

**Semiannual Radiological Effluent and Environmental Data  
(July through December 1996)**

**and**

**1996 Annual Total Effective Dose Equivalent to the Public**

**for the  
Bluewater Mill Site**

**License No. SUA-1470  
Docket No. 40-8902**

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## 1.0 Introduction

The Bluewater Uranium Mill Site (Site) is located approximately ten miles west of Grants, New Mexico. Atlantic Richfield Company (ARCO) owns the Site which is licensed by the U. S. Nuclear Regulatory Commission (NRC). The mill process buildings were decommissioned in 1990. Tailings areas reclamation, including cleanup of windblown tailings contaminated soils and placement of radon barriers and erosion protection on tailing piles was completed in December 1995. As an NRC licensee, ARCO is committed to maintaining an environmental monitoring program and submitting semiannual reports presenting the quarterly data. In addition, licensees are required to demonstrate that the annual radiation dose limits to the public are within the requirements of 10 CFR §20.1301. This report includes the following:

- Semiannual radiological effluent and environmental data, as required by 10 CFR §40.65, for the period of July through December 1996,
- Groundwater compliance monitoring data, as required by the License condition No. 34, and
- Demonstration of compliance of the annual radiation dose limits for 1996 to the public, as required by 10 CFR §20.1301.

Since the environmental data are being used for demonstrating that the site was in compliance with the 10 CFR §20.1301 radiation dose limit for individual members of the public, the analysis has been performed and included in this report. The dose limit to individual members of the public from NRC-licensed facilities is specified as a total effective dose equivalent of 100 mrem/year. Compliance may be demonstrated by calculations or measurements showing that the individual likely to receive the maximum dose from the facility does not exceed the limit, or by comparing the concentrations at the site perimeter to those specified in Table 2 of Appendix B to 10 CFR §20.0001-20.2401. Radiation from external sources for individuals in the unrestricted area may not exceed a dose equivalent of 0.002 rem in any hour or 0.050 rem in one year. The analysis of the dose to the public is presented in the next section.

## 2.0 Dose Assessment to the Public

Data from the environmental monitoring stations for the four quarters in 1996 were used in assessing the Total Effective Dose Equivalent (TEDE) to individuals of the public. Data collected by continuous measurements of the gamma exposure rates and air particulate concentrations for each of the four quarters for the year were used as well as annual sampling of the vegetation taken at the background location (Berryhill House), and the downwind location (Southeast Perimeter). The Southeast Perimeter sampling station is located downwind at a distance of approximately 1.5 miles from the center of the Main Tailings Pile (MTP). The highest TEDE received from the Site would be by a hypothetical individual living at the Southeast Perimeter sampling station. The radiological source term at the Site for 1996 consisted of reclaimed tailing piles and disposal areas with final radon barrier placement. ARCO has used environmental monitoring data collected as part of its license conditions to calculate the annual effective dose equivalent to the maximum exposed individual. The results are compared to the 100 mrem standard.

The pathways of importance in the dose assessment are the gamma exposure from external radiation sources, the drinking of contaminated ground water, the inhalation of airborne particulate, and the ingestion of meat and milk from cattle grazing on contaminated vegetation. These pathways were assessed even though the hypothetical individual living at the Southeast Perimeter sampling station did not own cattle, eat meat from locally raised cattle, or drink milk from local cows. Because of the semiarid nature of the region, home gardening is not practiced in the local area.

The outdoor radon levels in the Grants Uranium Belt are known to be high and variable, depending on the location relative to mine vents and topographical features. ARCO considers the environmental monitoring data for ambient radon concentrations inadequate to provide a true measure of the background radon concentrations for the Site. Similarly, no information has been collected on the degree of equilibrium of the radon progeny. Therefore ARCO has used a measured Site radon source term and modeled the TEDE at the Site boundary using the EPA CAP88-PC code.

For the particulate, ARCO followed the guidance of EPA (40 CFR Part 61, Section 61.107(3)) where environmental monitoring data collected in compliance with NRC Regulatory Guides 4.14 and 4.15 may be used to develop emission rates. ARCO used the more current ICRP 30 exposure-to-dose conversion factors along with NUREG-0859, Compliance Determination Procedures for

Environmental Radiation Protection Standards for Uranium Recovery Facilities- 40 CFR Part 190 to calculate the annual effective dose equivalent to the maximum exposed individual.

ARCO continued implementation of the environmental monitoring program using NRC approved procedures as a condition of the NRC license. The results from three sampling stations are used in these calculations. The background location, Berryhill House, is located upwind of the Site at a distance of approximately one mile. The other station is located in the SSE direction (which is in the predominant wind direction) at the Site perimeter.

Figure 2-1 is a map of the Site showing the environmental sampling stations and the distance and direction of the Nearest Residence and Southeast Perimeter relative to the MTP.

Third and Fourth quarter environmental data are presented in Sections 3-5. Data for the first two quarters was submitted to the NRC previously. Section 6 contains the results of the Groundwater Compliance Sampling Program for 1996.

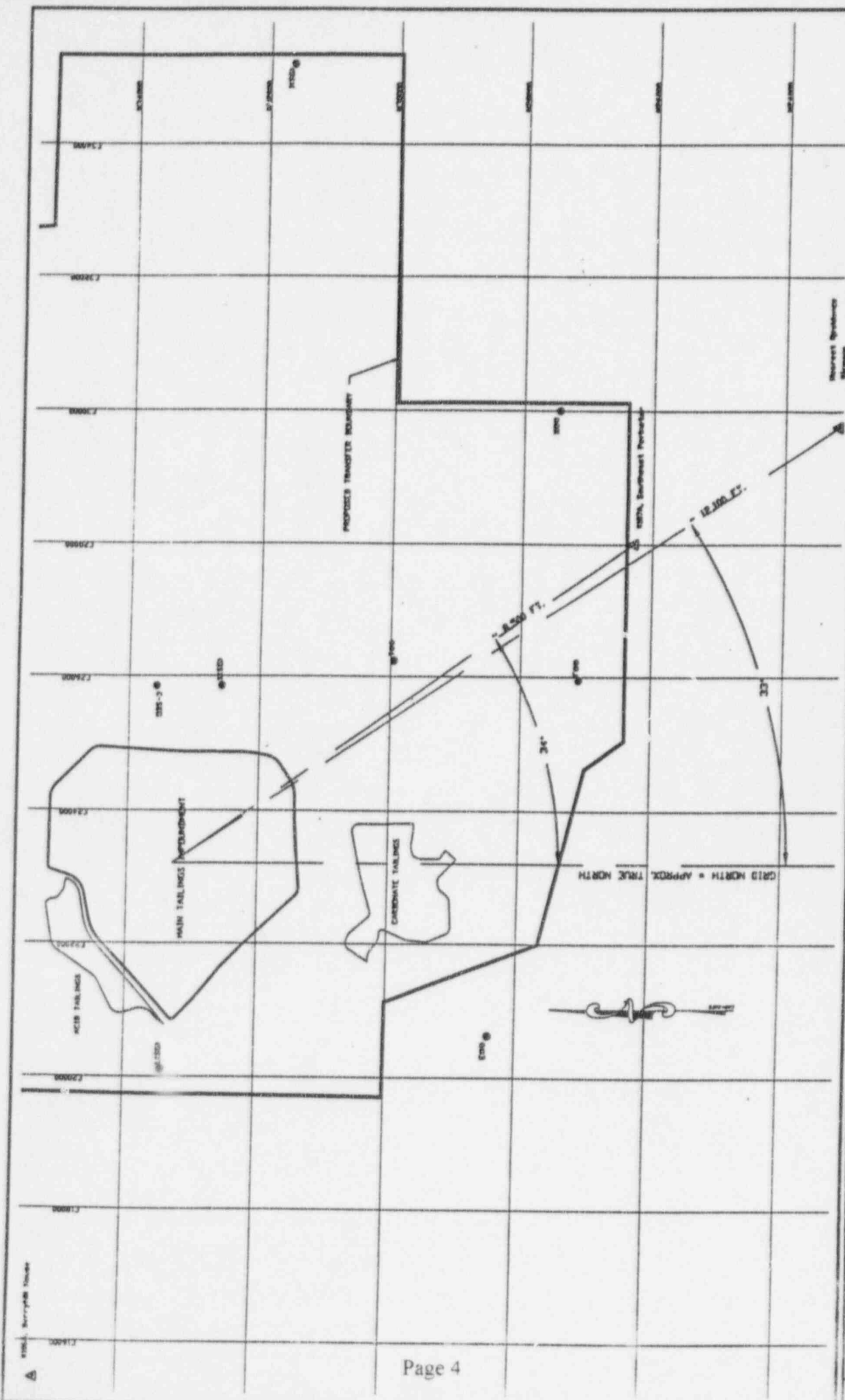
## **2.1 Dose from Long-Lived Particulate Radionuclides**

### **2.1.1 Dose from the Inhalation of Particulate Long-Lived Radionuclides**

The committed effective dose equivalent (H) from inhalation of particulate was calculated for the four principal long-lived radionuclides, U-238, U-234, Th-230, and Ra-226. The concentration of Pb-210 was measured but was not considered in this analysis since the exposure to Rn-222 and its progeny is addressed in Section 2.2.

Committed Effective Dose Equivalent (CEDE) per Unit Intake via Inhalation factors were taken from ICRP 30 tables. The values are given below:

<u>Nuclide</u>	<u>CEDE(mrem/<math>\mu</math>Ci)</u>
U-234	13.2E4
U-238	11.8E4
Th-230	32.6E4
Ra-226	8.6E3



 ATLANTIC RICHFIELD COMPANY		DATE: 10/1/81 DRAWN BY: [blank] CHECKED BY: [blank] APPROVED BY: [blank] PROJECT NO.: [blank] SHEET NO.: [blank]	
FIGURE 2-1 DIRECTION AND DISTANCE TO SOUTHEAST MONITORING STATIONS		ANDERSON ENGINEERING CO., INC. 123 South Main Street Salt Lake City, Utah 84101 Telephone: (801) 533-4888 Fax: (801) 533-4875	
CIVIL ENGINEERS		CONSTRUCTION NUMBER: [blank]	

Continuous occupancy at a breathing rate of 20,000 liters per day (Table A-1, NUREG-0859) was assumed. The CEDE was calculated for each of the radionuclides at each station. The values given in Tables 2-1 and 2-2 were derived by multiplying the airborne concentration by the CEDE per unit intake times the annual breathing rate. No background subtraction was made for the radionuclide concentrations at the Southeast Perimeter. Note that the second station, the Berryhill House, is the background location.

### 2.1.2 Dose from the Ingestion of Cattle Grazed on Contaminated Vegetation

The Committed Effective Dose Equivalent (H) was calculated using guidance provided in NUREG-0859 and the more recent CEDE per Unit Uptake via Ingestion factors from ICRP-30. The long-lived radionuclides in the U-238 decay series and their corresponding CEDE per unit intake are as follows.

<u>Nuclide</u>	<u>CEDE (mrem/<math>\mu</math>Ci)</u>
U-234	283
U-238	255
Th-230	548
Ra-226	1325

The annual CEDE, H, can be expressed as follows:

$$H = (I_h)(I_c)(C)(TC)(CEDE)$$

where  $I_h$  = adult meat ingestion rate 78.3 kg/year

$I_c$  = animal uptake of vegetation 50 kg/day

C = radionuclide concentration in vegetation

T, environmental transfer coefficients

=  $3.4E-4$  pCi/kg per pCi/d for Uranium

=  $2.0E-4$  pCi/kg per pCi/d for Thorium

=  $5.1E-4$  pCi/kg per pCi/d for Radium

CEDE = committed effective dose equivalent per unit intake

Table 2-1  
Annual Total Effective Dose Equivalent

Atlantic Richfield Company  
Blueswater Mill Site

STATION: Berryhill House (Background) Year: 1996

		AIRBORNE CONCENTRATION				ANNUAL EFFECTIVE DOSE EQUIVALENT			
		U-234 uCi/ml	U-238 uCi/ml	Th-230 uCi/ml	Ra-226 uCi/ml	Inhalation of Airborne Particulates			
		=====	=====	=====	=====	U-234 mrem	U-238 mrem	Th-230 mrem	Ra-226 mrem
1st qtr		1.50E-16	7.31E-17	1.70E-16	0.00E+00	0.005	0.002	0.167	0.002
2nd qtr		1.30E-16	6.34E-17	3.00E-17	3.00E-17				
3rd qtr		1.80E-16	8.77E-17	7.00E-17	2.00E-17				
4th qtr		1.30E-16	6.34E-17	1.00E-17	7.00E-17				
Average		1.48E-16	7.19E-17	7.00E-17	3.00E-17				
		VEGETATION CONCENTRATION				Ingestion of Meat from Cattle Grazing on Contaminated Vegetation			
		U-234 uCi/Kg	U-238 uCi/Kg	Ra-226 uCi/Kg	Th-230 uCi/Kg	U-234 mrem	U-238 mrem	Th-230 mrem	Ra-226 mrem
		=====	=====	=====	=====	=====	=====	=====	=====
1st qtr		9.00E-06	4.39E-06	4.39E-06	8.90E-05	0.002	0.001	0.009	0.235
2nd qtr									
3rd qtr									
4th qtr									
Average									
		Consumption of Milk From Cattle Grazing on Contaminated Vegetation				Annual External Exposure From Airborne Particulates			
		U-234 mrem	U-238 mrem	Th-230 mrem	Ra-226 mrem	U-234 mrem	U-238 mrem	Th-230 mrem	Ra-226 mrem
		=====	=====	=====	=====	=====	=====	=====	=====
1st qtr		0.005	0.004	0.000	0.452	0.000	0.000	0.000	0.000
2nd qtr									
3rd qtr									
4th qtr									
Average									
		TOTAL				TOTAL			
		=====	=====	=====	=====	=====	=====	=====	=====
1st qtr		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2nd qtr		0.000	0.000	0.000	0.000				
3rd qtr									
4th qtr									
Average									

Total Annual Effective Dose Equivalent = 1.01 mrem

Table 2-2  
Annual Total Effective Dose Equivalent

Atlantic Richfield Company  
Blueswater Mill Site

STATION: South East Perimeter (Downwind @ Boundry) YEAR: 1996

AIRBORNE CONCENTRATION							ANNUAL EFFECTIVE DOSE EQUIVALENT		
	U-234 uCi/ml	U-238 uCi/ml	Th-230 uCi/ml	Pa-226 uCi/ml	U-234 mrem	Th-230 mrem	Pa-226 mrem	TOTAL mrem	
1st qtr	1.60E-16	7.80E-17	1.10E-16	1.00E-17	0.109	0.096	0.232	0.440	
2nd qtr	2.20E-16	1.07E-16	1.20E-16	-1.00E-17					
3rd qtr	4.20E-16	2.05E-16	7.00E-17	2.00E-17					
4th qtr	1.30E-16	6.34E-17	9.00E-17	4.00E-17					
Average	2.38E-16	1.13E-16	9.75E-17	1.50E-17					
VEGETATION CONCENTRATION							Ingestion of Meat from Cattle Grazing on Contaminated Vegetation		
	U-234 uCi/Kg	U-238 uCi/Kg	Th-230 uCi/Kg	U-234 mrem	U-238 mrem	Th-230 mrem	Pa-226 mrem	TOTAL mrem	
1.30E-05	6.34E-06	6.34E-06	1.90E-04	0.002	0.002	0.004	0.503	0.511	
Consumption of Milk From Cattle Grazing on Contaminated Vegetation									
	U-234 mrem	U-238 mrem	Th-230 mrem	Pa-226 mrem	U-234 mrem	Th-230 mrem	Pa-226 mrem	TOTAL mrem	
0.007	0.006	0.000	0.965	0.979					
Annual External Exposure From Airborne Particulates									
	U-234 mrem	U-238 mrem	Th-230 mrem	Pa-226 mrem	U-234 mrem	Th-230 mrem	Pa-226 mrem	TOTAL mrem	
Whole Body Skin	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

The results shown in Tables 2-1 and 2-2 were calculated using the above model and the associated factors taken from NUREG-0859 and ICRP 30.

### 2.1.3 Dose from Consumption of Milk from Cattle Grazing on Contaminated Vegetation

The Committed Effective Dose Equivalent as a result of the consumption of milk was calculated using guidance provided in NUREG-0859 and the more recent CEDE per Unit Uptake via Ingestion factors from ICRP-30.

The long-lived radionuclides in the U-238 decay series and their corresponding CEDE per unit intake are as follows.

<u>Nuclide</u>	<u>CEDE (mrem/<math>\mu</math>Ci)</u>
U-234	283
U-238	255
Th-230	548
Ra-226	1325

The annual CEDE, H, can be expressed as follows:

$$H = (I_m)(I_c)(C)(TC)(CEDE)$$

where  $I_m$  = adult milk consumption rate: 130 liters/year

$I_c$  = animal uptake of vegetation: 50 kg/day

C = radionuclide concentration in vegetation

TC, environmental transfer coefficients

=  $6.1E-4$  pCi/l per pCi/d for uranium

=  $5.0E-4$  pCi/l per pCi/d for thorium

=  $5.9E-4$  pCi/l per pCi/d for radium

CEDE = committed effective dose equivalent per unit intake

The results shown in Tables 2-1 and 2-2 were calculated using the above model and the associated factors taken from NUREG-0459 and ICRP 30.

#### **2.1.4 Dose from External Exposure Resulting from Airborne Particulate**

The dose from external exposure from airborne particulate was evaluated using guidance given in NRC Regulatory Guidance 3.51, Table 4, p. 32. Factors to calculate the annual exposure from the average airborne concentrations are:

For U-234:  $2.49E6 \text{ (mrem/y)/}(\mu\text{Ci/ml})$

For U-238:  $1.57E6 \text{ (mrem/y)/}(\mu\text{Ci/ml})$

For Th-230:  $3.59E6 \text{ (mrem/y)/}(\mu\text{Ci/ml})$

For Ra-226:  $4.90E7 \text{ (mrem/y)/}(\mu\text{Ci/ml})$

This exposure pathway was shown to be insignificant.

## **2.2 Dose from Exposure to Radon**

The radon source term arises from two sources, the Ra-226 content of the material in the tailings disposal areas and the residual off-pile areas where the soils slightly exceed the natural background Ra-226 concentration levels. The dose from radon was assessed from the residual contamination above natural background in the off-pile areas and presented in "Radiological Dose and Risk Assessment of the Residual Windblown Tailings", January 1994, Atlantic Richfield Company. In that report, EPA CAP88-PC runs were made for each 1000-ft by 1000-ft grid block and the dose assessed at the perimeter fence in the SSE direction. The perimeter fence doses were summed for all grid blocks within the area addressed. This sum was then used to conservatively assign a maximum TEDE at the site perimeter. The TEDE at the site perimeter resulting from the Rn-222 from the area was calculated to be 0.5 mrem/y.

The other portion of the radon source term was estimated from radon flux measurements made on the reclaimed tailings piles and disposal areas. Final radon barriers were placed on all tailing piles and disposal areas by December 1995. The radon source term is summarized in Table 2-3.

Table 2-3, Radon Source Term

Disposal Site	Acres	Avg. Radon Flux Rate, pCi/m <sup>2</sup> sec	Radon Flux Measurement Date	Radon Source Term, Ci/year
Main and Acid Tailings Pile	344	2.8	05/22/94	122.9
Carbonate Tailings Pile	55	1.3	07/13/95	9.1
Ore Stock Pile Area, Plant Site, and Disposal Area No. 1	103	6.2	05/09/96	81.9
South Landfill	1.4	0.25	05/09/96	0.04
North Landfill	1.6	0.37	05/09/96	0.08
Asbestos Disposal Area	1.8	0.15	05/09/96	0.03
<b>Total</b>	<b>506.8</b>	<b>3.3</b>		<b>214.1</b>

The maximum radiation dose from the site is in the SSE sector (22.5 degrees). This sector is slightly west of the Southeast Perimeter Environmental Monitoring Station which lie approximately 33 degrees from a N-S line through the MTP. For simplicity, it was assumed that the Southeast Perimeter Stations is within the SSE sector at distances of 2400 from the center of the MTP. This distance is the respective distance from the sampling stations to the center of the MTP. Using a total radon point source term of 214.1 Ci/yr located at the center of the MTP, The CAP88-PC would calculate a TEDE of 0.13 mrem/y from radon and its progeny at the Southeast Perimeter sampling station.

### 2.3 Dose from Drinking Well Water

The well at the nearest residence is sampled quarterly and analyzed for natural uranium. The 1996 average U-nat concentration of the well water is 0.003 mg/l, or 2.0 pCi/l. The effluent concentration limit for the public for natural uranium, as presented in 10 CFR §20.1001-20.2401, Appendix B is 300 pCi/l and corresponds to a TEDE of 50 mrem per year. Using this information, the TEDE to an occupant of the nearest residence is 0.33 mrem/y. No subtraction of background concentration was made. No other radionuclides have been found in the groundwater at significant concentrations.

## 2.4 Dose from External Radiation Sources

Environmental Thermoluminescent Dosimeters (TLDs) were placed at each of the monitoring stations for each quarter and read by a vendor. Annual dose equivalent for the background station (Berryhill House) was  $108.0 \pm 11.6$  mrem, where the error is two standard deviations. Annual dose equivalents measured at the Southeast Perimeter station was reported as  $125.2 \pm 13.4$  mrem. Subtracting the background, the effective dose equivalent from the site is  $17.2 \pm 17.7$  mrem/y at the SE Perimeter. The propagation of the errors through the calculations show that at this very low level of exposure, the errors in the measurements overwhelm the results.

## 2.5 Calculated Annual Effective Dose Equivalent

Tables 2-1 and 2-2 provide the results of calculations from air particulate concentrations measured and vegetation sampling at the two environmental stations. The Berryhill House Station represents the local site background where the 1996 total annual effective dose equivalent,  $H$ , was calculated to be 1.01 mrem/y from the long-lived radionuclides. This value is essentially the same as that calculated for this location in 1995 (1.05 mrem/y), 1994 (0.85 mrem/y), 1993 (0.87 mrem/y) and in 1992 (0.88 mrem/y). The 1996 calculated TEDE at the Southeast Perimeter station was 1.93 mrem/y, essentially the same as that calculated for this location in 1995 (2.12 mrem/y), 1994 (2.04 mrem/y), and in 1993 (1.73 mrem/y). Subtracting the background effective dose equivalent from the Southeast Perimeter and Nearest Residence stations, the impact at the Southeast Perimeter station from airborne particulate generated at the Site is approximately 0.92 mrem/year.

The impact from the radon originating from the tailings piles was calculated using CAP88-PC. The TEDE at the Southeast Perimeter Station was calculated 0.13 mrem/y. As discussed previously, a conservative estimate of the TEDE at the site perimeter from the off-pile contaminated soils was 0.5 mrem/y. From the above, the total impact from radon and its progeny at the Southeast Perimeter station is 0.6 mrem/y.

From Section 2.3 above, the TEDE from the use of groundwater at the Nearest Residence is 0.3 mrem/y which would also be appropriate for someone living at the Southeast Perimeter.

## **2.6 Total Effective Dose Equivalent to the Public for 1996**

Summing the TEDE from the air particulate, radon, and drinking water pathways, the TEDE for a hypothetical individual living near the Southeast Perimeter monitoring station would be 2.0 mrem/y. After adding the dose exposure from external sources, the TEDE at the Southeast Perimeter station would be 19.2 mrem/y. This clearly shows that the TEDE to the public is in the compliance with the 100 mrem/y limit.

### 3.0 Environmental Airborne Radionuclide Concentrations

Environmental sampling was performed for airborne radionuclides (U-nat, Th-230, Ra-226, and Pb-210) at two permanent environmental air sampling stations at the mill as shown on the location map: Berryhill House #106A (background location), and Southeast Perimeter #107A (downwind location at the restricted area boundary). Air was sampled continuously through glass fiber filter paper using a low volume air sampler, at the rate of about seven to nine cubic feet per minute (CFM). Filters were changed weekly. The loaded weekly filters were composited quarterly for each station and were analyzed by a vendor laboratory (Acculab Research, Golden, Colorado) for an average quarterly radionuclide concentration.

The concentration for each radionuclide for the monitoring stations ranged as follows:

	<u>This Reporting Period</u> <u>(July - December 1996)</u>	<u>Previous Reporting Period</u> <u>(January - June 1996)</u>
U-nat	0.14% to 0.47% of Limit*	0.14% to 0.24% of Limit*
Th-230	0.05% to 0.45% of Limit*	0.15% to 0.85% of Limit*
Ra-226	<0.01% to 0.01% of Limit*	<0.01% to 0.01% of Limit*
Pb-210	2.50% to 3.83% of Limit*	2.67% to 4.33% of Limit*

The percentage of the Effluent Limit for air samples was calculated as follows:

$$\% = \frac{\text{Conc. in Air, } \mu\text{Ci/ml}}{\text{Effluent Limit, } \mu\text{Ci/ml (Table 2, Col. 1, Appendix B, 10CFR20)}} \times 100$$

\* Effluent Limit in air for the general public specified in Appendix B to 10 CFR § 20.1001 - 20.2401:

U-nat	9.0 E-14 $\mu\text{Ci/ml}$
Ra-226	9.0 E-13 $\mu\text{Ci/ml}$
Th-230	2.0 E-14 $\mu\text{Ci/ml}$
Pb-210	6.0 E-13 $\mu\text{Ci/ml}$

ARCO  
BLUEWATER MILL

Radiological Analyses of Environmental Air Particulate Samples

Location: BERRYHILL HOUSE

Date sampled: 01-02-96 to 03-31-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	1.50E-16	1.00E-17	1.00E-16	0.17
Th-230	1.70E-16	4.00E-17	1.00E-16	0.85
Ra-226	0.00E+00	6.00E-17	1.00E-16	0.00
Pb-210	1.60E-14	6.00E-16	2.00E-15	2.67

Location: S.E. PERIMETER

Date Sampled: 01-02-96 to 03-31-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	1.60E-16	1.00E-17	1.00E-16	0.18
Th-230	1.10E-16	3.00E-17	1.00E-16	0.55
Ra-226	1.00E-17	6.00E-17	1.00E-16	0.00
Pb-210	1.90E-14	6.00E-16	2.00E-15	3.17

\* Effluents limit for the public specified in Appendix B  
to 10 CFR 20.1001-20.2401

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

BERRYHILL HOUSE #106A

SAMPLING PERIOD: 01-02-96 To 03-31-96

FILTER # =====	DATE SAMPLED From =====	To =====	AIR SAMPLED ml =====	PARTICULATE gms =====	DUST CONC. ug/Cub. meter =====
1	01-02-96	01-09-96	2.08E+09	0.0275	13.25
2	01-09-96	01-16-96	2.11E+09	0.0415	19.71
3	01-16-96	01-23-96	2.06E+09	0.0186	9.02
4	01-23-96	01-30-96	2.07E+09	0.0222	10.74
5	01-30-96	02-06-96	2.07E+09	0.0179	8.65
6	02-06-96	02-13-96	2.06E+09	0.0568	27.64
7	02-13-96	02-20-96	2.05E+09	0.0370	18.03
8	02-20-96	02-27-96	2.07E+09	0.0153	7.39
9	02-27-96	03-05-96	2.07E+09	0.0216	10.41
10	03-05-96	03-12-96	2.05E+09	0.0298	14.55
11	03-12-96	03-19-96	2.08E+09	0.0245	11.75
12	03-19-96	03-26-96	2.06E+09	0.0487	23.70
13	03-26-96	03-31-96	1.77E+09	0.0403	22.71
TOTAL	01-02-96	03-31-96	2.66E+10	0.4017	15.10

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

SOUTH EAST PERIMETER #107A

SAMPLING PERIOD: 01-02-96 To 03-31-96

FILTER # =====	DATE SAMPLED From To =====		AIR SAMPLED ml =====	PARTICULATE gms =====	DUST CONC. ug/Cub. meter =====
1	01-02-96	01-09-96	2.11E+09	0.0173	8.19
2	01-09-96	01-16-96	2.12E+09	0.0360	16.99
3	01-16-96	01-23-96	2.07E+09	0.0128	6.17
4	01-23-96	01-30-96	2.10E+09	0.0070	3.34
5	01-30-96	02-06-96	2.06E+09	0.0137	6.64
6	02-06-96	02-13-96	2.06E+09	0.0540	26.22
7	02-13-96	02-20-96	2.06E+09	0.0330	16.00
8	02-20-96	02-27-96	2.09E+09	0.0146	7.00
9	02-27-96	03-05-96	2.10E+09	0.0207	9.84
10	03-05-96	03-12-96	2.06E+09	0.0307	14.94
11	03-12-96	03-19-96	2.09E+09	0.0264	12.65
12	03-19-96	03-26-96	2.07E+09	0.0700	33.89
13	03-26-96	03-31-96	1.77E+09	0.0420	23.78
=====					
TOTAL	01-02-96	03-31-96	2.68E+10	0.3782	14.14

ARCO  
BLUEWATER MILL

Radiological Analyses of Environmental Air Particulate Samples

Location: BERRYHILL HOUSE

Date sampled: 04-01-96 to 06-30-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	1.30E-16	1.00E-17	1.00E-16	0.14
Th-230	3.00E-17	2.00E-17	1.00E-16	0.15
Ra-226	3.00E-17	5.00E-17	1.00E-16	0.00
Pb-210	2.00E-14	3.10E-15	2.00E-15	3.33

Location: S.E. PERIMETER

Date Sampled: 04-01-96 to 06-30-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	2.20E-16	1.00E-17	1.00E-16	0.24
Th-230	1.20E-16	4.00E-17	1.00E-16	0.60
Ra-226	-1.00E-17	5.00E-17	1.00E-16	-0.00
Pb-210	2.60E-14	4.00E-15	2.00E-15	4.33

\* Effluents limit for the public specified in Appendix B  
to 10 CFR 20.1001-20.2401

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

BERRYHILL HOUSE #106A

SAMPLING PERIOD: 04-01-96 To 06-30-96

FILTER # =====	DATE SAMPLED From To =====	AIR SAMPLED ml =====	PARTICULATE gms =====	DUST CONC. ug/Cub. meter =====
1	04-01-96 04-08-96	2.02E+09	0.0403	19.97
2	04-08-96 04-15-96	2.02E+09	0.0425	21.05
3	04-15-96 04-22-96	2.01E+09	0.0409	20.33
4	04-22-96 04-29-96	1.98E+09	0.0482	24.33
5	04-29-96 05-06-96	1.97E+09	0.0344	17.45
6	05-06-96 05-13-96	1.96E+09	0.0500	25.54
7	05-13-96 05-20-96	1.90E+09	0.0545	28.73
8	05-20-96 05-27-96	1.91E+09	0.0532	27.93
9	05-27-96 06-03-96	1.92E+09	0.0440	22.86
10	06-03-96 06-10-96	1.89E+09	0.0635	33.69
11	06-10-96 06-17-96	1.96E+09	0.0543	27.74
12	06-17-96 06-24-96	1.92E+09	0.0438	22.83
13	06-24-96 06-30-96	1.94E+09	0.0347	17.89
TOTAL	04-01-96 06-30-96	2.54E+10	0.6043	23.80

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

SOUTH EAST PERIMETER #107A

SAMPLING PERIOD: 04-01-96 To 06-30-96

FILTER #	DATE SAMPLED From	To	AIR SAMPLED ml	PARTICULATE gms	DUST CONC. ug/Cub. meter
=====	=====	=====	=====	=====	=====
1	04-01-96	04-08-96	2.18E+09	0.0350	16.06
2	04-08-96	04-15-96	2.12E+09	0.0463	21.86
3	04-15-96	04-22-96	2.11E+09	0.0362	17.15
4	04-22-96	04-29-96	2.08E+09	0.0390	18.77
5	04-29-96	05-06-96	2.07E+09	0.0430	20.73
6	05-06-96	05-13-96	2.07E+09	0.0418	20.16
7	05-13-96	05-20-96	2.00E+09	0.0527	26.29
8	05-20-96	05-27-96	2.02E+09	0.0645	32.00
9	05-27-96	06-03-96	1.99E+09	0.0288	14.46
10	06-03-96	06-10-96	1.99E+09	0.0730	36.76
11	06-10-96	06-17-96	2.05E+09	0.0558	27.20
12	06-17-96	06-24-96	2.01E+09	0.0447	22.28
13	06-24-96	06-30-96	2.05E+09	0.0490	23.89
	=====	=====	=====	=====	=====
TOTAL	04-01-96	06-30-96	2.67E+10	0.6098	22.80

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

BERRYHILL HOUSE #106A

SAMPLING PERIOD: 07-01-96 To 09-30-96

FILTER #	DATE SAMPLED		AIR SAMPLED ml	PARTICULATE gms	DUST CONC. ug/Cub. meter
=====	=====	=====	=====	=====	=====
1	07-01-96	07-08-96	2.12E+09	0.0405	19.10
2	07-08-96	07-15-96	2.01E+09	0.0365	18.19
3	07-15-96	07-22-96	2.99E+09	0.0275	9.21
4	07-22-96	07-29-96	3.12E+09	0.0474	15.19
5	07-29-96	08-05-96	2.90E+09	0.0296	10.20
6	08-05-96	08-12-96	3.21E+09	0.0480	14.94
7	08-12-96	08-19-96	2.85E+09	0.0490	17.18
8	08-19-96	08-26-96	3.15E+09	0.0500	15.86
9	08-26-96	09-02-96	3.18E+09	0.0520	16.34
10	09-02-96	09-09-96	1.78E+09	0.0490	27.53
11	09-09-96	09-16-96	3.23E+09	0.0510	15.81
12	09-16-96	09-23-96	3.07E+09	0.0550	17.93
13	09-23-96	09-30-96	3.29E+09	0.0490	14.89
	=====	=====	=====	=====	=====
TOTAL	07-01-96	09-30-96	3.69E+10	0.5845	15.84

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

SOUTH EAST PERIMETER #107A

SAMPLING PERIOD: 07-01-96 To 09-30-96

FILTER #	DATE SAMPLED		AIR SAMPLED ml	PARTICULATE gms	DUST CONC. ug/Cub. meter
=====	=====	=====	=====	=====	=====
1	07-01-96	07-08-96	2.02E+09	0.0458	22.70
2	07-08-96	07-15-96	1.91E+09	0.0385	20.11
3	07-15-96	07-22-96	2.99E+09	0.0237	7.91
4	07-22-96	07-29-96	3.06E+09	0.0570	18.62
5	07-29-96	08-05-96	2.83E+09	0.0498	17.61
6	08-05-96	08-12-96	3.06E+09	0.0408	13.33
7	08-12-96	08-19-96	2.94E+09	0.0490	16.67
8	08-19-96	08-26-96	3.06E+09	0.0550	17.98
9	08-26-96	09-02-96	3.13E+09	0.0365	11.65
10	09-02-96	09-09-96	1.28E+09	0.0480	37.64
11	09-09-96	09-16-96	3.03E+09	0.0490	16.16
12	09-16-96	09-23-96	3.16E+09	0.0520	16.48
13	09-23-96	09-30-96	3.15E+09	0.0480	15.22
	=====	=====	=====	=====	=====
TOTAL	07-01-96	09-30-96	3.56E+10	0.5931	16.65

ARCO  
BLUEWATER MILL

Radiological Analyses of Environmental Air Particulate Samples

Location: BERRYHILL HOUSE

Date sampled: 07-01-96 thru 09-30-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	1.80E-16	1.00E-17	1.00E-16	0.20
Th-230	7.00E-17	2.00E-17	1.00E-16	0.35
Ra-226	2.00E-17	2.00E-17	1.00E-16	0.00
Pb-210	1.50E-14	2.30E-15	2.00E-15	2.50

Location: S.E. PERIMETER

Date sampled: 07-01-96 thru 09-30-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	4.20E-16	2.00E-17	1.00E-16	0.47
Th-230	7.00E-17	1.00E-17	1.00E-16	0.35
Ra-226	2.00E-17	2.00E-17	1.00E-16	0.00
Pb-210	1.60E-14	2.50E-15	2.00E-15	2.67

\* Effluents limit for the public specified in Appendix B  
to 10 CFR 20.1001-20.2401

ARCO  
BLUEWATER MILL

Radiological Analyses of Environmental Air Particulate Samples

Location: BERRYHILL HOUSE

Date sampled: 10-01-96 thru 12-30-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	1.30E-16	2.00E-17	1.00E-16	0.14
Th-230	1.00E-17	2.00E-17	1.00E-16	0.05
Ra-226	7.00E-17	5.00E-17	1.00E-16	0.01
Pb-210	2.10E-14	3.40E-15	1.00E-15	3.50

Location: S.E. PERIMETER

Date sampled: 10-01-96 thru 12-30-96

Radionuclide =====	Concentration uCi/ml =====	Error estimate uCi/ml =====	LLD uCi/ml =====	% of Limit* =====
U-nat	1.30E-16	2.00E-17	1.00E-16	0.14
Th-230	9.00E-17	5.00E-17	1.00E-16	0.45
Ra-226	4.00E-17	4.00E-17	1.00E-16	0.00
Pb-210	2.30E-14	3.70E-15	2.00E-15	3.83

\* Effluents limit for the public specified in Appendix B  
to 10 CFR 20.1001 - 20.2401

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

SOUTH EAST PERIMETER #107A

SAMPLING PERIOD: 10-01-96 To 12-31-96

FILTER #	DATE SAMPLED		AIR SAMPLED ml	PARTICULATE gms	DUST CONC. ug/Cub. meter
=====	From	To	=====	=====	=====
1	10-01-96	10-07-96	2.15E+09	0.0435	20.23
2	10-07-96	10-14-96	2.12E+09	0.0400	18.88
3	10-14-96	10-21-96	2.13E+09	0.0400	18.80
4	10-21-96	10-28-96	2.17E+09	0.0500	23.03
5	10-28-96	11-04-96	2.18E+09	0.0450	20.69
6	11-04-96	11-11-96	2.17E+09	0.0600	27.65
7	11-11-96	11-18-96	2.16E+09	0.0500	23.11
8	11-18-96	11-25-96	2.22E+09	0.0450	20.27
9	11-25-96	12-02-96	2.17E+09	0.0550	25.32
10	12-02-96	12-09-96	2.18E+09	0.0450	20.67
11	12-09-96	12-16-96	2.17E+09	0.0500	23.05
12	12-16-96	12-23-96	2.18E+09	0.0210	9.63
13	12-23-96	12-30-96	2.24E+09	0.0560	25.04
	=====	=====	=====	=====	=====
TOTAL	10-01-96	12-30-96	2.82E+10	0.6005	21.27

ARCO  
BLUEWATER MILL

Environmental Air Particulate Sample Composite

BERRYHILL HOUSE #106A

SAMPLING PERIOD: 10-01-96 To 12-31-96

FILTER #	DATE SAMPLED		AIR SAMPLED ml	PARTICULATE gms	DUST CONC. ug/Cub. meter
=====	From	To	=====	=====	=====
1	10-01-96	10-07-96	2.12E+09	0.0430	20.27
2	10-07-96	10-14-96	2.00E+09	0.0420	21.03
3	10-14-96	10-21-96	1.98E+09	0.0500	25.22
4	10-21-96	10-28-96	2.08E+09	0.0500	24.05
5	10-28-96	11-04-96	2.15E+09	0.0450	20.97
6	11-04-96	11-11-96	2.21E+09	0.0730	33.01
7	11-11-96	11-18-96	2.07E+09	0.0500	24.16
8	11-18-96	11-25-96	2.18E+09	0.0450	20.69
9	11-25-96	12-02-96	2.15E+09	0.0550	25.61
10	12-02-96	12-09-96	2.14E+09	0.0450	21.01
11	12-09-96	12-16-96	2.13E+09	0.0478	22.48
12	12-16-96	12-23-96	2.15E+09	0.0244	11.37
13	12-23-96	12-30-96	2.22E+09	0.0285	12.81
TOTAL	10-01-96	12-30-96	2.76E+10	0.5987	21.72

#### 4.0 Ambient Radon Concentration

Track Etch environmental radon monitoring devices are used to monitor ambient radon concentrations at the air sampling stations. The Track Etch devices were exposed for each quarter and analyzed by Landauer, Inc., the manufacturer of the devices, to obtain quarterly average radon concentrations. According to Landauer, Inc. the Lower Limit of Detection (LLD) of the Track Etch model used at the Bluewater Mill Site is 0.20 pCi/l.

The highest quarterly average radon concentration measured at the downwind station (Southeast Perimeter) was 1.0 pCi/l during the fourth quarter. After subtracting the background (Berryhill House #106A) concentration of 0.9 pCi/l, the SE Perimeter showed a concentration of 0.1 pCi/l. The third quarter average radon concentration at the SE Perimeter was 0.8 pCi/l, compared to the 0.7 pCi/l measured at the background (Berryhill House) station during the same quarter.

Also, at each station, a second Track Etch device is placed for an annual exposure (January-December), which were analyzed after the end of the exposure period. The annual sampling indicates an average ambient radon concentration of 0.8 pCi/l at the Southeast Perimeter and 0.4 pCi/l at the background (Berryhill House) station. The calculated annual average from quarterly sampling is 0.8 pCi/l at the Southeast Perimeter and 0.6 pCi/l at the background location.

ARCO  
BLUEWATER MILL

Environmental Ambient Radon Concentrations  
Quarterly Sampling\*

SAMPLING PERIOD: January 01 through March 31, 1996

Sampling Location =====	Avg. Radon Conc. pCi/l =====
Berryhill House (106A)	0.5
S.E. Perimeter (107A)	0.4

SAMPLING PERIOD: April 01 through June 30, 1996

Sampling Location =====	Avg. Radon Conc. pCi/l =====
Berryhill House (106A)	0.3
S.E. Perimeter (107A)	0.9

\* Radon Treck Etch device exposed for the entire quarter

ARCO  
BLUEWATER MILL

Environmental Ambient Radon Concentrations  
Quarterly Sampling\*

SAMPLING PERIOD: July 01 through September 30, 1996

Sampling Location =====	Avg. Radon Conc. pCi/l =====
Berryhill House (106A)	0.7
S.E. Perimeter (107A)	0.8

SAMPLING PERIOD: October 01 through December 30, 1996

Sampling Location =====	Avg. Radon Conc. pCi/l =====
Berryhill House (106A)	0.9
S.E. Perimeter (107A)	1.0

\* Radon Treck Etch device exposed for the entire quarter

ARCO  
BLUEWATER MILL

Environmental Ambient Radon Concentrations  
Annual Sampling\*

SAMPLING PERIOD: January 01 through December 30, 1996

Sampling Location =====	Avg. Radon Conc. pCi/l =====
Berryhill House (106A)	0.4
S.E. Perimeter (107A)	0.8

\* Radon Treck Etch device exposed for the entire year

AVM ENVIRONMENTAL SERVICES, INC  
ATTN: NATVER PATEL  
1717 DEL NORTE BLVD.  
GRANTS, NM 87020

# Radon Monitoring Report

LANDAUER

Landauer, Inc. 2 Science Road Glenwood, Illinois 60425-1586  
Telephone: (708) 755-7911 Facsimile: (708) 755-7016

Acct. No. 0406675

Detector Number	Detector Type	Starting Date	Ending Date	Field Data / Comments	Exposure pCi/l-days	Avg. Radon Conc. pCi/l	
4166147	DRNF	01-JUL-96	01-OCT-96	BERRYHILL 106-A	60.4	0.7	
4166148	DRNF	01-JUL-96	01-OCT-96	SOUTH EAST PERIMETER 107 A	72.4	0.8	

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Release WAB	Process No. A1B40B	Report Date 11-OCT-96	Date Received 04-OCT-96
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AVM ENVIRONMENTAL SERVICES, INC  
ATTN: NATVER PATEL  
1717 DEL NORTE BLVD.  
GRANTS, NM 87020

# Radon Monitoring Report

**LANDAUER**

Landauer, Inc. 2 Science Road Glenwood, Illinois 60425-1586  
Telephone: (708) 755-7911 Facsimile: (708) 755-7016

Acct. No. **0406675**

Detector Number	Detector Type	Starting Date	Ending Date	Field Data / Comments	Exposure pCi/t-days	Avg. Radon Conc. pCi/t	
4134979	DRNF	02-JAN-96	30-DEC-96	S. E. PERIMETER #107 A	279.3	0.8	
4134980	DRNF	02-JAN-96	30-DEC-96	BERRYHILL #106 A	147.2	0.4	
4189192	DRNF	01-OCT-96	30-DEC-96	S E PERIMETER 107 A	87.3	1.0	
4189193	DRNF	01-OCT-96	30-DEC-96	BERRYHILL 106 A	85.1	0.9	

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Q.C. Release <b>WAB</b>	Process No. <b>A18493</b>	Report Date <b>13-JAN-97</b>	Date Received <b>07-JAN-97</b>
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## 5.0 Direct Gamma Radiation

Environmental Thermoluminescent Dosimeters (TLDs) are utilized at each permanent air station to monitor direct gamma radiation. The TLDs are exposed for a quarter and exchanged and analyzed to determine a quarterly gamma radiation level in mrem per quarter. During the exposure period, the control TLD is kept at the office in the unrestricted area. The analyses is performed by TMA/Eberline, the manufacturer of the TLDs.

Direct gamma radiation exposure rate for the third quarter of 1996 was measured to be  $30.6 \pm 3.9$  mrem/quarter at the SE Perimeter (downwind) station #107A, with a control reading of  $25.6 \pm 6.7$  mrem/quarter. For the fourth quarter, the exposure rate at the SE Perimeter was  $38.2 \pm 2.6$  mrem/quarter, with a control reading of  $28.8 \pm 1.7$  mrem/quarter. The exposure rate at the Background Station (Berryhill House #106A), was  $26.4 \pm 5.2$  and  $31.2 \pm 1.7$  mrem/quarter for the third and fourth quarters, respectively.

ARCO  
BLUEWATER MILL

Environmental Direct Gamma Radiation Measurements

Measurement Period: January 01 through March 31, 1996

LOCATION =====	Exposure Rate mrem/quarter =====	Estimated Error mrem/quarter, 2 sigma =====
Control	25.6	8.6
Berryhill House (106A)	28.0	3.2
S.E. Perimeter (107A)	30.6	8.3

Measurement Period: April 01 through June 30, 1996

LOCATION =====	Exposure Rate mrem/quarter =====	Estimated Error mrem/quarter, 2 sigma =====
Control	23.8	5.9
Berryhill House (106A)	22.4	9.7
S.E. Perimeter (107A)	25.8	9.4

ARCO  
BLUEWATER MILL

Environmental Direct Gamma Radiation Measurements

Measurement Period: July 01 through September 30, 1996

LOCATION =====	Exposure Rate mrem/quarter =====	Estimated Error mrem/quarter, 2 sigma =====
Control	25.6	6.7
Berryhill House (106A)	26.4	5.2
S.E. Perimeter (107A)	30.6	3.9

Measurement Period: October 01 through December 30, 1996

LOCATION =====	Exposure Rate mrem/quarter =====	Estimated Error mrem/quarter, 2 sigma =====
Control	28.8	1.7
Berryhill House (106A)	31.2	1.7
S.E. Perimeter (107A)	38.2	2.6

Thermo NUtech

5635 Jefferson Street NE  
Albuquerque, NM 87109  
(505) 345-9931

# TLD ENVIRONMENTAL MONITOR REPORT

DATE ISSUED 10/01/96  
DATE RETURNED 01/06/97

DATE ANNEALED 09/16/96  
DATE READ 01/10/97

CUSTOMER NO. 06719  
PAGE 1 OF 1

ROSE MARIE TAUCHE  
DOSIMETRY SERVICES  
DATE 01/17/97

BADGE NUMBER	IDENTIFICATION	DOSIMETER READINGS (mrem)					AVERAGE	+ 2σ	MREM WEEK	FRE
		FIRST	SECOND	THIRD	FOURTH	FIFTH				
01000	CONTROL	28	28	29	29	30	28.8	1.7	1.72	Q
01001	BERRY HILL HOUSE	30	31	31	32	32	31.2	1.7	1.27	Q
01002	SE PERIMETER 107	36	39	39	38	39	38.2	2.6	2.29	Q

\* - DOSIMETER DAMAGED

FREQUENCY CODES

\*\* - BASED ON ELAPSED TIME  
FROM DATE ANNEALED TO  
DATE READ

M - MONTHLY  
Q - QUARTERLY  
S - SEMI-ANNUAL  
A - ANNUAL  
I - IRREGULAR

CUSTOMER  
ATTENTION  
ADDRESS  
CITY

AVM ENV. SERVICES, INC  
NATVER PATEL  
1717 DEL NORTE BLVD  
GRANTS

NM 87020

**TMA**  
Thermo Analytical

TMA/Eberline

5635 Jefferson Street NE  
Albuquerque, NM 87109

(505) 345-9931

# TLD ENVIRONMENTAL MONITOR REPORT

DATE ISSUED  
DATE RETURNED

07/01/96  
10/02/96

DATE ANNEALED  
DATE READ

06/15/96  
10/02/96

CUSTOMER NO. 08719  
PAGE 1 OF 1

ROSE MARIE TAUCHE  
DOSIMETRY SERVICES  
DATE 10/08/96

BADGE NUMBER	IDENTIFICATION	DOSIMETER READINGS (mrem)					AVERAGE	+ - 2σ	MREM WEEK	FREQ.
		FIRST	SECOND	THIRD	FOURTH	FIFTH				
01000	CONTROL	23	30	22	25	28	25.6	6.7	1.63	Q
01001	BERRY HILL HOUSE	27	29	22	27	27	26.4	5.2	1.08	Q
01002	SE PERIMETER 107	29	30	30	34	30	30.6	3.9	1.95	Q

\* - DOSIMETER DAMAGED

FREQUENCY CODES

\*\* - BASED ON ELAPSED TIME  
FROM DATE ANNEALED TO  
DATE READ

M - MONTHLY  
Q - QUARTERLY  
S - SEMI-ANNUAL  
A - ANNUAL  
I - IRREGULAR

CUSTOMER  
ATTENTION  
ADDRESS  
CITY

AVM ENV. SERVICES, INC  
NATVER PATEL  
1717 DEL NORTE BLVD  
GRANTS

NM 87020

## 6.0 Soil and Vegetation Sampling

A soil and vegetation sampling was performed at each permanent air sampling station and analyzed for U-nat, Th-230, Ra-226, and Pb-210. All results of vegetation analyses are reported in  $\mu\text{Ci}$  per Kg of wet vegetation, as it was collected in the field. Following is the summary of highest concentrations of radionuclides found in the soil and vegetation at the stations:

<u>Radionuclide</u>	<u>Soil, <math>\mu\text{Ci/gm}</math></u>	<u>Vegetation, <math>\mu\text{Ci/Kg}</math></u>
U-nat	1.56E-6 at S. E. Perimeter	1.30E-5 at S. E. Perimeter
Ra-226	4.20E-6 at S. E. Perimeter	1.90E-4 at S. E. Perimeter
Th-230	3.20E-6 at S. E. Perimeter	2.10E-5 at Berryhill House
Pb-210	3.20E-6 at S. E. Perimeter	1.20E-4 at S. E. Perimeter

**ATLANTIC RICHFIELD COMPANY  
BLUEWATER MILL**

**SOIL AND VEGETATION SAMPLING**

**October 14, 1996**

**Soil Sampling Procedure**

A nine point composite soil sample was collected over a 100 square meter area surrounding each of the monitoring stations. Soil was collected from the surface to four inches in depth. Soils were field textured and estimated for grain size. The composite soil samples were dried, crushed to two millimeters in diameter particle size or less (-10 mesh), and then blended prior to being split. The soil samples were split four times with a Jones splitter to obtain a representative aliquot for the laboratory performing the analysis. The aliquot sent to the laboratory equaled one eighths of the total composite sample collected. The remaining portion of the sample was temporarily stored.

**Vegetation Sampling Procedure**

Vegetation samples were collected over approximately a 1000 square meter area around each station. The percent abundance of each type of foliage was visibly estimated for the monitoring stations which were basically same as last years. The different types of foliage (shrubs, grasses, and forbs) for each station were bagged separately. The foliage types were then blended in proportions by weight equal to their percent abundance at each station. This procedure was utilized to obtain a representative aliquot for each station. The blended aliquot was bagged and sent for laboratory analysis.

**Sample Data by Station**

**Berryhill (#106-A):**

**Date Sampled: 10/14/96**

- Soil - The soil texture was estimated to be coarse to medium grained. The sample aliquot sent for analysis weighed 150 grams.
- Vegetation - The vegetation at this station was predominantly made up of grasses, shrubs, and forbs.
- Shrubs - approximately 15% of the vegetative cover  
(aliquot portion weighed 150 grams)
- Winterfat
  - 4 - Wingsalt bush
- Grass - approximately 55% of the vegetative cover  
(aliquot portion weighed 550 grams)
- Bluegrass

Forbs - approximately 30% of the vegetative cover  
(aliquot portion weighed 300 grams)

- Rubber Rabbit Brush
- Russian Thistle
- Broom Snake Weed
- Kochia

Total 1044 with bag

**New Southeast Perimeter (#107-A):**

**Date Sampled: 10/14/96**

Soil - The soil texture was estimated to be medium grained. The sample aliquot sent for analysis weighed 150 grams.

Vegetation - The vegetation at this station was predominantly made up of grasses, shrubs, and forbs.

Shrubs - approximately 25% of the vegetative cover  
(aliquot portion weighed 250 grams)

- Winterfat
- 4 - Wingsalt bush

Grass - approximately 40% of the vegetative cover  
(aliquot portion weighed 400 grams)


- Bluegrass
- Galleta
- Indian Rice Grass
- Bottle Brush Squirrel Tail

Forbs - approximately 35% of the vegetative cover  
(aliquot portion weighed 350 grams)

- Rubber Rabbit Brush
- Kochia
- Broom Snake Weed

Total 1050 with bag

Sampled by:

  
Arvind Patel

  
Natver M. Patel

ARCO  
Bluewater Mill

Radiological Analyses of Soil Samples  
(Nine Point Soil Composite)

Location: BERRYHILL HOUSE

Date sampled: 10-14-96

Radionuclide =====	Concentration uCi/gm =====	Error estimate uCi/gm =====	LLD uCi/gm =====
U-nat	8.12E-07	8.12E-08	2.00E-07
Ra-226	3.60E-06	1.10E-06	2.00E-07
Pb-210	1.40E-06	7.00E-07	2.00E-07
Th-230	0.00E+00	1.00E-07	2.00E-07

Location: SE PERIMETER

Date sampled: 10-14-96

Radionuclide =====	Concentration uCi/gm =====	Error estimate uCi/gm =====	LLD uCi/gm =====
U-nat	1.56E-06	1.56E-07	2.00E-07
Ra-226	4.20E-06	1.30E-06	2.00E-07
Pb-210	1.00E-07	6.00E-07	2.00E-07
Th-230	3.20E-06	3.00E-07	2.00E-07

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Radiological Analyses of Vegetation Samples

Location: Berryhill House #106A      Date sampled: 10-14-96  
Vegetation Comp (forbs 15%, grasses 55%, and shrubs 30%)

Radionuclide =====	Concentration uCi/Kg =====	Error estimate uCi/Kg =====	LLD uCi/Kg =====
U-nat	9.00E-06	2.40E-06	3.00E-06
Ra-226	8.90E-05	3.40E-05	3.00E-07
Pb-210	-1.60E-04	2.70E-04	5.00E-06
Th-230	2.10E-05	2.10E-05	1.00E-06

Location: South East Perimeter, #107A      Date sampled: 10-14-96  
Vegetation Comp (forbs 35%, shrubs 25%, and grasses 40%)

Radionuclide =====	Concentration uCi/Kg =====	Error estimate uCi/Kg =====	LLD uCi/Kg =====
U-nat	1.30E-05	2.40E-06	3.00E-06
Ra-226	1.90E-04	6.20E-05	3.00E-07
Pb-210	-1.20E-04	-2.40E-04	4.00E-06
Th-230	8.40E-06	1.80E-05	1.00E-06



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Date: 12/02/96

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## REPORT OF ANALYSIS

Mr Natver Patel  
AVM Environmental Services Inc  
1717 Del Norte Blvd  
Grants, NM 87020

Lab Job Number: 011833 AVM001  
Date Samples Received: 10/15/96

ALR Designation:	96-A21674	96-A21675
Client Designation:	S.E. PERIMETER	BERRYHILL
Sample Location:	#107A	#106-A
Location II:		
Date/Time Collected	10/14/96 9:55	10/14/96 10:45
Air Dry Loss (%)	2.9	1.9
Uranium, total (ug/g)	2.3	1.2
Lead-210, total (pCi/g)	0.1 +/- 0.6	1.4 +/- 0.7
Radium-226, total (pCi/g)	4.2 +/- 1.3	3.6 +/- 1.1
Thorium-230, total (pCi/g)	3.2 +/- 0.3	0.0 +/- 0.1

NOTES: When present, \*\*\* indicates that the analyte in question was not requested for that sample.  
All results reported on a dry weight basis.

Variability of the radioactive disintegration process (counting error) at the 95% confidence level is 1.96 sigma and the level of significance may exceed that of the reported analytical result.

Scheduled sample disposal/return date: January 1, 1997.

Bud Summers  
Radiochemistry Supervisor



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(303) 277-9514 FAX (303) 277-9512

Date: 12/04/96

Page 1

## REPORT OF ANALYSIS

Mr Natver Patel  
AVM Environmental Services Inc  
1717 Del Norte Blvd  
Grants, NM 87020

Lab Job Number: 011834 AVM001  
Date Samples Received: 10/15/96

ALR Designation:	96-A21676	96-A21677
Client Designation:	S.E. PERIMETER	BERRYHILL
Sample Location:	#107-A	#106-A
Location II:		
Date/Time Collected	10/14/96 9:40	10/14/96 10:35
Moisture (%)	71.6	68.2
Radium-226, total (uCi E-6/Kg)	190 +/- 62	89 +/- 34
Lead-210, total (uCi E-6/Kg)	-120 +/- 240	-160 +/- 270
Thorium-230, total (uCi E-6/Kg)	8.4 +/- 18	21 +/- 21
Uranium, total (uCi E-6/Kg)	13 +/- 2.4	9.0 +/- 2.4

NOTES: When present, \*\*\* indicates that the analyte in question was not requested for that sample.  
All results reported on a dry weight basis.

Variability of the radioactive disintegration process (counting error) at the 95% confidence level is 1.96 sigma and the level of significance may exceed that of the reported analytical result.

Scheduled sample disposal/return date: January 3, 1997.

Bud Summers  
Radiochemistry Supervisor

## **7.0 Groundwater Compliance Monitoring**

Groundwater compliance monitoring was continued during the second half of 1996, as per License Condition No. 34. One background well and two Point of Compliance (POC) wells are monitored in both the San Andres Aquifer and the Alluvial Aquifer. The Alluvial Aquifer is monitored for U-nat, selenium, and molybdenum; U-nat and selenium are monitored in the San Andres Aquifer. As indicated by the monitoring data and observed in the Time versus Concentration curve, the groundwater concentration trend for these parameter are generally stable or appear to decline with time.

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Ground Water Monitoring Results

Well Description: E(M), Alluvial Aquifer

Sample Date =====	pH =====	Water level Elevation feet =====	U-nat mg/l =====	Selenium mg/l =====	Molybdenum mg/l =====
06/14/88	7.72	6540.80	0.013	< 0.005	< 0.005
09/07/88	7.73	6541.93	0.017	< 0.005	< 0.005
12/06/88	7.04	6541.25	0.019	< 0.005	< 0.005
03/07/89	7.49	6540.25	0.022	< 0.005	< 0.005
06/15/89	7.14	6439.72	0.027	< 0.005	< 0.005
09/20/89	7.27	6539.67	0.017	< 0.005	< 0.005
12/18/89	7.21	6539.13	0.030	< 0.005	< 0.005
03/12/90	7.16	6538.98	0.029	< 0.005	< 0.005
04/09/90	7.18	6538.88	0.025	< 0.005	< 0.005
07/12/90	7.25	6539.58	0.027	< 0.005	< 0.005
09/17/90	6.90	6538.43	0.022	< 0.005	< 0.005
10/03/90	7.22	6538.38	0.030	< 0.005	< 0.005
12/18/90	7.22	6538.18	0.031	< 0.005	< 0.005
01/08/91	7.03	6538.03	0.031	< 0.005	< 0.005
04/03/91	7.09	6537.67	0.024	< 0.005	< 0.005
07/10/91	7.25	6537.63	0.027	< 0.005	< 0.005
10/03/91	7.15	6537.12	0.019	< 0.005	< 0.005
01/14/92	7.33	6536.97	0.024	< 0.005	< 0.005
04/14/92	7.24	6537.27	0.021	< 0.005	< 0.005
07/21/92	7.20	6537.24	0.022	< 0.005	< 0.005
10/06/92	7.30	6537.46	0.031	< 0.005	< 0.005
01/11/93	7.36	6537.78	0.025	< 0.005	< 0.005
04/05/93	7.30	6538.04	0.024	< 0.005	< 0.005
07/08/93	7.34	6538.47	0.032	< 0.005	< 0.005
10/05/93	7.32	6538.00	0.032	< 0.005	< 0.005
01/06/94	7.26	6538.18	0.024	< 0.005	< 0.005
04/12/94	7.21	6538.43	0.024	< 0.005	< 0.005
07/06/94	7.29	6539.18	0.032	0.006	< 0.005
10/06/94	7.32	6541.90	0.032	< 0.005	< 0.005
01/16/95	7.29	6542.31	0.028	< 0.005	< 0.005
04/10/95	7.48	6541.11	0.022	0.008	< 0.005
07/17/95	7.37	6538.53	0.024	< 0.005	< 0.005
10/23/95	7.34	6538.16	0.021	0.001	< 0.005
01/16/96	7.34	6537.84	0.023	< 0.001	< 0.03
04/03/96	7.36	6537.43	0.025	< 0.001	< 0.005
07/02/96	7.40	6537.02	0.020	< 0.001	< 0.005
10/09/96	7.68	6536.34	0.017	< 0.005	0.006

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BLUEWATER MILL

Ground Water Monitoring Results

Well Description: F(M), Alluvial Aquifer

Sample Date	pH	Water level Elevation feet	U--nat mg/l	Selenium mg/l	Molybdenum mg/l
=====	=====	=====	=====	=====	=====
06/14/88	7.54	6495.00	0.006	< 0.005	< 0.005
09/07/88	7.80	6494.71	0.007	< 0.005	< 0.005
12/06/88	7.46	6494.77	0.007	< 0.005	< 0.005
03/07/89	7.53	6494.65	0.007	< 0.005	< 0.005
06/15/89	7.10	6494.38	0.006	< 0.005	< 0.005
09/20/89	7.29	6494.38	0.005	< 0.005	< 0.005
12/18/89	7.25	6494.10	0.006	< 0.005	< 0.005
03/12/90	7.10	6493.63	0.007	< 0.005	< 0.005
05/23/90	7.27	6493.36	0.008	< 0.005	< 0.005
07/11/90					
09/17/90	7.20	6492.68	0.003	< 0.005	< 0.005
10/02/90	7.12	6492.71	0.007	< 0.005	< 0.005
12/18/90	7.00	6492.19	0.013	< 0.005	< 0.005
01/08/91	7.08	6492.11	0.008	< 0.005	< 0.005
04/03/91	7.14	6491.68	0.006	< 0.005	< 0.005
07/09/91	7.19	6491.27	0.008	< 0.005	< 0.005
10/03/91	7.22	6490.82	0.003	< 0.005	< 0.005
01/15/92	7.15	6490.61	0.004	< 0.005	< 0.005
04/07/92	7.20	6490.54	0.009	< 0.005	< 0.005
07/21/92	7.24	6490.37	0.009	< 0.005	< 0.005
10/05/92	7.25	6490.27	0.008	< 0.005	< 0.005
01/11/93	7.24	6490.25	0.014	< 0.005	< 0.005
04/05/93	7.32	6490.28	0.011	< 0.005	< 0.005
07/06/93	7.33	6490.32	0.013	< 0.005	< 0.005
10/11/93	7.32	6490.36	0.013	< 0.005	< 0.005
01/04/94	7.30	6490.55	0.012	< 0.005	< 0.005
04/05/94	7.32	6490.28	0.011	< 0.005	< 0.005
07/07/94	7.20	6490.92	0.013	0.006	< 0.005
10/10/94	7.14	6490.98	0.013	< 0.005	< 0.005
01/17/95	7.32	6491.58	0.012	< 0.005	< 0.005
04/10/95	7.06	6491.92	0.014	< 0.005	< 0.005
07/18/95	7.34	6492.03	0.011	< 0.005	< 0.005
10/23/95	7.24	6492.02	0.010	0.003	< 0.005
01/15/96	7.32	6492.38	0.013	< 0.001	< 0.03
04/10/96	6.99	6492.54	0.013	< 0.001	< 0.03
07/02/96	7.73	6492.46	0.014	0.001	< 0.005
10/08/96	7.77	6492.09	0.013	< 0.005	0.005

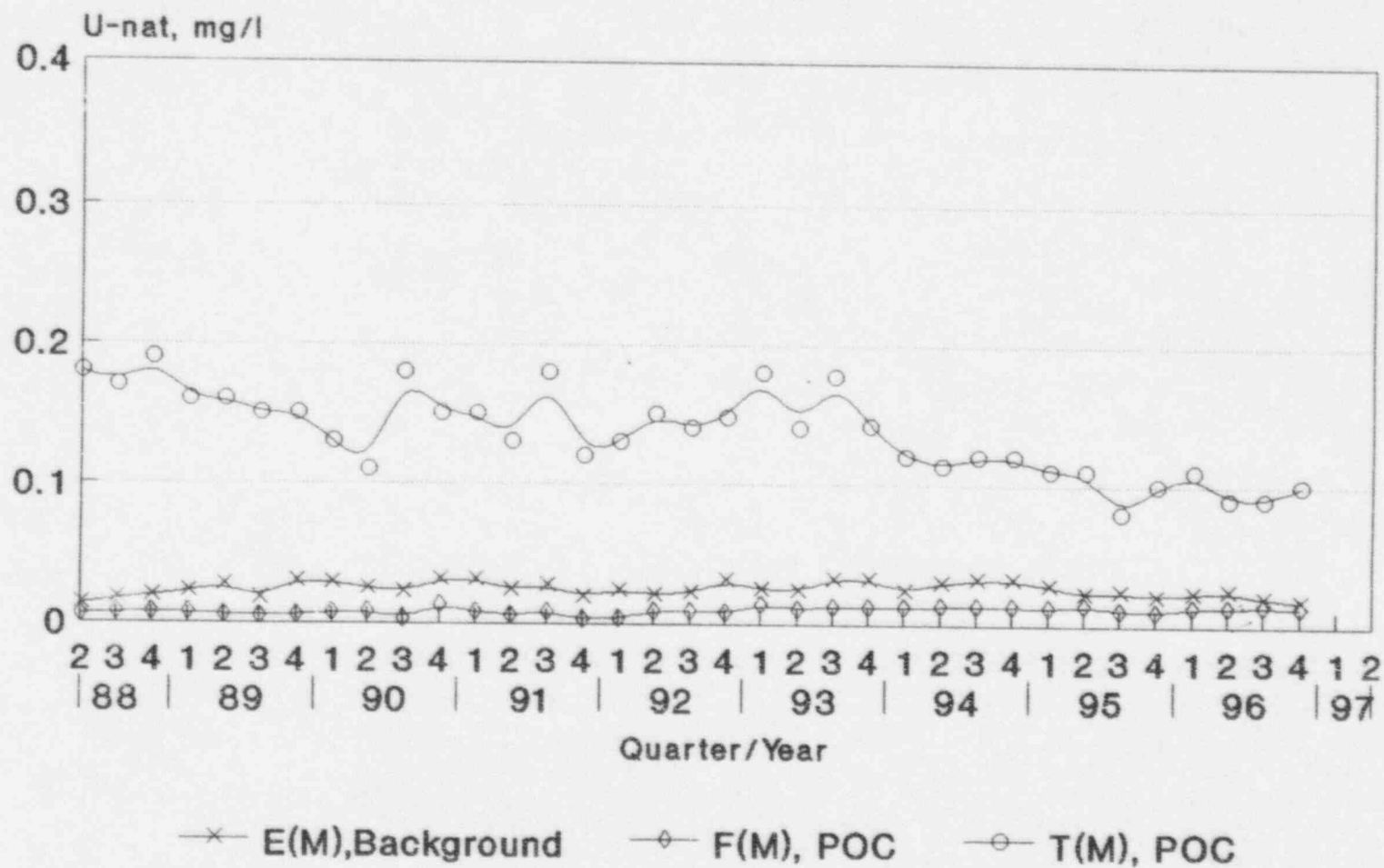
ARCO  
BLUEWATER MILL

Ground Water Monitoring Results

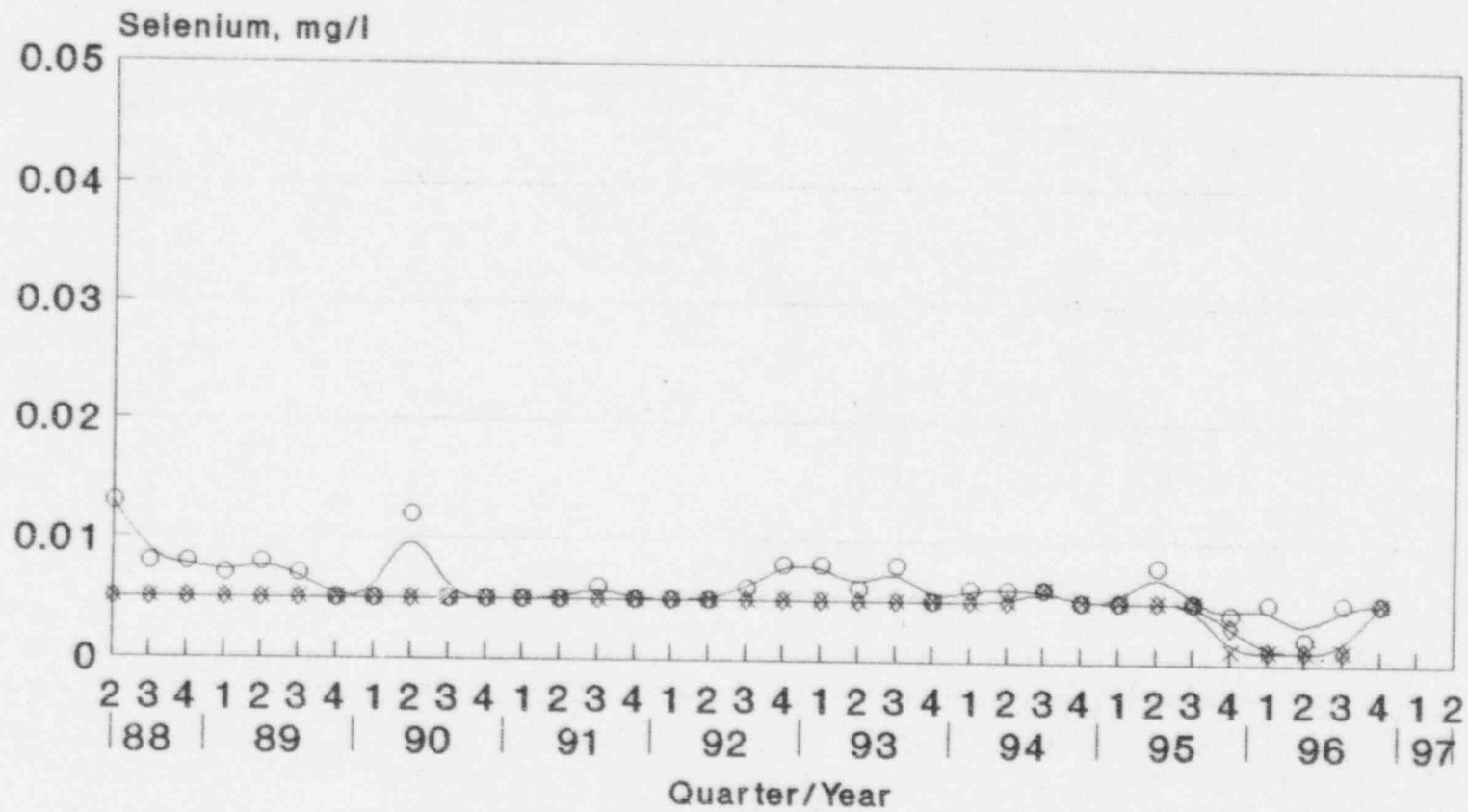
Well Description: T(M), Alluvial Aquifer

Sample Date	pH	Water level Elevation feet	U-nat mg/l	Selenium mg/l	Molybdenum mg/l
=====	=====	=====	=====	=====	=====
06/14/88	7.16	6493.85	0.18	0.013	0.027
09/07/88	7.46	6494.80	0.17	0.008	0.019
12/06/88	7.24	6494.92	0.19	0.008	0.027
03/07/89	7.19	6494.42	0.16	0.007	0.033
06/15/89	7.00	6493.72	0.16	0.008	0.034
09/20/89	7.07	6493.59	0.15	0.007	0.032
12/18/89	7.10	6486.83	0.15	< 0.005	0.045
03/14/90	7.01	6492.32	0.13	0.005	0.025
05/24/90	7.01	6491.58	0.11	0.012	0.034
07/11/90	7.08	6490.75	0.13	0.005	0.032
09/18/90	7.05	6489.95	0.18	0.005	0.028
10/01/90	7.02	6490.02	0.14	0.005	0.033
12/18/90	6.96	6489.40	0.15	< 0.005	0.034
01/09/91	6.95	6489.17	0.15	0.005	0.030
04/02/91	6.95	6488.38	0.13	0.005	0.037
07/10/91	7.21	6487.38	0.18	0.006	0.031
10/02/91	7.04	6487.30	0.12	< 0.005	0.033
01/16/92	6.99	6487.26	0.13	< 0.005	0.029
04/06/92	7.15	6486.89	0.15	0.005	0.029
07/20/92	7.10	6486.89	0.14	0.006	0.024
10/08/92	7.12	6486.89	0.15	0.008	0.030
01/12/93	7.02	6486.43	0.18	0.008	0.034
04/06/93	6.98	6486.27	0.14	0.006	0.030
07/07/93	7.06	6485.96	0.18	0.008	0.031
10/13/93	7.07	6487.29	0.14	< 0.005	0.031
01/05/94	7.04	6487.55	0.12	0.006	0.030
04/06/94	6.98	6486.27	0.14	0.006	0.030
07/06/94	7.20	6489.17	0.12	0.006	0.030
10/18/94	7.06	6490.74	0.12	< 0.005	0.038
01/17/95	6.96	6491.93	0.11	< 0.005	0.025
04/10/95	7.07	6491.41	0.11	0.008	0.026
07/17/95	7.19	6491.26	0.08	< 0.005	0.028
10/16/95	6.86	6492.23	0.10	0.004	0.026
01/15/96	7.05	6492.43	0.11	0.005	< 0.03
04/06/96	7.21	6492.03	0.09	0.002	< 0.03
07/03/96	7.42	6491.36	0.09	0.003	0.038
10/08/96	7.87	6490.80	0.10	0.006	0.032

# Bluewater Mill U-nat vs TIME Groundwater, Alluvial Aquifer



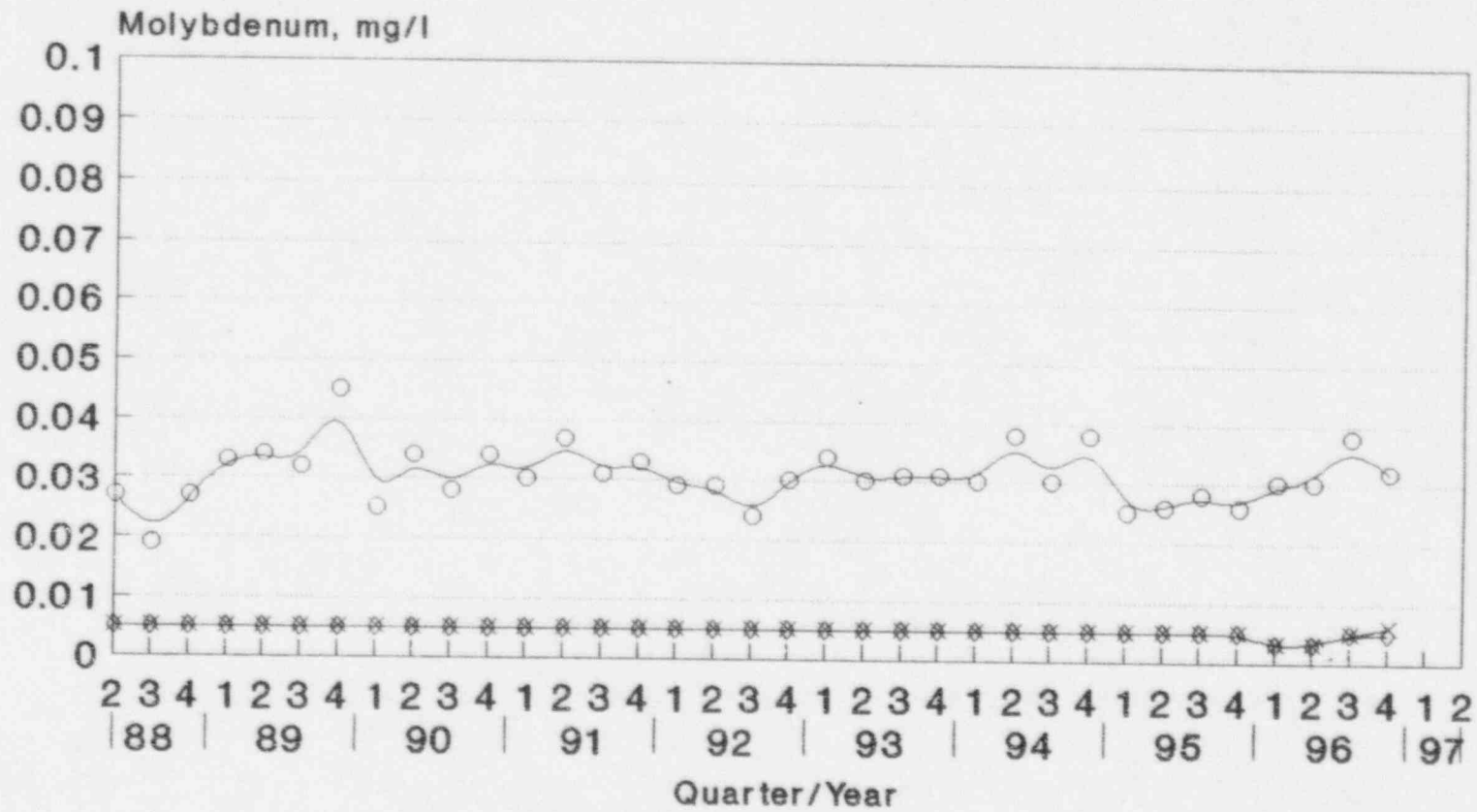
# Bluewater Mill Selenium vs TIME Groundwater, Alluvial Aquifer



# Bluewater Mill

## Molybdenum vs TIME

### Groundwater, Alluvial Aquifer



—x— E(M),Background    —◇— F(M), POC    —○— T(M), POC

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BLUEWATER MILL

Ground Water Monitoring Results

Well Description: L(SG), San Andres Aquifer

Sample Date =====	pH =====	Water level Elevation feet =====	U-nat mg/l =====	Selenium mg/l =====
06/14/88	6.97	6499.30	0.003	< 0.005
09/08/88	6.96	6500.81	0.005	< 0.005
12/08/88	6.96	6499.42	0.004	< 0.005
03/07/89	7.20	6497.61	0.004	< 0.005
06/15/89	6.88	6497.99	0.003	< 0.005
09/20/89	6.77	6496.21	0.002	< 0.005
12/18/89	6.60	6494.35	0.003	< 0.005
03/13/90	6.62	6493.20	0.002	< 0.005
04/10/90	6.73	6492.66	0.002	< 0.005
07/11/90	6.78	6488.98	0.003	< 0.005
09/18/90	6.75	6487.30	0.003	< 0.005
10/02/90	6.67	6487.87	0.002	< 0.005
12/18/90	6.79	6487.16	0.002	< 0.005
01/09/91	6.68	6487.16	0.002	< 0.005
04/03/91	6.56	6486.14	0.003	< 0.005
07/10/91	7.01	6488.46	0.002	< 0.005
10/02/91	6.96	6491.95	0.005	< 0.005
01/15/92	7.01	6490.11	0.001	< 0.005
04/08/92	6.85	6488.95	0.003	< 0.005
07/21/92	6.87	6490.39	0.003	< 0.005
10/08/92	6.86	6489.70	0.002	< 0.005
01/12/93	6.72	6488.57	0.003	< 0.005
04/05/93	6.84	6487.93	0.003	< 0.005
07/07/93	6.83	6488.27	0.004	< 0.005
10/05/93	6.90	6492.15	0.002	< 0.005
01/05/94	6.81	6491.65	0.003	< 0.005
04/05/94	6.84	6487.93	0.003	< 0.005
07/07/94	6.81	6493.80	0.002	< 0.005
10/13/94	6.72	6494.80	0.003	< 0.005
01/16/95	6.73	6493.57	0.002	< 0.005
04/10/95	6.70	6492.69	0.004	< 0.005
07/18/95	6.99	6496.69	0.002	< 0.005
10/18/95	6.73	6497.14	0.004	0.002
01/15/96	6.78	6494.78	0.003	< 0.001
04/03/96	6.76	6493.39	0.001	< 0.001
07/02/96	7.30	6494.12	0.003	< 0.001
10/09/96	7.08	6490.70	0.001	< 0.005

ARCO  
BLUEWATER MILL

Ground Water Monitoring Results

Well Description: S(SG), San Andres Aquifer

Sample Date =====	pH =====	Water level Elevation feet =====	U-nat mg/l =====	Selenium mg/l =====
06/14/88	6.95	6481.89	1.70	0.012
09/08/88	6.91	6482.32	1.40	0.010
12/08/88	6.84	6483.10	1.70	0.012
03/07/89	6.79	6482.19	1.50	0.007
06/15/89	6.80	6481.34	1.60	0.011
09/21/89	6.82	6480.08	1.20	0.009
12/18/89	6.68	6478.95	1.60	0.007
03/14/90	6.66	6478.89	1.64	0.009
05/24/90	6.65	6477.84	1.30	0.005
07/11/90	6.72	6476.48	1.62	0.006
09/17/90	6.79	6475.25	1.15	0.007
10/01/90	6.66	6474.99	1.30	0.005
12/18/90	6.60	6475.14	1.77	< 0.005
01/10/91	6.66	6474.58	1.20	0.005
04/02/91	6.65	6473.92	1.48	< 0.010
07/09/91	7.03	6473.89	1.40	< 0.010
10/02/91	6.93	6475.51	1.30	0.005
01/15/92	6.82	6475.39	0.98	< 0.005
04/06/92	6.86	6474.79	1.20	0.006
07/20/92	6.86	6475.10	1.39	0.006
10/06/92	6.83	6474.56	1.40	0.010
01/12/93	6.82	6474.02	1.20	0.012
04/08/93	6.90	6473.57	1.03	0.010
07/07/93	6.89	6474.01	1.20	0.009
10/06/93	6.88	6474.89	1.29	0.011
01/05/94	6.80	6475.57	1.45	<0.005
04/08/94	6.90	6473.57	1.03	0.008
07/06/94	6.79	6477.65	1.32	0.016
10/11/94	6.76	6477.06	1.40	0.005
01/14/95	6.81	6477.42	1.09	0.014
04/10/95	6.85	6476.54	0.96	0.013
07/18/95	6.90	6477.57	1.27	0.015
10/16/95	6.97	6479.30	1.15	0.016
01/16/96	7.00	6479.23	1.20	0.014
04/02/96	7.02	6478.26	1.05	0.013
07/02/96	7.21	6477.44	1.07	0.010
10/09/96	7.12	6476.03	1.01	0.013

ARCO  
BLUEWATER MILL

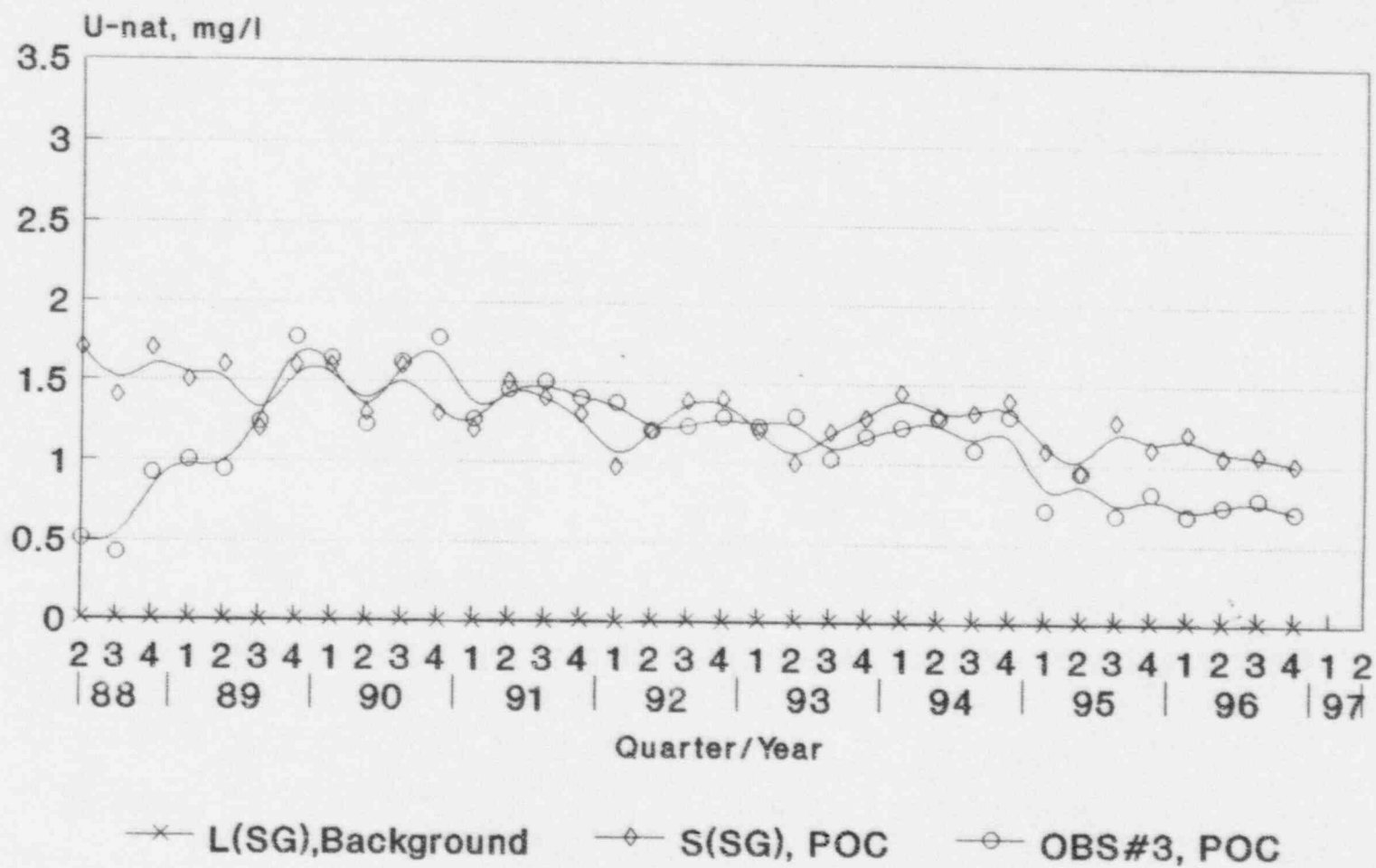
Ground Water Monitoring Results

Well Description: OBS#3, San Andres Aquifer

Sample Date =====	pH =====	Water level Elevation feet =====	U-nat mg/l =====	Selenium mg/l =====
06/14/88	7.11	6481.50	0.51	< 0.008
09/08/88	6.95	6482.81	0.42	0.010
12/08/88	6.94	6482.61	0.92	0.010
03/07/89	6.88	6482.61	1.00	0.011
06/15/89	6.67	6481.40	0.94	0.011
09/21/89	6.64	6479.53	1.24	0.020
12/19/89	6.44	6397.24	1.77	0.010
03/14/90	6.54	6478.33	1.64	0.014
05/24/90	6.66	6477.37	1.23	0.008
07/12/90	6.67	6476.69	1.62	0.008
09/18/90	6.77	6474.70	1.26	0.011
10/02/90	6.66	6474.52	1.77	0.010
12/18/90	6.60	6474.30	1.43	< 0.005
01/10/91	6.68	6474.07	1.26	0.011
04/02/91	6.67	6473.33	1.45	0.016
07/09/91	6.91	6473.29	1.50	< 0.010
10/02/91	6.69	6474.80	1.40	0.006
01/20/92	6.80	6474.81	1.38	< 0.005
04/07/92	6.85	6474.25	1.20	0.007
07/20/92	6.87	6473.90	1.23	0.007
10/19/92	6.77	6473.77	1.29	0.010
02/12/93	6.68	6473.30	1.23	0.005
04/12/93	6.84	6473.15	1.29	0.016
07/07/93	6.85	6473.33	1.03	0.014
10/13/93	6.78	6474.16	1.17	0.010
01/05/94	6.78	6474.93	1.23	<0.005
04/12/94	6.84	6473.15	1.29	0.016
07/06/94	6.98	6475.13	1.09	0.020
10/11/94	6.94	6476.62	1.30	0.018
01/16/95	6.90	6476.84	0.72	0.013
04/18/95	6.76	6476.06	0.95	0.014
07/18/95	7.05	6477.11	0.69	0.010
10/23/95	6.84	6478.73	0.83	0.017
01/15/96	7.15	6478.13	0.69	0.012
04/02/96	6.93	6477.86	0.75	0.011
07/02/96	7.31	6476.96	0.79	0.012
10/09/96	6.98	6475.69	0.71	0.015

# Bluewater Mill

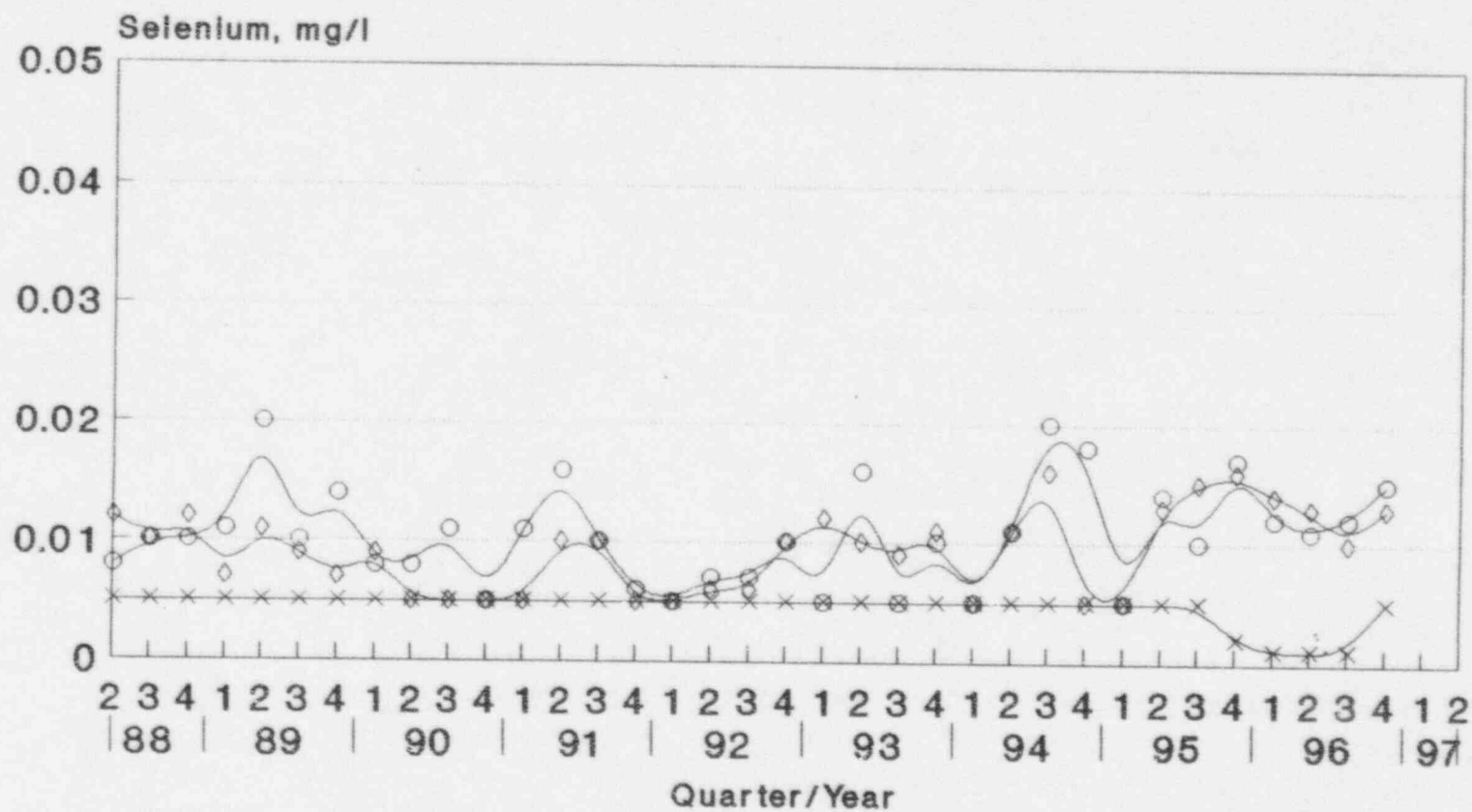
U-nat vs TIME  
Groundwater, San Andres Aquifer



# Bluewater Mill

## Selenium vs TIME

### Groundwater, San Andres Aquifer



—x— L(SG),Background      —◇— S(SG), POC      —○— OBS#3, POC