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Introduction

- Three million gallons of heavy metal contaminated water spilled into the Animas River on August 5, 2015 as part of EPA activity at the Gold King mine (GKM) in Silverton, Colorado.
- The contaminated water reached New Mexico through the Animas and San Juan Rivers and eventually into Lake Powell (Utah).
- Irrigation ditches were closed following the spill to avoid contamination reaching agricultural crop fields.
- The majority of contamination released by the GKM spill existed as suspended solids likely deposited within the streambed sediment of the Animas and San Juan Rivers, as well as in irrigation ditches that could not be closed ahead of the arrival of the contaminated plume.



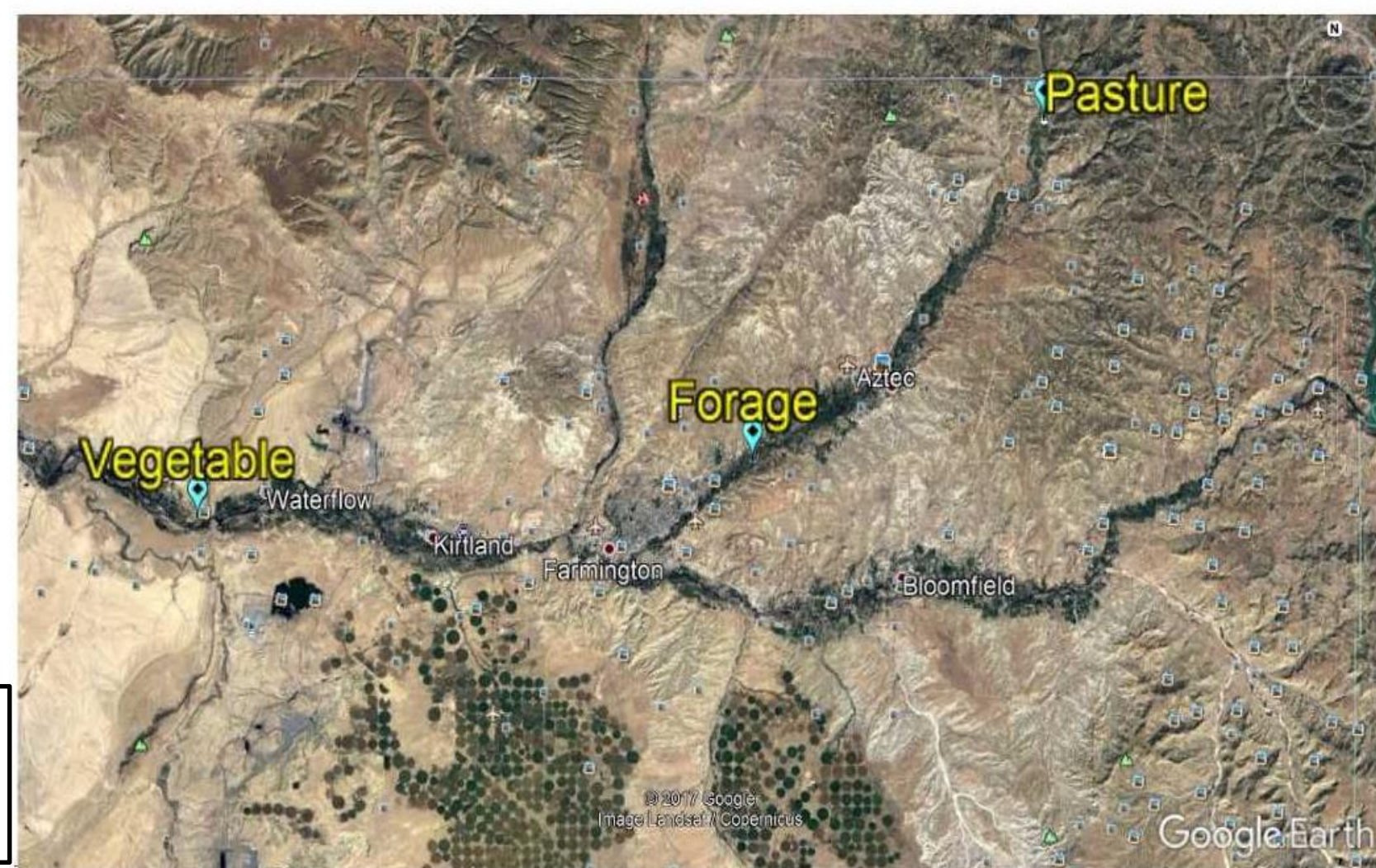
Animas river pre and post GKM
 Picture source-
<http://lastreelindians.com/wp-content/uploads/2016/03/animas-river.jpg>

Objectives

1. Monitor selected metal concentrations in agricultural fields within the Animas and San Juan River watershed.
2. Characterize the spatial and temporal variability of selected metals.

Materials and Methods

Metal(loid)s of concern from the GKM spill: As, Pb, Mn, Zn, Cu, Ca, Fe



Sampling locations in Aztec, Farmington and Shiprock (Navajo Nation)

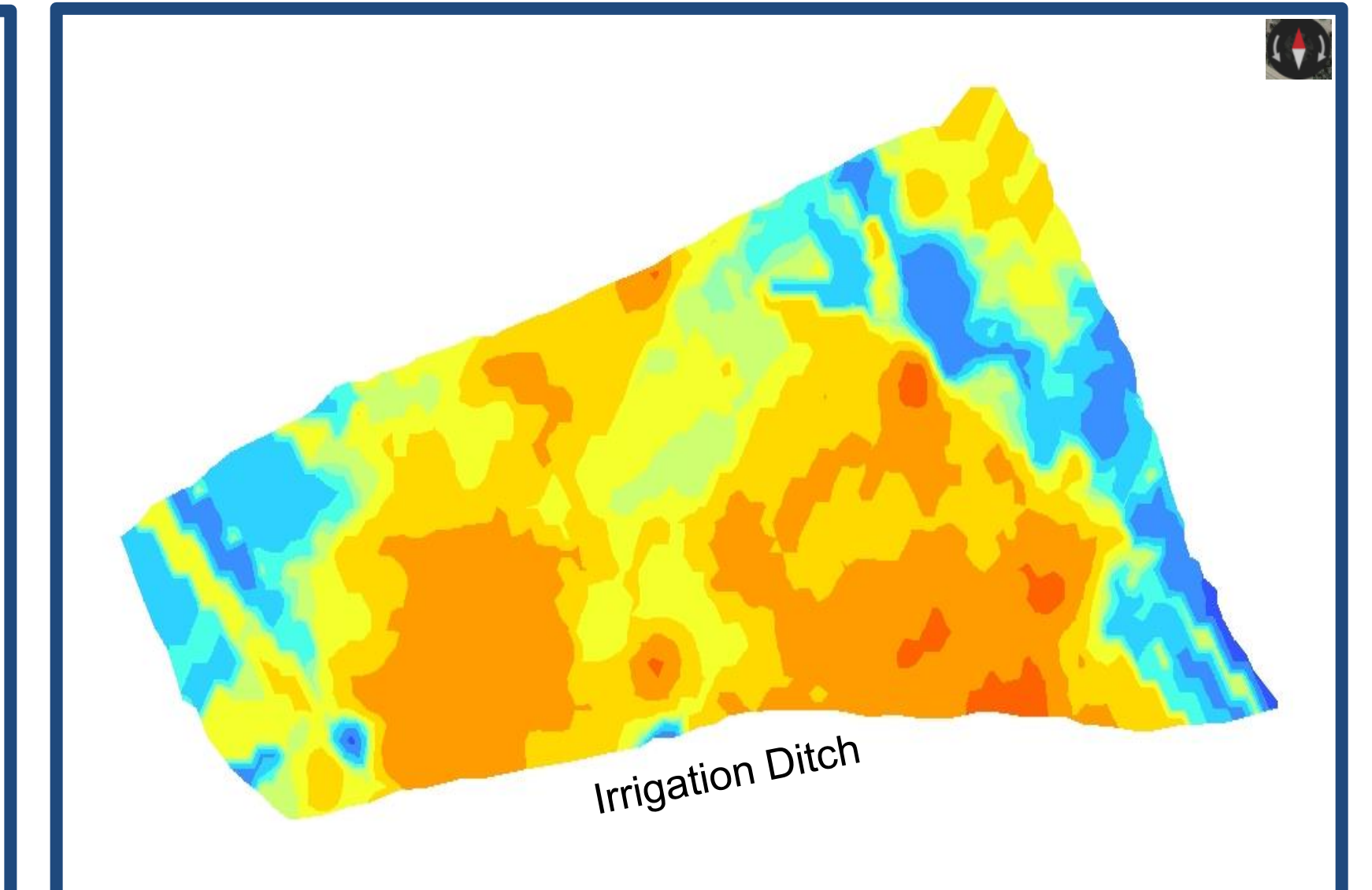
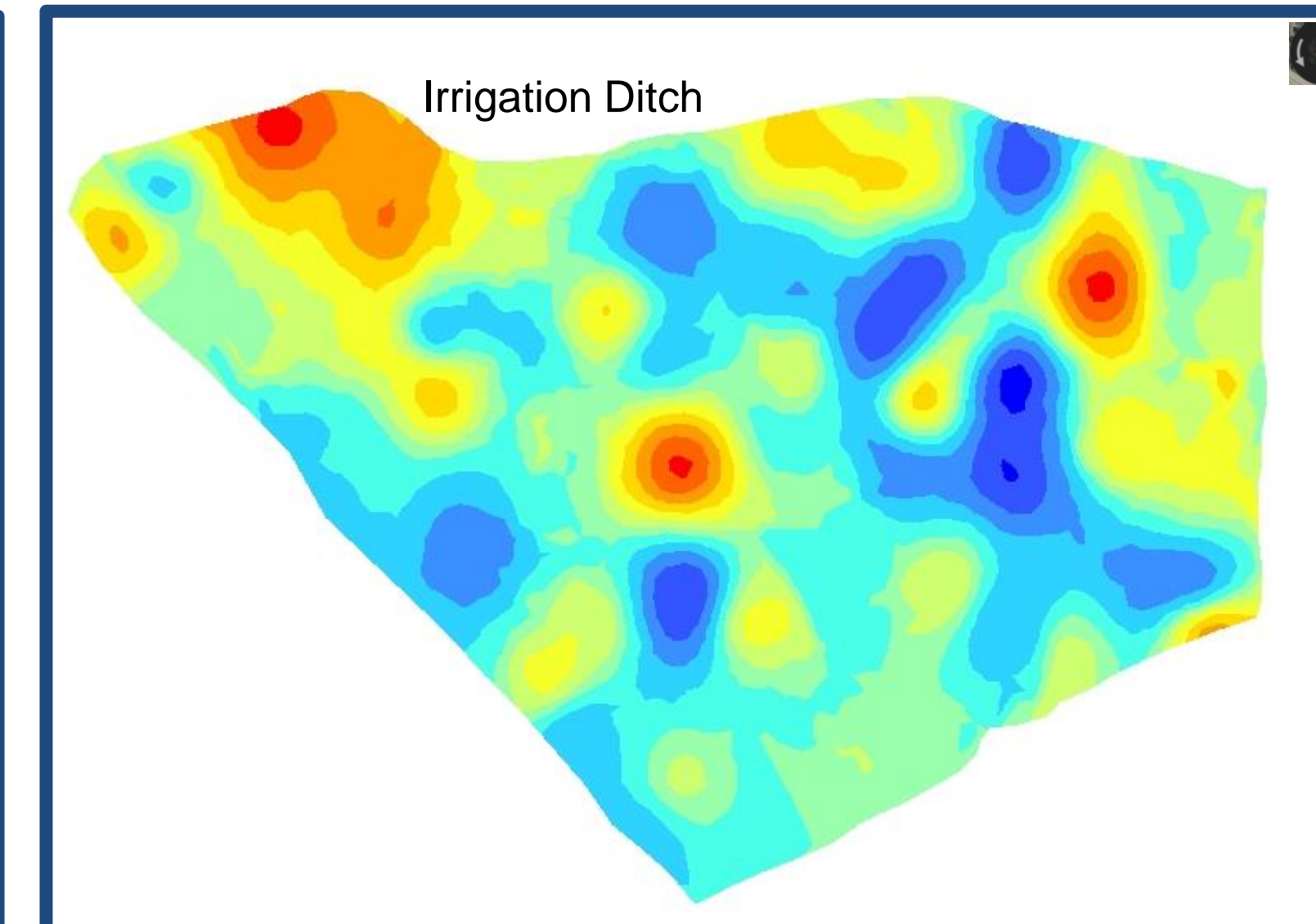
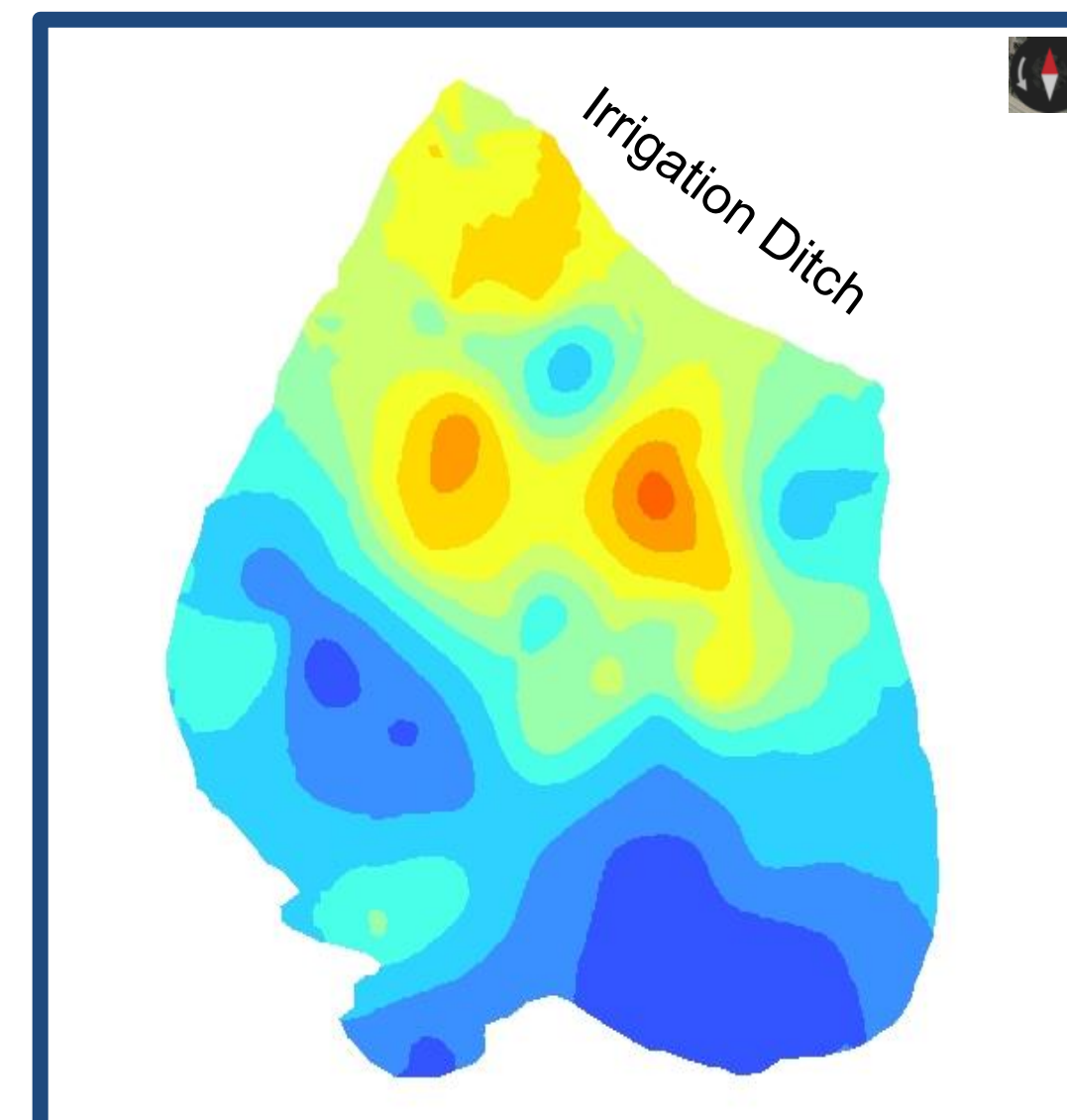
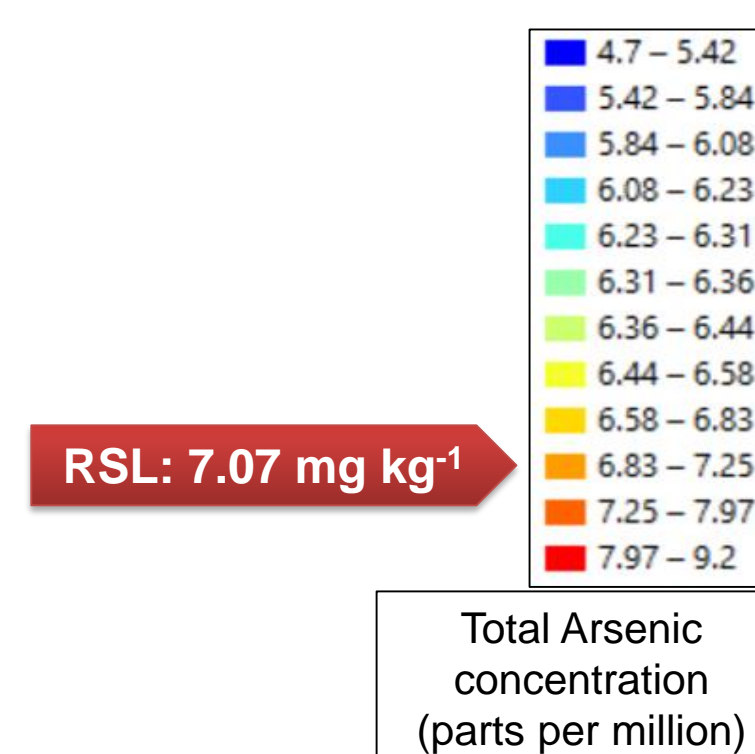
- In-situ rapid scans were taken for 0-2 cm soil layer at three fields irrigated by Animas River water during the pre-growing season (March to April, 2017) using a Delta Premium GeoChem Plus Portable X-ray Fluorescence (PXRF) Spectrometer.
- The three fields, *pasture*, *forage* and *vegetables*, were scanned at 75 randomized points per field for 120 seconds per reading using two beams of X-rays.
- Scanning was conducted in a proprietary software configuration known as Geochem/Soil Mode.
- The GPS coordinates were plotted into the respective shapefiles of three fields in ArcGIS (ArcMap 10.5.1). The concentrations of 7 metals were interpolated by Kriging using a spherical model.
- Metal concentrations attained by PXRF were compared to EPA residential screening levels (RSL).



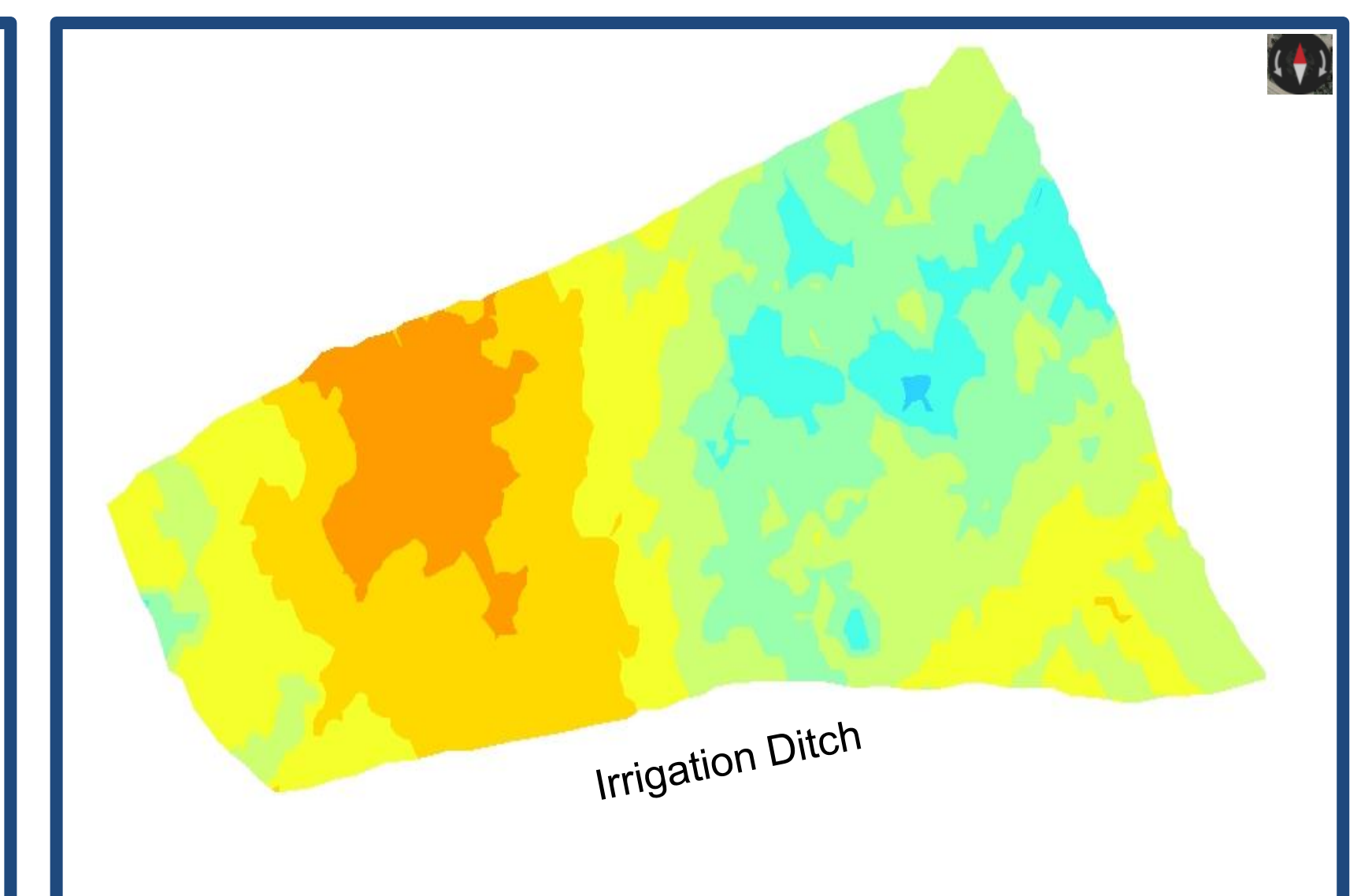
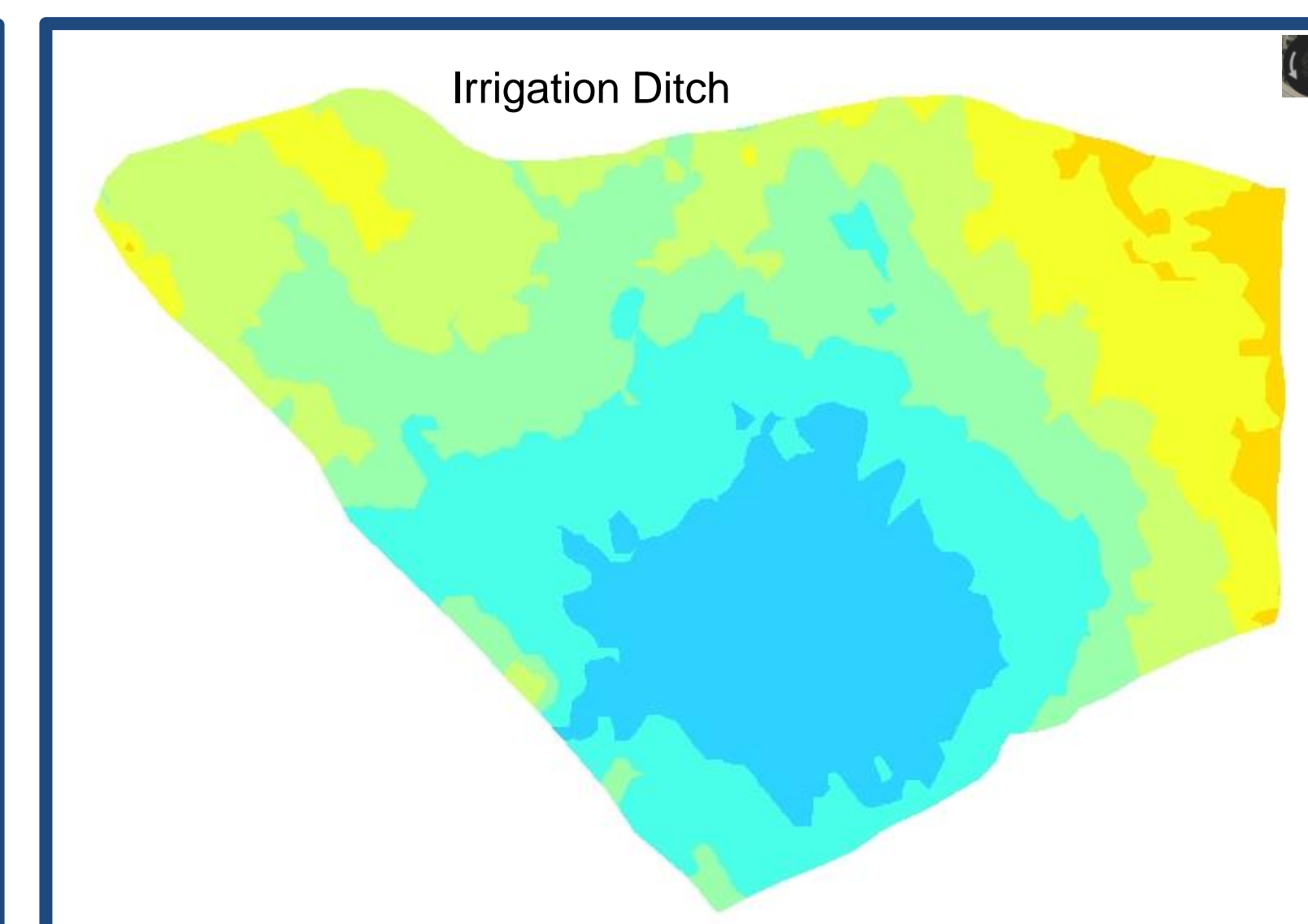
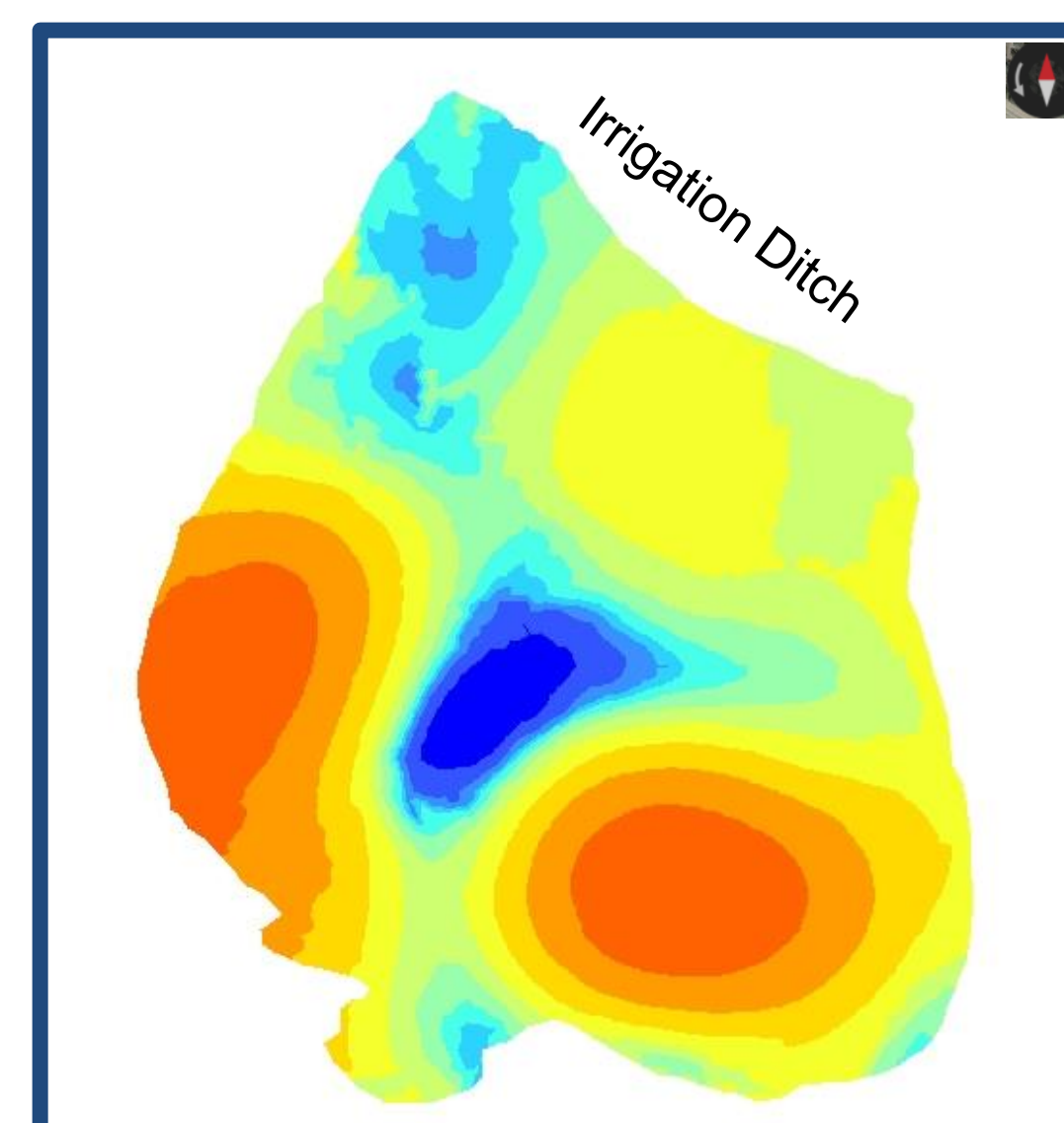
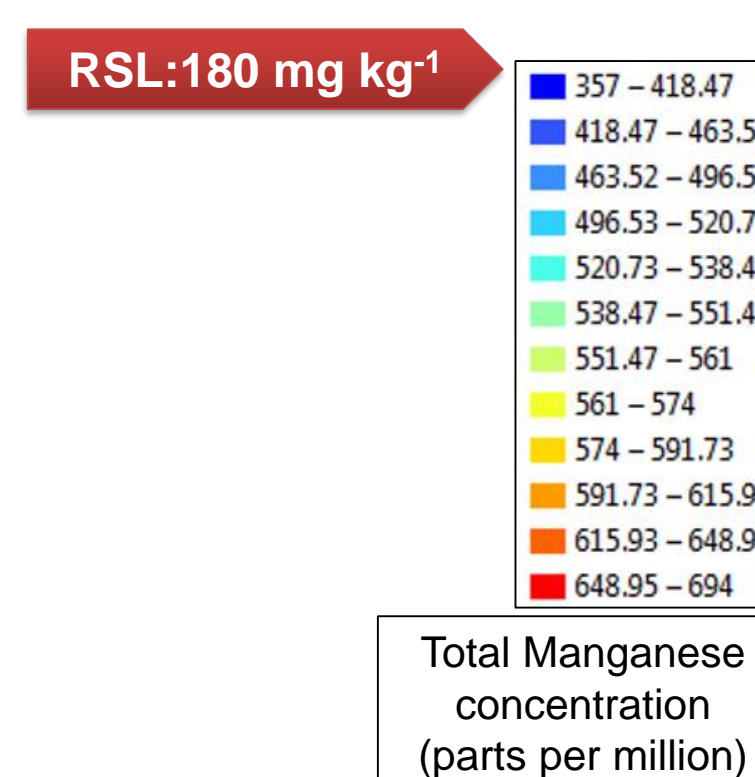
Portable X-Ray Fluorescence
 Picture credit-Gaurav Jha

Results

Arsenic (As)



Manganese (Mn)



Vegetation

Total field area

Location

Site

Pasture grass

14.1 hectares

36.9754662 (latitude),
 -107.8724999 (longitude)

Aztec

Forage (alfalfa)

3.04 hectares

36.77922315 (latitude),
 -108.1034758 (longitude)

Farmington

Vegetables

1.27 hectares

36.74499367 (latitude),
 -108.5491836 (longitude)

Shiprock (Navajo Nation)

Table: Average total metal(loid) concentrations (in mg kg⁻¹) in fields irrigated by Animas river water

Metal	Residential Screening Level (in mg kg ⁻¹)	Concentration (in mg kg ⁻¹) in Pasture land	Concentration (in mg kg ⁻¹) in Forage land	Concentration (in mg kg ⁻¹) in Vegetable Field
Arsenic	7.07	7.19	6.92	7.13
Lead	400	83.28	48.09	17.50
Calcium	-	10449.50	16608.96	37006.01
Zinc	2300	223.459	116.64	71.47
Copper	310	38.98	29.43	21.35
Manganese	180	874.92	545.04	312.84
Iron	5500	23838.50	23159.76	22859.84

Results Summary

- Total average arsenic concentration exceeded the RSL in pasture land and vegetable fields.
- Total manganese concentration was high in all three fields across the Animas watershed.
- Negative correlation was observed between Pb and Ca. Lead concentration decreased downstream while the calcium concentration increased.
- The concentrations of Pb, Zn and Cu were lower than the EPA-RSL.
- Total Fe concentration was higher in the region (perhaps due to pyritic parent material).

Future research

- Sequential extraction of metals that exceeded the RSL to determine their forms and availability.
- Analysis of plant samples to evaluate the uptake of selected metals in the plant matrix.
- Confirmatory analysis to correlate PXRF results with ICP analysis after acid digestion.

Acknowledgements

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