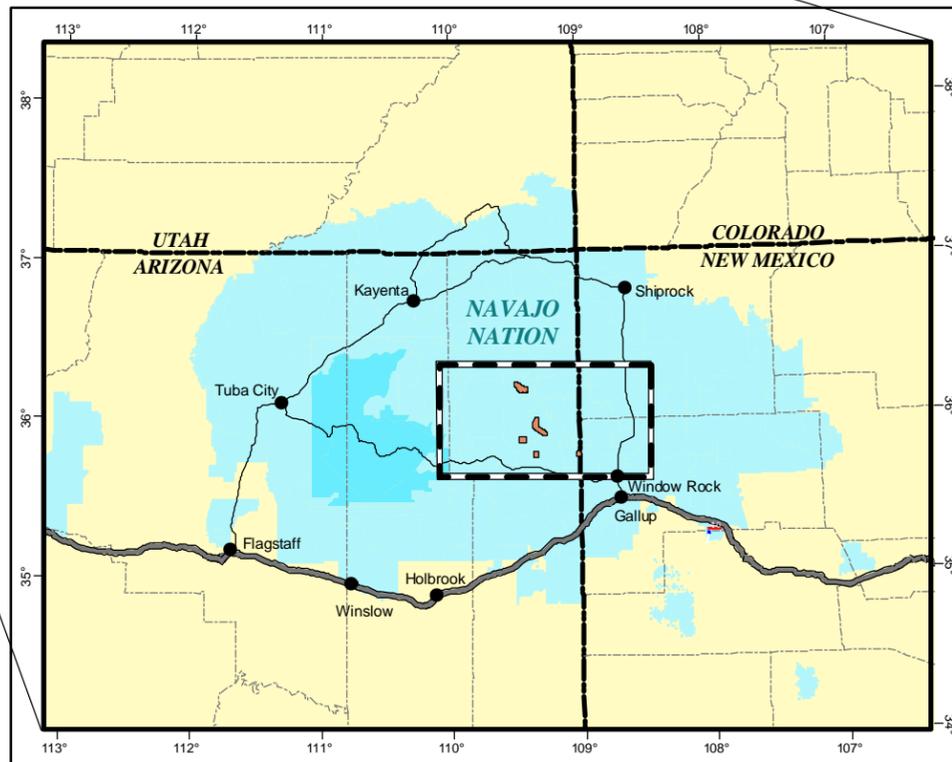
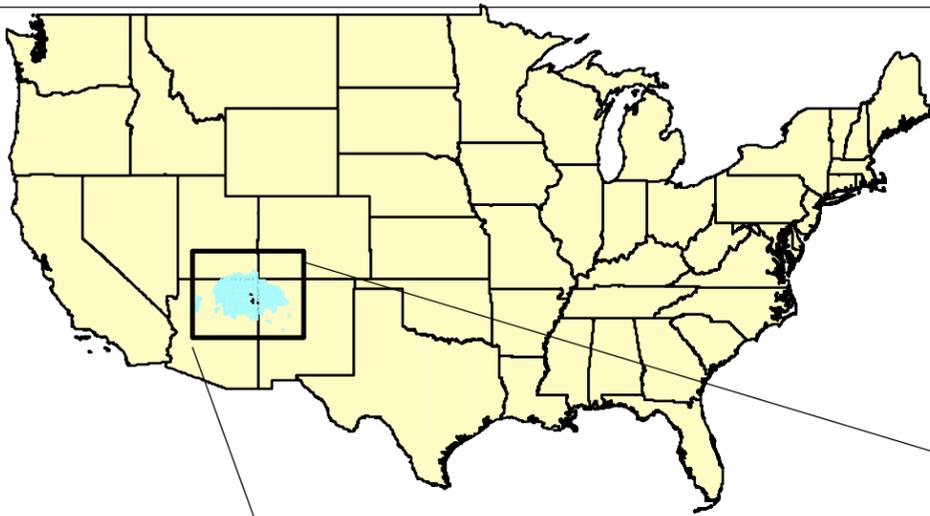


## Section 5

# CHINLE AREA



United States Environmental Protection Agency  
**ABANDONED URANIUM MINES PROJECT**  
**Chinle Area**  
**OVERVIEW MAP**



Fluted Rock Well



Tsegito Spring



Cottonwood Spring

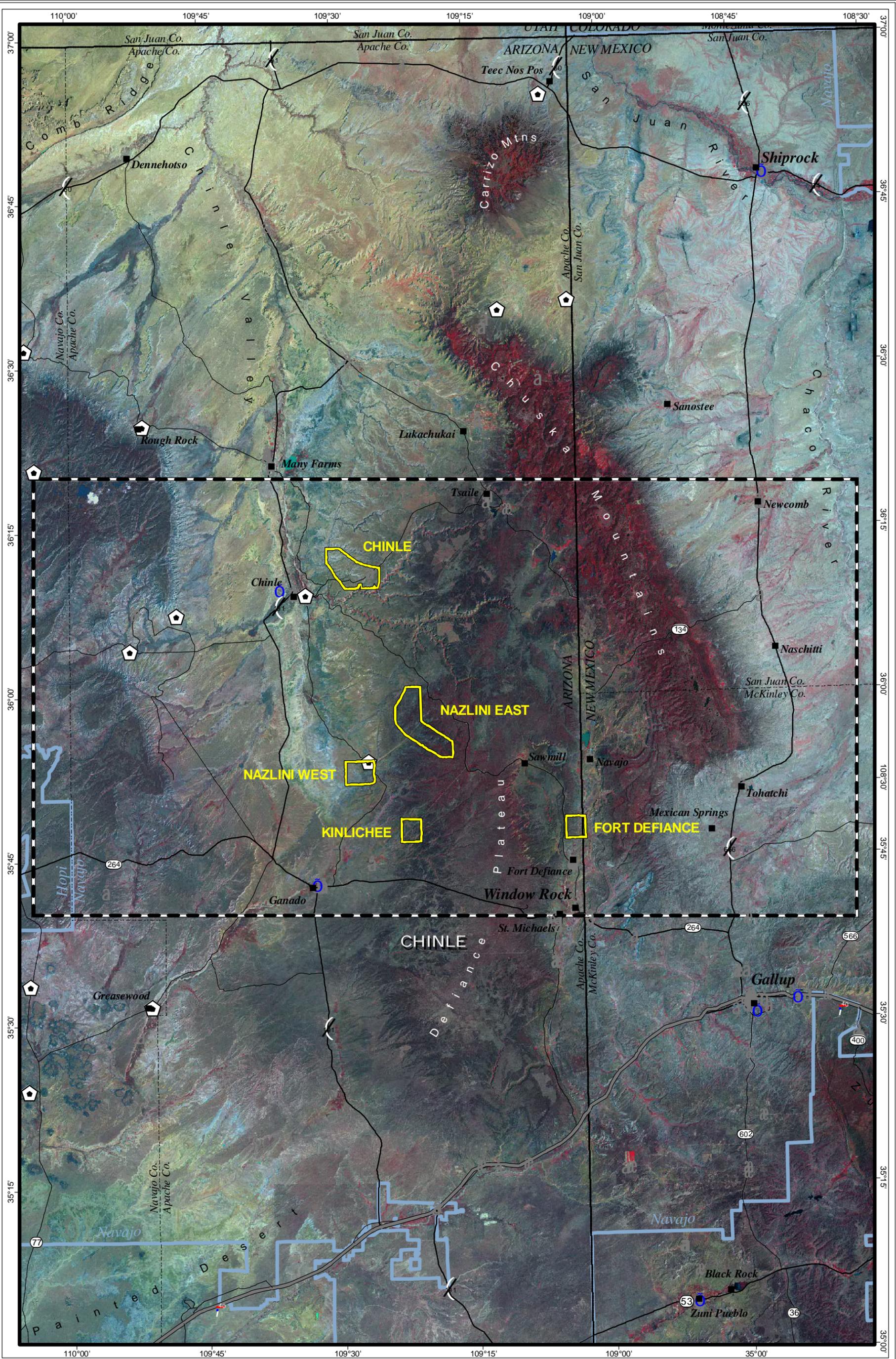


Tank 10K-236

The Chinle area is located on the central - eastern edge of Arizona and central-western edge of New Mexico. Some of the physiography of the area is shown above in photos taken by Glynn Alsup (USACE).

The overview map shown on the facing page provides the map extent boundary for the Chinle study area maps presented in Section 5. Five aerial radiation surveys were flown in the Chinle area: Chinle, Nazlini East, Nazlini West, Kinlichee, and Fort Defiance.

Water samples from 10 sites were collected in the Chinle area.

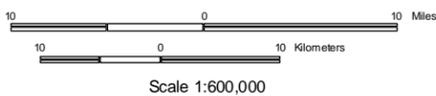


MAP FEATURES

-  Map Extent Boundary
-  Aerial Survey Boundary

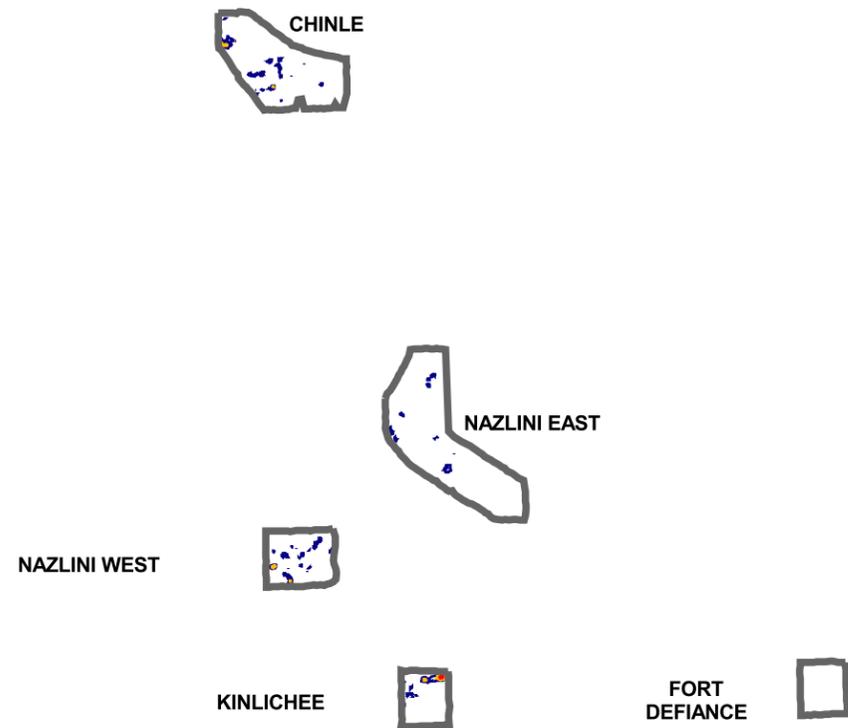
**4**

**OVERVIEW MAP**



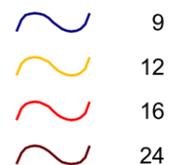
U.S. Environmental Protection Agency  
**ABANDONED URANIUM  
 MINES PROJECT**  
**Chinle Area**

AERIAL RADIATION CONTOURS - GROSS COUNT



Aerial Radiation Contours

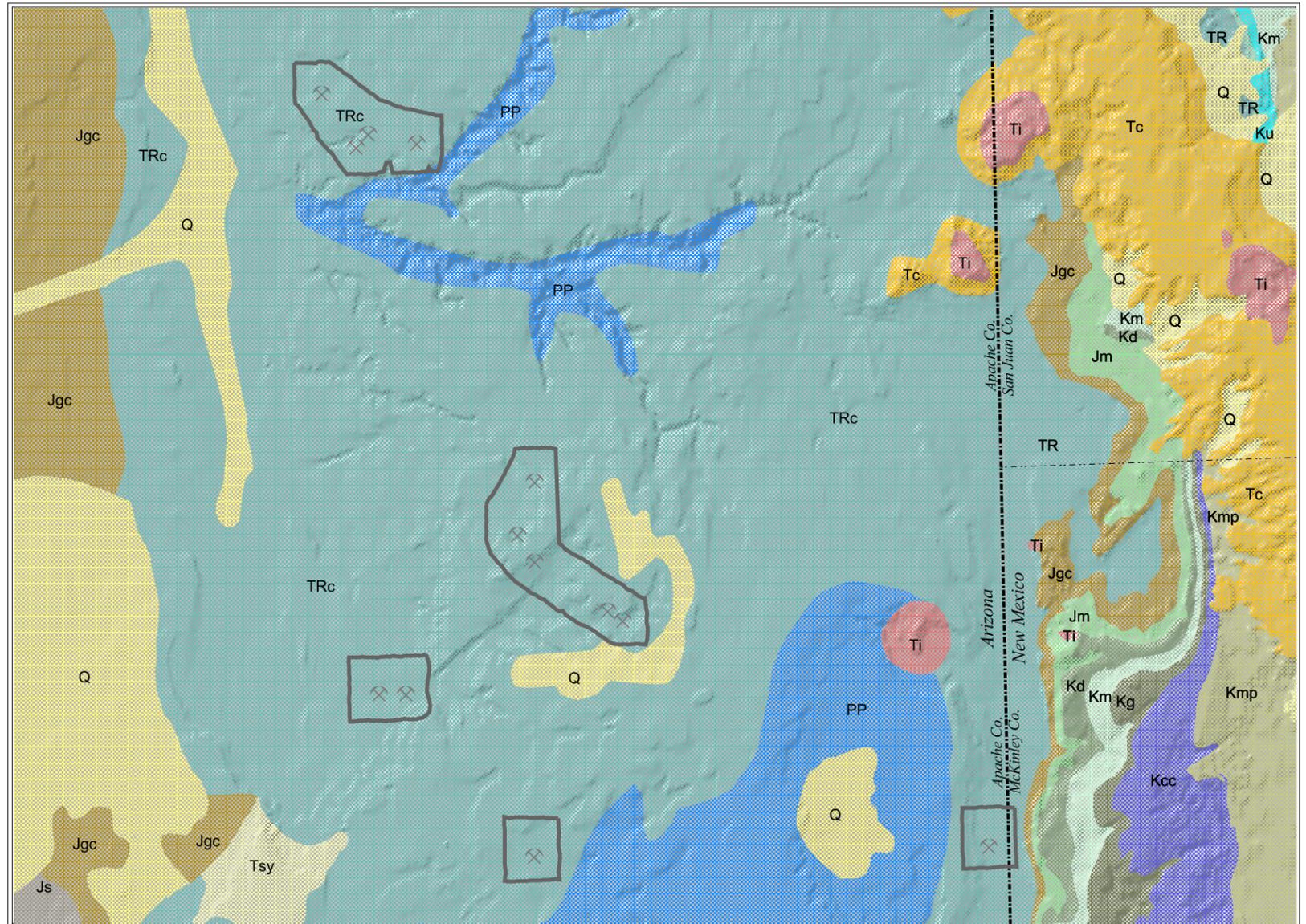
Derived terrestrial exposure rate at 1 meter above ground level. Does not include cosmic contribution (units: excess micro-R/hour)



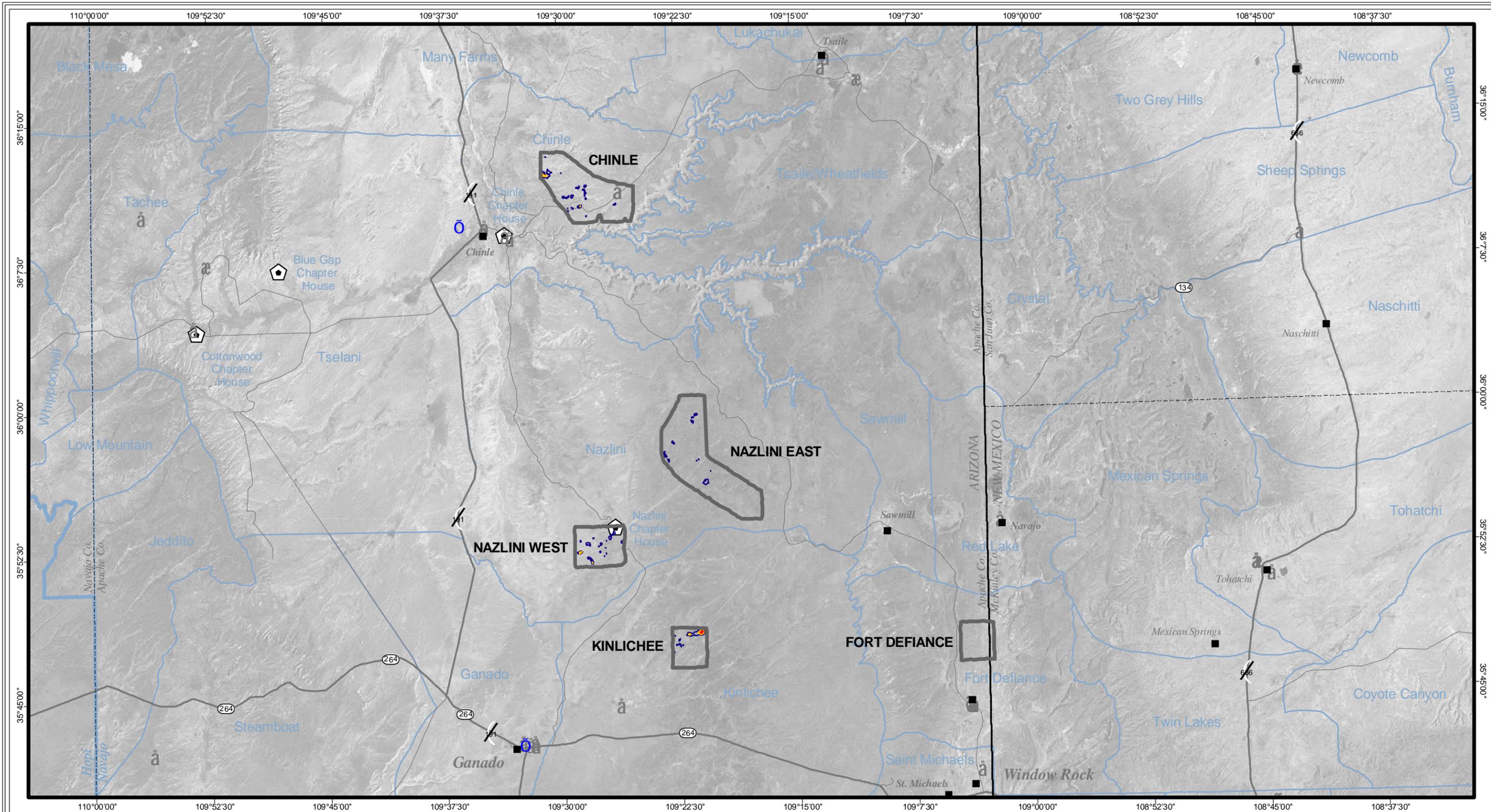
Aerial radiation contour values were compiled by Thane Hendricks, Department of Energy - Remote Sensing Laboratory. Units are in micro-Roentgens per hour. Derived from the total observed gamma spectrum. At the survey altitude of 150 feet, the footprint of the detection system is a circle approximately 300 feet in diameter. The data shown on this map are averages over this footprint at ground level.

Geological Units (Age and Unit Description)

<b>Q</b> Quaternary Alluvium and Colluvium	<b>Ku</b> Upper Cretaceous, undivided	<b>Kd</b> Cretaceous Dakota Sandstone
<b>Ti</b> Tertiary Intrusives and Volcanics	<b>Kmp</b> Cretaceous Menefee Formation	<b>Js</b> Jurassic San Rafael Group
<b>Tc</b> Tertiary Chuska Sandstone	<b>Km</b> Cretaceous Mancos Shale	<b>Jgc</b> Jurassic Glen Canyon Group
<b>Tsy</b> Early Tertiary Sedimentary Rocks	<b>Kg</b> Cretaceous Gallup Sandstone	<b>TRc</b> Triassic Chinle Formation
	<b>Kcc</b> Cretaceous Crevasse Canyon Formation	<b>PP</b> Permian to Pennsylvanian Sedimentary Rocks



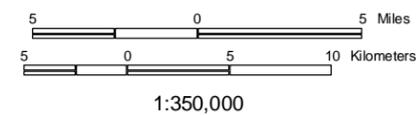
Sources: Aerial survey boundaries are from the Department of Energy, Remote Sensing Laboratory, Las Vegas, Nevada. Geological information from the Geologic Map of Arizona, GIS database (Richard and Kneale, 1997), and the Digital Geologic Map of New Mexico in ARC/INFO Format (Green and Jones, 1997). Uranium mine locations shown above are approximate and were compiled from various sources by Thane Hendricks, Department of Energy, Remote Sensing Laboratory.



See facing page for legend

# 4

## AERIAL RADIATION CONTOURS GROSS COUNT



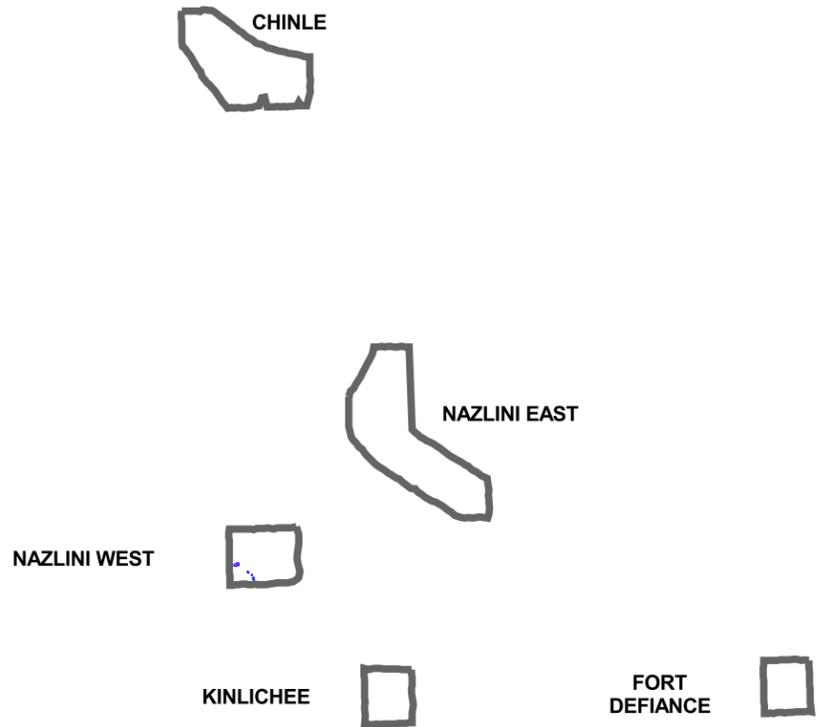
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MINES PROJECT

**Chinle Area**

CHINLE AREA  
AERIAL RADIATION CONTOURS - BISMUTH 214



5.6



Aerial Radiation Contours	Derived contour-level Bismuth 214 photo-peak (excess counts per second)	Estimated exposure rate from excess Bismuth 214 (excess micro-R/hour)
	80	3.5
	170	7.4
	250	10.9
	800	34.9
	1200	52.4

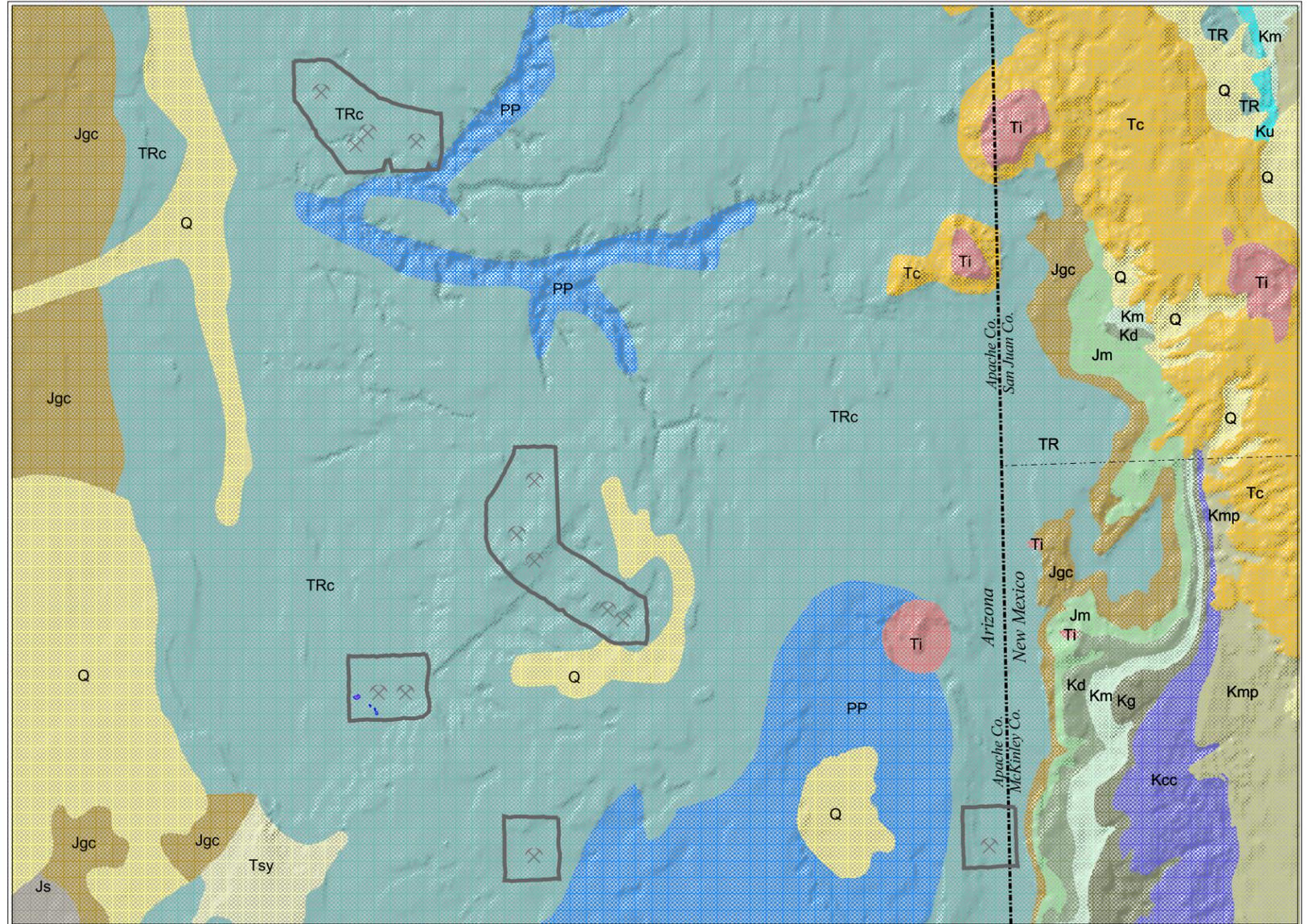
Aerial radiation gross count contours are indicative of uranium concentrations higher than the regional levels.

Units are in micro-Roentgens per hour. The Bismuth 214 photo peak is at 1760 KeV. At the survey altitude of 150 feet above ground level, the footprint of the detection system is a circle approximately 300 feet in diameter. The data shown are averages over this footprint at ground level.

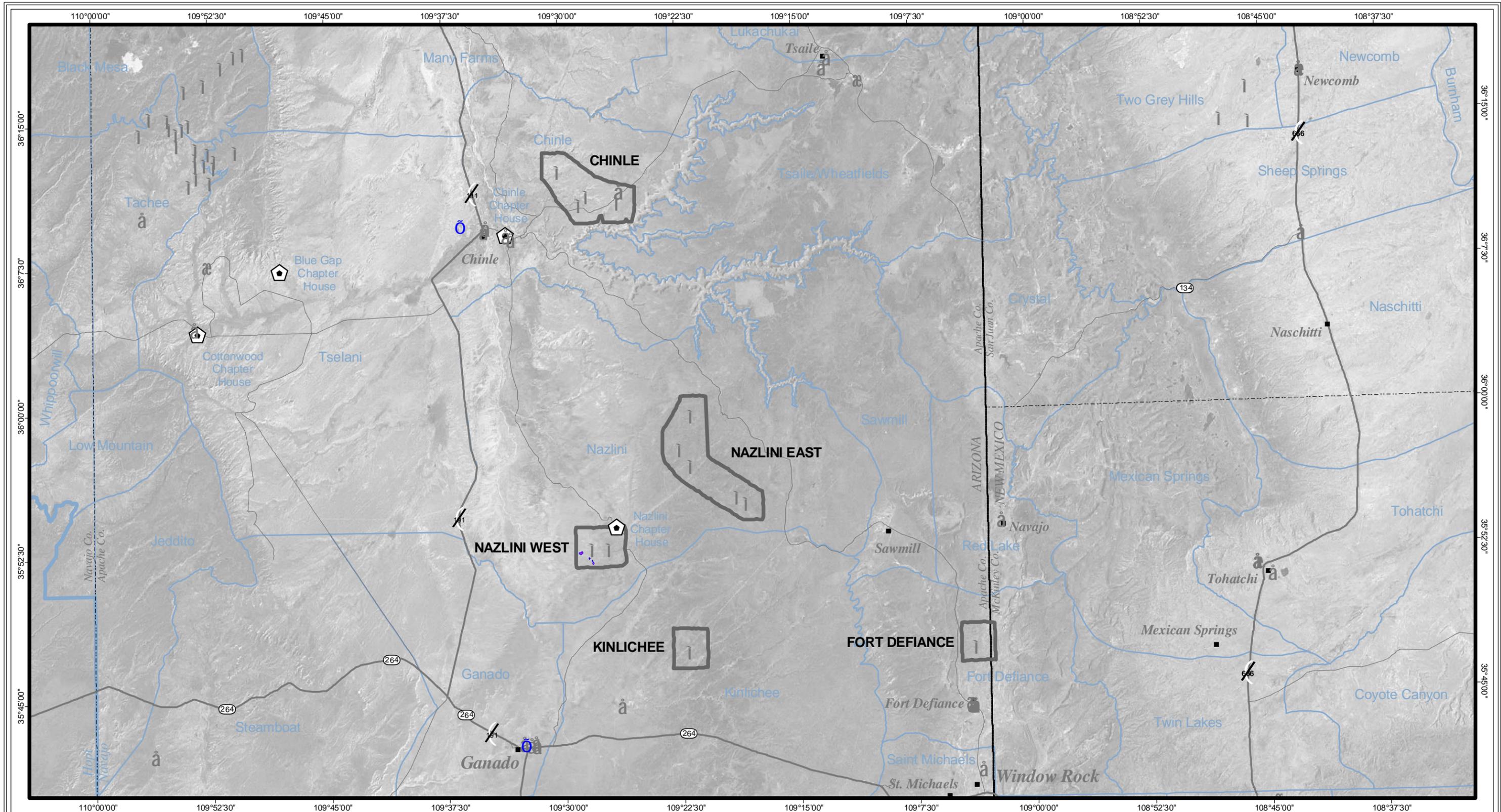
Derived and estimated values were compiled by Thane Hendricks, Department of Energy, Remote Sensing Laboratory, Las Vegas.

Geological Units (Age and Unit Description)

- Quaternary Alluvium and Colluvium
- Upper Cretaceous, undivided
- Cretaceous Dakota Sandstone
- Tertiary Intrusives and Volcanics
- Cretaceous Menefee Formation
- Jurassic San Rafael Group
- Tertiary Chuska Sandstone
- Cretaceous Mancos Shale
- Jurassic Glen Canyon Group
- Early Tertiary Sedimentary Rocks
- Cretaceous Gallup Sandstone
- Triassic Chinle Formation
- Cretaceous Crevasse Canyon Formation
- Permian to Pennsylvanian Sedimentary Rocks



Sources: Aerial survey boundaries are from the Department of Energy, Remote Sensing Laboratory, Las Vegas, Nevada. Geological information from the Geologic map of Arizona, GIS database, edited by S.M. Richard, 1997. Uranium mine locations shown above are approximate and were compiled from various sources by Thane Hendricks, Department of Energy, Remote Sensing Laboratory.

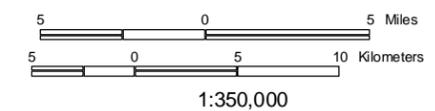


5.7

MAP FEATURES  
 — Aerial Survey Boundary

# 4

## AERIAL RADIATION CONTOURS BISMUTH 214

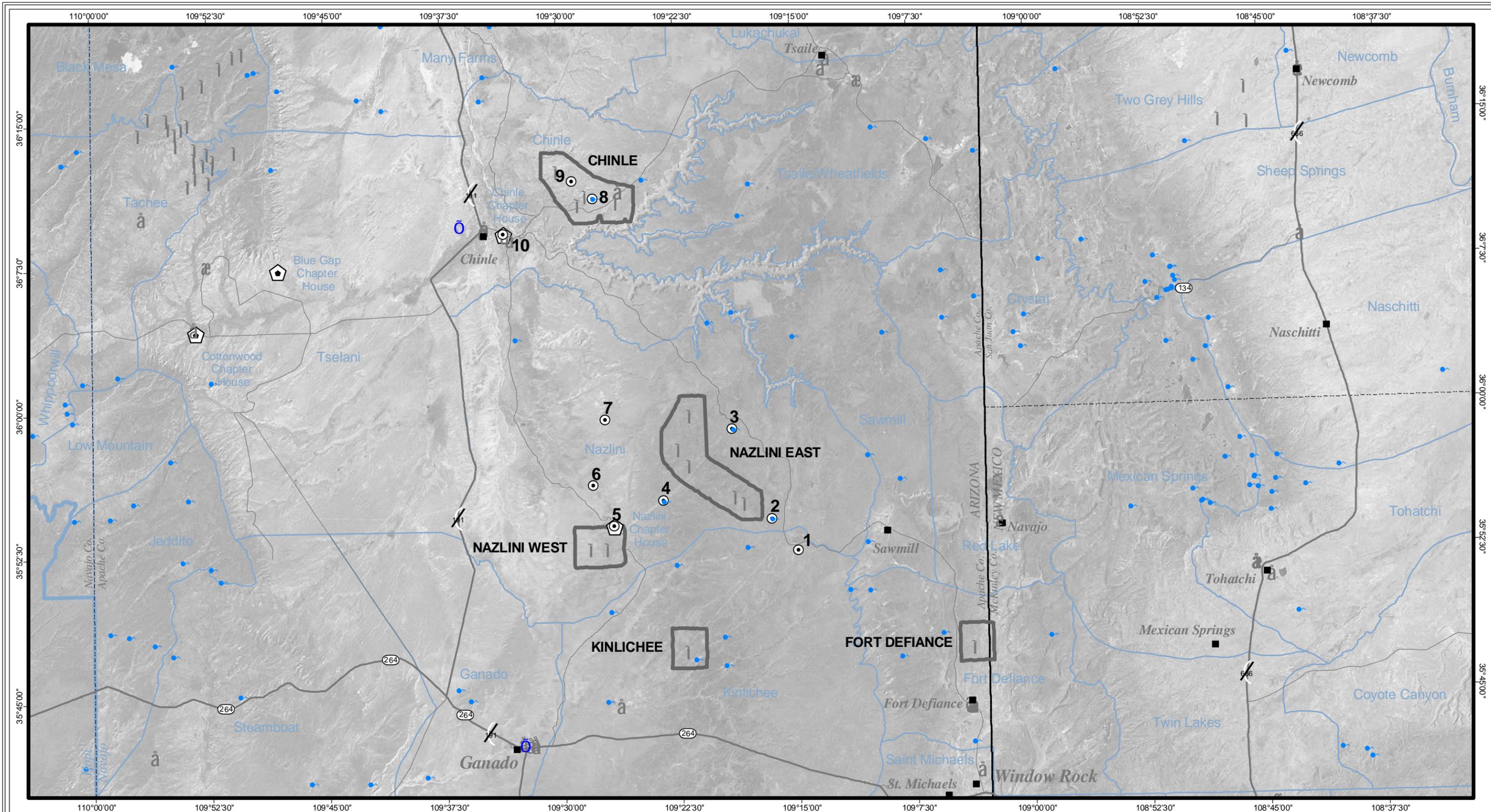


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 ABANDONED URANIUM  
 MINES PROJECT  
**Chinle Area**



**WATER SAMPLE INFORMATION**

Map ID	Sample ID	Field Type	Sample Name	Longitude (DMS) (W)	Latitude (DMS) (N)	Elevation (ft)	Sample Date	Sample Time
1	CH981117NZW003	Well	Fluted Rock Well	109 14 55.453	35 52 35.4647	7777	11/17/98	4:33 PM
2	CH981118NZS004	Spring	White Rock Spring	109 16 33.746	35 54 14.8859	7771	11/18/98	4:07 PM
3	CH981118NZS003	Spring	Honeymoon Spring	109 19 2.1587	35 58 55.0020	7212	11/18/98	9:45 AM
4	CH981117NZS001	Spring	Tsegito Spring	109 23 30.523	35 55 15.5093	6507	11/17/98	11:37 AM
5	CH981117NZW001	Well	Nazlini Chapter House	109 26 41.176	35 53 56.5847	6177	11/17/98	8:57 AM
6	CH981117NZS002	Spring	WSL Spring	109 27 57.906	35 56 4.75141	5979	11/17/98	2:12 PM
7	CH981117NZW002	Well	Tank 10R-24	109 27 8.6640	35 59 29.5487	6309	11/17/98	3:14 PM
8	CH981123CHS001	Spring	Cottonwood Spring	109 27 45.920	36 10 58.8600	6133	11/23/98	9:50 AM
9	CH981123CHW002	Wind Mill	Tank 10K-236	109 29 6.3989	36 11 53.0261	6154	11/23/98	1:15 PM
10	CH981123CHW001	Well	Chinle Chapter House	109 33 32.302	36 9 10.62241	5443	11/23/98	8:39 AM



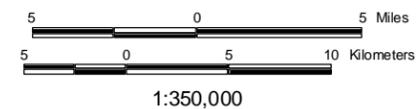
6.9

**MAP FEATURES**

- Water Sample Site
- Spring (GNIS) used in project planning
- | Mine or Mineral occurrence (MRDS and MILS) used in project planning

**4**

**WATER SAMPLE LOCATIONS**



U.S. Environmental Protection Agency  
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 MINES PROJECT**  
**Chinle Area**

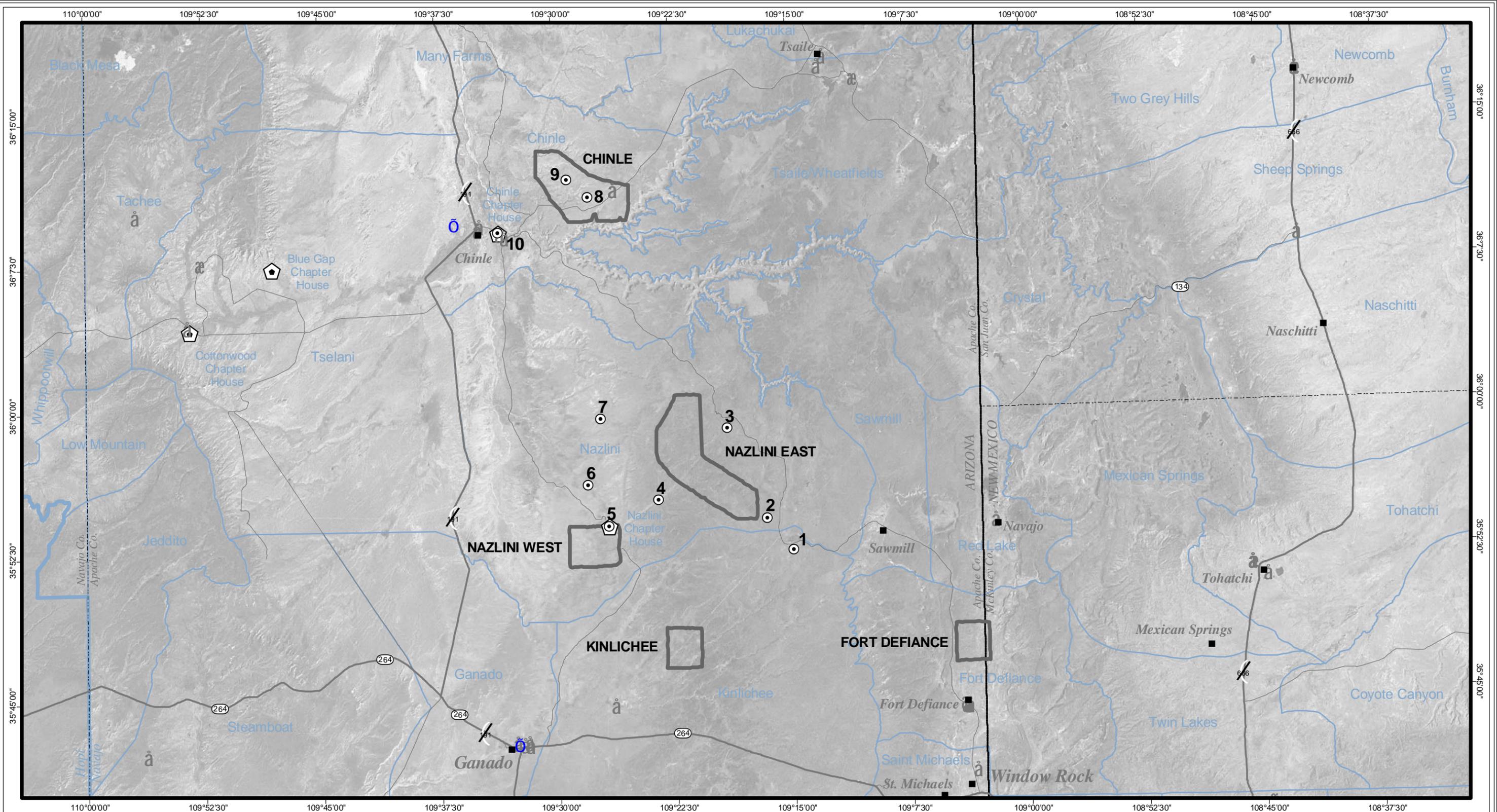


WATER SAMPLE ANALYSIS FOR STABLE METALS

Map ID	Sample ID	Sample Name	Al	Sb <sup>2</sup>	As <sup>2,4</sup>	Ba	Be <sup>2,4</sup>	Cd <sup>2,4</sup>	Cr <sup>2,5</sup>	Cu <sup>2</sup>	Fe <sup>2</sup>	Pb <sup>2</sup>	Mn <sup>2</sup>	Hg <sup>2</sup>	Ni <sup>2</sup>	Se <sup>2</sup>	Ag <sup>2</sup>	Th <sup>2,5</sup>	V <sup>2</sup>	Zn <sup>2</sup>	ILCRsta <sup>1,7</sup>	HI <sup>3,6</sup>
		Primary MCLs in Micrograms per Liter (µg/L) <sup>7</sup>	1000	6	50	1000	4	5	100	1300	300	15	50	2	None	50	100	2	None	5000		
		PRG Limits in Micrograms per Liter (µg/L) <sup>8</sup>	37000	15	0.045	2600	73	18	180	1400	1100	4	1700	11	730	189	180	2.6	260	11000		
1	CH981117NZW003	Fluted Rock Well	60.4	0	0	79.2	0	0	0	15.9	182.0	0	5.4	0.072	0	2.7	0	0	0	113.0	0.00E+00	0.09
2	CH981118NZS004	White Rock Spring	66.2	0	0	374.0	0	0	0	0	62.9	0	128.0	0.250	0	0	0.7	0	0	10.6	0.00E+00	0.25
3	CH981118NZS003	Honeymoon Spring	81.8	0	0	246.0	0	0	0	0	591.0	2.5	863.0	0.067	0	0	0	4.1	1.1	126.0	0.00E+00	2.26
4	CH981117NZS001	Tsegito Spring	79.0	0	0	271.0	0	0	0	0	16.5	0	8.2	0.063	0	0	0	0	3.6	2.2	0.00E+00	0.13
5	CH981117NZW001	Nazlini Chapter House	75.0	0	2.7	115.0	0	0	0	17.2	40.4	0	1.0	0.059	0	0	0	4.0	5.1	231.0	6.00E-05	1.89
6	CH981117NZS002	WSL Spring	222.0	0	0	147.0	0	0	0	0	119.0	0	18.0	0.070	0	0	0	0	1.1	6.2	0.00E+00	0.10
7	CH981117NZW002	Tank 10R-24	45.2	0	0	65.1	0	0	0	9.0	3,340.0	3.6	20.5	0.059	2.0	4.2	0	0	3.0	1,270.0	0.00E+00	0.51
8	CH981123CHS001	Cottonwood Spring	429.0	0	282.0	763.0	0.2	0	0	217.0	47,300.0	17.4	2550.0	0.120	9.4	6.5	0.7	0	18.7	1,540.0	6.27E-03	32.18
9	CH981123CHW002	Tank 10K-236	131.0	0	5.2	137.0	0.2	0	6.0	128.0	7,900.0	75.1	20.6	0.140	1.0	0	0.7	4.7	1.7	2,470.0	1.16E-04	3.44
10	CH981123CHW001	Chinle Chapter House	73.1	0	0	954.0	0	0	0	14.3	242.0	0	307.0	0.180	0	0	0.7	0	0	28.7	0.00E+00	0.60

1. ILCR = Incremental Lifetime Cancer Risk with Respect to Stable Metals.
2. The values of "0" represent a result of either "not detected" at the detection limit of the laboratory method or a negative count. In both cases, the result can be considered "0".
3. The evaluation of Beta is in two steps. The initial screening level is 50 pCi/L. If the measured level of Beta exceeds the 50 pCi/L, a further evaluation is merited. Beta-emitting radionuclides would be screened.
4. The values of "0" in the Pb210 column represent analytical results that measured less than the Minimum Detectable Activity (MDA).
5. Definition of final calculations and ranking is described and published in Appendix A.1 *Summary of the Characterization of Risk Leading to Exposure Reduction*.
6. When comparing these PRG's with the U.S. EPA's PRG list, the calculated PRG used for U238 is less than the EPA's PRG for U238D (D meaning that its decay daughters are included in the risk calculations).
7. MCL – Maximum Contaminant Levels are the maximum permissible level of a contaminant in water delivered to users of a public water system.
8. PRG – Preliminary Remediation Goals are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations derived from standardized equations, combining exposure information assumptions and EPA toxicity data.

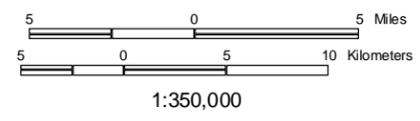
Al = Aluminum    Sb = Antimony    As = Arsenic    Ba = Barium    Be = Beryllium    Cd = Cadmium    Cr = Chromium    Cu = Copper    Fe = Iron    Pb = Lead    Mn = Manganese    Hg = Mercury    Ni = Nickel    Se = Selenium    Ag = Silver    Th = Thallium    V = Vanadium    Zn = Zinc    HI = Hazard Index



**MAP FEATURES**  
 ● Water Sample Site - Stable Metals

# 4

## WATER SAMPLE ANALYSIS FOR STABLE METALS



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 MINES PROJECT**

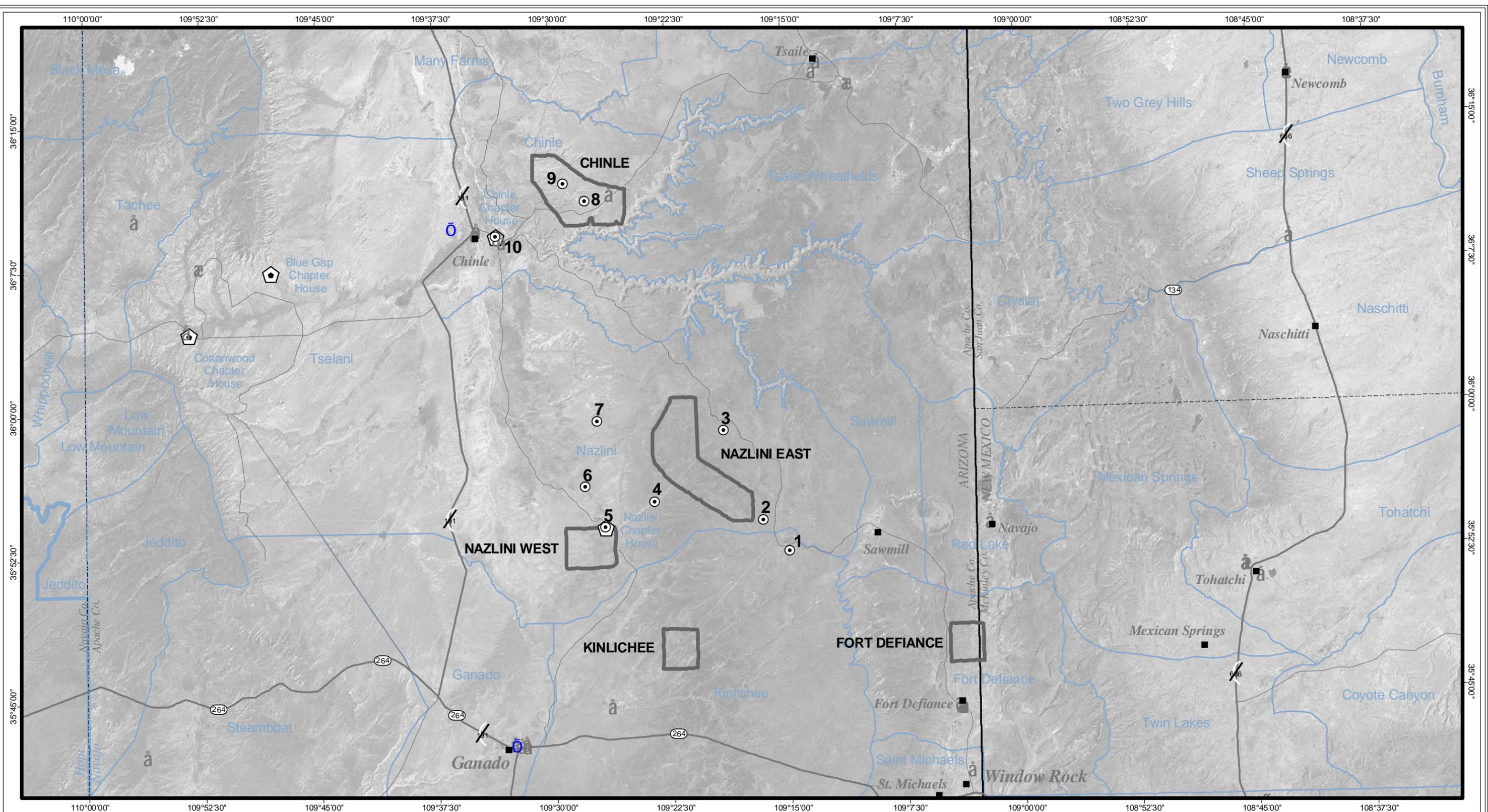
### Chinle Area



WATER SAMPLE ANALYSIS FOR RADIOACTIVE METALS

Map ID	Sample ID	Sample Name	Alpha <sup>2</sup>	Beta <sup>3</sup>	Lead210 <sup>4</sup>	Radium226 <sup>2</sup>	Radium228 <sup>2</sup>	Thorium228 <sup>2</sup>	Thorium230 <sup>2</sup>	Thorium232 <sup>2</sup>	Uranium234 <sup>2</sup>	Uranium235 <sup>2</sup>	Uranium238 <sup>2,6</sup>	ILCRrad <sup>1,5</sup>
		Primary MCLs in Pico-curies per Liter (pCi/L) <sup>7</sup>	15	50	None	5	5	None	None	None	20	20	20	
		PRG Limits in Pico-curies per Liter (pCi/L) <sup>8</sup>	None	None	0.047	0.16	0.19	0.21	1.3	1.5	1.1	1.1	0.71	
1	CH981117NZW003	Fluted Rock Well	1.62	5.58	0.61	0.101	0.751	0.002	0.012	0.000	3.13	0.039	2.40	1.09E-05
2	CH981118NZS004	White Rock Spring	4.30	5.02	0.76	0.075	0.386	0.009	-0.001	0.000	8.05	0.121	1.89	2.87E-05
3	CH981118NZS003	Honeymoon Spring	10.50	8.41	0.56	0.116	0.534	0.053	-0.001	0.000	5.50	0.232	3.19	1.35E-05
4	CH981117NZS001	Tsegito Spring	7.44	4.22	0.23	0.281	0.263	-0.002	0.004	-0.001	4.56	0.128	2.77	1.13E-05
5	CH981117NZW001	Nazlini Chapter House	10.40	6.71	0.46	0.208	0.975	0.028	0.022	0.000	5.44	0.080	2.91	1.57E-05
6	CH981117NZS002	WSL Spring	8.54	8.46	1.27	0.079	0.303	0.080	0.036	0.025	5.20	0.161	2.40	3.78E-05
7	CH981117NZW002	Tank 10R-24	8.74	8.85	0.05	0.121	0.358	0.007	0.000	0.000	6.22	0.143	3.47	1.33E-05
8	CH981123CHS001	Cottonwood Spring	36.10	23.60	6.57	3.070	1.220	0.401	0.047	0.013	11.40	0.222	10.80	1.93E-04
9	CH981123CHW002	Tank 10K-236	6.16	10.20	0.79	0.137	0.234	0.015	0.005	0.000	4.40	0.306	4.79	3.01E-05
10	CH981123CHW001	Chinle Chapter House	0.13	2.77	0.39	0.226	0.228	0.038	0.000	-0.001	0.04	-0.021	0.06	2.92E-06

1. ILCR = Incremental Lifetime Cancer Risk with Respect to Radioactive Metals.
2. The values of "0" represent a result of either "not detected" at the detection limit of the laboratory method or a negative count. In both cases, the result can be considered "0".
3. The evaluation of Beta is in two steps. The initial screen level is 50pCi/l. If the measured level of Beta exceeds the 50 pCi/L, a further evaluation is merited. The Beta-emitting radionuclides would be screened.
4. The values of "0" in the Lead210 column represent analytical results that measured less than the Method Detection Activity (MDA).
5. Definition of final calculations and ranking is described and published in Appendix A.1 *Summary of the Characterization of Risk Leading to Exposure Reduction*.
6. When comparing these PRG's with the U.S. EPA's PRG list, the calculated PRG used for Uranium238 is less than the EPA's PRG for Uranium238D (D meaning that its decay daughters are included in the risk calculations).
7. MCL – Maximum Contaminant Levels are the maximum permissible level of a contaminant in water delivered to users of a public water system.
8. PRG – Preliminary Remediation Goals are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations derived from standardized equations, combining exposure information assumptions and EPA toxicity data.

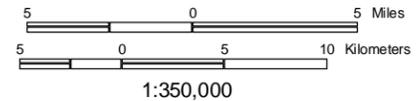


MAP FEATURES

⊙ Water Sample Site - Radioactive Metals

# 4

## WATER SAMPLE ANALYSIS FOR RADIOACTIVE METALS



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MINES PROJECT

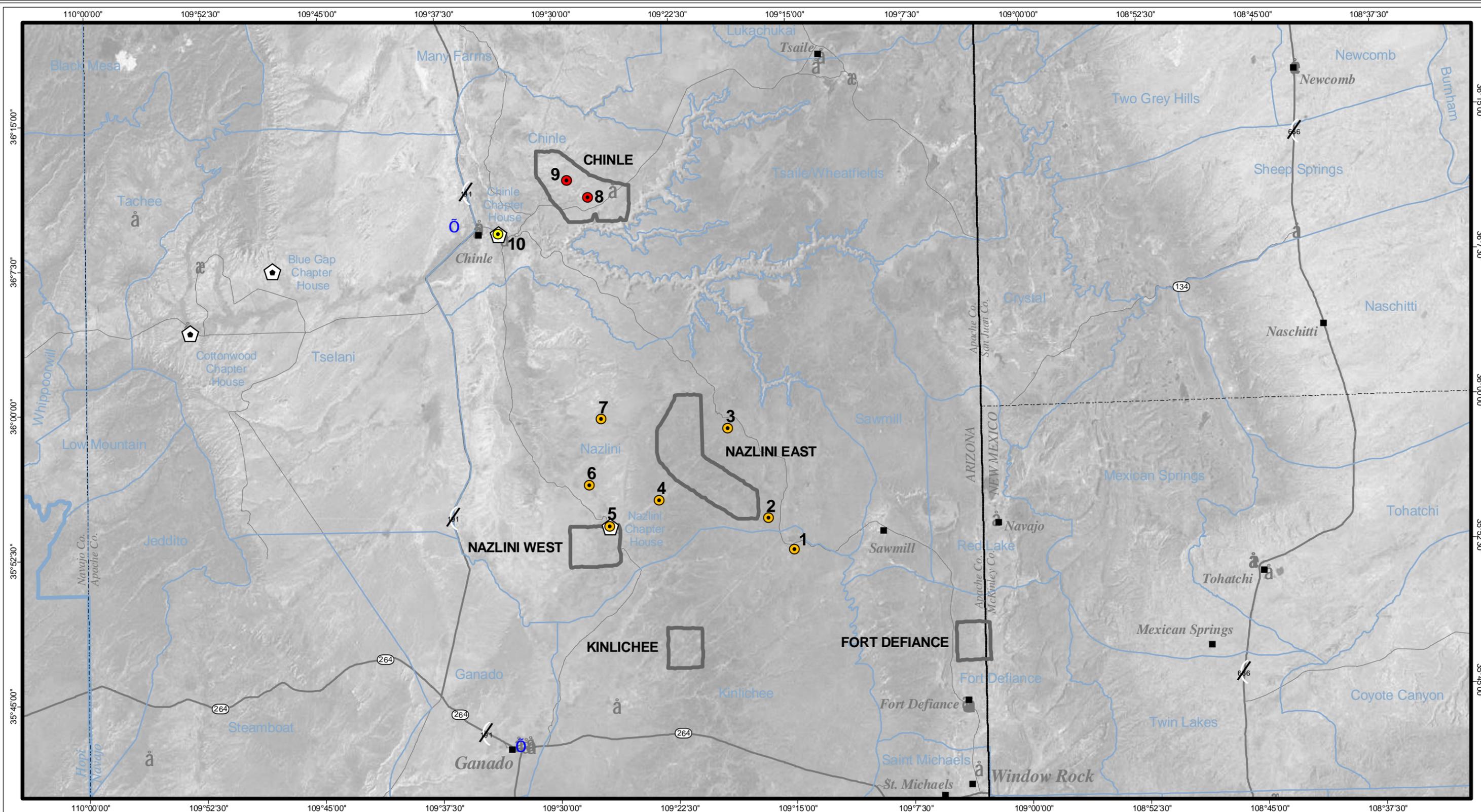
### Chinle Area



SUMMARY OF WATER QUALITY ANALYSIS WITH RESPECT TO STABLE AND RADIOACTIVE METALS

Map ID	Sample ID	Sample Name	Total Cancer Risk	Hazard Index (HI)	Arsenic <sup>3</sup>	Lead <sup>3</sup>	Total U <sup>2</sup>	Water Quality with Respect to Stable and Radioactive Metals <sup>4</sup>			Risk Category	Risk Ranking <sup>6</sup>
		Primary MCLs in Micrograms per Liter (µg/L) <sup>7</sup>			50	15	30 <sup>5</sup>					
		PRG Limits in Micrograms per Liter (µg/L) <sup>8</sup>			0.045	4	None	Less Risk	Some Risk	More Risk		
1	CH981117NZW003	Fluted Rock Well	1.09E-005	0.09	0	0	5.53		ILCR		SOME	2
2	CH981118NZS004	White Rock Spring	2.87E-005	0.25	0	0	9.94		ILCR		SOME	5
3	CH981118NZS003	Honeymoon Spring	1.35E-005	2.26	0	2.5	8.92		ILCR, HI		SOME	7
4	CH981117NZS001	Tsegito Spring	1.13E-005	0.13	0	0	7.33		ILCR		SOME	3
5	CH981117NZW001	Nazlini Chapter House	7.57E-005	1.89	2.7	0	8.35		ILCR, HI		SOME	6
6	CH981117NZS002	WSL Spring	3.78E-005	0.10	0	0	7.6		ILCR		SOME	4
7	CH981117NZW002	Tank 10R-24	1.33E-005	0.51	0	3.6	9.69		ILCR		SOME	8
8	CH981123CHS001	Cottonwood Spring	6.46E-003	32.18	282.0	17.4	22.20			ILCR, HI, Lead	MORE	10
9	CH981123CHW002	Tank 10K-236	1.46E-004	3.44	5.2	75.1	9.50			Lead	MORE	9
10	CH981123CHW001	Chinle Chapter House	2.92E-006	0.60	0	0	0	X			LESS	1

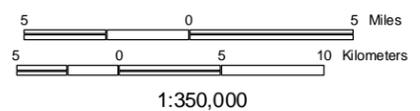
1. ILCR = Incremental Lifetime Cancer Risk with Respect to Stable Metals and Radioactive Metals.
2. The PRG's and MCL's for Alpha, Beta, and Uranium are in Pico-Curies per Liter (pCi/L).
3. The PRG's and MCL's for Lead and Arsenic are in Micrograms per Liter (µg/L).
4. Water Quality Levels:
  - Less Risk Total Cancer Risk is less than or equal to 1E-05 and Hazard Index (HI) is less than or equal to 1 and Lead is less than 4 and Total Uranium is less than 30.
  - Some Risk Total Cancer Risk is less than or equal to 6E-04 but greater than 1E-05 or Hazard Index is less than 10 but greater than 1 or Lead is less than 15 but greater than 4 and Total Uranium is less than 30.
  - More Risk Total Cancer Risk is greater than 6E-04 or Hazard Index is greater than 10 or Lead is greater than 15 or Total Uranium is equal to or greater than 30.
5. Proposed EPA MCL is 30 pCi/L for the sum of the three Uranium isotopes.
6. The definitions of the risk categories and the ranking is described and published in Appendix A.1 *Summary of the Characterization of Risk Leading to Exposure Reduction*.
7. MCL – Maximum Contaminant Levels are the maximum permissible level of a contaminant in water delivered to users of a public water system.
8. PRG – Preliminary Remediation Goals are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations derived from standardized equations, combining exposure information assumptions and EPA toxicity data.



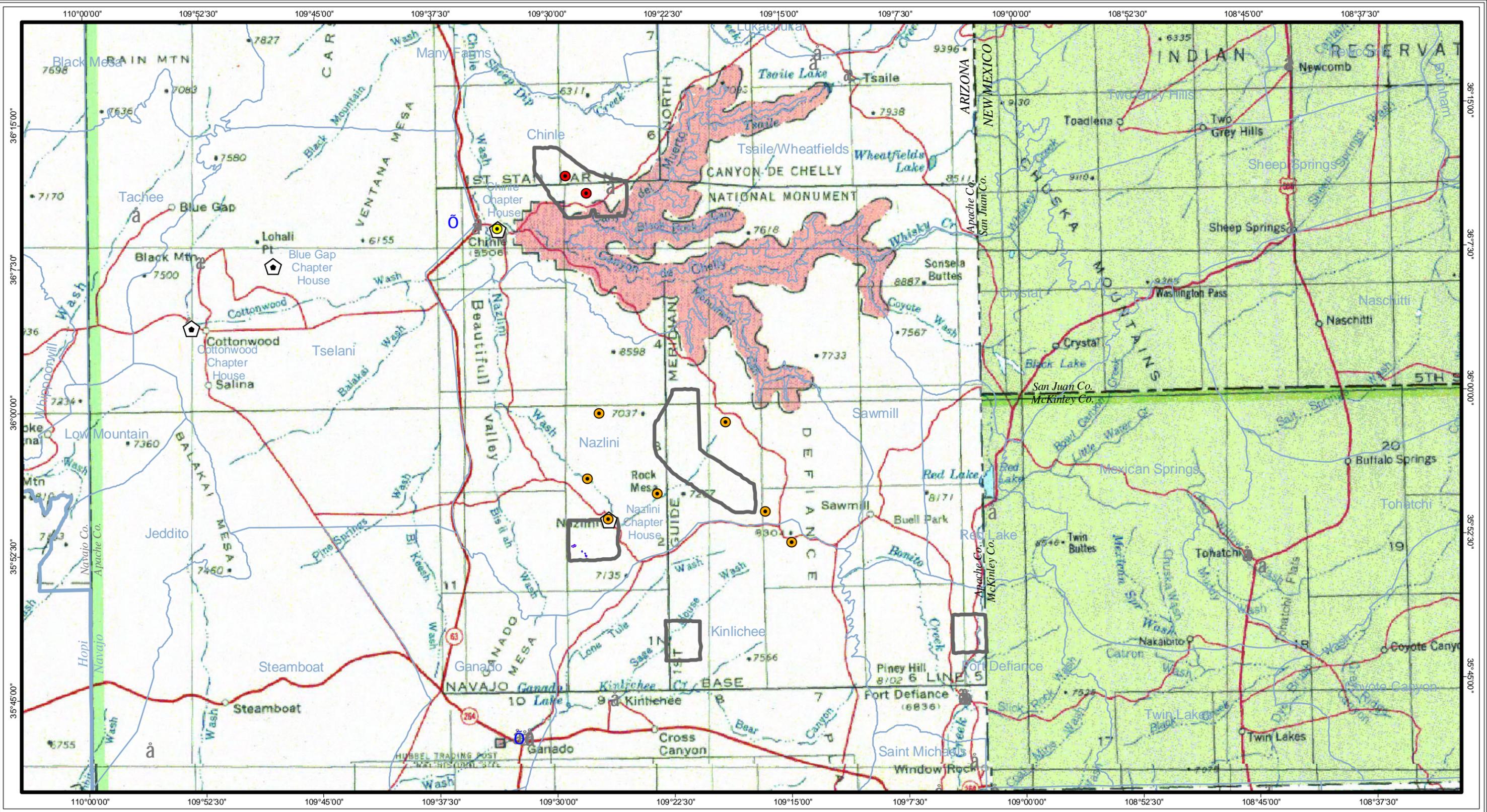
- **Less Risk**  
Total Cancer Risk is less than or equal to 1E-05 and Hazard Index is less than or equal to 1 and Lead is less than 4 and U is less than 30.
- **Some Risk**  
Total Cancer Risk is less than or equal to 6E-04 but greater than 1E-05 or Hazard Index is less than 10 but greater than 1 or Lead is less than 15 but greater than 4 and U is less than 30.
- **More Risk**  
Total Cancer Risk is greater than 6E-04 or Hazard Index is greater than 10 or Lead is greater than 15 or U is equal to or greater than 30.

# 4

## SUMMARY OF WATER QUALITY ANALYSIS WITH RESPECT TO STABLE AND RADIOACTIVE METALS



U.S. Environmental Protection Agency  
**ABANDONED URANIUM MINES PROJECT**  
**Chinle Area**

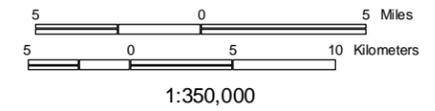


5.16

Risk Level	Aerial Radiation Contours	Derived contour-level Bismuth 214 photo-peak (excess counts per second)	Estimated exposure rate from excess Bismuth 214 (excess micro-R/hour)
Less Risk	Yellow circle	80	3.5
Some Risk	Orange circle	170	7.4
More Risk	Red circle	250	10.9
		800	34.9
		1200	52.4

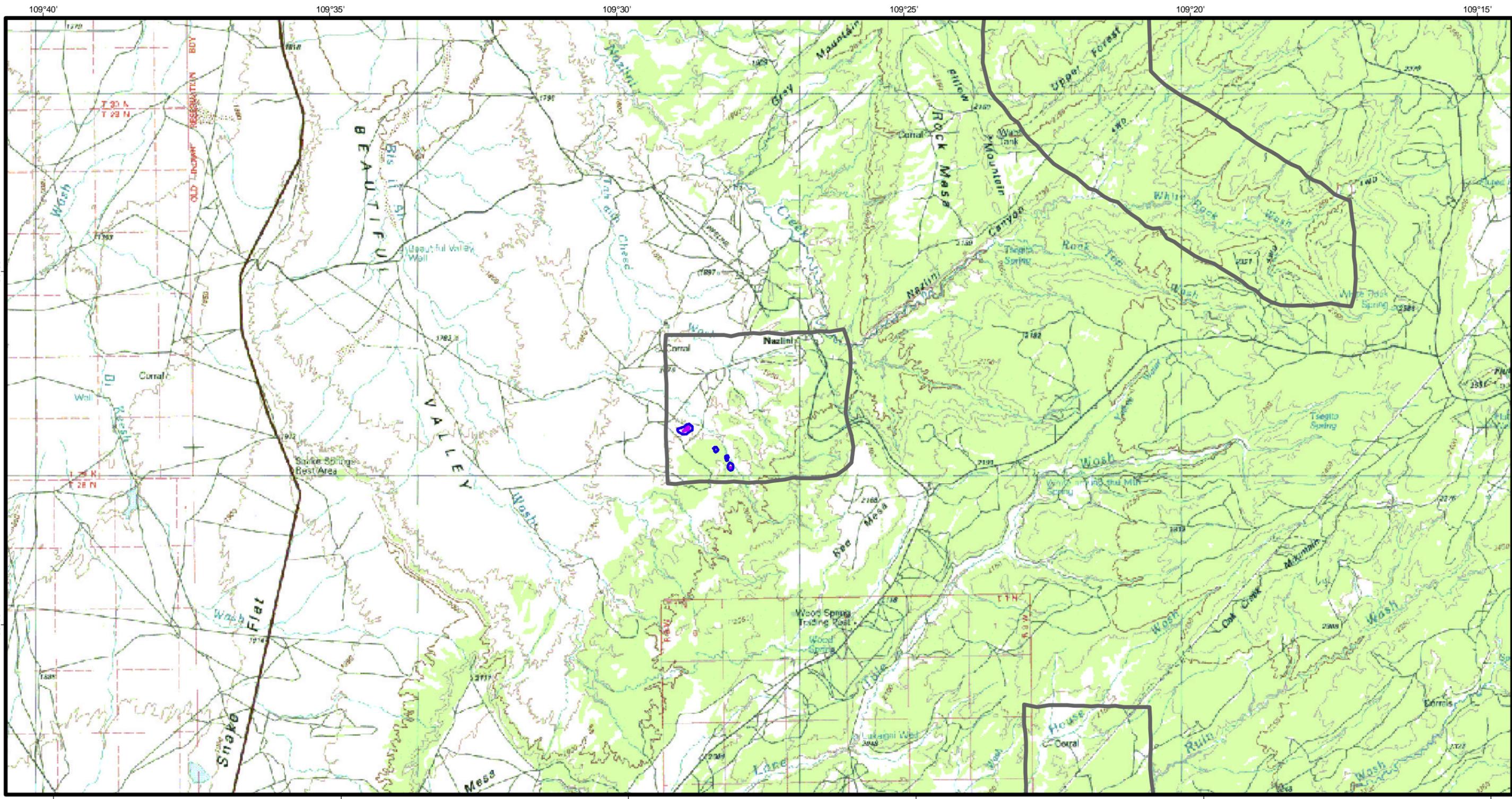
# 4

## SUMMARY OF WATER QUALITY ANALYSIS AND BISMUTH 214 CONTOURS



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 Chinle Area



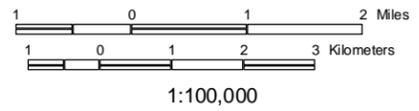


NAZLINI WEST

Aerial Radiation Contours	Derived contour-level Bismuth 214 photo-peak (excess counts per second)	Estimated exposure rate from excess Bismuth 214 (excess micro-R/hour)
	80	3.5
	170	7.4
	250	10.9
	800	34.9
	1200	52.4

4

AERIAL RADIATION CONTOURS  
BISMUTH 214  
NAZLINI WEST



U.S. Environmental Protection Agency  
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MINES PROJECT  
Chinle Area