MODERN IN SITU URANIUM RECOVERY TECHNOLOGY ASSURES NO ADVERSE IMPACT ON ADJACENT AQUIFER USES

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EMD
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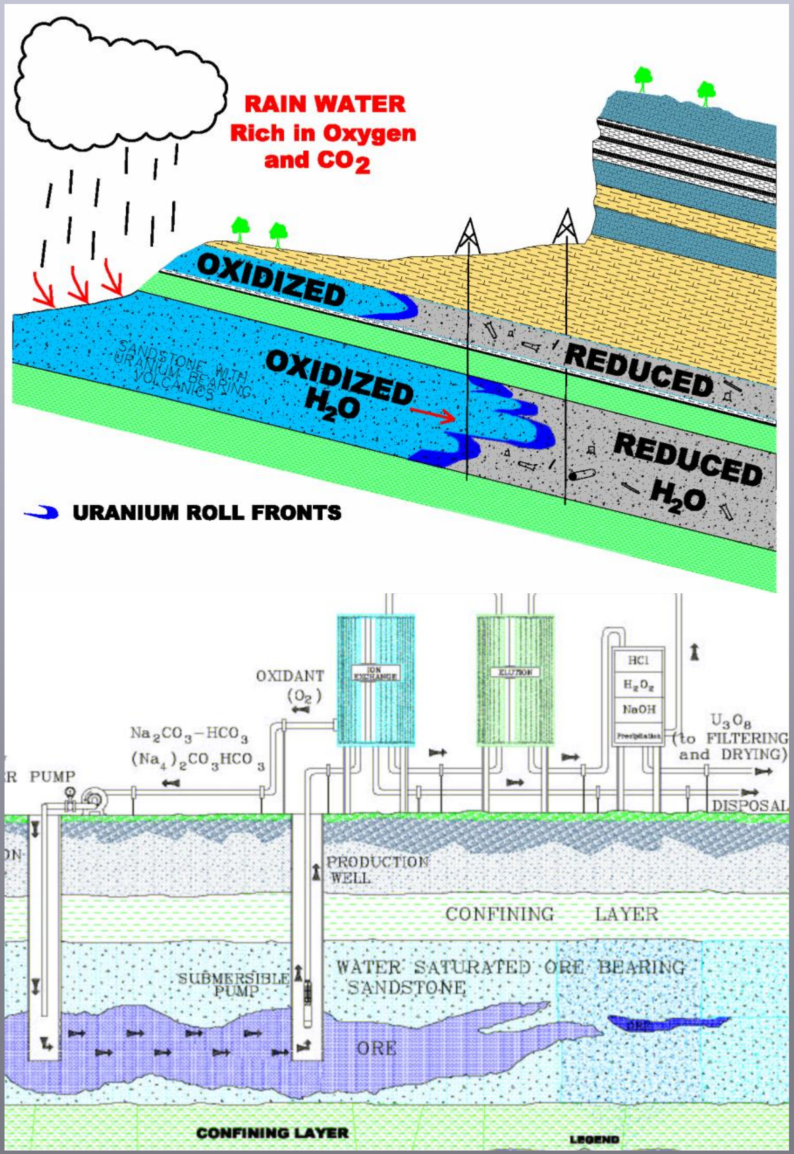
"IN-SITU" RECOVERY

In-situ recovery ("ISR") is an noninvasive mining process where uranium is extracted from sandstone aquifers by reversing the natural process which deposited the uranium. Existing groundwater fortified with oxygen is used to leach the uranium from sands. The uranium is then recovered by passing the leach solution over ion exchange resin, much like in a domestic water softener. The loaded resin is then processed. Finally, the groundwater is restored consistent with is previous quality and use.



O_2 INJECTION/CARBONATE COMPLEX
U4 to U6

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

$$UO_3 + 2NaHCO_3 \rightarrow NA_2UO_2(CO_3)_2 + H_2O$$

Uranium Resources

INCREASE TRACE ELEMENTS/SALINITY

Oxidation, pH↓ and Ion Exchange

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 ↓

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

Thiosulfate

Dissolution of calcium carbonate from lowered pH caused by oxidation of one mole of FeS_2 – $CaSO_4$ (ppt) HCO_3 ↑ 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 (IX)

$$Na_2UO_2(CO_3)_2 + 2RCl \rightarrow R_2\ UO_2(CO_3)_2 + 2NaCl$$

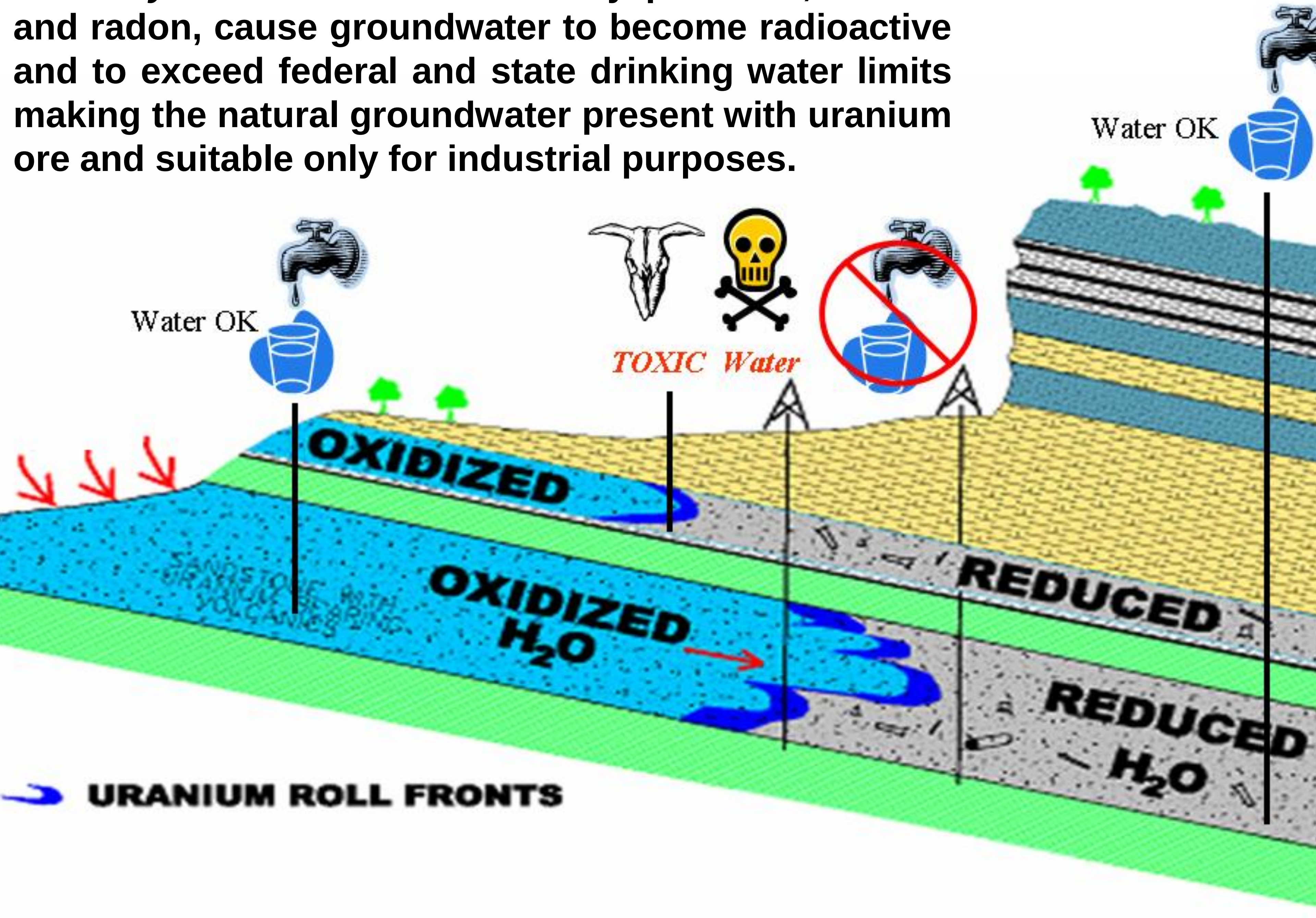
Uranium Resources

NO REGIONAL AQUIFER IMPACT

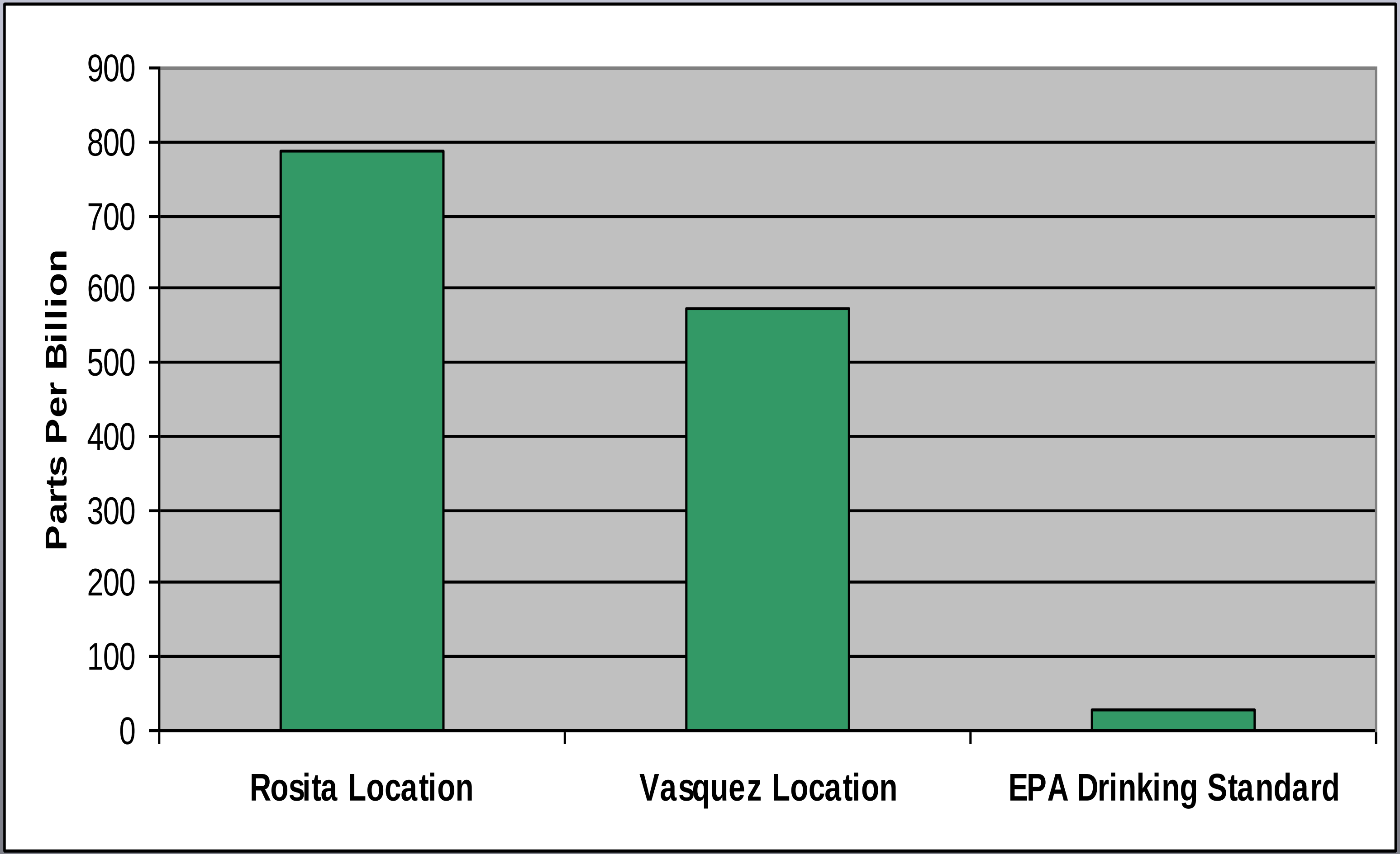
ISR is performed only in the localized mineralized zone of the aquifer.

1. **Wellfield patterns are engineered, balanced, a negative production bleed is maintained and the ore zone is surrounded by horizontal and vertical monitor wells.**
2. **Before monitoring ceases, restoration must be completed.**

Naturally **- uranium and its decay products, radium and radon, cause groundwater to become radioactive and to exceed federal and state drinking water limits making the natural groundwater present with uranium ore and suitable only for industrial purposes.**



NATURAL URANIUM CONCENTRATION BEFORE MINING



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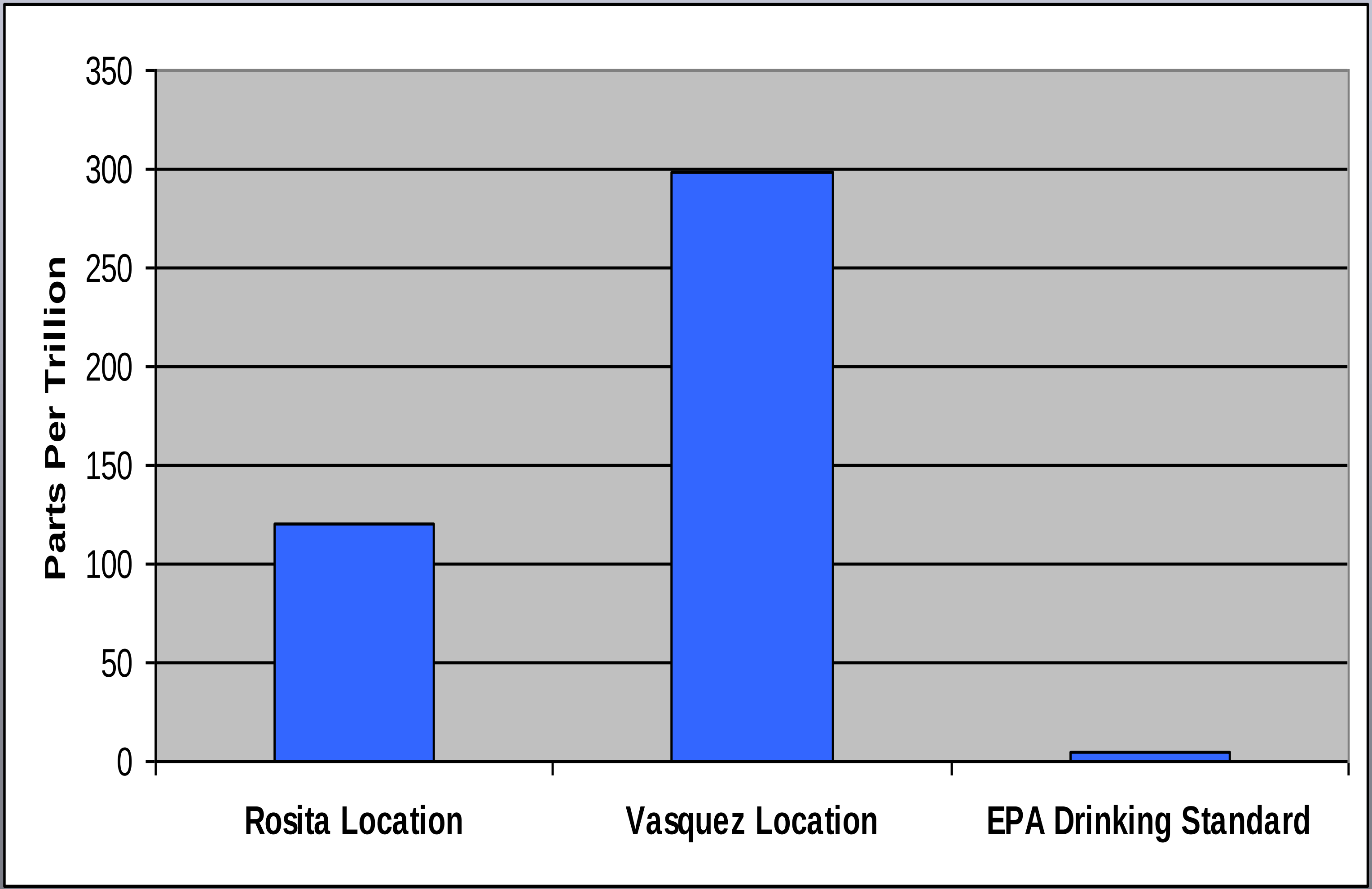
RADIUM CONCENTRATION BEFORE MINING



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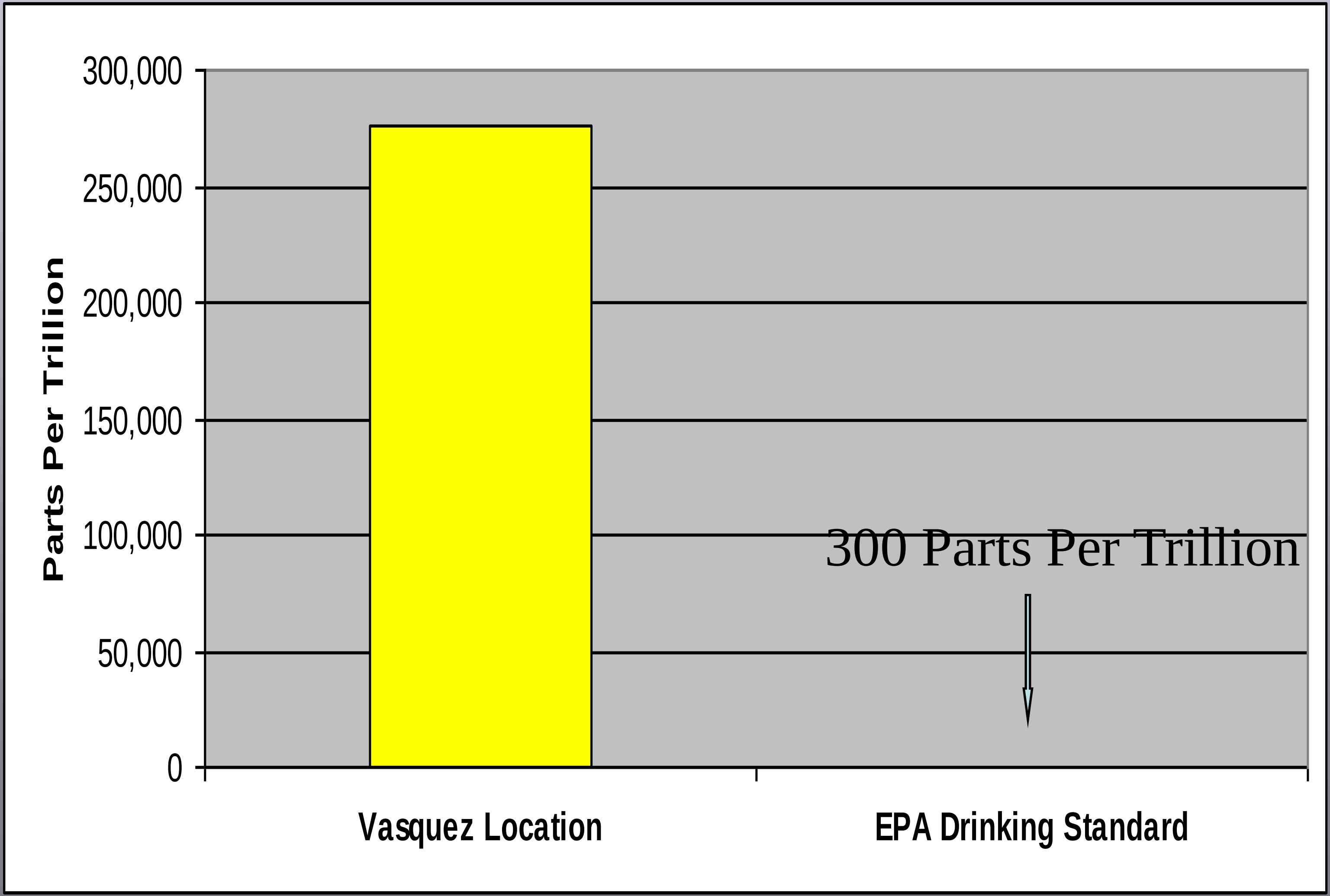
RADON CONCENTRATION BEFORE MINING



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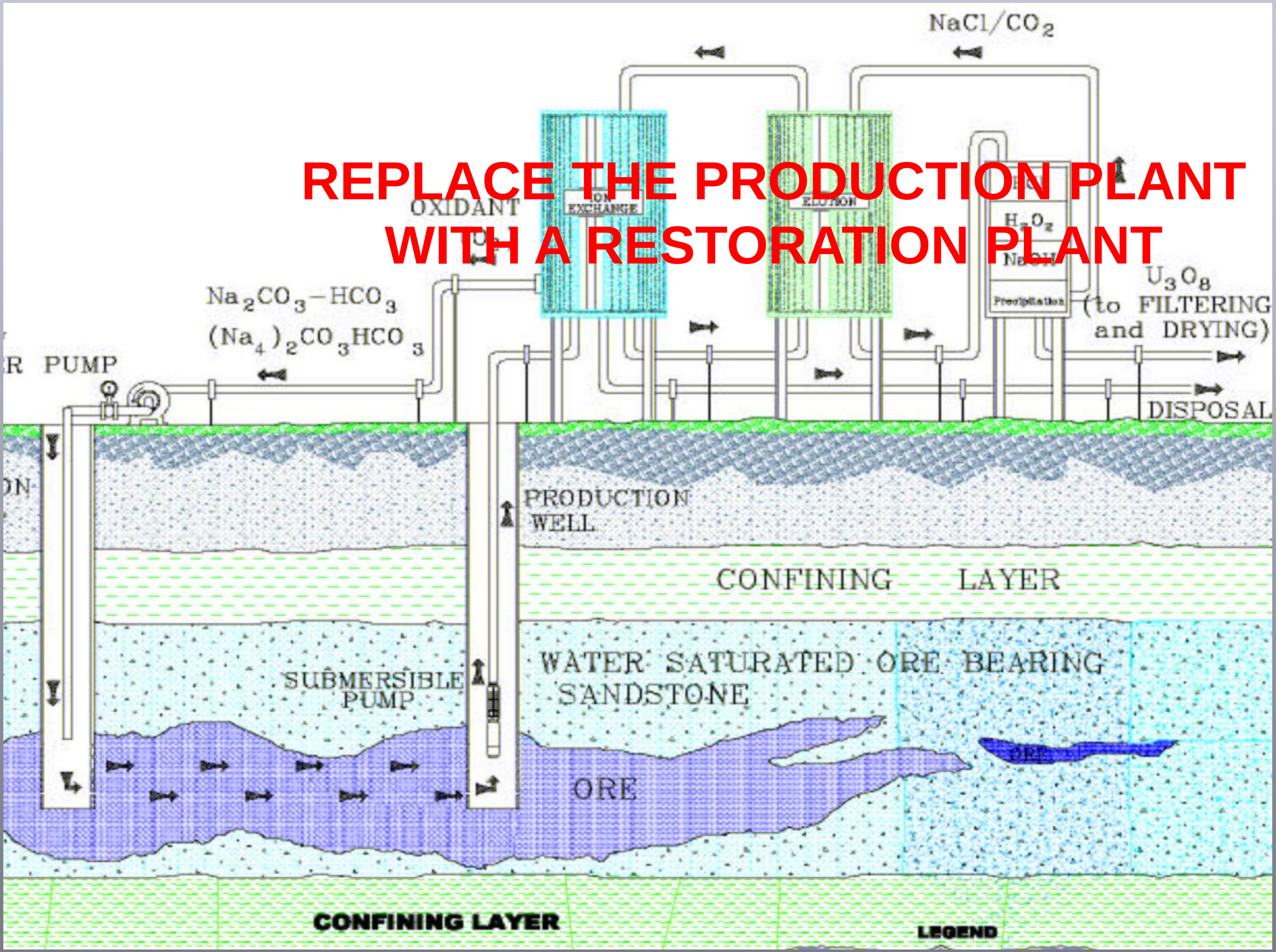
RESTORATION/RECLAMATION REGULATIONS

1. Groundwater Restoration (30TAC331.107)

2. Plugging and Abandonment of Wells (30TAC331.86)

GROUNDWATER RESTORATION



Uranium Resources

REVERSE OSMOSIS

WASTE DISPOSAL

Uranium Resources

RESTORATION VALUES NOT ACHIEVED

331.107(f) the commission will consider the following:

1. uses for which the groundwater was suitable at baseline water quality levels;
2. actual existing use of groundwater in the area prior to and during mining;
3. potential future use of groundwater of baseline quality and of proposed restoration quality;
4. the effort made by the permittee to restore the groundwater to baseline;
5. technology available to restore groundwater for particular parameters;
6. the ability of existing technology to restore groundwater to baseline quality in the area under consideration;
7. the cost of further restoration efforts;
8. the consumption of groundwater resources during further restoration; and
9. the harmful effects of levels of particular parameter.

INCREASE TRACE ELEMENTS

Oxidation

Oxidation of iron sulfides – $SO_4 \uparrow$

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

Oxidation of ferroselite – Se ↑

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Thiosulfate

Oxidation of UO_2

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

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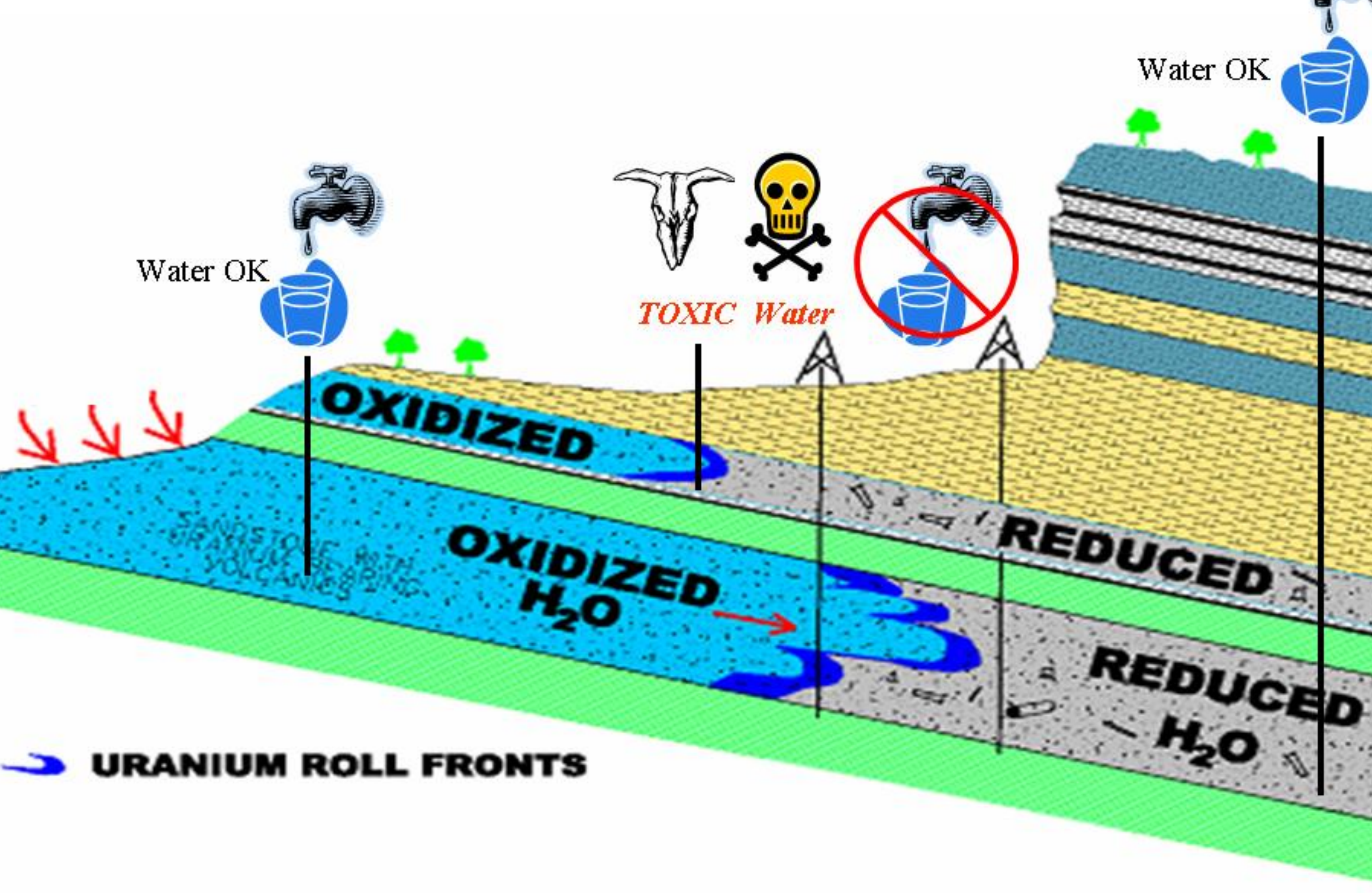
ATTENUATION / DISPERSION



ATTENUATION / DISPERSION MITIGATE

1. Premining contamination from uranium, radium and radon make the water undrinkable using EPA standards.
2. The ore deposit can be millions of years old with billions of gallons of groundwater having moved through the area, but water analysis shows that because of attenuation and dispersion the contamination remains confined to the uranium mineralization.
3. This process is active today. Roll fronts require broad areas of up gradient meteoric oxidation to keep uranium mobile until that oxidized water moves downgrade far enough to encounter a zone of abundant reductant.
4. The ore area is extremely small compared to the size of the regional aquifer so logically the regional reducing capacity of the aquifer will prevail over small pockets of residual oxidation.
5. It is unreasonable to conclude that a regional geologic formation maintains the capacity to absorb meteoric oxygen from expanses of slow moving ground water on a grand scale with resulting regional precipitation of metals, yet this same redox interface would be unable to absorb a far smaller amount of manually injected oxygen from equally slow moving post-restoration groundwater from an ISR operation and precipitate the very same metals in similar concentrations.

REDUCTION/BIOREMEDIATION

1. Reducing Agents
2. Nutrient Supplement
3. Hydrogen Injection

PLUGGING AND ABANDONMENT

ISL URANIUM RECOVERY RECLAMATION STATUS - 2007			
Operation	Status	County	Regional Aquifer
Caithness – McBride	G.W.Restored/Plugged/D&D	Duval	Oakville
Chevron – Palangana	G.W.Restored/Plugged/D&D	Duval	Goliad
Cogema – Holiday	G.W.Restored/Plugged	Duval	Catahoula
Cogema – El Mesquite	G.W.Restored/Plugged	Duval	Catahoula
Cogema - O’Hern	G.W.Restored/Plugged/D&D	Duval	Catahoula
Cogema – Cole	G.W.Restored/Plugged/D&D	Duval	Catahoula
Conoco- Trevino	G.W.Restored/Plugged/D&D	Duval	Oakville
Everest – Hobson	G.W.Restored/Plugged/D&D	Karnes	Oakville
Everest – Las Palmas	G.W.Restored/Plugged/D&D	Duval	Oakville
Everest – Mt Lucas	G.W.Restored/Plugged	Live Oak	Goliad
Everest – Tex-1	G.W.Restored/Plugged/D&D	Karnes	Oakville
IEC – Pawnee	G.W.Restored/Plugged/D&D	Bee	Oakville
IEC – Zamzow	G.W.Restored/Plugged/D&D	Live Oak	Oakville
IEC – Lamprecht	G.W.Restored/Plugged	Live Oak	Oakville
Mestena – Alta Mesa	Operation	Brooks	Goliad
URI – Benavides	G.W.Restored/Plugged/D&D	Duval	Catahoula
URI – KVD	G.W. Restoration/Operation	Kleberg	Goliad
URI – Longoria	G.W.Restored/Plugged/D&D	Duval	Catahoula
URI – Rosita	G.W.Restored/Operation	Duval	Goliad
URI – Vasquez	Operation	Duval	Goliad
U.S.Steel - Boots	G.W.Restored/Plugged/D&D	Live Oak	Oakville
U.S.Steel - Burns	G.W.Restored/Plugged/D&D	Live Oak	Oakville
U.S.Steel - Clay West	G.W.Restored/Plugged/D&D	Live Oak	Oakville
U.S.Steel - Mosier	G.W.Restored/Plugged/D&D	Live Oak	Oakville