Diné Network for Environmental Health (DiNEH) Project/
Navajo Uranium Assessment and Kidney Health Project*

Uranium mining and community exposures on the Navajo Nation

Chris Shuey, MPH
Southwest Research and Information Center
with Jamie deLemos, Tufts University, and
Christine George, Stanford and Columbia universities

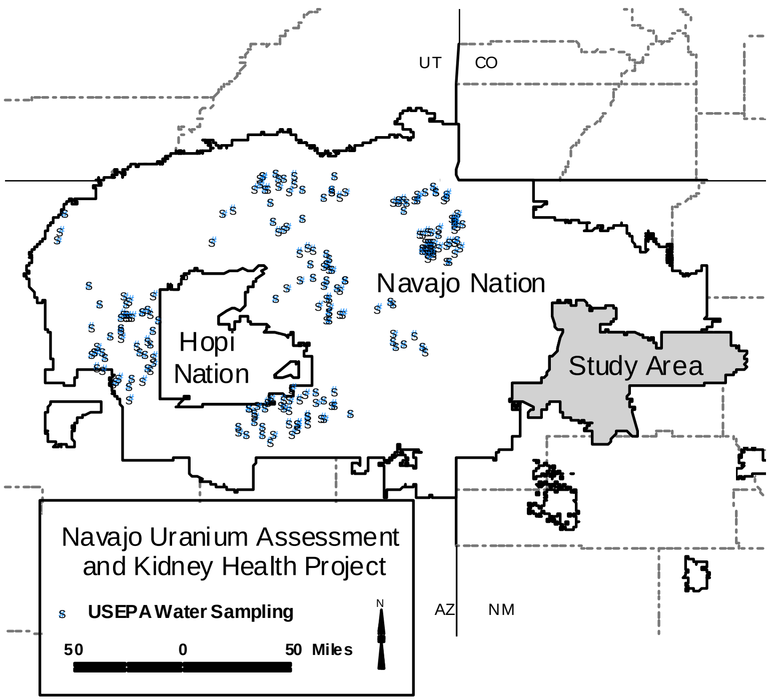
November 7, 2007

Presented at the American Public Health Association Annual Meeting, Washington, DC

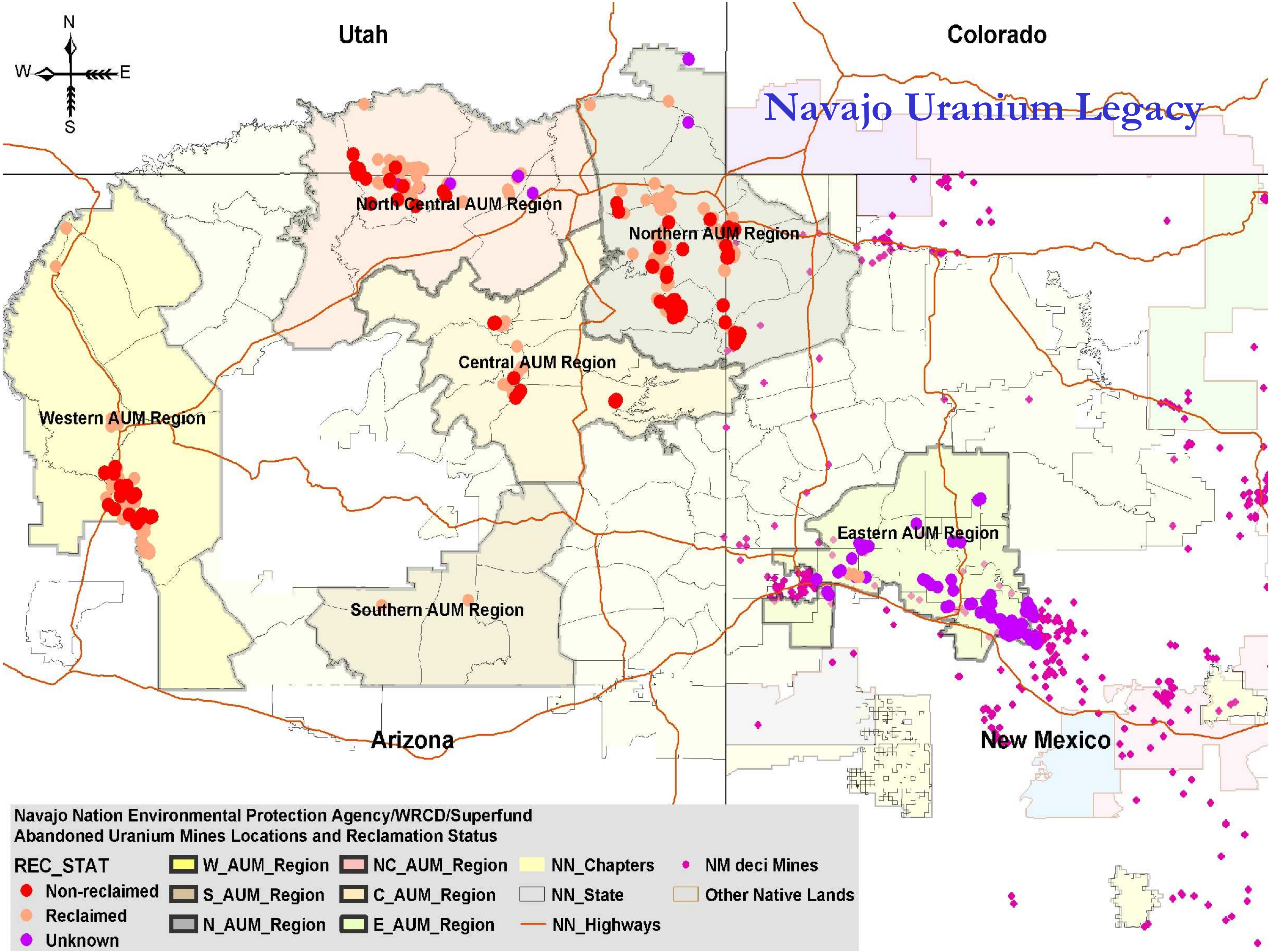
Project Collaborators: Gerald Brown, Miranda Cajero, Jeremy DeGroat, Mallery Downs, Sarah Henio-Adeky, Johnnye L. Lewis, Thomas L. Manning, Margaret Menache, Donald Molony, Teddy Nez, Bernice Norton, Bernadette Pacheco, Sandy Ramone, Tommy Rock, Bess Seschillie

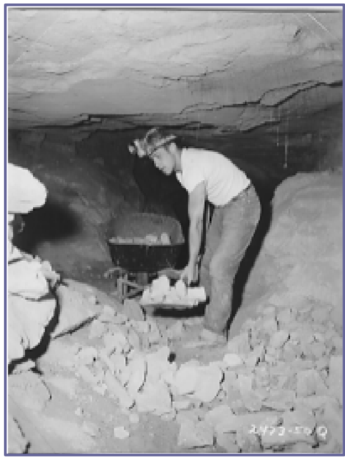
*Funded in part by Grant Nos. R25 ES013208, RO1 ES014565, P30 ES012072 from the National Institute of Environmental Health Sciences, and approved by the Navajo Nation Human Research Review Board and University of New Mexico Human Research Review Committee

Objectives of DiNEH Project



- Initiated by Eastern Navajo Health Board to:
  - build environmental health capacity in CSU
  - understand causes of high rates of kidney disease
  - address concerns about exposure to uranium in water, soils, from mining
  - assess water quality, human health conditions
  - work with 20 chapters on safe water alternatives


Navajo Uranium Legacy
N
W
E
S
Utah
Colorado
Arizona
New Mexico
North Central AUM Region
Northern AUM Region
Central AUM Region
Western AUM Region
Eastern AUM Region
Southern AUM Region
Navajo Nation Environmental Protection Agency/WRCD/Superfund
Abandoned Uranium Mines Locations and Reclamation Status
REC_STAT
Non-reclaimed
Reclaimed
Unknown
W_AUM_Region
S_AUM_Region
N_AUM_Region
NC_AUM_Region
C_AUM_Region
E_AUM_Region
NN_Chapters
NN_State
NN_Highways
NM deci Mines
Other Native Lands



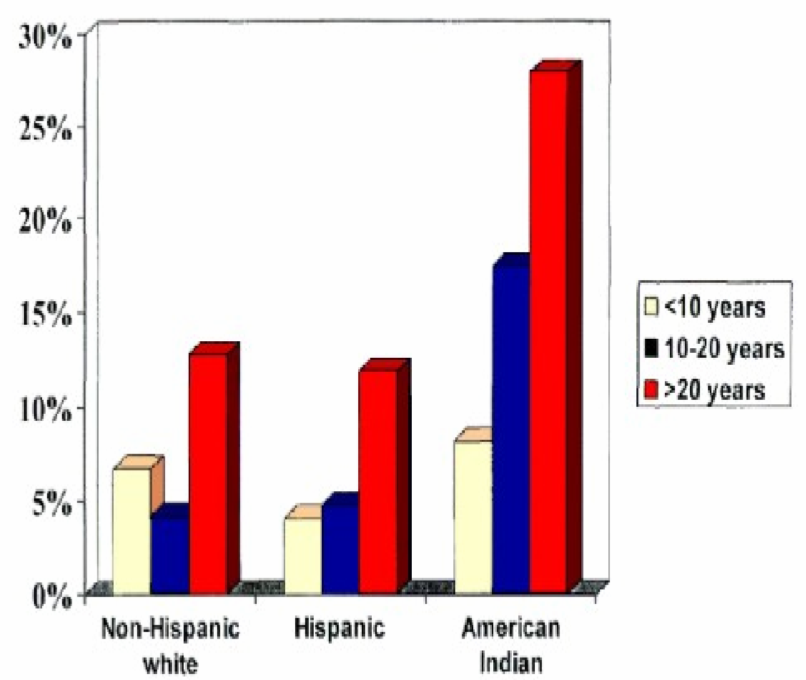
Navajo Uranium Legacy

- First mines opened in late-40s, early-50s
  - Navajo men paid incentives to open mines
  - No ventilation in “dog holes” (top left)
  - Poor ventilation, minimal work protections
- ~1,300 AUMs located
  - NNAML: 90% addressed for safety hazards, backfilling of pits, grading of waste dumps
- Reclamation: 4 uranium mills at Mexican Hat, Monument Valley, Shiprock, Tuba City (1950s-1960s)
  - Tailings at Tuba City off-site homesites, landfills
- Church Rock Uranium Mill (’75-’82)
  - NPL site since ’83; groundwater cleanup continuing
- 2005 — Navajo Nation Council bans uranium mining and processing in Navajo Country

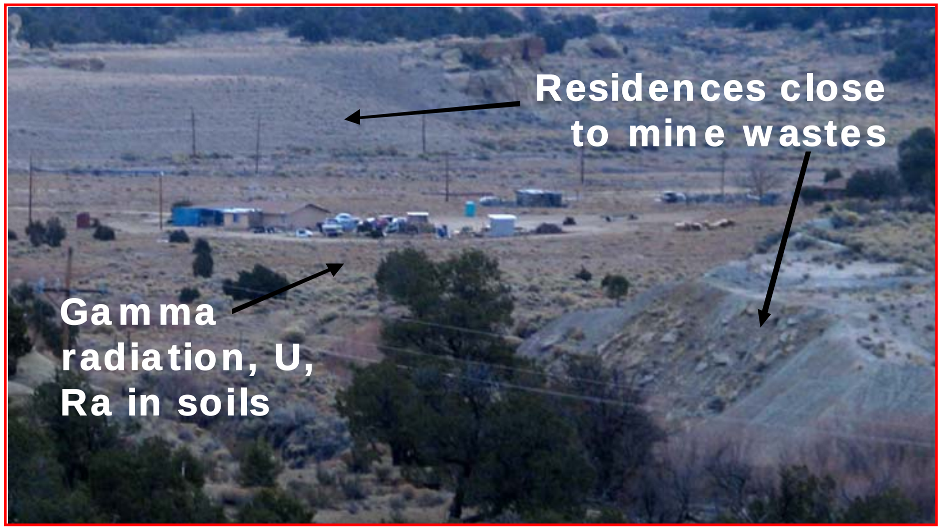
Occupational Exposures

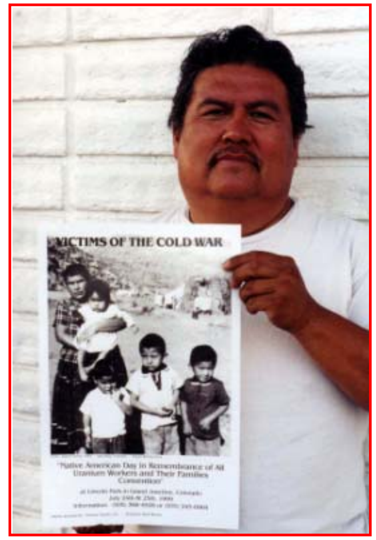
- Lung cancer in Navajo uranium miners 20x-30x greater than in Navajo men who never mined
  - Smoking did NOT account for the large RR (Gilliland, et al., 2000)
- 500-600 Navajo workers died by 1990; another 500-600 expected to have died by 2000 (Brugge & Goble, 2002)

Pneumonconioses (non-malignant respiratory fibrosis)



Community Exposures – air, water, soil

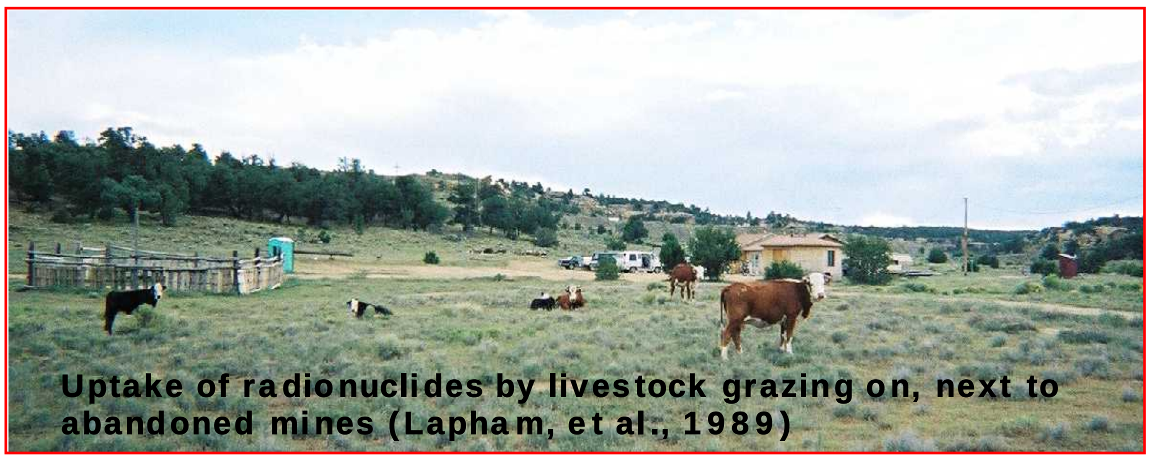




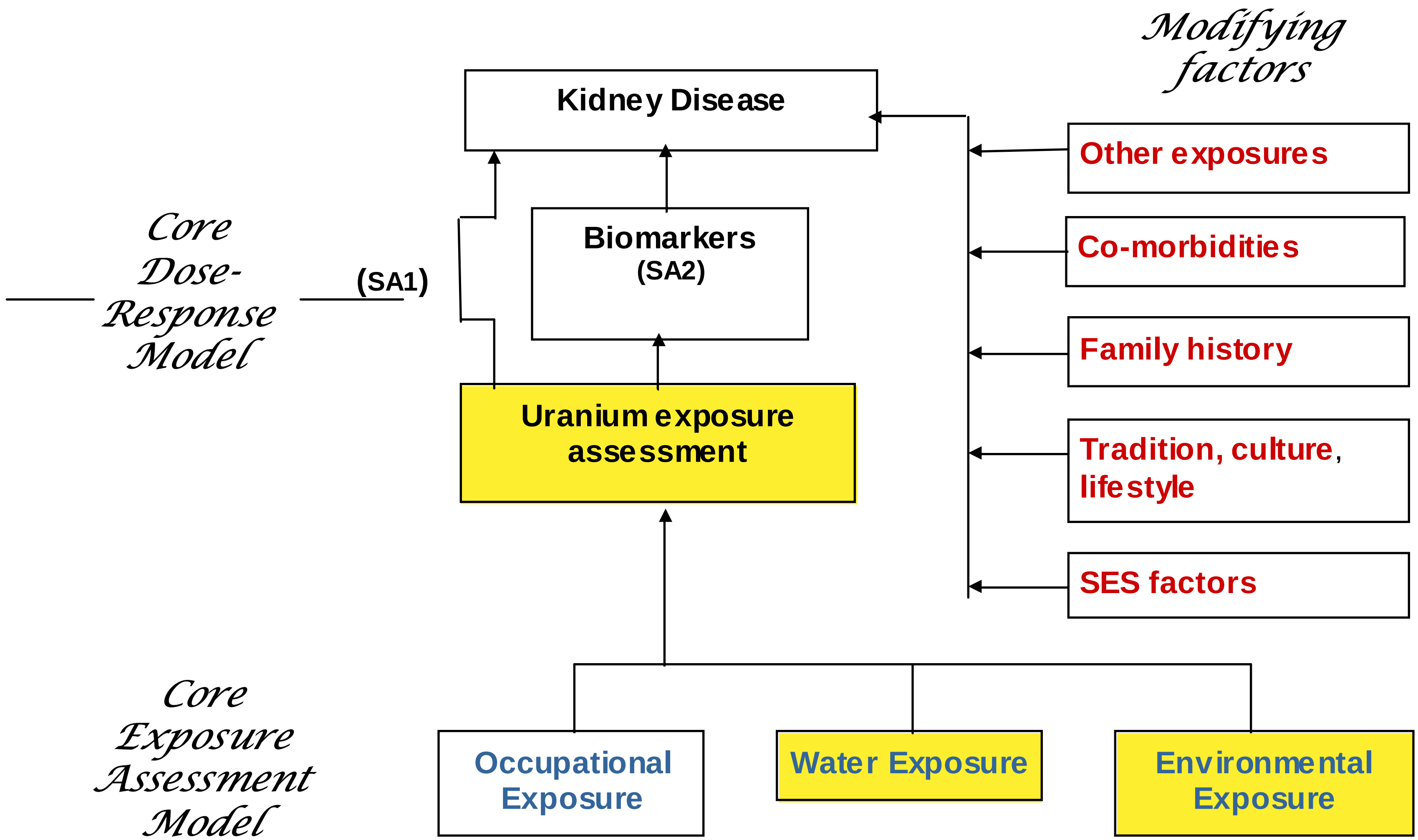
Families of uranium workers lived in mining camps, drank mine water, women exposed to mine, mill dusts

Uranium wastes used in hogan construction

Particulate monitoring near homes, mines

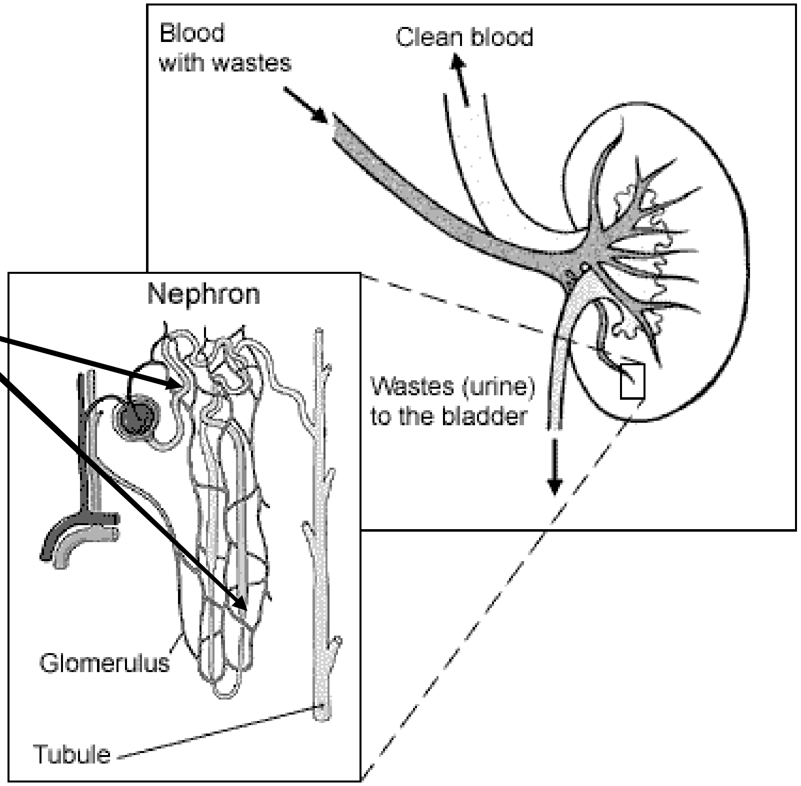


Multilevel Kidney Exposure Risk Model



Looking for Kidney Toxicants

- Chemical effects of uranium well-documented in studies over last 125 years
- U damages proximal, distal tubules of the human kidneys
- Adverse effects shown at *decreasing* U levels in water
- Other heavy metals also kidney toxicants
- What is role of U, other metals in high rates of chronic kidney disease in Eastern Agency?



Water Quality Assessment Program

Focus:

Unregulated water sources: windmills, dug wells, developed springs

Principal collaborators: Church Rock Uranium Monitoring Project, Navajo EPA, NM Environment Dept., USEPA Region IX

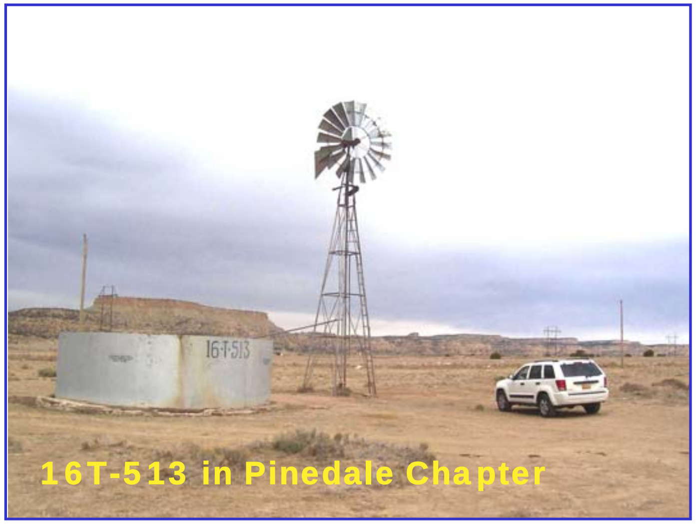
Methods, Testing, Standards

- Field tests with portable equipment
- Lab tests (USEPA Richmond CA lab)
  - General chemistry
  - Heavy Metals (ICPMS)
  - @ EPA-certified labs
- Standard sampling procedures, sample preservation

- We're testing:
  - Trace metals: As, Cd, Cr, Cu, Hg, Ni, Pb, U
  - Other inorganic elements
  - Aesthetic contaminants
- Comparisons:
  - Primary, secondary maximum contaminant levels (USEPA, NN drinking water standards)
- We're NOT testing:
  - Bacteria (e.g., E-coli)
  - Gasoline, petroleum products, hydrocarbons
  - Pesticides
  - Solvents, cleaning fluids
  - Radioactive materials

Field Activities

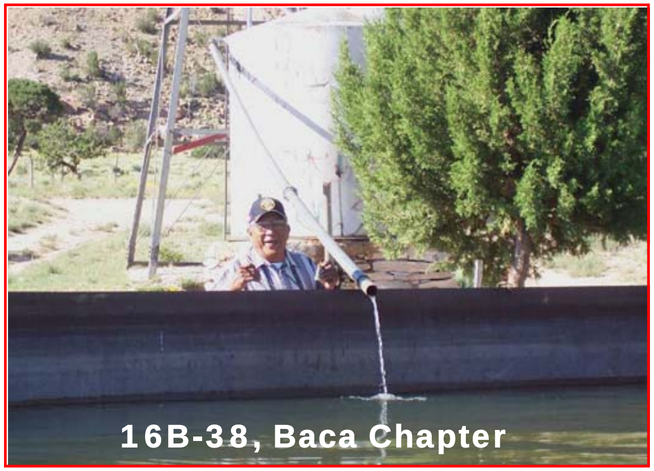
(thru August 2007)



- Located >100 different water sources
  - lat-long, photos
- Compiling existing water quality data
  - Created Access database
  - Added ≈70 water sources
  - Newly tested, sampled 47 (includes 4 ponds)
  - Obtained SDWA data for 11
  - Historic water quality data added to database as needed
- Water sources sampled in 13 of 20 chapters in study area

Water Quality Preliminary Findings

- Arsenic: 12% samples >MCL
- Uranium: 6% samples > MCL
- Radium: 11% samples > MCL
- Gross Alpha: 14% > MCL
- Cd, Cu, Hg, Pb, Ni: no exceedances of MCLs
  - Possible synergistic effects
- High NO_3 levels in some wells indicate effects of animal wastes
- TDS, Fe persistent contaminants
- Need tests for radionuclides, bacteriological contaminants



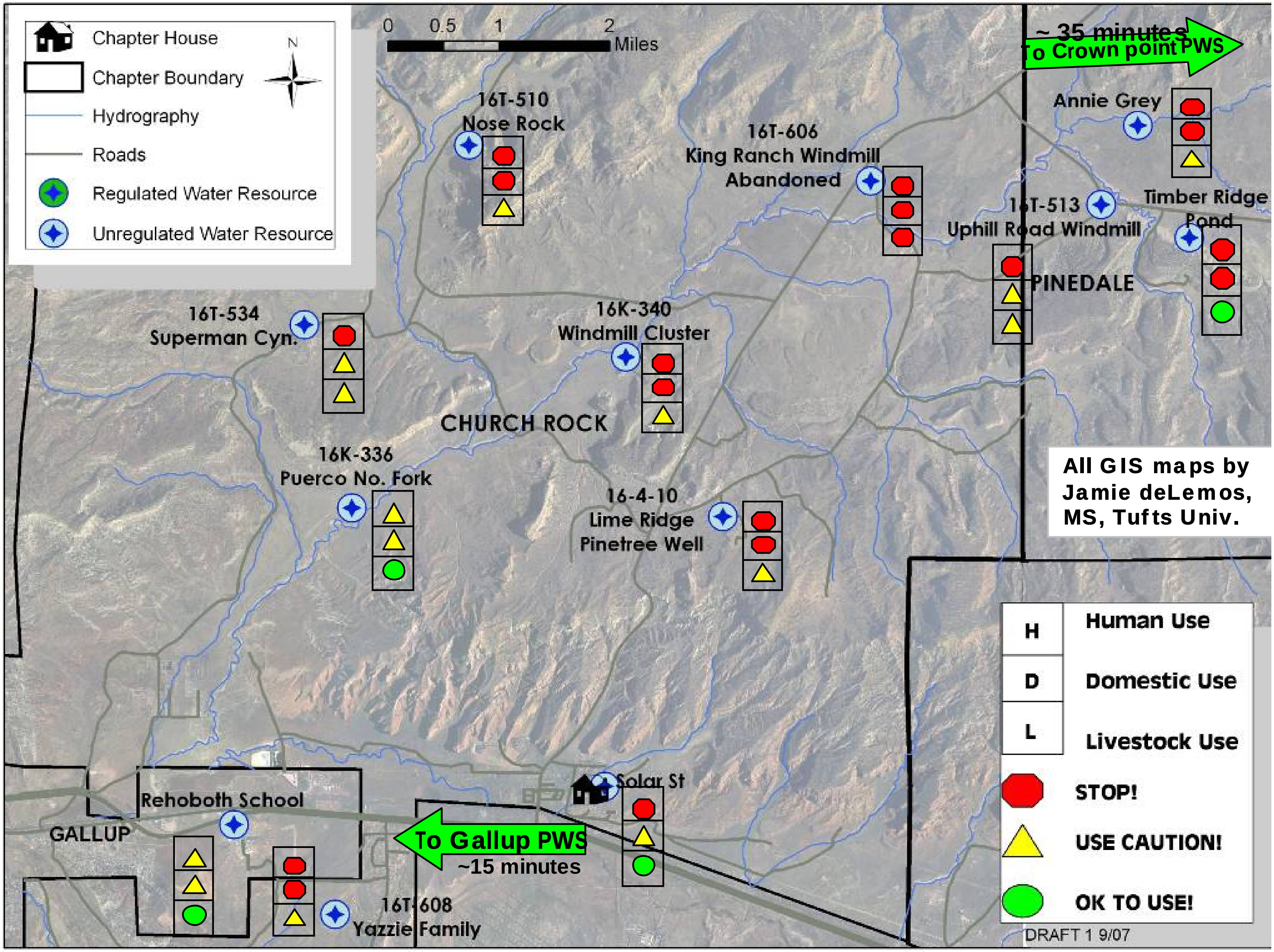
16B-38, Baca Chapter

Tó Adon Spring, Nahodishgish

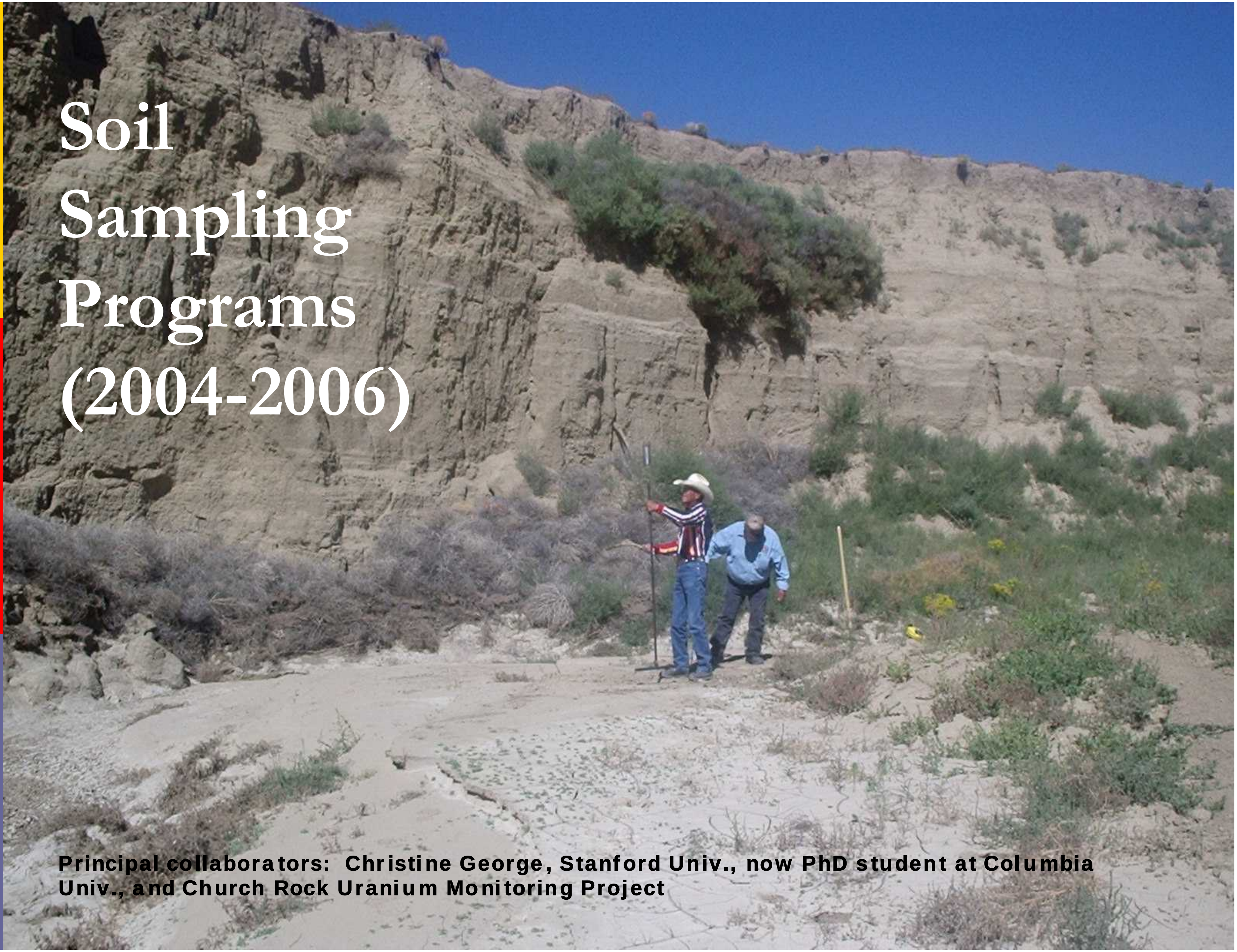
Presentation of Water Data, Use Recommendations

Water Source	Human Drinking*	Domestic Uses	Livestock Use
Annie Grey Well	▲	▲	🟢
Timber Ridge Pond	🛑	🛑	🟢
16T-348	▲	▲	🟢
16T-513	🛑	🛑	▲
16T-514	🛑	▲	🟢
16T-535	▲	🟢	🟢

***No green lights:** Navajo Nation policy discourages use of unregulated water for human consumption



Chapter House
Chapter Boundary
Hydrography
Roads
Regulated Water Resource
Unregulated Water Resource
N
0 0.5 1 2 Miles
~ 35 minutes
To Crown point PWS
16T-510
Nose Rock
16T-606
King Ranch Windmill
Abandoned
Annie Grey
16T-513
Uphill Road Windmill
Timber Ridge
Pond
PINEDALE
16T-534
Superman Cyn.
16K-340
Windmill Cluster
CHURCH ROCK
16K-336
Puerco No. Fork
16-4-10
Lime Ridge
Pinetree Well
All GIS maps by
Jamie deLemos,
MS, Tufts Univ.
H
Human Use
D
Domestic Use
L
Livestock Use
STOP!
USE CAUTION!
OK TO USE!
Rehoboth School
GALLUP
To Gallup PWS
~15 minutes
Solar St
16T-608
Yazzie Family
DRAFT 1 9/07

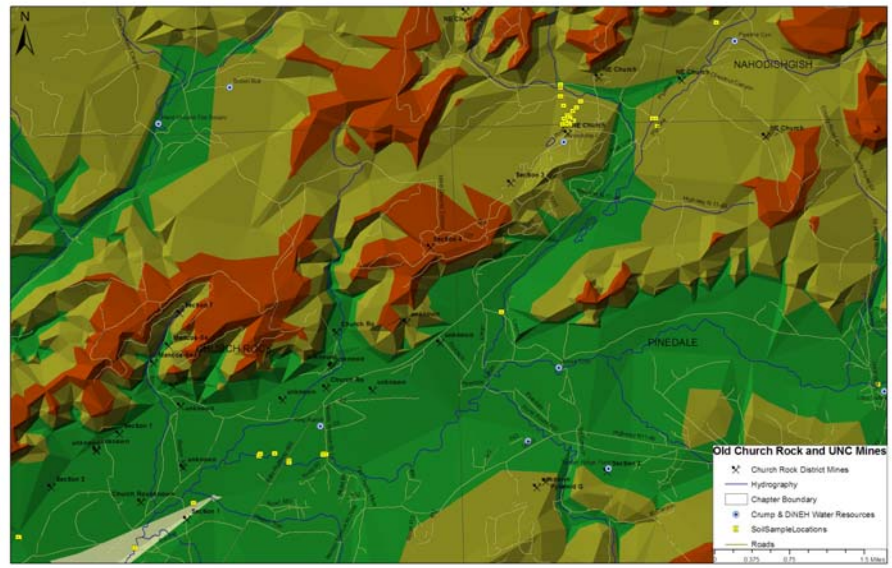


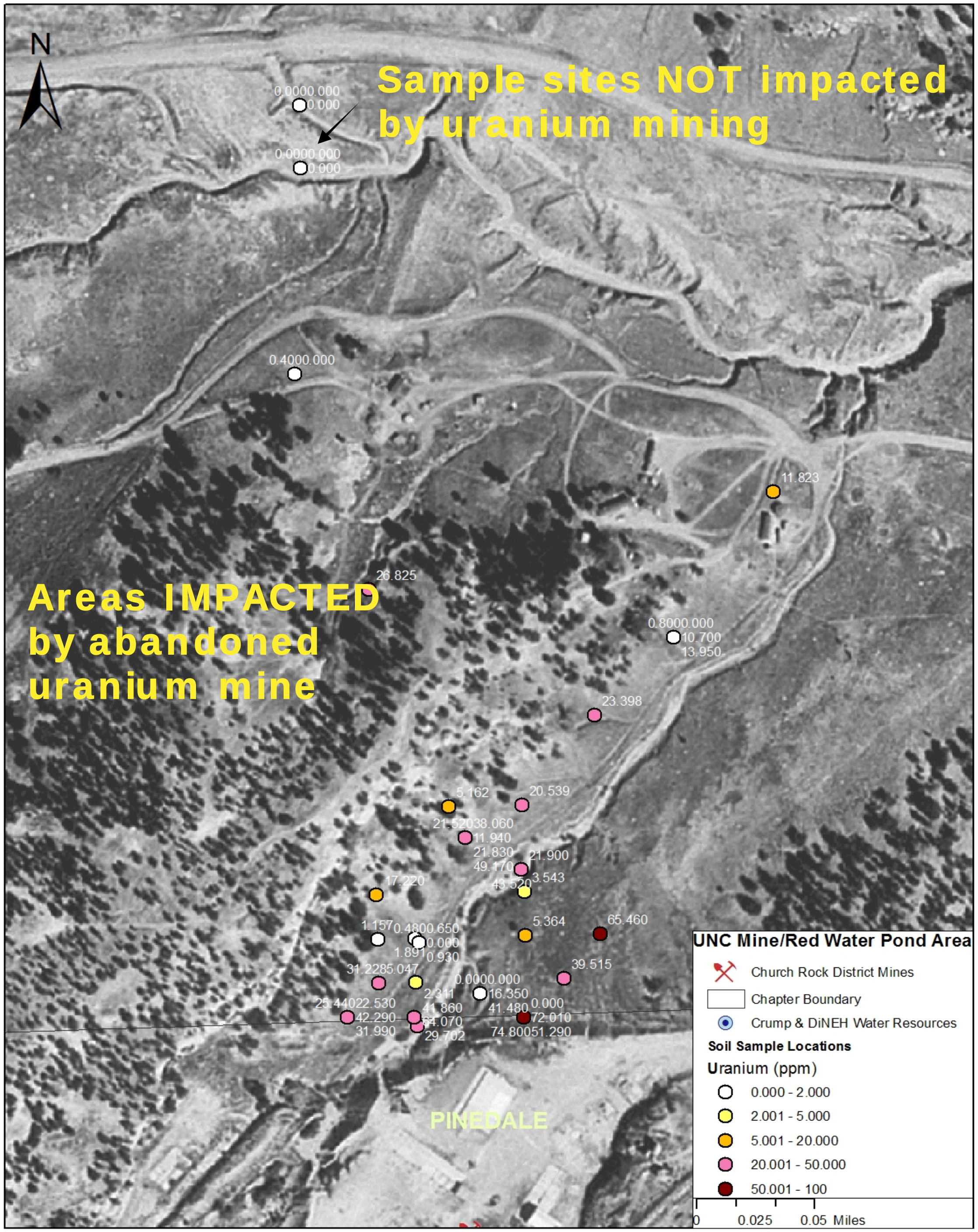
Soil Sampling Programs (2004-2006)

Principal collaborators: Christine George, Stanford Univ., now PhD student at Columbia Univ., and Church Rock Uranium Monitoring Project

Soil Sampling for Uranium, Other Metals

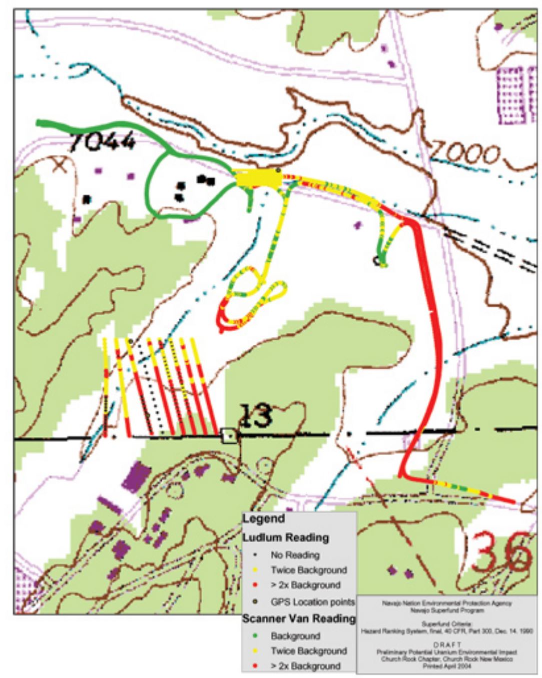
- Purpose
  - Obtain environmental data for predictive exposure model
  - Determine “background”
- Sampling sites
  - native soils, unaffected by uranium wastes
  - soils impacted by uranium mine wastes, discharges
  - varied topography
- Sampling methods:
  - Hand augers to dig holes
  - Depths: 2”, 8”, 18”, 36”
  - Lat-longitude coordinates
  - Samples analyzed at Stanford Univ. lab





Red Water Pond Road Area

- Heavily impacted by two uranium mines
- Sampled in December 2004, Summer 2005
- Supplemented gamma surveys, 2003-2004



Uranium in Soils:

Non-impacted, Possibly-impacted sites

Sampling Sites	# Samples	Range U in Soils (ppm)	Median (ppm)
Sites NOT impacted by uranium mining	16	0.3-1.83*	
Sites POSSIBLY impacted by uranium mining	52	0.31-2.61*	
IMPACTED site (Red Water Pond Rd.) (2"-12")	38	0.3-88.7	**16.8**
IMPACTED site (Red Water Pond Rd.) (18"-36")	12	0.48-72.0	**31.8**
USEPA Preliminary Remediation Goal (residential)	**56%**		16.0
Crustal average uranium, max. local background	**72%**		3.0
USEPA Radium-in-soils, RWPR area (2006-2007)	**263**	Mean Ra = 30.7 pCi/g (crustal ave. = 1.0)	

Geochemical controls on uranium mobility in the Church Rock Uranium Mining District

- **Purpose:** Link sediment data to a predictive exposure model
- **Objective:** Use mechanistic and kinetic information to inform health exposure assessment
- **Method:** Combine experimental measurements from sediment sampling with survey information from participants living in those areas and analyze in a multi-level risk model (logistic regression)
- **Setting:** Flash flooding of arroyos in Churchrock area, August 2006

Principal collaborator: Jamie deLemos, MS, doctoral student at Tufts Univ.

Geochemical relationships to inform exposure assumptions

Valence:

What form is uranium in?

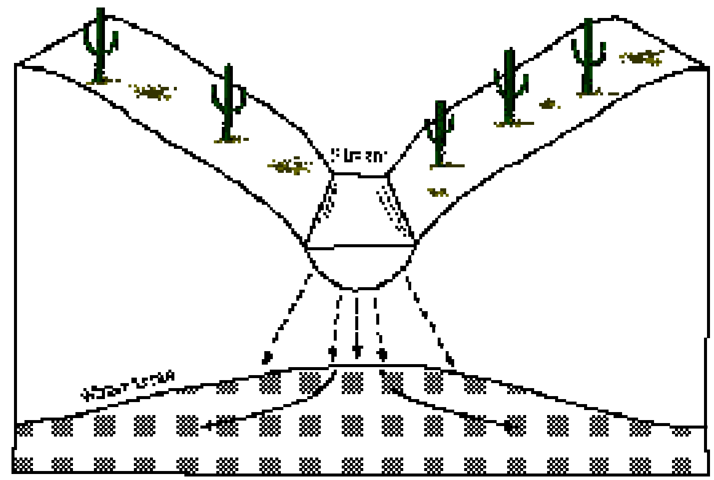
U^{+4} or U^{+6}

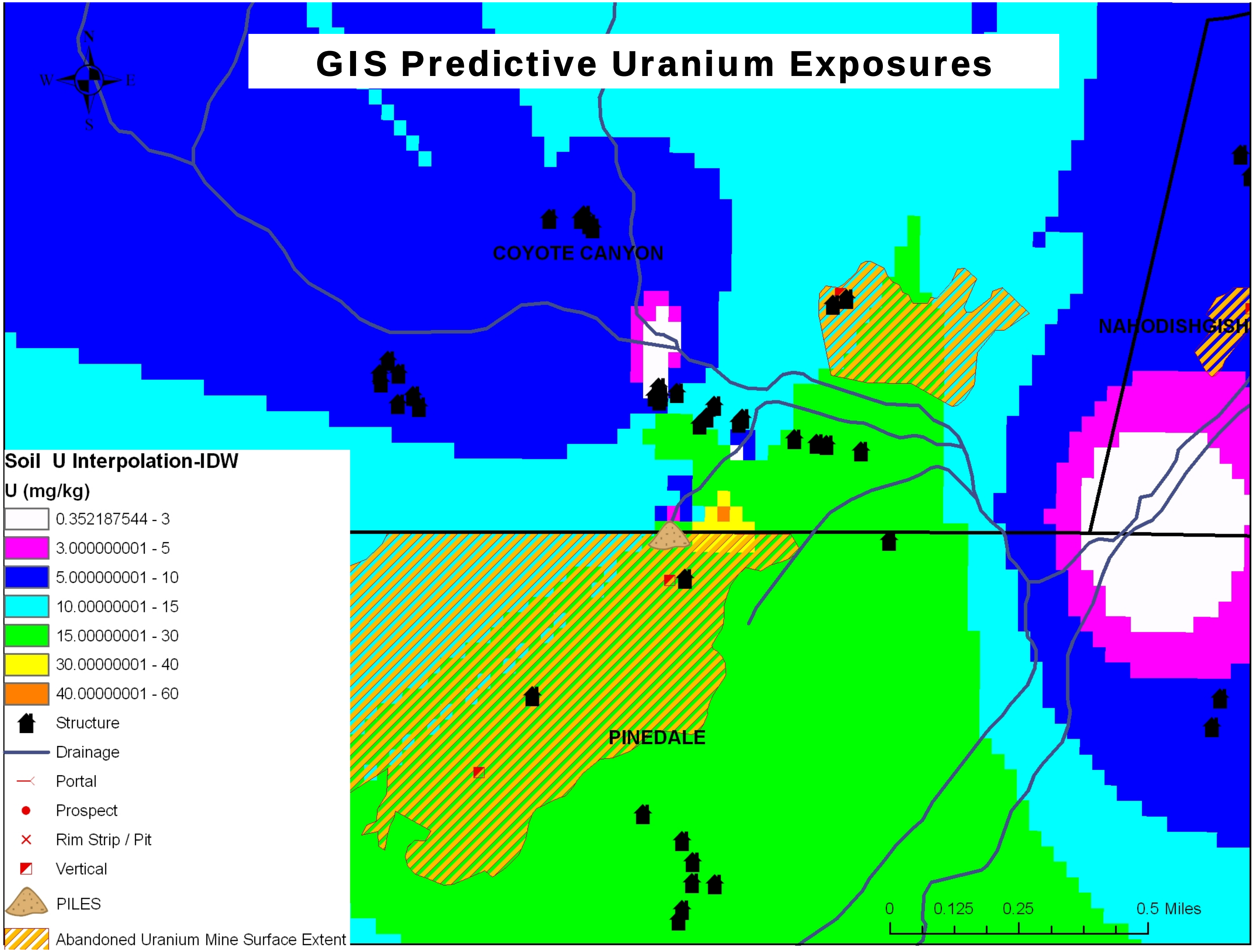
Solubility and Kinetics

Does it dissolve slowly or quickly?

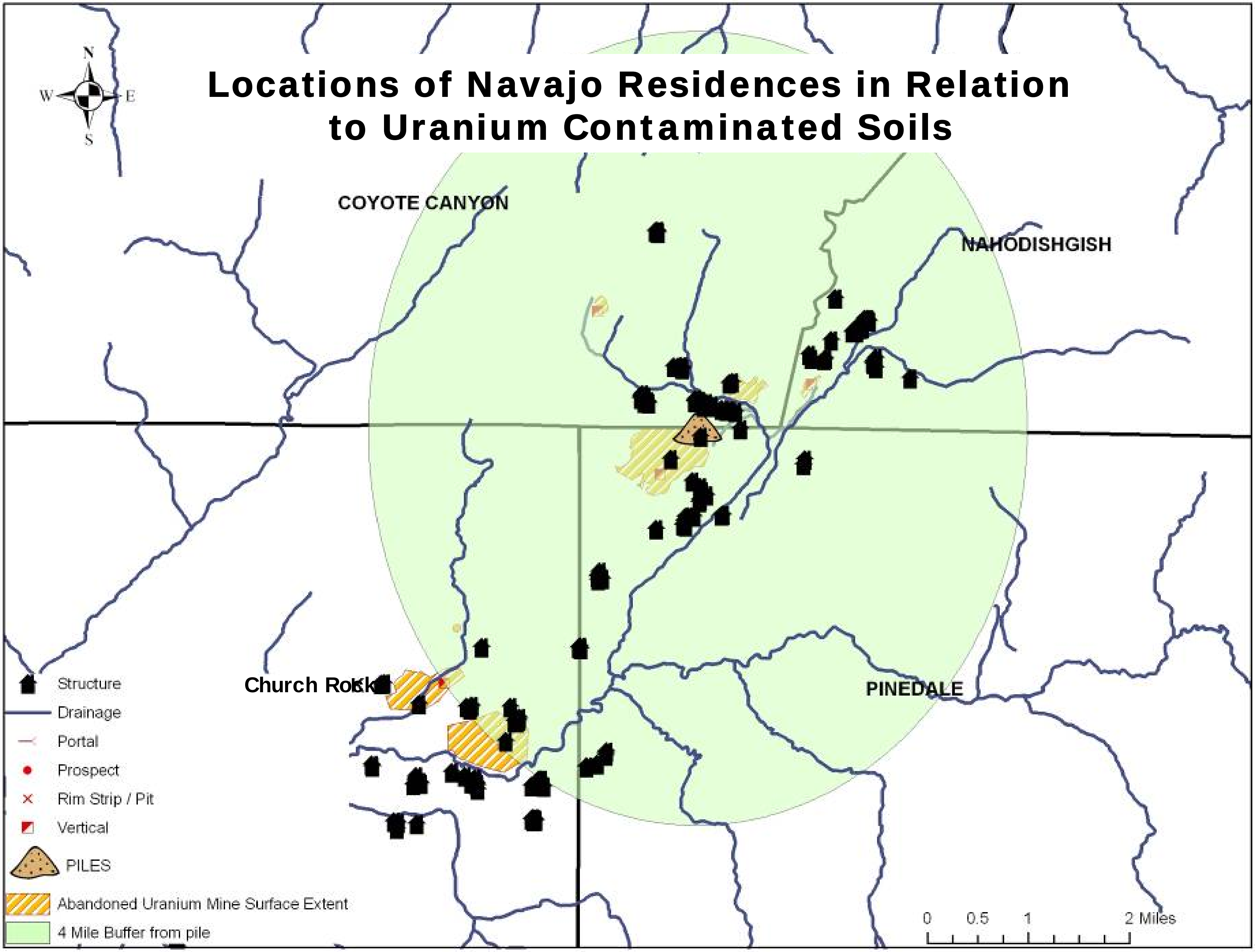
Transport

Where does it go?




GIS Predictive Uranium Exposures
N
S
E
W
COYOTE CANYON
NAHODISHGISH
PINEDALE
Soil U Interpolation-IDW
U (mg/kg)
0.352187544 - 3
3.000000001 - 5
5.000000001 - 10
10.00000001 - 15
15.00000001 - 30
30.00000001 - 40
40.00000001 - 60
Structure
Drainage
Portal
Prospect
Rim Strip / Pit
Vertical
PILES
Abandoned Uranium Mine Surface Extent
0
0.125
0.25
0.5 Miles

Locations of Navajo Residences in Relation to Uranium Contaminated Soils



Findings of uranium mobility studies

- U^{+6} easily dissolved
  - absorbed in GI tract!
- No difference between impacted and non-impacted sites in surface water U
  - moves with first flush
- U migrating downward in soil column
  - threatens groundwater quality
- Consistent with U-in-soil findings
- Used in exposure model soil predictions

Acknowledgements

- This work would not be without the dedication of our survey team and others who travel tirelessly the long distances necessary to conduct interviews, to take the GPS coordinates of homes and wells, and to collect the soil, sediment, water and air samples upon which our exposure assessment depends.