Section 5

CHINLE AREA
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.
AERIAL RADIATION CONTOURS - GROSS COUNT

Geological Units (Age and Unit Description)
- Quaternary Alluvium and Cobblestone
- Tertiary Intrusives and Volcanics
- Tertiary Chuska Sandstone
- Early Tertiary Sedimentary Rocks
- Upper Cretaceous, undivided
- Cretaceous Menefee Formation
- Cretaceous Mancos Shale
- Cretaceous Gallup Sandstone
- Cretaceous Chevassus Canyon Formation
- Cretaceous Dakota Sandstone
- Jurassic San Rafael Group
- Jurassic Glen Canyon Group
- Triassic Chiricahua Formation
- Permian to Pennsylvanian Sedimentary Rocks

Aerial Radiation Contours
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.

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 Kneasie, 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.
ABANDONED URANIUM MINES PROJECT

CHINLE AREA
AERIAL RADIATION CONTOURS - BISMUTH 214

Geological Units (Age and Unit Description)
- Quaternary Alluvium and Collovin
- Tertiary Intrusives and Volcanics
- Tertiary Chuska Sandstone
- Tertiary Early Tertiary Sedimentary Rocks
- Upper Cretaceous, undivided
- Jurassic San Rafael Sandstone
- Jurassic Glen Canyon Group
- Triassic Chiricahua Formation

Aerial Radiation Contours

<table>
<thead>
<tr>
<th>Derived contour</th>
<th>Estimated exposure rate from excess Bismuth 214, (excess micro-R/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>3.5</td>
</tr>
<tr>
<td>170</td>
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<td>250</td>
<td>10.9</td>
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<tr>
<td>800</td>
<td>34.9</td>
</tr>
<tr>
<td>1200</td>
<td>52.4</td>
</tr>
</tbody>
</table>

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.

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.
AERIAL RADIATION CONTOURS
BISMUTH 214

MAP FEATURES
- Aerial Survey Boundary

U.S. Environmental Protection Agency
ABANDONED URANIUM MINES PROJECT
Chinle Area
<table>
<thead>
<tr>
<th>Map ID</th>
<th>Sample ID</th>
<th>Field Type</th>
<th>Sample Name</th>
<th>Longitude (DMS) (W)</th>
<th>Latitude (DMS) (N)</th>
<th>Elevation (ft)</th>
<th>Sample Date</th>
<th>Sample Time</th>
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<td>Tsegi Spring</td>
<td>109 23 30.523</td>
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<td>6907</td>
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<td>11:37 AM</td>
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<td>Nizhin Chapter House</td>
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<td>35 53 56.5847</td>
<td>6177</td>
<td>11/17/98</td>
<td>8:57 AM</td>
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<tr>
<td>6</td>
<td>CH81117NZS002</td>
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<td>WSL Spring</td>
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<td>35 56 4.75141</td>
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<td>2:12 PM</td>
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<td>Spring</td>
<td>Cottonwood Spring</td>
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<td>36 10 58.6600</td>
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<td>Well</td>
<td>Chinle Chapter House</td>
<td>109 33 32.302</td>
<td>36 9 10.62241</td>
<td>5443</td>
<td>11/23/98</td>
<td>8:39 AM</td>
</tr>
</tbody>
</table>
## WATER SAMPLE ANALYSIS FOR STABLE METALS

### CHINLE AREA

#### ABANDONED URANIUM MINES PROJECT

| Map ID | Sample ID    | Sample Name         | Al | Sb² | As²⁴ | Ba | Be²⁴ | Cd²⁴ | Cr²⁵ | Cu²   | Fe²   | Pb²   | Mn²   | Hg²   | Ni²   | Se²   | Ag²   | Th³⁺ | V²   | Zn²⁺ | ILCRsta¹⁻² | Hi²⁻³ |
|--------|--------------|---------------------|----|-----|------|----|------|------|------|-------|-------|-------|-------|-------|-------|-------|------|------|------|--------|--------|
|        |              |                     |    |     |      |    |      |      |      |       |       |       |       |       |       |      |      |      |        |        |
| 1      | CH981117NW003 | 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      | CH981118NS004 | White Rock Spring   | 66.2 | 0   | 0   | 374.0 | 0 | 0 | 0 | 0 | 62.9 | 0 | 128.0 | 0.250 | 0 | 0.7 | 0 | 0 | 0 | 10.6 | 0.00E+00 | 0.25 |
| 3      | CH981118NS003 | Honeymoon Spring    | 81.8 | 0   | 0   | 246.0 | 0 | 0 | 0 | 0 | 591.0 | 2.5 | 863.0 | 0.067 | 0 | 0 | 4.1 | 1.1 | 126.0 | 0.00E+00 | 2.26 |
| 4      | CH981117NW001 | Tsolito Spring      | 79.0 | 0   | 0   | 271.0 | 0 | 0 | 0 | 0 | 16.5 | 0 | 8.2 | 0.063 | 0 | 0 | 0 | 0 | 0 | 3.6 | 0.00E+00 | 0.13 |
| 5      | CH981117NW001 | Nazlini Chapter House | 75.0 | 0   | 2.7 | 115.0 | 0 | 0 | 0 | 17.2 | 40.4 | 0 | 1.0 | 0.059 | 0 | 0 | 4.0 | 5.1 | 231.0 | 6.00E-05 | 1.89 |
| 6      | CH981117NW002 | WSU Spring          | 222.0 | 0   | 0   | 147.0 | 0 | 0 | 0 | 0 | 119.0 | 0 | 18.0 | 0.070 | 0 | 0 | 0 | 0 | 0 | 1.1 | 0.00E+00 | 0.10 |
| 7      | CH981117NW003 | Tank 10R-24         | 45.5 | 0   | 0   | 651.0 | 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   | 129.0 | 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 | 6.00E-03 | 32.18 |
| 9      | CH981123CHS002 | 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 | 1.8 | 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 | 367.0 | 0.180 | 0 | 0.7 | 0 | 0 | 0 | 26.7 | 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 Pr210 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
WATER SAMPLE ANALYSIS FOR STABLE METALS

MAP FEATURES
- Water Sample Site - Stable Metals

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

1:350,000 Scale

Chinle
Fort Defiance
Navajo
Mexican Springs
Tohatchi
Mexican Springs
Naschitti
Crystal
Tselani
Sheep Springs
Chinle
Tachee
Tsaile/Wheatfields
Two Grey Hills
Black Mesa
Newcomb
Fort Defiance
Kinlichee
NAZLINI EAST
NAZLINI WEST
MEXICO CITY
CHINLE
NAZLINI WEST
NAZLINI EAST
CHINLE
NAZLINI WEST
NAZLINI EAST
CHINLE
NAZLINI WEST
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NAZLINI WEST
NAZLINI EAST
CHINLE
NAZLINI WEST
NAZLINI EAST

110°00'00" 109°52'30" 109°45'00" 109°37'30" 109°30'00" 109°22'30" 109°15'00" 109°7'30" 109°00'00" 108°52'30" 108°45'00" 108°37'30"

5 0 5 Miles
5 0 5 Kilometers

Chinle Area
## ABANDONED URANIUM MINES PROJECT
### CHINLE AREA
### WATER SAMPLE ANALYSIS FOR RADIOACTIVE METALS

| Map ID | Sample ID | Sample Name           | Alpha  | Beta  | Lead210 | Radium226 | Radium228 | Thorium228 | Thorium230 | Thorium232 | Uranium234 | Uranium238 | Uranium238* | ILCR rad* |
|--------|-----------|-----------------------|--------|-------|---------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|---------|
| 1      | CH81117NW003 | 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      | CH81118NZS004 | White Rock Spring    | 4.30   | 5.02  | 0.79    | 0.075     | 0.396     | 0.009     | 0.001      | 0.000      | 8.05       | 0.121      | 1.89       | 2.87E-05  |
| 3      | CH81118NZS003 | 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      | CH81117NZS001 | Tsegiio Spring       | 7.44   | 4.22  | 0.23    | 0.281     | 0.263     | 0.002     | 0.004      | 0.000      | 4.56       | 0.108      | 2.77       | 1.13E-05  |
| 5      | CH81117NW001 | 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      | CH81117NZS002 | 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      | CH81117NW002 | Tsegiio Spring       | 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      | CH81123CHS001 | 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      | CH81123CHW002 | 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     | CH81123CHW001 | 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 50 pCi/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 PRGs 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.
WATER SAMPLE ANALYSIS
FOR
RADIOACTIVE METALS

MAP FEATURES
Water Sample Site - Radioactive Metals

4

WATER SAMPLE ANALYSIS
FOR
RADIOACTIVE METALS

U.S. Environmental Protection Agency
ABANDONED URANIUM
MINES PROJECT

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

<table>
<thead>
<tr>
<th>Map ID</th>
<th>Sample ID</th>
<th>Sample Name</th>
<th>Total Cancer Risk</th>
<th>Hazard Index (HI)</th>
<th>Arsenic</th>
<th>Lead</th>
<th>Total U</th>
<th>Water Quality with Respect to Stable and Radioactive Metals</th>
<th>Risk Category</th>
<th>Risk Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(MCL in Micrograms per Liter (µg/L))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(PRG Limits in Micrograms per Liter (µg/L))</td>
<td>Less Risk</td>
<td>Some Risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PRG = Incremental Lifetime Cancer Risk with Respect to Stable Metals and Radioactive Metals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PRG = Preliminary Remediation Goals are tools for evaluating and cleaning up contaminated sites.</td>
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<td>0</td>
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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.
SUMMARY OF WATER QUALITY ANALYSIS WITH RESPECT TO STABLE AND RADIOACTIVE METALS

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.
- Total Cancer Risk is less than or equal to 1E-05 but greater than 6E-06 or Hazard Index is less than 10 but greater than 1 and Lead is less than 15 but greater than 4 and U is less than 30.
- 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.

More Risk
- Total Cancer Risk is greater than 1E-04 or Hazard Index is greater than 1 or Lead is greater than 15 or U is equal to or greater than 30.

U.S. Environmental Protection Agency
ABANDONED URANIUM MINES PROJECT
Chinle Area
SUMMARY OF WATER QUALITY ANALYSIS AND BISMUTH 214 CONTOURS
AERIAL RADIATION CONTOURS
BISMUTH 214
NAZLINI WEST

Estimated exposure rates from excess Bismuth 214 (excess micro-R/hour):

- 80 - 3.5
- 170 - 7.4
- 250 - 10.8
- 800 - 34.9
- 1000 - 52.4