HOMESTAKE

GRANTS OFFICE

Alan D. Cox
Project Manager

21 July 2004

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Division of Fuel Cycle Safety and Safeguards
Chief of Fuel Cycle Facilities Branch (Mailstop T8-A33)
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11545 Rockville Pike
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Rockville, MD 20852-2738

Attn: Mr. Bill VonTill, Site Manager

Re: **Grants Reclamation Project**
Docket No. 40-8903 License No. SUA-1471
Corrections / Edits for "Background Water Quality Evaluation of the Chinle Aquifers" – October, 2003 and Associated Statistical Analyses Document

Dear Mr. VonTill:

Homestake Mining Company of California (HMC) recently provided responses to New Mexico Environment Department (NMED) comments on the above referenced documents via a letter to you dated June 23 2004. In follow-up to that letter, we have made edits and corrections to the Chinle background document and the associated water quality statistical analysis that reflect needed changes in the documents based upon the comments received from NMED.

In particular, the majority of the document corrections and changes relate to detection limit values for some of the older water quality data for vanadium and thorium-230. This necessitated a review of the data sets for those parameters and elimination of some data values due to the excessive detection limits that were associated with that data. A new statistical analysis was completed after correction of the data sets and resulted in a slight change in the proposed background values for vanadium and thorium-230.

Enclosed please find three (3) sets of page replacements and related replacement instructions for the 3 Chinle background documents that were transmitted to you in October 2003. Also enclosed are two (2) sets of page replacements for the statistical analysis documents that were sent to you at that time.

NM5501

We will be sending the same correction pages and instructions to EPA and NMED for incorporation into their copies of these documents (see cc: list below).

Thank you for your time and attention on this matter. If you have any questions, please contact me in our Grants office.

Sincerely yours,

HOMESTAKE MINING COMPANY
Alan D. Cox

Cc: (w/ enclosures as indicated)

D. Mayerson – New Mexico ED, Santa Fe	(2 – sets correction pages BG WQ Eval.) (1 – set correction pages Statistical Eval.)
M. Purcell – Region VI EPA, Dallas	(1 – set correction pages BG WQ Eval.) (1 – set correction pages Statistical Eval.)
R. Chase / B. Ingersoll, SLC	(1 – set correction pages BG WQ Eval)
K. Baker – ERG, Inc. – ABQ	(1 – set correction pages BG WQ Eval) (1 – set correction pages Statistical Eval.)
P. DeDycker – ASRC-ES-Lynx, Denver	(1 – set correction pages BG WQ Eval)
G. Hoffman – Hydro Eng., Casper	(w/o enclosures)
Grants Files	(2 – sets correction pages BG WQ Eval) (2 - sets correction pages Statistical Eval.)

REPLACEMENT PAGES
JUNE 2004

The following pages have been revised and are included for replacement or addition to the Grants Reclamation Project Background Water Quality Evaluation of the Chinle Aquifers report. Revision date(s) for each page are included in the lower right hand corner. The pages are subject to a complete replacement and should be substituted according to the following instructions.

Page No.	Action and Changes
Cover	Replace cover page
Page ES-3	Replace pg ES-3 with pg ES-3 modified Table ES-1 vanadium and thorium-230 values
Pgs. 6-1 and 6-2	Replace pgs 6-1 and 6-2 with pgs 6-1 and 6-2 modified Table 6-1 vanadium detection value on pg 6-2, pg 6-1 just reprint
Page 6-11	Replace pg 6-11 with pg 6-11 modified Table 6-4 vanadium and thorium-230 values
Figure C.2-6	Replace Figure C.2-6 (pg C.2-8) with Figure C.2-6 (pg C.2-8) modified with note of excessive detection limit
Figure C.3-6	Replace Figure C.3-6 (pg C.3-8) with Figure C.3-6 (pg C.3-8) modified with note of excessive detection limit

GRANTS RECLAMATION PROJECT
BACKGROUND WATER QUALITY EVALUATION
OF THE CHINLE AQUIFERS

FOR:

U.S. NUCLEAR REGULATORY COMMISSION
ROCKVILLE, MARYLAND

BY:

HOMESTAKE MINING COMPANY
ALBUQUERQUE, NEW MEXICO

&

HYDRO-ENGINEERING, L.L.C.
CASPER, WYOMING

October, 2003
Revised June 2004

THOMAS G. MICHEL, Ph.D.
HYDROLOGIST

GEORGE L. HOFFMAN, P.E.
5831 N.M. HYDROLOGIST

The existing ground water quality site standards for the alluvial aquifer were established by the Nuclear Regulatory Commission (NRC) in 1989 based upon a limited data set. Site standards have not been established for the Chinle aquifers. However, Chinle aquifer(s) site standards are necessary to establish ground water quality restoration objectives. A large background database has been collected since 1976 on the Grants Project site and, with subsequent additions to the data since 1989, a more complete analysis of the range of background ground water quality for the alluvial aquifer, Chinle mixing zone, and Chinle non-mixing zones is possible. Statistical analyses of the water-quality data were performed by ERG (1999 and 2003) to determine the range of background concentrations in the alluvial aquifer and the Chinle aquifers. In 2001, HMC filed an application to revise the alluvial background concentrations supported by the findings of the 1999 ERG statistical analysis. Based on both the 1999 and 2003 statistical evaluations the recommended background water-quality concentrations for the alluvial and Chinle aquifers are summarized on Table ES-1.

TABLE ES-1. GRANTS PROJECT ALLUVIAL AND CHINLE BACKGROUND CONCENTRATIONS

	CONSTITUENT, in mg/l except Thorium-230 and Ra226+Ra228 in pCi/l.									
Aquifer Zone	Selenium	Uranium	Molybdenum	TDS	Sulfate	Chloride	Nitrate	Vanadium	Thorium-230	Ra-226 +Ra-228
Alluvial	0.27	0.15	0.05	3060	1870	*250	23	* 0.02	*0.30	*5
Chinle Mixing	0.14	0.18	0.10	3140	1750	96	15	0.01	0.70	3.5
Upper Chinle Non-Mixing	0.06	0.09	0.08	2010	914	412	4.9	0.01	0.33	3.7
Middle Chinle Non-Mixing	0.07	0.07	0.05	1560	857	63	4.0	0.01	0.82	2.2
Lower Chinle Non-Mixing	0.32	0.02	0.03	4140	2000	634	3.0	0.01	0.72	3.2

NOTE: * = Existing site standard, background not calculated for this parameter.

6.0 BACKGROUND WATER QUALITY

This section provides information on the ground water monitoring program at the Grants Project, an assessment of full range of background concentrations for the alluvial and Chinle aquifers and the related mixing zone, and the rationale for identifying background monitoring wells and their related constituent levels.

6.1 WATER QUALITY MONITORING

HMC's Standard Operating Procedure (SOP) for monitoring ground water specifies exact procedures for sample collection, sample handling and shipping, laboratory processing and data review and management. The SOP lists the equipment to be used in .collecting samples, procedures for sample collection, and the sample preservation techniques. The procedure requires measurement of the static water level prior to sampling the well. Removal of at least two casing volumes of water from the well is usually produced before final field conductivity measurements are taken and prior to sample collection. Samples are filtered with a 0.45 micron filter, and the appropriate preservative is added to each sample prior to shipment to the laboratory. On an annual basis, ten percent of the regulatory permit related samples collected are split as a quality assurance-quality control measure.

The SOP also dictates the protocols used for the data review and validation. The most recent results are compared to those from previous analyses to determine if laboratory rechecks are necessary. Water quality constituent detection limits that have been customarily used for Grants Project samples by Energy Laboratory and the HMC on-site laboratory are shown in Table 6-1. These two laboratories analyzed a majority of the samples in the database. The New Mexico Environmental Department laboratory and Barringer Laboratory analyzed a few samples. The available detection limits for the NMED and Barringer samples were similar to those presented in Table 6-1 for Energy Laboratory and the HMC laboratory.

For the calculation of background constituent concentrations, wells were selected based on confirmation of acceptable well completion and the appropriateness of the well location for defining background water quality as defined in earlier sections of this report. The water-quality

TABLE 6-1. GRANTS PROJECT WATER QUALITY DETECTION LIMITS

Constituent	Lab	Period	Detection Value
Sulfate	Energy	1992 - 2003	1 mg/l
TDS	Energy	1992 - 2003	10 mg/l
Chloride	Energy	1992 - 2003	0.1 mg/l
Uranium	Energy	1992 - 1995	0.01 mg/l
	Energy	1995 - 2003	0.0003 mg/l
	HMC	1976 - 1993	0.01 mg/l
Selenium	Energy	1992 - 1996	0.01 mg/l
	Energy	1997 - 2003	0.005 mg/l
	HMC	1976 - 1993	0.01 mg/l
Molybdenum	Energy	1992 - 1993	0.01 mg/l
	Energy	1993 - 2003	0.03 mg/l
	HMC	1976 - 1993	0.01 mg/l
Nitrate	Energy	1992 - 2003	0.1 mg/l
	HMC	1976 - 1993	0.1 mg/l
Radium-226	Energy	1992 - 2003	0.2 pCi/l
	HMC	1976 - 1993	0.2 pCi/l
Radium-228	Energy	1992 - 2003	1 pCi/l
Vanadium	Energy	1992 - 2003	0.01 mg/l
	HMC	1976 - 1993	0.01 mg/l
Thorium-230	Energy	1992 - 2003	0.2 pCi/l

data from the selected wells were retrieved from the HMC database and supplied to the statistical evaluation contractor Environmental Restoration Group, Inc (ERG) of Albuquerque, N.M.

6.2 ALLUVIAL AQUIFER BACKGROUND WATER QUALITY

Site standards were set for the alluvial aquifer water-quality constituents at the Grants Project in the 1980's. The standards were established for the Grants Project site by averaging measured constituent concentrations for a limited number of samples. However, the use of an average concentration is not appropriate to represent background concentrations, because, by definition, concentrations in a portion of the samples used to calculate the average would exceed the average. In combination with a limited data set, the average concentration method for establishing a site standard does not produce a representative standard. A representative site standard must consider the range of background concentrations in order to determine when a true exceedance of a background concentration(s) has occurred. Alluvial aquifer background concentrations, which

sulfate concentrations are higher in the Lower Chinle aquifer non-mixing zone due to the increase of these constituent concentrations as the ground water slowly moves down-gradient in this low permeability aquifer. Nitrate and vanadium concentrations are lower in the Lower Chinle non-mixing zone than those in the Chinle mixing zone.

6.4.2 MIXING ZONE CONCENTRATIONS

The 95th percentile values as calculated by ERG (2003) for the Chinle background concentrations in the mixing zone are presented in Table 6-4. The background selenium concentration is 0.14 mg/l, and the background uranium concentration is 0.18 mg/l for the Chinle mixing zone. The 95th percentile (or upper range of background concentration) is also presented for molybdenum, TDS, sulfate, chloride, nitrate, vanadium, thorium-230 and radium-226 plus radium-228 for the Chinle mixing zone.

TABLE 6-4. GRANTS PROJECT - CHINLE BACKGROUND CONCENTRATIONS

	CONSTITUENT, in mg/l except Thorium-230 and Ra226+Ra228 in pCi/l.									
Aquifer Zone	Selenium	Uranium	Molybdenum	TDS	Sulfate	Chloride	Nitrate	Vanadium	Thorium-230	Ra-226 + Ra-228
MIXING ZONE										
Chinle Mixing	0.14	0.18	0.10	3140	1750	96	15	0.01	0.70	3.5
NON-MIXING ZONE										
Upper Chinle	0.06	0.09	0.08	2010	914	412	4.9	0.01	0.33	3.7
Middle Chinle	0.07	0.07	0.05	1560	857	63	4.0	0.01	0.82	2.2
Lower Chinle	0.32	0.02	0.03	4140	2000	634	3.0	0.01	0.72	3.2

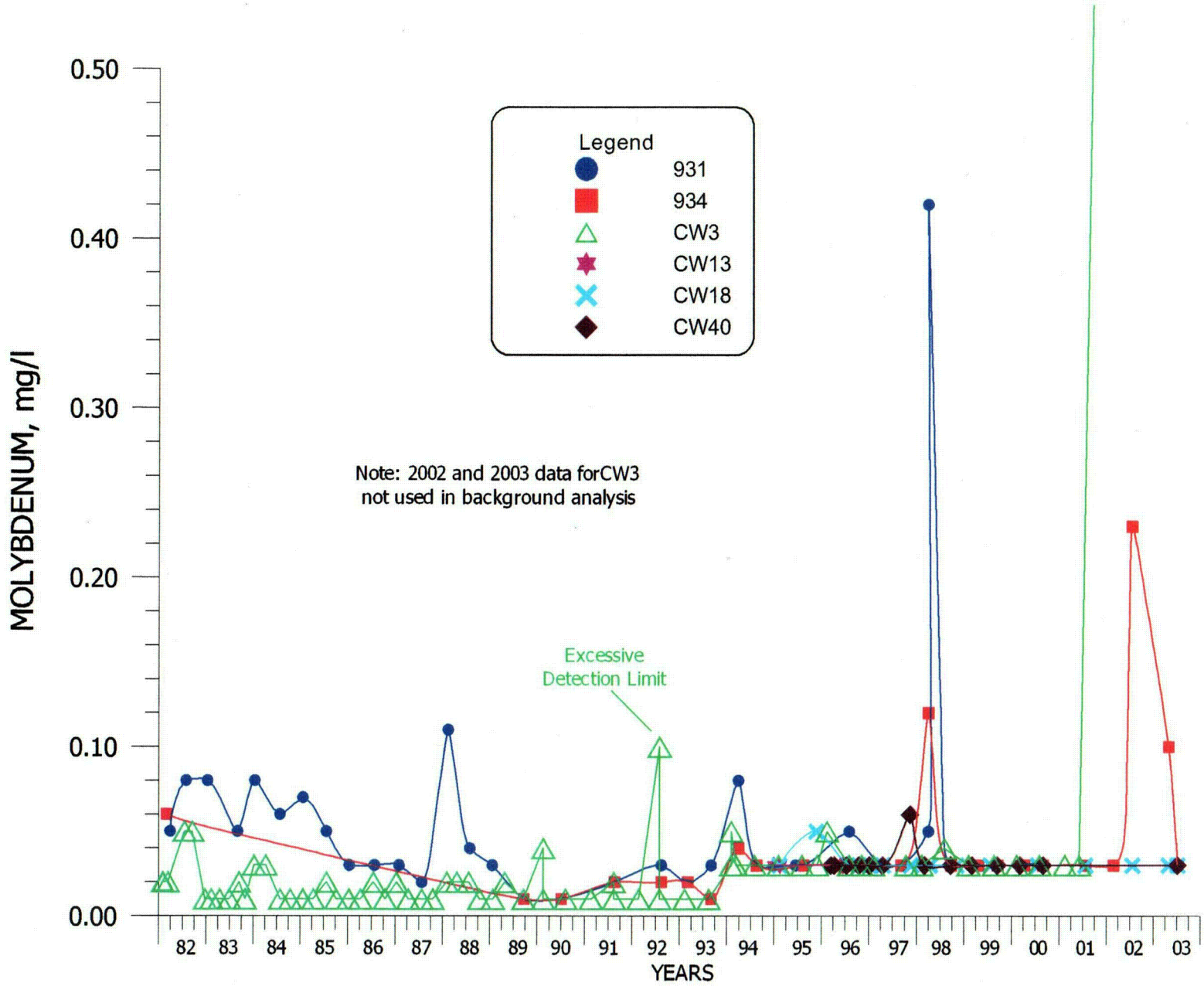

FIGURE C.2-6. MOLYBDENUM CONCENTRATIONS FOR UPPER CHINLE WELLS 931, 934, CW3, CW13, CW18 AND CW40 IN UPPER CHINLE NON-MIXING ZONE.

C01

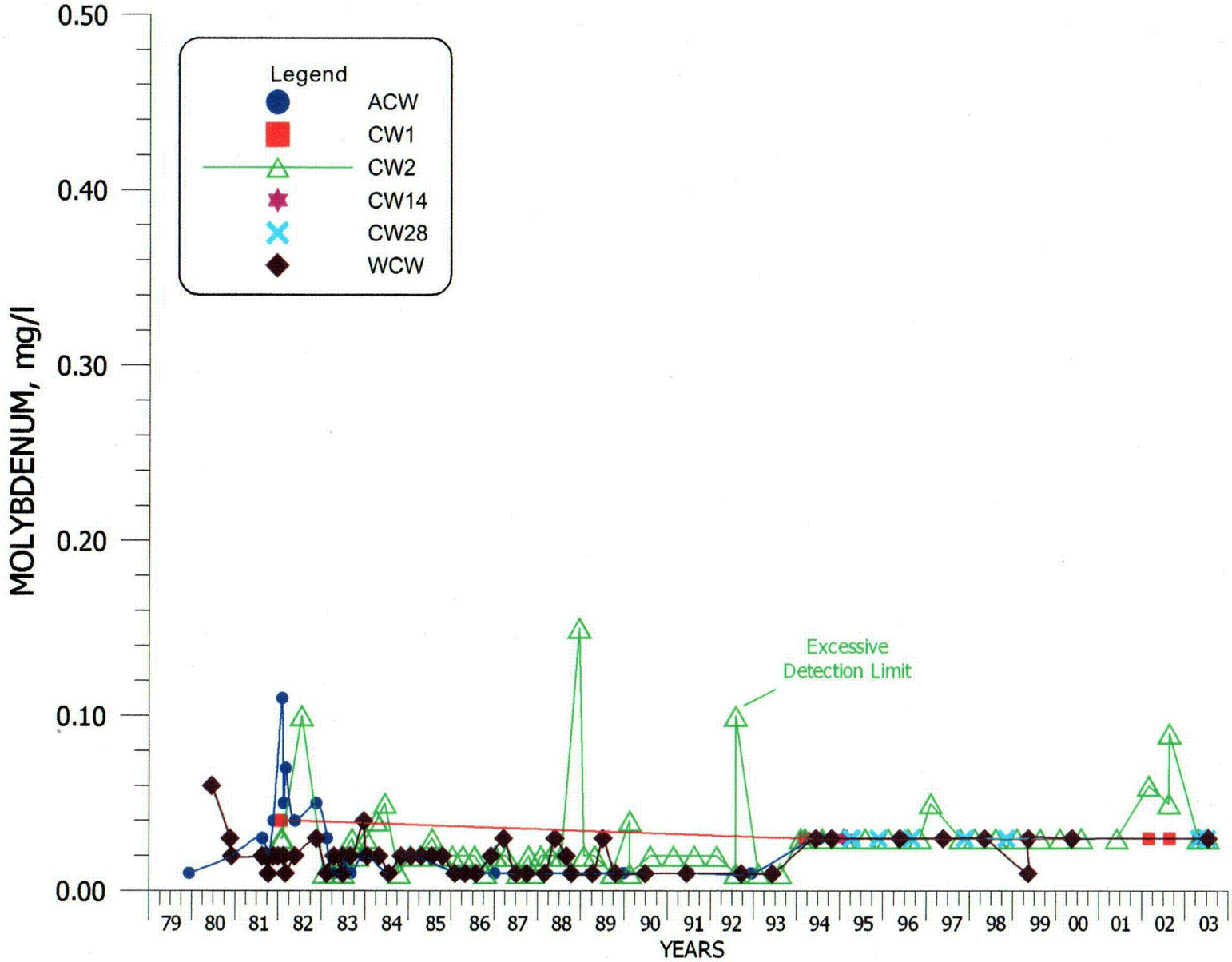

FIGURE C.3-6. MOLYBDENUM CONCENTRATIONS FOR MIDDLE CHINLE WELLS ACW, CW1, CW2, CW14, CW28 AND WCW IN MIDDLE CHINLE NON-MIXING ZONE.

C02

Replacement Pages - June, 2004

The following pages have been revised and are included for replacement or addition to the Grants Project Statistical Evaluation of Chinle Aquifer Quality at the Homestake Site Near Grants, NM report. Revision date(s) for each page are included in the lower left hand corner. The pages are subject to a complete replacement and should be substituted according to the following instructions.

Page Number	Action	Changes Made
Cover Page	Replace with revised cover page	Added revision date to cover page.
Table of Contents	Replace with revised TOC	TOC updated to reflect changes made to report.
ES-1 & ES-2	Replace with page ES-1 & revised page ES-2	Modified Table ES-1 to reflect change in number of samples in the molybdenum dataset and changes in vanadium and thorium-230 values.
5	Replace with revised page 5	Changes in text discuss the molybdenum, Th-230, and vanadium values removed due to reported high non-detect values.
14 & 15	Replace with page 14 & revised page 15	Modified Table 3-1 to reflect change in number of samples in the molybdenum dataset and changes in vanadium and thorium-230 values.
16 & 17	Replace with page 16 & revised page 17	Change to Section 3.1.3 (molybdenum) to reflect removal of samples due to high non-detect values.
18 - 22	Replace with revised pages 18 - 22	No change in text. Resulting from text shift due changes made on page 17.
23 & 24	Replace with revised pages 23 & 24	Changes to Section 3.1.8 (vanadium) and Section 3.1.9 (Th-230) due to removal of high non-detect values and addition of 2003 sample results to datasets.
25 & 26	Replace with revised pages 25, 26 & 27	Changes to Section 3.2 (Middle Chinle Non-Mixing Zone) and Section 3.4 (Chinle Mixing Zone) due to removal of high non-detect values and addition of 2003 sample results.
27 & 28	Replace with revised page 28 & page 29	Change to Section 4.0 (Summary) to reflect addition of 2003 sample results and only page number change on page 29.
Appendix A - Table of Contents	Replace with revised Appendix A TOC	TOC updated to reflect changes made to Appendix A.
A-1	Replace with revised Tables A-1 & A-2	Changes made to Tables A-1 and A-2.
A-10 & A-11	Add Tables A-14 & A-15	Addition of two new tables to reflect removal of samples with high non-detect values from the molybdenum, Th-230, and vanadium datasets and addition of 2003 sample results to Th-230 and vanadium datasets.

STATISTICAL EVALUATION OF CHINLE AQUIFER QUALITY AT THE HOMESTAKE SITE NEAR GRANTS, NM

URANIUM
SELENIUM
MOLYBDENUM
SULFATE
NITRATE
CHLORIDE
VANADIUM
THORIUM-230
TOTAL RADIUM

Prepared for:

Homestake Mining Company of California
Grants Project
P. O. Box 98
Grants, NM 87020

Prepared by:

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Albuquerque, NM 87113-2721

October, 2003
Revised June, 2004

Table of Contents

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Table of Contents – Figures

Executive Summary

Natural uranium, selenium, molybdenum, TDS, sulfates, nitrates, chloride, vanadium, thorium-230, and radium are key contaminants introduced into the shallow groundwater as a result of the processing of uranium ore at the Homestake site, located near Grants, New Mexico. However, a natural source of these same constituents exists in the region which influences natural background groundwater quality. The purpose of this report is to statistically characterize the concentrations of the aforementioned constituents in the three Chinle aquifers and the area known as the Chinle aquifer 'mixing zone'.

There are three Chinle aquifers from which groundwater data have been collected. The data from wells in the Upper Chinle, Middle Chinle and Lower Chinle aquifers have been sorted based upon whether or not they have been affected by the alluvial groundwater inflow. Data from the non-affected wells have been segregated into the Upper Chinle Non-Mixing Zone, Middle Chinle Non-Mixing Zone, and Lower Chinle Non-Mixing Zone datasets. The datasets were then used in defining natural background levels for the constituents of concern for these zones. The data from the affected wells have been grouped together and labeled as "Chinle Mixing Zone" data, and used to define the natural background levels for this mixing zone. The term "affected" is not meant to convey that a well has been impacted by tailings seepage, only alluvial groundwater inflow.

Samples were collected at wells in the Chinle aquifers from 1979 to 2003. A total of 31 wells provided the data to construct the datasets. Close examination of the groundwater database provided justification for elimination of select samples. Samples were eliminated based upon high detection limits, reported zero concentrations, no reported values, and extreme maximum and minimum concentrations (outliers). Only a minor percentage of samples were eliminated; the completeness of the dataset was not compromised.

Statistical analyses were performed on the individual datasets (constituent and zone specific) to determine distribution, statistical similarities between data, and upper tolerance limits. Results of the distribution analysis indicated that all but one dataset were nonparametrically distributed. The Upper Chinle Non-Mixing Zone sulfate dataset was determined to be parametrically distributed.

The 95th percentile was calculated as the nonparametric upper tolerance limit for nonparametric datasets and the Parametric Upper Tolerance Limit at a 95% confidence level was calculated for the parametric dataset. These results are used to define the natural background levels of the Chinle aquifers. If sample concentrations are greater than their respective upper tolerance limit (UTL), contamination may be indicated. However, it should be noted that since the 95th percentile and confidence level was calculated as the upper tolerance limit, statistically 5% of the time one would expect the upper tolerance limit to be exceeded. A summary table of the parameter, dataset, distribution, 95th percentile, range, arithmetic mean and number of samples is provided for all constituents except total radium as Table ES-1. The summary table for total radium, which includes results for dissolved Ra-226 and Ra-228, is provided as Table ES-2.

Table ES-1. Chinle Aquifer Statistical Analyses Summary Table

Parameter	Dataset	Distribution	95th Percentile or PUTL	Range		Arithmetic Mean	Number of Samples
				From	To		
U-nat	Upper	Nonparametric	0.09	0.0007	0.3610	0.031	166
	Middle	Nonparametric	0.07	0.0034	0.1357	0.019	190
	Lower	Nonparametric	0.02	0.0010	0.0260	0.012	60
	Mixing	Nonparametric	0.18	0.0020	0.2312	0.065	96
Selenium	Upper	Nonparametric	0.06	< 0.001	0.244	0.017	165
	Middle	Nonparametric	0.07	< 0.001	0.222	0.016	192
	Lower	Nonparametric	0.32	< 0.005	0.362	0.066	59
	Mixing	Nonparametric	0.14	< 0.001	0.520	0.048	96
Molybdenum	Upper	Nonparametric	0.08	< 0.01	0.235	0.027	142
	Middle	Nonparametric	0.05	< 0.01	0.150	0.022	165
	Lower	Nonparametric	0.03	< 0.01	< 0.03	0.015	32
	Mixing	Nonparametric	0.10	< 0.01	0.13	0.030	67
TDS	Upper	Nonparametric	2010	920	2160	1613	166
	Middle	Nonparametric	1557	560	1970	1273	187
	Lower	Nonparametric	4141	805	4180	2181	58
	Mixing	Nonparametric	3137	976	3217	1935	94
Sulfate	Upper	Parametric	914	535	998	747	167
	Middle	Nonparametric	857	319	1430	654	192
	Lower	Nonparametric	2002	284	2140	991	60
	Mixing	Nonparametric	1750	409	1880	1028	96
Nitrate	Upper	Nonparametric	4.89	< 0.01	7.9	1.21	124
	Middle	Nonparametric	4.00	0.04	5.02	1.08	138
	Lower	Nonparametric	2.99	< 0.1	3.2	0.87	27
	Mixing	Nonparametric	15.31	< 0.1	21.8	3.87	58
Chloride	Upper	Nonparametric	412	21	540	142	127
	Middle	Nonparametric	63	< 0.01	85	40	143
	Lower	Nonparametric	634	46	657	204	28
	Mixing	Nonparametric	96	8.5	114	62	60
Vanadium	Upper	Nonparametric	0.01	< 0.01	< 0.01	0.005	39
	Middle	Nonparametric	0.01	< 0.01	0.02	0.006	43
	Lower	Nonparametric	0.01	< 0.01	0.01	0.005	16
	Mixing	Nonparametric	0.01	< 0.01	< 0.01	0.005	38
Thorium 230	Upper	Nonparametric	0.33	< 0.1	0.90	0.15	36
	Middle	Nonparametric	0.82	< 0.1	1.10	0.21	39
	Lower	Nonparametric	0.72	< 0.02	0.80	0.23	17
	Mixing	Nonparametric	0.70	< 0.02	0.80	0.19	38

Notes:

1 Results are in mg/L for all constituents except Th-230. Th-230 results in pCi/L.

2 Upper: Upper Chinle Non-Mixing Zone
Middle: Middle Chinle Non-Mixing Zone
Lower: Lower Chinle Non-Mixing Zone

1.2 Data Preparation

The database consists of analytical results with descriptive information in seven fields of: well identification number, sample date, measured parameter, laboratory identification where the sample was processed, remark code (qualifiers), lab code, and concentration (mg/L and pCi/L). There is one deviation from this format. Total radium analytical results consist of both Ra-226 and Ra-228 results.

Examination of the database revealed isolated problems with individual data values. For example, Th-230 data for Upper Chinle Wells 931 (9/18/89), 934 (9/18/89) and CW3 (9/15/89 and 11/29/98) were omitted as uninformative because zero concentrations were reported. The same was true for Middle Chinle Wells 930 (9/15/89), WCW (10/20/89), CW2 (12/1/89), ACW (12/19/89) and CW2 (8/7/90). Total radium data for Upper Chinle Well CW3 (8/7/1990) was omitted due to a zero concentration reported for Ra-226. Duplicate Middle Chinle Well sample results for ACW (12/19/1989) were also omitted as uninformative due to a zero concentration reported for Ra-228.

At Upper Chinle Well CW3 one result for molybdenum (7/29/1992), one result for Th-230 (8/11/1993) and two results for vanadium (7/29/1992 and 8/11/1993) were removed due to high non-detect values. The same was true for Middle Chinle Well CW2 where one result for molybdenum (7/30/1992) and two results for vanadium (11/19/1987 and 7/30/1992) were removed due to high non-detects values. In the Chinle Mixing Zone, wells CW9 and CW10 each had one Th-230 (9/13/1993) and one vanadium (9/13/1993) result omitted due to high non-detect values reported.

Results for Th-230 and vanadium from sample collected in the Upper Chinle Non-Mixing Zone, Middle Chinle Non-Mixing Zone and the Chinle Combined Mixing Zone wells between May, 2003 and August, 2003 have been added to the their respective datasets. The Upper Chinle Non-Mixing Zone Th-230 and vanadium datasets each had one sample result added from wells 0934 (7/7/2003) and CW18 (7/7/2003). The Middle Chinle Non-Mixing Zone Th-230 and vanadium datasets each had one sample result added from wells WCW (7/17/2003), CW28 (7/7/2003), CW1 (7/10/2003), and CW2 (7/7/2003). The Combined Mixing Zone Th-230 and vanadium datasets each had one sample result added from wells CW15 (7/14/2003), CW17 (7/10/2003), CW24 (7/10/2003), CW35 (7/10/2003), CW36 (7/17/2003), CW37 (7/14/2003), CW39 (7/14/2003), CW43 (7/17/2003), CW50 (5/29/2003, 7/1/2003, and 8/14/2003), CW52 (6/11/2003, 7/1/2003, and 8/14/2003), CW9 (7/8/2003), and WR25 (7/10/2003).

The data used for statistical evaluation are presented for each constituent in tabular form in Appendix C.

3.0 Constituent Background Concentrations in Chinle Non-Mixing and Mixing Zone Aquifers

The data provided in Appendix C were processed using the test sequence and the methods presented in Section 2 of this report. The various test results for the Upper Chinle Non-Mixing Zone aquifer are discussed in detail in Section 3.1 with the results also shown in Tables A-1 through A-9 of Appendix A and Figures B-1 through B-12 of Appendix B. A summary of the Hypothesis testing is also presented in Table A-9, "Cumulative Test Results for Upper Chinle Non-Mixing Zone". This table shows the logic flow as leading to the results of the distribution analysis.

The results for the other aquifers have been abbreviated by discussing only the interesting aspects of the analyses and relying on the reader to find the values in the corresponding tables in Appendix A and corresponding charts in Appendix B. The results of the upper 95-percentile confidence level for nonparametric datasets, or the parametric upper tolerance limit for the parametric dataset, for all analyses of all constituents except total radium, are given in Table 3-1. The results for total radium, including Ra-226 and Ra-228, are given in Table 3-2.

3.1 Upper Chinle Non-Mixing Zone

3.1.1 Uranium

Uranium concentration data for the Upper Chinle wells were characterized by over 15 percent non-detects at laboratory detection limits of 0.00848 and 0.01 mg/L. The Upper Chinle uranium dataset consists of 166 sample results.

3.1.1.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 2.4 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

Because the Upper Chinle dataset had greater than 15% non-detects, the data were considered to be nonparametric (EPA 1989). Thus, no distribution tests were applied to these data. The data were assumed nonparametric and the 95th percentile was calculated. The results for the Percent Non-detects test are shown in Table A-2, found in Appendix A.

3.1.1.2 Determination of Upper Tolerance Limit

3.1.1.2.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 0.09 mg/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.2 Selenium

Selenium concentration data for the Upper Chinle wells were characterized by 45 percent non-detects at laboratory detection limits of 0.001, 0.002, 0.005, 0.0075, 0.01, and 0.0125 mg/L. The Upper Chinle selenium dataset consists of 165 sample results.

3.1.2.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 1.3 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

Table 3-1 Chinle Aquifer Statistical Analyses Summary Table

Parameter	Dataset	Distribution	95th Percentile or PUTL	Range		Arithmetic Mean	Number of Samples
				From	To		
U-nat	Upper	Nonparametric	0.09	0.0007	0.3610	0.031	166
	Middle	Nonparametric	0.07	0.0034	0.1357	0.019	190
	Lower	Nonparametric	0.02	0.0010	0.0260	0.012	60
	Mixing	Nonparametric	0.18	0.0020	0.2312	0.065	96
Selenium	Upper	Nonparametric	0.06	< 0.001	0.244	0.017	165
	Middle	Nonparametric	0.07	< 0.001	0.222	0.016	192
	Lower	Nonparametric	0.32	< 0.005	0.362	0.066	59
	Mixing	Nonparametric	0.14	< 0.001	0.520	0.048	96
Molybdenum	Upper	Nonparametric	0.08	< 0.01	0.235	0.027	142
	Middle	Nonparametric	0.05	< 0.01	0.150	0.022	165
	Lower	Nonparametric	0.03	< 0.01	< 0.03	0.015	32
	Mixing	Nonparametric	0.10	< 0.01	0.13	0.030	67
TDS	Upper	Nonparametric	2010	920	2160	1613	166
	Middle	Nonparametric	1557	560	1970	1273	187
	Lower	Nonparametric	4141	805	4180	2181	58
	Mixing	Nonparametric	3137	976	3217	1935	94
Sulfate	Upper	Parametric	914	535	998	747	167
	Middle	Nonparametric	857	319	1430	654	192
	Lower	Nonparametric	2002	284	2140	991	60
	Mixing	Nonparametric	1750	409	1880	1028	96
Nitrate	Upper	Nonparametric	4.89	< 0.01	7.9	1.21	124
	Middle	Nonparametric	4.00	0.04	5.02	1.08	138
	Lower	Nonparametric	2.99	< 0.1	3.2	0.87	27
	Mixing	Nonparametric	15.31	< 0.1	21.8	3.87	58
Chlorine	Upper	Nonparametric	412	21	540	142	127
	Middle	Nonparametric	63	< 0.01	85	40	143
	Lower	Nonparametric	634	46	657	204	28
	Mixing	Nonparametric	96	8.5	114	62	60
Vanadium	Upper	Nonparametric	0.01	< 0.01	< 0.01	0.005	39
	Middle	Nonparametric	0.01	< 0.01	0.02	0.006	43
	Lower	Nonparametric	0.01	< 0.01	0.01	0.005	16
	Mixing	Nonparametric	0.01	< 0.01	< 0.01	0.005	38
Thorium 230	Upper	Nonparametric	0.33	< 0.1	0.90	0.15	36
	Middle	Nonparametric	0.82	< 0.1	1.10	0.21	39
	Lower	Nonparametric	0.72	< 0.02	0.80	0.23	17
	Mixing	Nonparametric	0.70	< 0.02	0.80	0.19	38
Total Radium	Upper	Nonparametric	2.83	< 0.40	4.30	1.036	36
	Middle	Nonparametric	1.83	< 0.20	2.80	0.826	35
	Lower	Nonparametric	3.34	< 1.20	4.70	1.341	17
	Mixing	Nonparametric	3.99	< 1.20	4.30	1.483	24

Notes:

1 Results are in mg/L for all constituents except Th-230. Th-230 results in pCi/L.

2 Upper: Upper Chinle Non-Mixing Zone
Middle: Middle Chinle Non-Mixing Zone
Lower: Lower Chinle Non-Mixing Zone

Table 3-2 Chinle Aquifer Statistical Analyses Summary Table for Radium

Parameter	Dataset	Distribution	95th Percentile or PUTL	Range		Arithmetic Mean	Number of Samples
				From	To		
Total Radium	Upper	Nonparametric	3.66	< 0.6	4.7	1.77	17
	Middle	Nonparametric	2.20	< 0.2	2.8	1.46	33
	Lower	Nonparametric	3.24	0.3	4.3	1.46	35
	Mixing	Nonparametric	3.53	< 0.6	4.3	1.86	24
Ra-226	Upper	Nonparametric	1.00	< 0.2	1.4	0.506	17
	Middle	Nonparametric	0.46	0.1	0.9	0.424	33
	Lower	Nonparametric	0.63	0.1	1.0	0.267	35
	Mixing	Nonparametric	1.34	0.2	2.3	0.567	24
Ra-228	Upper	Nonparametric	2.66	< 1.0	4.1	1.265	17
	Middle	Nonparametric	1.74	< 0.1	2.5	1.033	33
	Lower	Nonparametric	2.61	0.1	4.0	1.189	35
	Mixing	Nonparametric	2.19	< 1.0	3.9	1.296	24

Notes:

1 Results are in pCi/L.

2 Upper: Upper Chinle Non-Mixing Zone
Middle: Middle Chinle Non-Mixing Zone
Lower: Lower Chinle Non-Mixing Zone

Because the Upper Chinle dataset had greater than 15% non-detects, the data were considered to be nonparametric (EPA 1989). Thus, no distribution tests were applied to these data. The data were assumed nonparametric and the 95th percentile was calculated. The results for the Percent Non-detects test are shown in Table A-2 in Appendix A..

3.1.2.2 Determination of Upper Tolerance Limit

3.1.2.2.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 0.06 mg/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.3 Molybdenum

One sample was removed from the molybdenum dataset due to an excessively high non-detect value of < 0.1 mg/L. This sample is listed in Table A-14 in Appendix A.

Molybdenum concentration data for the Upper Chinle wells were characterized by over 40 percent non-detects at laboratory detection limits of 0.01, 0.03, and 0.05 mg/L. The Upper Chinle molybdenum dataset consists of 142 sample results.

3.1.3.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 1.0 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

Because the Upper Chinle dataset had greater than 15% non-detects, the data were considered to be nonparametric (EPA 1989). Thus, no distribution tests were applied to these data. The data were assumed nonparametric and the 95th percentile was calculated. The results for the Percent Non-detects test are shown in Table A-2 in Appendix A.

3.1.3.2 Determination of Upper Tolerance Limit

3.1.3.2.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 0.08 mg/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.4 Total Dissolved Solids (TDS)

TDS concentration data for the Upper Chinle wells were characterized by zero percent non-detects. The Upper Chinle TDS dataset consists of 166 sample results

3.1.4.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 1.0 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

There were zero non-detects in the Upper Chinle TDS dataset. Because the dataset had less than 15 percent non-detects distribution tests were applied. The results for the Percent Non-detects test are shown in Table A-2 in Appendix A.

3.1.4.1.1 Coefficient of Variation

The regular and log-transformed datasets passed the CV screen. The CV value was 0.14 for the regular data, and 0.02 for the log-transformed data, compared to a critical value of 1. According to EPA 1998, if the CV is less than 1, the data may be normal and warrants further analysis. The coefficient of variation results are presented in Table A-3 in Appendix A.

3.1.4.1.2 Studentized Range Test

The regular dataset passed the Studentized range test. The calculated range (w) for the regular dataset divided by its standard deviation (s) produced a result of 5.59. The critical value range for a 95 percent confidence level and a population size of 166 is 4.65 to 6.25. When (w/s) falls inside the critical range it implies that the data may possibly be modeled by a normal curve (EPA 1998).

The log-transformed dataset failed the Studentized range test. The calculated range (w) for the log-transformed dataset divided by its standard deviation (s) produced a result of 6.29. When (w/s) falls outside the critical range, it implies that the data are not well modeled by a normal curve (EPA 1998). The Studentized range test results are shown in Table A-6 of Appendix A.

3.1.4.1.3 Geary's Test

The Geary's test on the Upper Chinle well data for TDS was not performed. This test is run on the EPA statistical application DataQUEST. DataQUEST has a dataset population limit of 150 sample results and the TDS dataset consists of 166 sample results.

3.1.4.1.4 Coefficient of Skewness

The regular and log-transformed datasets both passed the coefficient of skewness test. The calculated coefficient of skewness was 0.53 for the regular dataset and 0.08 for the log-transformed dataset. An acceptable value for a coefficient of skewness would fall in the range of -1 to 1. Both coefficients of skewness were within the acceptable range therefore a normal distribution may accurately approximate both datasets (EPA 1992). The calculated coefficients of skewness are shown in Table A-6 in Appendix A.

3.1.4.1.5 Shapiro-Francia (n >50) Test of Normality

The regular and log-transformed datasets failed the Shapiro-Francia test for normality. The calculated W' value was 0.937 for the regular dataset and 0.944 for the log-transformed dataset. The critical value for a 95 percent confidence level and a population size of 166 is 0.985. With both calculated W' values falling below the critical value, normality for both datasets was rejected (EPA 1992). These results are presented in Table A-7 in Appendix A.

3.1.4.1.6 Filliben's Statistic

The Filliben's Statistic test on the Upper Chinle well data for TDS was not performed. This test is run on the EPA statistical application DataQUEST. DataQUEST has a dataset population limit of 100 sample results for this test and the TDS dataset consists of 166 sample results.

3.1.4.1.7 Histograms

Figure B-1 shows the histogram of the Upper Chinle TDS regular dataset. The histogram shows an uneven distribution of data with a right skew. This histogram implies that the data may not follow a normal distribution and the assumption of normality could provide a poor approximation of the dataset.

Figure B-2 depicts the histogram for the log-transformed dataset. This figure also depicts a right skewness implying that the log-transformed data may not follow a normal distribution and the assumption of normality could also provide a poor approximation of the dataset.

3.1.4.1.8 Probability Plots

Figure B-3 shows the probability plot for the Upper Chinle TDS regular dataset. The plot depicts a line of data points with a bend. There are also a number of breaks in the line as the concentration approaches the lower range of results. This implies that the dataset may not follow a normal distribution.

Figure B-4 shows the probability plot for the log-transformed data. This plot also depicts a line with a bend and a number of breaks in it as the concentration approaches the lower range of results. This implies that the log-transformed data may not follow a normal distribution.

3.1.4.2 Determination of Distribution

The distribution analysis results for both the regular and log-transformed datasets were determined to be nonparametric. A summary of the distributional analyses results is shown in Table A-13 in Appendix A. In an attempt to remove outliers and possibly show that the distribution is normal, the regular dataset was chosen for application of the T_n statistic test.

3.1.4.2.1 The T_n Statistic Test

Though the Upper Chinle datasets were determined to be nonparametric, the T_n statistic outlier test was applied to the regular dataset in an attempt to remove any outliers. No outliers were identified using the T_n statistic. The table summarizing the T_n statistic results is presented as Table A-9 in Appendix A.

3.1.4.3 Determination of Upper Tolerance Limit

3.1.4.3.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 2010 mg/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.5 Sulfate

The sulfate concentration data for the Upper Chinle wells were characterized by zero percent non-detects. The Upper Chinle sulfate dataset consists of 167 sample results.

3.1.5.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 1.0 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

Since the dataset had fewer than 15 percent non-detects, distribution tests were applied. The results for the Percent Non-detects test are shown in Table A-2 in Appendix A.

3.1.5.1.1 Coefficient of Variation

The regular and log-transformed datasets passed the CV screen. The CV value was 0.11 for the regular data, and 0.02 for the log-transformed data, compared to a critical value of 1. According to EPA 1998, if the CV is less than 1, the

data may be normal and warrant further analysis. The coefficient of variation results are presented in Table A-3 in Appendix A.

3.1.5.1.2 Studentized Range Test

The regular and log-normal datasets passed the Studentized range test. The calculated range (w) for the regular dataset divided by its standard deviation (s) produced a result of 5.49. The calculated range (w) for the log-transformed dataset divided by its standard deviation (s) produced a result of 5.45. The critical value range for a 95 percent confidence level and a population size of 167 is 4.65 to 6.25. When (w/s) falls inside the critical range it implies that the data may possibly be modeled by a normal curve (EPA 1998). The Studentized range test results are shown in Table A-4 of Appendix A.

3.1.5.1.3 Geary's Test

The Geary's test on the Upper Chinle well data for sulfate was not performed. This test is run on the EPA statistical application DataQUEST. DataQUEST has a dataset population limit of 150 sample results and the sulfate dataset consists of 167 sample results.

3.1.5.1.4 Coefficient of Skewness

The regular and log-transformed datasets passed the coefficient of skewness test. The calculated coefficient of skewness was 0.09 for the regular dataset and -0.31 for the log-transformed dataset. An acceptable value for a coefficient of skewness falls in the range of -1 to 1. Both coefficients of skewness were within the acceptable range therefore a normal distribution may accurately approximate both datasets (EPA 1992). The calculated coefficients of skewness are shown in Table A-6 in Appendix A.

3.1.5.1.5 Shapiro-Francia (n >50) Test of Normality

The regular dataset passed the Shapiro-Francia test for normality. The calculated W' value was 0.989. The critical value for a 95 percent confidence level and a population size of 167 is 0.985. With the calculated W' value above the critical value, normality for the regular dataset can not be rejected (EPA 1992). These results are presented in Table A-7 in Appendix A.

The log-transformed dataset failed the Shapiro-Francia test for normality. The calculated W' value was 0.984 for the log-transformed dataset. The critical value for a 95 percent confidence level and a population size of 167 is 0.985. With the calculated W' value falling below the critical value, normality for the log-normal dataset was rejected (EPA 1992). These results are presented in Table A-7 in Appendix A.

3.1.5.1.6 Filliben's Statistic

The Filliben's Statistic test on the Upper Chinle well data for sulfate was not performed. This test is run on the EPA statistical application DataQUEST. DataQUEST has a dataset population limit of 100 sample results for this test and the sulfate dataset consists of 167 sample results.

3.1.5.1.7 Histograms

Figure B-5 shows the histogram of the Upper Chinle sulfate regular dataset. The histogram shows a symmetrical distribution of data with no skew. This histogram implies that the data may follow a normal distribution.

Figure B-6 depicts the histogram for the log-transformed dataset. This figure also depicts a slight right skewness implying a normal distribution may provide a poor approximation of the dataset

3.1.5.1.8 Probability Plots

Figure B-7 shows the probability plot for the Upper Chinle sulfate regular dataset. The plot depicts a line of data points with a slight bend and a few breaks at the upper and lower range of the results. This probability plot is not the ideal example of what a perfectly normal dataset would look like but it isn't necessarily a failure either. The plot implies that the dataset may or may not follow a normal distribution.

Figure B-8 shows the probability plot for the log-transformed data. This plot also depicts a line with a slight bend and a few breaks in it as the concentration approaches the upper and lower range of results. This plot implies that the log-transformed data, like the regular data, may or may not follow a normal distribution.

3.1.5.1.9 Determination of Distribution

Based on the distribution analysis results of both the regular and log-transformed datasets, the regular dataset is considered to be parametric. The log-transformed data is considered to be nonparametric. A summary of the distributional analyses results is shown in Table A-9 in Appendix A. Since the regular dataset was found to be parametric, no T_n statistic test was performed.

3.1.5.2. Determination of Upper Tolerance Limit

3.1.5.2.1 Parametric Upper Tolerance Limit

The Upper Chinle parametric upper tolerance limit was determined to be 914 mg/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.6 Nitrate

Nitrate concentration data for the Upper Chinle wells were characterized by over 30 percent non-detects at laboratory detection limits of 0.01, 0.1 and 1.0 mg/L. The Upper Chinle nitrate dataset consists of 124 sample results.

3.1.6.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 1.2 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

Because the Upper Chinle dataset had greater than 15% non-detects, the data were considered to be nonparametric (EPA 1989). Thus, no distribution tests were applied to these data. The data were assumed nonparametric and the 95th percentile was calculated. The results for the Percent Non-detects test are shown in Table A-2, found in Appendix A.

3.1.6.2 Determination of Upper Tolerance Limit

3.1.6.2.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 4.89 mg/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.7 Chloride

Chloride concentration data for the Upper Chinle wells were characterized by zero percent non-detects. The Upper Chinle chloride dataset consists of 127 sample results.

3.1.7.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 1.0 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

There were zero non-detects in the Upper Chinle chloride dataset. Because the dataset had less than 15 percent non-detects distribution tests were applied. The results for the Percent Non-detects test are shown in Table A-2 in Appendix A.

3.1.7.1.1 Coefficient of Variation

The regular and log-transformed datasets passed the CV screen. The CV value was 0.94 for the regular data, and 0.20 for the log-transformed data, compared to a critical value of 1. According to EPA 1998, if the CV is less than 1, the data may be normal and warrants further analysis. The coefficient of variation results are presented in Table A-3 in Appendix A.

3.1.7.1.2 Studentized Range Test

The regular and log-transformed datasets failed the Studentized range test. The calculated range (w) for the regular dataset divided by its standard deviation (s) produced a result of 3.88 for the regular dataset and 3.52 for the log-transformed dataset. The critical value range for a 95 percent confidence level and a population size of 127 is 4.42 to 6.05. When (w/s) falls outside the critical range, it implies that the data are not well modeled by a normal curve (EPA 1998). The Studentized range test results are shown in Table A-4 of Appendix A.

3.1.7.1.3 Geary's Test

The Geary's test on the Upper Chinle well data for chloride was performed using the EPA statistical application DataQUEST. For the regular dataset DataQUEST returned a sample value of 1.27 compared to a table value of 1.65. With the sample value less than the table value, there was not enough evidence to reject the assumption of normality with a 5 percent significance level. The results of Geary's test are presented in Table A-5 of Appendix A.

For the log-transformed dataset DataQUEST returned a sample value of 6.23 compared to a table value of 1.65. With the sample value greater than the table value, non-lognormality was detected at a 5 percent significance level.

3.1.7.1.4 Coefficient of Skewness

The regular dataset failed the coefficient of skewness test. The calculated coefficient of skewness was 1.22 for the regular dataset. An acceptable value for a coefficient of skewness would fall in the range of -1 to 1. Since the coefficient of skewness does not fall within the acceptable range, a normal distribution will not accurately approximate the dataset (EPA 1992).

The log-transformed dataset passed the coefficient of skewness test. The calculated coefficient of skewness was 0.37 for the log-transformed dataset. Since the coefficient of skewness was within the acceptable range a normal distribution may accurately approximate the log-transformed dataset (EPA 1992). The calculated coefficients of skewness are shown in Table A-6 in Appendix A.

3.1.7.1.5 Shapiro-Francia (n >50) Test of Normality

The regular and log-transformed datasets failed the Shapiro-Francia test for normality. The calculated W' value was 0.80 for the regular dataset and 0.90 for the log-transformed dataset. The critical value for a 95 percent confidence level and a population size of 127 is 0.985. With both calculated W' values falling below the critical value, normality for both datasets was rejected (EPA 1992). These results are presented in Table A-7 in Appendix A.

3.1.7.1.6 Filliben's Statistic

The Filliben's Statistic test was not performed on the Upper Chinle well data for chloride. This test is run on the EPA statistical application DataQUEST. DataQUEST has a dataset population limit of 100 sample results for this test and the chloride dataset consists of 127 sample results.

3.1.7.1.7 Histograms

Figure B-9 shows the histogram of the Upper Chinle chloride regular dataset. The histogram shows an uneven distribution of data with strong left skew. This histogram implies that the data may not follow a normal distribution and the assumption of normality could provide a poor approximation of the dataset.

Figure B-10 depicts the histogram for the log-transformed dataset. This figure also depicts a strong left skewness implying that the log-transformed data may not follow a normal distribution and the assumption of normality could also provide a poor approximation of the dataset

3.1.7.1.8 Probability Plots

Figure B-11 shows the probability plot for the Upper Chinle chloride regular dataset. The plot depicts a line of data points with a dramatic bend. There are also several breaks in the line throughout the entire range of results. This implies that the dataset may not follow a normal distribution.

Figure B-12 shows the probability plot for the log-transformed data. This plot also depicts a line with a bend and several breaks in it throughout the entire range of results. This implies that the log-transformed data may not follow a normal distribution.

3.1.7.2 Determination of Distribution

Based on the distribution analysis results for both the regular and log-transformed datasets, both are considered to be nonparametric. A summary of the distributional analyses results is shown in Table A-9 in Appendix A. For the purpose of selecting the dataset to further analyze for distribution using the T_n statistic and performing an upper tolerance limit calculation, a choice of which dataset best approximates normality must be made even though both datasets show poor approximation of normality. Based on the previous distributional analyses results, the log-transformed dataset is found to most closely follow a normal distribution.

3.1.7.2.1 The T_n Statistic Test

Though the Upper Chinle datasets were determined to be nonparametric, the T_n statistic outlier test was applied to the regular dataset in an attempt to remove any outliers. No outliers were identified using the T_n statistic. The table summarizing the T_n statistic results is presented as Table A-13 in Appendix A.

3.1.7.3 Determination of Upper Tolerance Limit

3.1.7.3.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 412 mg/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.8 Vanadium

Two samples were removed from the vanadium dataset due to excessively high non-detect values of < 0.1 mg/L. These samples are listed in Table A-14 in Appendix A. Two samples were collected in July, 2003 and later analyzed. Their values have been added to the dataset and are listed in Table A-15 in Appendix A.

Vanadium concentration data for the Upper Chinle wells were characterized by 100 percent non-detects at the laboratory detection limit of 0.01 mg/L. The Upper Chinle vanadium dataset consists of 39 sample results.

3.1.8.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. The two highest sample results, as well as all sample results, were the same at the non-detect limit of 0.01 mg/L. Results of the *a priori* test are presented in Table A-1 of Appendix A.

Because the Upper Chinle dataset had greater than 15% non-detects, the data were considered to be nonparametric (EPA 1989). Thus, no distribution tests were applied to these data. The data were assumed nonparametric and the 95th percentile was calculated. The results for the Percent Non-detects test are shown in Table A-2 in Appendix A.

3.1.8.2 Determination of Upper Tolerance Limit

3.1.8.2.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 0.01 mg/L. This result is the 95th percentile of the combined 39 "< 0.01" non-detect values. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.9 Thorium-230

Four sample results were removed from the thorium-230 dataset due to reported values of zero. These four samples are listed in Table A-13 in Appendix A. One sample was removed from the Th-230 dataset due to an excessively high non-detect value of < 1.0 pCi/L. This sample is listed in Table A-14 in Appendix A. Two samples were collected in July, 2003 and later analyzed. Their values have been added to the Th-230 dataset and are listed in Table A-15 in Appendix A.

Thorium-230 concentration data for the Upper Chinle wells were characterized by over 80 percent non-detects at laboratory detection limits of 0.1, 0.2, 0.3, and 0.4 pCi/L. The Upper Chinle thorium-230 dataset consists of 36 sample results.

3.1.9.1 Distribution Analysis Results

No outliers were identified or eliminated from the dataset. The *a priori* test compares the two highest sample results for closeness. An *a priori* test ratio of 2.3 was calculated indicating the highest test result was not at least three times higher than the second highest test result, and therefore elimination of the highest test result was not warranted based solely on this test. Results of the *a priori* test are presented in Table A-1 of Appendix A.

Because the Upper Chinle dataset had greater than 15% non-detects, the data were considered to be nonparametric (EPA 1989). Thus, no distribution tests were applied to these data. The data were assumed nonparametric and the 95th percentile was calculated. The results for the Percent Non-detects test are shown in Table A-2 in Appendix A.

3.1.9.2 Determination of Upper Tolerance Limit

3.1.9.2.1 95th Percentile

The Upper Chinle 95th percentile was determined to be 0.33 pCi/L. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.1.10 Total Radium

Total radium refers to the dissolved concentrations of both Ra-226 and Ra-228.

One sample result was removed from the Upper Chinle total radium dataset due to a reported value of zero. This sample is listed in Table A-13 in Appendix A.

Total radium concentration data for the Upper Chinle wells were characterized by over 15 percent non-detects for both Ra-226 and Ra-228 at laboratory detection limits of 0.2 pCi/L (Ra-226) and 0.1, 0.9 and 1.0 pCi/L (Ra-228). The Upper Chinle total radium dataset consists of 35 sample results.

3.1.10.1 Distribution Analysis Results

One outlier was identified and eliminated due to failure of the *a priori* test. The *a priori* test compares the two highest sample results for closeness and was performed on each individual radium dataset (Ra-226 and Ra-228) and the combined total radium dataset. If a sample failed either individual or the combined test the entire sample result was removed to ensure no suspect data would be included in the analyses. An *a priori* test ratio of 11.7 (Ra-226) was calculated indicating the highest test result was at least three times higher than the second highest test result, and therefore elimination of the highest test result was warranted based solely on this test. The sample result was removed and the test performed again and the maximum ratio calculated was 1.4. Results of the *a priori* test are presented in Table A-1 of Appendix A.

The Percent Non-detects Test was performed on both the individual data sets (Ra-226 and Ra-228) and the combined total radium dataset. All three test results for the Upper Chinle radium datasets had greater than 15% non-detects, the data were considered to be nonparametric (EPA 1989). Thus, no distribution tests were applied to these data. The data were assumed nonparametric and the 95th percentile was calculated. The results for the Percent Non-detects test are shown in Table A-2, found in Appendix A.

3.1.10.2 Determination of Upper Tolerance Limit

3.1.10.2.1 95th Percentile

The Upper Chinle 95th percentile for total radium is 3.20 pCi/L. This value was calculated by summing the Ra-226 95th percentile and the Ra-228 95th percentile. The table summarizing all upper tolerance limit test results is presented as Table 3-1.

3.2 Middle Chinle Non-Mixing Zone

There were no unusual findings in the distributional analyses of the Middle Chinle datasets. TDS, sulfate and chloride were the only constituents to pass the Determination of Percent Non-detects test. Further distributional analyses were performed on these constituents. The results of all individual tests are shown in Tables A-1 through A-8 in Appendix A. The table of cumulative test results is given in Table A-10.

One sample was omitted from the molybdenum dataset due to an excessively high non-detect value of < 0.1 mg/L.

There were two outliers identified in the TDS dataset. These outliers were identified by the T_n Statistic test, removed from the dataset, and the distributional analyses continued on the updated dataset.

There were ten outliers identified in the nitrate regular dataset. These outliers were identified using the T_n statistic test. Upon removal of these ten outliers the dataset failed the Determination of Percent Non-detects test and was immediately classified as nonparametric. No further distributional tests were applied to the nitrate dataset.

There were four outliers identified in the chloride dataset. These outliers were identified by the T_n Statistic test, removed from the dataset, and the distributional analyses continued on the updated dataset.

Two samples were omitted from the vanadium dataset due to excessively high non-detect values of < 0.1 mg/L. Four samples collected in July, 2003 were later analyzed and their values have been added to the vanadium dataset.

Five sample results were removed from the thorium-230 dataset due to reported values of zero. Four samples collected in July, 2003 were later analyzed and their values have been added to the thorium-230 dataset.

Two sample results were removed from the total radium dataset due to reported values of zero (Ra-228) and one outlier was identified by the a priori test and removed from the dataset prior to calculating the 95th percentile (Ra-226).

The aforementioned outliers and zero values are listed in Table A-13 in Appendix A. The aforementioned high non-detect values omitted are listed in Table A-14 in Appendix A. The aforementioned samples added to their respective datasets in year 2003 are listed in Table A-15 in Appendix A.

3.3 Lower Chinle Non-Mixing Zone

There were no unusual findings in the distributional analyses of the Lower Chinle datasets. Uranium, TDS, sulfate and chloride were the only constituents to pass the Determination of Percent Non-detects test. Further distributional analyses were performed on these constituents. The results of all individual tests are shown in Tables A-1 through A-8 in Appendix A. The table of cumulative test results is given in Table A-11.

There was one outlier identified in the molybdenum dataset. This outlier was identified by the *a priori* test and removed from the dataset prior to calculating the 95th percentile.

There were two outliers identified in the TDS dataset. One outlier was identified by the *a priori* test and removed from the dataset prior to distributional analyses. The second outlier was identified by the T_n Statistic test, removed from the dataset, and the distributional analyses continued on the updated dataset.

There was one outlier identified in the selenium dataset. This outlier was identified by the *a priori* test and removed from the dataset prior to calculating the 95th percentile.

The aforementioned outliers are listed in Table A-13 in Appendix A

3.4 Chinle Mixing Zone

There were no unusual findings in the distributional analyses of the Chinle Mixing Zone datasets. Uranium, selenium, TDS, sulfate and chloride were the only constituents to pass the Determination of Percent Non-detects test. Further distributional analyses were performed on these constituents. The results of all individual tests are shown in Tables A-1 through A-8 in Appendix A. The table of cumulative test results is given in Table A-12.

There was one outlier identified in the TDS dataset. This outlier was identified by the T_n Statistic test, removed from the dataset, and the distributional analyses continued on the updated dataset.

There were two outliers identified in the chloride dataset. The outliers were identified by the T_n Statistic test, removed from the dataset, and the distributional analyses continued on the updated dataset.

Two samples were omitted from the vanadium dataset due to excessively high non-detect values of < 0.1 mg/L. Sixteen samples collected between May, 2003 and August, 2003 were later analyzed and their values have been added to the vanadium dataset.

Two samples were omitted from Th-230 dataset due to excessively high non-detect values of < 1.0 pCi/L. Sixteen samples collected between May, 2003 and August, 2003 were later analyzed and their values have been added to the thorium-230 dataset.

There was one outlier identified in the total radium dataset (Ra-226). This outlier was identified by the *a priori* test and removed from the dataset prior to calculating the 95th percentile.

The aforementioned outliers are listed in A-13 in Appendix A. The aforementioned high non-detect values omitted are listed in Table A-14 in Appendix A. The aforementioned samples added to their respective datasets in year 2003 are listed in Table A-15 in Appendix A.

4.0 Summary

Samples were collected at the Chinle Upper, Middle and Lower Non-Mixing Zone wells, and the Chinle Mixing Zone wells, from 1979 to 2003. Five wells provided the Upper Chinle well data. Six wells provided the Middle Chinle data. Six wells provided the Lower Chinle well data. Thirteen wells provided the Chinle Mixing Zone data. Close examination of the groundwater database provided justification for elimination of select samples. Samples were eliminated based upon high detection limits, reported zero concentrations, and extreme maximum concentrations. Sample results obtained after the initial statistical evaluation have since been added to the Th-230 and vanadium datasets for the Upper Chinle Non-Mixing Zone, Middle Chinle Non-Mixing Zone, and the Chinle Mixing Zone.

Statistical analyses were performed on the individual datasets to determine distribution and upper tolerance limits. Results of the distribution analysis indicated that all datasets were nonparametrically distributed, with the exception of the Upper Chinle sulfate dataset.

The 95th percentile was calculated as the nonparametric upper tolerance limit for all analyzed datasets. For the Upper Chinle sulfate dataset the parametric upper tolerance limit was calculated for a 95 percent confidence level. It should be noted that since the 95th percentile, and 95th percent confidence level, were calculated as the upper tolerance limits, statistically, one would expect the upper tolerance limit to be exceeded 5% of the time. Two summary tables of the parameter, dataset, distribution, 95th percentile, range, and sample number are provided in Section 3 as Tables 3-1 and 3-2.

5.0 References

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Appendix A - Statistical Analyses Tables

Table A-1 *A Priori* Test Results

	Upper Chinle Non-Mixing Zone	Middle Chinle Non-Mixing Zone	Lower Chinle Non-Mixing Zone	Chinle Mixing Zone
U-nat	2.4	1.2	1.0	1.0
Se	1.3	2.2	1.1	2.2
Mo	1.0	1.4	1.0	1.0
TDS	1.0	1.1	1.0	1.0
SO_4	1.0	1.0	1.0	1.0
NO_3	1.2	1.0	1.0	1.3
Cl	1.0	1.0	1.0	1.1
V	1.0	1.0	2.0	1.0
Th-230	2.3	1.1	1.1	1.1
Total Radium	1.1	1.5	1.57	1.0
Ra-226	*1.4*	*1.3*	*1.56*	*1.6*
Ra-228	*1.3*	*1.4*	*1.78*	*1.8*

Note:

1. The a priori test results are the ratio of the highest to second highest sample analysis results. A ratio of 3.0, or greater indicates outlier status. The high analysis result is removed and the test run again. The results above are of the final dataset used for distributional analyses. If a sample failed the a priori test it will be listed in Table A-13 as an outlier.

2. The total radium results are calculated by dividing the maximum combined Ra-226 and Ra-228 analytical results by the second highest combined Ra-226 and Ra-228 analytical results. The individual Ra-226 and Ra-228 results are for those individual isotopes exclusively.

Table A-2 Percentage of Non-detects Test Results

	Upper Chinle Non-Mixing Zone	Middle Chinle Non-Mixing Zone	Lower Chinle Non-Mixing Zone	Chinle Mixing Zone
U-nat	0.16	0.32	0.05	0.02
Se	0.45	0.36	0.27	0.14
Mo	0.42	0.30	1.00	0.66
TDS	0.00	0.00	0.00	0.00
SO_4	0.00	0.00	0.00	0.00
NO_3	0.34	0.15	0.33	0.21
Cl	0.00	0.14	0.00	0.00
V	1.00	0.93	0.94	1.00
Th-230	0.83	0.74	0.77	0.74
Total Radium	0.57	0.48	0.18	0.17
Ra-226	0.69	0.58	0.18	0.25
Ra-228	0.66	0.79	0.82	0.71

Note:

1. The total radium results are calculated by counting as non-detect only the samples that had non-detects for both Ra-226 and Ra-228. The individual Ra-226 and Ra-228 results are for those individual isotopes exclusively.

Table A-14 High Non-detect Values Removed from Datasets

	Constituent	Well	Sample Date	Removed ND Value
Upper Chinle Non-Mixing Zone	Molybdenum	CW3	7/29/1992	< 0.1
	Vanadium	CW3	7/29/1992	< 0.1
	Vanadium	CW3	8/11/1993	< 0.1
	Th-230	CW3	8/11/1993	< 1.0
Middle Chinle Non-Mixing Zone	Molybdenum	CW2	7/30/1992	< 0.1
	Vanadium	CW2	11/19/1987	< 0.1
	Vanadium	CW2	7/30/1992	< 0.1
Chinle Mixing Zone	Vanadium	CW9	9/13/1993	< 0.1
	Vanadium	CW10	9/13/1993	< 0.1
	Th-230	CW9	9/13/1993	< 1.0
	Th-230	CW10	9/13/1993	< 1.0

Table A-15 2003 Sample Results Added To Datasets

	Constituent	Well	Sample Date	Added Value
Upper Chinle Non-Mixing Zone	Vanadium	934	7/7/2003	< 0.01
	Vanadium	CW18	7/7/2003	< 0.01
	Th-230	0934	7/7/2003	0.3
	Th-230	CW18	7/7/2003	0.3
Middle Chinle Non-Mixing Zone	Vanadium	WCW	7/17/2003	< 0.01
	Vanadium	CW28	7/7/2003	< 0.01
	Vanadium	CW1	7/10/2003	< 0.01
	Vanadium	CW2	7/10/2003	< 0.01
	Th-230	WCW	7/17/2003	< 0.2
	Th-230	CW28	7/7/2003	< 0.2
	Th-230	CW1	7/10/2003	< 0.2
	Th-230	CW2	7/10/2003	< 0.2
Chinle Mixing Zone	Vanadium	CW15	7/14/2003	< 0.01
	Vanadium	CW17	7/10/2003	< 0.01
	Vanadium	CW24	7/10/2003	< 0.01
	Vanadium	CW35	7/10/2003	< 0.01
	Vanadium	CW36	7/17/2003	< 0.01
	Vanadium	CW37	7/14/2003	< 0.01
	Vanadium	CW39	7/14/2003	< 0.01
	Vanadium	CW43	7/17/2003	< 0.01
	Vanadium	CW50	7/1/2003	< 0.01
	Vanadium	CW50	5/29/2003	< 0.01
	Vanadium	CW50	8/14/2003	< 0.01
	Vanadium	CW52	6/11/2003	< 0.01
	Vanadium	CW52	7/1/2003	< 0.01
	Vanadium	CW52	8/14/2003	< 0.01
	Vanadium	CW9	7/8/2003	< 0.01
	Vanadium	WR25	7/10/2003	< 0.01
	Th-230	CW15	7/14/2003	< 0.2
	Th-230	CW17	7/10/2003	< 0.2
	Th-230	CW24	7/10/2003	< 0.2
	Th-230	CW35	7/10/2003	< 0.2
	Th-230	CW36	7/17/2003	< 0.2
	Th-230	CW37	7/14/2003	< 0.2
	Th-230	CW39	7/14/2003	< 0.2
	Th-230	CW43	7/17/2003	< 0.2
	Th-230	CW50	7/1/2003	0.3
	Th-230	CW50	5/29/2003	0.3
	Th-230	CW50	8/14/2003	0.5
	Th-230	CW52	6/11/2003	0.3
	Th-230	CW52	7/1/2003	0.3
	Th-230	CW52	8/14/2003	0.5
	Th-230	CW9	7/8/2003	0.3
	Th-230	WR25	7/10/2003	< 0.2