

*Gardening: Connecting Mother Earth to Human Health and Wellness*





COLLEGE OF PHARMACY  
METAL EXPOSURE AND TOXICITY ASSESSMENT  
ON TRIBAL LANDS IN THE SOUTHWEST



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# UNM METALS Superfund Research Center

*Metal Exposure and Toxicity Assessment on tribal Lands in the Southwest*



## **UNM METALS SRP Report-back to Village of Old Laguna on Soil, Plant and Water Testing**

**Pueblo of Laguna  
October 6, 2022**

**Presenters:  
Derek Capitan, Kyle Swimmer,  
Chris Shuey, Adrian Brearley**

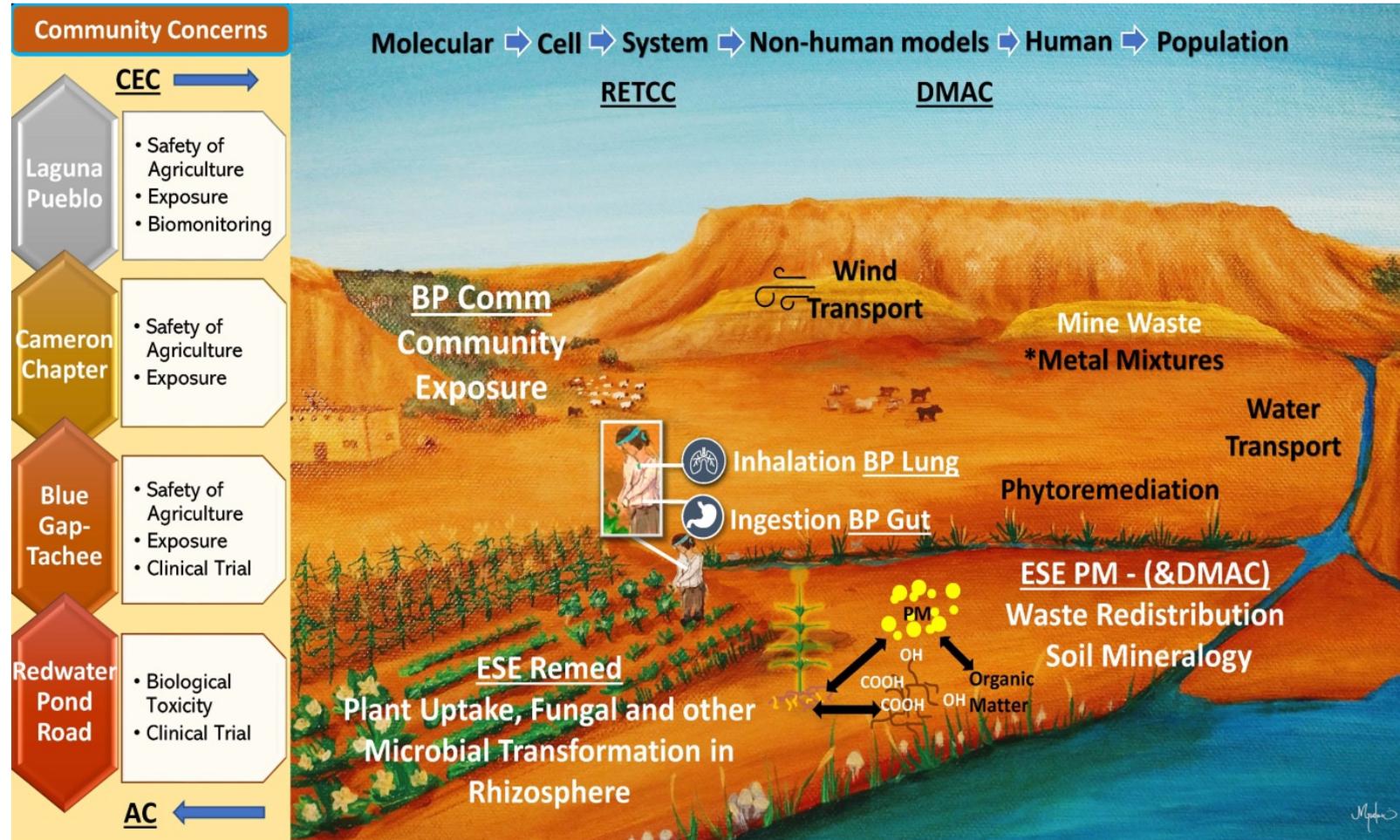
**Presentation developed by  
Derek Capitan, Eliane El Hayek**

# METALS SRP: From the Land to the Cell...and Back Again



UNM METALS works with the community to understand and reduce health risks

Four Indigenous communities affected by uranium mining legacy



Original artwork by Mallery Quetawki (Zuni)



# *Acknowledgements*

***Guuwaadzi – UNM’s work evidences the importance of developing community-driven research to work together and bring scientists, gardeners and farmers as a team to answer community concerns and investigate mining legacy.***

We acknowledge that through the trial and tribulation we continue to stand strong. For it’s the rest of our story that will make us who we are and who we chose to be.

Our key for the future: Blending traditional practices with modern day technology.

Special acknowledgement– Leadership and staff of the ***Laguna Environmental and Natural Resources Department*** for their partnership, support and oversight.

**UNM Acknowledgement Statement:** *The University of New Mexico sits on the traditional homelands of the Pueblo of Sandia. The original peoples of New Mexico have deep connections to the land and have made significant contributions to the broader community statewide. We honor the land itself and those who remain stewards of this land and acknowledge our committed relationship to Indigenous peoples.*



# *Objective*

- ***Inform the community about metals levels in soils and crops, particularly corn and vegetables (squash, pumpkin, cucumber, melon)***

# *Main*

- ***Metals levels in soils at the investigated farming sites are consistent with natural background, and do not indicate impacts of uranium mine wastes***

# *Message*

- ***Tested fruiting vegetables are safe to eat***



# Methods: About soil and plant sampling sites

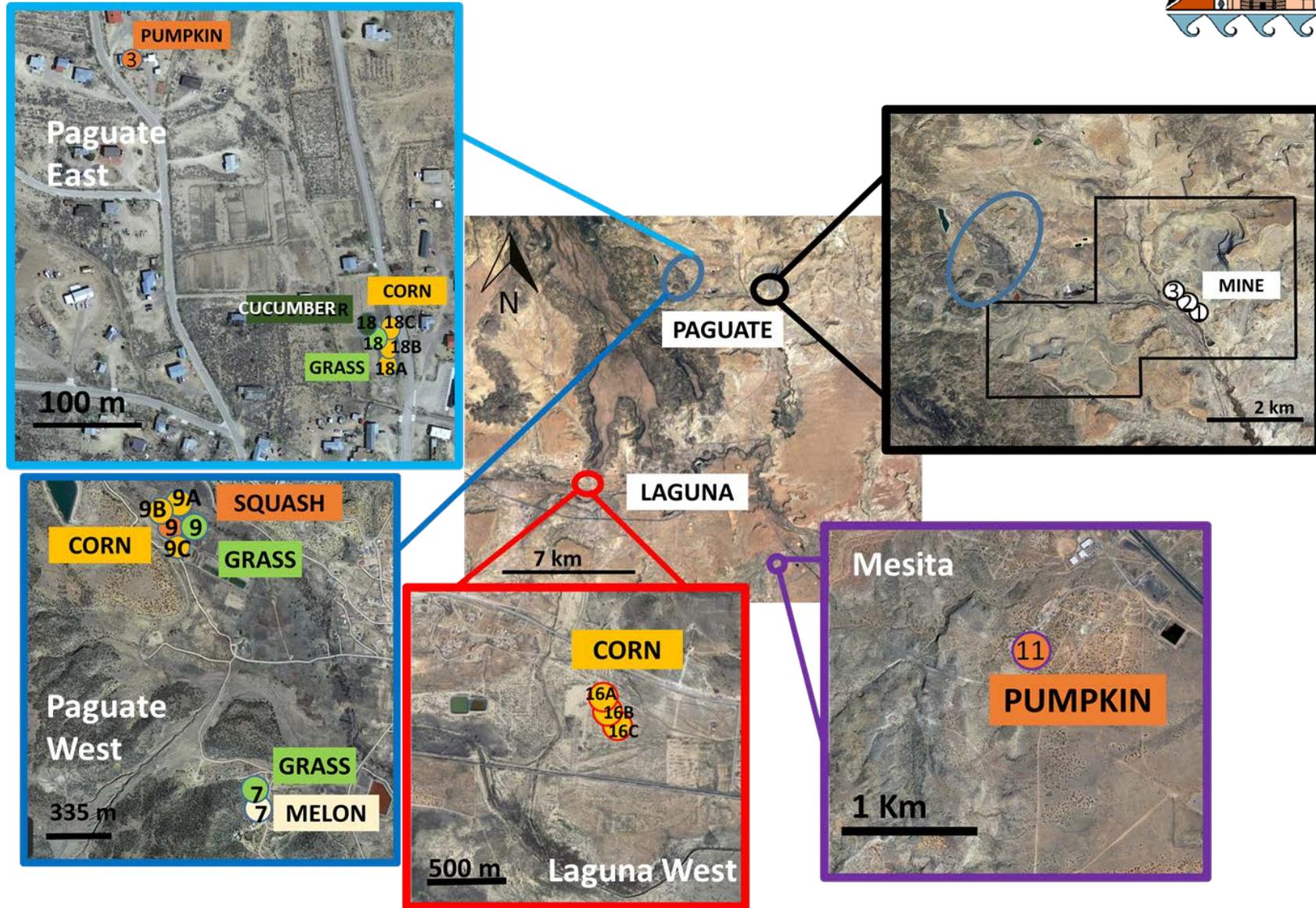


- Surface access agreements executed with 21 families
- Sampling sites: Paguate (17), New Laguna (4), Mesita (1)
- Sampling locations selected based on
  - Agreements with growers who volunteered for the program
  - Geographic distribution, proximity to Jackpile Mine
  - No previous soil or plant-metals data (sites were not pre-screened)
- Crops: corn from 3 sites, fruiting vegetables from 5 sites
- Surface soils (12"-inch depths) from three sites inside the Jackpile Mine ~ 3 km away from Paguate village

# Locations of soil and plant sampling sites\*



Site No.	Village	Samples
3 (garden)	Paguete	soil, pumpkin
7 (garden)	Paguete	soil, melon, grasses
9 (farm)	Paguete	soil, corn, squash, grasses
11 (garden)	Mesita	soil, pumpkin
16 (farm)	Laguna	soil, corn
18 (garden)	Paguete	Soil, corn, cucumber, grasses
Jackpile Mine	Paguete	Soil, grasses, roots

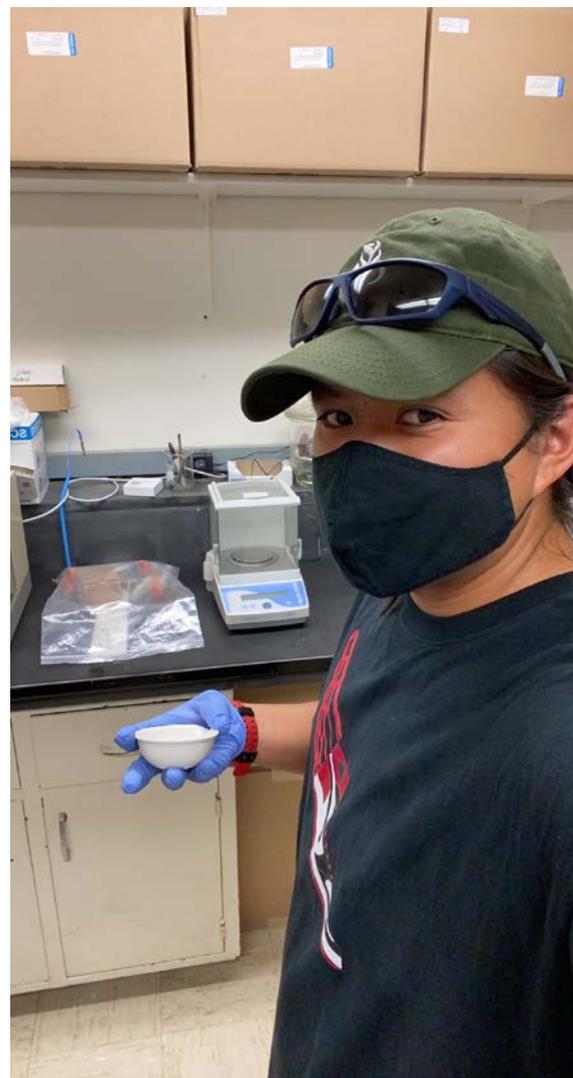


\*Not all sampling sites shown on these maps



# *Methods of Analysis*

1. Drying of soils
2. Sieving into different size fractions (grinding of sample)
3. Digestion in acid (Getting sample into its purest form)
4. Followed by analyses using ICP-MS\* technology (data interpreter)



Derek Capitan processed many Laguna soil and plant samples at the UNM lab

[\\*ICP-MS = Inductively coupled plasma mass spectrometry](#)

# Units (Measurements) used for DATA



- Levels of metals in crops or soil –  
**“parts per million” or “ppm”**  
(diagram)
- 1 ppm means that for every million  
“parts” of dry soil, there is 1 part of  
the metal being measured
- 1 ppm = 1 milligram of element in 1  
kilogram of dry soil, or “mg/kg-dry  
wgt”

Units of measure for metals in water or sediment:

**1 milligram per liter (mg/L) =  
1 part per million (ppm)**

Or 1 minute over 2 years or 4 drops in a  
55 gallon drum.





# *Comparison Values*

Concentrations, or “levels”, of elements that establish their abundance in the Earth’s crust or their risk to human health; examples:

- **Crustal Averages** – average concentrations of elements in Earth's crust, based on published USGS Prof. Paper 1270 (1984) and *CRC Handbook of Chemistry and Physics*, 97th edition (2016– 2017), p. 14-17 (chart shows top 8 elements)
  - We most often **use crustal average concentrations** for comparison purposes
- **Soil Screening Levels** – maximum concentrations of elements in soils adopted as regulations or guidelines and often based on lifetime risk of cancer (NM SSL, USEPA PRGs)



## *Soil results*

- **Impacts of mining on agricultural soils *were not detected in our sampling sites***
- Uranium, vanadium, arsenic and lead in soils from the mine site and croplands compared with average “background” levels in western US in soils, as reported in USGS 1984
- Uranium was higher than the **background level** (2.5 mg/kg) in the topsoil *only* at the three Jackpile Mine sampling locations
- Arsenic and lead in soil near or above background regional levels is not uncommon; the presence of these metals may be related to the geology of the area where soils were sampled

- ***Soils inside Jackpile Mine are still contaminated and should be avoided***
  - Concentrations of uranium (4.4-48.4 mg/kg) and vanadium (217.8 mg/kg) in the topsoils at the mine sites (~ 3 km from the village) are *higher than the natural background levels*



# Crop results

- Metals that are of potential human health concern, including arsenic and lead, were detected **below** health-based guidance in all fruiting vegetables
- Lead and arsenic mainly accumulated in the roots of all crops at the farmlands that are close to the mine waste sites
- Concentration in roots are a little higher than recommended, only few samples were analyzed
- Remember: All plants you eat, including those grown in Laguna, contain *very small* amounts of metals that occur naturally in Mother Earth





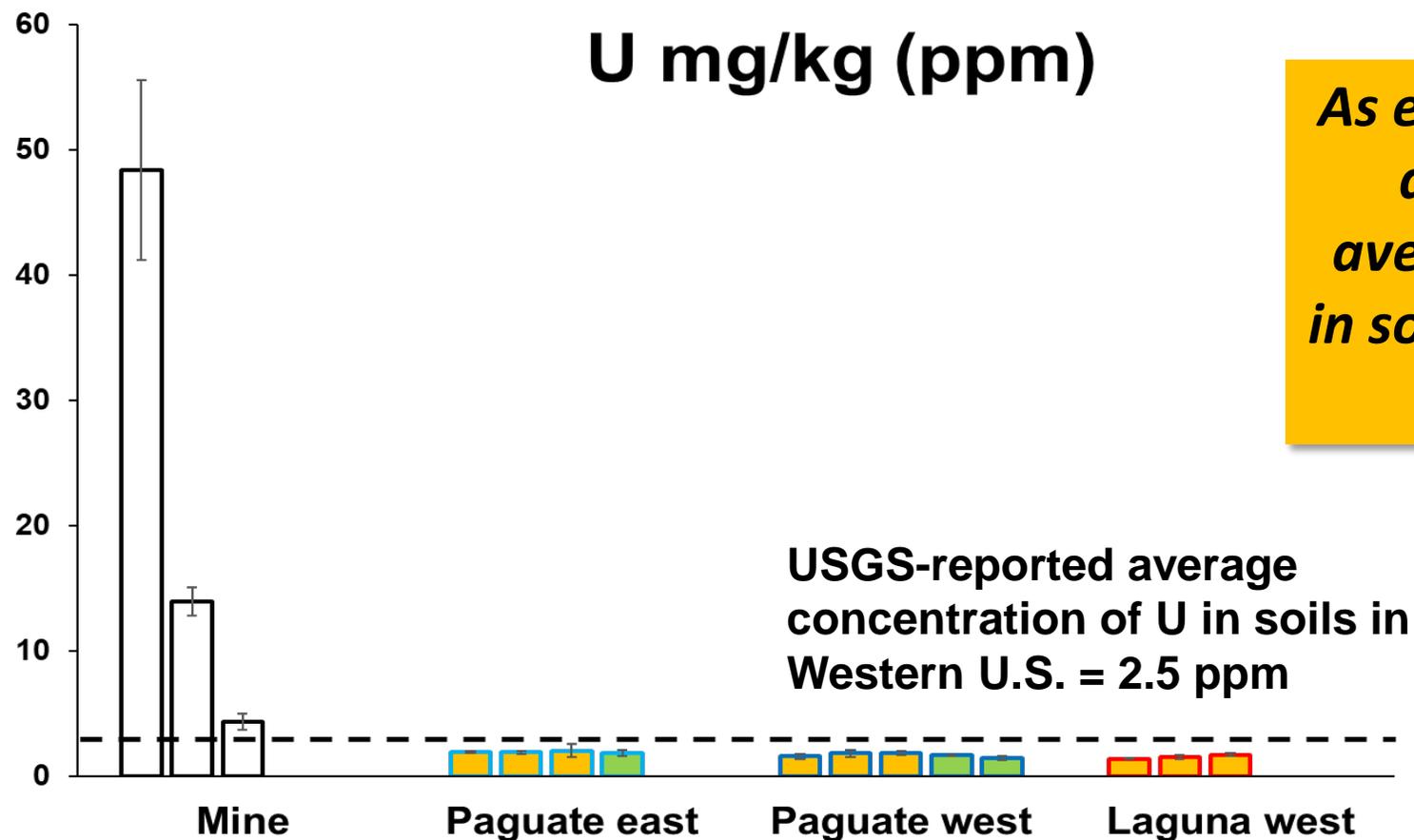
# *Important notes related to crop results*



- The United States Food and Drug Administration (FDA) has ***no limits or recommendations*** for lead and arsenic in fruits or vegetables.
- We compared metals levels in plants with the levels listed by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO).



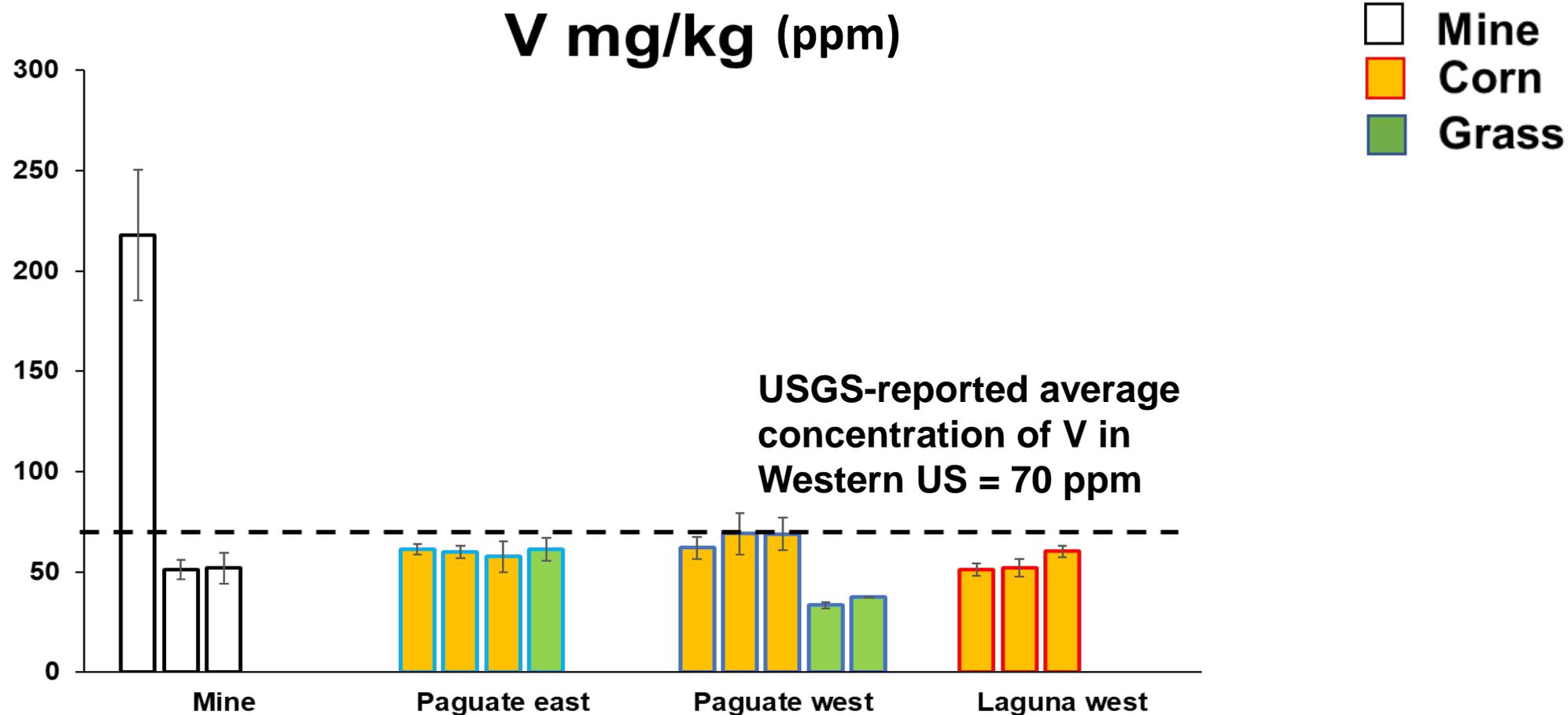
# Uranium (U) in soils



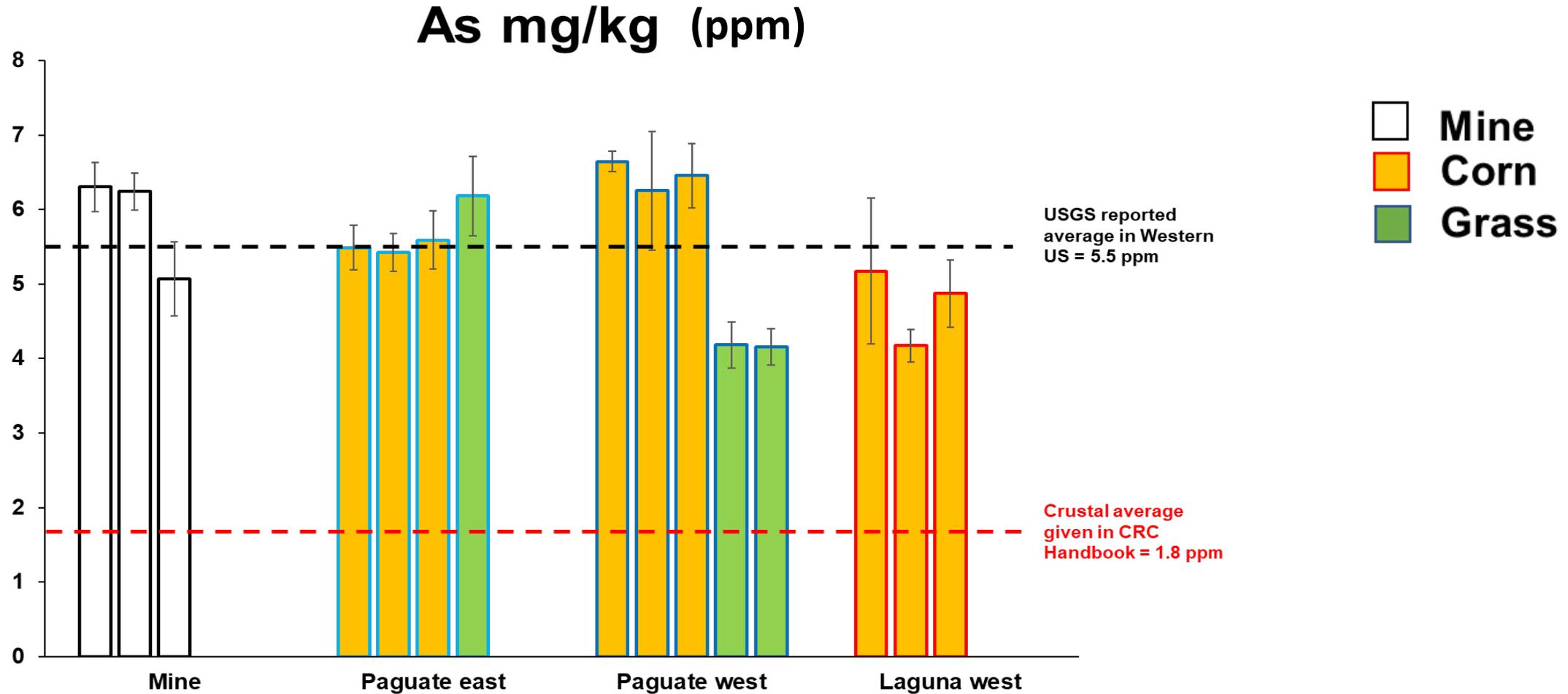
*As expected, uranium is above the crustal average concentration in soil collected from the Jackpile Mine*



# Vanadium (V) in soils



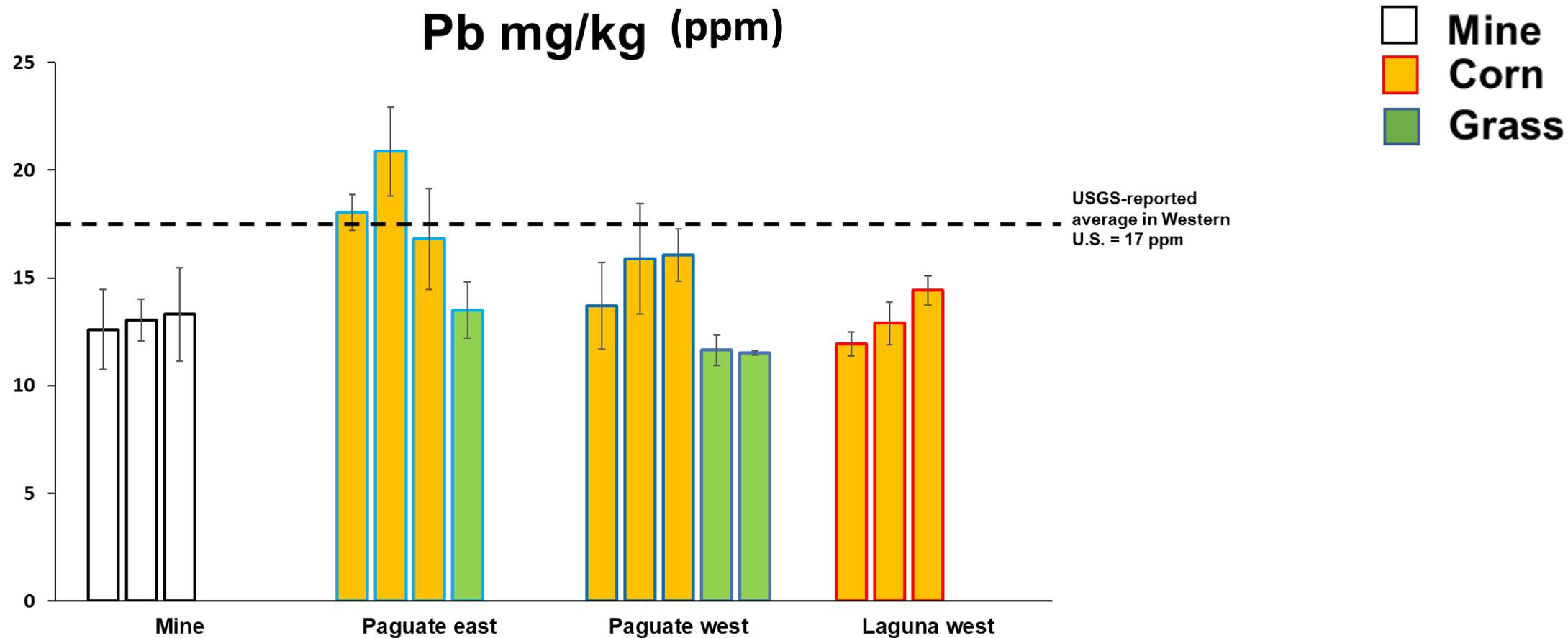
# Arsenic (As) in soils



As levels in tested soils are around the USGS reported level in Western US

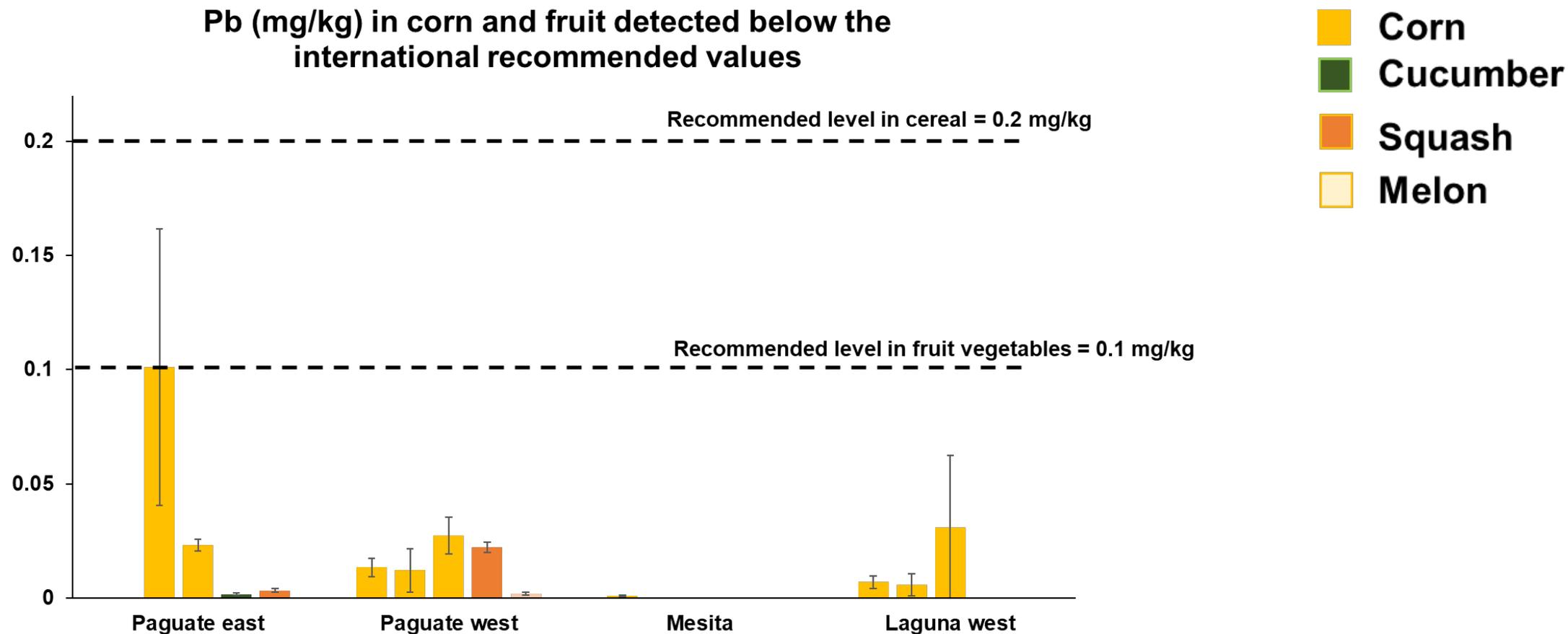


# Lead (Pb) in soils



Pb levels in tested soils are below or around the USGS reported level in Western US

# Lead (Pb) in produce

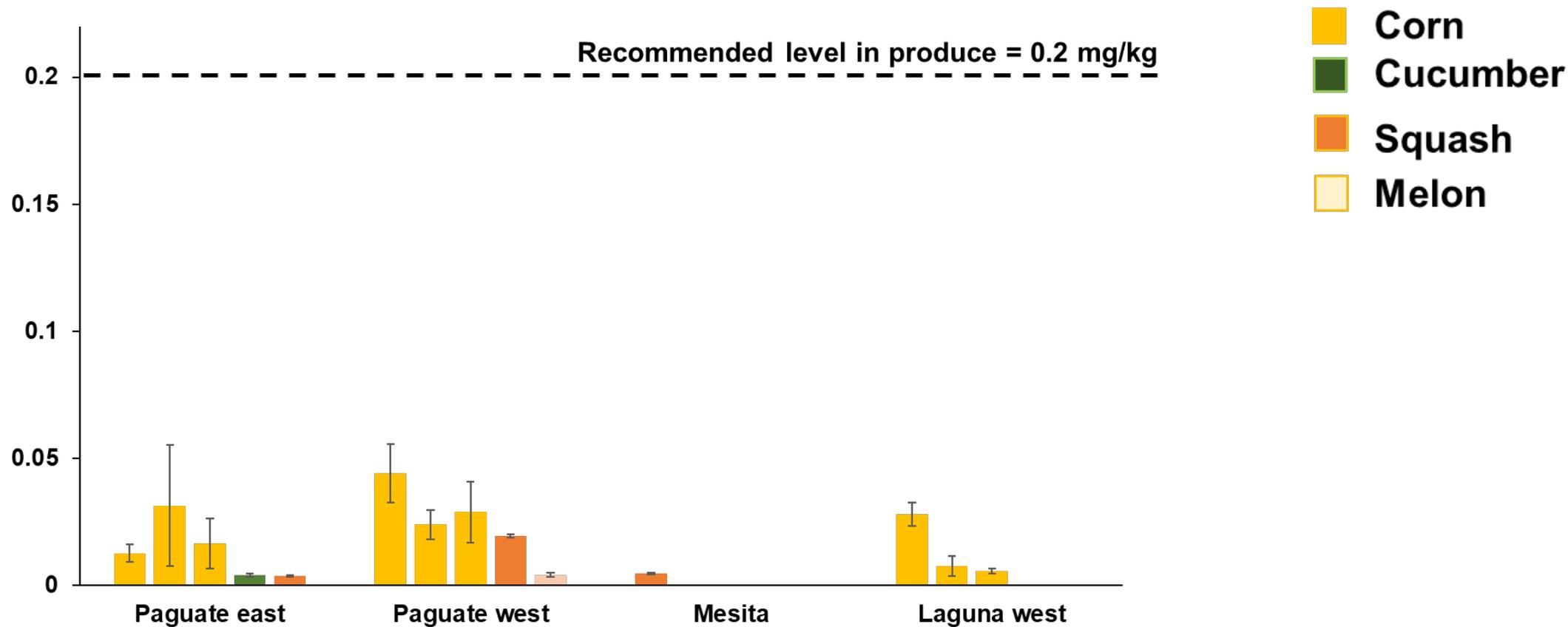


Pb levels in the tested fruiting vegetable are below the international recommended values



# *Arsenic (As) in produce*

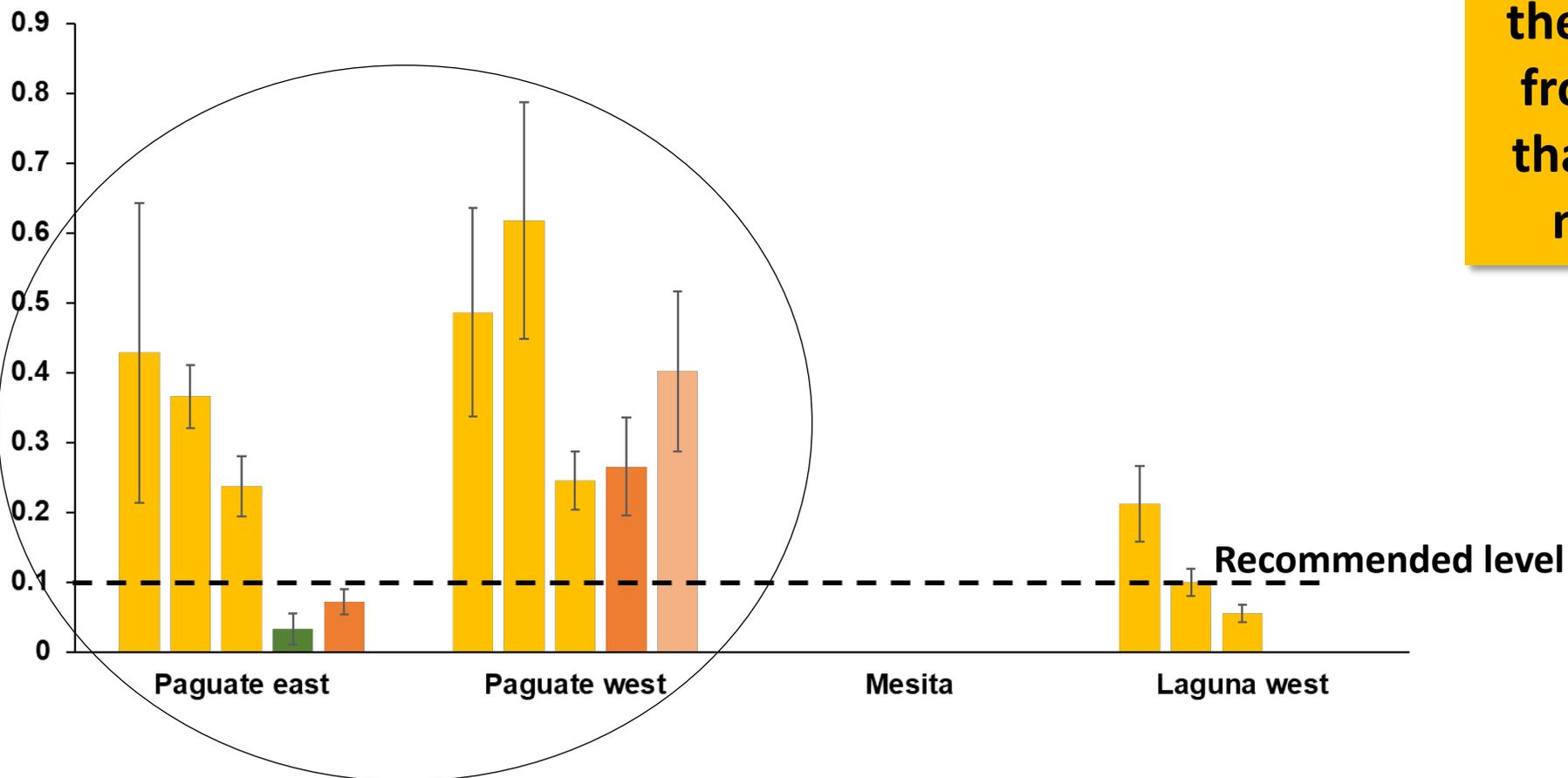
As (mg/kg) in fruiting vegetables detected below the international recommended values





# Lead (Pb) in roots

Pb mg/kg in roots detected higher than the recommended level for root vegetables



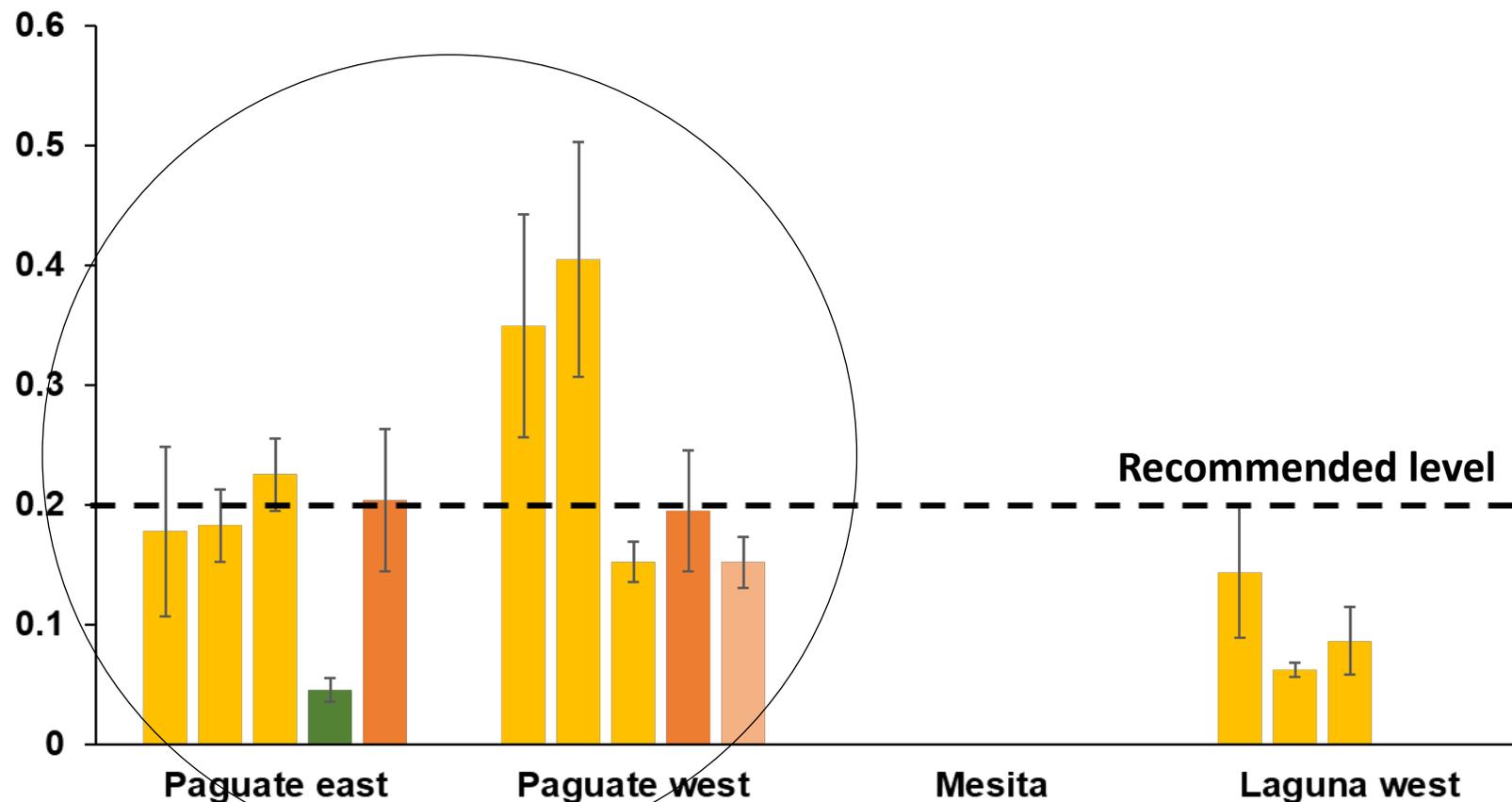
Lead and arsenic were accumulated mainly in the roots of all crops from the farmlands that are close to the mine waste sites

- Corn
- Cucumber
- Squash
- Melon



# Arsenic (As) in roots

As mg/kg in roots detected higher than the recommended level



- Corn
- Cucumber
- Squash
- Melon



# *Recommended Community Actions*

- Use specifically selected clothes only for gardening, farming
- Wash hands thoroughly after gardening
- Keep children's hands clean while in the field, discourage touching their mouths with dirty hands
- Wash fruiting, leafy and root vegetables before eating them



# Surface Water Quality Sampling



Environmental Science Processes & Impacts

PAPER

Check for updates

Cite this: DOI: 10.1039/c6em00032a

## Uranium mobility and accumulation along the Rio Paguate, Jackpile Mine in Laguna Pueblo, NM†

Johanna M. Blake,<sup>a</sup> Cherie L. De Vore,<sup>b</sup> Sumant Avasthala,<sup>b</sup> Abdul-Mehdi Ali,<sup>c</sup> Claudia Roldan,<sup>d</sup> Fenton Bowers,<sup>e</sup> Michael N. Spilde,<sup>f</sup> Katerina Artyushkova,<sup>g</sup> Matthew F. Kirk,<sup>h</sup> Eric Peterson,<sup>g</sup> Lucia Rodriguez-Freire,<sup>g</sup> and Josée Cerrato<sup>g</sup>

The mobility and accumulation of uranium (U) along the Rio Paguate, adjacent to the Jackpile Mine, New Mexico was investigated using aqueous chemistry, electron microprobe (EMPA) and laser-induced fluorescence (LIF) to identify elevated concentrations of U in the Rio Paguate. It is not common to identify elevated concentrations of U in the Rio Paguate. It is a unique site that concerns the Laguna Pueblo community. To better understand the geochemical processes that affect the U concentration in the Rio Paguate, we identify key hydrogeological and geochemical processes that affect the U concentration in the Rio Paguate. Solid analyses using X-ray fluorescence (XRF) indicate U concentrations in the Rio Paguate range from 100 to 1000 mg kg<sup>-1</sup>. The presence of uranyl (UO<sub>2</sub>)<sup>2+</sup> in the Rio Paguate is confirmed by EMPA analyses. The U concentration in surface water is highest during the southwestern monsoon season. Samples collected during the southwestern monsoon season showed higher U concentrations in surface water adjacent to the Jackpile Mine compared with those at a wetland 4.5 kilometers downstream. U concentrations in the stream bed and bank along the reach co-located in the stream bed and bank along the reach were 0.4–150 and U concentrations 0–21 mg kg<sup>-1</sup>, respectively. The U concentration in the stream bed and bank along the reach was amenable to complexation with L-metionine. The U concentration in solution was observed over time in the reactor. The findings from this study may affect the reactivity of U present in the vadose zone and influence of organic-rich sediments on U accumulation.

**Environmental impact**  
Uranium mobility and accumulation in the environment can affect surface water and sediment quality. This study provides information on the U concentration in the Rio Paguate and within a wetland and reservoir 5 km downstream from the Jackpile Mine. The U concentration in the Rio Paguate and within a wetland and reservoir 5 km downstream from the Jackpile Mine are the source of U in the Rio Paguate. The U concentration in the Rio Paguate and within a wetland and reservoir 5 km downstream from the Jackpile Mine are the source of U in the Rio Paguate. The U concentration in the Rio Paguate and within a wetland and reservoir 5 km downstream from the Jackpile Mine are the source of U in the Rio Paguate.

† Full text available on the Royal Society Open Access website: <https://doi.org/10.1039/c6em00032a>

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rsc.li/process-impacts

Environmental Science Processes & Impacts

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UNM METALS Superfund Research Center

UNM METALS Superfund Research Center (Research Brief No. 3.4)  
Jackpile Mine wastes source of uranium in Rio Paguate and likely source of metals building up in sediments behind Paguate Reservoir

How uranium moves and accumulates in the environment can affect the quality of surface water while also contributing to the buildup of metals in river and reservoir sediments.

Between 2014 and 2017, UNM researchers, led by geochemist Johanna Blake (now with the U.S. Geological Survey) and Professor Jose Cerrato, an environmental engineer, investigated the mobility of uranium in water and accumulation in sediments along the Rio Paguate and Paguate Reservoir behind Aleta Dam (map below). The investigators found that ore and mine wastes on the surface of the Jackpile Mine are the source of uranium in the surface water.

They also found that the amount of uranium in the Rio Paguate varies seasonally, with higher concentrations during the summer monsoon season. While the surface water concentration in downstream of the mine, found to accumulate, or sediments in the Paguate Reservoir wetland.

The UNM findings are consistent with studies conducted in the 1970s when the Jackpile Mine was operating. New Mexico Bureau of Mines and Mineral Resources researchers found increased concentrations of uranium, other metals and radioactive elements derived from the decay of uranium in the bottom sediments of the Reservoir (Popp, et al., 1983).

These studies, spaced nearly 40 years apart, document continuing impacts of the mine on Laguna water sources—long after mining stopped and initial reclamation was conducted. They help inform discussions about the extent of remediation of the possible effects of the mine releases on downstream resources.

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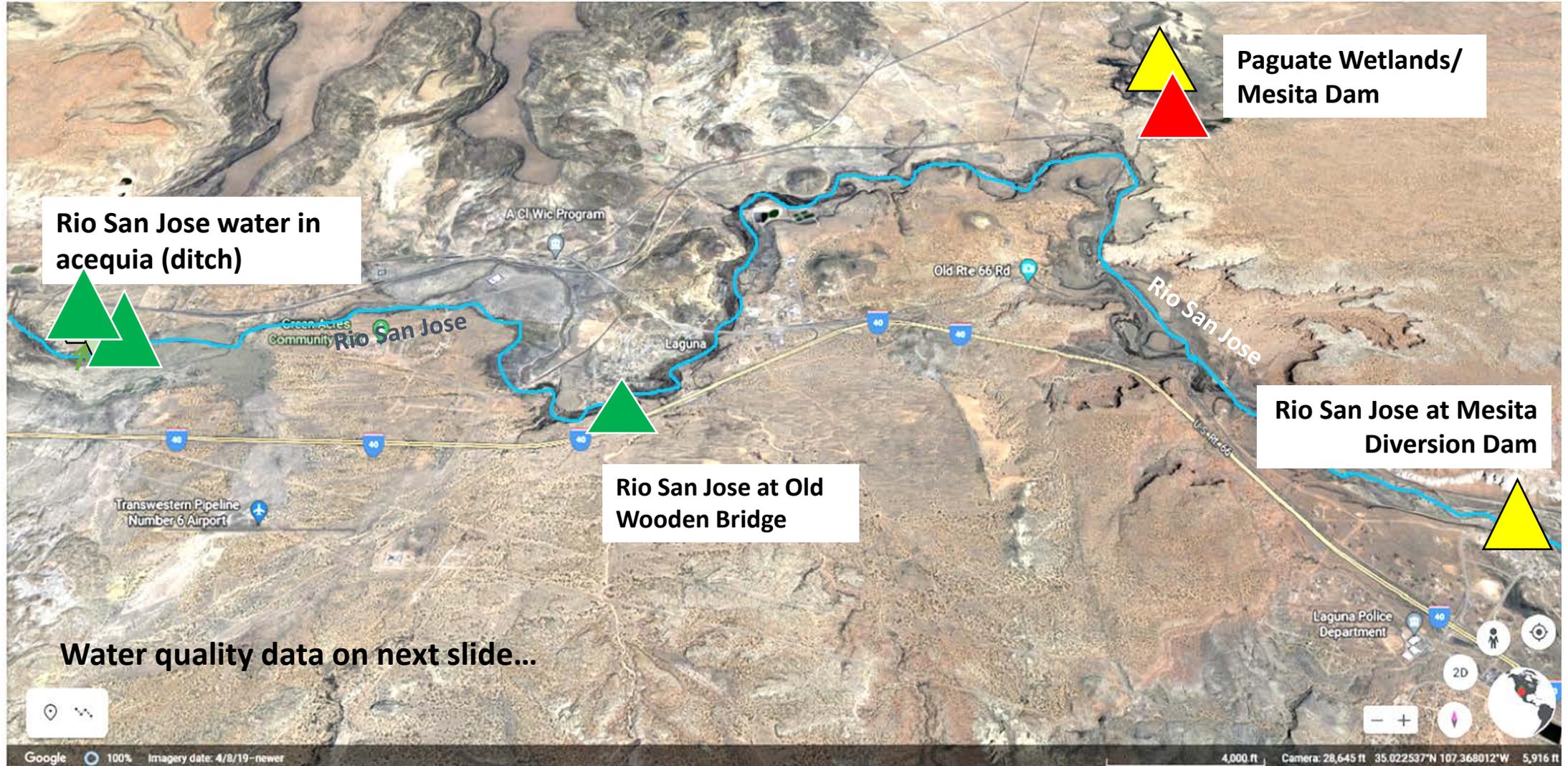


- METALS – Sampling of Rio Paguate, 2014-2021; Rio San Jose 2017, 2020; nearly 80 samples
- Supplements surface water sampling by ENRD under Clean Water Act grants from EPA
- Published paper, research brief on Jackpile Mine impacts on water quality in Rio Paguate
- Data shared with ENRD
- Maintaining database of Laguna surface water quality data

# Water Quality in Rio San Jose and Paguete Wetlands/Mesita Dam, 2015-2021

Cond = Conductivity  $\mu\text{s}/\text{cm}$  (a measure of salt content); U = uranium ( $\mu\text{g}/\text{l}$ );

**green** = good; **yellow** = use caution; **red** = don't drink!



# Selected Water Quality Data for Rio San Jose and Paguete Wetlands/Mesita Dam, 2015-2021

(legends on previous slide)



## Rio San Jose water in acequia (ditch)

8/26/20	#16	U	3.34
8/26/20	#17	U	3.66
8/26/20	#16	Cond	229
8/26/20	#17	Cond	513

## Rio San Jose at Old Wooden Bridge

6/2/2017	U	6.13
3/24/2017	Cond	1501
6/2/2017	Cond	1914
4/16/2021	Cond	1166

## Rio San Jose at Mesita Diversion Dam

3/24/2017	U	7.98
3/24/2017	Cond	1880
6/2/2017	Cond	4129

## Paguete Wetlands/Mesita Dam

Period	# samples	Parameter	Ave.	Min.	Max.	Std.
2015-2017	14	U	36.4	5.46	110.41	30 ug/l
6/2/2017	1	Cond			2107	~750-800 uS/cm

**Take-home message:** Rio San Jose is LOW in uranium, but increasingly salty from west to east. Paguate Wetlands/Mesita Dam water LOW to HIGH in U; moderately saline.

**Note:** Laguna ENRD routinely samples and tests waters in streams on the Pueblo of Laguna as part of its surface-water monitoring program funded by USEPA Region 6. The data presented here were generated by the METALS SRP team and supplement data from sampling conducted by ENRD.

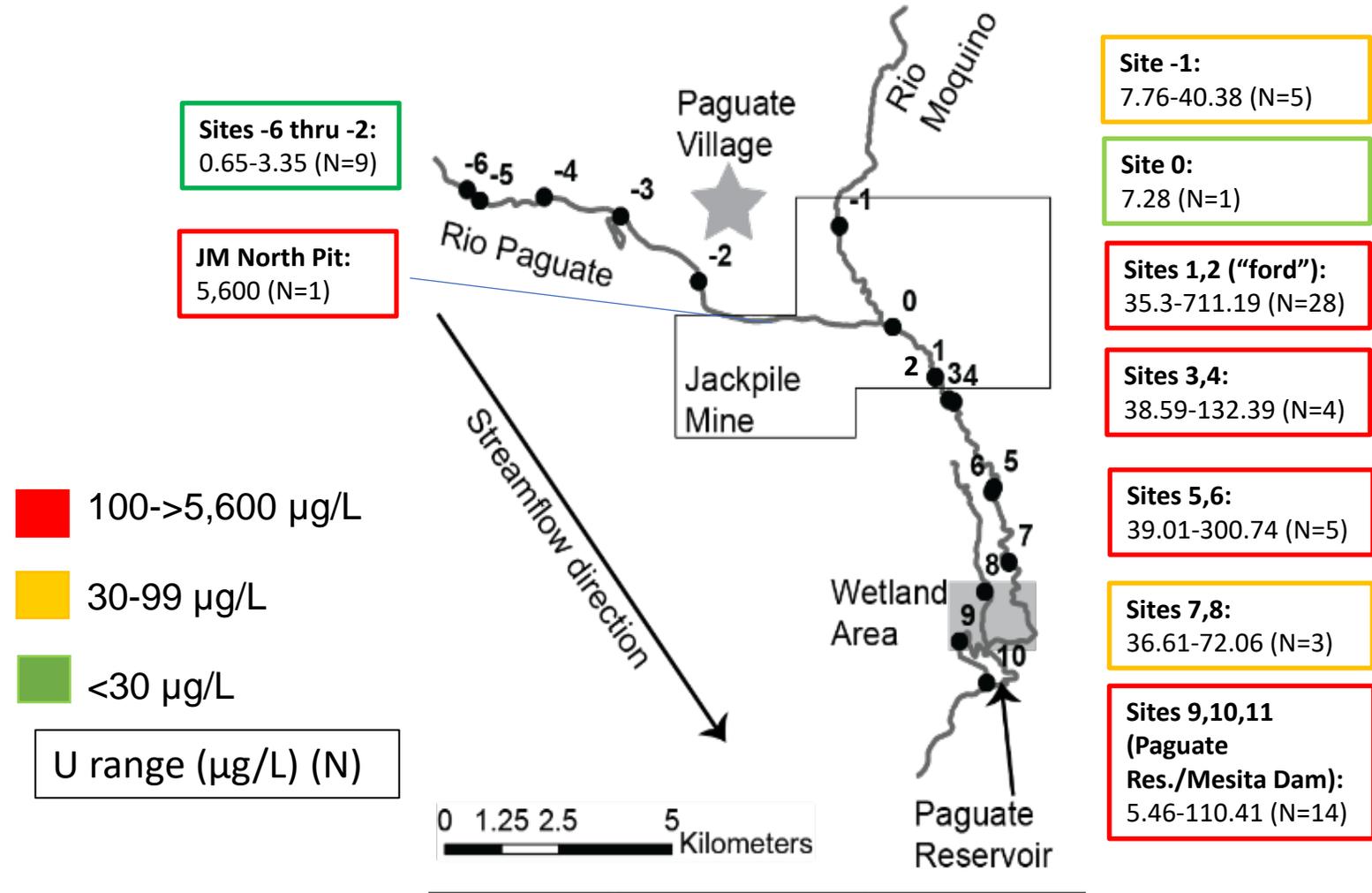
# Uranium Concentrations in Rio Paguete System, Pueblo of Laguna, 2014-2021

(Sources: UNM METALS SRP, Laguna ENRD, Precient Technologies)



## Findings for Rio Paguete:

- Water EXCELLENT for irrigation upstream of North Pit (green): low U, low salts (Sites -6 thru -2)
- Abrupt* worsening of water quality inside Jackpile Mine (red) (sites 0-6)
- Uranium in Rio Paguete wetlands behind Mesita Dam varies from good to poor, depending on flows (sites 7-11)
- No human consumption documented of Rio Paguete water inside and downstream from Jackpile Mine; wildlife, livestock exposed inside mine





## *What's next? (Further questions)*



- Soil and plant sampling limited to 23 locations representative of current conditions in the communities, but they may not be reflective of metals levels throughout the Pueblo
- Next soil sampling should prioritize fields in Mesita, other ag lands
- Continuing presence of high uranium and vanadium concentrations in soils in the Jackpile Mine *requires further investigation*
- UNM returning collection of samples (executing promises)



# *Dawaeh (Thank you)*

To all the villages of the Pueblo of Laguna!

Derek Capitan, Kelsie Herzer, Casey Miller, Kyle Swimmer, Luna Natoli, Chris Shuey, Abdul-Mehdi S. Ali, Paul Robinson, Michael Spilde, Adrian J. Brearley, Jennifer Rudgers, Eliane El Hayek, José M. Cerrato



**Research team practicing social distancing, August 2020**

These results are summarized in a poster prepared by Derek Capitan at the UNM Research Day, April 28, 2022, and shared with National Institutes of Health (NIH) officials on tour of Jackpile Mine on April 29.



# Metal occurrence in agricultural lands near legacy uranium mine sites in the southwestern US using a community-engaged study

Co-authors: [Derek Capitan](#), Kelsie Herzer, Casey Miller, Kyle Swimmer, Chris Shuey, Abdul-Mehdi S. Ali, Michael Spilde, Adrian J. Brearley, Eliane El Hayek, José M. Cerrato

**Guuwaadzi haupa-** Our work evidences the importance of developing a community driven research to work together and bring scientists, gardeners and farmers as a team to answer community concerns and investigate mining legacy.



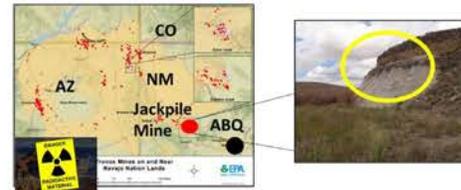
METALS scientist working with gardeners and the community members in collecting soil samples, Summer 2020



METALS scientist Luna Natoli trains community members in collecting soil samples, Feb. 2020

## Mining legacy near indigenous community

The New Mexico, Laguna Pueblo, Jackpile Mine  
 -Villages are less than 1 km from mine site  
 -Largest open pit uranium mine in 1960's



Vietnam Veteran's Road View of Jackpile Mine, Apr. 2022

## Gardening: Connecting Mother Earth to Human Health and Wellness



Local farmers, gardeners and growers volunteered to work with the scientists from the UNM METALS Superfund Research Center and the Pueblo of Laguna Environmental and Natural Resources Department (ENRD) to address a key community concern: *Is my soil impacted with metals associated with mining?*

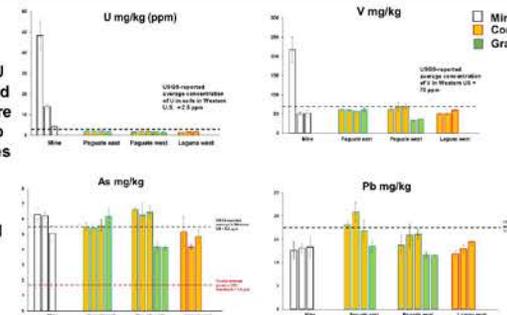
## What's in my garden?

Site No.	Village	Samples
3 (garden)	Paguete	soil, pumpkin
7 (garden)	Paguete	soil, melon, grasses
9 (farm)	Paguete	soil, corn, squash, grasses
11 (garden)	Mesita	soil, pumpkin
16 (farm)	Laguna	soil, corn
18 (garden)	Paguete	Soil, corn, cucumber, grasses
Jackpile Mine	Paguete	Soil, grasses, roots

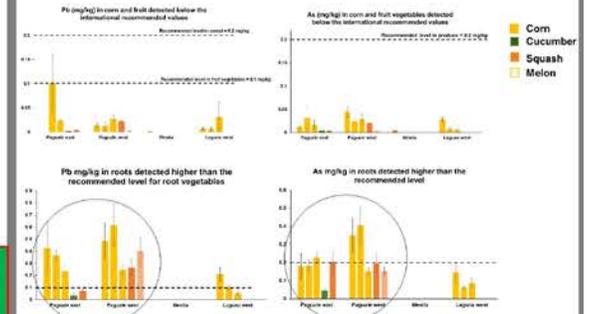


## Metals in soil

Concentrations of U (4.4-48.4 mg kg<sup>-1</sup>) and V (217.8 mg kg<sup>-1</sup>) were measured in the top soils at the mine sites (~ 3 km from the village), which are higher than the natural background levels.

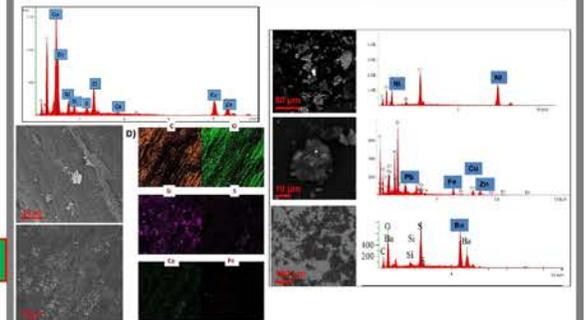


## Metals in crops



Metals that are of potential human health concern, including U, V, As and Pb, were detected below health-based guidance in all fruit vegetables and corn. Pb and As were identified mainly accumulated in the roots of all crops (0.1-0.3 mg per kg fresh weight) at the farmlands that are close to the mine waste sites

## The dust and the surface of leaves as tracers of atmospheric deposition



Our results show that the nature of bioaccumulated metals, including metals particulates, near abandoned mine sites can provide critical information for human exposures in sites affected by mining legacy.

## Acknowledgments

