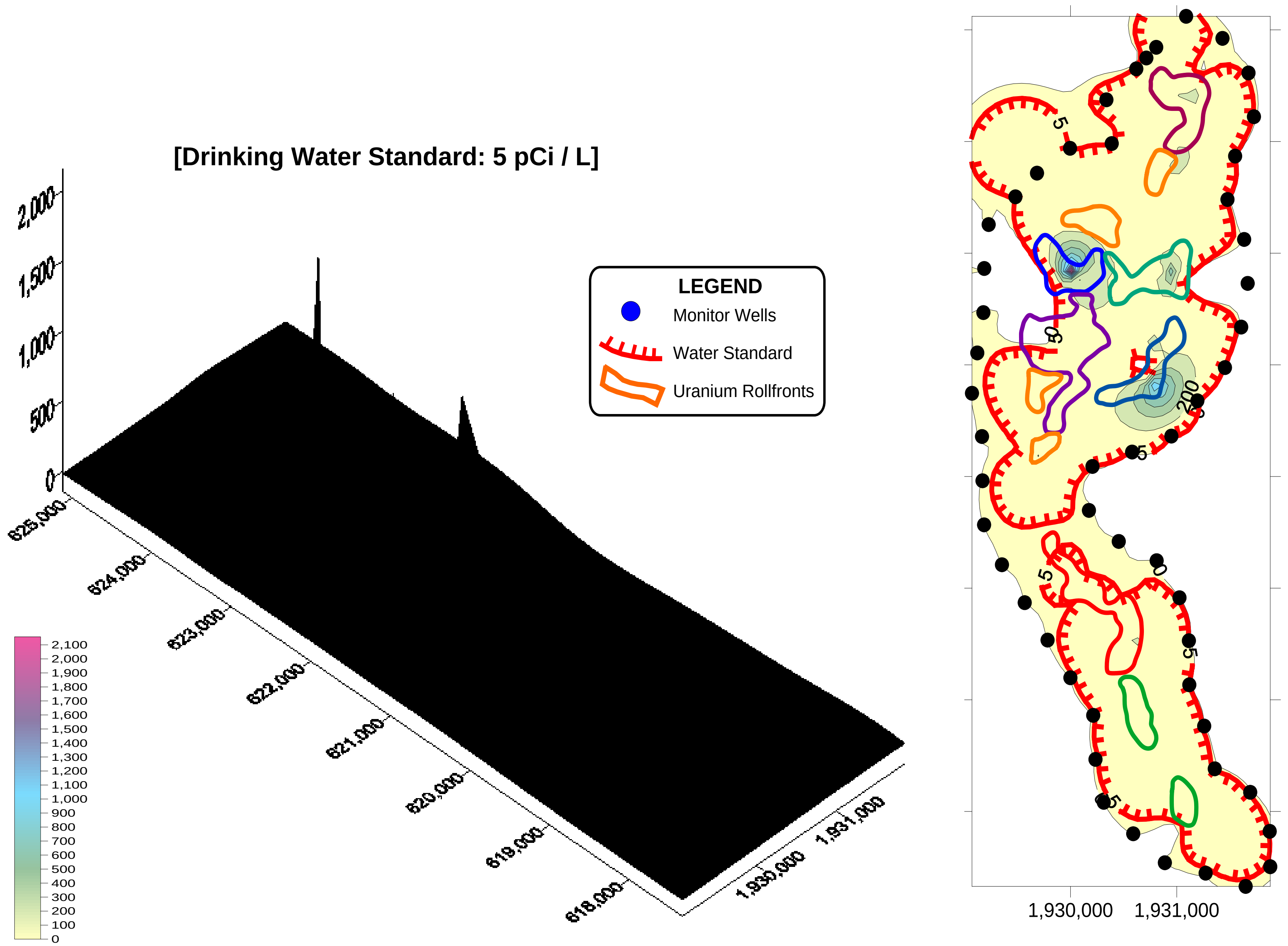
URI's Vasquez ISR Project

Baseline Uranium (U) [ppb]

[Drinking Water Standard: 30 ppb]







[Drinking Water Standard: 5 pCi / L]
LEGEND
Monitor Wells
Water Standard
Uranium Rollfronts
2,000
1,500
1,000
500
0
625,000
624,000
623,000
622,000
621,000
620,000
619,000
618,000
1,930,000
1,931,000
2,100
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
1,930,000 1,931,000

VASQUEZ URANIUM AND PROGENY AVERAGES

Parameter	Monitor Well Ring	Wellfield Baseline Wells	Drinking Standard
Uranium (ppb)	34	393	30
Radium 226 (pCi/l)	7.4	137	5
Radon 222 (pCi/l)	N/A	169,760	300
Gross Alpha (pCi/l)	N/A	818	15
Gross Beta (pCi/l)	N/A	167	
Number Wells	35	185	

U & Ra POST RESTORATION RESULTS

Avg. Uranium 50 PAs (MUs)				Avg. Radium 50 PAs (MUs)			
Baseline Average	Post Stability Average	Δ	MCL	Baseline Average	Post Stability Average	Δ	MCL
0.45 mg/l	**1.13 mg/l**	**0.68 mg/l**	**0.03** Δ **mg/l**	**124 pCi/l**	**128 pCi/l**	**4 pCi/l**	**5 pCi/l**

Gallons to achieve restoration in 33 out of 50 of these PAs (MUs) – 11,400,000,000