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APPENDIX D
(1/16/79, Exhibit 2)

PRELIMINARY TREATMENT

of

BASELINE DEFINITION AND EXCURSION DETECTION

by

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1.0 SUMMARY

In this paper we have given preliminary arguments for a method of defining baseline concentrations and their precisions for various parameters in well waters associated with in-situ mining sites. We have then determined procedures for establishing relative concentration levels above the mean which are probable indicators of true excursions from baseline concentrations. We have then listed the parameters most likely to give early indication of true excursion. Finally, we have applied these criteria to the determination of baseline parameters and alarm levels at the Collins Draw site.

2.0 INTRODUCTION

The definitions of baseline and excursion were once thought to be a straight forward process. Baseline would be defined by calculating the mean for each parameter or analyte and a 10% increase was suggested as an indicator of excursion. From experience we have learned that natural fluctuations are oftentimes greater than 10%. This is due to natural groundwater variations in composition as well as the error involved in chemical analysis. Moreover, composition and degree of fluctuation will vary considerably for each aquifer. It is the purpose of this study to devise an excursion criterion which accounts for the natural variability and yet would still allow one to assert with a high degree of reliability that an excursion had indeed occurred. We will also select key parameters or indicators to use in monitoring excursion.

Our attention will be confined to the small research and development patterns (on the order of 1 acre) used in Wyoming. In this situation, two approaches might be used. First, one might proceed to determine the spatial variation in composition, considering the wells to be independent or isolated from each other. In this method a composition would be determined for each monitor well prior to the onset of mining. Appreciable positive deviation of an individual well after mining has

begun would be termed an excursion.

In reality, monitor wells are unlikely to be independent over such a small area prior to mining. Certainly considerable mixing of water will occur in the area after mining has begun. This is due to influx from a bleed stream, as well as hydrologic pressure gradients imposed by the wellfield. These stresses can cause solutions to migrate radially inward as well as laterally. Hence it appears more reasonable to consider a second approach in which the wells are viewed as samples of one localized aquifer water. After sampling, mean values for each parameter can be calculated by averaging, and fluctuations of each sample about the mean can be observed and characterized by their standard deviations. The theory for this is developed in the next section.

3.0 THEORY

In determining whether or not the water quality of a particular aquifer has been adversely affected by mining, two basic considerations are necessary:

1) For each parameter, a "mean baseline" concentration must be established prior to any mining disturbance.

2) For each parameter a concentration level needs to be determined which indicates with a high probability that the quality of the water has deteriorated subsequent to the onset of mining.

As previously discussed, we assume that we are sampling one body of water. Each parameter possesses a mean value across the body of water. The dispersion or spread about the mean is due either to measurement error or to some spatial distribution of concentration (or to fluctuations in composition with time). The variability in values of concentration will be assumed to be adequately approximated by a normal distribution.

Let us begin by assuming that prior to mining, n wells have been sampled resulting in a total of N individual water samples. The value of N is to some extent arbitrary. However, we will assume that it is sufficiently large to provide a good approximation to the mean and standard deviation. The precision can be checked by calculating the sample mean and standard deviation and in turn

calculating the standard deviation or possible error in the calculated mean.

For each parameter analyzed, the mean μ and standard deviation σ may be computed by the use of standard statistical formulas which are commonly available in many reference books. Once these quantities have been computed, an estimate of percentage error is found from using the standard deviation of the sample mean (Mendenhall p. 175)

$$\% \text{ error} = \frac{\sigma}{\mu\sqrt{N}} \times 100\%. \qquad (1)$$

Or in words we divide the standard deviation by the mean and the square root of the total number of samples and multiply by 100%.

In the above discussion we do not distinguish between true sample means, standard deviations and their estimates. This is because a good approximation of their true values is obtained from their estimates whenever N is greater than 30 (Mendenhall, p. 175, Speigel, p. 117).

Using the calculated statistical values for each parameter we must now arrive at a deviation criterion for signaling an excursion. The criterion will be based on the well established confidence limit techniques commonly used in quality control.

4.0 CONFIDENCE LIMIT FOR EXCURSION DETECTION

To set a confidence limit to detect excursion we must first recognize that we are only interested in increase in concentration, not decrease. If, for example, we are interested in the 90% confidence level, we must find the value which corresponds to 80% of the total area under the normal distribution. This is because confidence levels are usually expressed in terms of the mean plus or minus a multiple of the standard deviation. Ten percent of the area lies above and 10% lies below the given range. Hence a 90% confidence level implies that 10% of the measurements will lie outside the range. Five percent will be high while 5% will lie at the low end. Since we are interested in increased concentrations we must find the value which corresponds to

$$2 \times P - 100\% \qquad (2)$$

in the normal probability tables. In the above equation P is the percentage of samples that will fall below a given level. For example, by referring to a table of the normal distribution a value of P = 90% means that on a purely statistical basis 9 out of 10 samples from a given well will be less than the mean value plus 1.28 times the standard deviation. In other words if the mean value were 10 ppm and the standard deviation 2 ppm then

9 out of 10 concentration measurements for a substance sampled in a well would lie below

$$10 \text{ ppm} + 1.28 \times 2 \text{ ppm} = 12.6 \text{ ppm}.$$

One out of ten would be higher. Our intent is to select a confidence interval which considers the number of sample taken and insures to a high degree of probability that the measured value is not due to random chance but instead is the result of an excursion. In such a case one would then monitor the situation more frequently to see if a trend toward increased values was developing and take preventive measures.

Our purpose is to avoid false alarms and the attendent frequent sampling. This is because frequent unnecessary pumping may in itself draw solutions from the mined area and cause a needless excursion.

Table 1 gives the multiple of the standard deviation for a given confidence level. When it is multiplied by the standard deviation of an individual sample and added to the mean it results in the maximum tolerance. Greater values would signal more frequent sampling to begin to determine if an excursion trend were developing.

TABLE 1 STANDARD DEVIATION MULTIPLIER AS A FUNCTION OF CONFIDENCE LEVEL

Confidence Level	Multiple of Standard Deviation
80%	.84
90%	1.28
95%	1.65
98%	2.05
99%	2.33
99.5%	2.58
99.9%	3.08

If the project life is taken to be 2 years and sampling performed on the order of once or twice a month, then approximately 24 to 48 samples will be taken from a given well. If a 90% confidence level were selected then on a purely random basis a given well would be expected to trigger approximately 2 to 5 false excursion mode alarms. This would be expected even if no solution were injected! A 95% confidence level would be expected to trigger 1 - 2 false alarms while a 99% confidence level would be expected to trigger at most .5 (or less than one) false alarm.

Now if four monitor wells were used then we have a possible total of 96 to 192 samples. Thus at the low end a 99% confidence level would insure that out of 96 samples only 1% or approximately one of the samples would have a statistical chance of being higher and hence giving

rise to a false alarm. At the high end a 99.5% confidence interval would yield the same result. Under these conditions we would choose a confidence limit of 99.5% which from Table 1 results in a multiplier of 2.58. Therefore, all values lying in excess of the mean value plus 2.58 times the standard deviation for a given parameter would be termed an excursion.

5.0 BASELINE MEANS AND STANDARD DEVIATION FOR THE COLLINS DRAW SITE

Fourteen wells at the Collins Draw site were sampled over a period of time to give from 31 to 52 values for each analyzed parameter. Selected baseline parameters are listed in Table 2. These were compiled from the more complete set of baseline values given in Table 3. The parameters given in Table 2 were chosen on the basis of their importance and significance during the solution mining process.

All parameters have low percentage error estimates for the sample means with the exception of the highly variable iron, uranium and radium. It is doubtful that these errors could be reduced significantly since by Eq. 1 the error declines inversely as the square root of the sample number. To achieve error estimates below 10% for these quantities approximately 1000 sample analyses would have to be done for iron, uranium and radium. The small gain in accuracy does not appear to be warranted by the prohibitive cost of analyzing the large number of samples.

Table 2 also lists the relative levels above the mean (Relative Alarm Levels) and the absolute concentration levels (Absolute Alarm Levels) which are recommended as probable alarm indicators for the various individual parameters. Note that for each parameter, the 99% alarm would have been sounded at least once for the 44 samples analyzed.

6.0 EXCURSION PARAMETERS AND VALUES

In choosing parameters to detect excursion, indicators should be selected which are highly mobile and at the same time directly related to the process used. The criterion of high mobility implies that anions should be used instead of cations. This is due to the fact that anions have in general a factor of 10 less absorption capacity or affinity for the clay matrix in the formation. This implies further that anions will travel more closely with the fluid as an ideal tracer. Uranium, complexed by carbonates, will also be highly mobile.

Thus, the parameters most likely to give early indication of excursion from baseline in systems using carbonate extracting solutions are uranium, carbonate alkalinity, sulfate, and conductivity.

TABLE 2 SIGNIFICANT BASELINE PARAMETERS

Parameter	Units	No. (N) Measurements	Average(μ)	σ	% RSD(σ/μ x 100)	% Error Estimate	Alarm Levels Relative* 99%	Relative* 99.5%	Absolute 99%	Absolute 99.5%
Alkalinity(Bicarb)	ppm	44	166	31	18.6%	2.8%	43.3%	48.0%	238	246
Sulfate	ppm	44	149	80	53.7%	8.1%	125%	139%	335	356
Conductivity(Lab)	μMhos	45	628	149	23.7%	3.6%	55.3%	61.1%	975	1012
Conductivity(field)	μMhos	51	1295	629	48.6%	6.7%	113%	125%	2758	2914
Total Dissolved Solids	ppm	44	419	115	27.4%	4.1%	63.9%	70.7%	687	715
Sodium	ppm	44	108	31	28.7%	4.4%	66.9%	74.0%	180	188
Calcium	ppm	44	29	11	36.2%	5.5%	84.3%	93.4%	53	56
pH (Lab)	-	44	8.19	0.36	4.4%	0.7%	10.2%	11.3%	9.03	9.12
pH (field)	-	52	7.72	0.65	8.4%	1.2%	19.6%	21.7%	9.23	9.40
Iron	ppm	27	0.62	0.83	134%	25.8%	312%	345%	2.55	2.76
Radium	pCi/L	31	12.5	23.5	188%	33.7%	438%	485%	67	73
Uranium	ppm	39	0.084	0.16	191%	30.9%	443%	491%	0.46	0.50

* above baseline

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 139W

Date Sampled	5/25/78	6/9/78	6/23/78	7/10/78	7/25/78	
Date Assay Received	6/26/78	6/26/78	7/25/78	8/14/78	8/28/78	
Parameter mg/l						
Total Dissolved Solids (calc.)	360	357	376	342	334	
Total Dissolved Solids (105°C)	416	392	338	320	348	
Conductivity 77°F µMohs (lab)	625	605	555	555	490	
Conductivity µMohs (field)	1000	1280	1050	1500	550	
Sodium (calc.)	97	97	106	89	94	
Sodium (observed)	96	99	82	98	89	
Potassium	7	8	5	6	6	
Calcium	26	25	24	25	21	
Magnesium	2	1	2	3	3	
Sulfate	135	138	143	135	114	
Chloride	12	10	12	12	12	
Carbonate	12	0	24	0	36	
BiCarbonate	140	159	122	146	98	
pH, unit (lab)	8.3	8.1	8.5	8.1	8.7	
pH, unit (field)	7.8	7.4	8.0	8.5	6.0	
Ammonia (as N)	0.12	0.11	0.12	0.28	0.13	
Nitrate (as N)	ND	ND	ND	1.16	ND	
Nitrite (as N)	ND	0.02	ND	0.07	ND	
Aluminum	ND	ND	ND	ND	ND	
Arsenic	ND	ND	-	ND	ND	
Barium	ND	ND	ND	ND	ND	
Boron	ND	ND	ND	ND	ND	
Cadmium	ND	ND	ND	ND	ND	
Chromium	ND	ND	ND	ND	ND	
Copper	ND	ND	ND	ND	ND	
Fluoride	0.18	0.17	0.16	0.12	0.12	
Iron	0.72	ND	0.38	.64	0.68	
Lead	ND	ND	ND	ND	ND	
Manganese	0.03	ND	0.03	.04	ND	
Mercury	ND	ND	ND	ND	.02	
Selenium	ND	ND	-	ND	ND	
Nickel	ND	ND	ND	ND	ND	
Zinc	0.01	ND	ND	ND	ND	
Molybdenum	ND	ND	ND	ND	ND	
Vanadium	ND	ND	ND	ND	ND	
Uranium	0.024		0.006	.011	ND	
Radium 226 pCi/l	25.3 ± .9	0.16 ± .10	.61 ± .15		16.0 ± .3	
Temperature Field °C		12.	13.5	15.	13.5	

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 146W

Date Sampled	5/25/78	6/9/78	6/23/78	7/11/78	7/25/78	
Date Assay Received	6/26/78	6/26/78	7/25/78	8/14/78	8/28/78	
Parameter mg/l						
Total Dissolved Solids (calc.)	343	376	376	347	359	
Total Dissolved Solids (105°C)	416	396	355	361	348	
Conductivity 77°F µMohs (lab)	625	666	580	570	510	
Conductivity µMohs (field)	1090	1250	1320	1020	600	
Sodium (calc.)	91	101	102	90	96	
Sodium (observed)	92	99	89	103	91	
Potassium	7	7	6	7	6	
Calcium	27	26	27	27	26	
Magnesium	2	2	2	2	5	
Sulfate	120	152	143	135	114	
Chloride	12	10	12	14	16	
Carbonate	12	12	12	0	36	
BiCarbonate	146	134	146	146	122	
pH, unit (lab)	8.3	8.3	8.3	8.1	8.5	
pH, unit (field)	7.4	7.2	8.2	8.7	7.5	
Ammonia (as N)	0.09	0.32	0.42	.01	ND	
Nitrate (as N)	ND	0.46	ND	ND	ND	
Nitrite (as N)	ND	0.01	ND	.08	ND	
Aluminum	0.20	ND	ND	ND	ND	
Arsenic	0.016	ND	-	ND	ND	
Barium	ND	ND	ND	ND	ND	
Boron	ND	ND	ND	ND	ND	
Cadmium	ND	ND	ND	ND	ND	
Chromium	ND	ND	ND	ND	ND	
Copper	ND	ND	ND	ND	ND	
Fluoride	0.20	0.18	0.18	.14	.14	
Iron	1.02	ND	0.05	.80	1.18	
Lead	ND	ND	ND	ND	ND	
Manganese	0.02	ND	.01	.02	0.02	
Mercury	ND	ND	ND	ND	ND	
Selenium	ND	ND	-	ND	ND	
Nickel	ND	ND	ND	ND	ND	
Zinc	ND	ND	ND	ND	ND	
Molybdenum	ND	ND	ND	ND	ND	
Vanadium	ND	ND	ND	ND	ND	
Uranium	0.790		0.067	.052	0.012	
Radium 226 pCi/l	99.0 ± 1.8	.19 ± .12	5.11 ± .44		46.7 ± .3	
Temperature Field °C		16.	14	15.	13.5	

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 191W

Date Sampled	5/31/78	6/21/78	7/10/78	7/26/78		
Date Assay Received	7/24/78	7/28/78	8/14/78			
Parameter mg/l						
Total Dissolved Solids (calc.)	1011	570	455			
Total Dissolved Solids (105°C)	1031	602	500			
Conductivity 77°F µMohs (lab)	1410	835	715			
Conductivity µMohs (field)	3100	1600	2100	920		
Sodium (calc.)	242	150	122			
Sodium (observed)	272	139	141			
Potassium	14	7	7			
Calcium	61	38	27			
Magnesium	14	5	4			
Sulfate	598	258	205			
Chloride	22	16	18			
Carbonate	12	24	0			
BiCarbonate	98	146	146			
pH, unit (lab)	8.1	8.6	8.1			
pH, unit (field)	7.9	8.3	7.7	8.5		
Ammonia (as N)	0.05	0.03	.15			
Nitrate (as N)	ND	ND	ND			
Nitrite (as N)	0.03	ND	.09			
Aluminum	0.15	ND	ND			
Arsenic	0.01	ND	ND			
Barium	ND	ND	ND			
Boron	ND	ND	ND			
Cadmium	ND	ND	ND			
Chromium	ND	ND	ND			
Copper	ND	ND	ND			
Fluoride	0.14	0.27	.14			
Iron	2.38	0.24	1.10			
Lead	ND	ND	ND			
Manganese	0.03	ND	0.03			
Mercury	ND	ND	ND			
Selenium	ND	ND	ND			
Nickel	ND	ND	ND			
Zinc	ND	ND	ND			
Molybdenum	ND	ND	ND			
Vanadium	ND	ND	ND			
Uranium	.005	.005	.033			
Radium 226 pCi/l		9.62 ± .68				
Temperature Field °C		13.	11.5	14		

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 230W

Date Sampled	6/20/78	7/7/78	7/25/78			
Date Assay Received	7/25/78	8/14/78	8/28/78			
Parameter mg/l						
Total Dissolved Solids (calc.)	515	653	460			
Total Dissolved Solids (105°C)	508	626	498			
Conductivity 77°F µMohs (lab)	820	710	700			
Conductivity µMohs (field)	1820	2200	800			
Sodium (calc.)	131	192	105			
Sodium (observed)	135	187	119			
Potassium	7	7	7			
Calcium	30	39	42			
Magnesium	8	2	6			
Sulfate	12	245	210			
Chloride	255	12	12			
Carbonate	0	0	0			
BiCarbonate	146	317	159			
pH, unit (lab)	8.1	7.8	8.0			
pH, unit (field)	7.6	7.4	meter B/O			
Ammonia (as N)	0.22	0.32	0.46			
Nitrate (as N)	ND	0.02	ND			
Nitrite (as N)	ND	0.12	0.06			
Aluminum	ND	ND	ND			
Arsenic	ND	.024	ND			
Barium	ND	ND	ND			
Boron	ND	ND	ND			
Cadmium	ND	ND	ND			
Chromium	ND	ND	ND			
Copper	ND	.01	ND			
Fluoride	0.21	.11	0.08			
Iron	ND	2.50	3.20			
Lead	ND	ND	ND			
Manganese	ND	.03	0.06			
Mercury	ND	ND	ND			
Selenium	ND	.016	0.12			
Nickel	ND	ND	ND			
Zinc	ND	.01	ND			
Molybdenum	ND	ND	ND			
Vanadium	ND	ND	ND			
Uranium	0.060	.020	0.012			
Radium 226 pCi/l	9.31 ± .56	1.9 ± .28	2.1 ± .3			
Temperature Field °C	14	14.5	14			

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 231W

Date Sampled	6/1/78	6/21/78	7/10/78	7/26/78		
Date Assay Received	6/27/78	7/28/78	8/14/78			
Parameter mg/l						
Total Dissolved Solids (calc.)	347	405	370			
Total Dissolved Solids (105°C)	414	402	380			
Conductivity 77°F µMohs (lab)	625	550	590			
Conductivity µMohs (field)	1310	1120	1700	780		
Sodium (calc.)	90	112	99			
Sodium (observed)	88	99	102			
Potassium	5	6	6			
Calcium	31	29	29			
Magnesium	1	1	1			
Sulfate	128	155	145			
Chloride	14	12	12			
Carbonate	0	24	0			
BiCarbonate	159	135	159			
pH, unit (lab)	8.1	8.4	7.8			
pH, unit (field)	7.2	7.1	8.1	6.5		
Ammonia (as N)	0.06	0.05	0.15			
Nitrate (as N)	.10	ND	.06			
Nitrite (as N)	.01	ND	.11			
Aluminum	ND	ND	ND			
Arsenic	ND	ND	ND			
Barium	ND	ND	ND			
Boron	ND	ND	ND			
Cadmium	ND	ND	ND			
Chromium	ND	ND	ND			
Copper	ND	ND	ND			
Fluoride	0.13	0.026	.14			
Iron	0.14	ND	.16			
Lead	ND	ND	ND			
Manganese	0.01	0.01	.01			
Mercury	ND	ND	ND			
Selenium	ND	ND	ND			
Nickel	ND	ND	ND			
Zinc	0.02	ND	ND			
Molybdenum	ND	ND	ND			
Vanadium	ND	ND	ND			
Uranium		.027	.047			
Radium 226 pCi/l	13.7 ± .8	7.25 ± .56				
Temperature Field °C	13	15	14	14		

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 232W

Date Sampled	6/2/78	6/21/78	7/10/78	7/26/78		
Date Assay Received	7/24/78	7/28/78				
Parameter mg/l						
Total Dissolved Solids (calc.)	357	389	367			
Total Dissolved Solids (105°C)	386	406	414			
Conductivity 77°F µMohs (lab)	570	575	590			
Conductivity µMohs (field)	1200	1320	1720	2550		
Sodium (calc,)	102	111	101			
Sodium (observed)	111	102	106			
Potassium	13	9	9			
Calcium	15	19	21			
Magnesium	1	2	2			
Sulfate	140	158	148			
Chloride	32	24	20			
Carbonate	12	12	0			
BiCarbonate	85	110	134			
pH, unit (lab)	8.5	8.4	7:5			
pH, unit (field)	8.0	8.1	7:4	7:3		
Ammonia (as N)	0.04	0.05	.12			
Nitrate (as N)	ND	ND	ND			
Nitrite (as N)	0.01	ND	.13			
Aluminum	ND	ND	ND			
Arsenic	0.02	ND	ND			
Barium	ND	ND	ND			
Boron	ND	ND	ND			
Cadmium	ND	ND	ND			
Chromium	ND	ND	ND			
Copper	ND	ND	ND			
Fluoride	0.12	0.26	.17			
Iron	ND	ND	.26			
Lead	ND	ND	ND			
Manganese	ND	ND	ND			
Mercury	ND	ND	ND			
Selenium	ND	ND	ND			
Nickel	ND	ND	ND			
Zinc	ND	ND	ND			
Molybdenum	ND	ND	ND			
Vanadium	ND	ND	ND			
Uranium	0.003	.014	.033			
Radium 226 pCi/l	.26 ± .14	7.02 ± .53				
Temperature Field °C	16.5	14	15	14		

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 233W

Date Sampled	5/26/78	6/20/78	7/6/78	7/26/78		
Date Assay Received	6/25/78	7/25/78	8/14/78			
Parameter mg/l						
Total Dissolved Solids (calc.)	361	376	363			
Total Dissolved Solids (105°C)	422	392	388			
Conductivity 77°F µMohs (lab)	570	570	555			
Conductivity µMohs (field)	980	1820	1700	3700		
Sodium (calc.)	97	99	99			
Sodium (observed)	97	99	100			
Potassium	7	6	4			
Calcium	28	29	29			
Magnesium	1	1	1			
Sulfate	132	155	134			
Chloride	12	14	12			
Carbonate	0	0	0			
BiCarbonate	171	146	171			
pH, unit (lab)	8.0	8.1	7.9			
pH, unit (field)	7.7	7.6	7.3	7.1		
Ammonia (as N)	0.06	0.07	0.06			
Nitrate (as N)	ND	ND	.16			
Nitrite (as N)	0.03	ND	ND			
Aluminum	0.11	ND	ND			
Arsenic	ND	ND	ND			
Barium	ND	ND	ND			
Boron	ND	ND	ND			
Cadmium	ND	ND	ND			
Chromium	ND	ND	ND			
Copper	ND	ND	ND			
Fluoride	0.19	.26	.15			
Iron	0.34	ND	ND			
Lead	ND	ND	ND			
Manganese	0.01	ND	ND			
Mercury	ND	ND	ND			
Selenium	ND	ND	ND			
Nickel	ND	ND	ND			
Zinc	0.01	ND	.01			
Molybdenum	ND	ND	ND			
Vanadium	ND	ND	ND			
Uranium	.040	.060	.032			
Radium 226 pCi/l	86.9 ± 1.6	7.37 ± .58	.71 ± .17			
Temperature Field °C	13	14	15	13.5		

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 234W

Date Sampled	6/21/78	7/6/78	7/25/78	5/31/78		
Date Assay Received	7/28/78	8/14/78	8/28/78	7/24/78		
Parameter mg/l						
Total Dissolved Solids (calc.)	378	353	329	345		
Total Dissolved Solids (105°C)	436	392	343	382		
Conductivity 77°F µMohs (lab)	575	550	520	555		
Conductivity µMohs (field)	1180	1580	500	910		
Sodium (calc.)	101	94	83	90		
Sodium (observed)	96	107	85	101		
Potassium	6	5	6	7		
Calcium	27	28	31	27		
Magnesium	3	2	1	1		
Sulfate	145	130	118	138		
Chloride	12	16	12	10		
Carbonate	12	0	0	0		
BiCarbonate	146	159	159	146		
pH, unit (lab)	8.5	7.8	7.9	8.1		
pH, unit (field)	7.5	7.8	7.4	7.4		
Ammonia (as N)	0.08	.08	0.13	0.07		
Nitrate (as N)	ND	ND	ND	ND		
Nitrite (as N)	0.06	ND	ND	0.01		
Aluminum	ND	ND	ND	0.09		
Arsenic	ND	ND	ND	0.01		
Barium	ND	ND	ND	ND		
Boron	ND	ND	ND	ND		
Cadmium	ND	ND	ND	ND		
Chromium	ND	ND	ND	ND		
Copper	ND	ND	ND	ND		
Fluoride	0.26	.18	0.13	0.17		
Iron	.01	ND	0.07	0.16		
Lead	ND	ND	ND	ND		
Manganese	ND	ND	0.01	0.01		
Mercury	ND	ND	ND	ND		
Selenium	ND	ND	ND	ND		
Nickel	ND	ND	ND	ND		
Zinc	ND	ND	ND	ND		
Molybdenum	ND	ND	ND	ND		
Vanadium	ND	ND	ND	ND		
Uranium	.041	.030	.046	.039		
Radium 226 pCi/l	5.67 ± .45	10.2 ± .8	15.1 ± .3			
Temperature Field °C	13.5	15.	14.	13.		

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 237W

Date Sampled	6/23/78	7/11/78	7/28/78			
Date Assay Received	7/25/78	8/14/78				
Parameter mg/l						
Total Dissolved Solids (calc.)	344	312				
Total Dissolved Solids (105°C)	340	313				
Conductivity 77°F µMohs (lab)	570	526				
Conductivity µMohs (field)	1400	1000	500			
Sodium (calc.)	110	101				
Sodium (observed)	82	98				
Potassium	13	8				
Calcium	10	12				
Magnesium	2	1				
Sulfate	67	68				
Chloride	64	38				
Carbonate	36	24				
BiCarbonate	85	122				
pH, unit (lab)	9.4	8.5				
pH, unit (field)	9.2	9.2	8.8			
Ammonia (as N)	0.39	0.03				
Nitrate (as N)	0.50	0.61				
Nitrite (as N)	0.09	0.38				
Aluminum	ND	ND				
Arsenic						
Barium	ND	ND				
Boron	ND	ND				
Cadmium	ND	ND				
Chromium	ND	ND				
Copper	ND	ND				
Fluoride	0.39	.33				
Iron	ND	ND .12				
Lead	ND	ND				
Manganese	ND	ND				
Mercury	ND	ND				
Selenium		ND				
Nickel	ND	ND				
Zinc	ND	ND				
Molybdenum	ND	ND				
Vanadium	ND	ND				
Uranium	0.020	.027				
Radium 226 pCi/l	.77 ± .18					
Temperature Field °C	18	12	14.			

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 238W

Date Sampled	6/2/78	6/22/78	7/12/78	7/31/78		
Date Assay Received	7/24/78	7/24/78	8/14/78			
Parameter mg/l						
Total Dissolved Solids (calc.)	367	356	360			
Total Dissolved Solids (105°C)	391	320	350			
Conductivity 77°F µMohs (lab)	555	555	555			
Conductivity µMohs (field)	1090	1200	820	600		
Sodium (calc.)	105	100	99			
Sodium (observed)	105	97	95			
Potassium	9	7	7			
Calcium	21	24	25			
Magnesium	1	0	0			
Sulfate	138	135	143			
Chloride	12	12	14			
Carbonate	24	12	0			
BiCarbonate	116	134	146			
pH, unit (lab)	8.6	8.5	8.0			
pH, unit (field)	8.0	7.9	8.5	8.4		
Ammonia (as N)	0.03	.36	.07			
Nitrate (as N)	0.51	ND	ND			
Nitrite (as N)	ND	ND	.15			
Aluminum	ND	ND	ND			
Arsenic	ND	ND	.01			
Barium	ND	ND	ND			
Boron	ND	ND	ND			
Cadmium	ND	ND	ND			
Chromium	ND	ND	ND			
Copper	0.02	ND	ND			
Fluoride	0.11	0.23	.10			
Iron	ND	ND	.07			
Lead	ND	ND	ND			
Manganese	ND	ND	ND			
Mercury	ND	ND	ND			
Selenium	ND	ND	ND			
Nickel	ND	ND	ND			
Zinc	ND	ND	ND			
Molybdenum	ND	ND	ND			
Vanadium	ND	ND	ND			
Uranium	0.45	.466	.406			
Radium 226 pCi/l	.15 ± .1	6.99 ± .51				
Temperature Field °C	15	13.	15.	15		

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 239W

Date Sampled	7/31/78	6/22/78	6/5/78	7/12/78		
Date Assay Received		7/24/78	7/24/78	8/14/78		
Parameter mg/l						
Total Dissolved Solids (calc.)		445	519	430		
Total Dissolved Solids (105°C)		440	494	446		
Conductivity 77°F µMohs (lab)		770	909	650		
Conductivity µMohs (field)	70?	1200	1790	1020		
Sodium (calc.)		98	120	98		
Sodium (observed)		106	112	99		
Potassium		8	9	8		
Calcium		52	61	50		
Magnesium		5	2	3		
Sulfate		130	155	125		
Chloride		56	64	50		
Carbonate		0	0	0		
BiCarbonate		195	220	195		
pH, unit (lab)		7.9	8.1	7.6		
pH, unit (field)	7.8	7.0	6.9	6.0		
Ammonia (as N)		0.14	.01	.04		
Nitrate (as N)		ND	ND	ND		
Nitrite (as N)		ND	.01	.23		
Aluminum		ND	ND	ND		
Arsenic		ND	.01	ND		
Barium		ND	ND	ND		
Boron		ND	ND	ND		
Cadmium		ND	ND	ND		
Chromium		ND	ND	ND		
Copper		ND	.01	ND		
Fluoride		0.25	.11	.14		
Iron		.04	ND	.19		
Lead		ND	ND	ND		
Manganese		.05	.06	.05		
Mercury		ND	ND	ND		
Selenium		ND	ND	ND		
Nickel		ND	ND	ND		
Zinc		ND	ND	ND		
Molybdenum		ND	ND	ND		
Vanadium		ND	ND	ND		
Uranium		.050	.061	.049		
Radium 226 pCi/l		5.03 ± .43	2.81 ± .31			
Temperature Field °C	13	14.5	13.5	15		

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 240W

Date Sampled	5/23/78	6/7/78	6/22/78	7/11/78	7/31/78	
Date Assay Received	6/26/78	6/27/78	7/24/78	8/14/78		
Parameter mg/l						
Total Dissolved Solids (calc.)	391	308	348	340		
Total Dissolved Solids (105°C)	430	442	344	378		
Conductivity 77°F µMohs (lab)	610	620	580	560		
Conductivity µMohs (field)	1009	1180	1050	980	600	
Sodium (calc.)	112	112	98	94		
Sodium (observed)	100	111	106	113		
Potassium	6	6	[illegible]	6		
Calcium	26	29	24	22		
Magnesium	0	2	1	2		
Sulfate	143	139	125	128		
Chloride	20	34	20	16		
Carbonate	12	12	0	0		
BiCarbonate	146	146	153	146		
pH, unit (lab)	8.2	8.2	8.1	7.2		
pH, unit (field)	7.6	7.4	7.7	7.8	8.0	
Ammonia (as N)	0.05	0.03	0.07	0.11		
Nitrate (as N)	ND	0.28	ND	ND		
Nitrite (as N)	ND	ND	ND	0.16		
Aluminum	ND	ND	ND	ND		
Arsenic	ND	ND	ND	ND		
Barium	ND	ND	ND	ND		
Boron	ND	ND	ND	ND		
Cadmium	ND	ND	ND	ND		
Chromium	ND	ND	ND	ND		
Copper	ND	ND	ND	ND		
Fluoride	.17	.18	.26	0.13		
Iron	.18	ND	ND	0.04		
Lead	ND	ND	ND	ND		
Manganese	0.02	ND	ND	0.01		
Mercury	ND	ND	ND	ND		
Selenium	ND	ND	ND	ND		
Nickel	ND	ND	ND	ND		
Zinc	0.01	ND	ND	0.03		
Molybdenum	ND	ND	ND	ND		
Vanadium	ND	ND	ND	ND		
Uranium	.020		.003	.029		
Radium 226 pCi/l		.86 ± .18	1.14 ± .22			
Temperature Field °C		15.	16.5	15	12.	

BASELINE MEASUREMENTS

TABLE 3 WELL NO. 241W

Date Sampled	6/5/78	6/22/78	7/11/78	7/28/78		
Date Assay Received	7/24/78	7/24/78	8/14/78			
Parameter mg/l						
Total Dissolved Solids (calc.)	401	382	346			
Total Dissolved Solids (105°C)	424	361	371			
Conductivity 77°F µMohs (lab)	665	600	545			
Conductivity µMohs (field)	1500	1250	600	meter B/O		
Sodium (calc.)	98	105	90			
Sodium (observed)	94	96	98			
Potassium	8	7	7			
Calcium	40	30	28			
Magnesium	1	0	2			
Sulfate	140	130	123			
Chloride	36	20	18			
Carbonate	12	24	12			
BiCarbonate	134	134	134			
pH, unit (lab)	8.5	8.4	8.3			
pH, unit (field)	7.5	7.7	8.0	8.2		
Ammonia (as N)	0.01	0.12	ND			
Nitrate (as N)	0.50	0.14	ND			
Nitrite (as N)	0.05	ND	.34			
Aluminum	ND	ND	ND			
Arsenic	.02	ND	ND			
Barium	ND	ND	ND			
Boron	ND	ND	ND			
Cadmium	ND	ND	ND			
Chromium	ND	ND	ND			
Copper	.01	ND	ND			
Fluoride	.15	.27	.16			
Iron	ND	ND	.07			
Lead	ND	ND	ND			
Manganese	ND	ND	.01			
Mercury	ND	ND	ND			
Selenium	ND	ND	ND			
Nickel	ND	ND	ND			
Zinc	ND	ND	.01			
Molybdenum	ND	ND	ND			
Vanadium	ND	ND	ND			
Uranium	.054	.042	.071			
Radium 226 pCi/l	.42 ± .13	.40 ± .15				
Temperature Field °C	12.5	15.5	13	14		

REFERENCES

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