SOUTHWEST RESEARCH AND INFORMATION CENTER
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January 22, 2024

Ms. Alexandra Oppelt
Remedial Project Manager
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Transmitted by electronic mail to oppelt.alexandra@epa.gov

Dear Ms. Oppelt,

Southwest Research and Information Center (SRIC), the Red Water Pond Road Community Association (RWPRCA) and the Multicultural Alliance for a Safe Environment (MASE) submit this letter as comments on three Engineering Evaluation/Cost Analyses (EE/CAs) for remediation of seven abandoned uranium mines located in Mariano Lake and Smith Lake chapters of the Navajo Nation. The EE/CAs describe proposed remediation of the Mariano Lake Mine (Chevron), Ruby Mines 1 and 3 (Western Nuclear), and Mac 1, Mac 2, Black Jack 1 and Black Jack 2 mines (Homestake Mining). Because of the way these documents were compiled in the Administrative Records section of the EPA website (see, https://www.epa.gov/navajo-nation-uranium-cleanup/administrative-records-abandoned-mines-and-other-superfund-cleanups), we could not effectively start our review of these materials until after December 13, 2023. At a combined 1,800 pages and 201MB of data, reviewing the EE/CAs was a challenge over the past five weeks. As a consequence, there was not enough time allotted to the public to conduct a thorough examination of these critical documents. Instead, we had to identify major issues of concern with the proposed actions and preferred alternatives as described in the EE/CAs. Our focus was on content of the Homestake Mining Co. EE/CA for the Mac and Black Jack Mines, but we were also able to peruse the Mariano Lake and Ruby Mines EE/CAs to see the commonalities – and key differences – across the three EE/CAs.

1. INCOMPLETE CONSIDERATION OF REASONABLE DISPOSAL OPTIONS, SPECIFICALLY NOT INCLUDING THE RED ROCK LANDFILL PROPERTY AS A POSSIBLE OPTION FOR DISPOSAL OF MORE THAN 1 MILLION CUBIC YARDS OF WASTES AT THE 7 SITES

Disposal alternatives for the seven AUMs covered in the three EE/CAs do not include the option of removing mine wastes at these sites to a regional disposal cell at the Red Rock Landfill property located five miles west of Thoreau. In fact, Red Rock Landfill (RRL) isn't even mentioned in the three EE/CAs. We are concerned about EPA's lack of consistency between the preferred alternative for the Quivira

Churchrock 1 and 1E Mine and the preferred alternatives for the seven AUMs covered in the three EE/CAs. EPA's preferred alternative for Quivira is to truck 1 million cubic yards of wastes to RRL, approximately 40 miles away. *None* of the alternatives for the seven AUMs in Mariano Lake and Smith Lake chapters includes disposal of 1.4 million cubic yards of mine wastes combined from these sites at RRL, which is only 15 to 20 miles away. Furthermore, EPA is also now proposing to dispose of Section 32 Mine wastes located east of Casamero Lake Chapter at the RRL. The Northwest New Mexico Regional Solid Waste Authority landfill property totaling about 600 acres has plenty of space to develop a below-grade, lined disposal cell or cells apart from the municipal solid waste landfill (see Comment #3 below for more discussion of design features). A cell or cells would be permitted under the New Mexico Solid Waste Act in a rigorous regulatory process. This inconsistency jeopardizes public acceptance of the Quivira preferred alternative, which is supported by the local community (Red Water Pond Road Community Association). Re-issuing or supplementing the EE/CAs for the seven AUMs in Mariano Lake and Smith Lake to include disposal at RRL is recommended.

2. REMOVAL OF THE MARIANO LAKE MINE WASTES TO AN OFF-SITE LOCATION IS WARRANTED TO PROTECT PUBLIC HEALTH

We agree with EPA that the Mariano Lake Mine wastes must be excavated and removed to an off-site location (Mariano Lake EE/CA, Alternative 4A at 42). Removal of the wastes is needed to substantially reduce exposures to the 15 to 20 families that have lived next to the mine for the last 50+ years – two to three generations. As we discuss in Section 4 below, living in close proximity to mine wastes significantly increases risks of kidney disease during the Mining Era and hypertension and autoimmunity in the Legacy Period after the mines closed (Hund et al., 2015; Harmon et al., 2017; Harmon et al., 2018; Erdei et al., 2019; Erdei et al, 2023). However, as we discuss in Section 3 below, we do not believe that the cap-in-place/evapotranspiration (CIP/ET) cover planned for the consolidated waste repository at the Mac-1 site about 1 mile east of the current Mariano Lake site is protective enough to prevent intrusion and to safely contain the mine wastes for 100 years.

3. LACK OF ACTUAL DESIGN DIAGRAMS AND SPECIFICATIONS FOR 'CAP-IN-PLACE' COVERS INHIBITS COMMUNITIES FROM WEIGHING THE RISKS OF LEAVING WASTES AT THEIR CURRENT SITES VERSUS EXCAVATING THE WASTES FOR REMOVAL TO AN OFFSITE, CENTRALIZED DISPOSAL FACILITY

None of the CIP/ET cover alternatives set forth in the three EE/CAs is acceptable because detailed engineering designs of these covers are absent from the EE/CAs. Out of more than 1,800 pages in the three EE/CAs combined, EPA provides only two diagrams of the "typical" cover (Mariano Lake EE/CA, Fig. 4-14, and the Ruby Mines EE/CA, Fig. 4-2 at 128); the Homestake EE/CA contains no such drawings, but includes text that provides a description of and the rationale for the ET cover design (Homestake EE/CA at 4.6 at 47):

> *With proper design and construction of an ET cover for the MRM, in this precipitation-deficit environment, a bottom liner beneath the MRM provides no additional protection of the natural environment. A sloped repository would be designed to shed the majority of the precipitation and overland flow during storm events and the revegetated surface would be designed to remove the majority of any infiltration via evapotranspiration. Using an ET cover,* ***which has been used at other nearby mine sites*** [emphasis added]***,*** *is a cost-effective solution that fits the natural environment using*

local vegetation and soils to isolate the MRM and is expected to have a longer design life than what a synthetic liner provides.

We find this rationale lacking. First, the "sloped repository" design for the Homestake Mines is not shown. "Overland flow" at the Black Jack 1 mine could potentially impact the drainage channel that connects the mine site to the western edge of the Navajo Housing Authority (NHA) residential area west of Smith Lake Chapter. The channel curves to the south at the edge of the NHA housing area and empties into the Smith Lake – which as late as mid-2023 had accumulated water from winter and spring runoff.

Second, EPA asserts that ET covers "are proven effective capping technologies in arid and semi-arid environments" (Mariano Lake EE/CA at 42), but we can find no technical information in the EE/CA on the long-term performance of ET covers. And third, the rationale doesn't explain how a 2.5-foot layer of dirt with the promise of a vegetative cover will be sufficient to safely contain the wastes below forever and, importantly, will be guarded from human access and intrusions many years from now.

Our understanding is that the U.S. Forest Service installed an ET cover on the San Mateo Mine wastes, located about 2 miles west of the Mt. Taylor Mine and village of San Mateo, and that Navajo AML worked with Lawrence Livermore National Laboratory (LLNL) to evaluate an ET design on the TseTah disposal cell in the Four Corners Area. (We note here that the TseTah disposal cell was designed with bottom and side synthetic liners, but the LLNL evaluation of the cover was limited to one year in 2016). We recommend that EPA provide documentation of ET cover performance in the Southwest so the affected communities can be assured that the design will protect them from releases of hazardous substances.

The EE/CAs indicate that EPA will develop an actual design of the covers *after* selecting a preferred alternative for each site. This places the burden on the public to evaluate the long-term protectiveness of the alternatives in the absence of engineering designs. An alternative to the CIP/ET design is the more robust and long-term containment of radioactive wastes envisioned in the Nuclear Regulatory Commission's (NRC) "prime option" of below-grade disposal in lined trenches and a reclaim-as-you-go approach to covering the wastes to minimize impacts of wind and water erosion and rodent intrusion (see 10 CFR Part 40, Appendix A, Criterion 3). In **Figure 1**, we compare containment system diagrams in the EE/CAs with a diagram of the below-grade design of the proposed Pinon Ridge uranium mill in Montrose, Colorado. While the Pinon Ridge mill was never built, the Department of Energy is using a design akin to the NRC's preferred method at the Crescent Junction, UT site for disposal of the Atlas mill tailings in Moab.

Finally, the cap-in-place design is found to be "cost-effective" in part because it is the least-cost method of remediation (other than "no action"). But it comes at a cost to the Navajo Nation in terms of land lost to permanent waste disposal. By leaving mine wastes where they are, EPA is essentially dedicating tribal lands for a purpose for which they were never intended – waste management and disposal. The Federal Government's response to the Navajo Uranium Legacy is well documented (EPA 10-Year Plan, 2021), but its ultimate responsibility for cleaning up uranium wastes produced under government contracts is not recognized as a guiding policy of EPA's Superfund Program.

4. EPA SHOULD USE FINDINGS OF PUBLIC HEALTH STUDIES CONDUCTED ON THE NAVAJO NATION OVER THE PAST 25 YEARS TO INFORM MINE WASTE REMEDIATION DECISIONS.

The Human and Ecological Risk Assessment (HERA) appended to the Homestake and Mariano Lake Mine EE/CAs (Appendix A) contains hundreds of pages of results of regulatory risk assessment modeling to

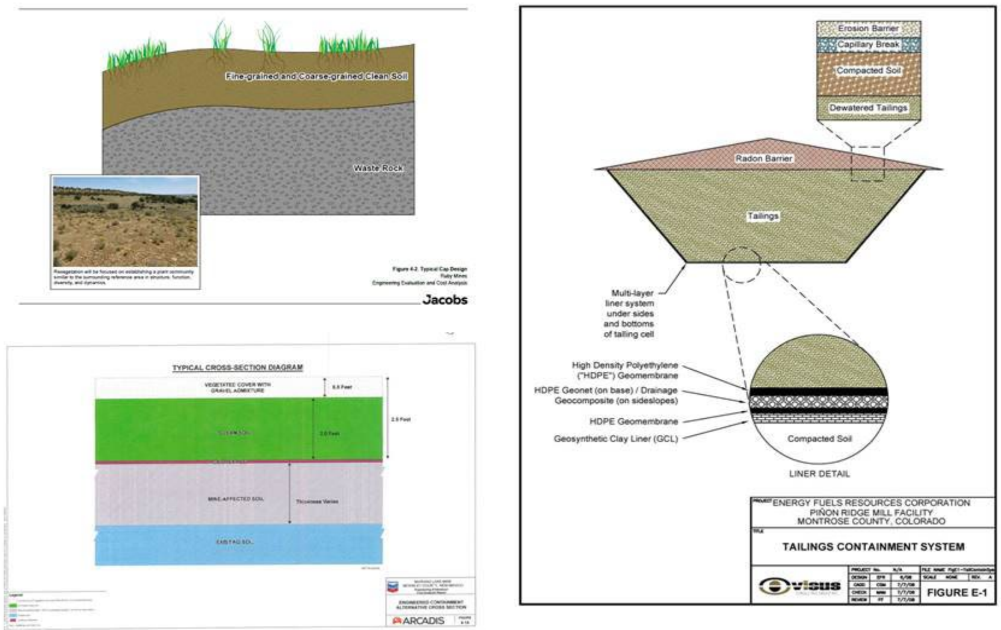
Figure 1. Comparison of Mine Waste Covers

"Typical" evapotranspiration (ET) cover diagrams

Ruby Mines EE/CA, Fig. 4-14

Mariano Lake EE/CA, Fig. 4-14

Tailings cover design, Pinon Ridge Mill, Montrose Co., Colorado (2008)



support a finding by the agency that the preferred alternative in each EE/CA is protective of human health. EPA, however, did not summarize findings of recent public health studies conducted in the ENA or provide data on current health conditions in the impacted communities. Such information should supplement the HERA so that risks of disposing of mine wastes are evaluated again actual public health data and findings.

Our research group documented local health conditions in published papers and community report-backs of findings of the DiNEH Project Kidney Health Study (NNHRRB #04-145) between 2001 and 2012. Mariano Lake and Smith Lake were two of 20 chapters participating in the study, and were provided results applicable to their chapters in report-backs in 2009, 2010, 2011, 2018 and 2020. The community-engaged study was developed between 2001 and 2003 through a collaboration of healthcare providers, the Eastern Navajo Health Board, SRIC and the UNM Community Environmental Health Program (CEHP). The consensus of more than 60 community leaders who attended trainings in 2002-2003 was that environmental health research should examine the role of uranium ingestion from water and exposures from abandoned mines in the high rates of chronic kidney disease observed in the Crownpoint Service Unit (U.S. Public Health Service and Navajo Area Indian Health Service (NAIHS)) in the 1990s and early 2000s.

Self-reported uranium exposures and health problems were obtained through surveys administered by Navajo-speaking interviewers to 1,304 Eastern Agency residents making the DiNEH Project the largest cross-sectional biomedical study ever conducted on the Navajo Nation. Self -reports of health problems were validated through biomonitoring (blood and urine testing) among 267 DiNEH participants in 2010-2011. The following charts show results for self-reported uranium exposures and health problems among 138 Mariano Lake and Smith Lake residents (69 participants each) who participated in the study.

In **Table 1**, we see that people living in Smith Lake and Mariano Lake had some of the highest prevalences of self-reported exposures among the 20 chapters participating in the DiNEH Project study. (Prevalence is

Table 1. Prevalence of self-reported exposures to uranium wastes among Mariano Lake (69) and Smith Lake (69) participants compared with all DiNEH Project participants (1,304), 2004-2011

(*red typeface indicates prevalence among the top three highest values across all chapters)

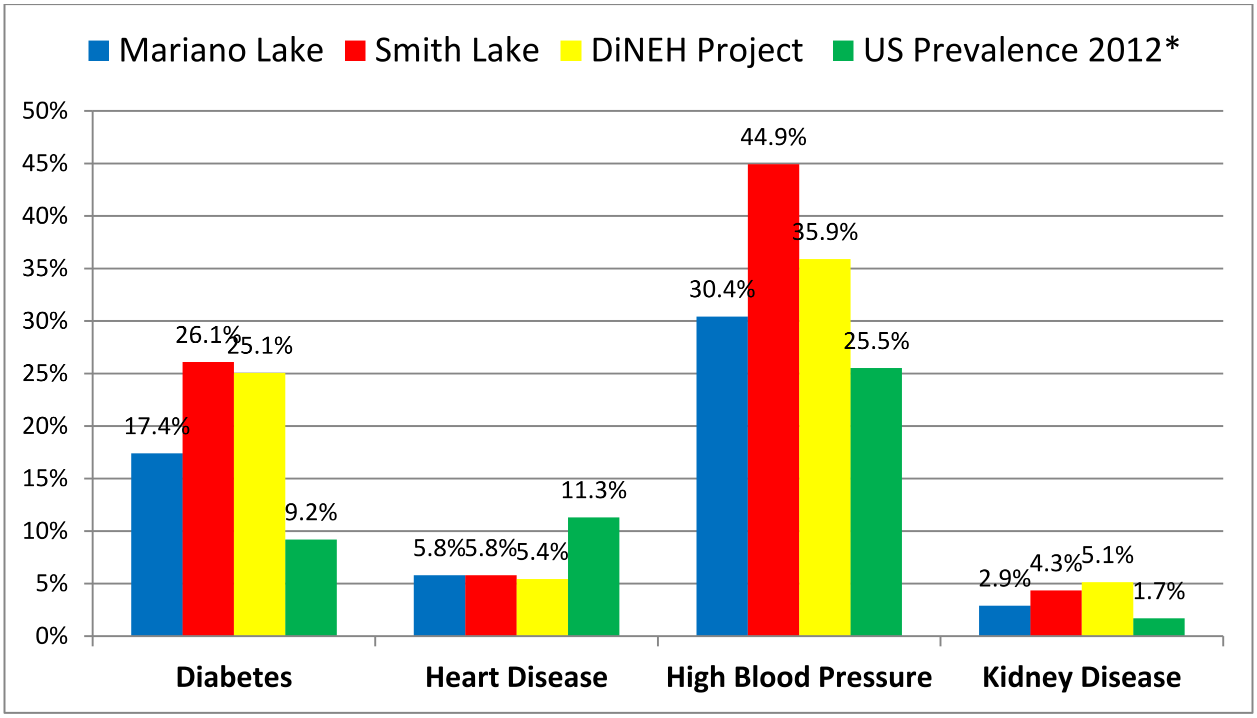
Exposure Variable	Mariano Lake (%) (N=69)	Smith Lake (%) (N=69)	All Chapters (%) (N=1,304)
Number of AUMs in chapter	4	6	86
Occupational Exposures			
Worked in U mine	18.8*	13.0	9.8
Worked in U reclamation	1.4	1.4	2.1
Worked in U mill	2.9*	0.0	1.8
Lived in mining camp	3.3	5.8*	3.6
Population Exposures			
Sheltered livestock in mine	5.0	1.4	1.8
Lived Near U mill	4.3	5.8	5.5
Played next to U waste pile	17.4	14.5	11.9
Played on U waste pile	15.9	12.9	12.7
Drank or contacted mine water	11.6	8.7	13.0
Herded livestock on mine waste	15.9	21.7	13.3
Used mine materials at home	31.9*	31.9*	17.1
Washed clothing of U worker	31.9*	27.5*	21.6
Lived near U mine	27.5	46.4*	22.3

defined as an exposure or adverse health outcome reported at a point in time.) These included working in a uranium mine, working in a uranium mill, living in a mining camp, having used mine waste materials in home or corral construction, having washed clothing of a uranium worker and having lived near a uranium mine. Those exposures ranked Smith Lake and Mariano Lake among the top five chapters for all uranium exposures, following only participants in Baca-Prewitt-Haystack, Churchrock and Coyote Canyon chapters.

Figure 2 shows key chronic disease rates from self-reported survey responses by residents of Mariano Lake, Smith Lake, and all DiNEH chapters compared with national rates published by the Centers for Disease Control and Prevention through the NHANES survey (National Health and Nutrition Evaluation Survey). Here we see that Mariano Lake and Smith participants reported higher rates of hypertension (i.e., high blood pressure), diabetes (largely diabetes mellitus 2) and chronic kidney disease than NHANES-reported rates. Rates of heart disease among DiNEH Project participants were generally about half of those among Americans surveyed by CDC. Rates of self-reported autoimmunity (not shown in Figure 1) were also less than the national rate, but as we discuss in more detail below, autoimmunity is a major adverse health outcome that appears to be associated with environmental exposures among DiNEH participants.

The most frequently reported health problems among Smith Lake participants were high blood pressure (44.9%), diabetes (26.1%) and arthritis (18.8%). The most frequently reported health problems among Mariano Lake participants were high blood pressure (30.4%), diabetes (17.4%) and kidney disease/kidney stone (8.7%). While our findings show that exposures are associated with these chronic metabolic diseases, EPA does not appear to have evaluated the cumulative public health impacts of multiple abandoned mines concentrated in clusters throughout the Eastern Agency, including in Smith Lake and

Figure 2. Prevalences of self-reported chronic diseases among Mariano Lake and Smith Lake residents compared with all DiNEH Project participants and rates reported in NHANES, 2012.



Mariano Lake. This was noted by a commenter at EPA's October 21 public meeting at Pinedale Chapter who asked why EPA was not presenting or referencing data and findings from the DiNEH Project.

SRIC recently presented a preliminary a meta-analysis of findings from more than a dozen published studies emerging from the DiNEH Project and the Navajo Birth Cohort Study (NBCS) since 2010. (See Appendix A.) As set forth in our analysis, *residential proximity to mine sites* consistently predicted adverse outcomes for cardiovascular disease, autoimmunity and chronic kidney disease. Biomonitoring of blood and urine – a proven method for developing direct evidence of exposure to environmental metals, including those in mine wastes – revealed significant associations between metals exposures and adverse health outcomes, especially with respect to ingestion of uranium, arsenic, radium and nickel in water sources at concentrations generally *below* current federal and tribal drinking water standards. EPA does not engage in or evaluate biomonitoring data to understand existing health conditions in the impacted chapters and whether in-place remediation will reduce or heighten those risks. EPA cannot asserts that its remediation decisions are protective of human health as long as it declines to compile, analyze and apply actual environmental public health data in remediation decision-making.

5. POST-CLOSURE SITE CONTROL PERIOD LACKS DETAILED ELEMENTS

The post removal site control (PRSC) period covers 100 years after construction in Alternatives 2, 3, and 4; and 5 years post-construction for Alternatives 5 and 6 (Homestake EE/CA, Table 4-3). While the EE/CAs indicate that monies will be available for PRSC (Table 4-2), the technical and legal elements of the PRSC are not specified. All three EE/CAs for the seven AUMs should specify what EPA will do during the post-closure period at each of the sites. Table 4.3 describes costs, but provides no technical details. Fencing, signage, erosion-control maintenance, post-closure care and the community's role in passing down information about the locations of mine sites should be specified in order to evaluate the safety of in-place disposal. If CIP/ET is eventually chosen as the preferred method of disposal, EPA should provide grants to each of the chapters to facilitate local land-use planning, citizen monitoring of remediated mine sites, and development of multi-generational storytelling as a way to prevent future generations from unknowingly digging into and releasing mine wastes.

We appreciate the opportunity to comment on the EE/CAs and reserve the right to submit additional comments as our review of these critical decision-making documents continues.

Respectfully Submitted,

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Southwest Research and Information Center
Co-investigator, DiNEH Project
Co-investigator, Navajo Birth Cohort Study-ECHO+
Co-investigator, Thinking Zinc Clinical Trial
505-350-0833

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APPENDIX A

Shuey C, Erdei E, Molony D. Environmental Health Studies Can Inform Uranium Mine Remediation on the Navajo Nation. Navajo Nation Human Research Review Board Biennial Research Conference, Flagstaff AZ, October 19, 2024.

Environmental Health Studies Can Inform Uranium Mine Remediation on the Navajo Nation

Navajo Nation Human Research Review Board Biennial Conference

Chris Shuey, MPH[1], Esther Erdei, Ph.D., MPH[2], and Donald A. Molony, MD[3]

Twin Arrows Resort, Flagstaff, AZ
October 19, 2023

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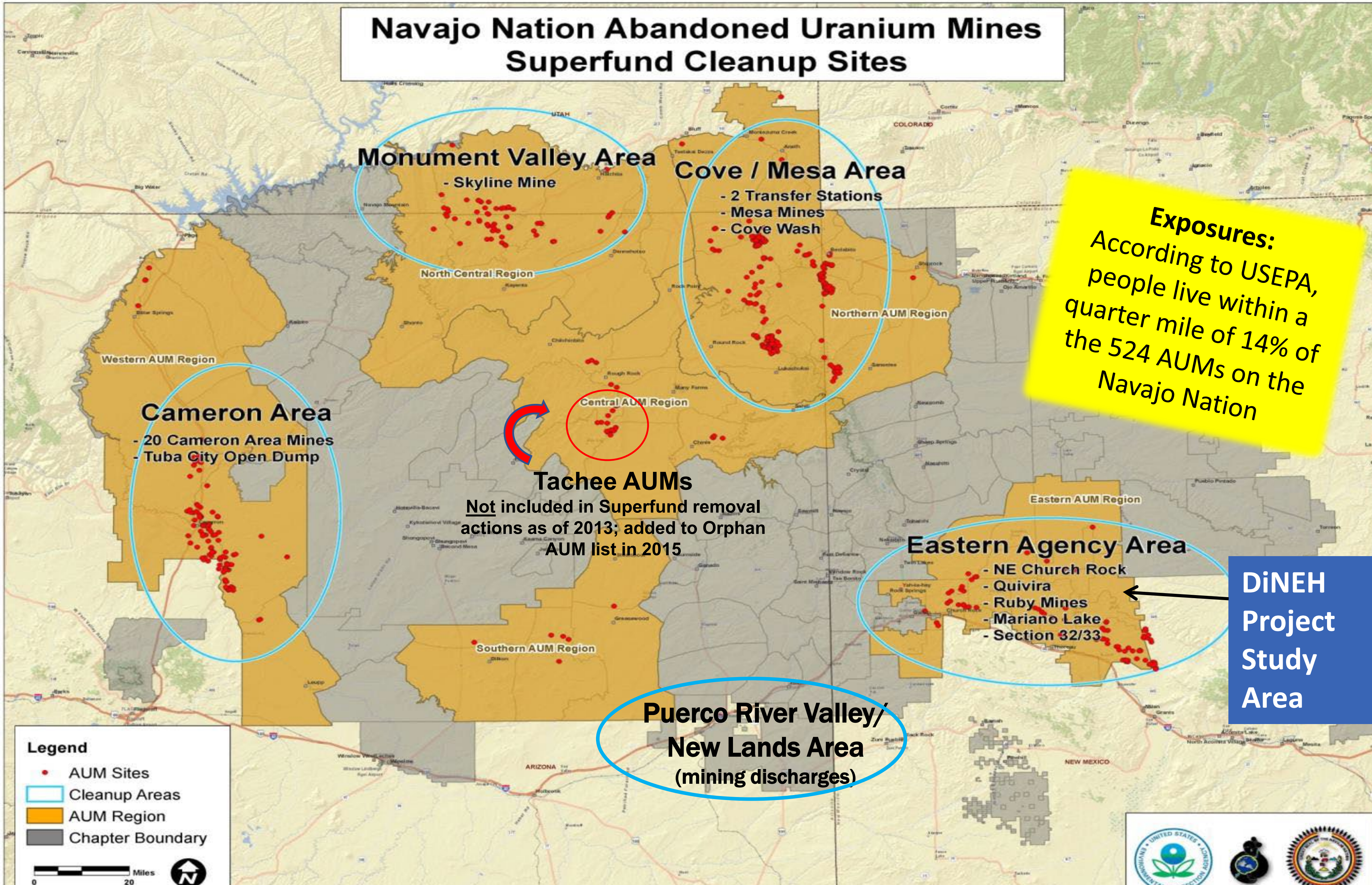
- **Approvals:** Human research is approved and monitored by the UNM Human Research Protections Office and Navajo Nation Human Research Review Board: DiNEH Project, NNR-04-145; NBCS, NNR-11.323; NBCS-ECHO+, NNR-19.360; Thinking Zinc, NNR-18.330T. This presentation was approved by NNHRRB on the basis of an abstract submitted 8/18/23.
- **Disclaimer:** This material was developed in part under cited research awards to the University of New Mexico. It has not been formally reviewed by the funding agencies. The views expressed are solely those of the speakers and do not necessarily reflect those of the agencies.
- **DiNEH Project contributors (2001-2012)** – Miranda Cajero, Jeremy DeGroat, Mallery Downs, Esther Erdei, Molly Harmon, Sarah Henio-Adeky, Lauren Hund, Johnnye Lewis, Donald A. Molony, Teddy Nez, Bernadette Pacheco, Sandy Ramone, Tommy Rock, Bess Seschillie, Chris Shuey, Glenn Stark

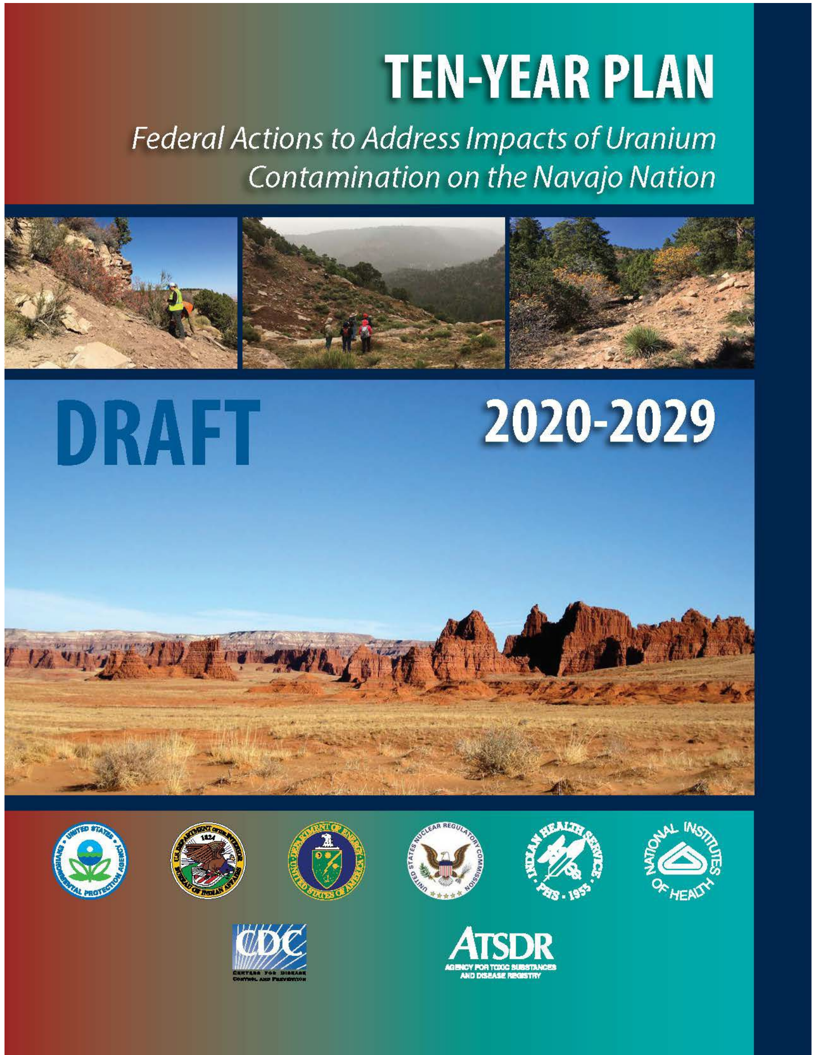
Acknowledgement Statement: *The University of New Mexico sits on the traditional homelands of the Pueblo of Sandia. The original peoples of New Mexico have deep connections to the land and have made significant contributions to the broader community statewide. We honor the land itself and those who remain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

Cover photo of Quivira Churchrock I Mine waste dump and homes in Red Water Pond Road Community, Coyote Canyon Chapter



Map courtesy USEPA Region 9, modified by SRIC

Navajo Uranium Legacy: By the Numbers

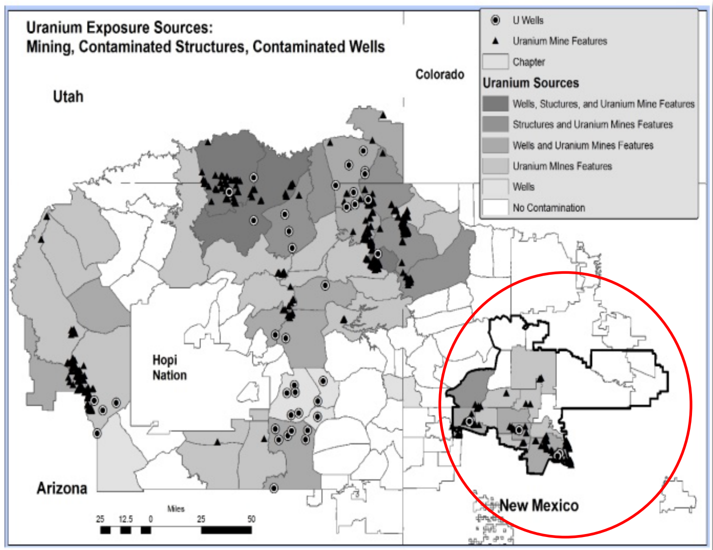


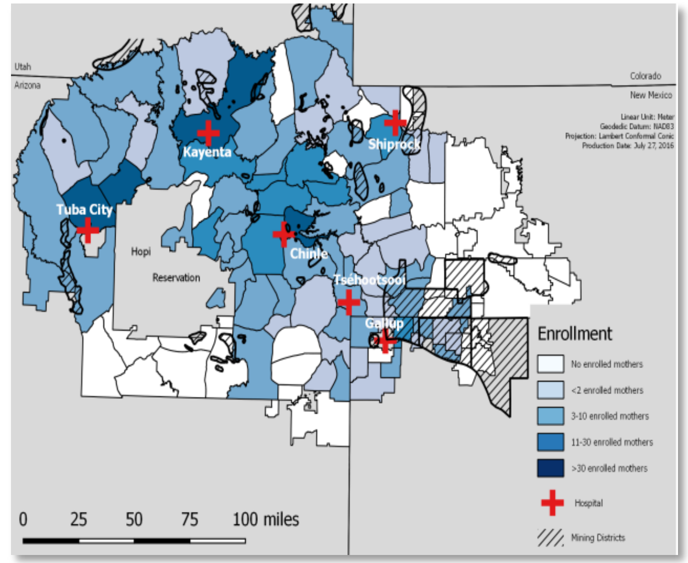
Cover of USEPA Ten-Year Plan, Jan. 2021

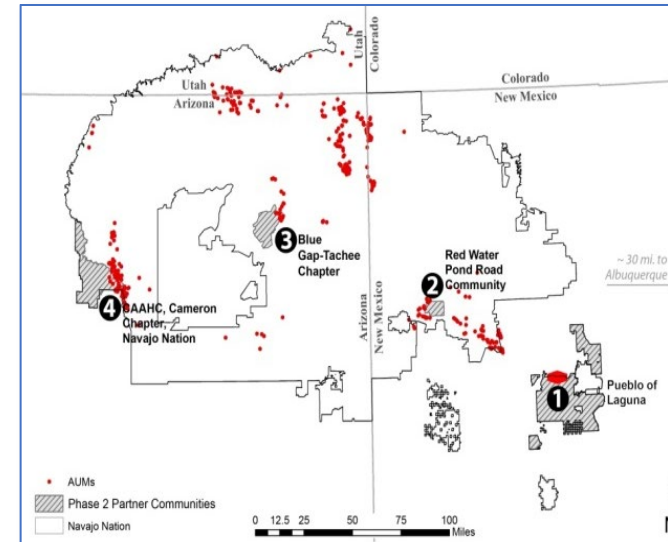
524	Abandoned uranium mines (AUMs), plus >1,100 mine "features"
0	***Fully remediated AUMs***
4	Interim AUM remedial actions to contain wastes
96	AUM site radiation screening reports
130	Site assessments (RSEs) expected to be completed by end of 2022
10-15	EE/CAs* expected to be completed by end of 2022
$1.7 billion	Money USEPA says it has available for remediating **~40% AUMs** through Tronox bankruptcy, settlements with mining companies, federal contributions
3	Congressional hearings: 1979, 1993, 2007
3	Federal response plans: 2008, 2014, 2021
57	Navajo Chapters w/ 1-3 uranium exposure sources (AUMs, water sources, contaminated structures)

*EE/CA = Engineering Evaluation/Cost Analysis

Community questions about exposures have driven UNM environmental health research







<u>DiNEH Project, 2002-2012</u>

- Does U in drinking water increase risk of kidney disease?
- Do multi-pathway exposures to metals in mine wastes increase risks of chronic disease?
- *Community-based trainings to develop study design, implementation methods, consents*

<u>Navajo Birth Cohort Study, 2010-present</u>

- Do exposures to U mine waste affect child health, development?
- Do exposures to metals in mine wastes increase chronic disease?
- *Extensive trainings to develop EH capacity among community members hired by UNM, SRIC and NNDOH*

<u>METALS SRP, 2014-present</u>

- Do mixed-metal U mine wastes contribute to air, water and farmland contamination?
- Do exposures to U wastes result in immunologic, cardiovascular, pulmonary effects?
- Status of remediation?
- *Community defines research*

UNM Population-based EH studies to ascertain exposures and health outcomes

Study	Design	Population	Target Health Outcomes
DiNEH Project, Navajo Uranium Assessment Kidney Health	Cross-sectional; iterative, multi-pathway analysis	Phase I – 1,304 participants in 20 chapters of ENA; Phase II – 267 participants in blood and urine collections	▪ Chronic kidney disease ▪ Cardiovascular disease ▪ Autoimmunity
Navajo Birth Cohort Study	Longitudinal cohort	More than 1,800 mothers, fathers, babies in 3 phases across Navajo Nation	▪ Child development ▪ Metals and pre-term births ▪ Upper airway effects
Thinking Zinc	Clinical trial	52 volunteers from Churchrock and Blue Gap-Tachee communities	▪ Zn supplementation to repair metals-induced damage to DNA repair mechanisms
METALS Superfund Research Center	Laboratory animals	Community members exposed to dust from AUMs	▪ Cardiopulmonary effects of exposure to metals-laden “nanoparticles”





Common methods to ascertain exposures, health outcomes

Method	DiNEH Project	NBCS-ECHO+	Thinking Zinc	UNM METALS
Surveys administered Navajo-speaking researchers	●	●	●	
Geospatial analyses (locations of homes, AUMs)	●	●	●	●
Water quality in public water systems, unregulated wells	●	●		●
Home assessments, including radiation surveys, indoor radon, indoor dusts		●		
Assessments of biomarkers of effects	●		●	
Biomonitoring (detection of metals in human tissues, including urine, blood, hair, toenails)	●	●	●	
Child developmental assessments		●		
Laboratory animal studies of environmental exposures to mine dust				●
Administration of zinc supplements to repair damage from metals exposures			●	

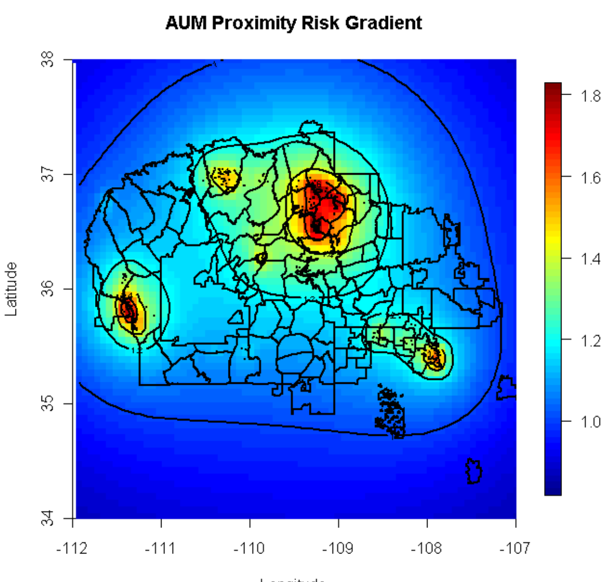
Summary of *Significant* Exposure Variables and Key Findings across UNM Environmental Health Studies (see complete chart at end)

AID = autoimmune disease; CKD = chronic kidney disease; CVD = cardiovascular disease

Exposure variables	Studies	Selected results
Promixity to AUM sites	Hund et al, 2015; Harmon et al, 2017; Erdei et al, 2019; Erdei et al, 2023	▪ CVD: 62%-81% increase in the risk of hypertension during legacy period (after 1986); Increased inflammatory potential ▪ AID: Twofold increase in ANA positivity; proximity associated with clinically defined ANA response (OR*=3.07, *p*=0.025) ▪ CKD: Doubling risk in active mining era, 1950-1986 (10% of participants were U workers)
Environmental metals from biomonitoring	Erdei et al, 2022 (NBCS, N=52); Dashner-Titus et al, 2022 (Thinking Zinc N=52); Hoover et al, 2020 (NBCS, N=783); Harmon et al, 2018 (N=252)	▪ CVD: 92% of babies with detectable urine U at birth born to mothers who had urine-U levels greater than national norms; As exposure increased oxidative stress, a contributor to CVD ▪ 4-fold increase in U levels among Thinking Zinc participants ▪ AID: 7 cytokines indicative of immune dysfunction were higher than U.S. U levels (OR = 2.21 (1.08–4.52)) ▪ Pregnant Navajo women have higher U exposures than all U.S. women
Metals in drinking water	Erdei et al, 2019 (N=239); Harmon et al, 2018 (N=252); Erdei et al, 2023 (N=239) Hoover et al, 2017	▪ CVD: Consumption of U correlated with increased C-reactive protein ▪ AID: Elevated autoantibody biomarkers associated with U at levels <MCL of 30 ug/L ▪ AID: As (OR=1.79; *p*=0.012) and Ra (OR=1.04, *p*=0.001) associated with anti-dsDNA serum response for ANA positivity ▪ AID: Hg consumption associated with increased ANA response (OR=2.34; *p*=0.008); Ni consumption predicts increased serum anti-U1-RNP ▪ CVD: As (15.1%), U (12.5%) most frequently measured metals exceeding their drinking water standards in nearly 500 unregulated water sources on the Navajo Nation, including ~100 in Eastern Agency
Age	Erdei et al, 2023 Erdei et al, 2019	▪ Associated with increased serum ANA response (OR*=1.07, *p*=0.018) ▪ Associated with increased antibodies to denatured DNA

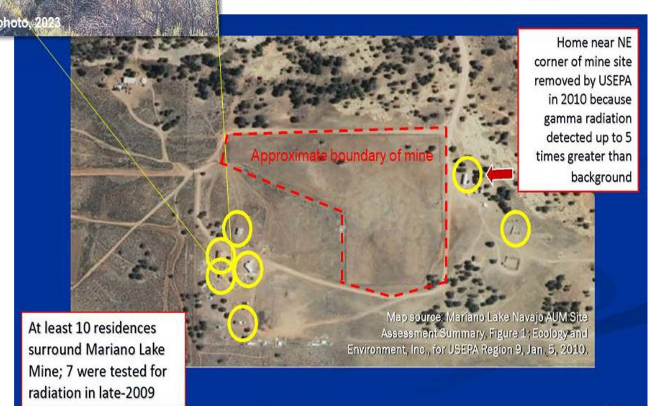
This is what “proximity” looks like

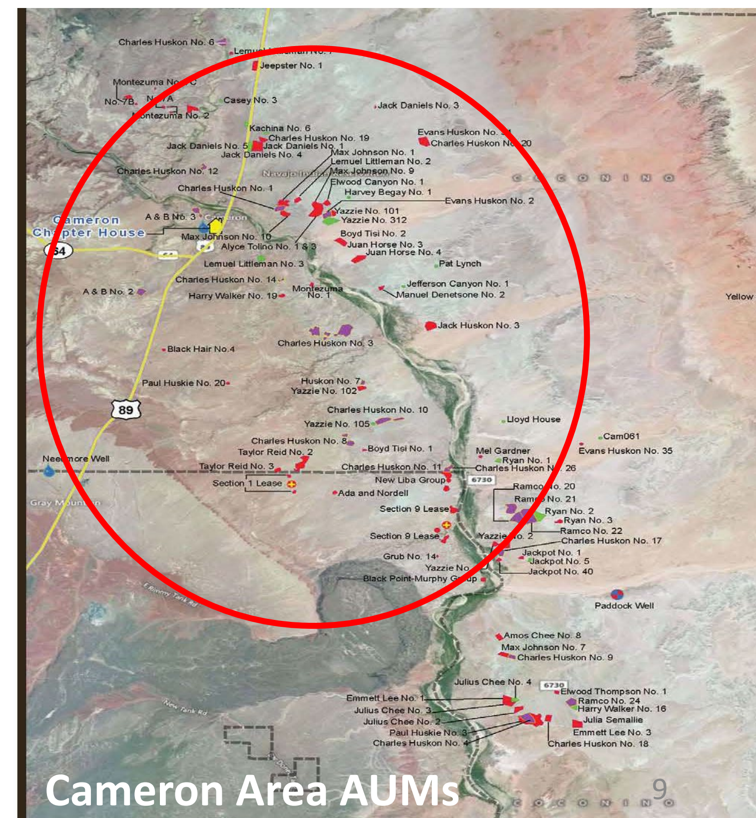
Claim 28 Mine in Blue Gap-Tachee



Example: Mariano Lake Mine

- Operated by Gulf Mineral Resources 1977-1982; closed 1986; Chevron current responsible party
- Interim actions: buildings removed, site graded and fenced; one home abandoned
- 10 to 15 residences surround the mine site

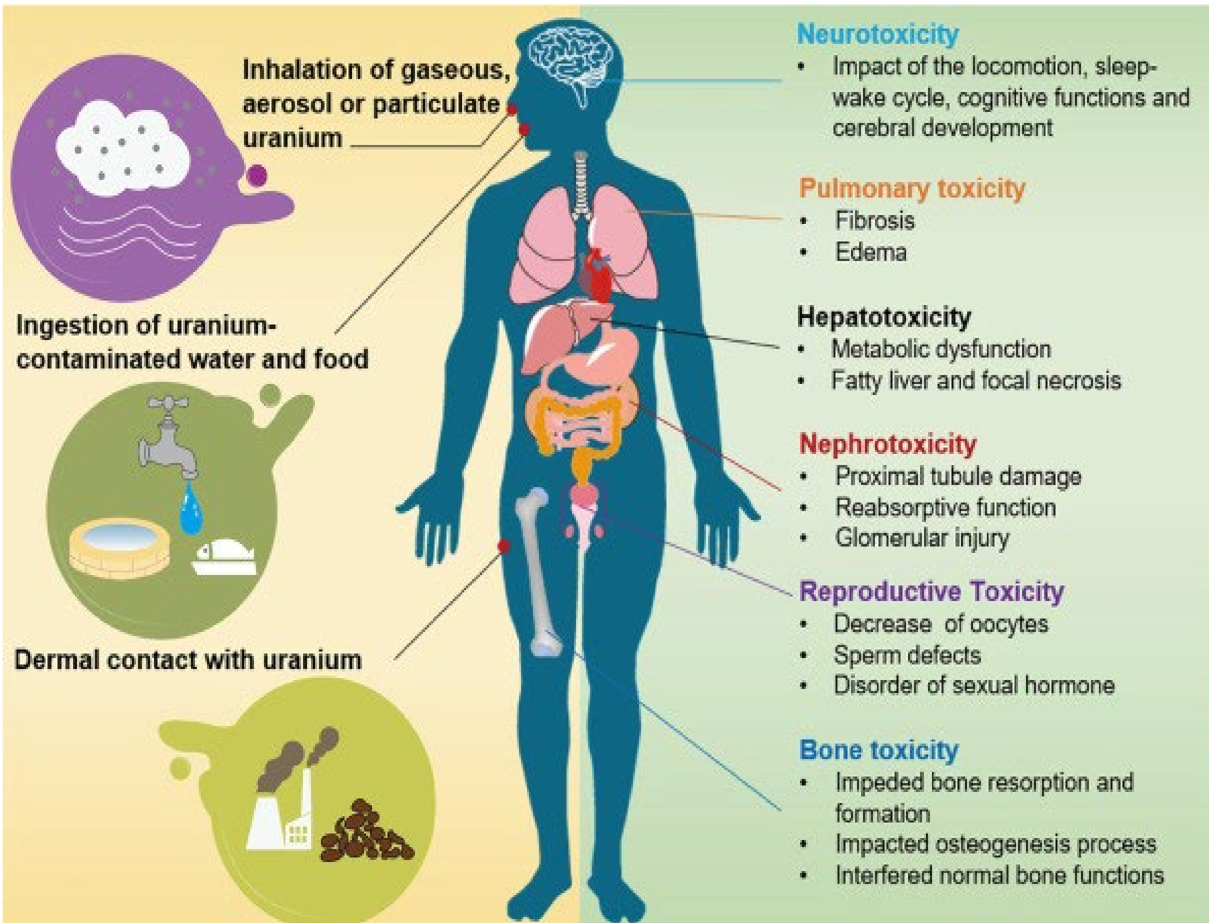




In preparation: "Biomarkers of Chronic Kidney Disease among Navajo Community Members Living in Proximity to Abandoned Uranium Mines and Associated Waste Sites"

- Community concern about uranium exposure focused on high rates of chronic kidney disease and diabetes observed in the Eastern Navajo Agency in early-2000s
- In previous research (Harmon et al., 2018), our team detected oxidative molecular damage that is considered a cardiovascular disease (CVS) risk
    - Linked to consumption of arsenic in drinking water sources
    - Provided evidence of *circulatory and inflammatory* conditions that affected the kidneys
- Diabetes, as measured by hemaglobin A1c, was not a significant predictor of kidney disease among DiNEH participants, suggesting that environmental factors may be at play in development of CKD independent of diabetes-2 status
- For research purposes and to directly address long-standing community concerns, using a wide range of renal biomarkers allows us to see early effects of uranium and metal mixtures on the DiNEH participants' kidneys
- This overall approach is useful to use later as well because it can guide IHS primary care visits and would help to find susceptible community members

Uranium exposure and nephrotoxicity – damage to the kidney, our current focus of study



From Ma et al., Environment International, 2020

- Prior "evidence" from dozens of epidemiological and animal studies on the possible role of uranium in causing kidney disease
- **DiNEH Project:** Urine analyses of biomarkers to characterize kidney injury associated with uranium exposure
- Identify multiple kidney sites of injury with kidney biomarkers panel
- Exploring impact of U exposure on cardiovascular health occurring together with kidney disease
- Implications for understanding the burden of kidney disease on the health of individuals and families and for measuring the success of mine remediation

Nephron – functional unit of the kidney; each kidney has 1 million nephrons

1. Glomerular filtration: The kidney filter

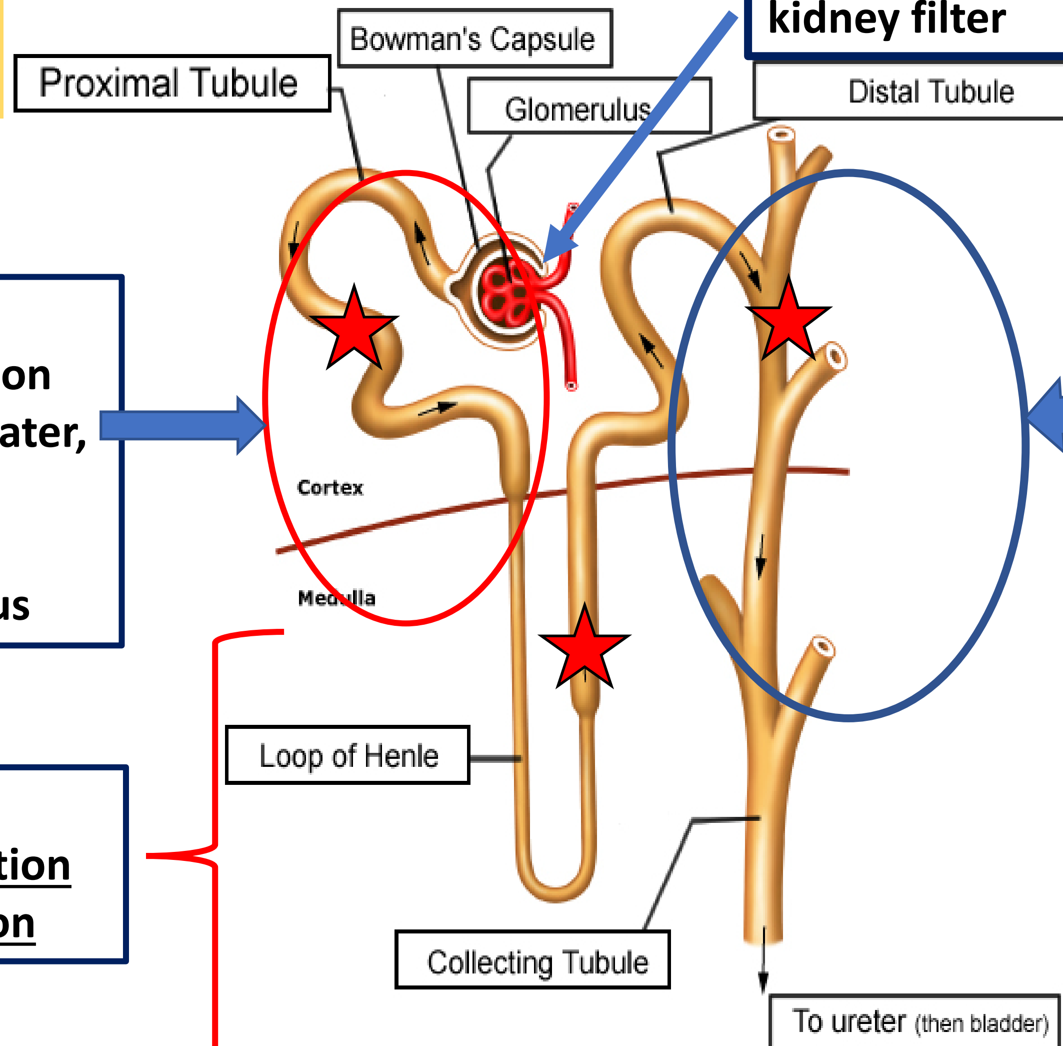
***Cells of the interstitial compartment. Structural, nutritional, immunologic and functional/ hormonal support.

Tubular interstitial structures key

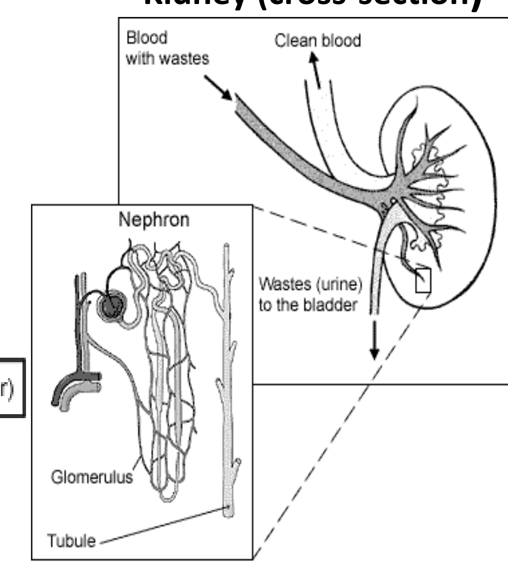
2. Bulk reabsorption of NaCl, water, proteins, glucose, phosphorus

<u>3. Powers concentration and dilution</u>

4. Final regulation of NaCl, potassium, acid- base balance



Kidney (cross-section)

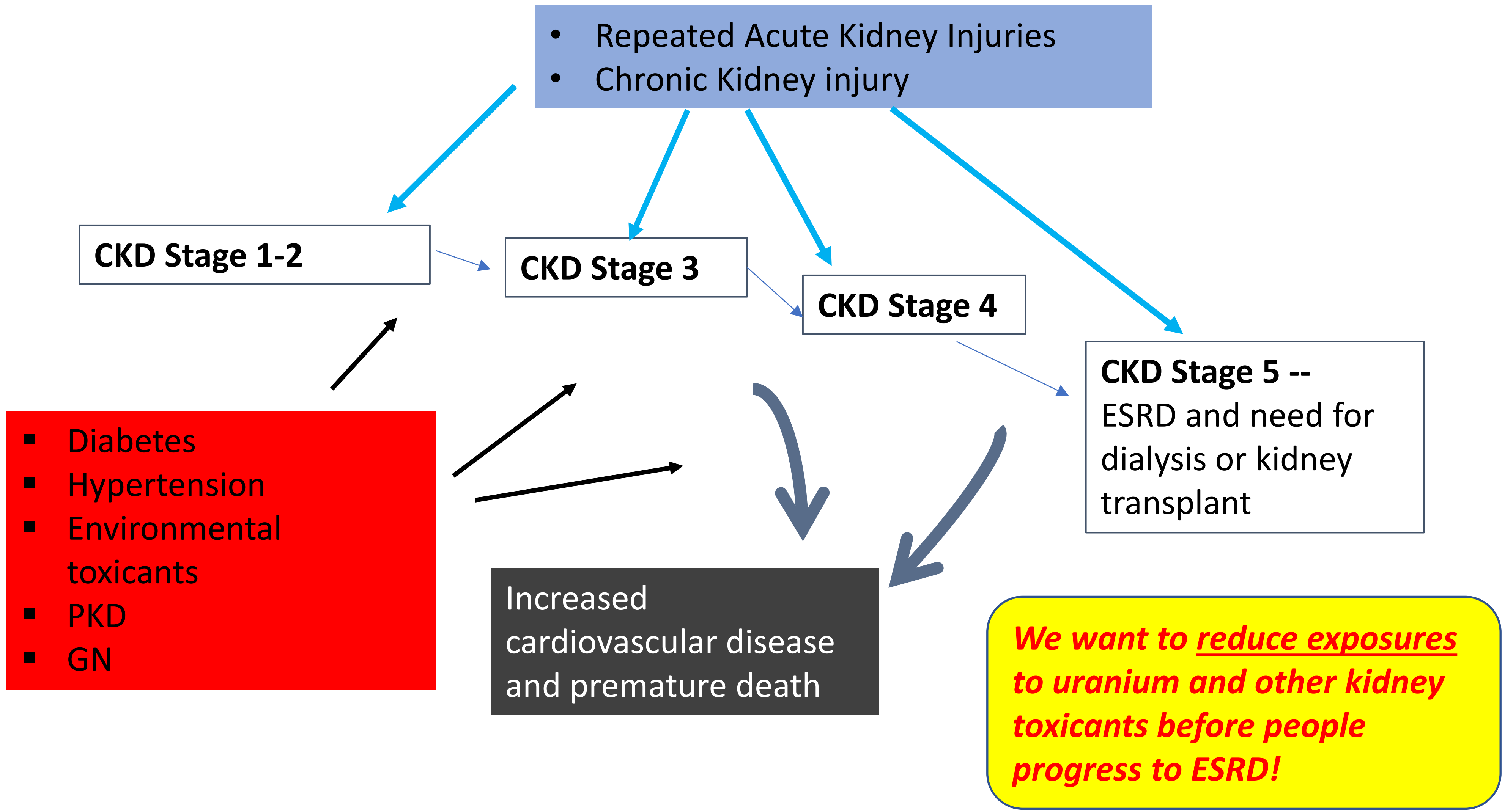


Sites of uranium toxicity; large molecular size of the U ion contributes to cell death, inhibiting proximal and distal tubules' reabsorption of low-molecular weight proteins

Biomarkers of effect – Recognizing the injury before renal failure develops

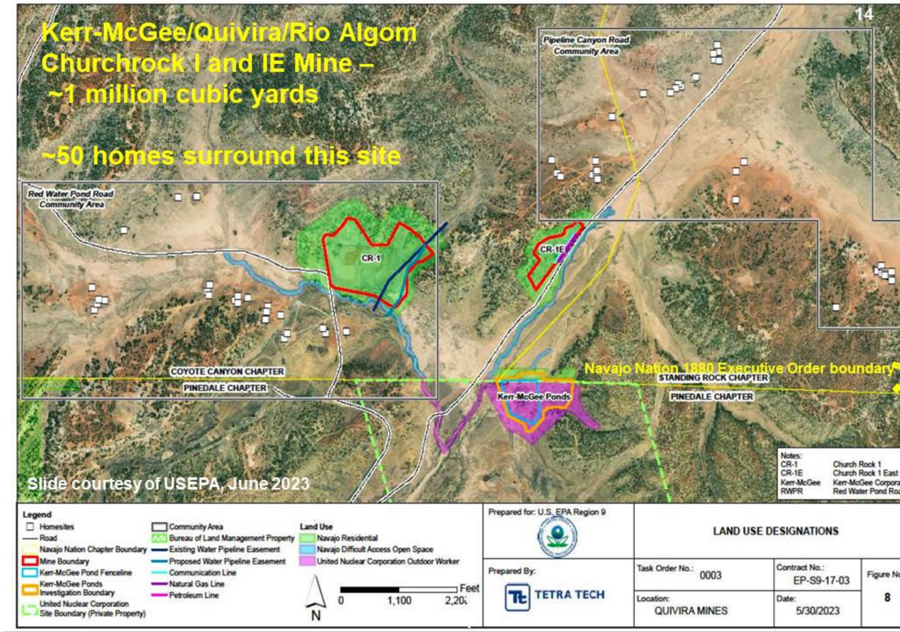
Site of Kidney Injury	Kidney Biomarkers
Proximal Tubule	• Deaminase Binding Protein • Alkaline Phosphatase • Beta-**macro**globulin • N-Acetyl-B-D-glucosaminidase (NAG) • N-GAL; KIM-1; MCP-1; RBP
Thick Ascending Limb	• Uromodulin - Tamm Horsfall • Kallikrein /EGF • LDH
Collecting Duct	• Kallikrein

Can We Interrupt the Natural History of Chronic Kidney Disease (CKD) to End-Stage Renal Disease (ESRD)?



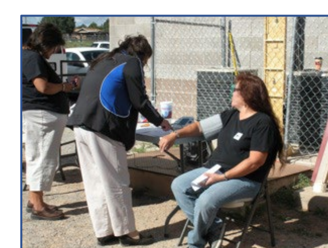
Implications for remediation

- Recognize "proximity" as a risk factor — prioritize remediation of AUM waste sites located near where people live
- Consider synergism between kidney disease and cardiovascular disease in the Navajo population – increased risks of both from U exposures!
- Consider cultural practices that tie *Diné* people to their homelands — resist the practice of relocating people unless exposures cannot be mitigated
- Use biomonitoring — assessment of contaminants in bodily fluids — as companion to regulatory risk assessment that depends on environmental data only
- Embrace environmental health findings in remediation decision making
- Consolidate wastes into fewer sites to reduce exposures; e.g., Cameron, Churchrock, Smith Lake, Mariano Lake, Lukachukai Mountains



Conclusions

- DiNEH Project – Largest cross-sectional study of exposure to uranium on the Navajo Nation
- Navajo Birth Cohort Study – Largest cohort study of mothers, fathers and babies
- Thinking Zinc – First-ever community-based clinical trial showing elevated concentrations of metals in blood and urine, exceeding national norms
- Studies developed in partnership with community members, designed to answer community questions about effects of exposures to uranium wastes
- Exposure to mine wastes, contaminants in drinking water, and metals in blood and urine associated with increased risks of chronic, metabolic diseases
- Proximity to uranium wastes consistent significant relationship to disease outcomes
- Metal contaminants in drinking water – As, Ra, Hg, Ni, U – associated with biomarkers of cardiovascular disease, autoimmunity
- Critical findings of these studies can inform federal investigations of abandoned uranium mines and plans for remediation
- Biomonitoring of contaminant levels in people living near mines should supplement regulatory risk assessments
- More complete understanding of the magnitude and effects of exposures on cardiovascular and kidney health best characterized through continuation of long-term cross-sectional and longitudinal studies




Summary of *Significant* Exposure Variables and Key Findings across UNM environmental health studies

Exposure Variable	Population	Cardiovascular Disease-Hypertenson	Autoimmunity	Chronic Kidney Disease	References
Proximity to uranium waste sites	DiNEH Project cohort subset (N=239)		Twofold increase in ANA positivity versus national rate; proximity associated with clinically defined increased ANA response (OR*=3.07, p=0.025)		Erdei et al., 2023
	DiNEH Project cohort subset (N=267)	Increased inflammatory potential (as measured by endothelial transcriptional responses) associated with proximity to AUMs suggests a role for inhalation exposure as a contributor to cardiovascular disease	Age and the extent of exposure to legacy waste from 100 abandoned uranium mine and mill sites were associated with antibodies to denatured DNA		Erdei et al., 2019 Harmon et al., 2017
	DiNEH Project, 2004-2012 (N=1,304)	A 62% to 81% increase in the risk of hypertension was found during the environmental legacy period (after 1986)		A more than doubling of the risk of kidney disease detected for exposures during the active mining era, 1950-1986 (~10% of cohort were U workers)	Hund et al, 2015
Environmental metals exposures from biomonitoring	Thinking Zinc Supplementation Intervention (N=51)	Thinking Zinc participants have elevated levels of uranium approximately 4-fold greater than those detected in the general US population (NHANES). “Episodic” exposures to specific metals differ between Navajo communities.			Dashner-Titus et al., 2022
	Navajo Birth Cohort Study (52 matched serum samples)	92% of babies with detectable urine U at birth were born from mothers who had urine U concentrations greater than national norms during pregnancy	7 cytokines indicative of immune dysfunction were higher than the national U concentrations (OR = 2.21 (1.08–4.52)).		Erdei et al., 2022
	Navajo Birth Cohort Study (327 children)	Prenatal exposures to lead, arsenic, copper, barium, antimony, and molybdenum negatively affected at least one ASQ:I domain scores. Mothers with lower socioeconomic status (e.g., maternal educational attainment, annual income), were at higher risk for metal exposure and having children with lower ASQ scores.			Nozadi et al., 2021
	Navajo Birth Cohort Study (783 pregnant women)	Median and 95th percentile values of maternal NBCS urine concentrations of uranium, manganese, cadmium, and lead exceeded respective percentiles for NHANES (2011-2012) among women ages 14–45. Median NBCS maternal urine U concentrations were 2.67 (enrollment) and 2.8 (delivery) times greater than the NHANES median concentration, indicating that pregnant Navajo women are exposed to metal mixtures and have higher uranium exposure compared with national data for women.			Hoover et al., 2020
	DiNEH Project water monitoring data from 130 sources	Arsenic (15.1%) and uranium (12.5%) were the most frequently measured metals exceeding their drinking water standards in nearly 500 unregulated water sources on the Navajo Nation, including ~100 in Eastern Agency			Hoover et al., 2017

Summary of *Significant* Exposure Variables and Key Findings across UNM environmental health studies (continued)

Exposure Variable	Population	Cardiovascular Disease-Hypertenson	Autoimmunity	Chronic Kidney Disease	References
Environmental arsenic exposure from biomonitoring	Navajo Birth Cohort Study (pregnant women) (N=132)	Associated with increased oxidative stress, a contributor to CVD			Dashner-Titus et al., 2018
	DiNEH Project cohort subset (N=252)	As promotes oxidation of oxLDL, a crucial step in vascular inflammation and chronic vascular disease			Harmon et al., 2018
Nanoparticle (i.e., dust) exposure from abandoned U mine	METALS SRP: Laboratory animal study	Increased neutrophil activity in mice lungs lavaged w/ solution of submicron particles from an AUM site			Zychowski, et al., 2018
Consumption of uranium in drinking water	DiNEH Project cohort subset (N=239)	Correlated with increased C-reactive protein, a CVD marker	Associated with urinary specific autoantibodies at U concentrations <MCL		Harmon et al., 2018; Erdei et al., 2019
Age			Associated with increased serum ANA response (OR*=1.07, p=0.018)		Erdei et al., 2023
Consumption of arsenic and radium in drinking water			Associated with anti-dsDNA serum response for ANA positivity: As (OR=1.79; p=0.012) Ra (OR=1.04, p=0.001)		
Consumption of mercury in drinking water			Associated with increased ANA response (OR=2.34; p=0.008)		
Consumption of nickel in drinking water			Ni consumption significantly predicts increased serum anti-U1-RNP production		

Full references available upon request to Mr. Shuey (sric.chris@gmail.com): Dashner-Titus et al., 2022; Dashner-Titus et al., 2018; Erdei et al., 2023; Erdei et al., 2022; Erdei et al., 2019; Harmon et al., 2018; Harmon et al., 2017; Hoover et al., 2020; Hoover et al., 2017; Hund et al, 2015; Nozadi et al., 2021; Zychowski, et al., 2018.

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Bold indicates Current Team
Non-bold are former team members

The people of the Navajo Nation:
- > 1000 participating Navajo families
- Many supporting chapters
- HEHSC, Tribal and Agency Councils, Executive Branch, NNEPA, GIB
- NAIHS & PL-638 hospital laboratory staff, leadership, and health boards

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Ahéhee'! Questions?