Environmental Health Research on the Navajo Nation:

Preliminary Results of the Navajo Birth Cohort Study and Selected Case Studies of Exposures to Uranium in Mining Wastes and Drinking Water

Annual Meeting of the CHR Outreach Program, Navajo Nation Department of Health
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Presented by
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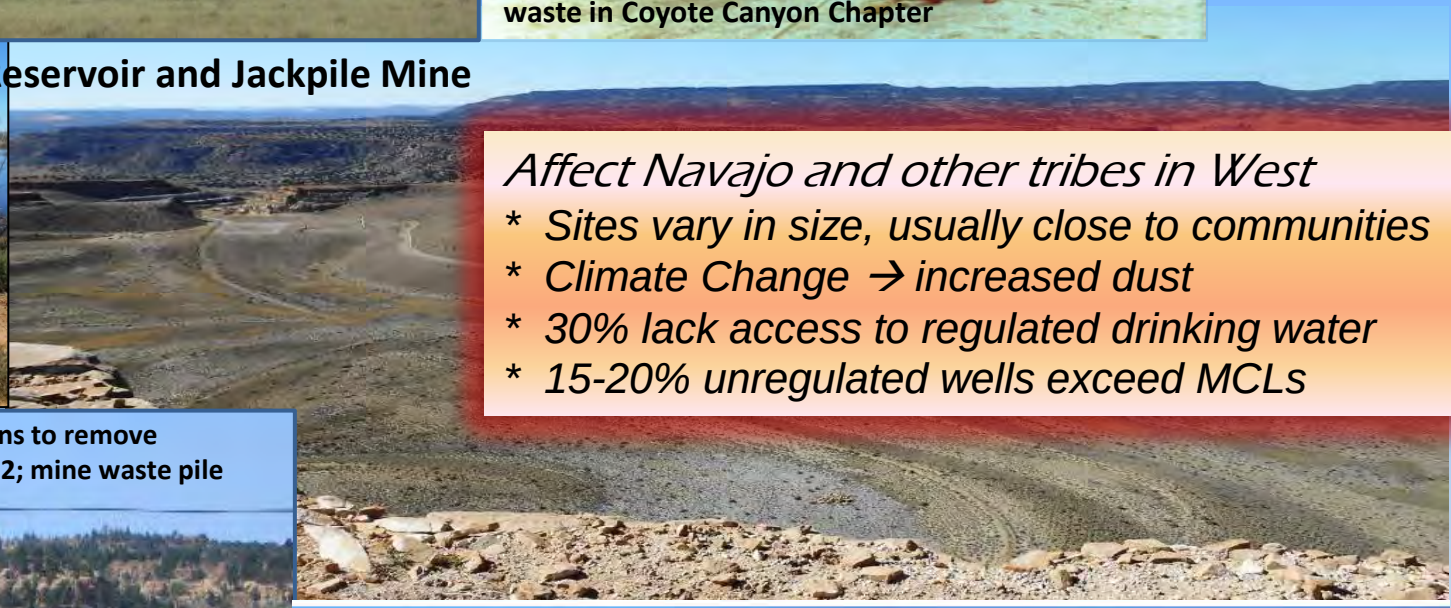
Learning Objectives

- Become familiar with preliminary results of the Navajo Birth Cohort Study (NBCS)
- Learn how CHRs can help promote and discuss the benefits of enrolling in the NBCS
- Understand basic environmental health principles
- Learn about ongoing uranium-exposure problems in Navajo communities through brief case studies

Why do we care about abandoned mines in the West?



Affect Navajo and other tribes in West

* *Sites vary in size, usually close to communities*
* *Climate Change → increased dust*
* *30% lack access to regulated drinking water*
* *15-20% unregulated wells exceed MCLs*

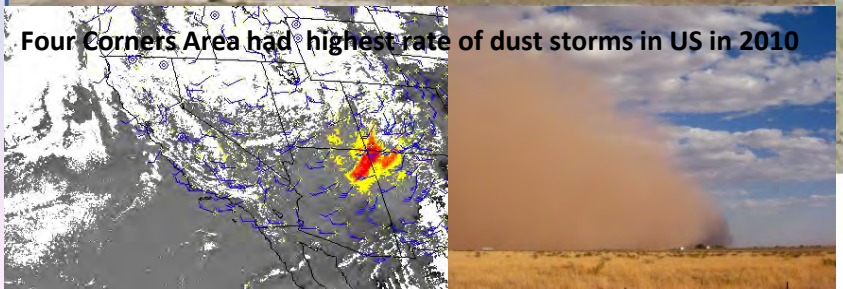


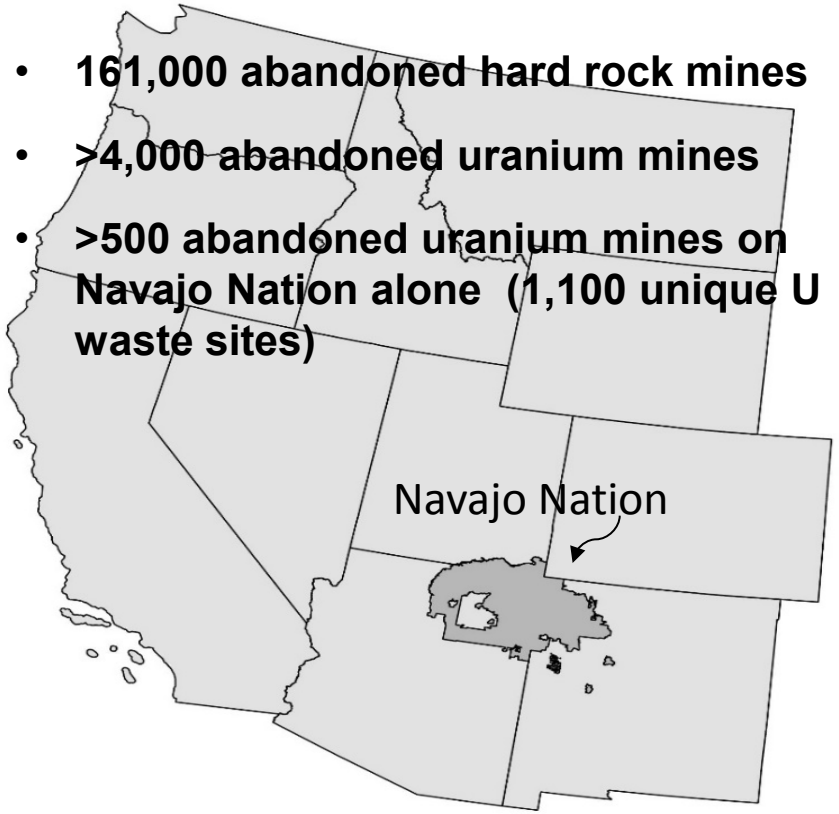
Photo montage shows spring winds resuspending dust from Old Church Rock Mine site (right) onto Navajo grazing lands (left), April 2003.

Highest concentration of abandoned hardrock mines in states with highest Native American populations

— *GAO & US Census, 2010*

Western United States

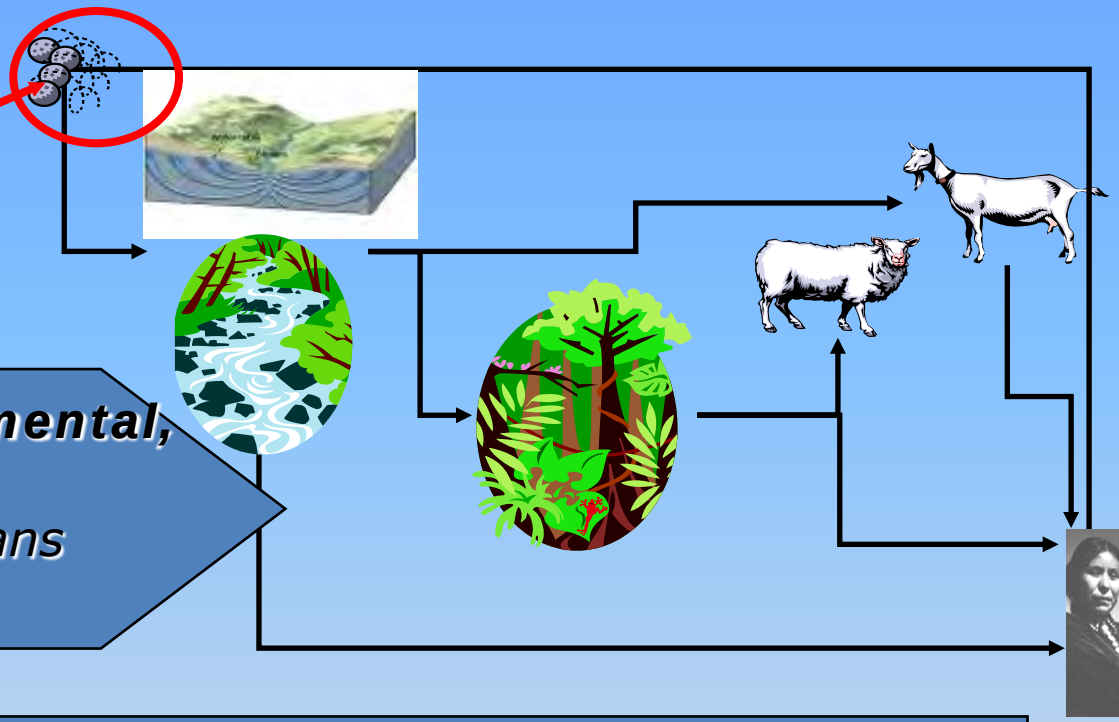
- **161,000 abandoned hard rock mines**
- **>4,000 abandoned uranium mines**
- **>500 abandoned uranium mines on Navajo Nation alone (1,100 unique U waste sites)**



Impacts of release of ~3 million gallons of metal-laden waste water from Gold King Mine on Aug. 5, 2015 could be seen as orange-yellow stains in Animas River two weeks after spill

Our research considers all exposure pathways and routes of exposure of study participants

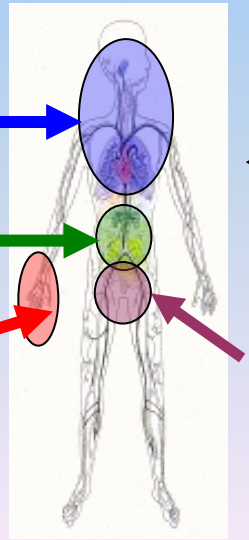
SOURCES: Potentially harmful contaminants in the environment



Exposure Pathways: environmental, outside the body

Air, water, plants, animals, humans

(can be very simple or quite complex)



Inhalation (Breathing)

Ingestion (Eating, Drinking)

Absorption (Skin Contact)

Exposure Routes: inside the body

How contaminants enter the body

Circulation:

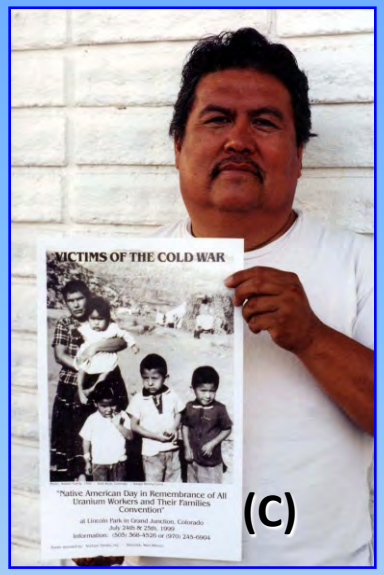
- **Transplacental transfer?**
- **Epigenetic changes?**

Target Organ:

Where a contaminant ends up in the body; e.g., bone, kidney, lung

DiNEH Project Results: Modeling of survey responses and geospatial data:

Active-mining era exposures (workers and families) *increased risk* of kidney disease



Active-mining related exposures were estimated from <u>self-reported survey data</u>

A: Washed the clothes of a uranium worker (22%)
B: Worked in a uranium mine (10%)
C: Lived in a mining camp (4%)
D: Worked in a uranium mill (2%)
E: Worked on a uranium mine or mill reclamation or hauled uranium ore or tailings in a pickup truck (2%)

Note: Many workers have already died from lung cancer; cohort had more family members than workers. Source: Hund et al., 2015, Journal of Royal Statistical Society, Series A, Statistics in Society.

DiNEH results may reflect synergy of multiple pathway exposures:
Ongoing environmental legacy exposures → increased risk for hypertension, autoimmune disease

Exposures to the environmental legacy of uranium mine and mill waste were estimated from two sources of data:

1) The proximity of each resident's home* to all of the abandoned uranium mine and mill waste features (100)
2) Reported activities that may result in exposure to uranium mine and mill wastes

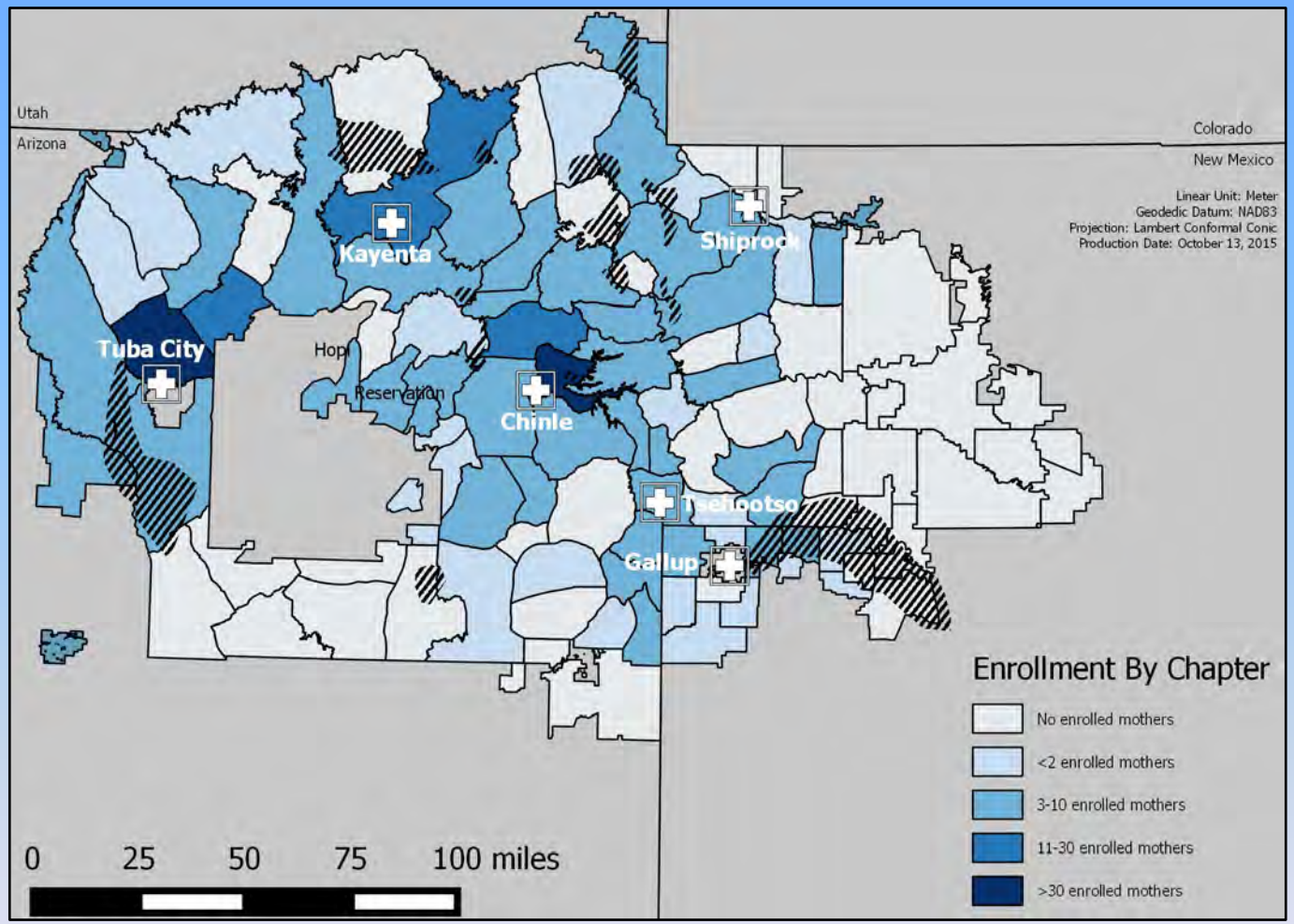
A: Used materials from abandoned uranium mine or mill (17%)
B: Herded livestock next to uranium mine, mill or waste dump (13%)
C: Drunk or contacted uranium mine waste water (13%)
D: Played on a uranium tailings pile or waste dump (13%)
E: Played outdoors near a uranium mine, mill, or waste dump (12%)
F: Sheltered livestock in an abandoned uranium mine (2%)

**Note: Median length of residence in current homes was 33 years*

Hund et al., 2015, Journal of Royal Statistical Society, Series A, Statistics in Society

Navajo Birth Cohort Study recruiting, enrolling participants from communities throughout the Navajo Nation

- Eligibility criteria:
  - Ages 14-45
  - Confirmed pregnancy
  - Willing to deliver and receive prenatal care at 6 hospitals on NN
  - Lived on NN for at least 5 years
  - Eligible for IHS services
- 585 Mothers enrolled thru 11/30/15
- 24 families (7% of mapped homes) live in former mining areas (within black outline regions)



Map and statistical analysis by Joe Hoover, UNM-CEHP

NBCS assessing effects of exposures to uranium wastes on reproductive outcomes and early-childhood development

Outcomes Model Structure

EXPOSURE INPUTS

Uranium
Proximity, dust, occupation, water, land use
Survey, GPS, NURE data, Biomonitoring, Existing water quality, in-home dust, parent biomarker analyses

Radiation
Home scans
Biomonitoring, Existing data

Radon
In-home
Canister monitoring

MODIFIERS

Reproductive History
Mother and father
Survey & Medical Records

Nutritional Status
Mother
WIC, FFQ, Biomonitoring

Demographic Variables
Parental income, education, parental ages
Survey

Alcohol, Substance Abuse
Surveys, Meconium, Medical Record

Co-Exposures
Other metals, PAHs, Particulates, Sulfur Compounds
Biomonitoring, Surveys, Home Assessments

REPRODUCTIVE OUTCOMES

Reproductive Difficulty
Miscarriage, delivery complications
Medical Record

Low Birth Weight
Medical Record Review

Congenital Malformation
Medical Record, Survey

DEVELOPMENTAL OUTCOMES

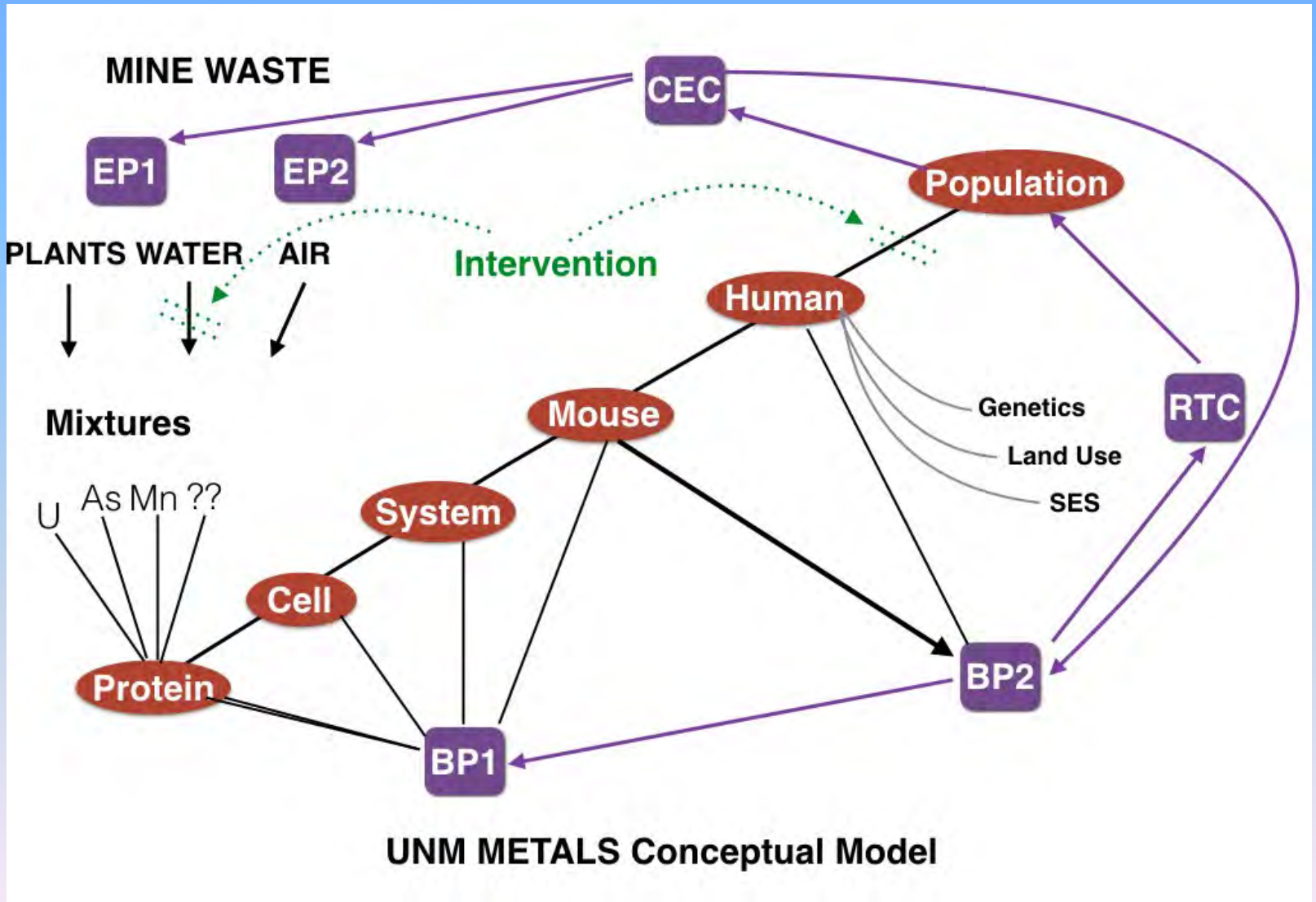
Development: Behavior
communication, gross & fine motor skills, problem solving and personal social skills
ASQ-I & Mullen

Development: Physical
Length, weight, head circumference
Anthropometry

Development: Medical
Infections, Morbidity, Mortality
Medical Record Review

Development: Biomarker
Inflammation, Immune system
Laboratory Analysis

Continuum of environmental/biomedical research: from the population to the molecule



NBCS Participant Exposure Assessments

- Exposure Survey @ Enrollment (administered principally by CHERS)
  - Occupational history
  - Time and activity patterns
  - Family history of exposures
- Home Environmental Assessment (conducted by RFS)
  - 22 metals in indoor dust
  - Indoor radon (invisible, odorless radioactive gas)
  - Gamma radiation survey indoors and outdoors
  - Contaminants in drinking water
- Biomonitoring
  - Urine metals (36-element panel, including uranium)
  - Whole blood (lead, cadmium, total mercury)
  - Serum (copper, selenium, zinc)

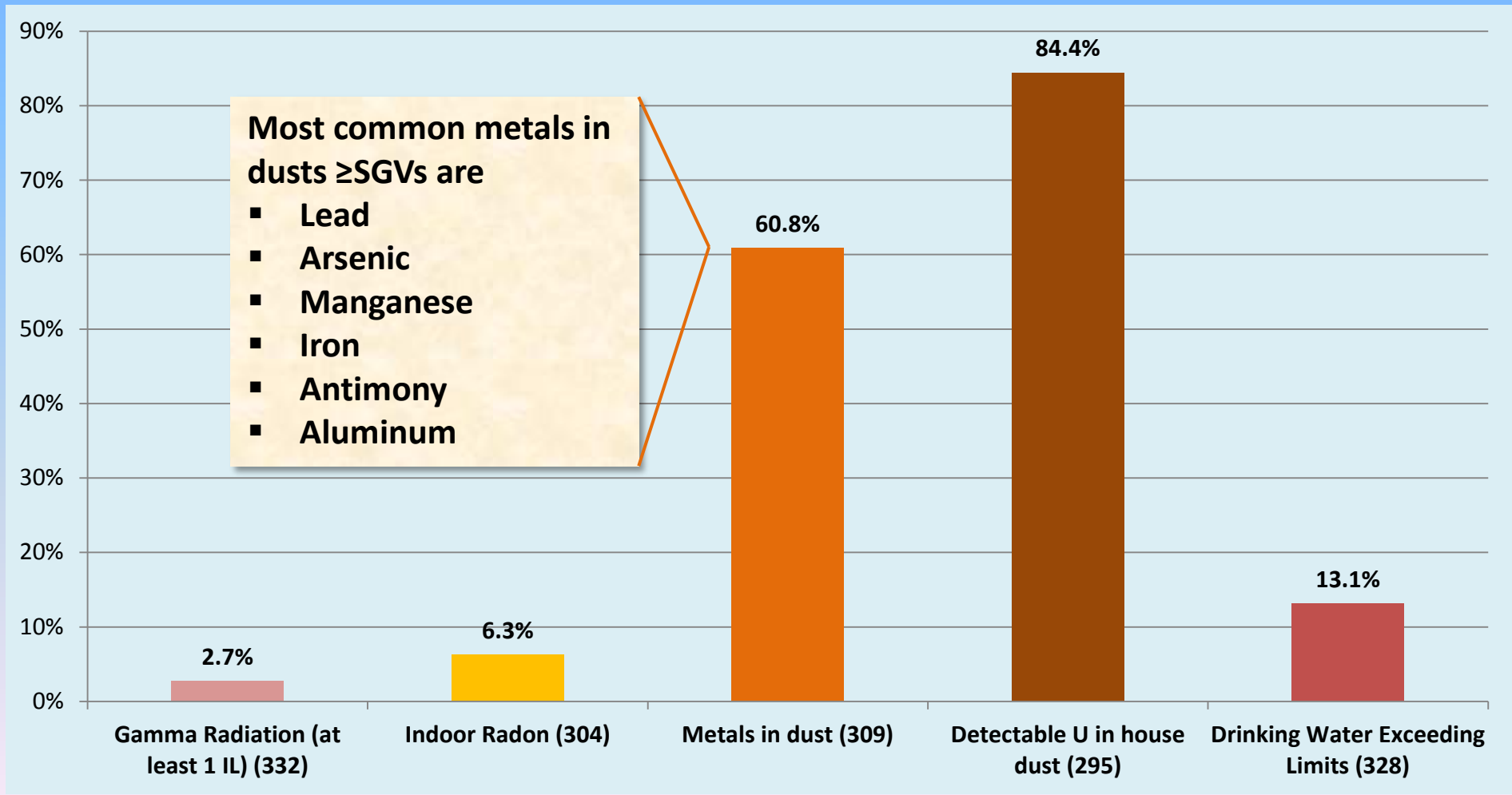
NBCS Sample Collection Points

	Blood	Urine	Meconium
Mother	➢ Enrollment ➢ Delivery	➢ Enrollment ➢ Delivery	
Father	➢ Enrollment	➢ Enrollment	
Baby	➢ Birth (cord blood) ➢ 2-6 months of age ➢ 12 months of age	➢ Birth ➢ 2-6 months of age ➢ 12 months of age	➢ Birth

Home environmental assessments (HEAs) conducted at nearly 420 homes covering about 75% of the women enrolled in the study through mid-October 2015

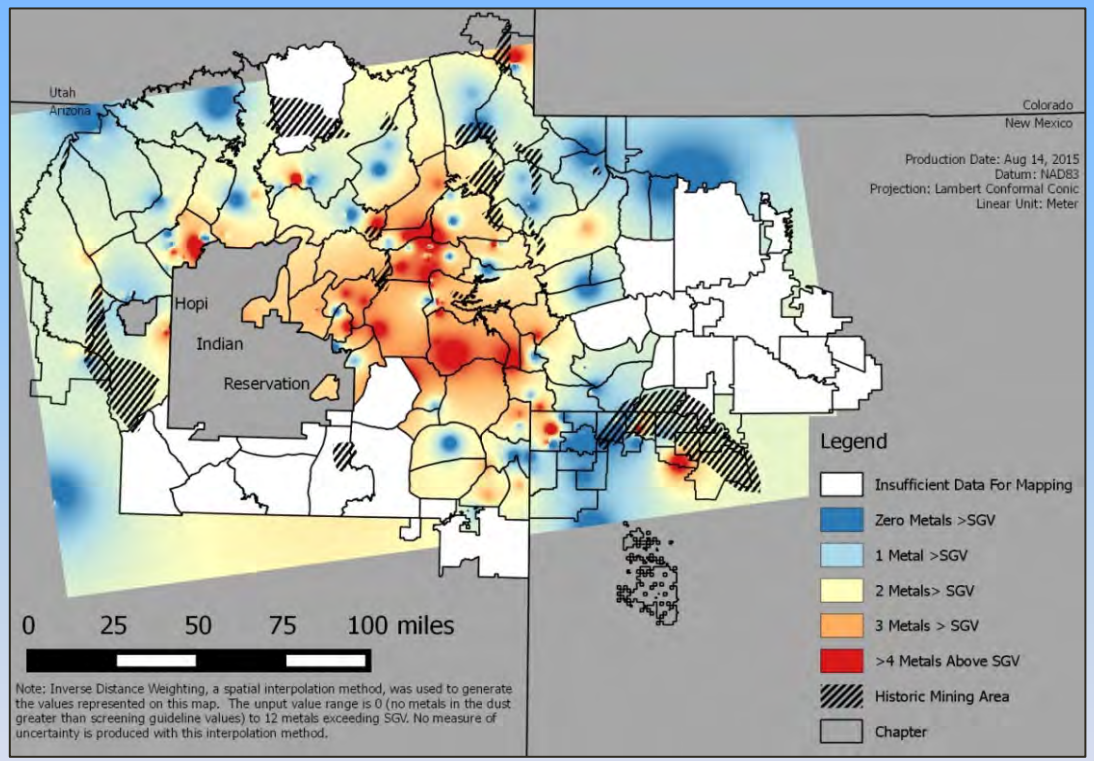
Major exposure sources in participants' homes

Chart below shows percentage of homes with contaminants exceeding screening guidelines and percentage of homes having detectable levels of uranium in indoor dust (Results through April 30, 2015)



Indoor dust major exposure source

(air is the pathway, inhalation the route)



Map by J. Hoover, UNM-CEHP

- Indoor dust collected on cloth "wipes", sent to USEPA lab in California for analyses of 22 metals
- Metal concentrations compared with Screening Guideline Values (SGV) adapted from those adopted by multi-agency response to WTC collapse, corrected for chronic exposures
- Map shows occurrences of metals in indoor dust with greatest concentration of multiple metals in central portion of Navajo Nation
  - Regional exceedance of SGV for >3 (orange) or >4 other metals (red)
- **Metal *mixtures* are greatest concern for health**
- Uranium not depicted on this map, but as noted has been detected in dust in nearly 85% of homes

Drinking water may contribute to metal exposure

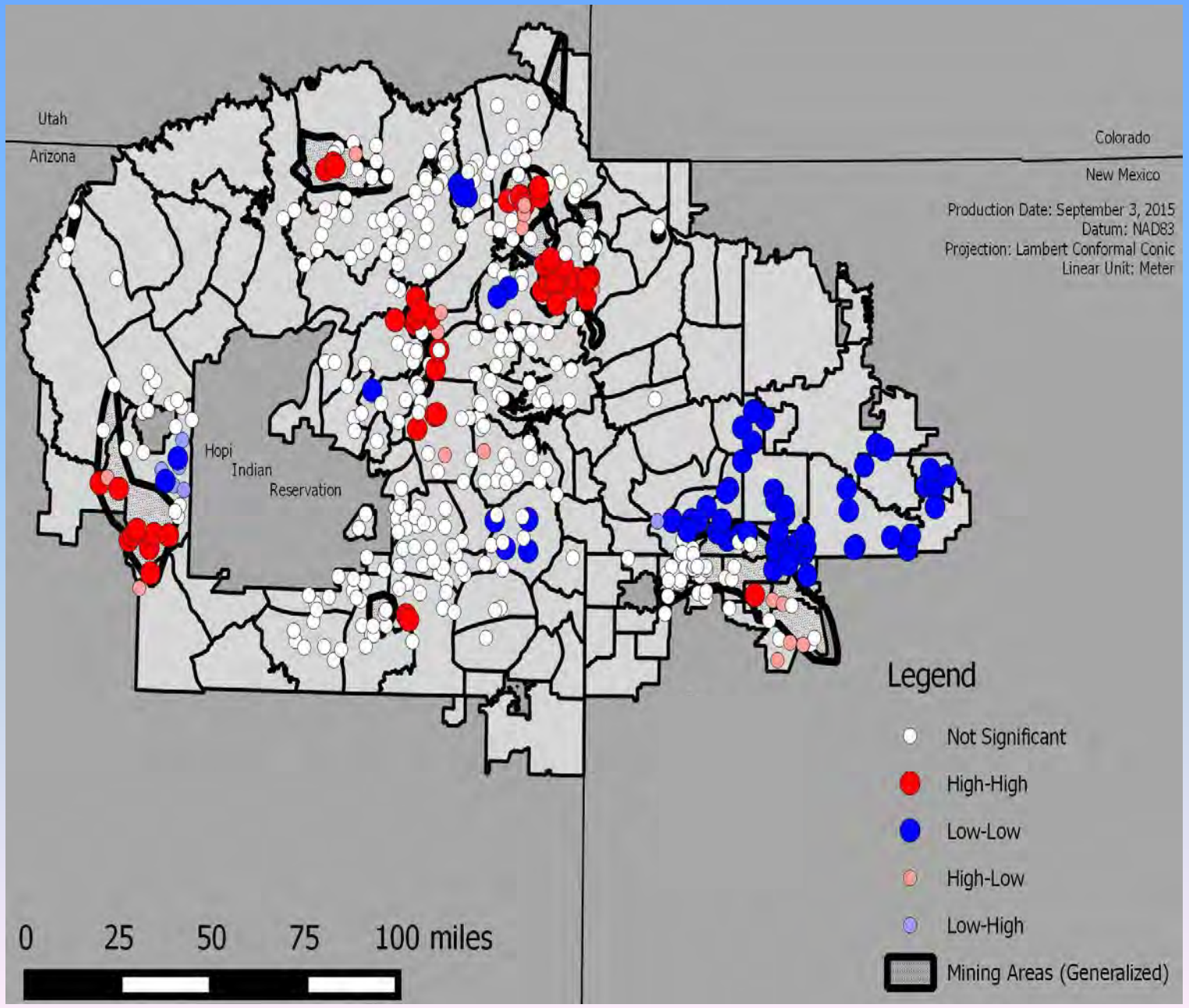
Unregulated Sources

Sources with possible co-exposure to As and U
Note: some (not all) in mining areas

Sources with low As and U
Note: some (not all) outside mining areas

Regulated Sources

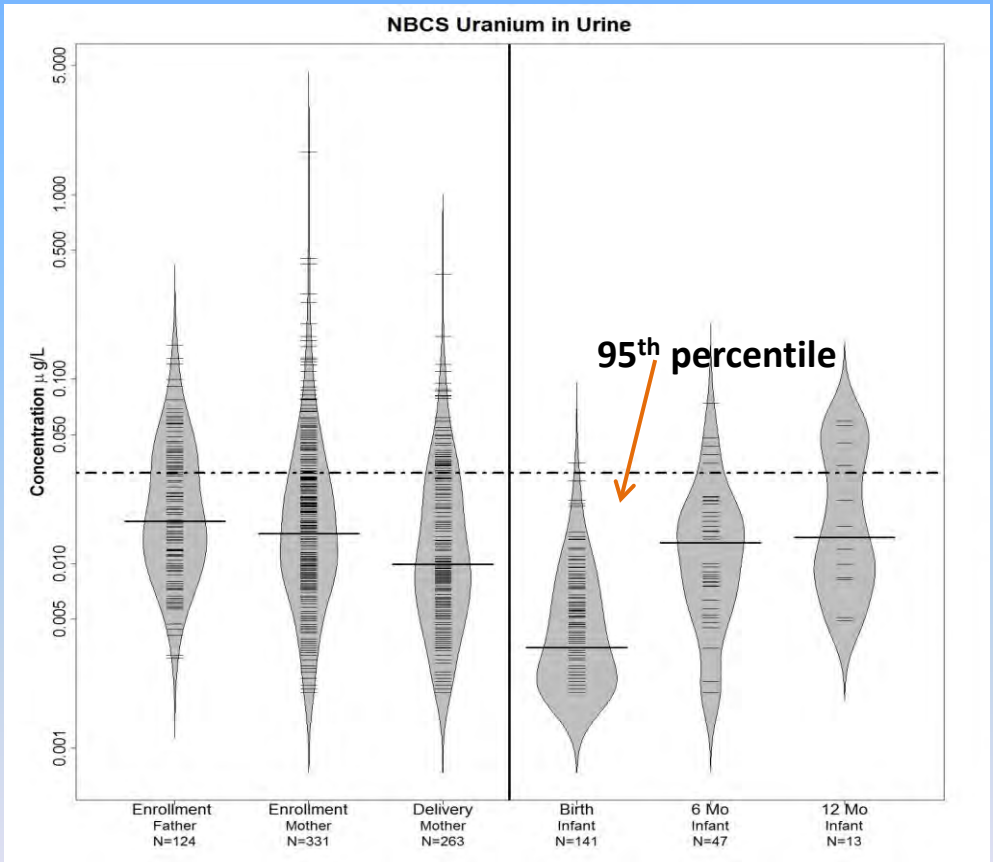
- 12 exceed MCL for U and/or As
- No difference in urine-U in those drinking from regulated sources



Biomonitoring results:

NBCS participants have much higher concentrations of uranium in their urine than other people in the US

Parents **Babies**



"Bean" chart by Joe Hoover and Jennifer Ong, UNM-CEHP

- **17%** of study participants have **urine uranium** concentrations *greater than the* US 95th percentile
  - NHANES national averages, 2011-12
  - 95th percentile is 0.031 micrograms per liter

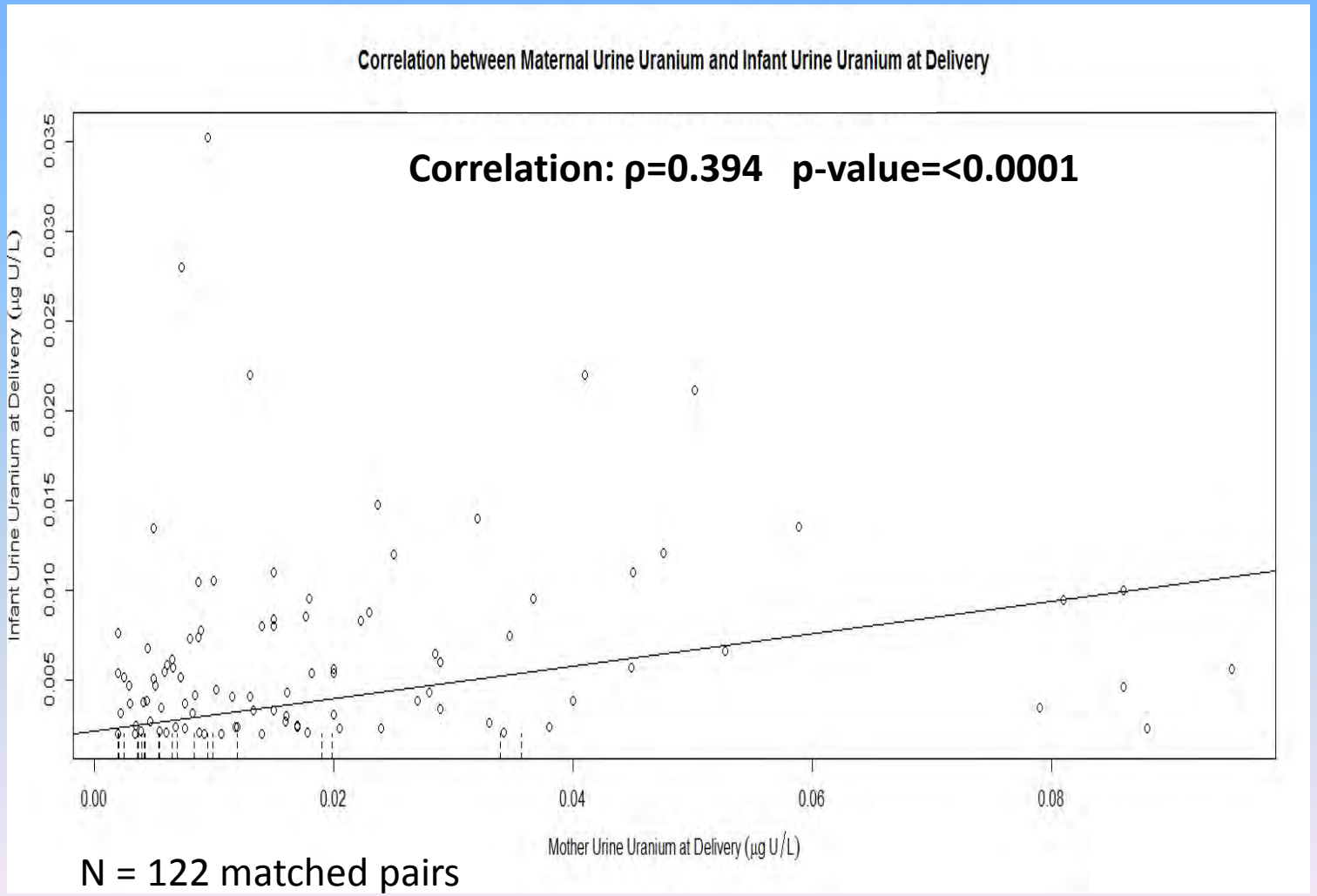
That means that about 3 out of every 20 NBCS participants have a higher level of uranium in their urine than 1 out of every 20 other Americans

- Mothers: 16%
- Fathers: 27%
- Babies*:
  - Birth: 0.7%
  - 6 months: 10.9%
  - 12 months: 30.8%
  - ***Babies are accumulating U in the first year***

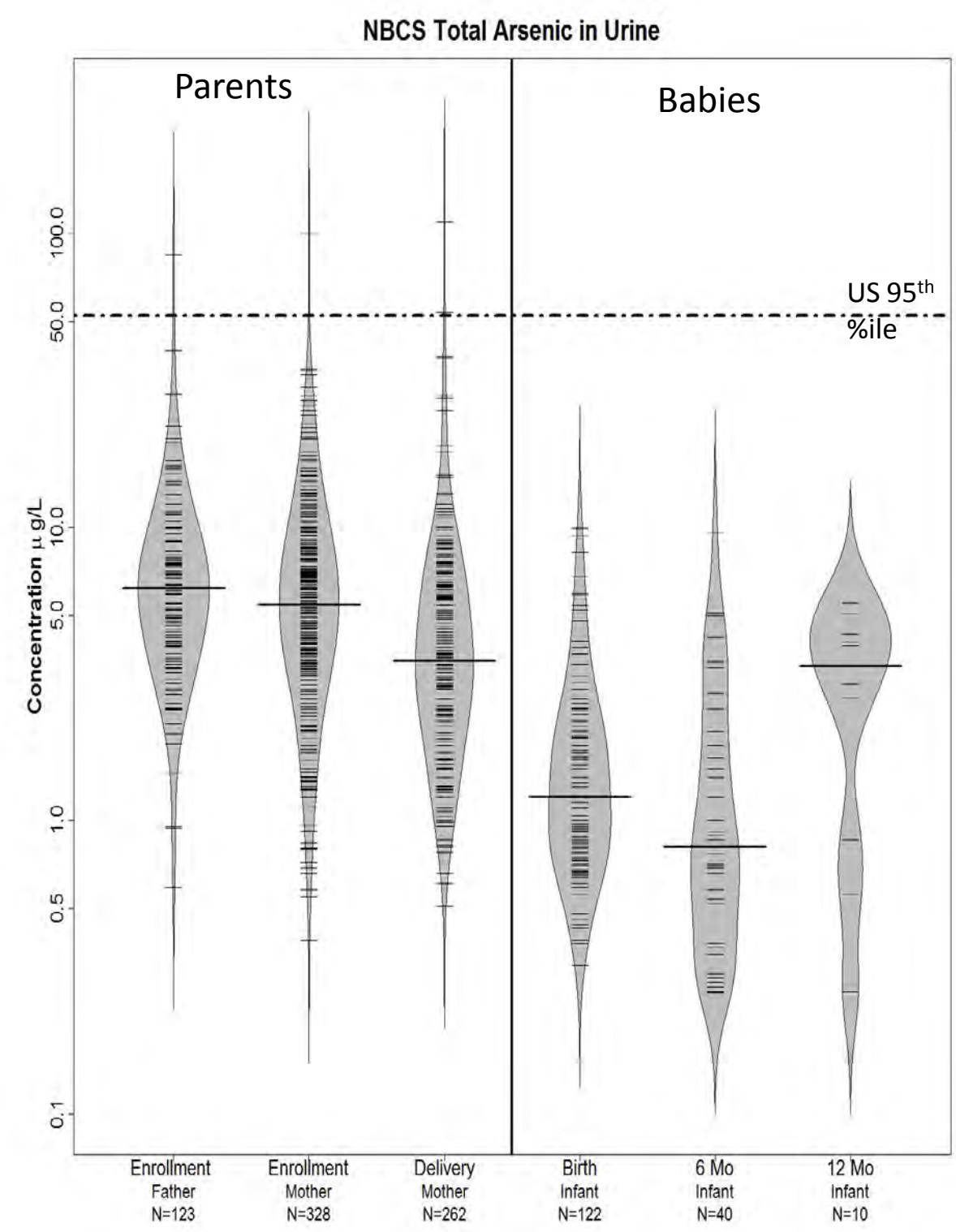
***Note:** Not necessarily repeated samples on same individuals.*

Maternal/infant urine-uranium at delivery/birth are moderately correlated

Note: poorest correlations is at extremes of either!



N = 122 matched pairs



Arsenic

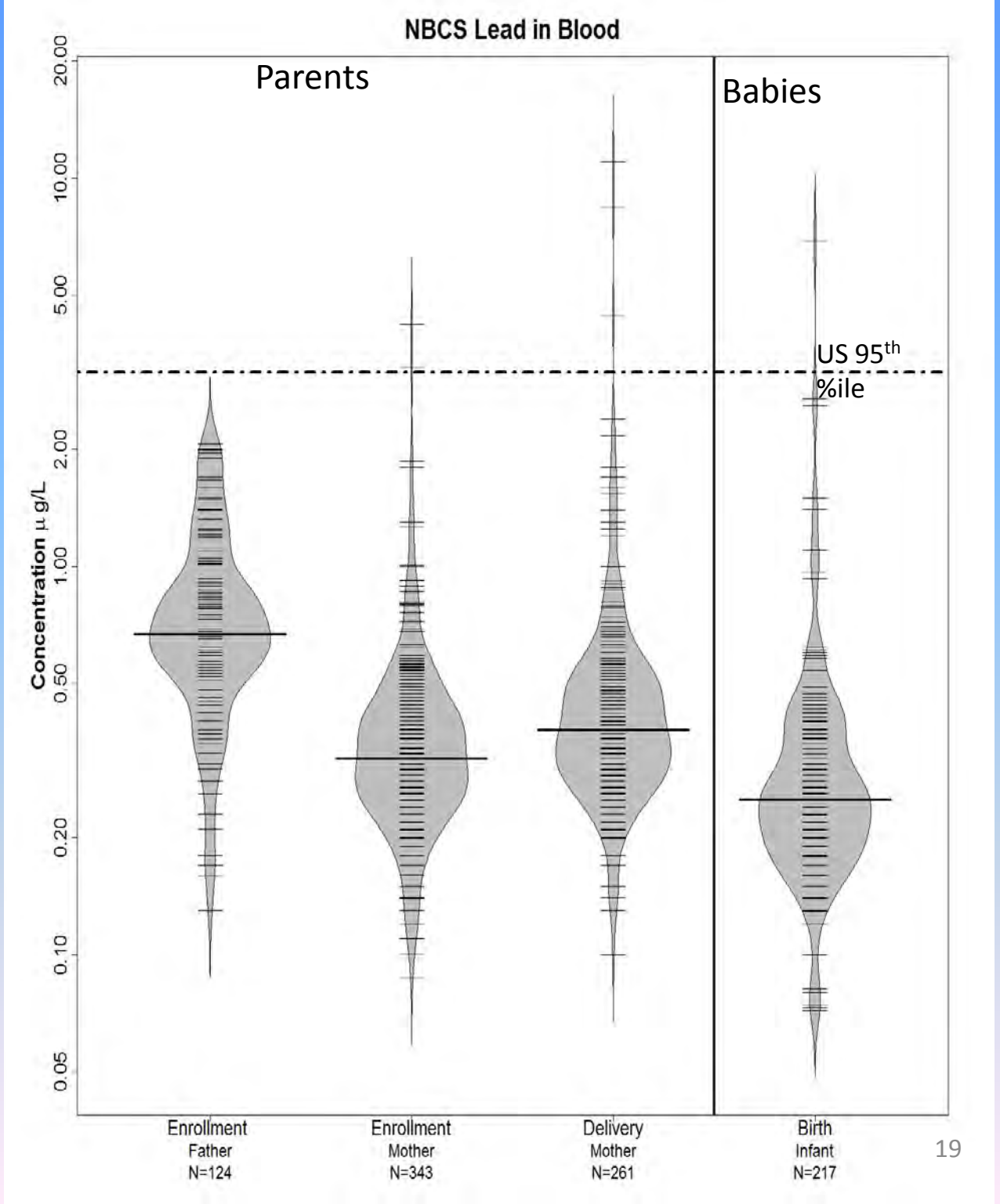
Urine total arsenic distribution for NBCS mothers, fathers and infants has *lower* mean and 95th percentile than the US population (NHANES)

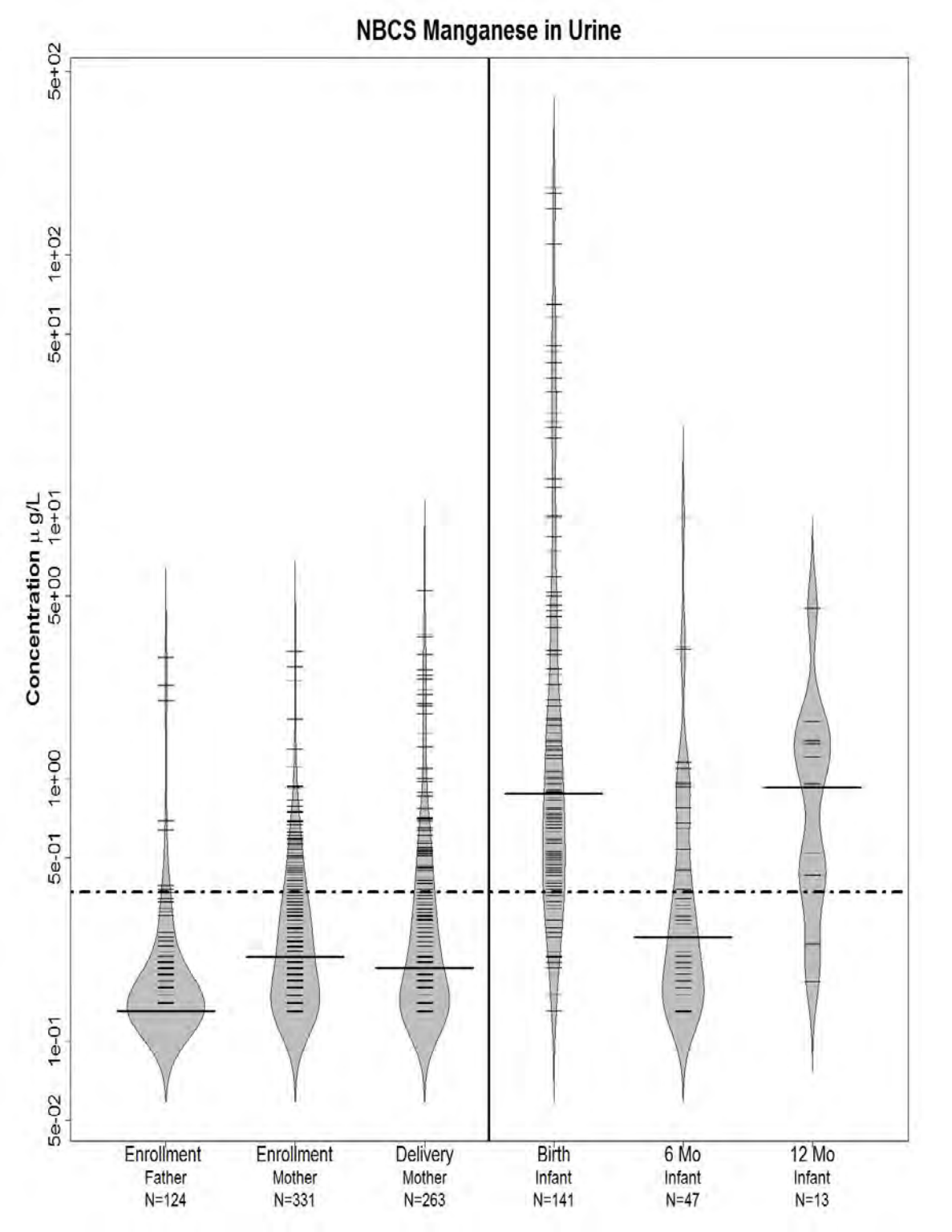
This finding is surprising because arsenic is

- Component of mine wastes
- Prevalent in home dust
- Most frequent contaminant (15%) exceeding MCL in unregulated water sources

Lead

Blood lead for NBCS mothers, fathers and infants is *lower* than the mean and 95th percentile for the US population





Manganese

Neurotoxicant found at concentrations *exceeding* US 95th percentile in NBCS blood and urine samples – especially in babies at birth

Manganese detected in many regulated water sources

Other metals for which NBCS distribution is greater than mean levels in US adults, based on NHANES data

Mercury (inorganic and total)

- Of concern due to coal burning in regional power plants and in homes
- Known neurotoxicant
- Elevated above US population for moms, dads, **babies at birth**

Antimony

- Replaced cadmium in solder
- Used in semiconductors, alloys, hardens lead in batteries, used as fire retardant
- Toxicity to lungs, skins, liver, cardiovascular system reported, potential carcinogen
- Similar mechanism of action to arsenic -- increased DNA damage. Hypothesized to inhibit repair enzymes
- Elevated in moms, dads, **babies**

Tin

- Combustion byproduct of coal, waste; common in dusts
- Toxicity relatively low – some reproductive and neurotoxic studies

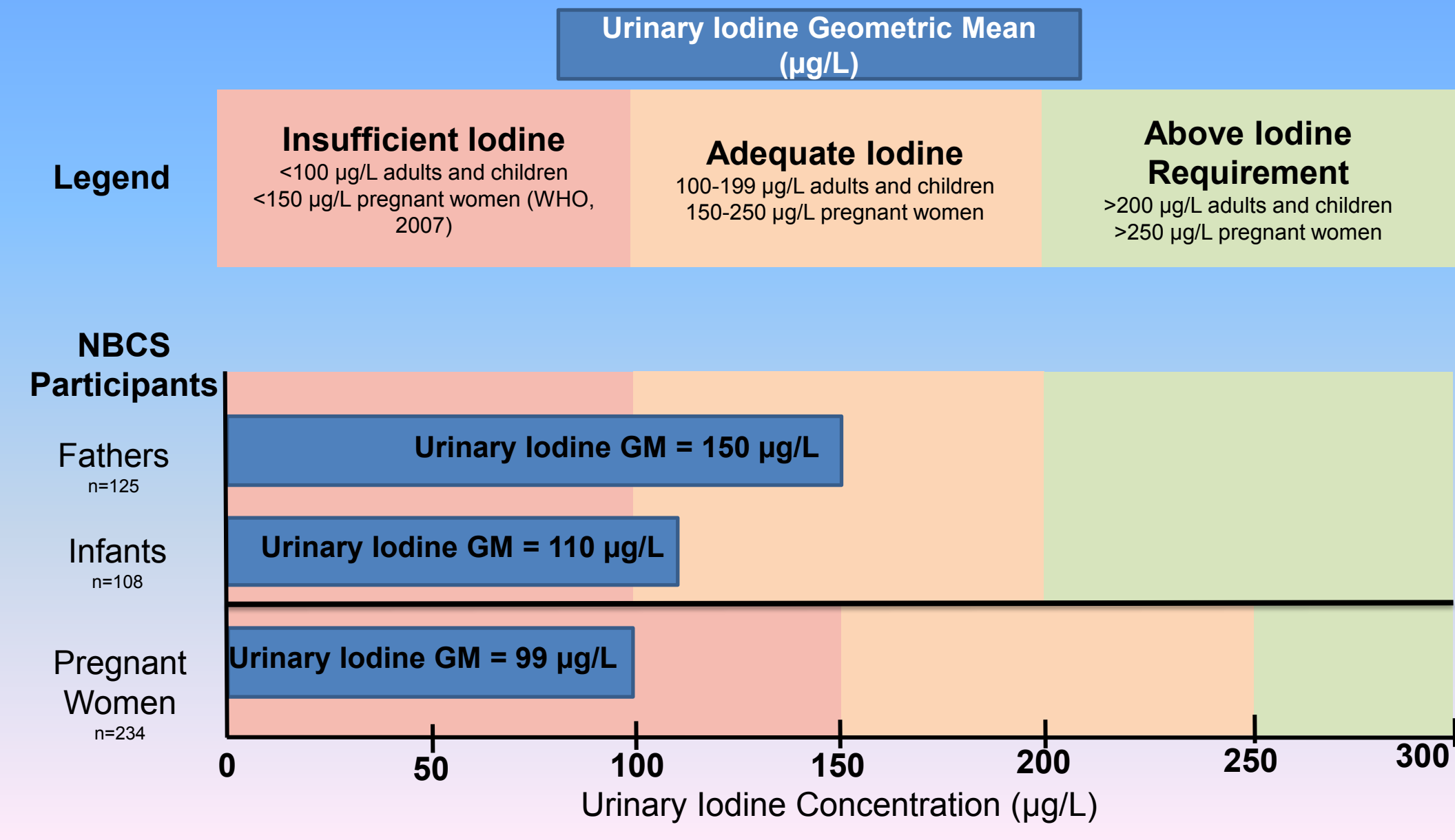
Tungsten

- Used in bullets, fishing weights, darts, golf clubs, grinding wheels & cutting tools (and light bulbs)
- Used to replace depleted uranium in armor penetrating weapons, lead in bullets
- Often alloyed with nickel, copper – toxicity not well studied for metal or alloys
- Only elevated in babies at birth!

Micronutrient status in NBCS cohort

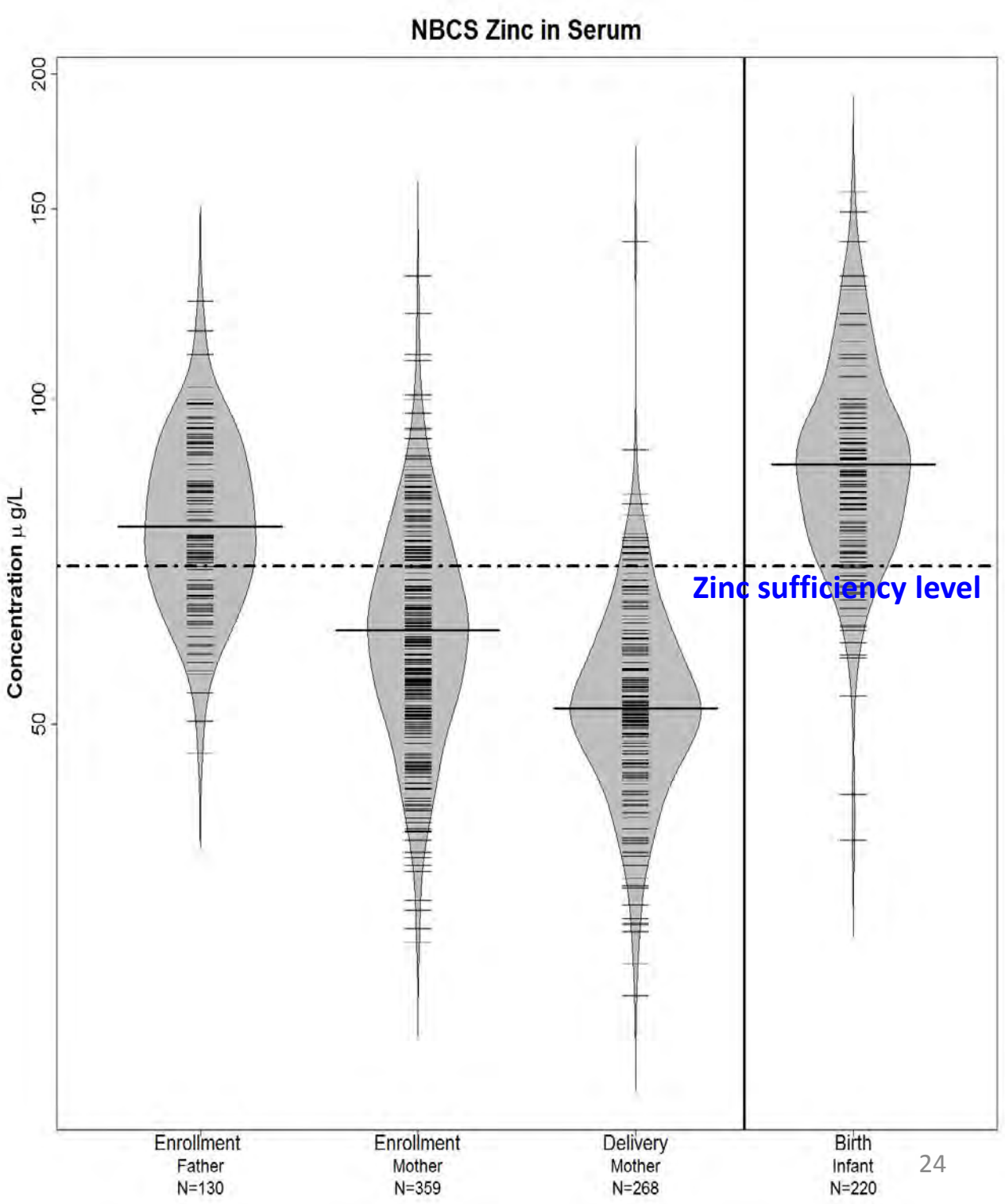
- Iodine, zinc, copper, selenium measured
- Last evaluation in 1981 – moms low in most micronutrients at that time
- Major findings to date:
  - NBCS mothers are insufficient in iodine, an essential nutrient for proper immune function
  - Some moms and dads are deficient in zinc, an essential nutrient for repairing damage to DNA from toxicant exposure

NBCS Mothers are *iodine insufficient*



Serum Zinc

- Mom's deficient – common in pregnancy
- Most babies sufficient
- Dads are low
- Important in reversing arsenic- and uranium-induced inhibition of DNA repair in laboratory systems
- Preliminary data show same reversal in cohort parents
- Looking for markers other than serum to reflect intracellular sufficiency
- Vitamins only effective prior to pregnancy



What exposure factors may be causing the high urine-uranium levels observed in NBCS participants?

NBCS participants with urine uranium > NHANES 95th Percentile

Potential Exposure Source	Yes	No
Indoor dust contains U	91%	9%
Burn wood for heat	72%	28%
Burn coal for heat	32%	68%
Live within a U mining district	14%	86%
Drink water with U >30 µg/L	14%	86%

- 91% of participants with urine-uranium >NHANES 95th percentile have detectable concentrations of uranium in indoor dust
- 14% of participants drink water from a public water system with current or historic (within last 5 years) uranium exceedances
- Only 1 person lives within a mining district, burns wood and coal, drinks water with U >30 µg/L ***and*** lives in a home that has U in the dust

Why focus on dust and water?

Dust

- Occupational studies (U mining and milling) demonstrated increased mortality and increased risk of malignant and non-malignant respiratory diseases
- Indoor dust presents inhalation risk to mother, father, baby
- Dust sources include ash and soot from wood- and coal-burning stoves, dirt blown or tracked into homes, work clothing, in-home work environments
- High prevalence of uranium in dust revealed in dust-wipe samples

Water

- Previous population studies demonstrated subclinical and clinical kidney disease from uranium ingestion through drinking water
- 70%-80% of U intake from water, only 5% taken up through gut

However,

- Previous studies in NM found high urine-U in non-Native and native populations with *little or no concurrent water ingestion*
- DiNEH Project study in ENA found increased risks of hypertension, kidney disease, immune system impairment in people who lives near uranium wastes and came in contact with uranium wastes during their lives

Synergies

- Inhalation and ingestion concurrent
- Mixtures of metals and radioactive materials
- Time and activity patterns, sociodemographics of population

Correlation Results* for uranium in indoor dust and drinking water

Exposure Factor	Participant Category	Correlation coefficient
Uranium in indoor dust	Father's enrollment urine sample	0.402
Uranium in drinking water	Mother's delivery urine sample	0.153
Uranium in drinking water	Father's enrollment urine sample	0.149
Uranium in drinking water	All Chinle participants with urine samples at delivery	0.124

- Cohort subset: Participants enrolled through Chinle Service Unit
- Chinle SU = 225 participants
- Only mothers had urine samples collected at both enrollment and delivery
- Fathers' urine collected at enrollment (usually, prenatal period)
- Babies' urine collected at delivery (within first 24 hours of birth)
- Only father's enrollment urine sample was *moderately correlated* with uranium in indoor dust
- Correlation coefficients for all other factors <0.08, indicating no correlation

**Analyses performed by C. Shuey and J. Hoover*

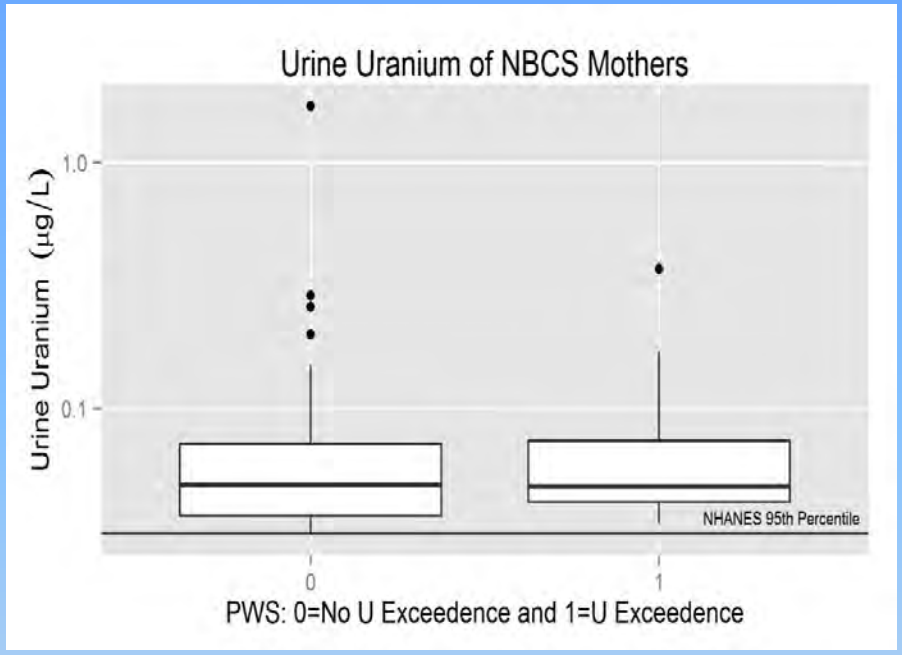
Uranium in community water systems does not explain elevated urinary U (>NHANES 95th percentile) in mothers or fathers

However – likely a contributor in some individuals

Mothers

CWS U Exceedence	N	Median (ng/g)
No	63	49.0
Yes	12	47.0

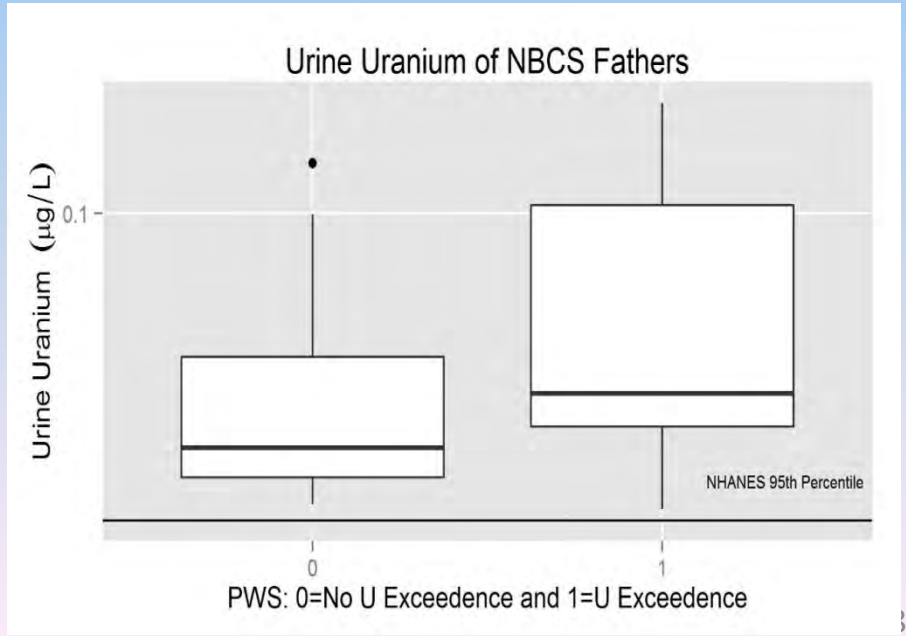
Note: Difference between groups is not significant (p=0.676)



Fathers

CWS U Exceedence	N	Median (ng/g)
No	28	40.5
Yes	6	48.6

Note: Difference between groups is not significant (p=0.19)



Note: N represents number of individuals

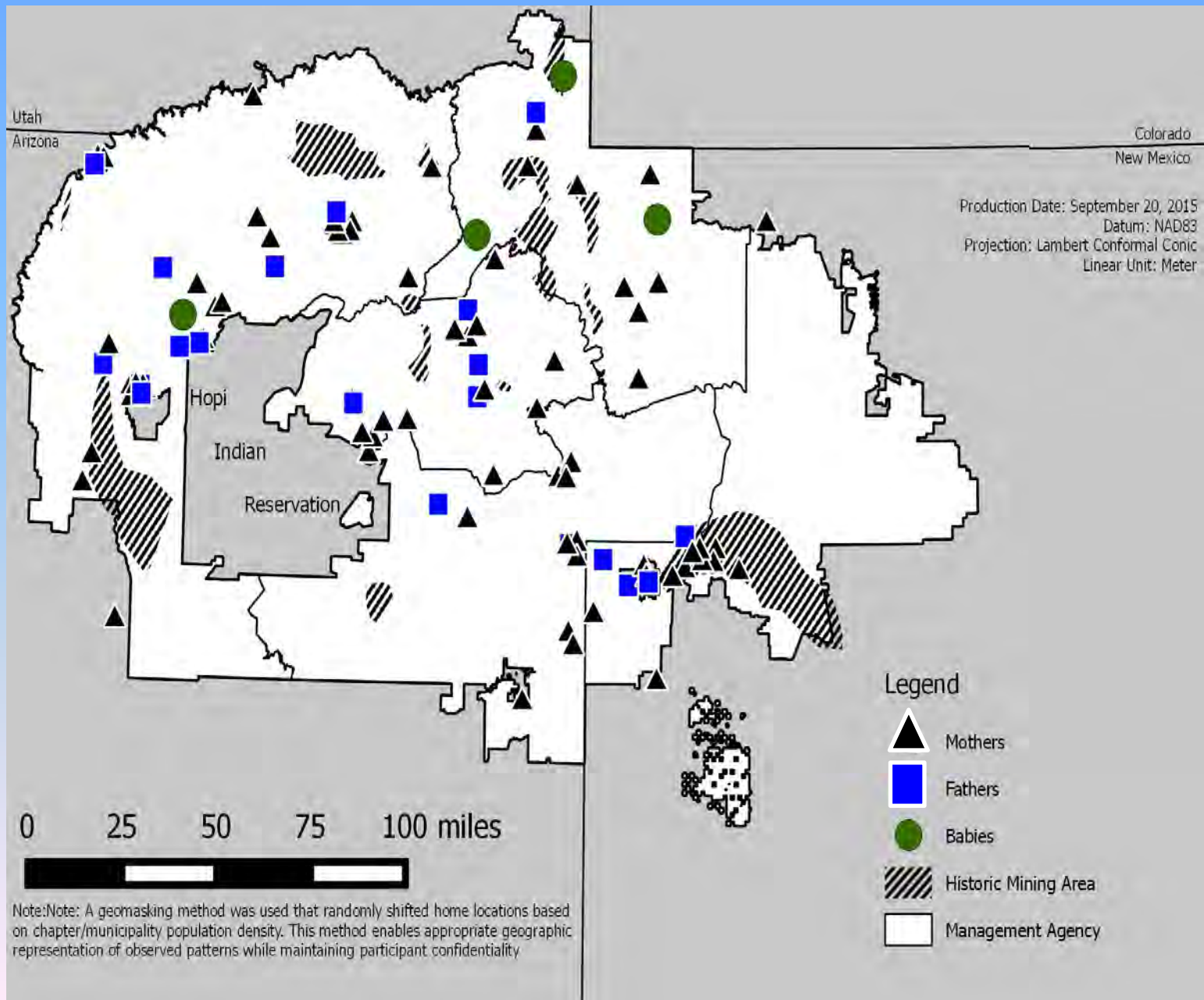
Only 14% of participants with urine uranium >US 95th percentile **live in a former mining area***

Home locations known for 101 of 118 participants with urine uranium > NHANES 95th percentile

87 participants live **outside** former mining areas

14 participants live **in** former mining areas

*Note – home assessments in progress; not all latitude-longitude coordinates available



Translation to communities and clinics

Uranium Levels in Urine of Navajo Birth Cohort Study Participants

19 out of 20 United States residents have urine uranium concentrations **less than 0.031 µg/L**

1 out of 20 United States residents has urine uranium concentrations ***above 0.031 µg/L***

< 0.031 | > 0.031

17 out of 20 NBCS participants have urine uranium concentrations **less than 0.031 µg/L**

3 out of 20 NBCS participants have urine uranium concentrations ***above 0.031 µg/L***

0.031 µg Uranium per Liter = 1 pinch of Bluebird Flour in ~250 stock water tanks

Uranium occurs **naturally** in our environment and is caused by **human activity** such as mining, burning trash and coal.

Uranium exposure ***may*** increase your risk of:

- Kidney disease
- Hypertension
- Autoimmune disease

Health effects of uranium at concentrations observed in NBCS participants are uncertain.

Tips to Reduce Exposure

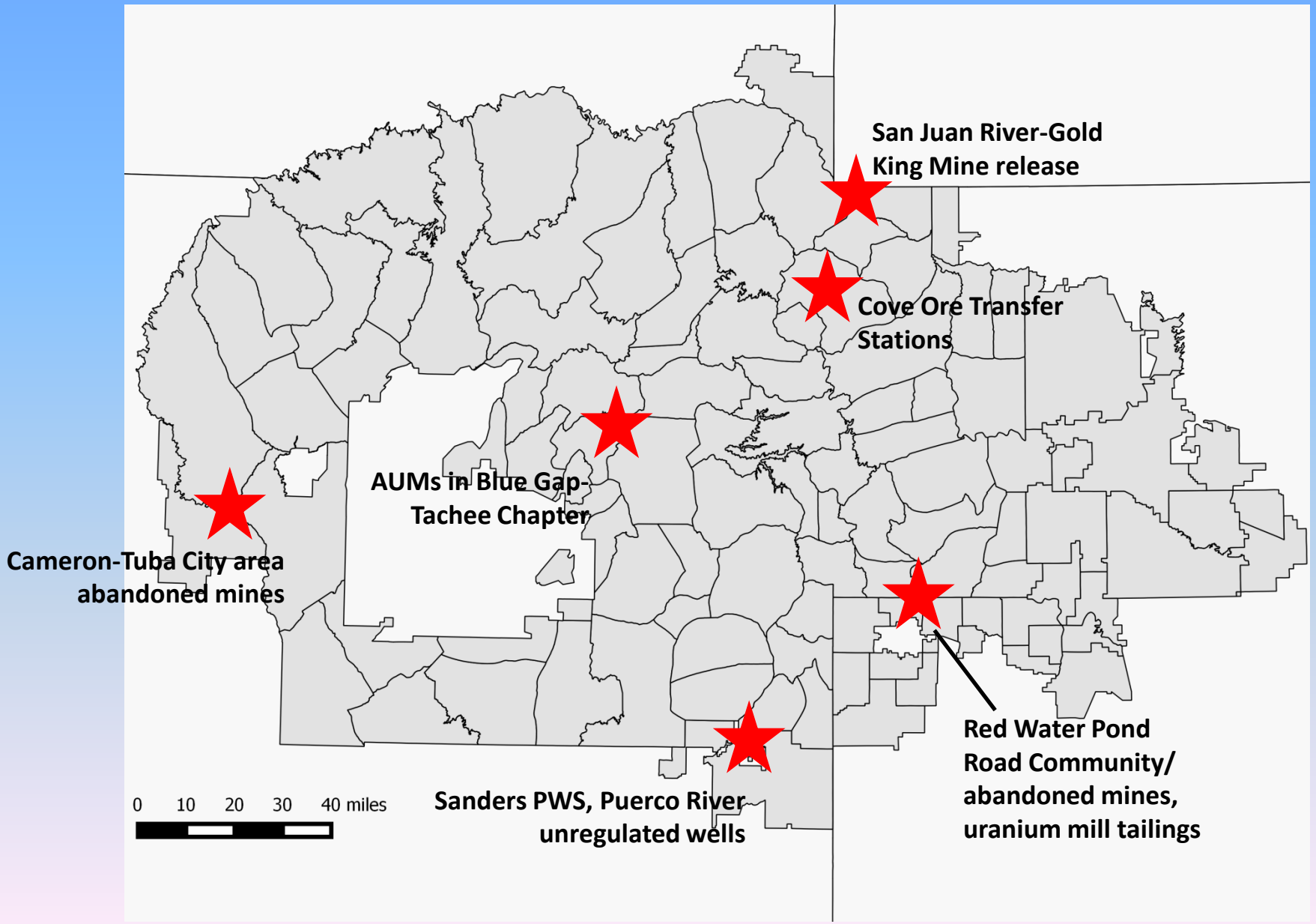
Your body **does not need** uranium. To reduce exposure:

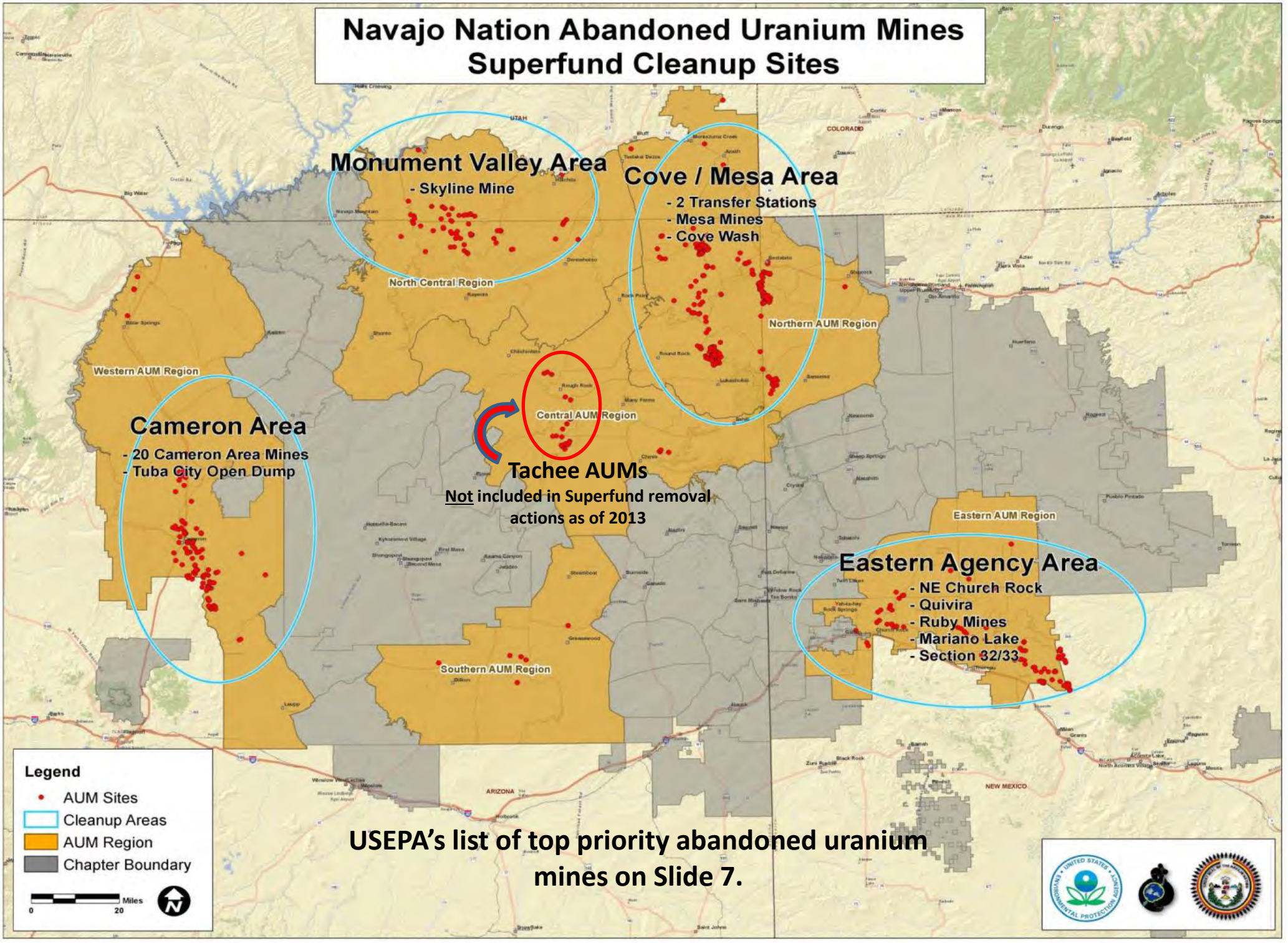
- ***Avoid*** abandoned uranium mines, mills and waste sites
- ***Do not burn*** coal in a wood burning stove
- If you drink regulated water, ***ask*** your water supplier for a Consumer Confidence Report
- ***Do not drink*** water from livestock tanks or wells

NBCS conclusions to date

- NBCS participants: >urine-U than US adult population (NHANES 2011-12)
  - Preliminary geometric mean shows ~ 2-fold increase in unadjusted urine uranium concentrations
  - 17.4% of the study population, including mothers, fathers, and infants, have urine uranium concentrations that exceed the US 95th percentile
  - Babies can exceed US adult 95th %ile at birth, increase over the first year
- Home environmental assessments suggest indoor dust is one possible source of exposure
  - 86% of homes having detectable levels of uranium in dust
  - Likely explains only a portion of the observed urine uranium
  - Regulated and unregulated drinking water sources also likely contributors for some
  - Living in proximity to mining areas explains only a portion of the urine-U > US 95th percentile
- Mercury, Antimony, Manganese, Tin and Tungsten also show shift to right of US distribution
- Iodine deficiency will need to be assessed as contributor to any outcome measures
- Preliminary analyses suggest zinc plays a role in reversing arsenic- and uranium-induced DNA damage

Environmental "hot spots" on the Navajo Nation




Navajo Nation Abandoned Uranium Mines
Superfund Cleanup Sites
Monument Valley Area
- Skyline Mine
North Central Region
Cove / Mesa Area
- 2 Transfer Stations
- Mesa Mines
- Cove Wash
Northern AUM Region
Western AUM Region
Cameron Area
- 20 Cameron Area Mines
- Tuba City Open Dump
Central AUM Region
Tachee AUMs
Not included in Superfund removal actions as of 2013
Eastern AUM Region
Eastern Agency Area
- NE Church Rock
- Quivira
- Ruby Mines
- Mariano Lake
- Section 32/33
Southern AUM Region
UTAH
COLORADO
ARIZONA
NEW MEXICO
Legend
AUM Sites
Cleanup Areas
AUM Region
Chapter Boundary
Miles
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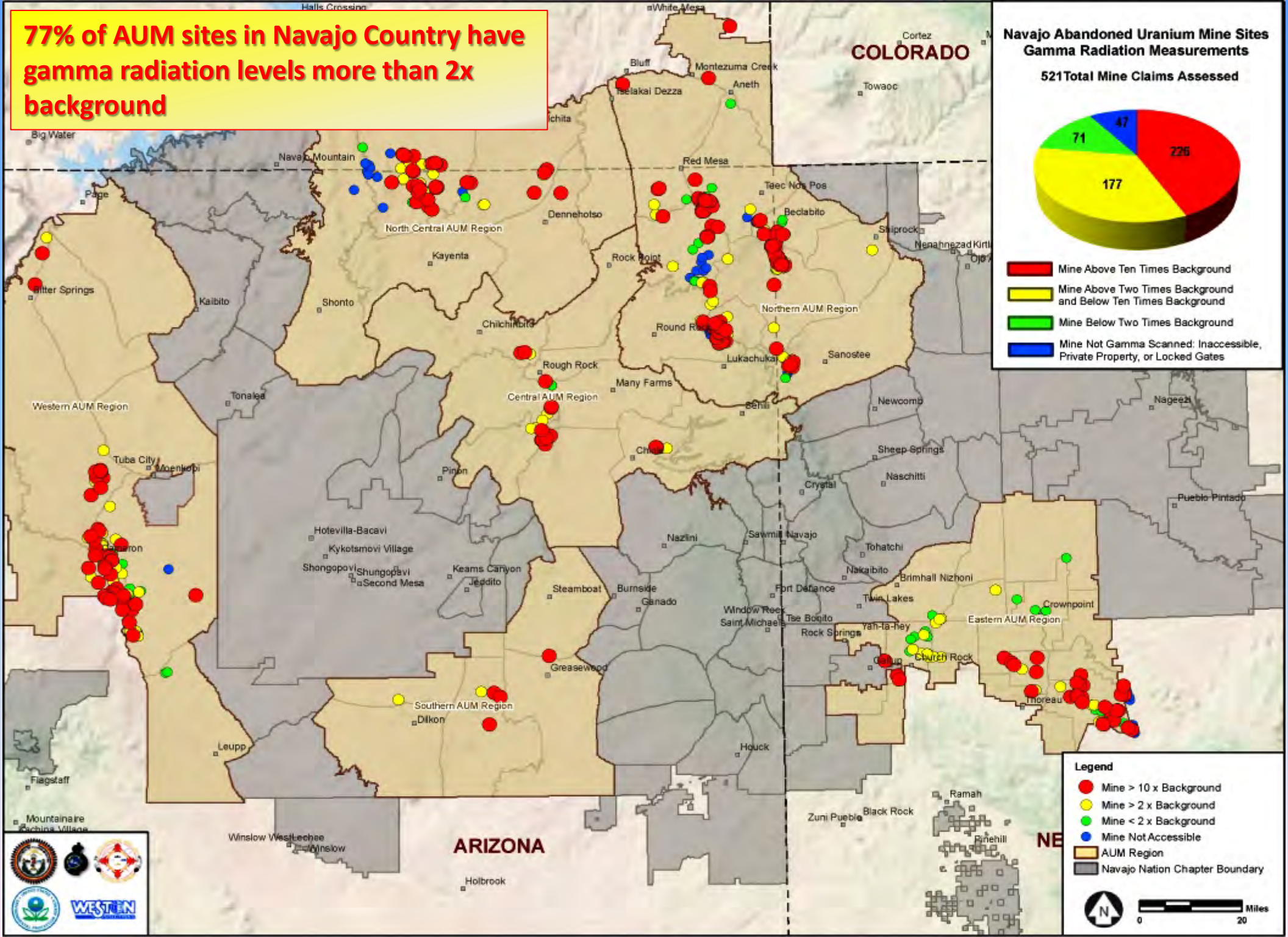
USEPA's list of top priority abandoned uranium mines on Slide 7.

77% of AUM sites in Navajo Country have gamma radiation levels more than 2x background



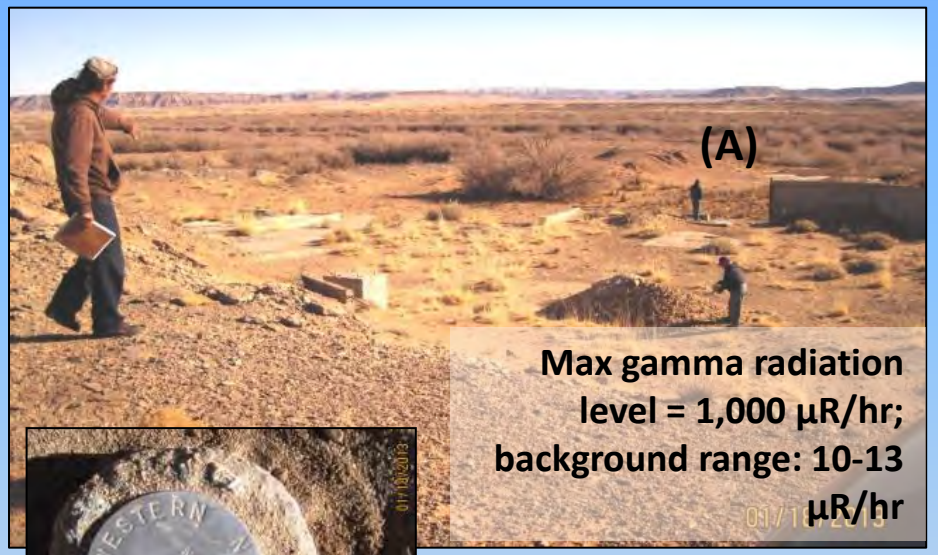
Western AUM Area: Cameron Open Pits, Then and Now

1982: SRIC staff took the photos below before these open pit uranium mines were backfilled and closed by NMAML in the 1990s. Most of these pits no longer have standing water. Residents and livestock consumed water from these pits, which was shown to be contaminated by uranium and other radioactive substances.

High levels of uranium & radium found in water in these pits in 1970s

EPNG will conduct site assessments in 2014-15 under USEPA order of 9/13/13

2013: (A) Unreclaimed ore transfer station and (B) open pit mine, ~10.5 mi SE Cameron Chapter within ¼-mile Little Colorado River; (C) Western Nuclear benchmark next to open pit.



Priority Mines in Cameron AUM Region (A. Pease, EPA, June 2015)

	El Paso Natural Gas	Coltec Industries, Inc.	Babbitt Ranches
Total Number of Mine Claims	19	2	1
Number of Priority Mines	2	2	1
Step in Superfund Process	Cultural & Biological Resource Surveys	General Notice letter sent	General Notice letter sent

There are 2 priority mines in Western AUM Region that do not have known responsible companies: Boyd Tisi No. 2 & Juan Horse No. 3

- EPA will assess all priority mines as a part of the 2014 – 2018 Five- Year Plan

Air, land (soil) and water exposure pathways near Claim 28 AUM in Blue Gap-Tachee Chapter

(current as of November 2015)

Air, soil, water: Claim 28 Abandoned Uranium Mine

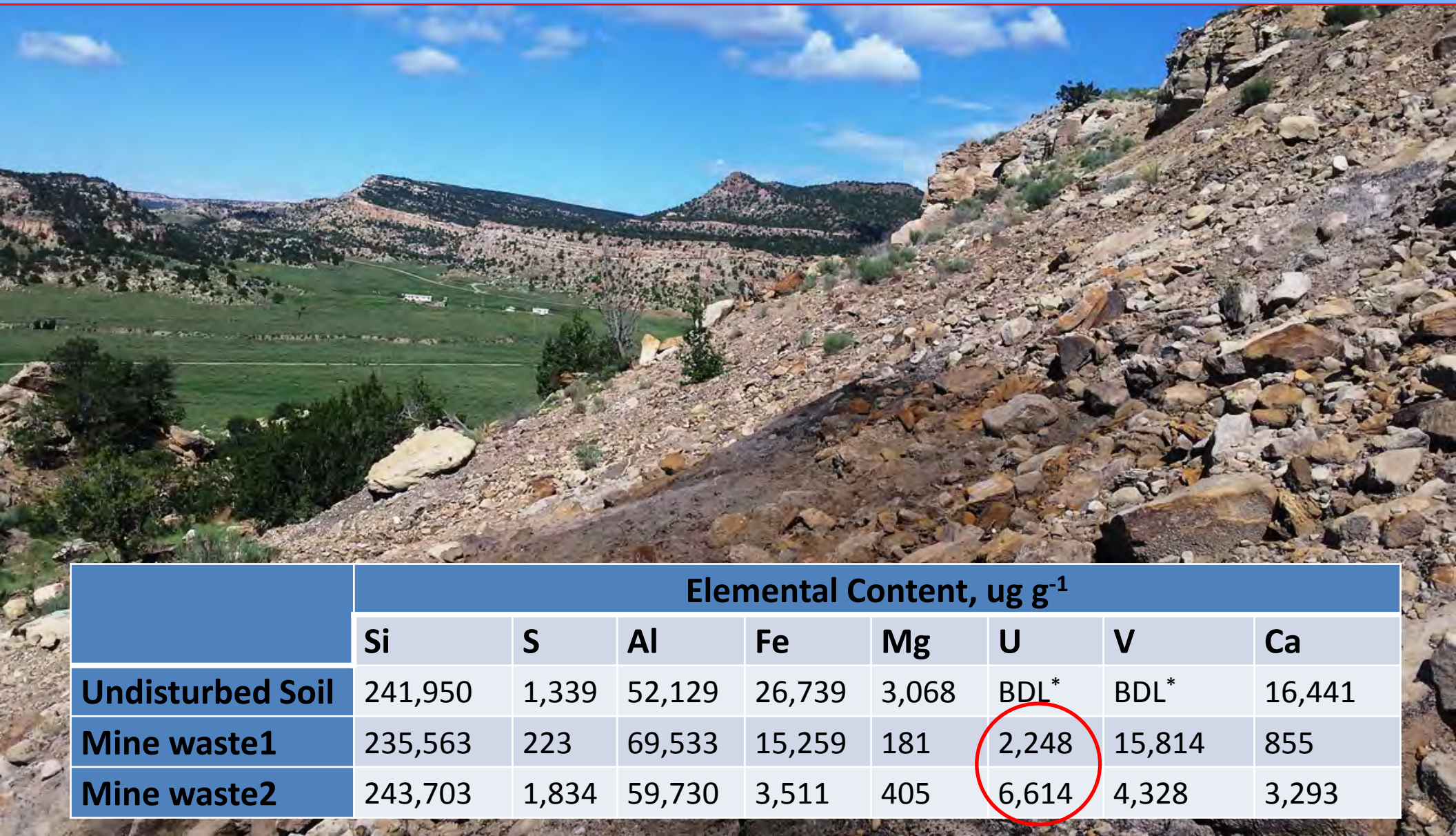
• Appx. location, seep in mine waste (not used)

Water: Actively used Windmill, 4T-386

Occupied homes

Occupied homes ~0.25 mi from mine site

We count at least 17 homes within 1 mile of the Claim 28 AUM, including the homes shown in distance. Metals in mine wastes (foreground) shown in table below.



	Elemental Content, ug g^{-1}							
	Si	S	Al	Fe	Mg	U	V	Ca
Undisturbed Soil	241,950	1,339	52,129	26,739	3,068	BDL*	BDL*	16,441
Mine waste1	235,563	223	69,533	15,259	181	2,248	15,814	855
Mine waste2	243,703	1,834	59,730	3,511	405	6,614	4,328	3,293

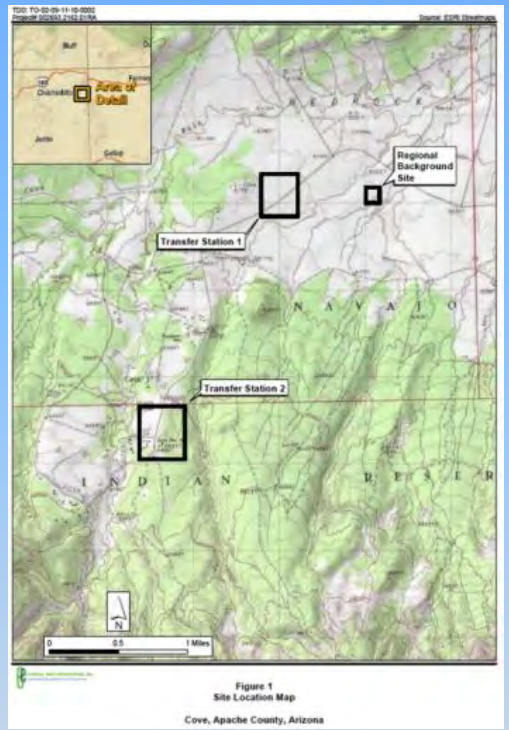
Summary of Water Quality Data in Blue Gap-Tachee Water Sources, and Use Recommendations

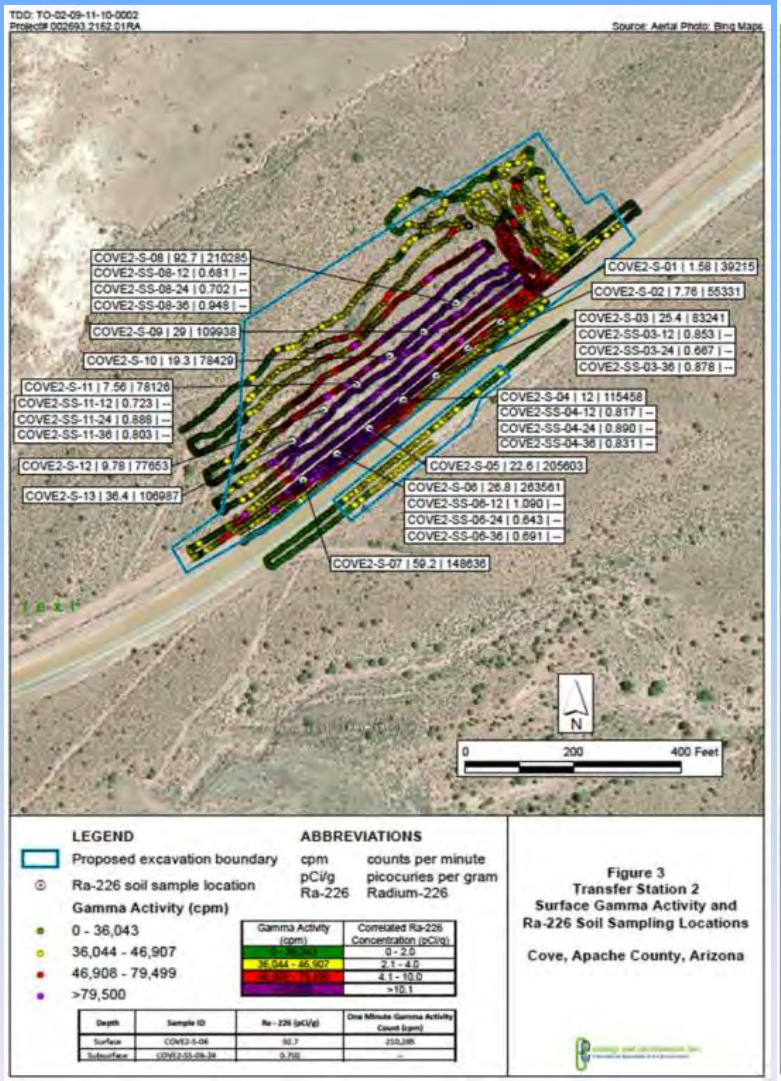
Well or water source	Contaminants >MCLs	Contaminants >SDWS	Test period	2015 Status (Uses)	Use Recommendations		
					Human	Domestic	Livestock
NTUA System (NN0403004)	None	None published	2011-2012	OP (PWS)	●	●	●
4K-388 (Chapter Windmill)	Arsenic: >½MCL	Aluminum, iron, TDS	2015	OP (UNR:LS)	▲	●	●
4T-386 (Old School Windmill)	Radium: >½MCL	Aluminum, iron, manganese	1998	INOP (UNR: LS)	*Produces no water; will need testing if returned to operation*		
Claim 28 Mine seep	Gross alpha, total radium, uranium, fluoride, nitrate; lead: >½MCL	Aluminum, iron, manganese, pH, TDS	2014-2015	INOP (no uses)	⬢	⬢	⬢
					Do NOT go on to this site! High radiation levels, unsafe footing		
Waterfall Spring	Gross alpha, total radium, uranium, fluoride, nitrate; lead: >½MCL	Aluminum, iron, sulfate, TDS	1998, 2013-2015	OP (UNR:LS)	⬢	⬢	▲
					Avoid use for livestock if another, safer water source is available		
White Clay Spring	Gross alpha, uranium, radium: >½MCL	Aluminum, iron, sulfate, TDS	1998, 2014-2015	OP (UNR:LS)	⬢	⬢	▲
Private Stock Pond	Lead, gross alpha, uranium: >½MCL	Aluminum, iron, sulfate	2014-2015	OP (UNR:LS)	⬢	⬢	▲
Polacca Wash near Chapter House	None	Not enough data	2015	OP (runoff)	▲	▲	●
Private Well	Arsenic, lead: >½MCL	Aluminum, iron, pH, sulfate, TDS	2015	OP (UNR:LS)	⬢	⬢	▲

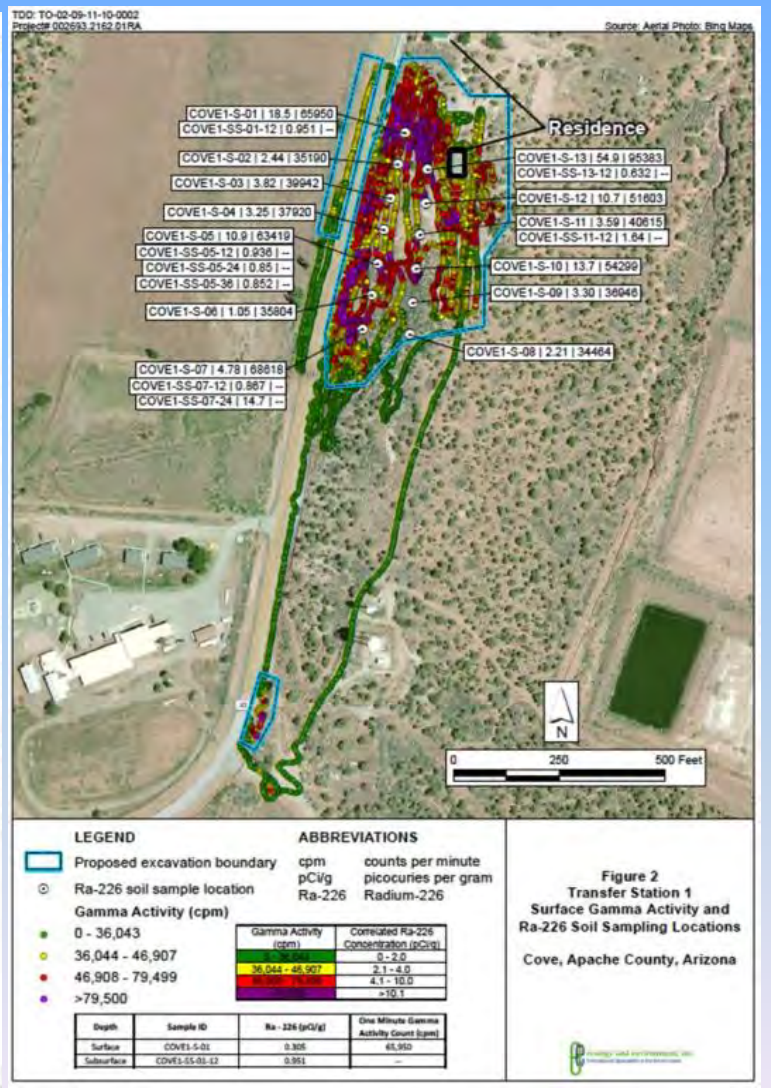
Key: INOP = inoperative; LS = livestock; MCL = Maximum Contaminant Level: OP = operating; PWS = public water supply (regulated); UNR = unregulated

Cove Mesa Area: Cove Uranium Ore Transfer Stations

Two uranium ore transfer stations located in Cove Chapter (map on left) were the sites of removal of radioactive wastes by USEPA and Navajo EPA in 2012. The two sites were contaminated by years of dumping and storing uranium ore removed from mines on nearby mesa slopes. Radiation surveys showed high levels of gamma radiation near homes (middle map) and a school (right map). *Maps courtesy USEPA.*



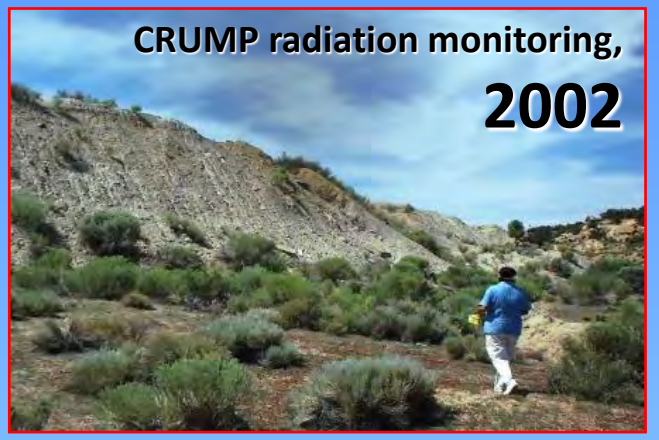




In the maps above, green dots indicate "background," or natural radiation levels. Yellow, red and purple dots indicate increasing levels of gamma radiation indicative of mining-related contamination.

Northeast Church Rock Mine and Red Water Pond Road Community, 1972-2009

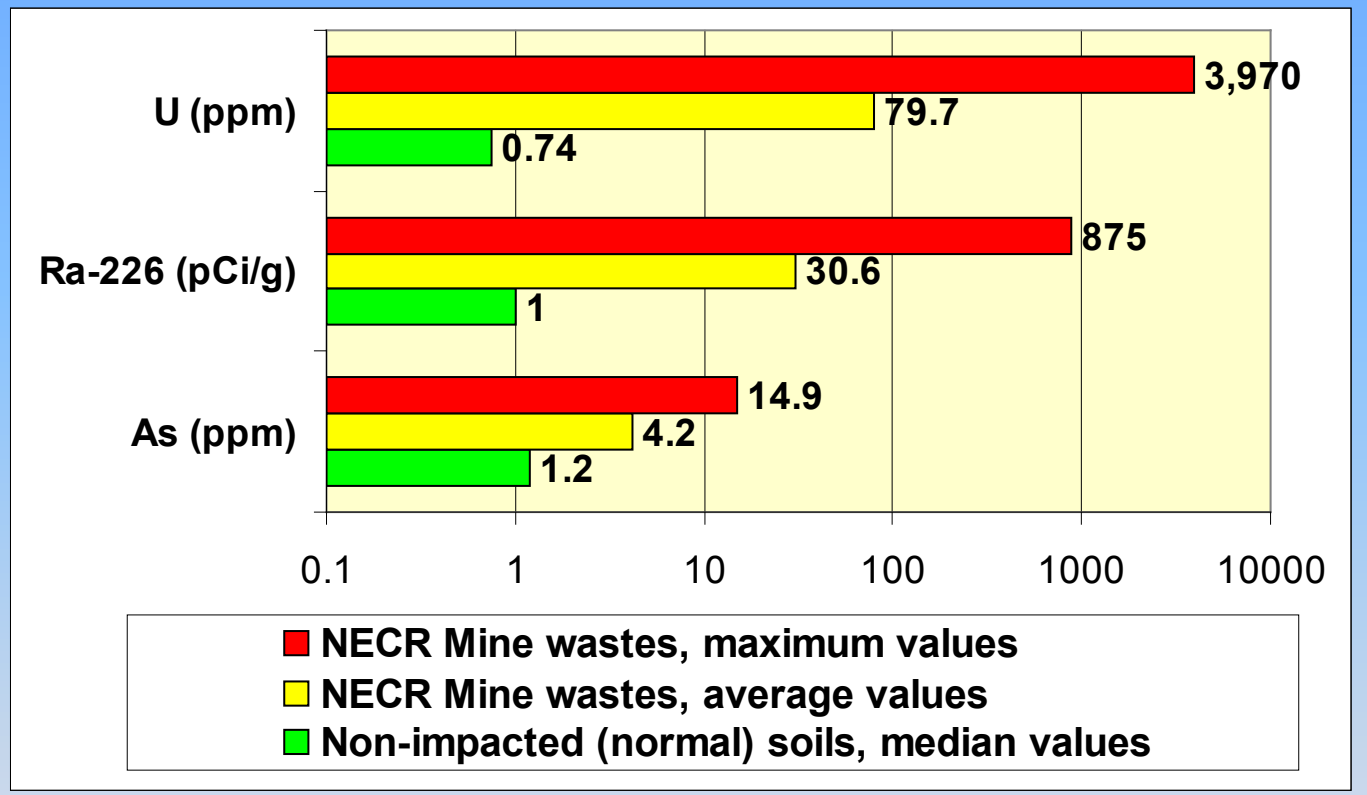
Mine water discharges to Pipeline Arroyo, 1969-1983: More radioactivity released to Puerco River system by mine dewatering than 1979 tailings spill.



Church Rock uranium mine wastes have contaminant levels significantly higher than normal soils

NECR Mine wastes, 2003, before partial recontoured in 2009

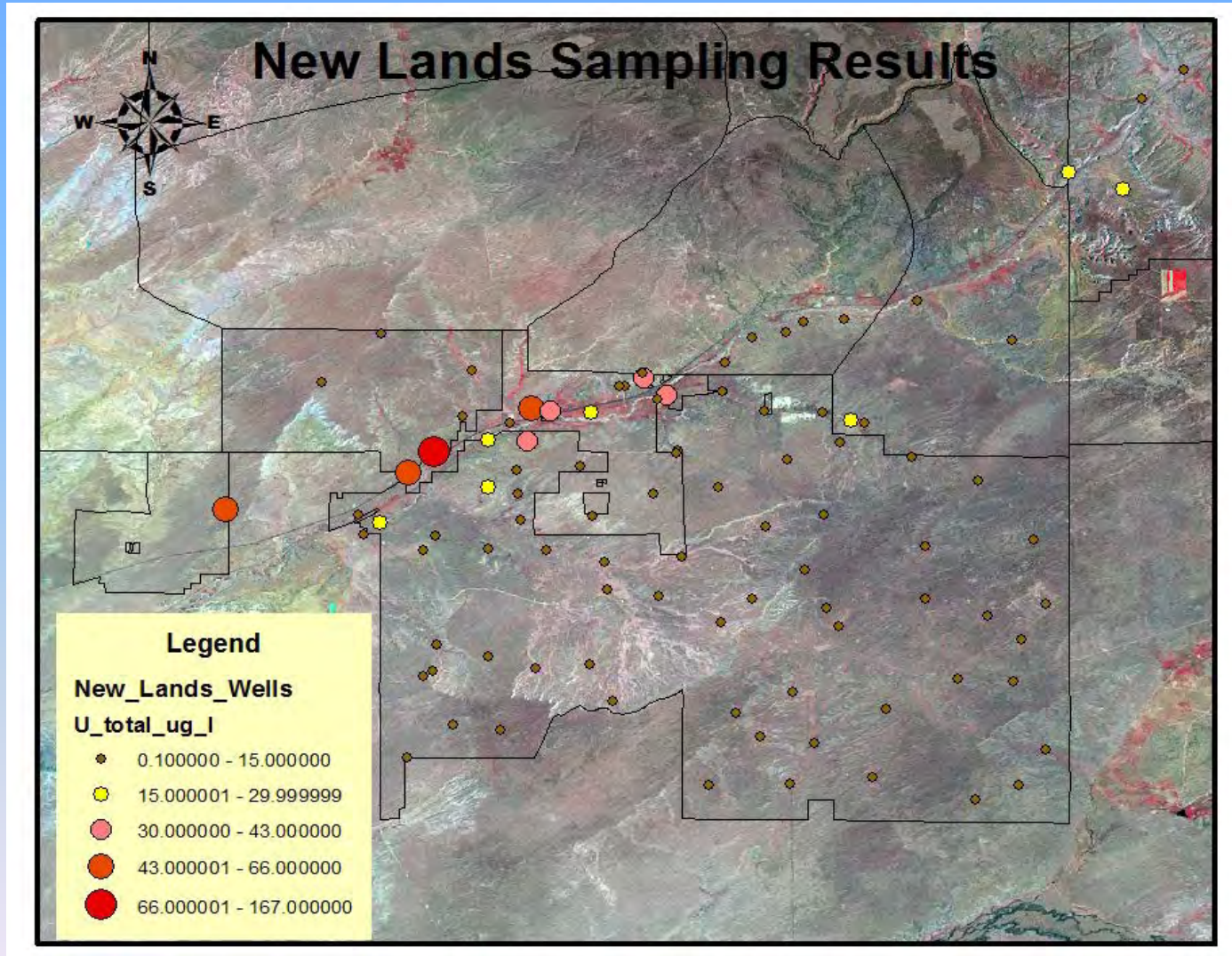
DiNEH staff collect background soil samples in Church Rock, 2005.



- Uranium mine wastes (1) contain all the radionuclides that decay of U-238, and (2) contain trace metals indigenous to the ores
- Only uranium removed in milling; mill wastes contain all other contaminants in original ores

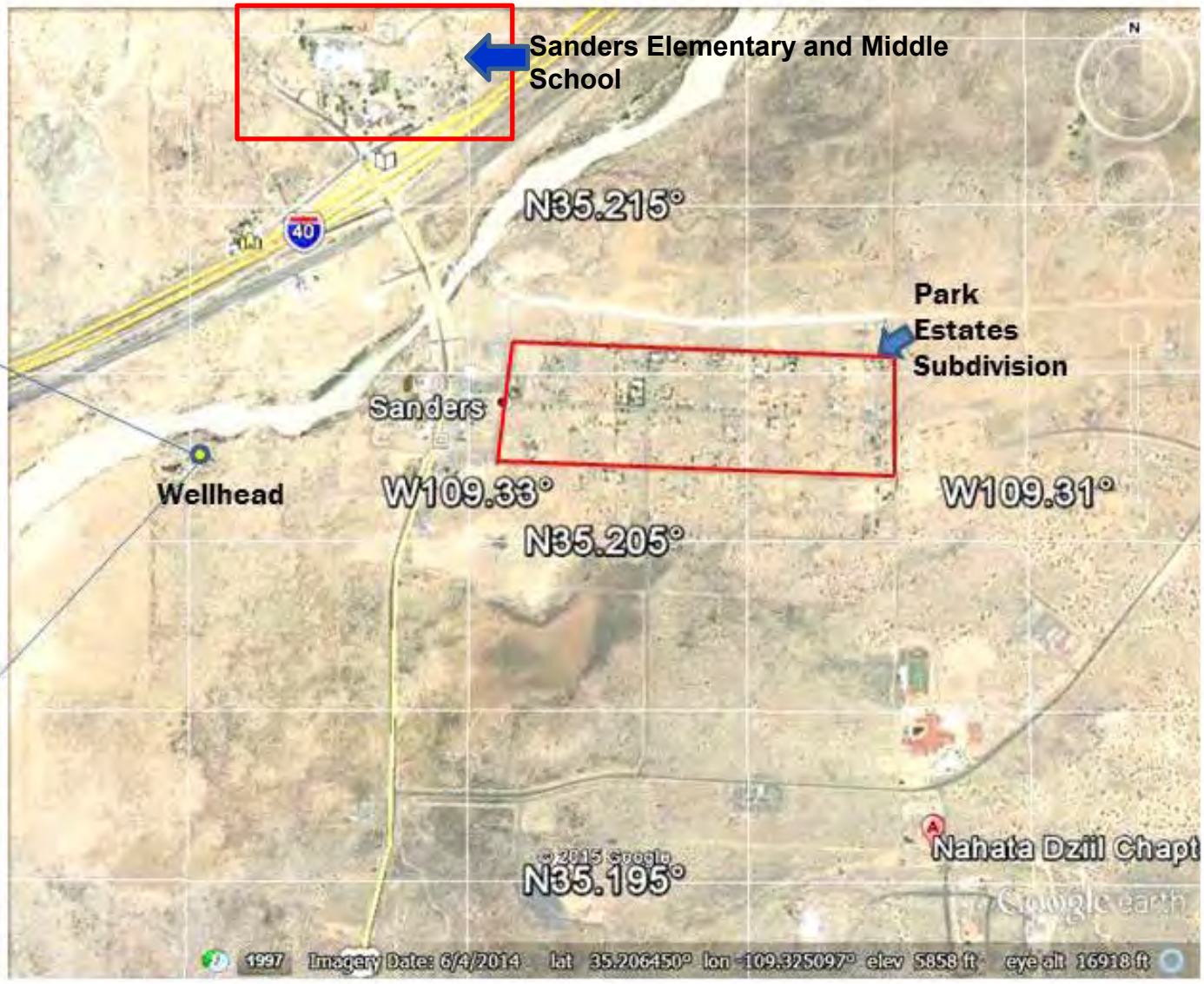
Uranium-contaminated wells concentrated along the axis of the Puerco River

As shown on this map, the majority of wells sampled by TLE do not have elevated uranium concentrations (i.e., >1/2 of MCL). In fact, only about 12% of wells tested had U levels >30 µg/l. However, nearly all of the wells with elevated U (yellow, orange and red dots) are located along the axis of the Puerco River. A preliminary review of previous studies in the region suggests that many, if not most, of the contaminated wells are completed in the alluvium.

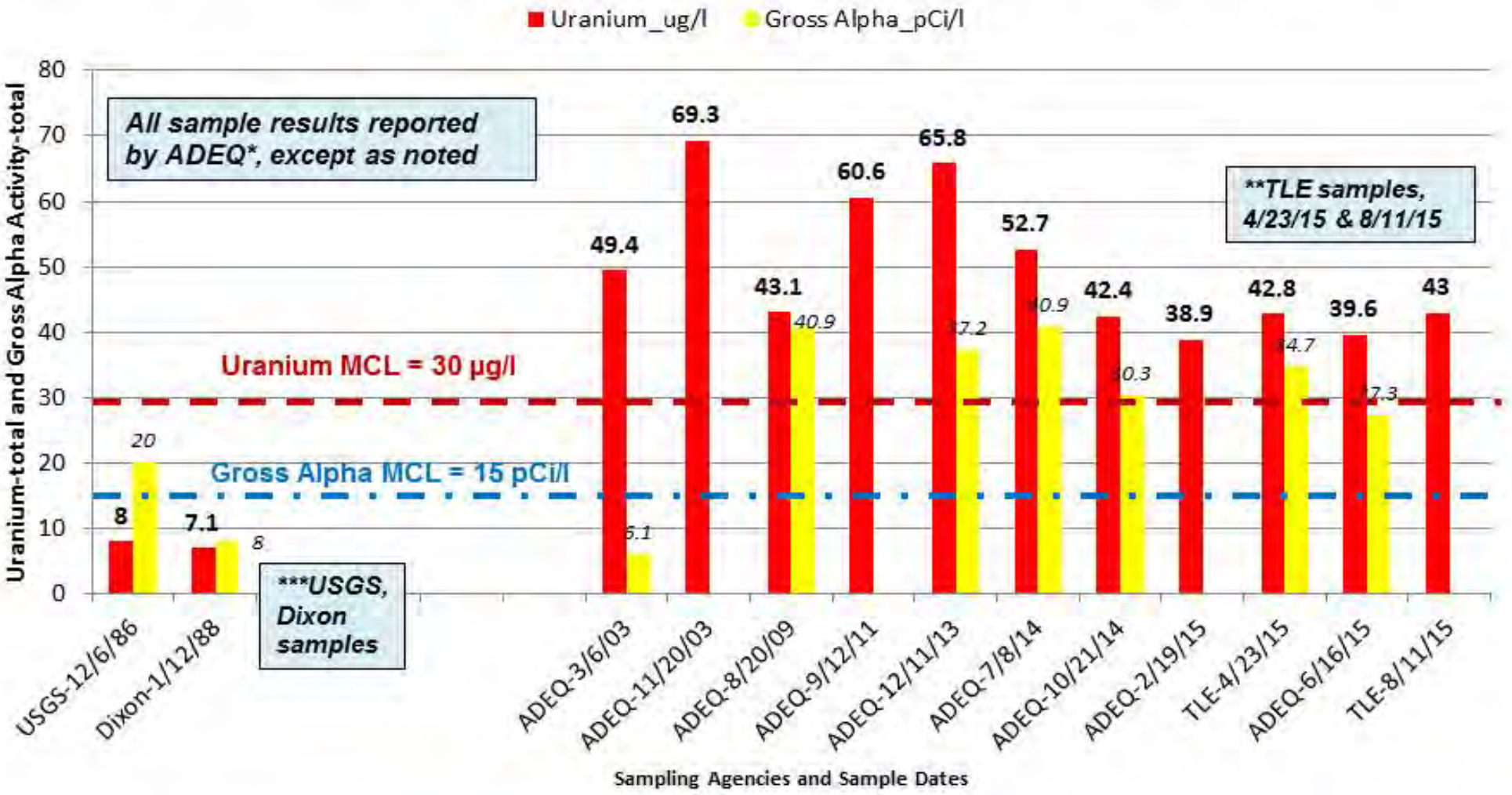


Map by Tommy Rock

Sanders/New Lands Area showing Park Estates and Sanders Schools



Uranium (total) and Gross Alpha Particle Activity (total) in Arizona Windsong Water Co. PWS System, Sanders AZ



Sources: *ADEQ 2008-2015 (see, http://azsdwis.azdeq.gov/DWW_EXT/JSP/WaterSystemDetail.jsp?tinwsys_is_number=9&tinwsys_st_code=AZ; Radiochemistry results for samples collected in 2003, converted from pCi/l to ug/l; Public Notice, Aug. 4, 2015; **Tó Łani Enterprises Puerco-LCR Water Quality Project, 2015. ***Webb et al, WRI-87-4126; Dixon, Masters Thesis, 1990. MCL = Maximum Contaminant Level (40 CFR 141).

NBCS biomonitoring and HEA data may assist evaluation of exposures to GKM release contaminants

Gold King Mine – Navajo Nation Chapters (and municipalities) Adjacent to San Juan River

NATIVE EH EQUITY

Biomonitoring and home **environmental** data collected for participants who live near San Juan River

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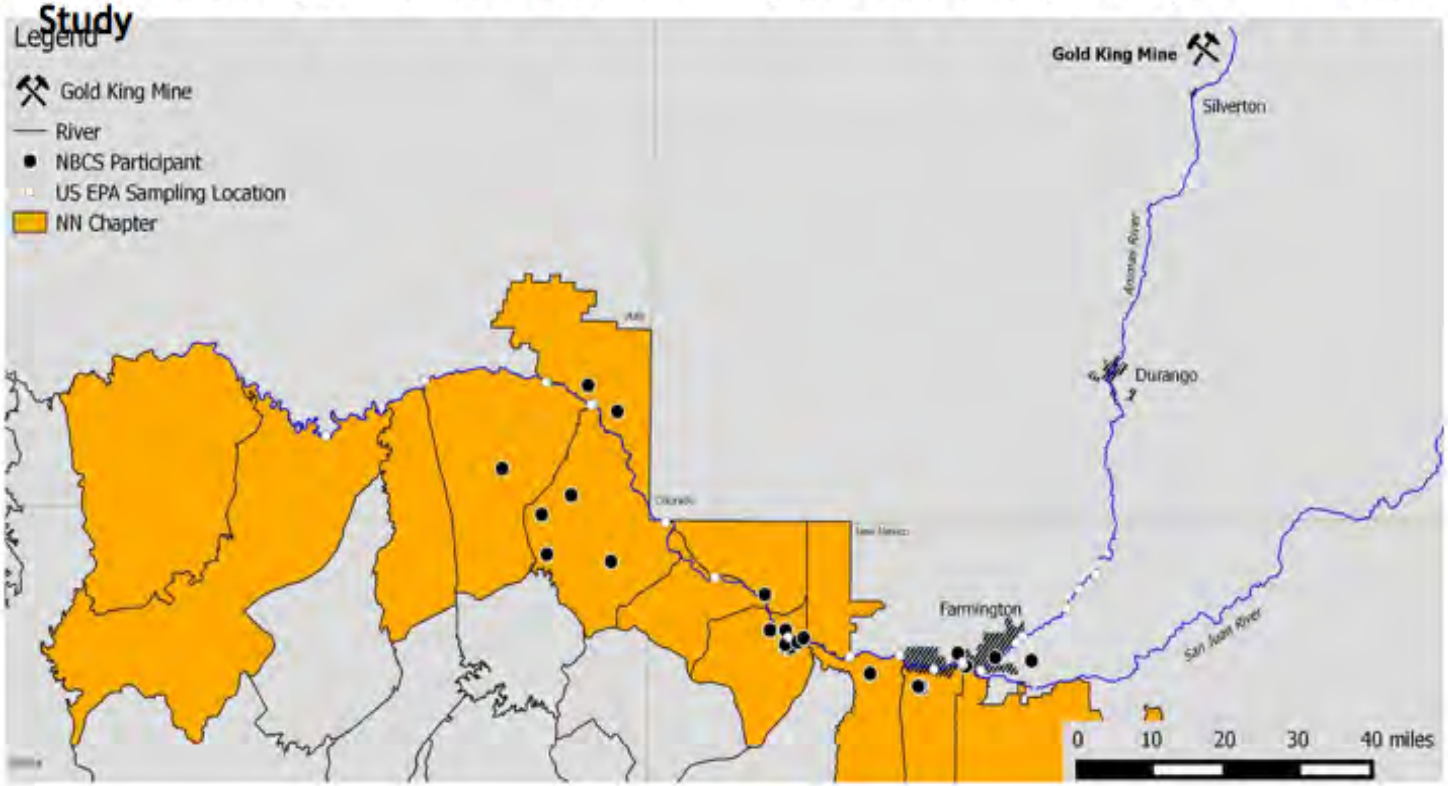
Maria Welch

Build on existing partnerships and community presence through **Navajo Birth Cohort Study**



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The people of the Navajo Nation:

- **2000 Navajo families**
- **110 chapters**
- **HEHSC, Tribal and Agency Councils, Executive Branch, NNEPA, GIB**

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DiNEH and NBCS Research is reviewed and monitored by Navajo Nation Human Research Review Board

Navajo Team Members in bold

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ATSDR AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

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