

# Addressing Uranium Contamination on the Wind River Reservation: Environmental Justice, Phytoremediation and Risk Analysis



Honors Thesis/EPSCoR  
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# Project Overview

## Environmental Justice

- Site Background
- Injustice

## Phytoextraction Project

- Process
- Outcomes
- XPS Data

## @Risk Analysis

- Results
- Recommendations



# The Fact of the Case



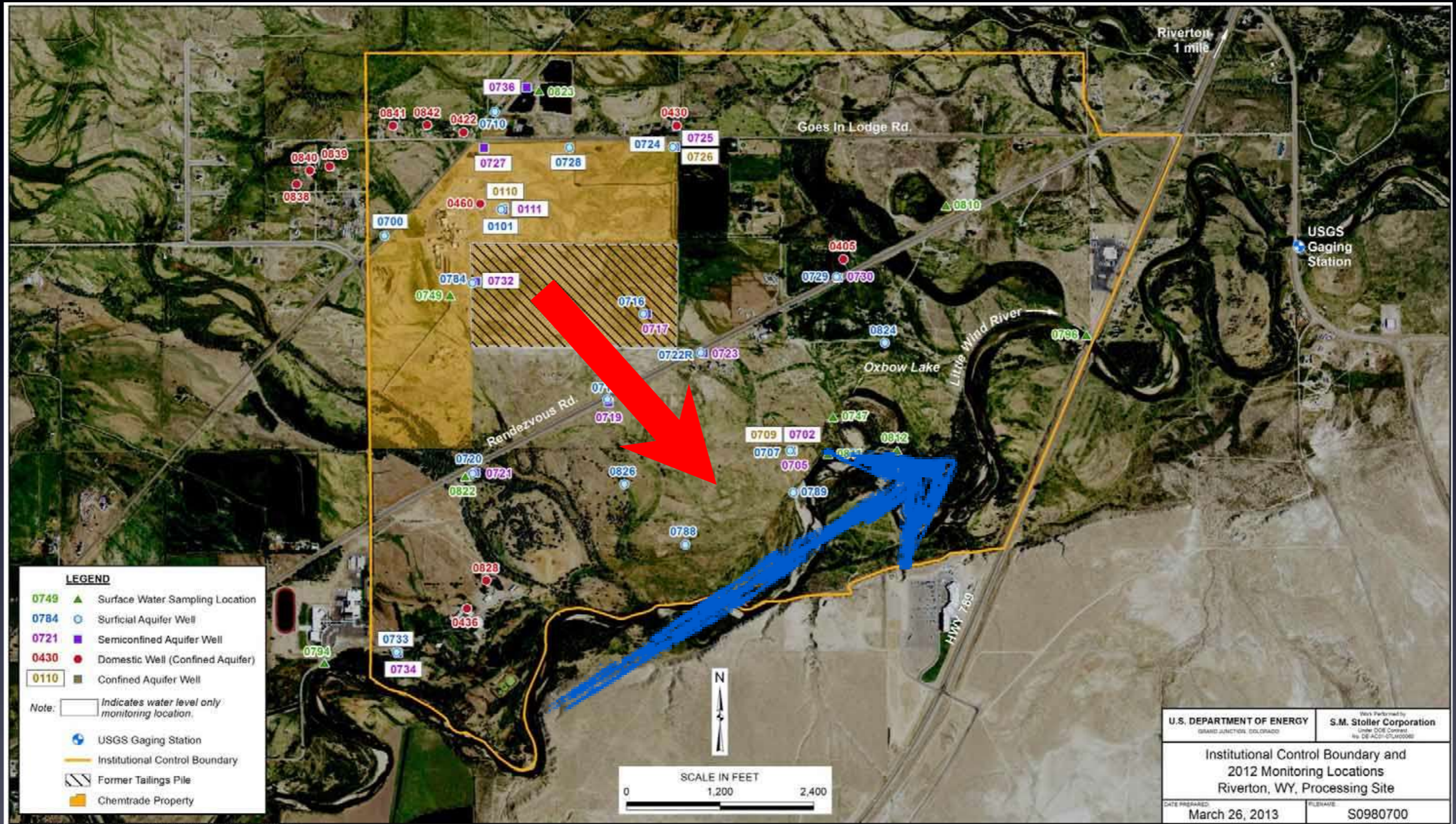
- 1958, Susquehanna-Western dumped 1.8 million cubic yards of the radioactive material

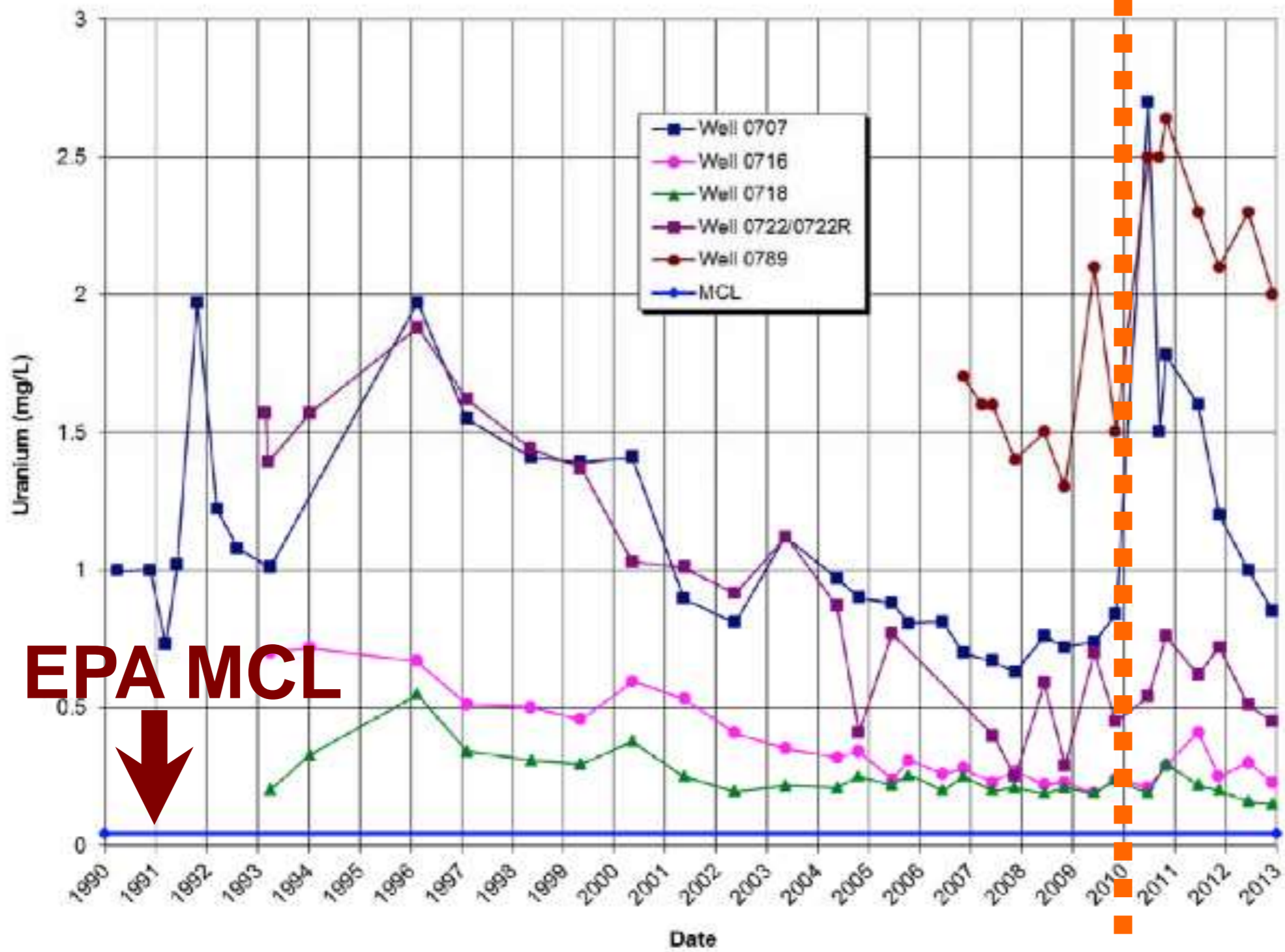
# Tribal Sovereignty: Asserting Responsibility Against Structurally Produced Injustice

DOE mission: “to ensure America’s security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions” (Mission-DOE)

“all those who contribute by their actions to structural processes with some unjust outcomes share responsibility for the injustice” (Young).

# Site Dynamics





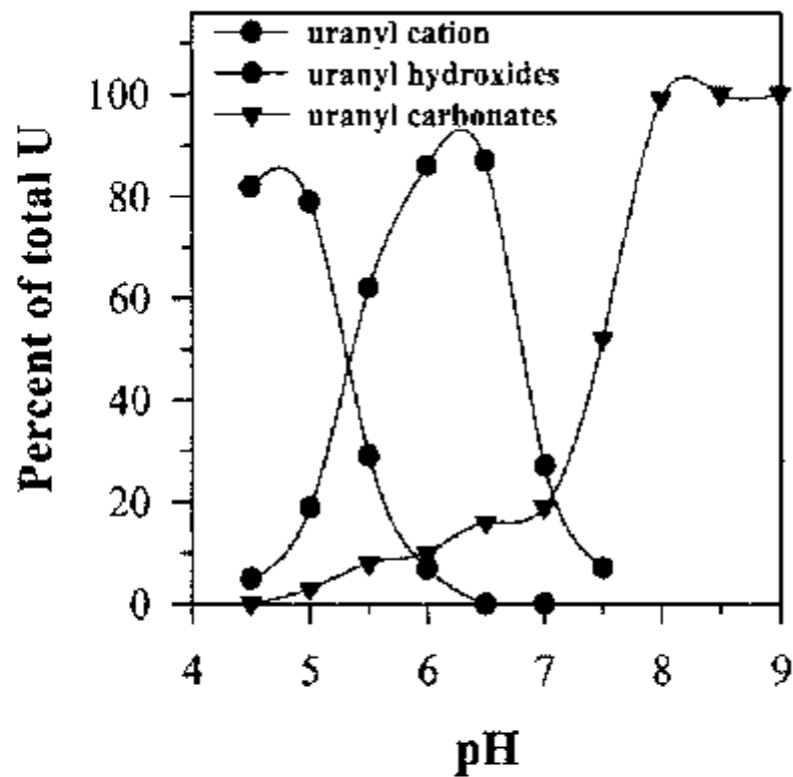
**EPA MCL**



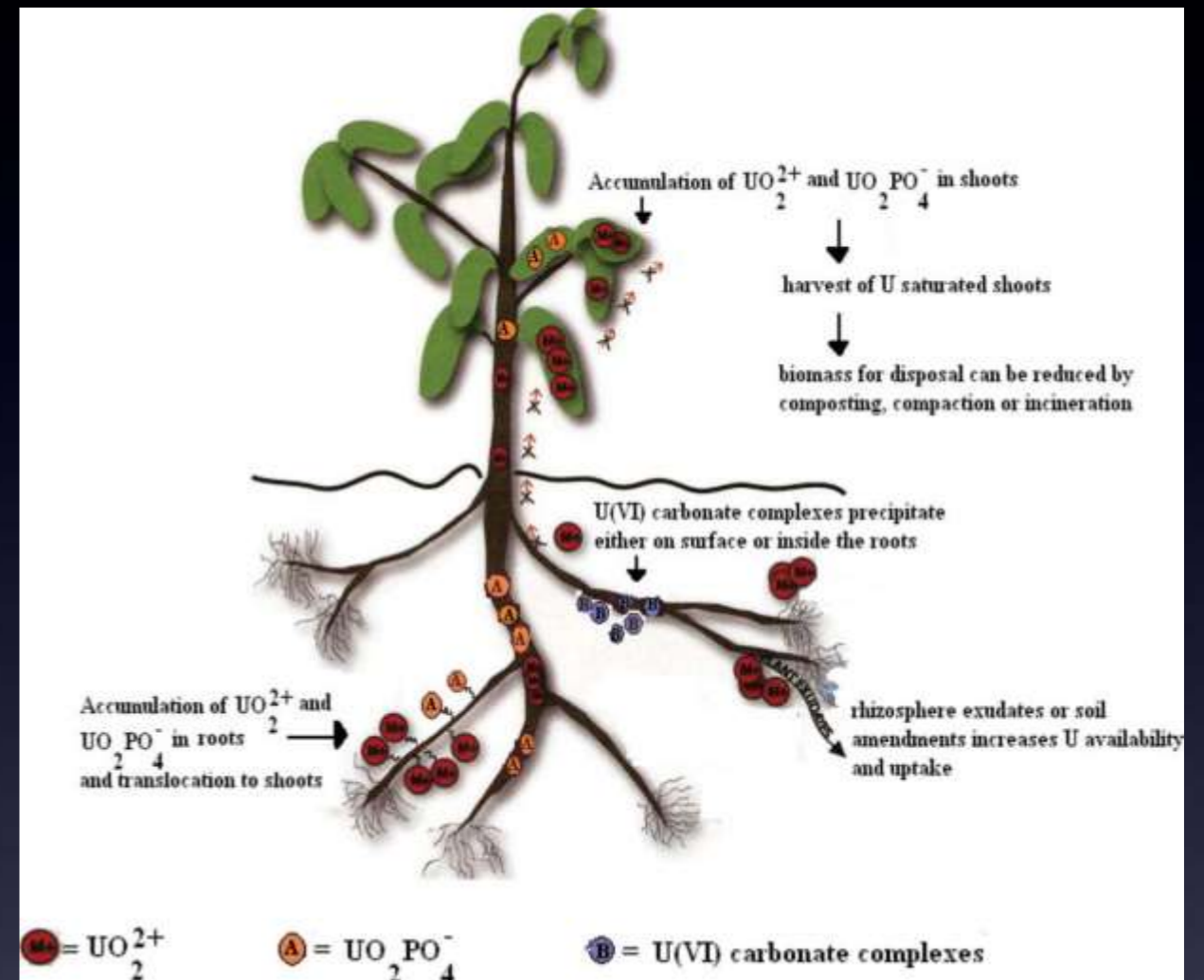
Figure 11. Uranium Concentrations in Surficial Aquifer Wells within the Contaminant Plume

**2010 Flood!!**

# Bioremediation?



**HG1** Predicted Distribution of Uranium Species in Modified Johnson's Nutrient Solution; Phosphorus Was Excluded from Solution to Preclude Formation of Stable Uranyl Phosphates



Plants up-concentrate uranium differently depending on uranium species which are site specific

# Project

Plant Species	Common Name
<i>Helianthus annuus</i>	Sunflower
<i>Phaseous vulgaris</i>	Bean
<i>Brassica juncea</i>	Mustard
<i>Spirodela Polyrhiza</i>	Duckweed (aquatic)

Table 1. Latin names and common names of plants used in experiment.



Figure 1. Taking samples from the UMTRCA with members of the Wind River Environmental Quality commission May 29, 2014

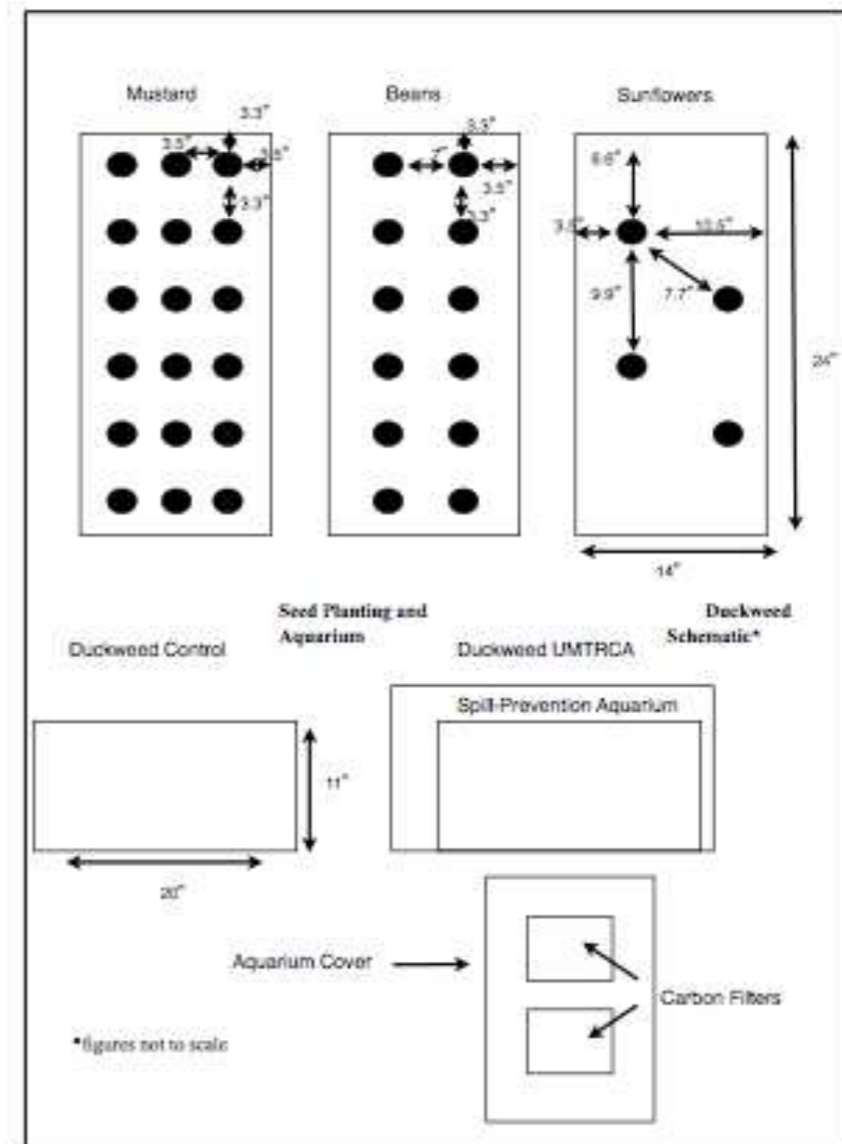


Figure 1. Seed Planting and Duckweed Aquarium Schematic



# Results



Sunflower up-concentrated uranium 15.8 times the soil concentration

||

Lab #	Sample ID #	Total U mg/kg
R4886	Control dirt #1	<0.01
R4887	Control dirt #2	<0.01
R4888	Control dirt #3	<0.01
R4889	UMTRA dirt #1	0.03
R4890	UMTRA dirt #2	0.05
R4891	UMTRA dirt #3	0.02
W4462	Control water	<0.01
W4463	UMTRA water	<0.01

Figure 2. Baseline concentrations of U (mg/kg) in the UMTRA site samples

Dirt [Uranium]



Lab #	Sample ID #	Total U mg/kg
P135	control mustard	0.01
P133	UMTRA mustard #1	0.14
P137	UMTRA Mustard #2	0.11
P136	control sunflower	0.01
P134	UMTRA sunflower #1	0.79
P138	UMTRA Sunflower #2	0.79

Figure 3. Concentrations of U(mg/kg) in mustard and sunflower

Plant [Uranium]

# Implications

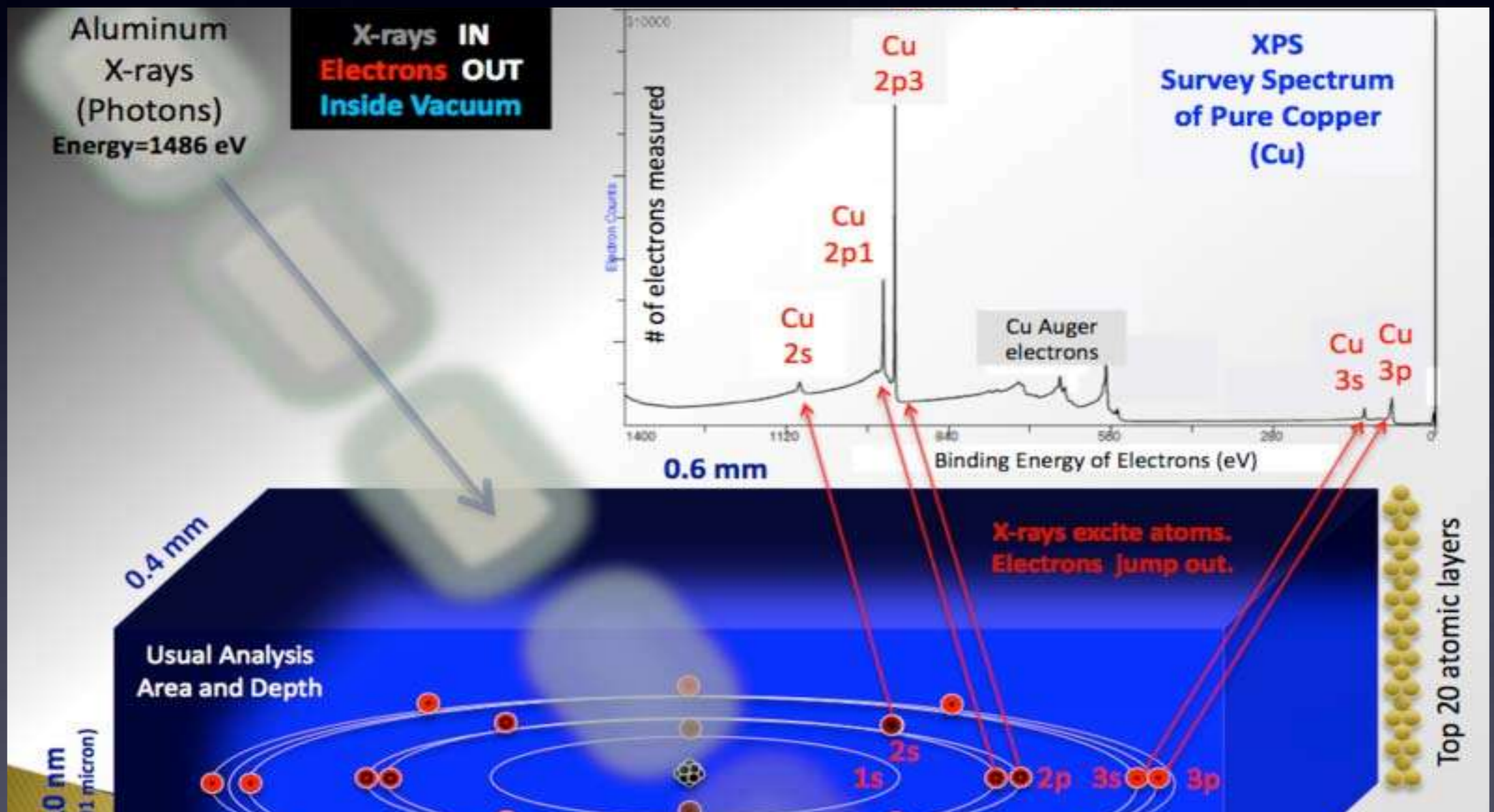


Needs  
characterization

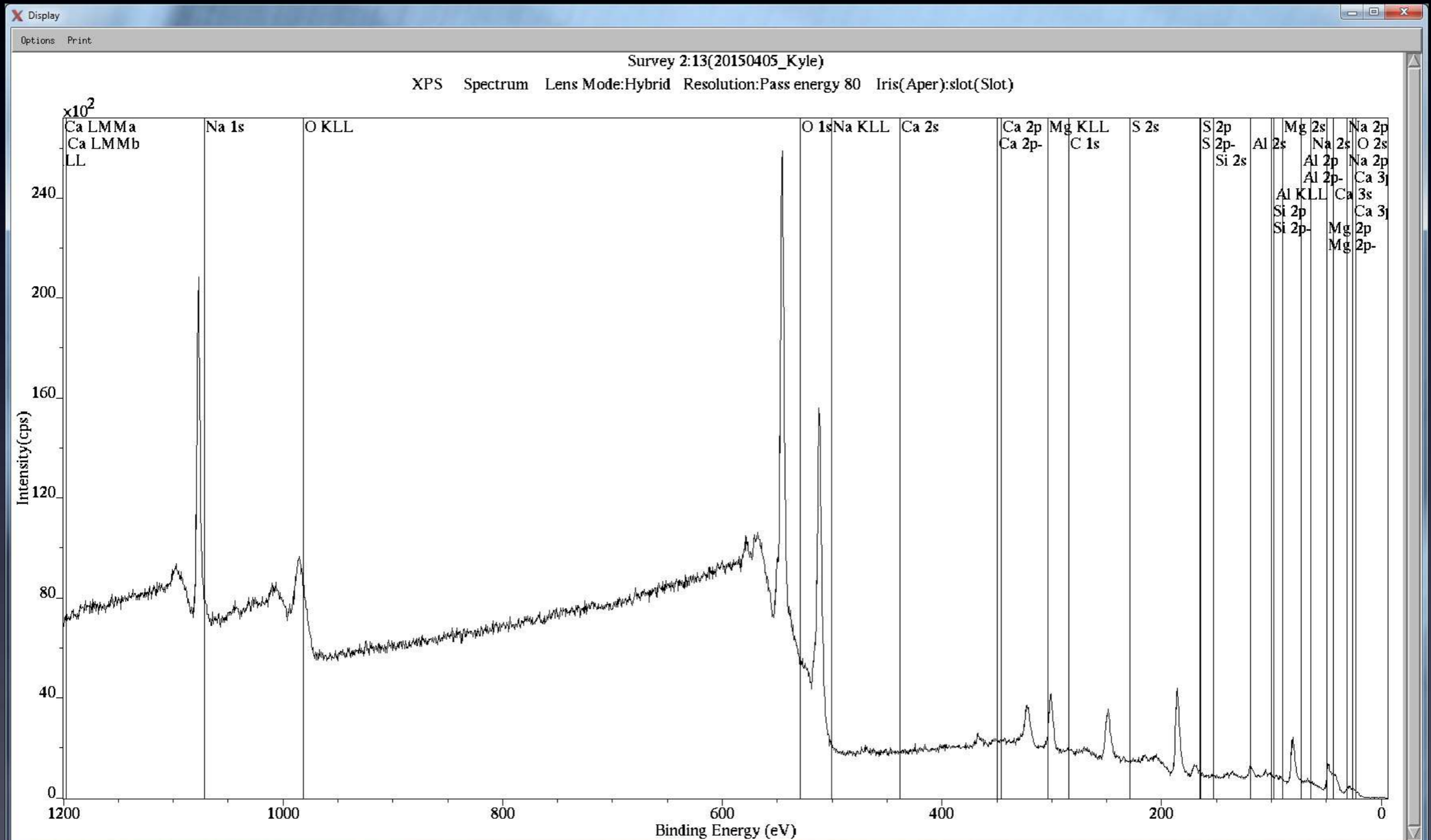


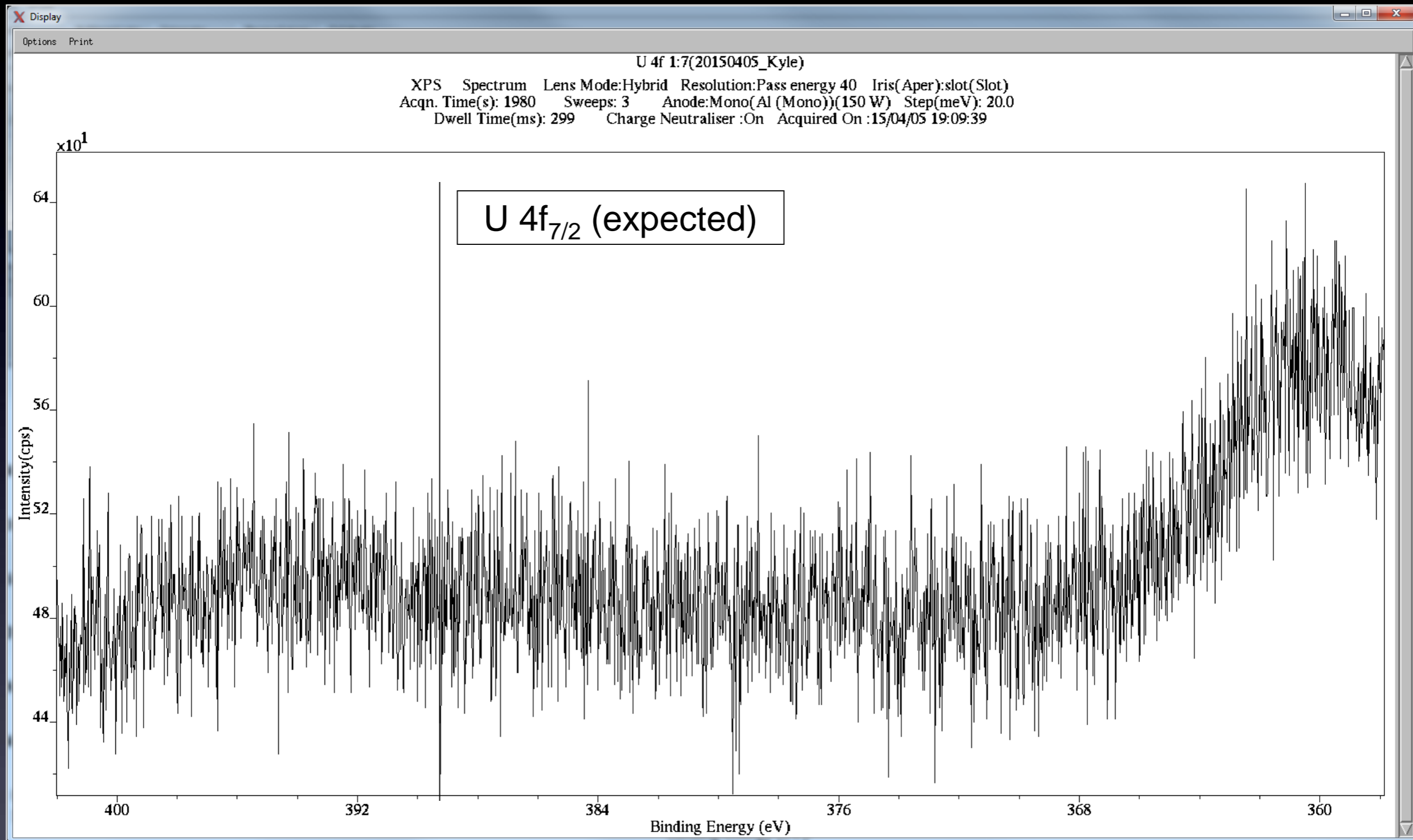
- Planting many sunflowers could possibly lower uranium levels in soil
- **New risk analysis** w/updated plant values

# X-Ray Photoelectron Spectroscopy (XPS)



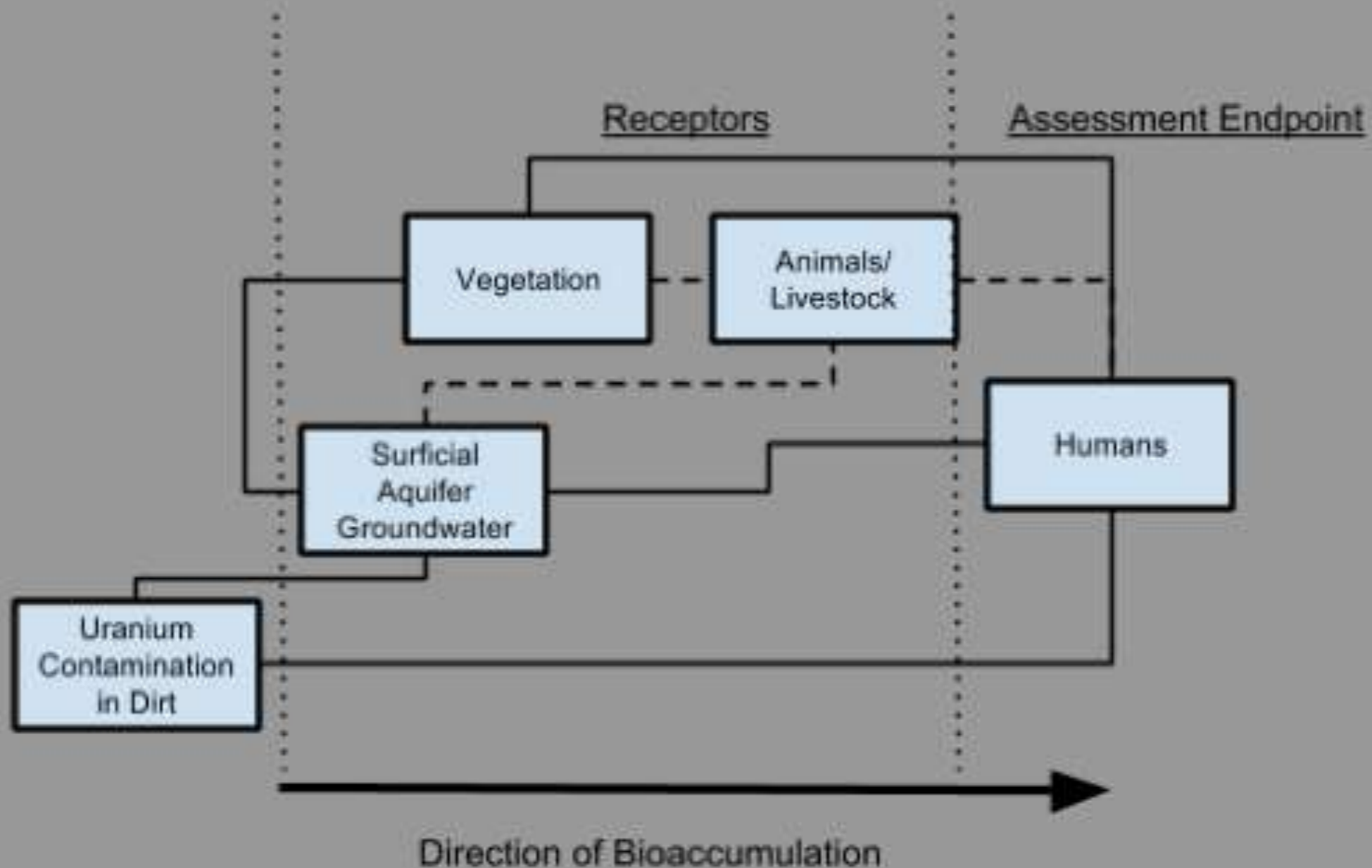
# Crystal Precipitate





# Risk Analysis

## Conceptual Model



# @Risk

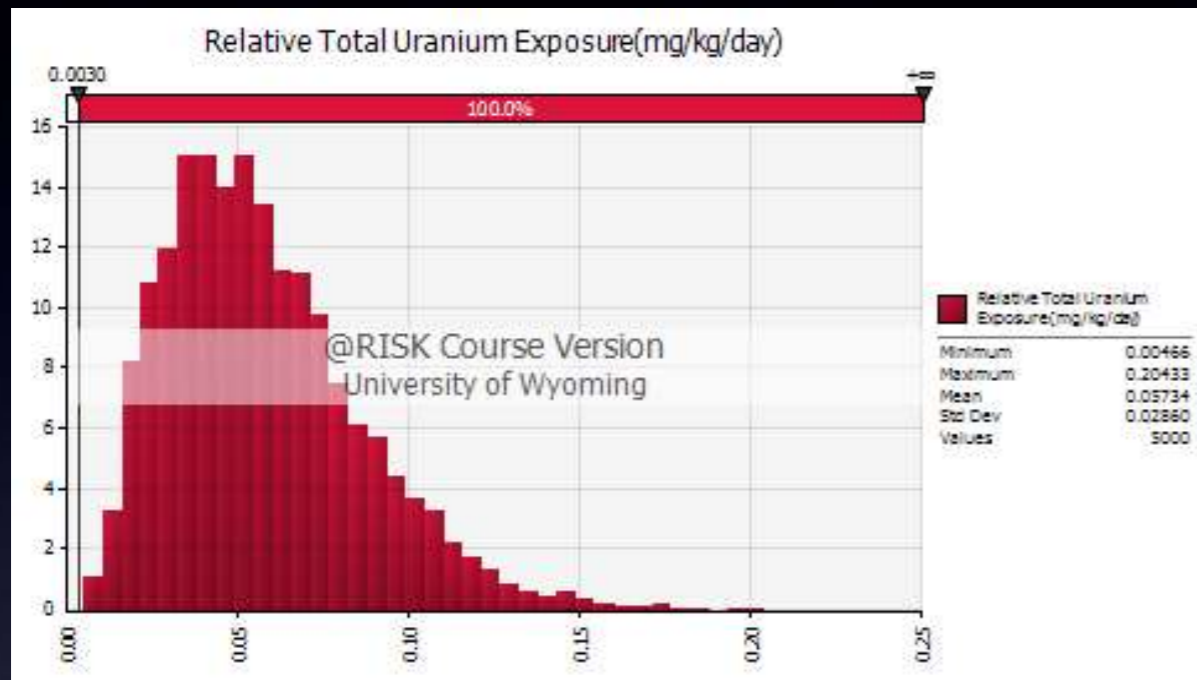
Inputs

Outputs

Units	Mean:	Median:	Minimum:	Maximum:	Probability Distribution:	Source:	Notes:
mg/kg	-	0.96	0.04	4.8	1.933333333	09799-pg.48	
L/kg	43.57	-	4.3	158.75	68.87333333	09799-pg.60	*Look at pg.53, says Kd not accurate. Also compared to MODFLOW data (pg. 73), higher Kd value. Realistically, Kd is probably higher.
mg/L	0.3231	-	0.0022	2.1	0.808433333	09799-pg.50	*All data taken from pg. 22-23. The 2.7 from flood event was thus not included.
mg/L	-	-	-	-	0.028070855		*To find [U] in water from dirt, divide [U] in dirt/Kd value (THIS VALUE NOT USED SINCE [U] IN WATER GIVEN)
-	-	-	1.8	15.8	6.533333333	BLRA-RVT-pg.7-5	*15.8 from U uptake study as compared to soil (the [highest] increase in the report was only 3.8 though!!!)
mg/kg	-	-	-	-	12.63111111	09799-pg. 73	*The [U in dirt] x Soil to Plant Uptake Factor (plants have been recorded hyperaccumulating much more than given)
mg/L	0.005	-	-	-	-	BLRA-RVT-pg. 7-2	
-	-	-	-	-	N/A		*Uranium Ingestion via meat/hunting not included because not many animals onsite
kg/day	0.00005	-	-	-	-	(EPAExpFactors)	
g/kg/day	0.11739	-	-	-	-	(EPAExpFactors)	
g/kg/day	0.0017	-	-	-	N/A	(EPAExpFactors)	
mg/kg/day	0.003	-	-	-	-	(EPA RFD)	
Exposure dose (pCi/lifetime):	23284238	-	-	-	-	BLRA-RVT-pg. 6-10	*We decided to use the same value as the 1995 Risk Assessment Used for Cancer Risk so our results can be compared
Oral Slope Factor (1/pCi):	1.60E-11	-	-	-	-	BLRA-RVT-pg. 6-10	*Does not factor in body weight
Cancer Risk:	3.73E-04	-	-	-	-	BLRA-RVT-pg. 6-10	
EPA Cancer Risk Limit:	1.00E-04	-	-	-	-	BLRA-RVT-pg. 6-10	
Human Exposure	-	-	-	-	-		
Body Weight:	kg	-	-	31.8	55.9	(EPAExpFactors)	Does the level of Uranium Ingested exceed the EPA's MCL? Yes
Exposure frequency:	Days	365	-	-	-	(EPAExpFactors)	Does the level of Uranium Ingested exceed the EPA's Cancer Risk? Yes
Exposure duration:	Years	30	-	-	-	BLRA-RVT-pg. 6-10	
Uranium Exposure from Water:	mg U/day	-	-	-	1.616866667		
Uranium Exposure from Dirt Ingestion:	mg U/day	-	-	-	9.66667E-05		
Uranium Exposure from Plant Ingestion:	mg U/day	-	-	-	1.482766133		
Uranium Exposure from Meat Ingestion:	mg U/day	-	-	-	N/A		
Total Uranium Exposure:	mg U/day	-	-	-	3.099729467		
Total Relative Uranium Exposure:	mg U/kg/day	-	-	-	0.055451332		
Total Uranium Exposure:	pCi/day	-	-	-	2126.414414		

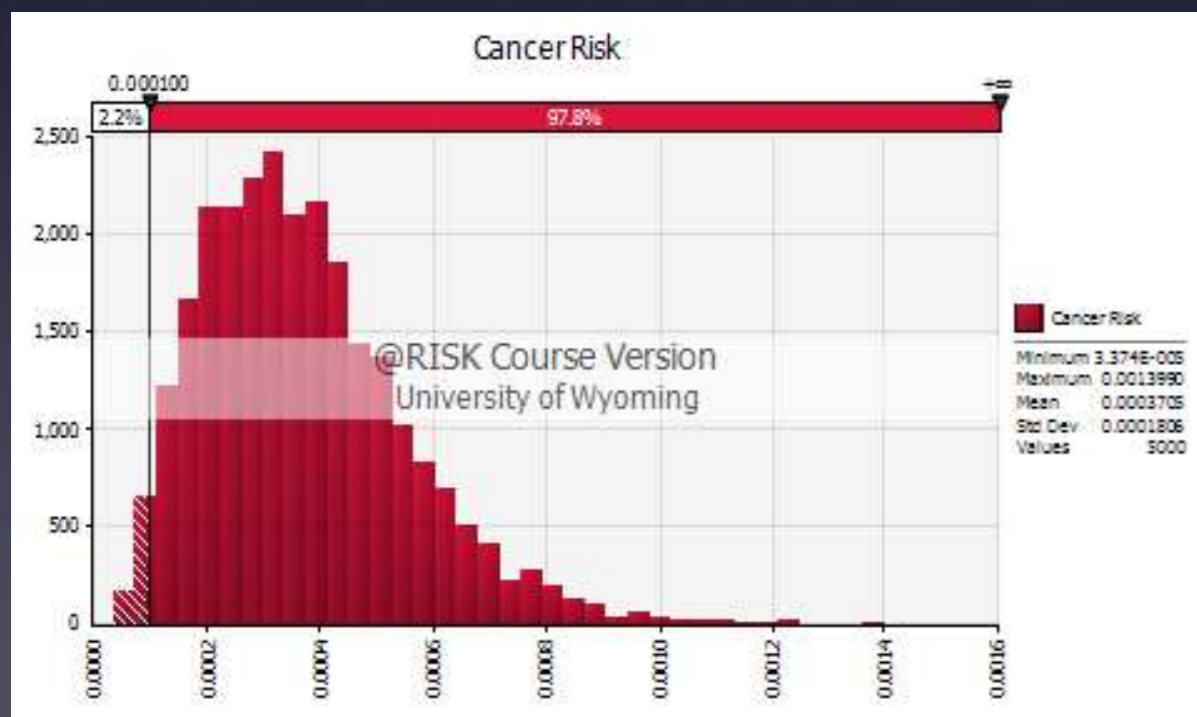
From Study!!

# Results



- **100% chance** of uranium exposure **exceeding** EPA maximum concentration limit (MCL) of 0.003 mg/kg/day of uranium

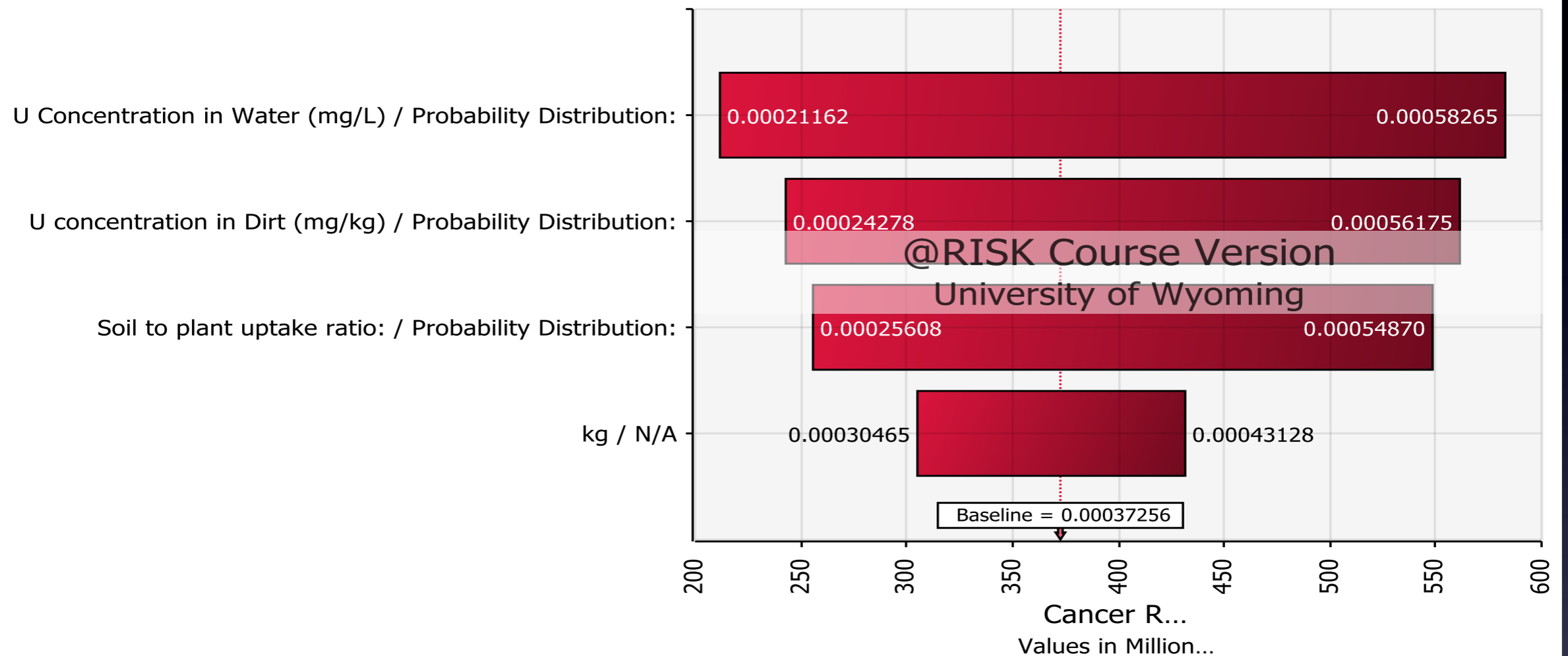
$$\text{Hazard Quotient } (0.05734/0.003)=19.11$$



- **97.8% chance** of cancer risk **exceeding** National Contingency Plan lifetime cancer risk limit of 1/10,000 (based on 30 year exposure according to 1995 Risk Analysis)

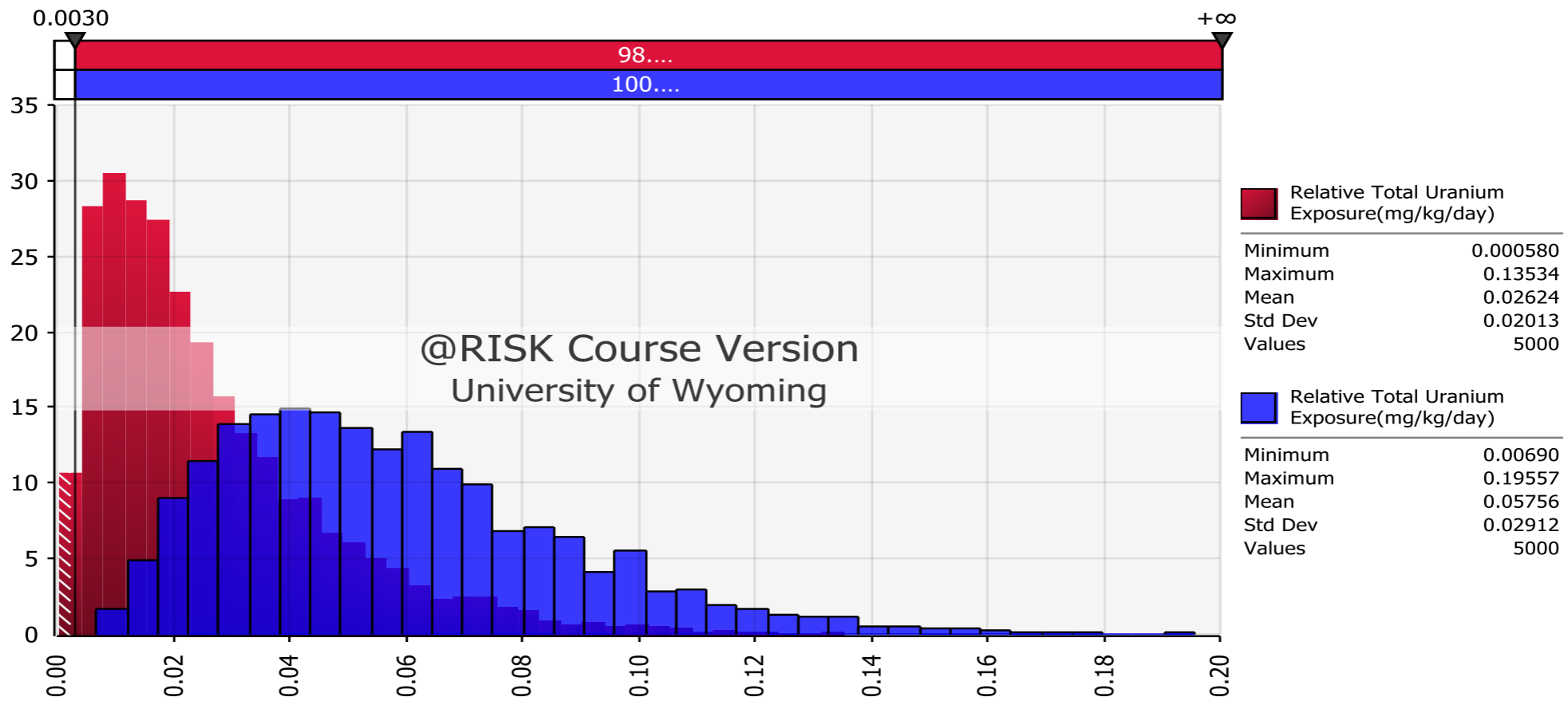
### Cancer R...

Inputs Ranked By Effect on Output Me...

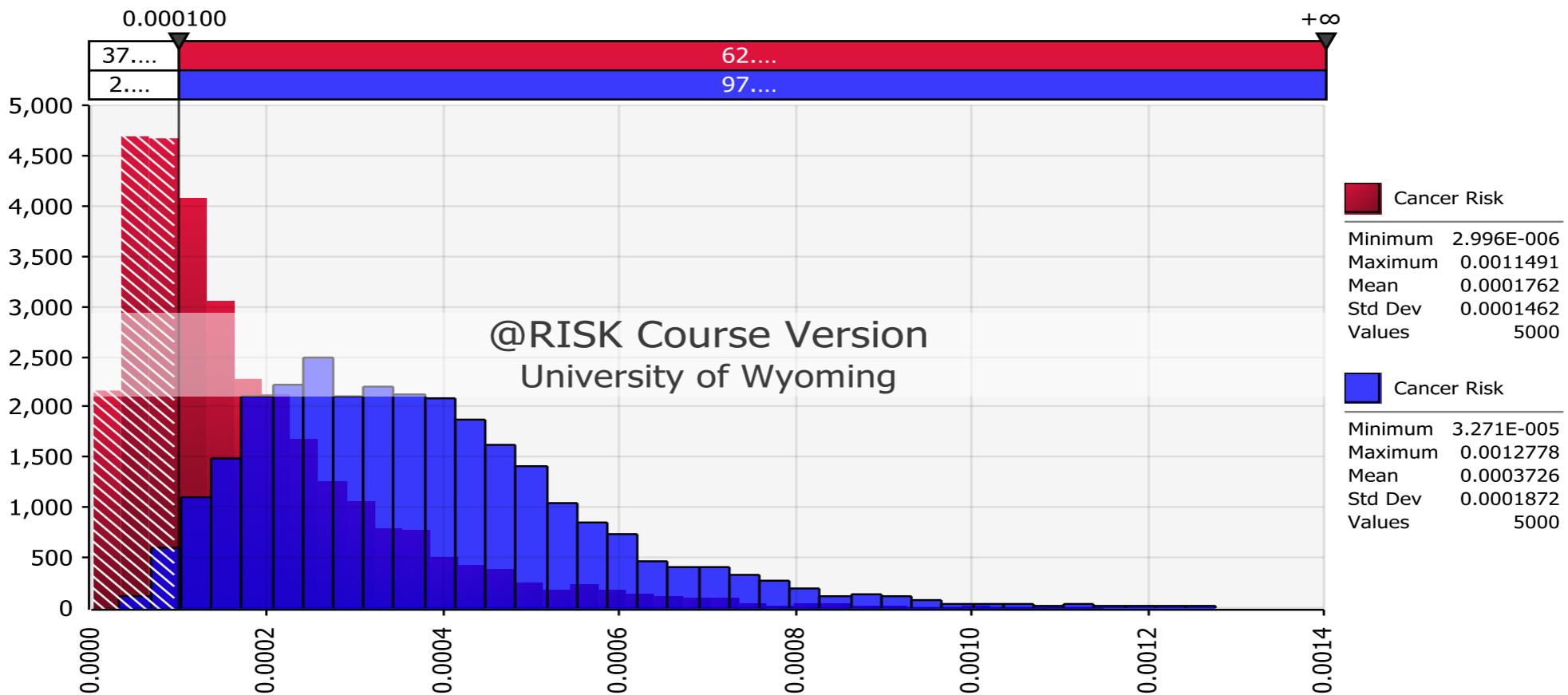


What if water is removed from model?

### Relative Total Uranium Exposure(mg/kg/d...

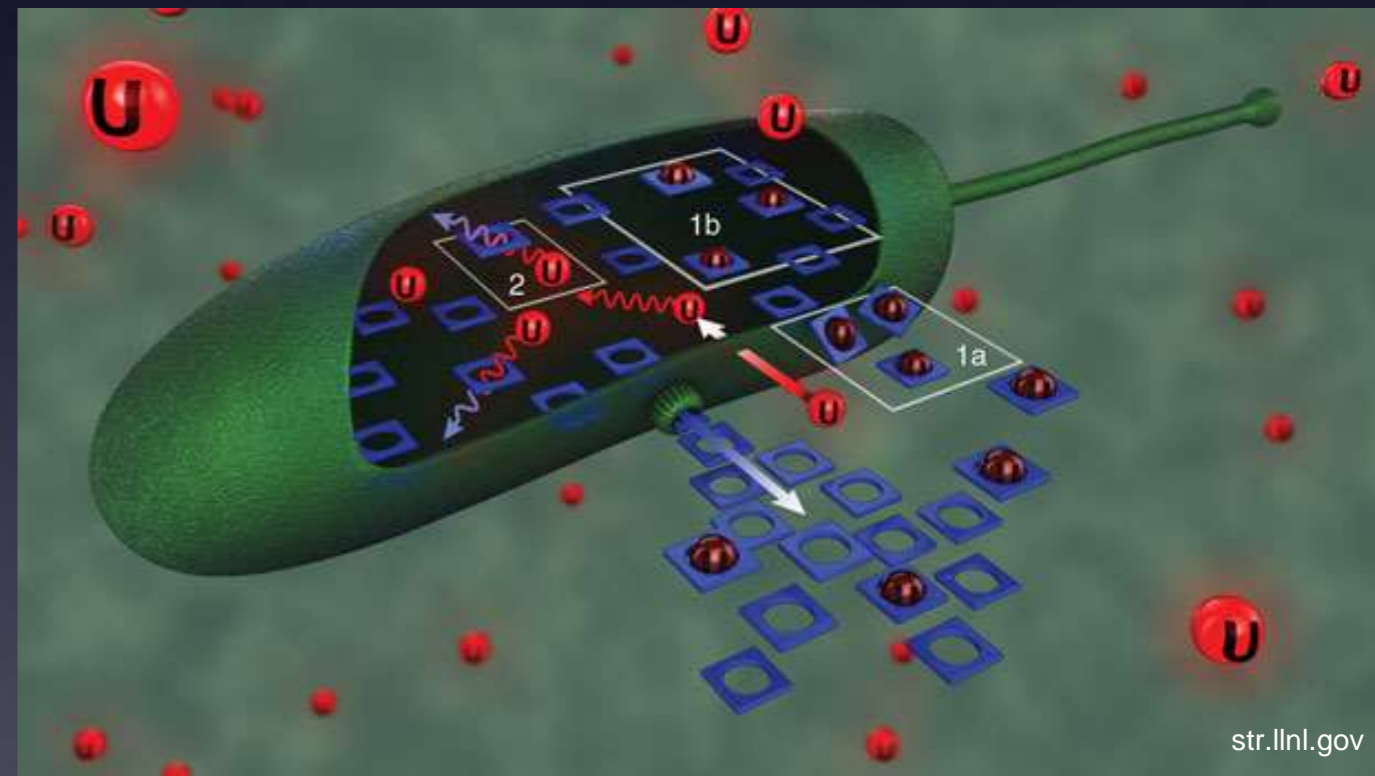


### Cancer R...

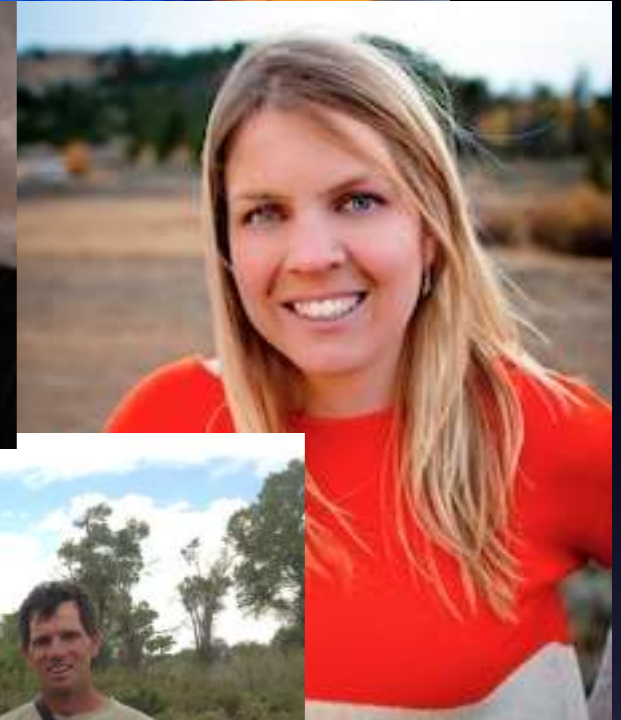


# Recommendations

- **Further studies** to see how uranium levels in dirt may bio-accumulate through plants/animals/etc and **disperse beyond the site**
- Continue to **promote communication** between site managers and community
- **Connections:** Bowman Labs & Lawrence Livermore National Laboratory?



- Yufna Soldier-Wolf
- Rachel Watson, advisor
- Courtney Carlson
- John Willford
- Maggie Bourque
- Pete Stahl & Calvin Strom
- Bill Dam, DOE
- Rick Trosper & Steve Babits
- Erwin Sabio, XPS Analysis



# Thank You!

# Sources

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