

Environmental Survey
April 3 - April 5, 1979

ANACONDA COPPER COMPANY
Yerington, Nevada

April 17, 1979

INTRODUCTION AND PURPOSE

The environmental survey of Anaconda's Yerington Operations began on April 3, 1979 and was conducted for three days. The study included a radiological survey (gamma emission) of the mine dumps, open pit, stock piles and the tailings areas. Soil, water and vegetation samples were also collected at select locations for radiological analysis.

The purpose of this study is to locate any possible radiological hazards within the mining and milling areas.

PROCEDURE

The gamma survey was conducted from a pick-up truck using a PRM-7 Micro R Meter. All dumps, stockpiles and tailings ponds were surveyed as access and time permitted. Readings were recorded every 20-40 meters. The instrument was operating continuously between recording points to check for any anomaly. Any exposure rates greater than 25 u R/hr were staked and recorded. A fine grid survey is set up on such anomalies with readings taken every 7-10 meters in all directions away from the anomaly until background readings are encountered. The field data sheets and maps with gamma survey routes are included with this report. The survey route on the maps has a corresponding data sheet page number. Dumps with gamma readings where the standard deviation of the group is less than 35% of the population are deemed as uniform and only require a 9 point composite soil sample. Dumps that are not uniform are soil sampled on a finer grid.

Soil was sampled on all dumps, stockpiles and tailings sites. Soil was also sampled at any anomaly. Nine composite sub-samples were taken on sites that comply with the uniformity criteria. The non-uniform sites were sampled with two sets of composites. The sample area is 10 meters square and approximately 300 grams of soil material was collected at each of the points. The composites will be analyzed for Ra226, Thorium 230 and Uranium-Nat.

Vegetation was sampled in the same locality as was the soil, when possible. A composite sample of the vegetative species (2 Kilograms) was collected on dumps supporting growth. This sampling will reveal uptake of radiological materials from subsurface soils. Many areas at the mine did not support vegetation because of recent disturbance or leach treatments.

Three water samples were collected and will be analyzed radiologically. All soil, vegetation and water sample locations are pin pointed on the mine maps.

Five anomalous readings were located on the Yerington property. All the five sites are staked, marked and on the maps. Abnormal readings 1 and 2 (marked A-1 and A-2) are not serious but finger ponds 3, 4 and 5 (marked A-3, A-4 and A-5) display high gamma readings particularly pond 5. Pond solids will be analyzed and the results will more closely identify the problem.

Laboratory results of water, soil and vegetation samples will be forwarded as soon as recieved.

OPERATIONS COMPANY
Operations

ENVIRONMENTAL SURVEY
(Gamma)

All readings in uR/hr

<u>Location</u>	<u>Date</u>	<u>Mean Reading</u>	<u>Standard Deviation</u>	<u>*Uniformity</u>
Background				
Road to Singatze Peak	4-3-79	14.4	1.88	0.04
W-3 Oxide	4-3-79	13.27	1.33	0.03
DW-13**	4-3-79	15.6	3.26	0.08
DW-6 (40 pts)	4-3-79	13.5	2.0	0.05
DW-6 (Lower Deck)	4-3-79	16.2	1.85	0.10
DW-6 (Lower Deck)**	4-3-79	17.0	3.62	0.061
DW-6 (Lowest Deck)	4-3-79	12.6	1.05	0.062
DW-11	4-3-79	13.9	1.37	0.02
DW-1	4-4-79	11.8	1.85	0.09
DW-3 South	4-4-79	11.6	2.14	0.08
DW-3 Pit	4-4-79	12.4	1.78	0.01
DW-3 North of Dw-3 pit	4-4-79	12.9	1.3	0.01
DW-3 Northeast Deck	4-4-79	14.11	1.36	0.15
DW-3 North	4-4-79	12.8	1.28	0.06
DW-3 Sulfide	4-4-79	13.44	0.98	0.05
S-23 (Low grade Stockpile)	4-4-79	14.47	1.93	0.09
Oxide Tails, Lower Deck (55 pt)	4-4-79	14.8	2.66	0.01
Oxide Tails, Mid Deck	4-4-79	13.38	1.57	0.08
Oxide Tails, Top Deck	4-4-79	12.94	1.24	0.07
Sulfide Tails, Covered with Oxide Tails	4-5-79	13.5	1.31	0.02
Sulfide Tails Uncovered	4-5-79	15.53	1.06	0.07
Sulfide Tails Evaporation Area (P-2)	4-5-79	17.36	1.61	0.07
Evaporation Ponds	4-5-79	14.00	1.61	0.02
Finger Ponds				
#1	4-5-79	15.0	1.50	0.12
#2	4-5-79	15.66	1.43	0.11
#3	4-5-79	26.83	4.19	0.35**
#4	4-5-79	23.84	3.50	0.26
#5	4-5-79	93.00	15.90	1.06**

*A group is uniform provided the Standard Deviation is less than 35% of the population

**Locations that require two composite soil samples

ANOMALOUS READINGS (Greater than 25 uR/hr)

<u>Location</u>	<u>Date</u>	<u>Reading</u>	<u>Additional Sampling</u>
DW-13 South Crest A-1	4-3-79	25 uR/hr	Soil - Veg
DW-6 Near center on Road A-2	4-3-79	27 uR/hr	Soil - Veg
Finger Evap Pond #3 A-3	4-5-79	30 uR/hr	Soil
Finger Evap Pond #4 A-4	4-5-79	32 uR/hr	Soil
Finger Evap Pone #5 A-5	4-5-79	120 uR/hr	Soil

ANACONDA COPPER COMPANY
Yerington Operations

ENVIRONMENTAL SURVEY

Soil samples to be analyzed for Uranium-Nat., Radium 226 and Thorium 230.
All sample locations are noted on the maps included with this report.

1. Dump W-13 Oxide	9 point composite
2. Dump W-13 A-1	9 point composite
3. Dump W-6	9 point transect composite
4. Dump W-6	9 point transect composite
5. Dump W-6 (Top deck) A-2	9 point composite
6. Dump W-11	9 point transect composite
7. Dump W-1	9 point composite
8. Dump W-3 (South)	9 point composite
9. Dump W-3 (Pit or slot)	9 point composite
10. DW-3 (North of Pit or slot)	9 point composite
11. DW-3 (NE Deck)	9 point composite
12. DW-3 (North Deck)	9 point composite
13. DW-3 Sulfide	9 point composite
14. S-23 Lowgrade	9 point composite
15. Oxide Tails (Mid Deck)	9 point composite
16. Oxide Tails (Lower Deck)	9 point composite
17. Uncovered Sulfide Tails	9 point composite
18. Evaporation Tails Ponds	9 point composite
19. Large Evaporation Ponds	9 point composite
20. Finger Pond 3 - A-3	18 point composite
21. Finger Pond 4 - A-4	9 point composite
22. Finger Pond 5 - A-5	18 point composite

ANACONDA COPPER COMPANY
Yerington Operations

ENVIRONMENTAL SURVEY

Vegetation samples to be analyzed for Uranium-Nat., Radium 226 and Thorium 230.
All sample locations are noted on the maps included with this report.

- | | | |
|----|-------------------------|-----------------------------|
| 1. | Dump W-13 Oxide | Composite vegetation sample |
| 2. | Dump W-13 A-1 | Composite vegetation sample |
| 3. | Dump W-6 (South end) | Composite vegetation sample |
| 4. | Dump W-6 (North end) | Composite vegetation sample |
| 5. | Dump W-6 (Top deck) A-2 | Composite vegetation sample |
| 6. | Dump W-11 | Composite vegetation sample |
| 7. | Dump W-1 | Composite vegetation sample |
| 8. | Dump W-3 Slot or pit | Composite vegetation sample |

ANACONDA COPPER COMPANY
Yerington Operations

ENVIRONMENTAL SURVEY

Water samples to be analyzed for Uranium-Nat., Radium 226 and Thorium 230.
All sample locations are noted on the maps.

- | | | | |
|----|------------------------------|--------|-------------|
| 1. | Open Pit | 4-4-79 | Grab sample |
| 2. | Sulfide Tailings (Uncovered) | 4-5-79 | Grab sample |
| 3. | Evaporation Pond (S) | 4-5-79 | Grab sample |



WESTERN RADIATION CONSULTANTS, INC. Industrial, Medical, Environmental

1306 Winfield Drive
Fort Collins, Colorado 80526
303-221-4118
303-482-3029

RECEIVED

JUL 18 1984

July 17, 1984

HEALTH, SAFETY & ENVIRONMENT

To: Arthur P. O'Hayre
Project Representative
Health, Safety & Environment Dept.
Anaconda Minerals Company
555 Seventeenth Street
Denver, Colorado 80202

Subject: Draft report of review of radiological analyses of groundwater samples; Data submitted to Western Radiation Consultants, Inc. July 9, 1984.

The data submitted to WRC included analyses for gross alpha, gross beta and total uranium for eleven samples and gross alpha, gross beta, total uranium, Ra-226, Th-230, and Pb-210 for four additional samples. The data were reviewed for conditions of secular equilibrium, comparison with existing and proposed standards, and radiation risk associated with ingestion of water from these sources. Recommendations for future work were also formulated.

The description of services supplied by Anaconda indicated that only eight samples were analyzed for gross alpha, gross beta and total uranium. However, our examination of the data showed eleven such samples. These eleven samples included two domestic wells and a ditch. In addition, the data sheets indicated that some values were in error. *Since these were collected from previous transmittals, the review was based on those* ~~values were not supplied to WRC.~~ Therefore, the review was based on those data available.

James E. Johnson, Ph.D., Certified Health Physicist Janet A. Johnson, M.S., Certified Health Physicist Hilding G. Olson, Ph.D., Nuclear Engineer, P.E.
Eugene L. Paulter, Ph.D., Biophysicist F. Ward Whicker, Ph.D., Radiocologist

I. Conditions of Secular Equilibrium

For the four samples on which complete analyses were performed (W5AA-2, W4AB-2, USGS-2B, and USGS-13) the condition of secular equilibrium apparently was not present. Uranium concentrations were generally much higher than thorium and radium concentrations. Thorium concentrations were higher than radium concentrations. The standard deviations of the Pb-210 values are too high to allow for interpretation in this regard.

URANIUM >
THORIUM >
RADIUM

Since gross alpha and gross beta concentrations are similar in the eleven samples analyzed only for gross alpha, gross beta and total uranium, Th-234 and Pa-234 beta emitting daughters, as would be expected, appear to be in secular equilibrium with the parent U-238. This could be partly due to the ingrowth of the beta emitting daughters of uranium during the period between sample collection and analysis. The large error limits preclude any definitive interpretation with regard to secular equilibrium in these samples.

Short hand

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II. Compliance with Standards

All Ra-226 samples are within current U.S.E.P.A. drinking water standards.

Uranium apparently accounts for the gross alpha activity in all samples except for W5BB and USGS 1B. The uranium activity calculated from the mass concentration reported exceeds or is approximately equal to the gross alpha in most cases. (Inherent uncertainty in the analysis may account for the situations in which the uranium activity concentration exceeds the gross alpha concentration.) The gross alpha concentration standard (15 pCi/l excluding radon and uranium) is not exceeded except possibly for

Sample US65-1B where the difference between gross alpha concentration and uranium activity concentration is 24 pCi/l. Gross alpha and gross beta concentrations are in general agreement indicating approximate secular equilibrium conditions and lend support to the assumption that the gross alpha count is almost entirely due to uranium.

The Colorado Water Quality Standard for natural uranium (40 pCi/l) is exceeded by six of the fifteen samples. However, this standard is also exceeded in a large number of wells in the Denver area.

-No standard

Drinking water standards for uranium have been proposed as low as 10 pCi/l. Eleven of the 15 samples would exceed this level.

260-1

Although a few of the samples may slightly exceed U.S.E.P.A. drinking water standards currently in effect, based on gross alpha, the data is insufficiently precise to make that determination.

III. Risk assessment.

All of the data relating to radiation risk assessment are based on relatively high radiation doses. Risk from low-level radiation doses (less than 100 mSv) cannot be accurately determined. However, based on the linear dose response assumption, a practical upper limit for risk from low-level radiation can be estimated from dose response data at higher radiation doses.

The concentrations of Ra-226, Th-230, and Pb-210 in all water samples analyzed are below regulatory limits and radiation risk is minimal. The estimated risk from natural uranium in the water supplies tested was calculated from ICRP annual limits of intake (ALI) for radiation workers. The ICRP ALI results in a radiation dose of 50 mSv/y. The mean ALI for natural uranium isotopes is about 4.5×10^5 Bq. The estimated annual

intake for ingestion of water containing 0.88 mg U-nat/l is 1.77×10^4 Bq. Therefore, the estimated annual weighted committed dose equivalent is 2.0 mSv. Assuming a linear dose response, the risk of fatal cancer is 1×10^{-5} /mSv. Therefore, the lifetime risk of ingesting water containing 0.88 mg U-nat/l is 0.1%. This can be compared to the normal lifetime risk of fatal cancer of approximately 20%.

IV. Recommendations

1. The proper error limit to be applied to any analytical determination of radionuclide concentration should not be simply the $1.96 \times$ the std. dev. due to counting. The total methodological error determined by replicate analysis should be reported for any individual sample analysis. For any critical location, multiple samples should be analyzed. This would add environmental variation to the methodological variation.
2. Additional samples should be collected and analyzed for those locations where samples possibly exceeded current U.S.E.P.A. drinking water standards.
3. Future analytical results should indicate whether the sample was filtered before analysis (i.e. whether the results are due to dissolved or suspended solids or both).

Jaseth B. Johnson
7/18/84



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

July 3, 1984
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Mr. Mike Day
 Applied Hydrology Associates
 1338 Forest St.
 Denver, CO 80220

RE: 9046-17896-22
 Date Samples Rec'd 4-16-84

CORRECTED REPORT

REPORT OF ANALYSIS

	9046-17896-22-1	9046-17896-22-2	9046-17896-22-3	9046-17896-22-4	9046-17896-22-5
ALR Designation					
Sponsor Designation	YERINGTON	YERINGTON	YERINGTON	YERINGTON	YERINGTON
	W4CB-1	W4CB-2	Well W5AA-1	Well W5AA-2	Well W5AB-1
	4-6-84	4-5-84	4-3-84	4-3-84	4-4-84

<u>Determination pCi/L</u>	<i>- picocuries per liter</i>				
Gross Alpha, total, ± counting error*	0 ± 3	320 ± 70	2 ± 2	140 ± 30	67 ± 9
Gross Beta, total, ± counting error*	6 ± 4	110 ± 40	5 ± 3	74 ± 22	24 ± 6

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Mr. Mike Day
Applied Hydrology Associates

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CORRECTED REPORT

REPORT OF ANALYSIS

<u>ALR Designation</u>	<u>9046-17896-22-6</u>	<u>9046-17896-22-7</u>	<u>9046-17896-22-8</u>	<u>9046-17896-22-9</u>	<u>9046-17896-22-10</u>
<u>Sponsor Designation</u>	YERINGTON Well W5AB-2 4-4-84	YERINGTON Well W5BB 4-4-84	YERINGTON Well W5DB 4-5-84	YERINGTON Well W3DC 4-4-84	YERINGTON Well USGS-1A

Determination pCi/L

Gross Alpha, total, ± counting error*	140 ± 70	310 ± 60	21 ± 6	3 ± 2	--
Gross Beta, total, ± counting error*	230 ± 80	180 ± 40	9 ± 4	5 ± 3	--

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Mr. Nike Day
Applied Hydrology Associates

RE: 9046-17896-22
Date Samples Rec'd 4-15-84

CORRECTED REPORT

REPORT OF ANALYSIS

	9046-17896-22-11	9046-17896-22-12	9046-17896-22-13	9046-17896-22-14	9046-17896-22-15
ALR Designation	YERINGTON	YERINGTON	YERINGTON	YERINGTON	YERINGTON
Sponsor Designation	Well USGS-1B	Well USS-2A 4-6-84	Well USGS-2B 4-6-84	Well USGS-7 4-4-84	Well USGS-13 4-4-84

Determination pCi/L

Gross Alpha, total, ± counting error*	46 ± 10	--	490 ± 300	--	33 ± 14
Gross Beta, total, ± counting error*	45 ± 7	--	560 ± 300	--	81 ± 14

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Mr. Mike Day
Applied Hydrology Associates

RE: 9046-17896-22
Date Samples Rec'd 4-16-84

CORRECTED REPORT

REPORT OF ANALYSIS

LOCATION??

ALR Designation	9046-17896-22-16	9046-17896-22-17	9046-17896-22-18	9046-17896-22-19	9046-17896-22-20
Sponsor Designation	YERINGTON Domestic Well No. 1 4-3-84	YERINGTON Domestic Well No. 2 4-3-84	YERINGTON Wabuska Drain Site 1	YERINGTON Wabuska Drain Loc. No. 2 4-6-84	YERINGTON Wabuska Drain Loc. No. 3 4-6-84

Determination pCi/L

Gross Alpha, total, ± counting error*	19 ± 4	14 ± 3	--	--	--
Gross Beta, total, ± counting error*	15 ± 4	6 ± 3	--	--	--

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Mr. Nike Day
Applied Hydrology Associates

RE: 9046-17896-22
Date Samples Rec'd 4-16-84

CORRECTED REPORT

REPORT OF ANALYSIS

LOCATION?

ALR Designation	9046-17896-22-21	9046-17896-22-22
Sponsor Designation	W-DITCH Site No. 4 4-5-84	YERINGTON WABUSKA No. 5 at Campbell LA 4-6-84

Determination pCi/L

Gross Alpha, total, ± counting error*	21 ± 18	--
Gross Beta, total, ± counting error*	9 ± 18	--

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.
These samples are scheduled to be disposed of 45 days after the date of this report.


Bud Summers
Radiochemistry
Supervisor

BS/dh

dh



Accu-Labs Research, Inc.

11485 W. 48th Avenue Wheat Ridge, Colorado 80033
(303) 423-2766

July 3, 1984

Page 1 of 3

Mr. Mike Day
Applied Hydrology Associates
1338 Forest St.
Denver, CO 80220

RE: 9046-17896-22
Date Samples Rec'd 5-29-84

REPORT OF ANALYSIS

ALR Designation	9046-17896-22-1	9046-17896-22-2	9046-17896-22-3	9046-17896-22-4	9046-17896-22-5
Sponsor Designation	YERINGTON	YERINGTON	YERINGTON	YERINGTON	YERINGTON
	Well W4CB-1	Well W4CB-2	Well W5AA-1	Well W5AA-2	Well W5AB-1
	4-6-84	4-5-84	4-3-84	4-3-84	4-4-84

Determination pCi/L

Radium-226, total, ± counting error*	--	--	--	-0.2 ± 0.8	--
Thorium-230, total, ± counting error*	--	--	--	0.0 ± 0.1	--
Lead-210, total, ± counting error*	--	--	--	-0.6 ± 1.4	--
Uranium (as U), total, mg/L	0.003	0.47	0.003	0.21	0.096

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.

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Mr. Nike Day
Applied Hydrology Associates

RE: 9046-17896-22
Date Samples Rec'd 5-29-84

REPORT OF ANALYSIS

ALR Designation	9046-17896-22-6	9046-17896-22-7	9046-17896-22-8	9046-17896-22-9	9046-17896-22-11
Sponsor Designation	YERINGTON Well W5AB-2 4-4-84	YERINGTON Well W5BB 4-4-84	YERINGTON Well W5DB 4-5-84	YERINGTON Well W3DC 4-4-84	YERINGTON Well USGS-1B

Determination pCi/L

Radium-226, total, ± counting error*	-0.4 ± 0.6	--	--	--	--
Thorium-230, total, ± counting error*	0.2 ± 0.2	--	--	--	--
Lead-210, total, ± counting error*	-0.4 ± 1.7	--	--	--	--
Uranium (as U), total, mg/L	0.048	0.38	0.019	0.003	0.032

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.

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Mr. Mike Day
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REPORT OF ANALYSIS

LOCATION?

ALR Designation	9046-17896-22-13	9046-17896-22-15	9046-17896-22-16	9046-17896-22-17	9046-17896-22-21
Sponsor Designation	YERINGTON Well USGS-2B 4-6-84	YERINGTON Well USGS-13 4-4-84	YERINGTON Domestic Well No. 1 4-3-84	YERINGTON Domestic Well No. 2 4-3-84	YERINGTON W-Ditch Site No. 4 4-5-84

Determination pCi/L

Radium-226, total, ± counting error*	2.5 ± 0.6	3.2 ± 0.7	--	--	--
Thorium-230, total, ± counting error*	5.8 ± 1.4	7.5 ± 1.2	--	--	--
Lead-210, total, ± counting error*	1.2 ± 4.2	7.7 ± 3.4	--	--	--
Uranium (as U), total, mg/L	0.88	0.026	0.037	0.019	0.036

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ. These samples are scheduled to be disposed of 45 days after the date of this report.


Bud Summers
Radiochemistry
Supervisor

BS/dh

dh

until shipment via UPS could be made from Reno, Nevada. Samples were shipped to Accu-labs for radiological analysis (gross alpha and beta), and a sample split of USGS 2b was sent to Western Radiological Consultants of Fort Collins, Colorado.

2.2.4 Radiological Water Quality

Table 4 presents the results of radiological analysis performed by Accu-Labs of Wheatridge, Colorado. These analyses include the determination of Gross Alpha and Gross Beta, total and dissolved Radium-226, and Uranium (as U). Appendix A lists the original laboratory results as reported by Accu-labs.

3.0 PUMP TESTS

As part of the field program, AHA conducted pump tests on well sites W4-CB, W5-AA, W5AB, W5-BB, W5-DB, and the drive-in movie theater. Multiple well tests were performed at well sites W4-CB, 5AA and 5AB to obtain values of transmissivity, horizontal and vertical hydraulic conductivity, and storage coefficient (W5-AB only). Single well tests were performed on the remaining wells to yield values of transmissivity and horizontal hydraulic conductivity. These tests were conducted mainly to determine the range of aquifer properties for numerical modeling and comparison with estimates from lithologic data.

Table 4 Results of Radiological Analyses, Fall 1984, Yerington Operations, Weed Heights, Nevada

Well No.	Date	¹ Gross Alpha, Total	¹ Gross Alpha, Diss.	¹ Gross Beta, Total	¹ Gross Beta, Diss.	¹ Radium-226, Total	¹ Radium-226, Diss.	Uranium (as U) Total, mg/l	Uranium (as U) Diss., mg/l
USGS-1B	09-20-84	67 ± 13	--	53 ± 8	--	0.5 ± 0.1	--	0.12	--
USGS-2B (Sample 1)	09-17-84	980 ± 560	--	580 ± 290	--	2.2 ± 0.3	--	1.1	--
USGS-2B (Sample 2)	09-18-84	380 ± 460	--	300 ± 280	--	4.4 ± 0.4	--	1.1	--
USGS-2B (Sample 3)	09-18-84	1000 ± 600	--	620 ± 290	--	2.6 ± 0.3	--	1.1	--
USCR-2B (Sample 4)	09-19-84	950 ± 560	--	590 ± 290	--	9.2 ± 0.5	--	1.2	--
USGS-2B (Sample 5)	09-20-84	660 ± 510	--	330 ± 280	--	0.6 ± 0.4	--	1.1	--
USGS-2B (Sample 6)	09-20-84	900 ± 530	170 ± 250	490 ± 280	310 270	7.6 ± 0.5	0.1 ± 0.2	0.98	0.024
W3AA2	09-19-84	210 ± 40	--	20 ± 19	--	0.1 ± 0.1	--	0.30	--
W5AB1	09-15-84	58 ± 12	--	28 ± 7	--	0.1 ± 0.1	--	0.11	--
W5AB2	09-16-84	300 ± 90	290 ± 100	190 ± 70	170 70	0.1 ± 0.1	0.1 ± 0.2	0.063	0.58
W4CB2	09-19-84	260 ± 50	--	130 ± 28	--	0.1 ± 0.2	--	0.51	--
W5BB	09-21-84	420 ± 70	--	170 ± 40	--	0.0 ± 0.1	--	0.78	--
D5AC1	09-21-84	480 ± 80	460 ± 80	220 ± 40	150 40	1.6 ± 0.2	-0.1 ± 0.1	0.25	0.071
D5AD1	09-14-84	1300 ± 400	820 ± 280	970 ± 300	860 220	2.4 ± 0.3	-0.2 ± 0.2	1.3	0.12
D8AB2	09-21-84	660 ± 160	410 ± 120	570 ± 100	220 80	18 ± 1	0.0 ± 0.2	1.0	0.58
DW-1	09-20-84	14 ± 7	--	15 ± 6	--	0.0 ± 0.1	--	0.033	--
Phipps	09-21-84	27 ± 6	--	7 ± 3	--	0.0 ± 0.1	--	0.029	--

¹ Concentration in pCi/l.

APPENDIX A

Results of Laboratory Analysis

January 15, 1985
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Mr. Mike Day
Applied Hydrology

RE: 9046-18822-22
Date Samples Rec'd 10-9-84
CORRECTED REPORT

REPORT OF ANALYSIS

ALR Designation	9046-18822-22-6	9046-18822-22-7	9046-18822-22-8	9046-18822-22-9	9046-18822-22-10
Sponsor Designation	Yerington USGS No. 2B Sample No. 2 9-18-84 <u>Unfiltered</u>	Yerington USGS No. 2B Sample No. 3 9-18-84 <u>Unfiltered</u>	Yerington USGS No. 2B Sample No. 4 9-19-84 <u>Unfiltered</u>	Yerington USGS No. 2B Sample No. 5 9-20-84 <u>Unfiltered</u>	Yerington USGS No. 2B Sample No. 6 9-20-84 <u>Unfiltered</u>
Determination: pCi/L					
Gross Alpha, total, ± counting error*	380 ± 460	1000 ± 600	950 ± 560	660 ± 510	900 ± 550
Gross Beta, total, ± counting error*	500 ± 280	620 ± 290	590 ± 290	330 ± 280	490 ± 280
Gross Alpha, dissolved, ± counting error*	--	--	--	--	--
Gross Beta, dissolved, ± counting error*	--	--	--	--	--

January 15, 1985
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Mr. Mike Day
Applied Hydrology

RE: 9046-18822-22
Date Samples Rec'd 10-9-84
CORRECTED REPORT

REPORT OF ANALYSIS

ALR Designation	9045-18822-22-11	9046-18822-22-12	9046-18822-22-13	9046-18822-22-14	9046-18822-22-15
Sponsor Designation	Yerington	Yerington	Yerington	Yerington	Yerington
	W4 CB2	W5 AA2	W5 AB1	W5 AB2	W5 BB
	9-19-84	9-19-84	9-15-84	9-16-84	9-21-84
	<u>Unfiltered</u>	<u>Unfiltered</u>	<u>Unfiltered</u>	<u>Unfiltered</u>	<u>Unfiltered</u>
Determination: pCi/L					
Gross Alpha, total, ± counting error*	260 ± 50	210 ± 40	58 ± 12	200 ± 90	420 ± 70
Gross Beta, total, ± counting error*	130 ± 28	20 ± 19	28 ± 7	180 ± 70	170 ± 40
Gross Alpha, dissolved, ± counting error*	--	--	--	--	--
Gross Beta, dissolved, ± counting error*	--	--	--	--	--

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Mr. Mike Day
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RE: 9046-18822-22
Date Samples Rec'd 10-9-84
CORRECTED REPORT

REPORT OF ANALYSIS

ALR Designation	9046-18822-22-16	9046-18822-22-17	9046-18822-22-18	9046-18822-22-19	9046-18822-22-20
Sponsor Designation	Yerington Domestic Well 9-20-84 Unfiltered	Yerington Phipp's Well 9-21-84 Unfiltered	Yerington D5 AC1 9-21-84 Filtered	Yerington D5 AD-1 9-14-84 Filtered	Yerington D8 AB-2 9-21-84 Filtered
Determination: pCi/L					
Gross Alpha, total, ± counting error*	14 ± 7	27 ± 6	--	--	--
Gross Beta, total, ± counting error*	15 ± 6	7 ± 3	--	--	--
Gross Alpha, dissolved, ± counting error*	--	--	460 ± 80	820 ± 280	410 ± 120
Gross Beta, dissolved, ± counting error*	--	--	150 ± 40	860 ± 220	220 ± 80

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Mr. Mike Day
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RE: 9046-18822-22
Date Samples Rec'd 10-9-84
ADDITIONAL ANALYSIS

REPORT OF ANALYSIS

ALR Designation Sponsor Designation	9046-18822-22-21 Yerington USGS - 2B Sample No. 6 9-20-84 <u>Filtered</u>	9046-18822-22-22 Yerington W5 AB2 9-16-84 <u>Filtered</u>
Determination: pCi/L		
Radium-226, total, ± counting error*	--	--
Radium-226, dissolved, ± counting error*	0.1 ± 0.2	0.1 ± 0.2
Uranium (as U), total, mg/L	--	--
Uranium (as U), dissolved, mg/L	0.024	0.58

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.
These samples are scheduled to be disposed of 45 days after the date of this report.


Bud Summers
Radiochemistry
Supervisor

BS/dh *dh*
cc: Art O'Hayre

January 15, 1985
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Mr. Mike Day
Applied Hydrology

RE: 9046-18822-22
Date Samples Rec'd 10-9-84
CORRECTED REPORT

REPORT OF ANALYSIS

ALR Designation
Sponsor Designation

9046-18822-22-21
Yerington
USGS - 2B
Sample No. 6
9-20-84
Filtered

9046-18822-22-22
Yerington
W5 AB2
9-16-84
Filtered

Determination: pCi/L

Gross Alpha, total,
± counting error*

--

--

Gross Beta, total,
± counting error*

--

--

Gross Alpha, dissolved,
± counting error*

170 ± 250

290 ± 100

Gross Beta, dissolved,
± counting error*

310 ± 270

170 ± 70

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.
These samples are scheduled to be disposed of 45 days after the date of this report.



Bud Summers
Radiochemistry
Supervisor

BS/dh




January 15, 1985
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Mr. Mike Day
 Applied Hydrology
 1338 Forest St.
 Denver, CO 80220

RE: 9046-18822-22
 Date Samples Rec'd 10-9-84
ADDITIONAL ANALYSIS

REPORT OF ANALYSIS

ALR Designation	9046-18822-22-1	9046-18822-22-2	9046-18822-22-3	9046-18822-22-4	9046-18822-22-5
Sponsor Designation	Yerington D5AC-1 9-21-84 Unfiltered	Yerington D5AD-1 9-14-84 Unfiltered	Yerington D8AB-2 9-21-84 Unfiltered	Yerington USGS No. 1B 9-20-84 Unfiltered	Yerington USGS No. 2B Sample No. 1 No date Unfiltered
Determination: pCi/L					
Radium-226, total, ± counting error*	1.6 ± 0.2	2.4 ± 0.3	18 ± 1	0.5 ± 0.1	2.2 ± 0.3
Radium-226, dissolved, ± counting error*	--	--	--	--	--
Uranium (as U), total, mg/L	0.25	1.3	1.0	0.12	1.1
Uranium (as U), dissolved, mg/L	--	--	--	--	--

BY: APPLIED HYDROLOGY ASSOCIATES, INC.

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Applied Hydrology

RE: 9046-18822-22
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ADDITIONAL ANALYSIS

REPORT OF ANALYSIS

ALR Designation	9046-18822-22-6	9046-18822-22-7	9046-18822-22-8	9046-18822-22-9	9046-18822-22-10
Sponsor Designation	Yerington	Yerington	Yerington	Yerington	Yerington
	USGS No. 2B				
	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6
	9-18-84	9-18-84	9-19-84	9-20-84	9-20-84
	<u>Unfiltered</u>	<u>Unfiltered</u>	<u>Unfiltered</u>	<u>Unfiltered</u>	<u>Unfiltered</u>
Determination: pCi/L					
Radium-226, total, ± counting error*	4.4 ± 0.4	2.6 ± 0.3	9.2 ± 0.5	0.6 ± 0.4	7.6 ± 0.5
Radium-226, dissolved, ± counting error*	--	--	--	--	--
Uranium (as U), total, ng/L	1.1	1.1	1.2	1.1	0.98
Uranium (as U), dissolved, mg/L	--	--	--	--	--

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Mr. Mike Day
Applied Hydrology

RE: 9046-18822-22
Date Samples Rec'd 10-9-84
ADDITIONAL ANALYSIS

REPORT OF ANALYSIS

ALR Designation	9046-18822-22-11	9046-18822-22-12	9046-18822-22-13	9046-18822-22-14	9046-18822-22-15
Sponsor Designation	Yerington W4 CB2 9-19-84 Unfiltered	Yerington W5 AA2 9-19-84 Unfiltered	Yerington W5 AB1 9-15-84 Unfiltered	Yerington W5 AB2 9-16-84 Unfiltered	Yerington W5 BB 9-21-84 Unfiltered
Determination: pCi/L					
Radium-226, total, ± counting error*	0.1 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.0 ± 0.1
Radium-226, dissolved, ± counting error*	--	--	--	--	--
Uranium (as U), total, mg/L	0.51	0.30	0.11	0.063	0.78
Uranium (as U), dissolved, mg/L	--	--	--	--	--

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RE: 9046-18822-22
Date Samples Rec'd 10-9-84
ADDITIONAL ANALYSIS

REPORT OF ANALYSIS

ALR Designation	9046-18822-22-16	9046-18822-22-17	9046-18822-22-18	9046-18822-22-19	9046-18822-22-20
Sponsor Designation	Yerington Domestic Well 9-20-84 Unfiltered	Yerington Phipp's Well 9-21-84 Unfiltered	Yerington D5 ACI 9-21-84 Filtered	Yerington D5 AD-1 9-14-84 Filtered	Yerington D8 AB-2 9-21-84 Filtered
Determination: pCi/L					
Radium-226, total, ± counting error*	0.0 ± 0.1	0.0 ± 0.1	--	--	--
Radium-226, dissolved, ± counting error*	--	--	-0.1 ± 0.1	-0.2 ± 0.2	0.0 ± 0.2
Uranium (as U), total, mg/L	0.033	0.029	--	--	--
Uranium (as U), dissolved, mg/L	--	--	0.071	0.12	0.58

Geochemical Investigation

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GEOCHEMICAL INVESTIGATION
ABANDONED MINE TAILINGS SITE
YERINGTON, NEVADA

1.0 INTRODUCTION

This Geochemical Investigation for the Abandoned Mine Tailings site in Yerington, Nevada was conducted to evaluate the chemical characteristics of the ground water affected by tailings seepage and to identify and quantify geochemical mechanisms that control the migration of constituents in tailing seepage. The ground water quality was compared to newly promulgated Nevada standards to determine whether exceedances exist and where they occur. The characterization was also made to determine whether radionuclides pose a problem in site ground waters.

Investigative efforts for this study were prompted by a clearly defined, increasing trend of iron and sulfate in ground water from Well W5AB-1 downgradient from the tailings impoundment. Iron concentrations in water from this well increased two times within the last three years from approximately 0.4 milligrams per liter (mg/l) in 1987 to 0.8 mg/l in 1990. In the same time period and the same location, sulfate increased from 1400 mg/l to 2000 mg/l.

Despite the increasing trend of iron and sulfate concentration in Well W5AB-1, sulfate concentrations dropped six times and most metals concentrations dropped to nondetectable levels within a short distance (less than 1,300 feet) from the tailings impoundments (e.g., Well D4BC-1 on Figure 1). This decrease in constituent concentrations indicates the presence of a natural geochemical barrier at the site that reduces the rate of constituent migration downgradient from the tailings impoundments. The geochemical evaluation presented in this report confirms the existence of such a barrier for sulfate and metals.

1.1 Geochemical Investigation Program

The geochemical program included collection and analysis of ground water and soil samples from the site. The ground water samples were analyzed for the major ions, metals, and radionuclides (listed in Table 1) to assess the potential exceedances with the Nevada Water Quality Standards (NWQS). The

soil samples were analyzed for soil pH and total iron to assess the geochemical mechanisms controlling the migration of these chemical constituents. Figure 1 shows the water and soil sampling locations.

Ground water samples were collected from six wells that are distributed throughout the site. Water samples from Well USGS-2B, downgradient from the tailings impoundment, and Wells W5AB-1 and W5AB-2, downgradient from the evaporation ponds, were collected to characterize the water quality under these potential sources of contamination. Water samples from Wells D4BC-1 and USGS-13 were collected to assess the ground water quality downgradient from the tailings and evaporation ponds, respectively. In order to characterize the water quality outside the apparent influence of the tailings seepage, a temporary well was installed at the northeastern corner of the property.

As shown on Figure 1, soil samples GC-1, GC-2, GC-3A, GC-3B, and GC-4 were collected from auger holes installed adjacent to the wells. The soil samples were collected from the same depth as the screened interval of each well, so that both the soil and water samples represent approximately the same geochemical conditions at each location.

1.2 Summary of Findings

Results of the investigation showed that ground water quality at the site is similar to that of the previous characterizations as documented in annual reports submitted between 1986 and the present. As in the past, metals and sulfate concentrations are elevated in ground water under the tailings area and decrease several orders of magnitude reaching nondetectable levels within a short distance from the tailings area (approximately 1,300 feet). Radionuclides were reported in concentrations below the water quality standards or were nondetectable. In addition, gross alpha particle activities, which appear to be elevated in previous analyses, were shown to be present below the gross alpha standard.

1.2.1 Conceptual Geochemical Model

The results of the chemical analyses for water and soils samples were used to develop a conceptual geochemical model that characterizes the evolution of tailings seepage. This model defines a geochemical barrier that causes retardation of metals and sulfate by precipitation and/or adsorption mechanisms. The model consists of three zones in which different geochemical processes dominate. Figure 2 shows the extent of the three geochemical zones included in the model.

1. Acidic Zone - This zone includes the area underneath the tailings impoundment and the former evaporation ponds. In this zone soil and water pH is acidic (approximately 3.5 pH unit) and, as a result, sulfate and metals (cadmium, copper, iron, lead, manganese, silver, and zinc) remain in solution.
2. Neutralizing Zone - This zone is located immediately downgradient from the Acidic Zone. In this zone, the neutralization process occurs when the acidic ground water (pH of 3.5) from the Acidic Zone contacts neutral soil (pH of 7). This process results in ground water with neutral pH and in retardation of metals and sulfate due to precipitation/adsorption.

Elevated concentrations of cadmium, copper, lead, silver, and zinc drop to nondetectable levels. Iron and manganese concentrations were reduced by several orders of magnitude compared to the Acidic Zone water. Sulfate concentrations in the Acidic Zone water were reduced up to several orders of magnitude due to sulfate precipitation as gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$).

3. Neutral Zone - This zone is located downgradient from the Neutralizing Zone and is characterized by neutral soil and water pH, low concentrations of sulfate, and low to nondetectable levels of metals. Only iron, manganese, and sulfate migrate into this zone from the Neutralizing Zone in concentrations exceeding the

standards. In the Neutral Zone, iron and manganese gradually drop out of solution by adsorption. However, the remaining sulfate migrating from the Neutralizing Zone continues to migrate in the water with little change in concentration.

The conceptual geochemical model indicated that the Neutralizing Zone is a naturally occurring geochemical barrier for metals and sulfate. However, not all sulfate, iron, and manganese concentrations can be retarded by this geochemical barrier, mostly because these constituents have high initial concentrations within the upgradient Acidic Zone (17,400 mg/l, 2,690 mg/l, and 162 mg/l, respectively).

Concentrations of iron and manganese remaining in water migrating from the Neutralizing zone (7.3 mg/l and 14 mg/l, respectively) continue to migrate downgradient into the Neutral Zone. These constituents progressively decrease up to two orders of magnitude in the Neutral Zone due to adsorption of these metals onto the soil particles. Although Neutral Zone soils act as a geochemical barrier for iron and manganese migration, they do not have the capacity to reduce sulfate concentrations. Therefore, sulfate (greater than 500 mg/l) will continue to migrate in water.

2.0 GROUND WATER QUALITY CHARACTERIZATION

The ground water quality was characterized to determine the nature and extent of seepage from the tailings impoundment and the evaporation ponds. The evaluation utilized the data developed from the ground water sampling program conducted in June 1990. Figure 1 shows the ground water sampling locations. The water samples collected from these locations were analyzed for the inorganics (major ions and metals) and radionuclides listed in Table 1.

Ground water quality was compared with NWQS established in Nevada Water Pollution Control Regulation Rule 455.117. These standards are similar to the primary and secondary Maximum Contaminant Levels (MCLs) established by the Environmental Protection Agency (EPA). Since the NWQS have no standard for radionuclides, for this investigation, primary MCLs established by the EPA for gross alpha and total radium were applied. As for uranium, standards established by the states of New Mexico and Wyoming were used in this investigation.

2.1 Inorganic Chemicals

Table 2 provides the results of the analyses of major ions and metals and compares these constituents with the primary and secondary MCLs. As shown in the table, sulfate and metals concentrations are elevated in the acidic water (pH of 3.4) under the tailings area (e.g., Well USGS-2B on Figure 1). Water from Well USGS-2B exceeds the primary MCLs for lead, cadmium, and silver. The secondary MCLs for total dissolved solids (TDS), sulfate, copper, iron, manganese, and zinc are also exceeded.

At approximately 1,300 feet from the tailings impoundment and the evaporation ponds, sulfate and metals concentrations are reduced or dropped to nondetectable levels. For example, sulfate concentrations dropped approximately six times from 17,400 mg/l in water from Well USGS-2B to 2,750 mg/l in water from downgradient Well D4BC-1. Also, lead, cadmium, silver,

copper, and zinc concentrations dropped to nondetectable levels. Iron reduced 17 times and manganese reduced 2.6 times in water between Wells USGS-2B and D4BC-1.

At a greater distance from the tailings impoundment, ground water quality is improved further. Water from Well USGS-13 is located directly down-gradient from the evaporation ponds and had exceedances of secondary MCLs for sulfate, TDS, and manganese. In contrast, the Temporary Well, which is located outside the apparent influence of the tailings seepage, shows only exceedances for TDS. This elevated TDS concentration may represent the natural water quality in the area.

2.2 Radionuclides

Table 3 provides the results of the radionuclide analyses. These analyses included gross alpha particle activities, natural uranium, radium-226, radium-228, and thorium-230. The results of radionuclide analyses were compared to the primary MCLs listed in Table 3.

The results of the corrected gross alpha activities showed no exceedances of the gross alpha standard with an apparent exception in water from Well W5AB-1. This well had higher alpha activity [16.1 picoCuries per liter (pCi/l)] compared to the standard of 15 pCi/l. This exceedance is believed to be due to an analytical error rather than a representation of actual ground water quality.

The following reasons justify the exceedance of gross alpha activity in water from Well W5AB-1 as an analytical error:

1. Water from the adjacent shallower Well W5AB-2, which shows a relatively higher impact from the tailings seepage, does not show such elevated corrected gross alpha activities; and
2. None of the water samples collected from the other wells showed elevated gross alpha activities.

Since a standard of 5 pCi/l for total radium (radium-226 + radium-228) was established, radium-226 and radium-228 were evaluated together. The results of analyses showed that total radium throughout the site is always 1.4 to 5 times less than the standard of 5 pCi/l.

A standard for thorium-230 has not been established. Thorium-230 results, as shown in Table 3, are generally nondetectable.

Uranium does not have an established standard in Nevada nor an established EPA MCL. The states of New Mexico and Wyoming established a standard of 5 mg/l for uranium. At the site, uranium concentrations range from 0.04 mg/l in water from Well USGS-2B to 0.76 mg/l in water from Well W5AB-1, which are 6.5 to 120 times less than the standard of 5 mg/l.

3.0 CONCEPTUAL GEOCHEMICAL MODEL

A conceptual geochemical model was developed based on the characterization of ground water and soils. Tables 2 and 4 show the results of the water and soil analyses, respectively, that were used for the development of the model. The primary geochemical mechanism in the model is the neutralization of the acidic seepage by the site soils. The neutralization causes metals and sulfate to drop out of solution and to be retained in the soil by precipitation and/or adsorption.

The conceptual geochemical model consists of three zones in which different geochemical processes dominate. Figure 2 shows the approximate extent of these zones.

1. Acidic Zone, which includes the area under the tailings impoundment (e.g., Well USGS-2B) and the evaporation ponds, is characterized by low retention of metals and sulfate due to acidic conditions;
2. Neutralizing Zone, which includes the area in the vicinity of Wells D4BC-1, W5AB-1, and W5AB-2, is characterized by high sulfate and metal retardation due to the neutralization process; and
3. Neutral Zone, which includes the outlying area downgradient from the Neutralizing Zone, is characterized by metals retardation due to adsorption. Sulfate stays in solution under Neutral Zone conditions.

In order to verify and quantify the geochemical mechanisms identified in the model, the distribution coefficient (K_d) for iron was calculated for each geochemical zone by utilizing iron concentrations in ground water and soils as presented in Tables 2 and 4, respectively. Iron was selected in this investigation to represent the geochemical conditions for pH-dependent metals because it is present in detectable concentrations in ground water throughout the site. Estimated K_d values for iron, shown on Figure 2, indicate a measure of the mobility of iron in ground water moving through

site soils. A large K_d value [(greater than 10 milliliters per gram (ml/gm)] indicates high retention by the soils, and low K_d values (less than 1) indicate minimal retention of the iron by soils.

3.1 Acidic Zone

The Acidic Zone is characterized by acidic soil and water pH. As shown on Figure 2, ground water and soil pH are acidic (approximately 3.5 pH units) in water from USGS-2B and soil from the adjacent auger hole GC-1. The most notable characteristics of this zone are the elevated concentrations of sulfate (17,400 mg/l) and metals (e.g., iron, manganese, silver, cadmium, copper, lead, and zinc). Under the acidic conditions in this zone, sulfate and metals remain in solution.

As shown on Figure 2, an iron K_d value of approximately 0.6 ml/gm was calculated for the Acidic Zone. This low K_d value confirms that under acidic conditions iron and the other pH-dependent metals (e.g., manganese, cadmium, copper, lead, and zinc) remain mobile in ground water.

3.2 Neutralizing Zone

The neutralization process occurs when the acidic ground water from the Acidic Zone comes in contact with neutral soil. This process results in ground water with neutral pH conditions. The neutralizing zone conditions are represented by the soil samples GC-2, GC-3A, and GC-3B and water samples from Wells D4BC-1, W5AB-1, and W5AB-2. As shown on Figure 2, both ground water and soil pH are neutral in these locations.

Two major geochemical processes affecting constituent migration occur in the Neutralizing Zone. These are:

1. Precipitation of sulfate as gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) that begins in the early stages of the neutralization; and

2. Precipitation and adsorption of iron and other metals in ground water that begins in the early stages of neutralization and continues throughout the process.

3.2.1 Sulfate Precipitation

Acidic water from the Acidic Zone migrating into the Neutralizing Zone soils dissolves the naturally occurring calcium carbonate and frees calcium cations into the solution. The newly freed calcium cations react with sulfate anions in solution and both precipitate out as gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). This precipitation process reduces the sulfate concentration in ground water.

Once the acidic water is neutralized, calcium carbonate in the soils can no longer be dissolved so that free calcium cations are no longer available to precipitate out sulfate. Therefore, in later stages of the neutralization process where gypsum precipitation no longer occurs, the remaining sulfate ions migrate with the ground water.

As shown on Figure 2, sulfate concentrations of 17,400 mg/l in the Acidic Zone (e.g., Well USGS-2B) decreased to 2,750 mg/l during the neutralization process (e.g., water from Well D4BC-1). However, subsequent to gypsum precipitation during the initial stages of the neutralization process, sulfate concentrations (greater than 2,500 mg/l) do not show significant retardation in downgradient wells.

3.2.2 Metals Precipitation/Adsorption

The Neutralizing Zone attenuates pH-dependent metals such as iron, manganese, cadmium, copper, lead, and zinc. The attenuation of these metals is accomplished by both precipitation and adsorption mechanisms. In this zone, silver, cadmium, copper, and lead drop out of solution and have nondetectable levels. In contrast, iron and manganese concentrations, present in higher initial concentrations, decreased from 2,690 mg/l and 162 mg/l in the Acidic Zone water from Well USGS-2B to 7.3 mg/l and 14 mg/l in water from Well W5AB-2, respectively.

The high attenuation capacity of soils for iron is also confirmed by a calculated K_d value for iron of up to 2,240 ml/gm. This high K_d value indicates that iron and other pH-dependent metals precipitate out from solution and are adsorbed by the soil particles.

3.3 Neutral Zone

The Neutral Zone has the same geochemical characteristics as the Neutralizing Zone. The only difference is that the acidic water migrating downgradient was neutralized in the Neutralizing Zone before reaching the Neutral Zone. Therefore, the Neutral Zone still retains its intact neutralization potential to provide an infinite geochemical buffer.

Only iron, manganese, and sulfate concentrations migrate into the Neutral Zone. In the Neutral Zone, the migration of constituents is controlled mainly by the adsorption mechanism. The adsorption potential for metals in this zone is as high as that of the Neutralizing Zone (e.g., iron K_d as high as 2,240 ml/gm). However, sulfate, a conservative constituent which has minimal adsorption capacity, will migrate downgradient in the Neutral Zone with the ground water.

4.0 CLOSING REMARKS

Results of the geochemical investigation showed that ground water quality at the site is similar to the results of the previous characterizations where metals and sulfate are elevated under the tailings area and drop within a short distance from the tailings area. No exceedances of primary MCLs were observed outside the property boundary. The only exceedances outside the property boundary were secondary MCLs for TDS and manganese.

Elevated gross alpha activities reported in water from the monitoring wells are due to uranium activities, and the corrected gross alpha results do not exceed the gross alpha standard of 15 pCi/l. The remaining radionuclides were reported in concentrations below the standards or were nondetectable.

The conceptual geochemical model shown on Figure 2 illustrates that the neutralization process provides a geochemical barrier for migration of metals and sulfate. This barrier reduces iron and sulfate concentrations up to 370 and 6 times, respectively. However, high initial concentrations of iron (2,690 mg/l) and sulfate (17,400 mg/l) cannot be attenuated to nondetectable levels by this barrier. Iron concentrations were attenuated to low levels by the adsorption mechanism in the areas remote from the tailings. Sulfate is a conservative constituent and will not be dropped out of solution in the Neutral Zone and, consequently, will continue to migrate downgradient and beyond the property boundary with time.

Respectfully submitted,



Gültekin Savcı, Ph.D.
Project Scientist

GS/h1a

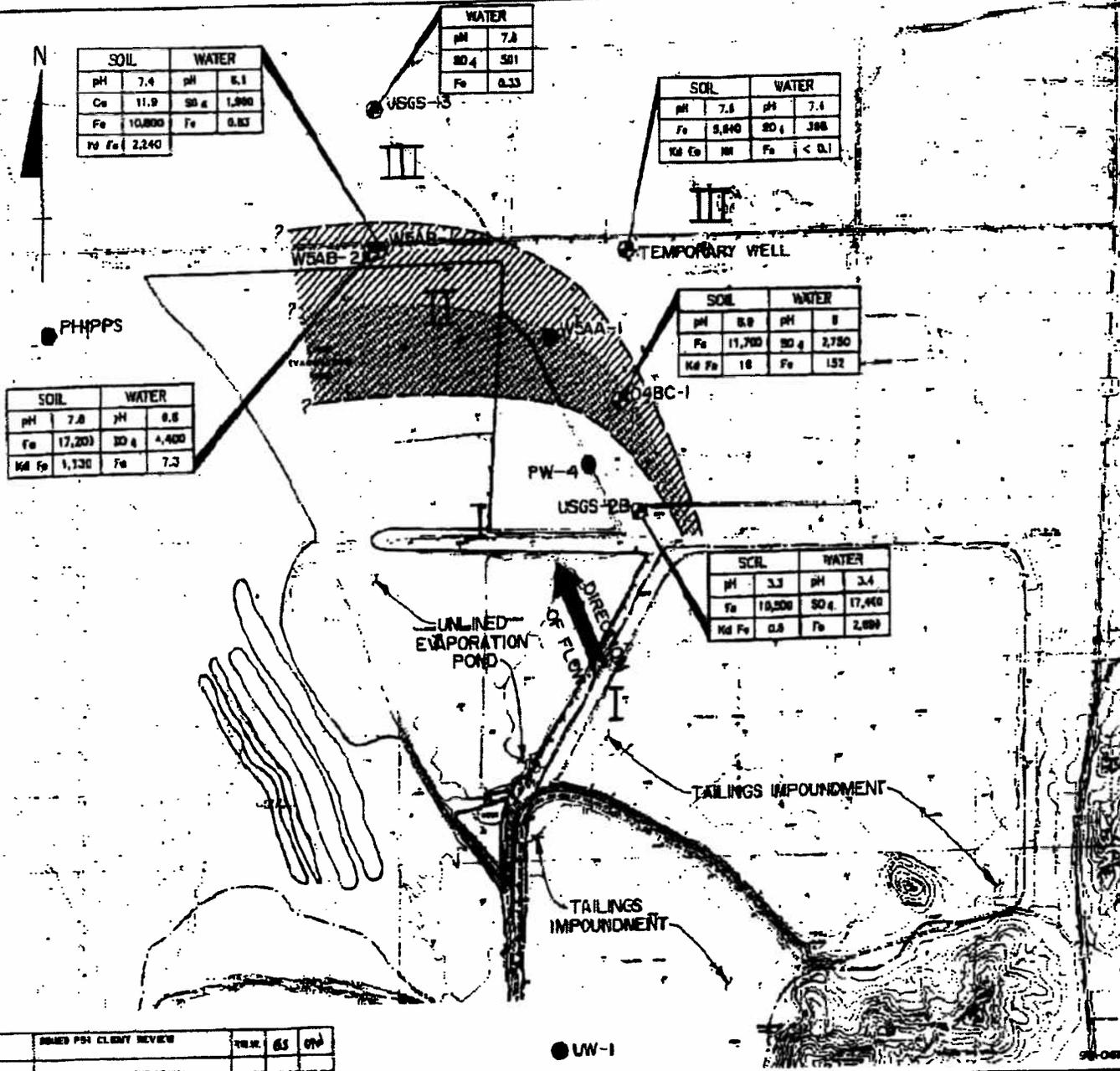
TABLES

CanonieEnvironmental

TABLE 1
ANALYTES FOR WATER QUALITY SAMPLES

Inorganics		Radionuclides
Metals	Major Ions	
Aluminum	Bicarbonate	Gross Alpha
Arsenic	Calcium	Radium-226
Barium	Carbonate	Radium-228
Boron	Chloride	Thorium-230
Cadmium	Fluoride	Uranium Isotopes (U-234, U-235, U-238)
Chromium	Magnesium	
Cobalt	Nitrate as N	
Copper	pH	
Iron	Phosphate	
Lead	Potassium	
Manganese	Sodium	
Mercury	Sulfate	
Molybdenum	Total Dissolved Solids	
Nickel		
Selenium		
Silver		
Zinc		

90-061-B4
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SOIL		WATER	
pH	7.4	pH	6.1
Ce	11.9	SO ₄	1,990
Fe	10,800	Fe	0.87
Md Fe	2,240		

WATER	
pH	7.8
SO ₄	381
Fe	0.33

SOIL		WATER	
pH	7.8	pH	7.4
Fe	8,840	SO ₄	388
Md Ce	NI	Fe	< 0.1

SOIL		WATER	
pH	8.9	pH	8
Fe	11,700	SO ₄	2,750
Md Fe	18	Fe	152

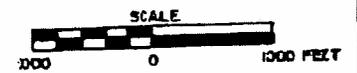
SOIL		WATER	
pH	7.8	pH	6.6
Fe	17,203	SO ₄	4,400
Md Fe	1,130	Fe	7.3

SOIL		WATER	
pH	3.3	pH	3.4
Fe	10,500	SO ₄	17,400
Md Fe	0.8	Fe	2,880

LEGEND:

- I ACIDIC ZONE
 - II NEUTRALIZING ZONE
 - MICHAELIS PRECIPITATION AND ADSORPTION ZONE
 - SULFATE PRECIPITATION ZONE
 - III NEUTRAL ZONE
- USGS-13 WATER SAMPLING LOCATION AND DESIGNATION
 - WSAA-1 MONITORING WELL EXCLUDED IN THE GEOCHEMICAL INVESTIGATION

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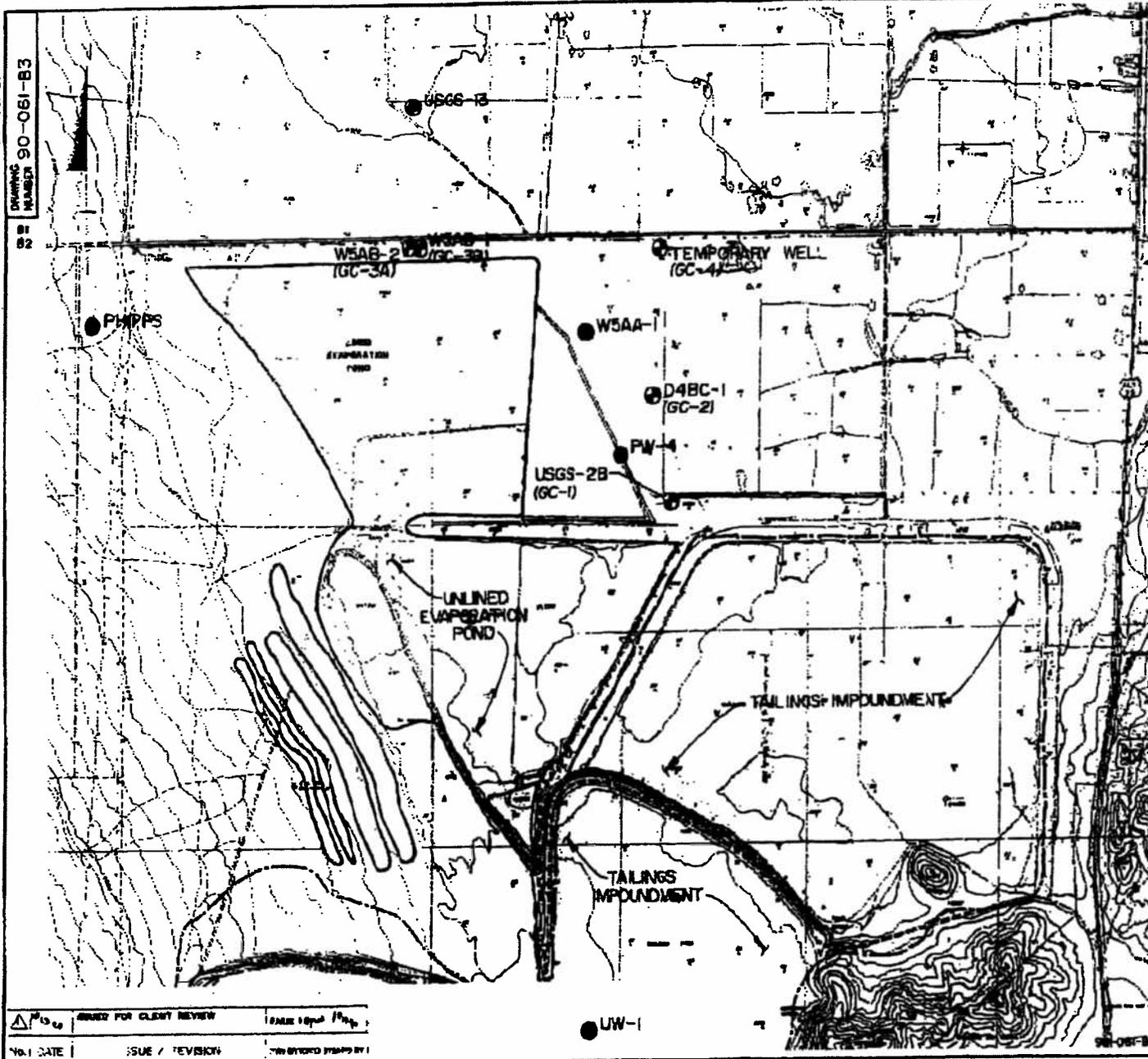
CONCEPTUAL GEOCHEMICAL MODEL
 ILLUSTRATING THE APPROXIMATE
 EXTENT OF GEOCHEMICAL ZONES

PREPARED FOR
 LINDSAY, HART, NEIL, & WEIGLER
 SEATTLE, WASHINGTON
Canonic Environmental

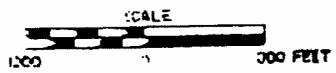
NO.	DATE	ISSUE / REVISION	BY	CHKD
			BS	070

DATE 9-18-90
 SCALE AS SHOWN
 FIGURE 2
 DRAWING NUMBER 90-061-B4

90-061-B1
 DRAWING NUMBER 90-061-B3



- LEGEND:**
- USGS-13 WATER SAMPLING LOCATION AND DESIGNATION
 - W5AA-1 MONITORING WELL EXCLUDED IN THE GEOCHEMICAL INVESTIGATION
 - (GC-2) SOIL SAMPLE DESIGNATION



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GROUND WATER AND SOIL
 SAMPLING LOCATIONS
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DWG. 9-19-90	FIGURE 1	DRAWING NUMBER 90-061-B3
SCALE AS SHOWN		



a
SUMMARY OF EXCEEDANCES
YERINGTON, NEVADA

Within Tailings Site (D4AB-1, USGS-2B, PN-4)	Percent Exceedance	Within Plume, Shallow (D4BC-1, VSAB-2, UV-1)	Percent Exceedance	Edge of Plume Shallow and Deep (USGS-13, VSAB-1)	Percent Exceedance	Unaffected Area, Deep (VSAA-1, Phipps)	Percent Exceedance	Drinking Water Standard ^c
Chloride	0	Chloride	20					250/400
Fluoride	2,000	Fluoride	100					1.4 - 2.4
^b Nitrate	100							10
pH	100							5.0 - 9.0
Sulfate	9,000	Sulfate	1,500	Sulfate	40			250/500
TDS	9,000	TDS	2,000	TDS	200			500/1,000
^b Aluminum	14,000							5.0
Arsenic	1,100							0.05
^b Boron	450	Boron	300	Boron	170	Boron	50	0.75
Cadmium	1,600	Cadmium	240					0.01
^b Cobalt	14,000	Cobalt	1,400	Cobalt	20			0.05
Copper	3,000							1.0
Iron	2,000,000	Iron	45,000					0.3/0.6
Lead	450	Lead	1,000	Lead	60	Lead	16	0.05
Manganese	520,000	Manganese	150,000	Manganese	1,000			0.05/0.1
^b Nickel	2,500	Nickel	95					0.2
Selenium	0	Selenium	3,200					0.01
Silver	1							0.05
Zinc	300							5.0
^b Gross Alpha	4,700							15.0 pCi/l

^a
^b Data for water samples analyzed in November 1985.

^c New Mexico, Wyoming, or Federal standards used for comparison. Nevada Standards not currently established.

Concentrations in mg/l except where noted.