40-6659

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March 9, 1998

Mr. Joseph J. Holonich, Chief
Uranium Recovery Branch MS-T-7-J-9
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Reference: Alternate Concentration Limits Application – Response to open issue 5 – Source Material License SUA-551

Dear Mr. Holonich:

Submitted herewith in triplicate is the Addendum to response to NRC open issue 5 (model verification).

As requested, the model was verified over the five-year period 1993 through 1997. The flow model was initialized to average hydrologic conditions for 1992. Annual average pumping rates from the recovery wells were computed for the period 1993-1997, and input directly into the flow model for the verification simulation. Average annual tailings leakage (recharge) estimates were obtained directly from the ACL application. The verification simulation was run and has been compared to the existing conditions. Results of the ground water flow model verification indicate the site flow model is capable of simulating complex hydrologic conditions with accuracy, and can be used with confidence to make future predictions.

Please contact me if you have questions or need further information.

Sincerely,

NL05

R. A. Juday
Supervisor

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C PDR

Enclosure: ACL Application, Response to open issue 5.

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PETROTOMICS TAILINGS FACILITY APPLICATION FOR ALTERNATE CONCENTRATION LIMITS SOURCE MATERIAL LICENSE SUA 551

ADDENDUM TO RESPONSE TO NRC OPEN ISSUE 5 (MODEL VERIFICATION)

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ADDENDUM TO RESPONSE TO NRC OPEN ISSUE 5 (MODEL VERIFICATION)

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Attachment B	Monitoring Well Water Quality Data

1. INTRODUCTION

On October 27, 1997, Petrotomics responded to comments from the U.S. Nuclear Regulatory Commission (NRC) and its subcontractor (CNWRA), regarding remaining technical "open issues" concerning Petrotomics' application for Alternate Concentration Limits (Petrotomics, 1997). On November 19, 1997, the NRC contacted Petrotomics by telephone and indicated that, although Petrotomics' responses were generally satisfactory, additional verification was needed to further demonstrate the conservatism of the site ground water flow and transport models (NRC Open Issue 5). Based on subsequent telephone conversations between Petrotomics, NRC and the CNWRA, a scope of work was agreed upon that allowed the flow and transport models to be verified (Attachment A). This document summarizes the methods, results, and conclusions of the model verification effort.

2. FLOW MODEL VERIFICATION

2.1 Model Assumptions and Input Data

The calibrated MODFLOW model was verified over the five-year period 1993 through 1997. The flow model was initialized to average hydrologic conditions (e.g. water levels, pumping rates, tailings leakage rates) for 1992. Annual average pumping rates from site recovery wells were computed for the period 1993-1997, and input directly into the flow model for the verification simulation (Table 2-1). Average annual tailings leakage (recharge) estimates were obtained directly from the ACL application (Figure 2-2, Petrotomics, 1996).

Calibrated flow model parameters were not adjusted during the verification simulation, with one exception. Pit 4 was backfilled in September, 1996. Prior to 1997, Pit 4 was simulated as a sink. In order to simulate the backfilled condition, the hydraulic conductivity of the open pit for 1997 was assigned a value of 40 ft/day to represent compacted backfill, and evaporation from the pit lake surface was terminated.

2.2 Verification Targets

Annual average water levels in site monitoring wells (observed) and open pits (estimated) were tabulated and used as flow model verification targets. Table 2-2 summarizes pit water level assumptions for the verification period.

2.3 Verification Results

The ground water flow model was used to simulate average annual conditions over the five year verification period. The model was run in transient mode to incorporate changing pumping rates, tailings leakage rates, and aquifer storage effects.

Simulated water levels were compared to observed (target) water levels on an annual basis to assess the adequacy of the flow model predictions. Tables 2-3 through 2-7 compare modeled and observed water levels for each year of the verification period, and provide a statistical analysis of model results. Figure 2-1 provides a graphical representation of model results at the end of the verification period (1997).

Figures 2-2 and 2-3 illustrate the simulated contoured water levels in the Upper and Main Sands for 1996. These figures can be compared to Figures 2-4 and 2-5 that illustrate the observed water levels in May, 1996, reproduced directly from the original ACL application (Petrotomics, 1996).

Results of the verification effort indicate the flow model is capable of simulating complex hydrologic conditions with accuracy, and can be used with confidence to make future predictions.

Table 2-1 Recovery Well Pumping Rates for Verfication Period

Well Number	Recovery Rate 1993	Recovery Rate 1994	Recovery Rate 1995	Recovery Rate 1996	Recovery Rate 1997
Seep Collection	0	0.76156	1.353014	0.901754	0
51SC	0.009014	0.006712	0	0	0
54SC	0.172218	0.376657	0.490384	0.768274	0.392575
58SC	1.378137	1.195946	0.648986	0.694247	0.298409
59SC	0.043343	0.147671	0.17989	0.113725	0.000192
62SC	0.021288	0.032411	0.025506	0.036631	0.005178
63SC	0.023055	0.172218	0.065972	0.053506	0.01074
64SC	0.392576	0.146712	0	0.009397	0.001151
PT6	0.946823	1.388876	0.649753	0.856109	0.088027
PT7	0.314136	0.314713	0.165124	0.312218	0
PT9	2.123206	0.190822	0	0	0
5DC	18.93423	0	0	0	0
12DC	14.50534	20.09192	17.95636	18.53715	19.0441
18DC	0	0	1.200356	3.189699	1.801973
Totals	39.07237	24.82621	22.73535	25.47271	21.64266

Note: Recovery rates in gallons per minute (gpm).
Locations of "PT" series recovery wells are provided on Figure 1-2 of original ACL application (Petrotomics, 1996).

Table 2-2 Estimated Pit Water-Levels for Verification Period

Pit Name	Avg. Water Level 1993	Avg. Water Level 1994	Avg. Water Level 1995	Avg. Water Level 1996	Avg. Water Level 1997
Area 2/8	6840	6860	6875	6900[a] 6880[b]	6917[a] 6903[b]
Area 3	6820	6820	6820	6840	6891
Pit 4	6941.6	6940.7	6940	6938[c]	-
Jenkins	6919	6919	6919	6919	6919
Sullivan	6913	6913	6913	6913	6913

[a] - Area 2

[b] - Area 8

[c] - Backfilled beginning September 1996.

Locatons of regional pits are provided on Figure 2-5 of original ACL Application (Petrotomics, 1996).

Table 2-3 Modeled vs. Observed Water Levels, 1993

Name	X	Y	Layer[1]	Observed	Compute	Residual
56SC	11394	31141	1	6949.5	6951.399	-1.89919
17DC	11740	31000	2	6903	6898.313	4.687018
9DC	12086	30862	2	6904.6	6900.005	4.594879
13DC	15820	30004	2	6923.5	6919.82	3.680356
42SC	9805	28584	1	6997.4	6998.465	-1.06481
5SC	11077	28595	1	7002.2	7003.345	-1.14488
61SC	11049	28587	1	7005	7003.48	1.520293
8DC	11623	28932	2	6926.8	6922.034	4.765539
45SC	11863	28694	1	7000.7	6997.224	3.476493
11DC	13016	29383	2	6922.9	6922.525	0.375432
14DC	15028	27916	2	6937.9	6937.081	0.8188
10DC	14656	27081	2	6942.5	6941.085	1.414923
44SC	10601	28120	1	7005.1	7007.428	-2.3275
41SC	9755	26568	1	7036.4	7033.679	2.720705
Residual Mean						1.544147
Res. Std. Dev.						2.420695
Sum of Squares						115.4181
Abs. Res. Mean						2.46363
Min. Residual						-2.3275
Max. Residual						4.765539
Head Range						133.4
Std. Dev./Head Range						0.018146

[1] Layer 1 represents upper sand, layer 2 represents main sand.

Table 2-4 Modeled vs. Observed Water Levels, 1994

Name	X	Y	Layer[1]	Observed	Compute	Residual
56SC	11394	31141	1	6947.8	6951.609	-3.80857
17DC	11740	31000	2	6906.9	6899.313	7.587376
9DC	12086	30862	2	6906.2	6900.982	5.217526
13DC	15820	30004	2	6925.3	6920.768	4.531925
42SC	9805	28584	1	6998.7	7000.601	-1.90095
5SC	11077	28595	1	7002.2	7003.642	-1.44169
61SC	11049	28587	1	7002.3	7003.782	-1.48227
8DC	11623	28932	2	6924.4	6920.893	3.507348
45SC	11863	28694	1	7000.8	6996.932	3.868398
11DC	13016	29383	2	6923.3	6922.018	1.282493
14DC	15028	27916	2	6936.8	6935.924	0.876279
10DC	14656	27081	2	6940.6	6939.515	1.084794
44SC	10601	28120	1	7005.4	7007.478	-2.07813
41SC	9755	26568	1	7038.3	7033.679	4.620669
Residual Mean						1.5618
Res. Std. Dev.						3.27435
Sum of Squares						184.2482
Abs. Res. Mean						3.092029
Min. Residual						-3.80857
Max. Residual						7.587376
Head Range						132.1
Std. Dev./Head Range						0.024787

[1] Layer 1 represents upper sand, layer 2 represents main sand.

Table 2-5 Modeled vs. Observed Water Levels, 1995

Name	X	Y	Layer[1]	Observed	Compute	Residual
56SC	11394	31141	1	6945.6	6950.673	-5.07325
17DC	11740	31000	2	6910.2	6902.573	7.627454
9DC	12086	30862	2	6911.4	6903.989	7.41137
13DC	15820	30004	2	6927.7	6923.247	4.452651
42SC	9805	28584	1	7000.2	7003.621	-3.42066
5SC	11077	28595	1	7001.9	7003.968	-2.06798
61SC	11049	28587	1	7002	7004.147	-2.1473
8DC	11623	28932	2	6923.2	6920.353	2.847386
45SC	11863	28694	1	7000.5	6996.674	3.825685
11DC	13016	29383	2	6924.1	6921.89	2.209717
14DC	15028	27916	2	6936	6935.469	0.531026
10DC	14656	27081	2	6938	6938.465	-0.46502
44SC	10601	28120	1	7005.3	7007.812	-2.5118
41SC	9755	26568	1	7038.7	7003.681	5.019052
Residual Mean						1.302739
Res. Std. Dev.						3.919945
Sum of Squares						238.8833
Abs. Res. Mean						3.543596
Min. Residual						-5.07325
Max. Residual						7.627454
Head Range						128.5
Std. Dev./Head Range						0.030505

[1] Layer 1 represents upper sand, layer 2 represents main sand.

Table 2-6 Modeled vs. Observed Water Levels, 1996

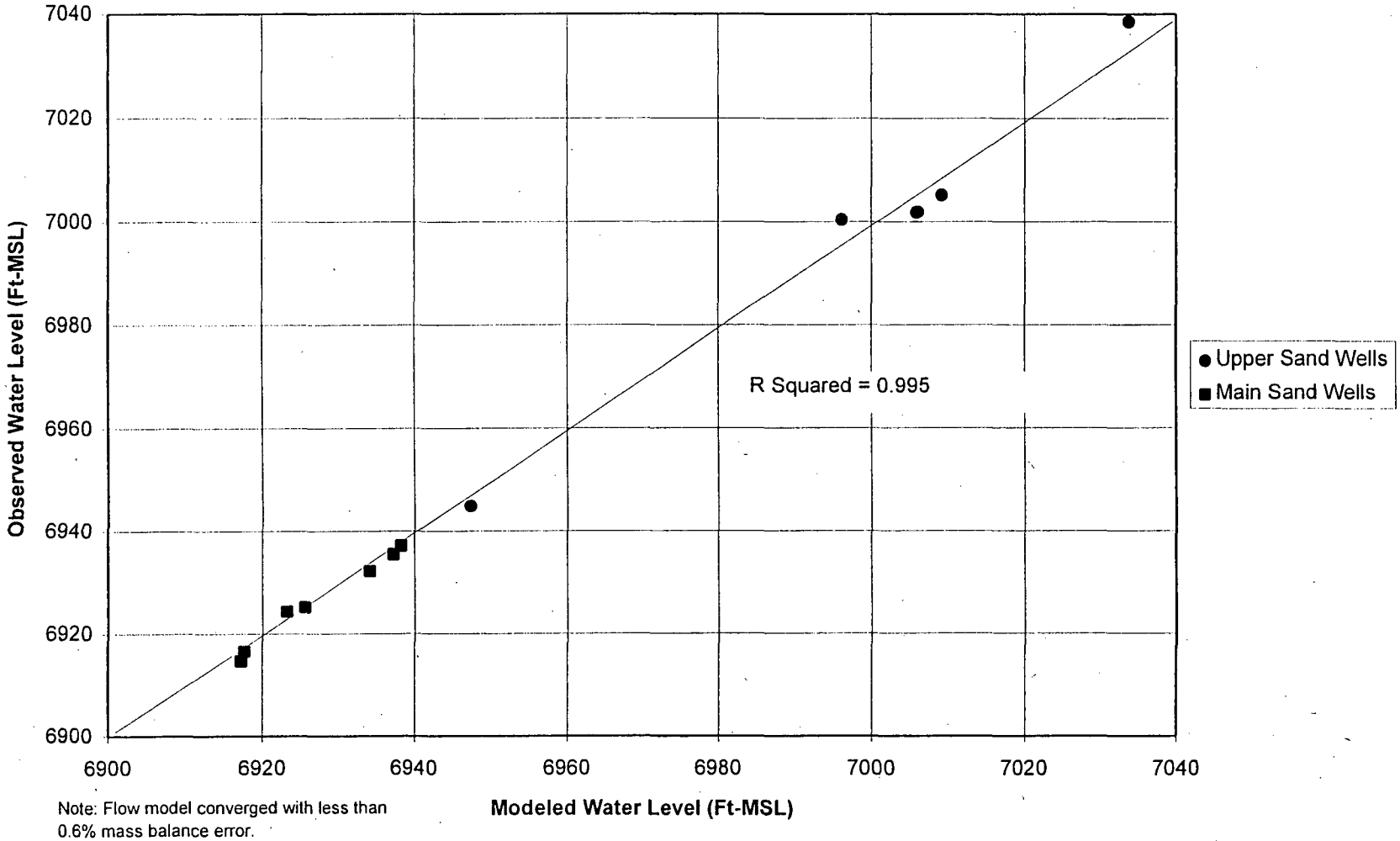
Name	X	Y	Layer[1]	Observed	Compute	Residual
56SC	11394	31141	1	6945.6	6948.515	-2.91487
17DC	11740	31000	2	6910.2	6909.202	0.997631
9DC	12086	30862	2	6911.4	6910.23	1.170251
13DC	15820	30004	2	6927.7	6925.754	1.946478
5SC	11077	28595	1	7001.9	7004.535	-2.6355
61SC	11049	28587	1	7002	7004.761	-2.76114
8DC	11623	28932	2	6923.2	6920.877	2.323275
11DC	13016	29383	2	6924.1	6922.789	1.310617
14DC	15028	27916	2	6936	6935.309	0.690796
10DC	14656	27081	2	6938	6937.764	0.235739
44SC	10601	28120	1	7005.3	7008.44	-3.1399
41SC	9755	26568	1	7038.7	7033.681	5.019083
Residual Mean						0.186872
Res. Std. Dev.						2.440951
Sum of Squares						71.91797
Abs. Res. Mean						2.095439
Min. Residual						-3.1399
Max. Residual						5.019083
Head Range						128.5
Std. Dev./Head Range						0.018996

[1] Layer 1 represents upper sand, layer 2 represents main sand.

Table 2-7 Modeled vs. Observed Water Levels, 1997

Name	X	Y	Layer[1]	Observed	Compute	Residual
56SC	11594	31141	1	6944.9	6947.336	-2.43601
17DC	11740	31000	2	6914.8	6917.229	-2.42941
9DC	12086	30862	2	6916.7	6917.651	-0.95071
13DC	15820	30004	2	6932.2	6934.148	-1.94838
5SC	11077	28595	1	7001.8	7005.852	-4.05187
61SC	11049	28587	1	7001.9	7006.058	-4.145762
8DC	11623	28932	2	6924.4	6923.166	1.234408
45SC	12045	28634	1	7000.4	6996.139	4.261057
11DC	13016	29383	2	6925.3	6925.535	-0.23503
14DC	15028	27916	2	6935.5	6937.219	-1.71889
10DC	14656	27081	2	6937.2	6938.245	-1.04537
44SC	10601	28120	1	7005.2	7009.228	-4.02817
41SC	9755	26568	1	7038.5	7033.682	4.818246
Residual Mean						-0.97598
Res. Std. Dev.						2.788456
Sum of Squares						113.4643
Abs. Res. Mean						2.562706
Min. Residual						-4.15762
Max. Residual						4.818246
Head Range						123.7
Std. Dev./Head Range						0.022542

[1] Layer 1 represents upper sand, layer 2 represents main sand.



Note: Flow model converged with less than 0.6% mass balance error.

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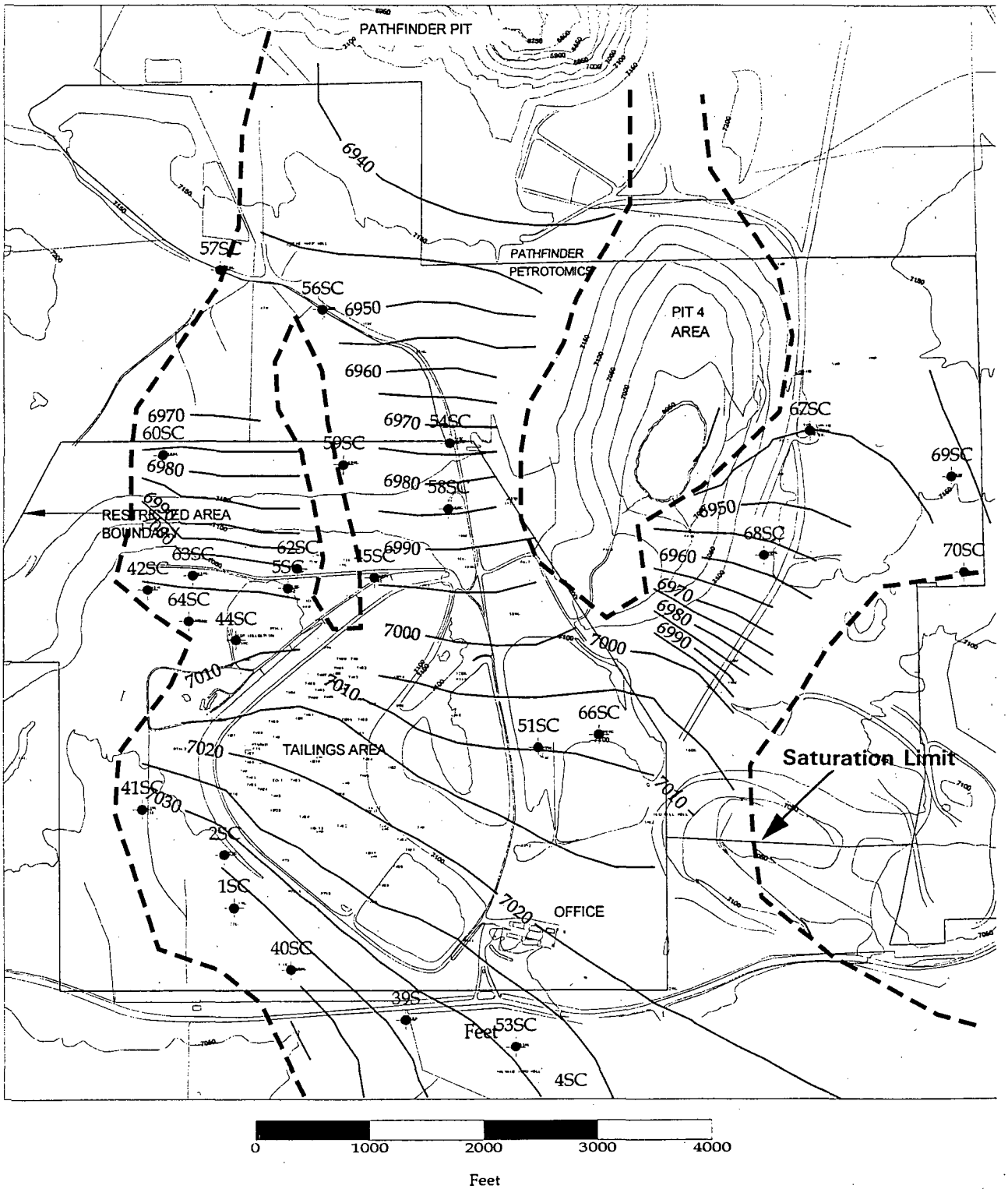
Figure 2-1

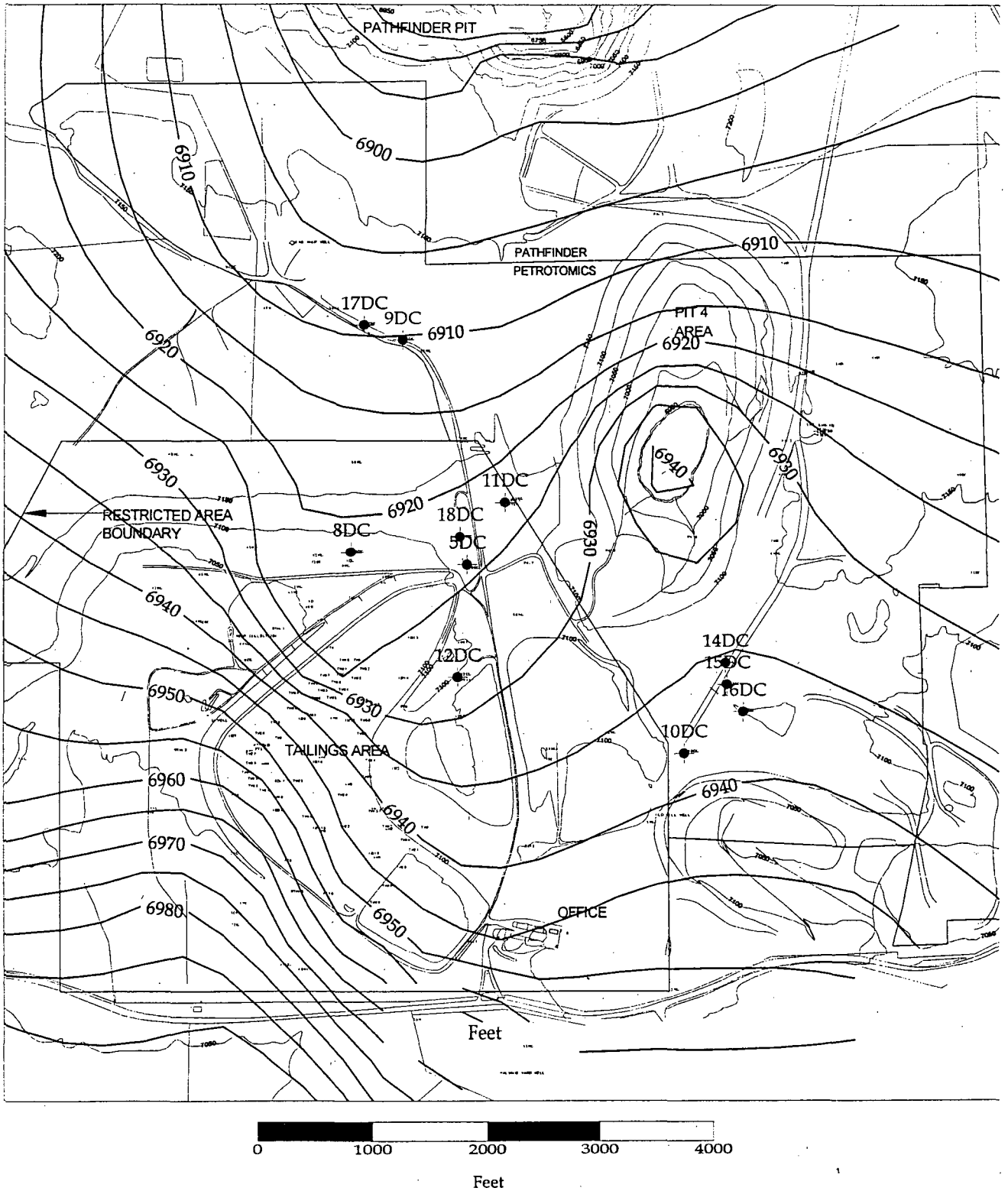
Modeled vs. Observed Water Levels, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt



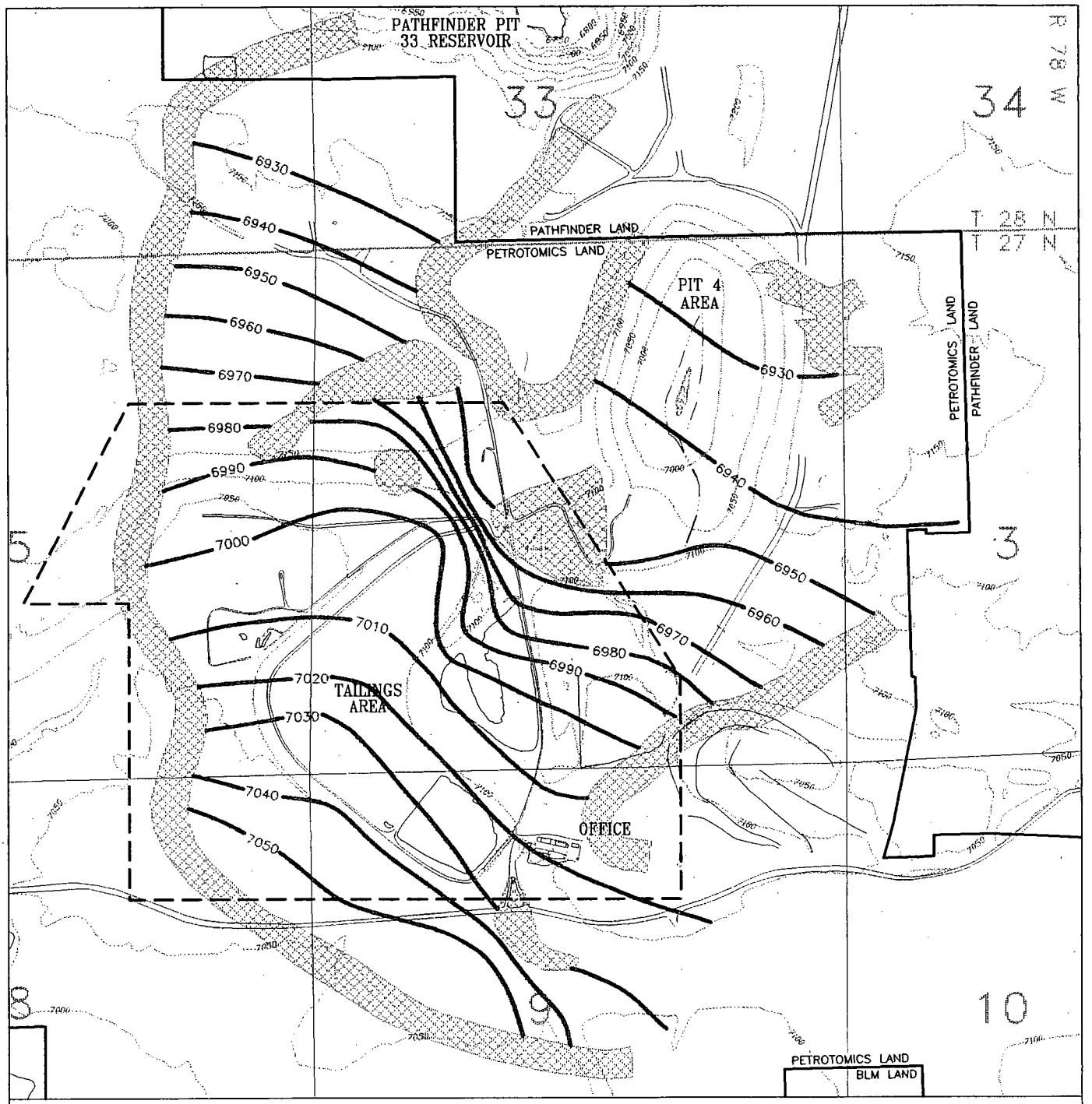
PETROTOMICS COMPANY
Figure 2-2
Simulated Water Level Elevations, Upper Sand, 1996

Date:	March 1998
Project:	100119
File:	form.ppt



PETROTOMICS COMPANY
Figure 2-3
Simulated Water Level Elevation, Main Sand, 1996

Date:	March 1998
Project:	100119
File:	form.ppt



Elevation in feet above MSL

LEGEND

NRC PETROTOMICS PROPERTY BOUNDARY

NRC RESTRICED AREA BOUNDARY

NO FLOW AREAS

7010 GROUND WATER ELEVATION

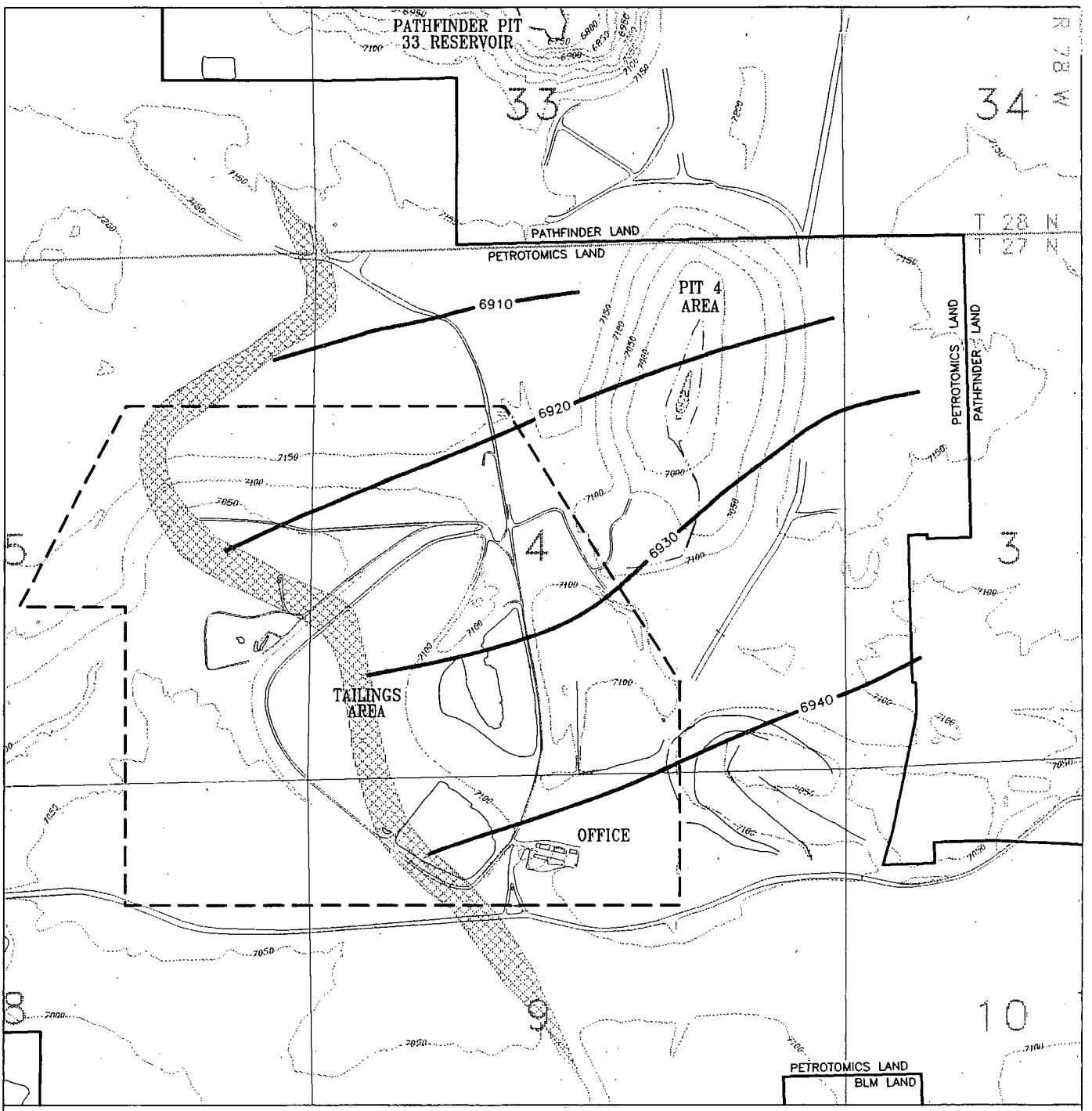
SCALE IN FEET

1500 0 3000

N

PETROTOMICS COMPANY		
WATER LEVEL ELEVATION UPPER SAND, MAY 1996		
FIGURE 2-4	SCALE 1" = 1500'	DATE: MAR. 1998

100119\WAT1996



Elevation in feet above MSL

LEGEND

- PETROTOMICS PROPERTY BOUNDARY
- NRC RESTRICED AREA BOUNDARY
- NO FLOW AREAS
- 6930 GROUND WATER ELEVATION

SCALE IN FEET

1500 0 3000

N

PETROTOMICS COMPANY		
WATER LEVEL ELEVATION MAIN SAND, MAY 1996		
FIGURE 2-5	SCALE 1" = 1500'	DATE: MAR. 1998

100119\WAT1996

3. TRANSPORT MODEL VERIFICATION

3.1 Model Assumption and Input Data

The site transport model was verified in a similar fashion as the ground water flow model, over the identical five-year period (1993-1997). Computed water levels from the ground water flow model were used to compute the ground water velocity distribution for use in the transport model simulations. This was accomplished using a short FORTRAN program, PREMOD3D (Koch and Prickett, 1993). Ground water velocity files representing each year of the verification period were produced and imported directly into RAND3D, the site transport model code. Original transport model parameters for sulfate and uranium were used in the verification simulations, including dispersivity, effective porosity, and retardation factors (section 2.2.4.2 Petrotomics, 1996).

The transport model was initialized by digitizing contoured concentration maps representing average uranium and sulfate concentrations for 1992, and importing the resulting map into RAND3D using a short FORTRAN program, PMASS. The initial uranium and sulfate plume maps for the Upper and Main Sands are provided in Figures 3-1 through 3-4.

Annual source loading rates from the tailings impoundment for sulfate and uranium were obtained directly from conservative estimates presented in the original ACL application (Figures 2-3 and 2-4, Petrotomics 1996).

3.2 Verification Targets

Ground water quality data for uranium and sulfate from site monitoring wells were tabulated and used as transport model verification targets. Attachment B provides a tabular listing of monitoring well water quality over the verification period.

3.3 Verification Results

3.3.1 Uranium

The site transport model was used to simulate average annual uranium concentrations over the five year verification period. Simulated concentrations were compared to observed (target) concentrations to assess the adequacy of the transport model predictions. Table 3-1 compares modeled and observed uranium concentrations at the end of the verification period (1997), and provides a statistical analysis of model results.

Figures 3-5 and 3-6 illustrates the simulated contoured uranium distribution in the Upper and Main Sands at the end of the verification period (1997). These figures can be compared directly to Figures 3-7 and 3-8, which illustrate the observed sulfate distribution in 1997. In addition, Figures 3-9 and 3-10 illustrate the simulated uranium concentration in the Upper and Main Sands in 1995. These figures can be compared directly to Figures 3-11 and 3-12 that illustrate the observed uranium concentration in 1995 (figures reproduced from the ACL application report).

Results of this verification effort indicates the transport model overpredicts the uranium concentration at the end of the verification period in 11 of 14 site monitoring wells (79 percent) (Table 3-1). Furthermore, the model overpredicts the uranium concentration in all six monitoring wells located on the downgradient edge of the plume, indicating the extent of the plume has also been overestimated. These results indicate that transport model predictions are highly conservative.

3.3.2 Sulfate

The site transport model was used to simulate average annual sulfate concentrations over the five year verification period. Simulated concentrations were compared to observed (target) concentrations to assess the adequacy of the transport model predictions. Table 3-2 compares

modeled and observed sulfate concentrations at the end of the verification period (1997), and provides a statistical analysis of model results.

Figures 3-13 and 3-14 illustrates the simulated contoured sulfate distribution in the Upper and Main Sands at the end of the verification period (1997). These figures can be compared directly to Figures 3-15 and 3-16, which illustrate the observed sulfate distribution in 1997. In addition, Figures 3-17 and 3-18 illustrate the simulated sulfate concentration in the Upper and Main Sands in 1995. These figures can be compared directly to Figures 3-19 and 3-20 that illustrate the observed sulfate concentration in 1995 (figures reproduced from the ACL application).

Results of this verification effort indicate the transport model overpredicts the sulfate concentration at the end of the verification period in 22 of 28 site monitoring wells (79 percent) (Table 3-2). Furthermore, the model overpredicts the sulfate concentration in 11 of 12 monitoring wells (92 percent) located on the downgradient edge of the plume, indicating the extent of the plume has also been overestimated. These results indicate that transport model predictions are highly conservative.

Table 3-1 Modeled vs. Observed Uranium Concentrations End of Model Verification Period (1997)

Well Number	1997 Modeled Uranium Concentration (mg/l)	1997 Observed Uranium Concentration (mg/l)[1]	Difference (mg/l)[2]	% Difference[2]
5SC	8.4	7.13	1.3	18
42SC	0.45	1.49	-1.0	-222
44SC	6.3	2.50	3.8	152
45SC	1.3	2.32	-1.0	77
51SC[a]	0.18	0.009	0.17	1900
58SC[b]	0.25	0.008	0.24	3000
60SC[b]	0.65	0.618[3]	0.03	5
62SC	2.5	1.63	0.87	53
63SC	2.3	5.01	-2.71	-117
64SC	2.8	2.65	0.15	6
5DC[b]	0.8	0.001	0.8	80,000
11DC[b]	0.35	0.001	0.35	35,000
12DC	8.7	6.86	1.84	27
18DC[b]	0.45	0.001	0.45	45,000
16 upgradient / background wells	<0.10	<0.10	-	-
		Average	+0.38	+11,800

Note: Background wells not used in calculation of averages.

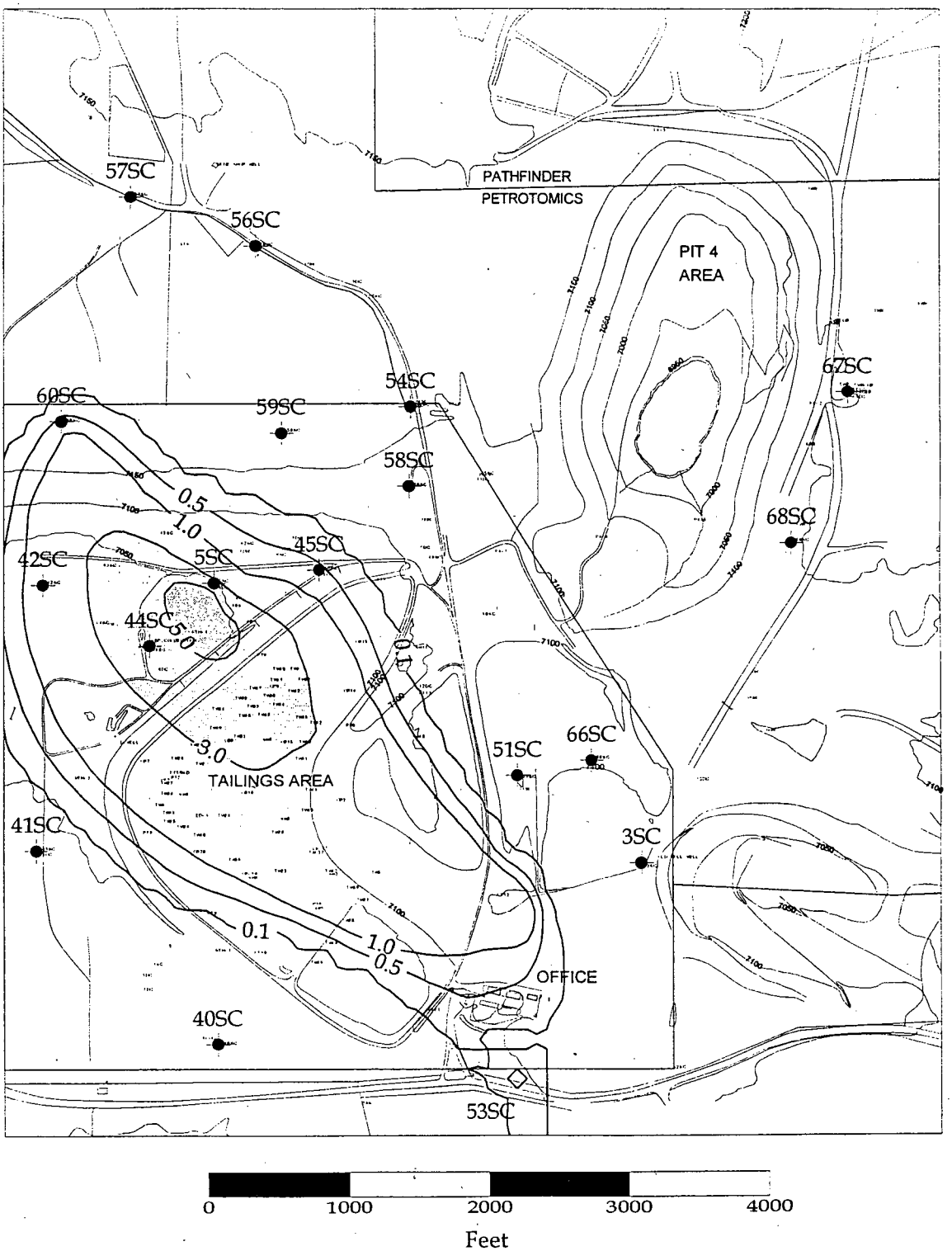
[1] - Represents latest sampling data available through fourth quarter 1997.
[2] - Positive values indicate overestimation; negative values indicate underestimation.
[3] - Most recent data is February 1996.
[a] - represents a downgradient well on the easternmost "leading edge" of the plume.
[b] - represents a downgradient well on the northernmost "leading edge" of the plume.

Table 3-2 Modeled vs. Observed Sulfate Concentrations, End of Model Verification Period (1993-1997)

Well Number	1997 Modeled Sulfate Concentration (mg/l)	1997 Observed Sulfate Concentration (mg/l)[1]	Difference (mg/l)[2]	% Difference[2]
5SC	14,100	11,800	2300	19
42SC	1560	2440	-880	-56
44SC	16,200	7500	8700	116
45SC	16,000	12,600	3400	27
51SC	15,000	12,300	2700	22
54SC[b]	12,000	7500	4500	60
56SC[b]	3480	2560	920	36
57SC[b]	2900	3000	-100	-3
58SC	14,400	16,600	-2200	-15
60SC[b]	5800	4160[3]	1640	39
62SC	14,400	17,500	-3100	-22
63SC	16,800	7550	9250	123
64SC	9600	4280	5320	124
66SC	10,800	11,600	-800	-7
67SC[a]	4100	1020	3080	302
68SC[a]	9000	8320	680	8
5DC	12,000	4200	7800	186
8DC	18,000	6830	11,170	164
9DC[b]	11,400	10,000	1400	14
10DC	1300	1110	190	17
11DC	4200	1310	2890	221
12DC	6500	16,800	-10300	-158
13DC[a]	1200	910	290	32
14DC[a]	7500	7100	400	6
15DC[a]	7000	7000	0	0
16DC[a]	2900	1240	1660	134
17DC[b]	5200	2960	2240	76
18DC	10,500	6850	3650	53
9 Background / Upgradient Wells	<1000	<1000	-	-
		Average	+2028	+54

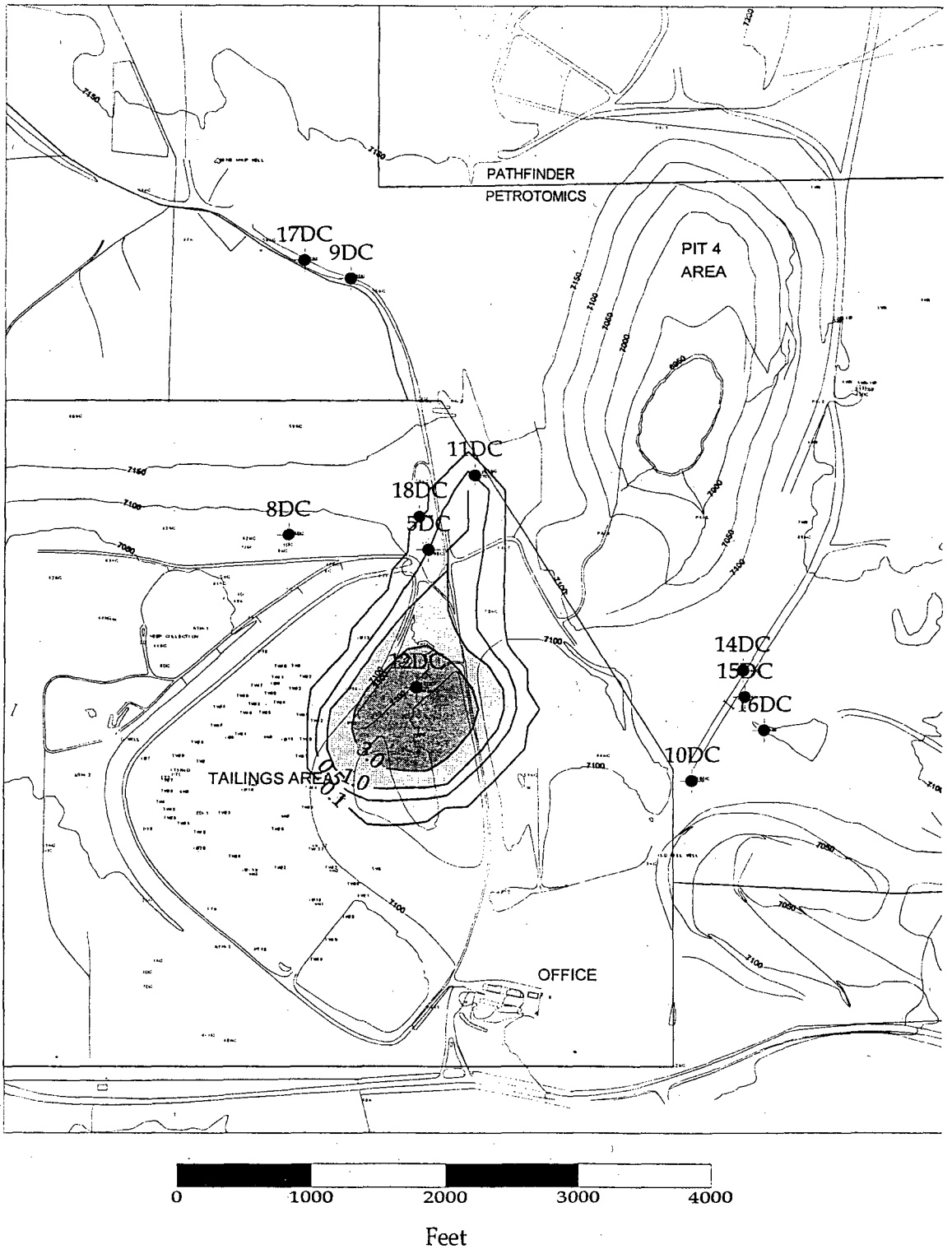
Note: Background wells not included in calculation of averages.
[1] - Represents latest sampling data available through fourth quarter 1997.
[2] - Positive values indicate overestimation; negative values indicate underestimation.
[3] - Most recent data is February 1996.

[a] - represents a downgradient well on the easternmost "leading edge" of the plume
[b] - represents a downgradient well on the northernmost "leading edge" of the plume



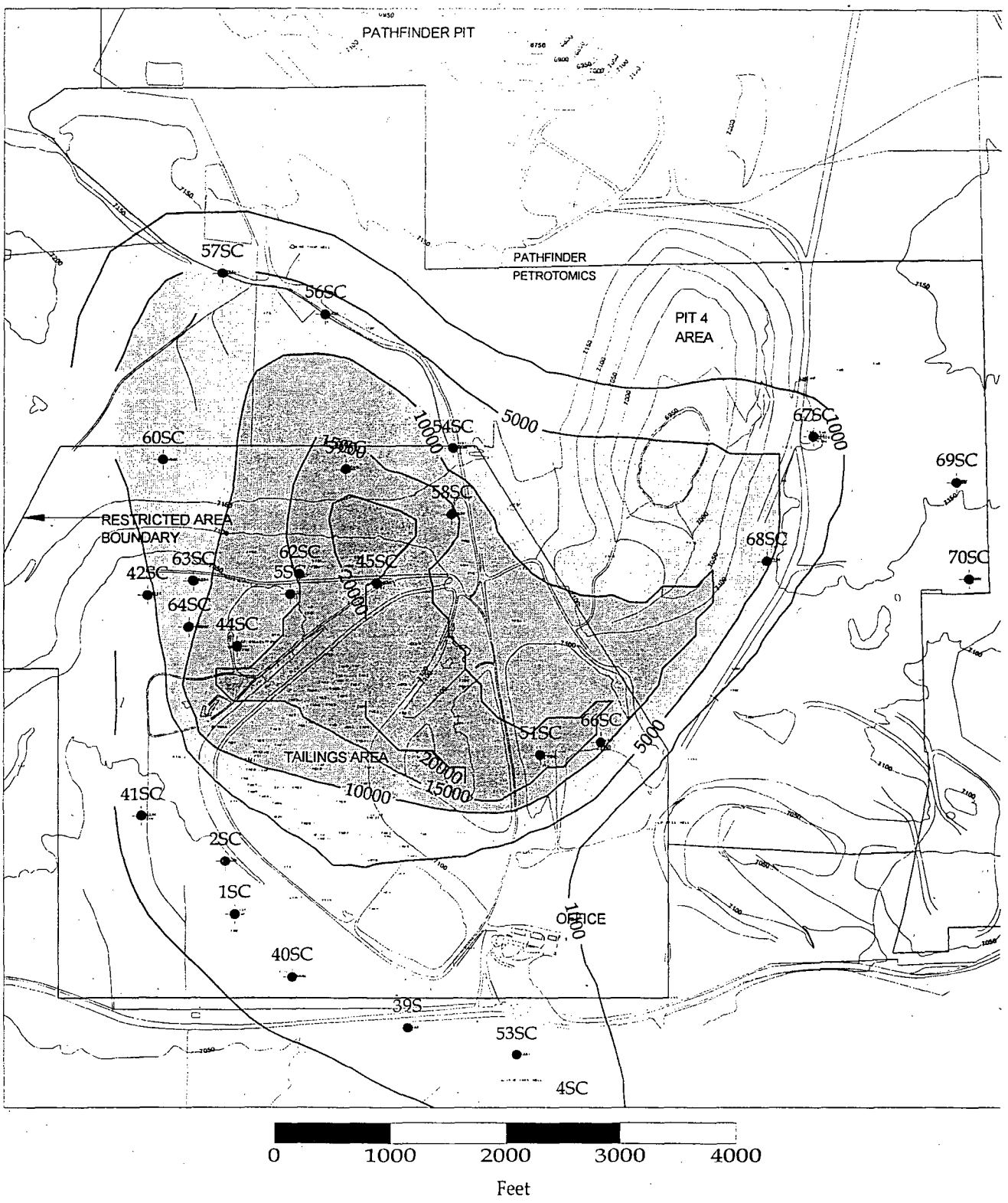
PETROTOMICS COMPANY
Figure 3-1
Initial Uranium Concentration, Upper Sand, 1992

Date:	March 1998
Project:	100119
File:	form.ppt



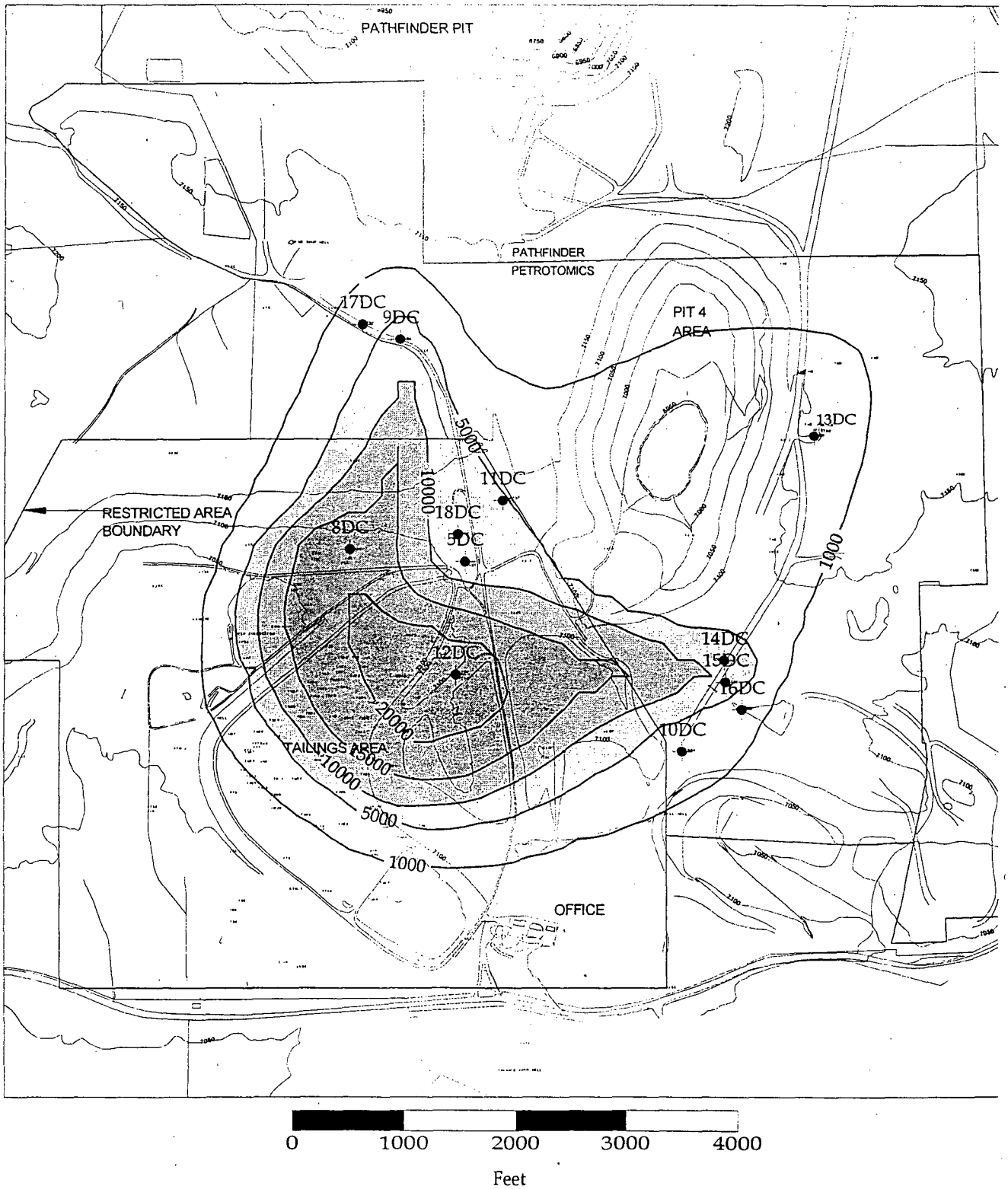
PETROTOMICS COMPANY
Figure 3-2
Initial Uranium Concentration, Main Sand, 1992

Date:	March 1998
Project:	100119
File:	form.ppt



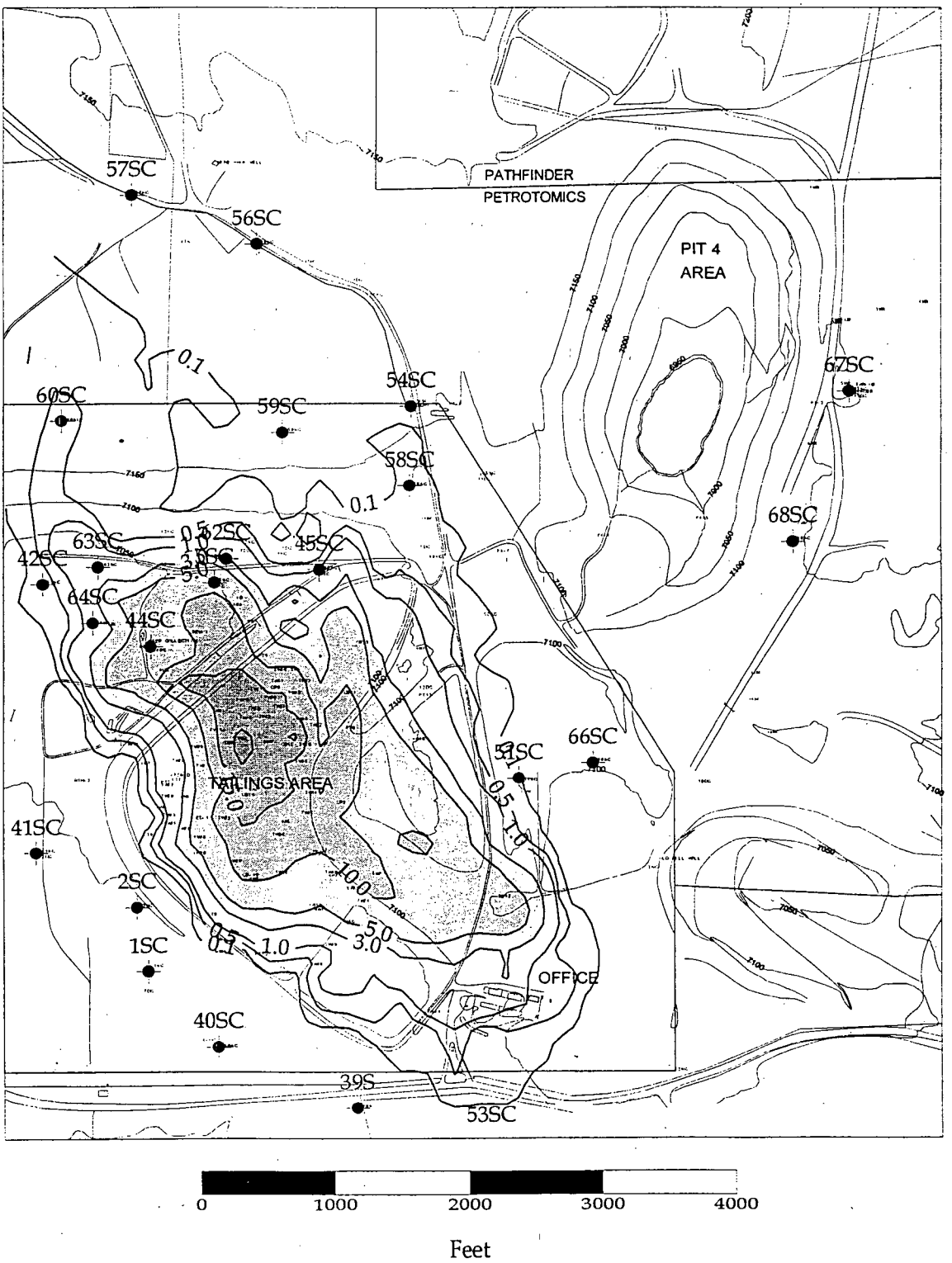
PETROTOMICS COMPANY
Figure 3-3
Initial Sulfate Concentration, Upper Sand, 1992

Date:	March 1998
Project:	100119
File:	form.ppt



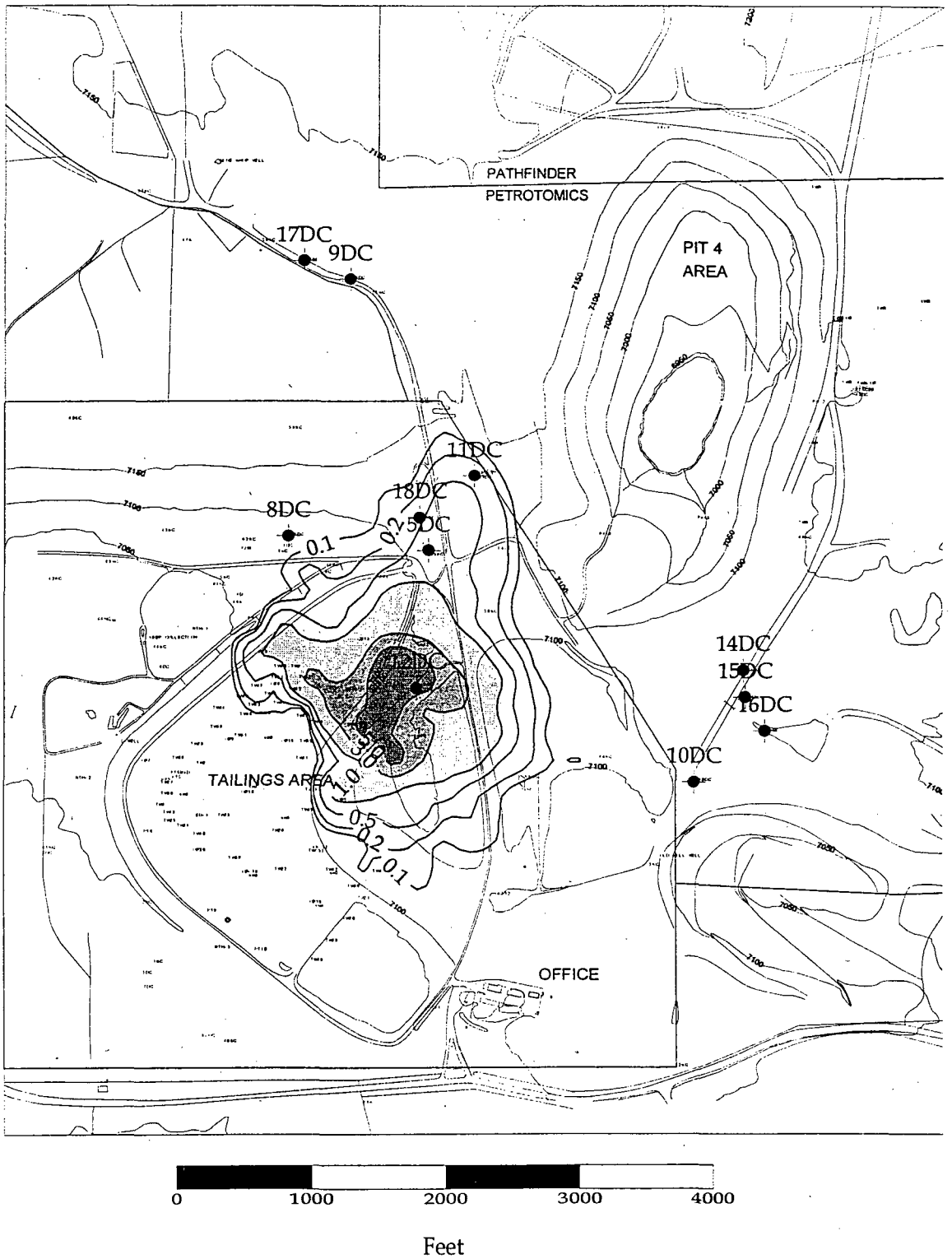
PETROTOMICS COMPANY
Figure 3-4
Initial Sulfate Concentration, Main Sand, 1992

Date:	March 1998
Project:	100119
File:	form.ppt



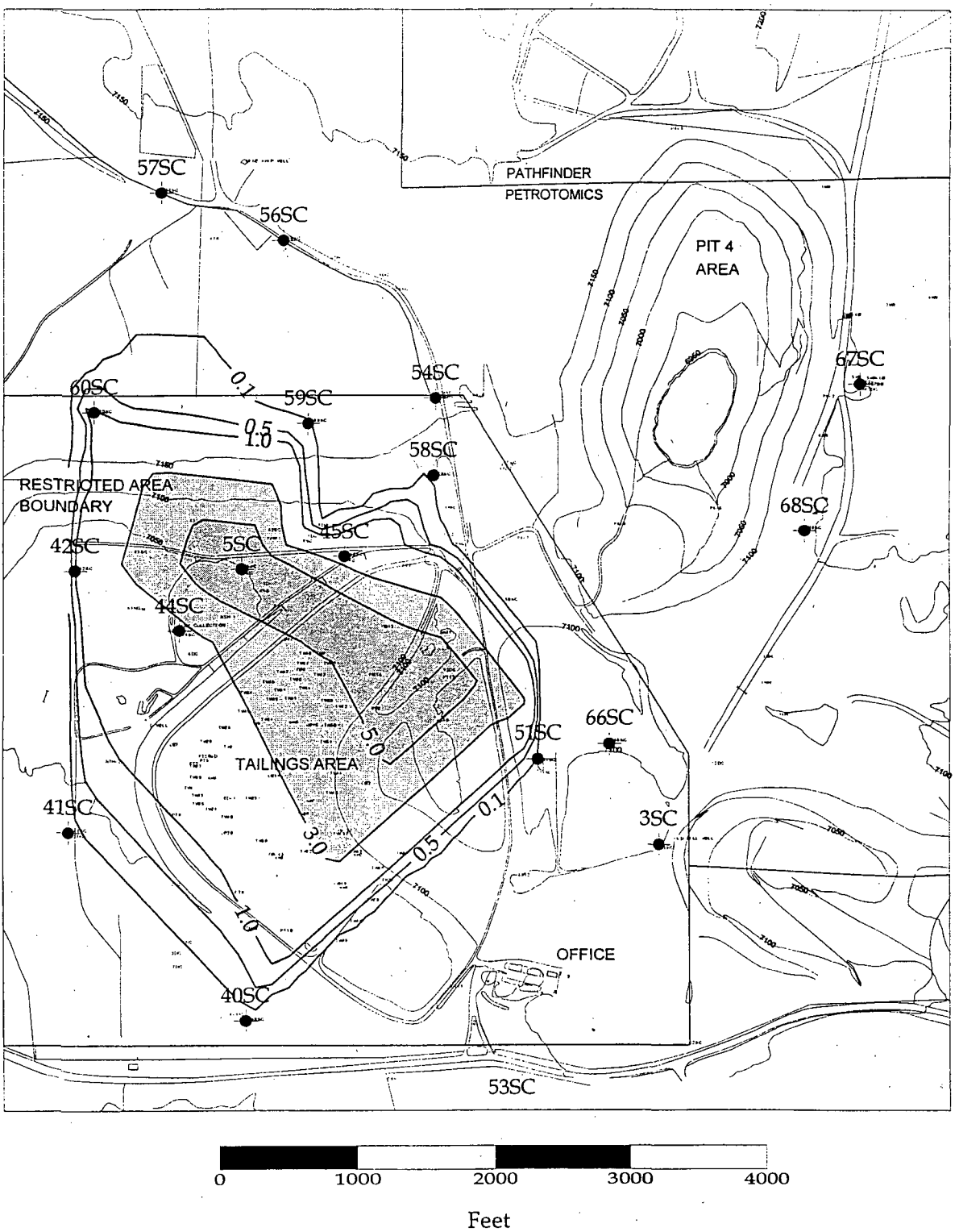
PETROTOMICS COMPANY
Figure 3-5
Simulated Uranium Concentration, Upper Sand, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt

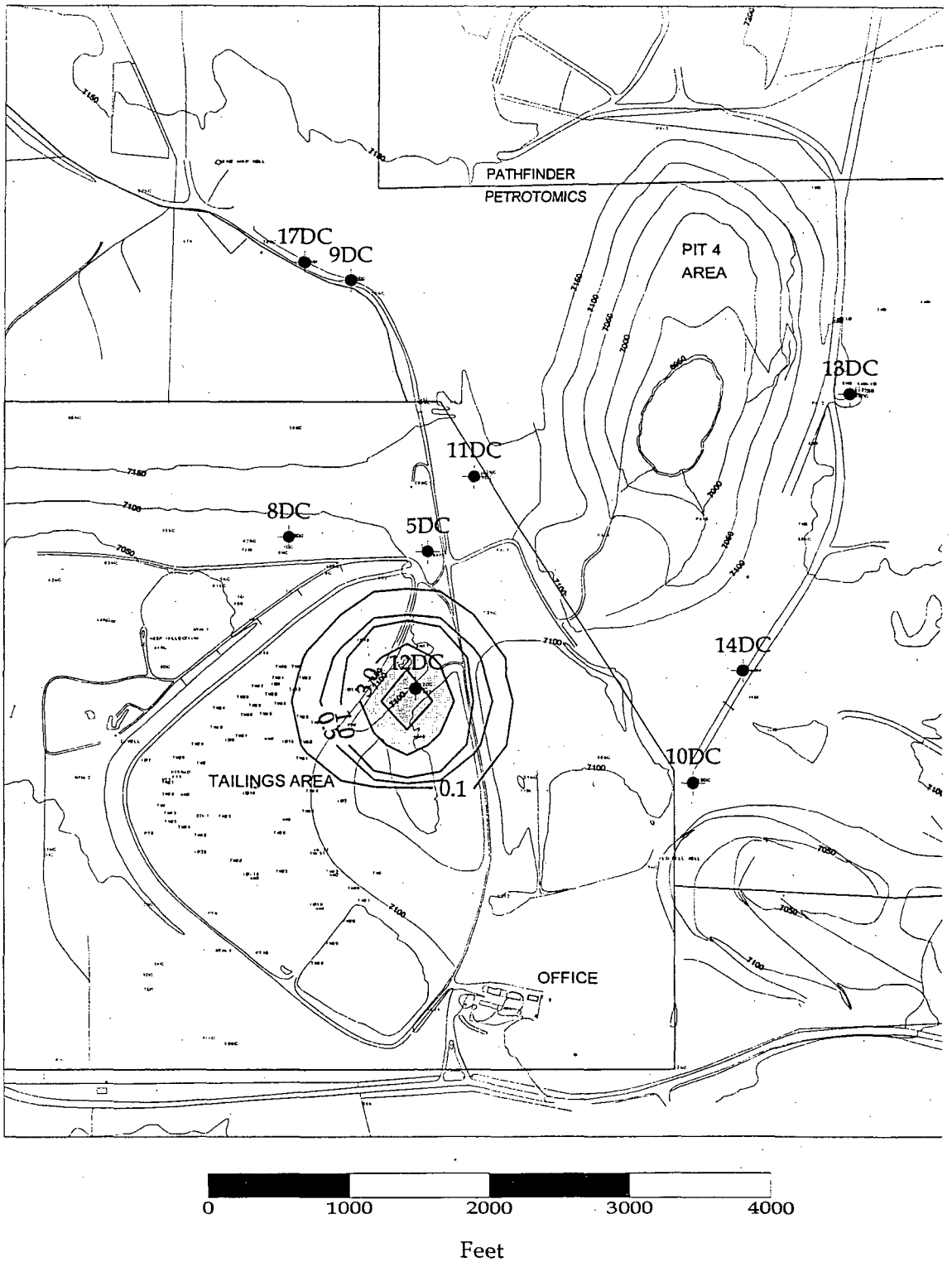


PETROTOMICS COMPANY
Figure 3-6
Simulated Uranium Concentration, Main Sand, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt

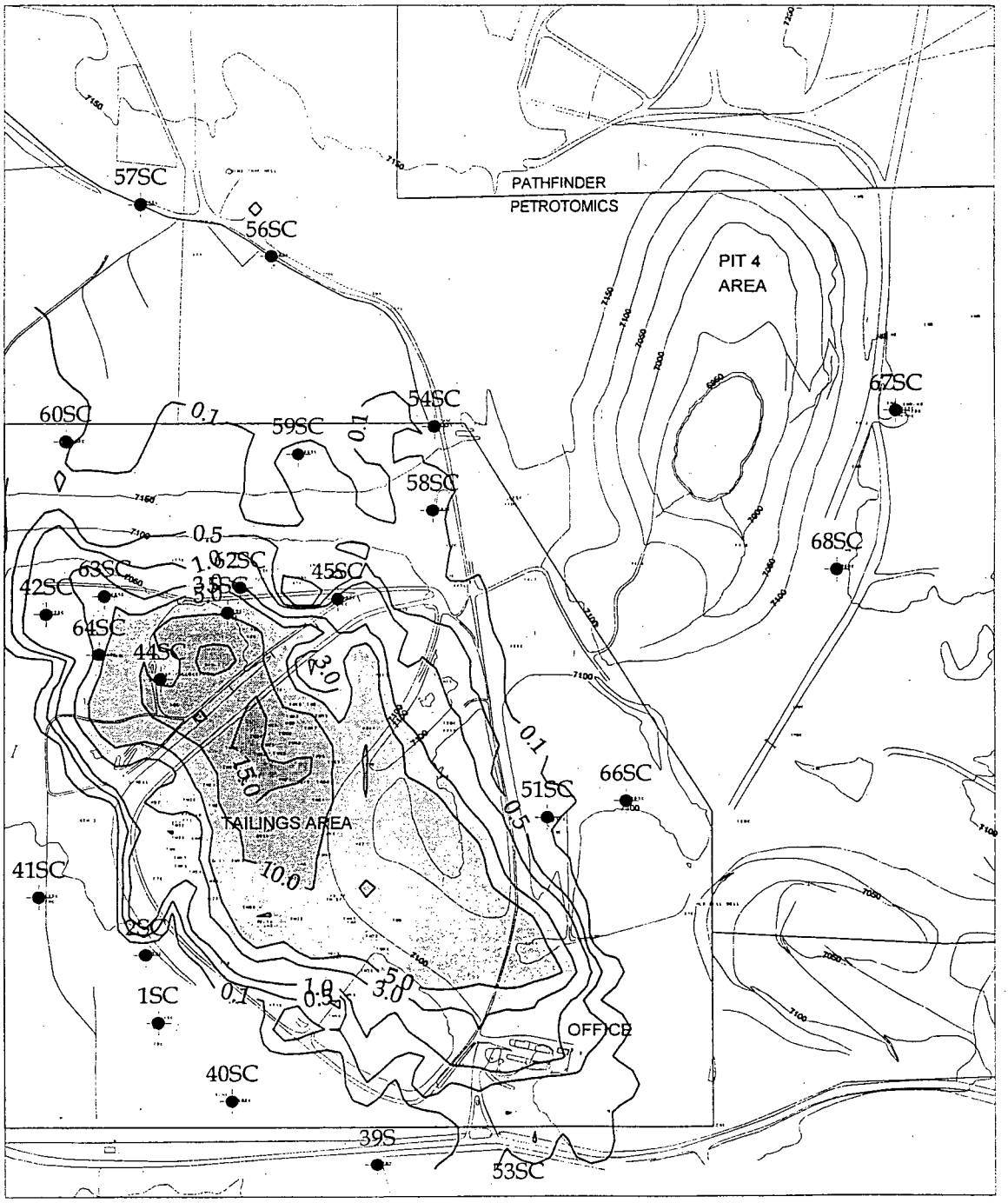


PETROTOMICS COMPANY **Figure 3-7** **Observed Uranium Concentration, Upper Sand, End of Verification Period (1997)**	Date: March 1998 Project: 100119 File: form.ppt



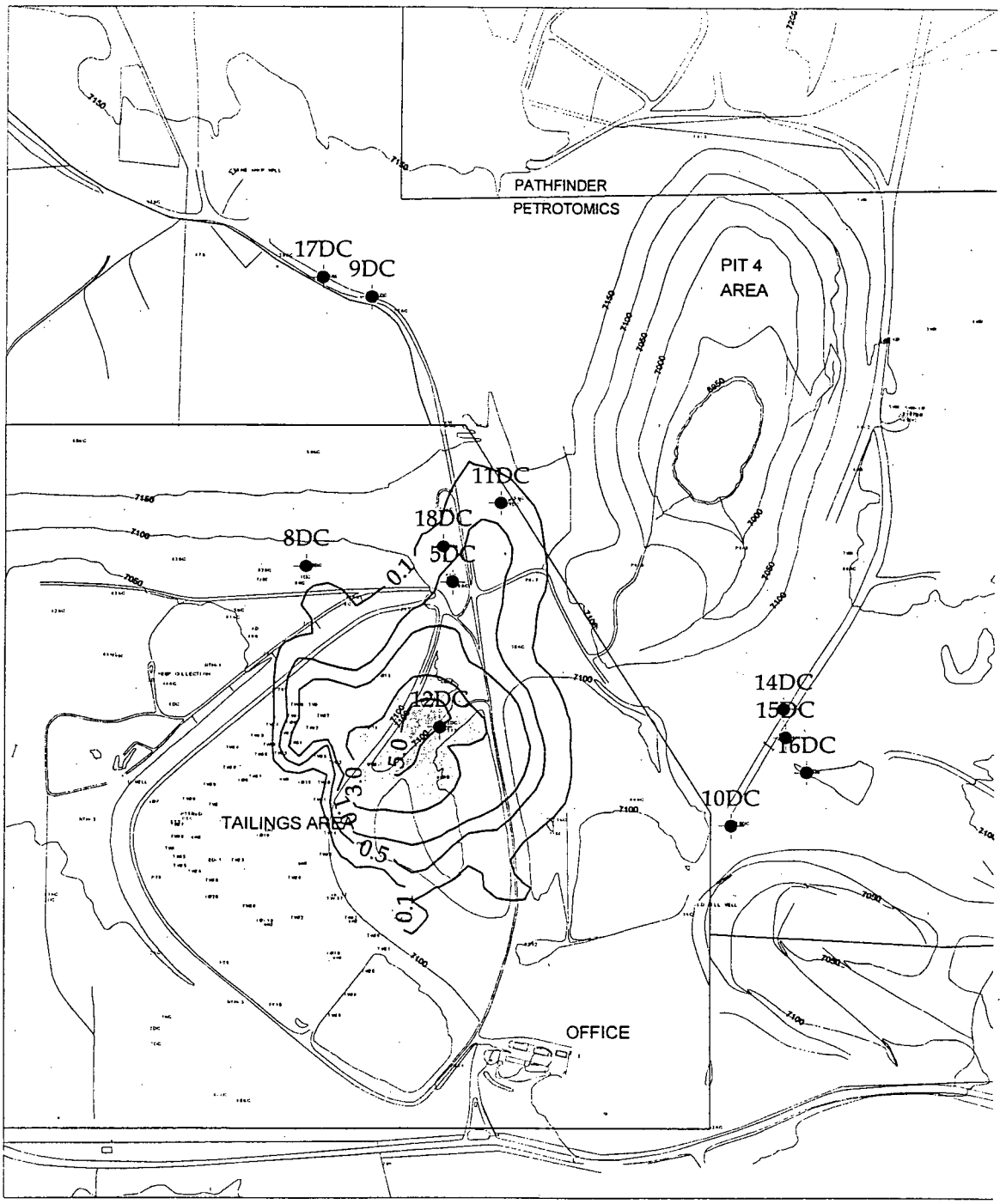
PETROTOMICS COMPANY
Figure 3-8
Observed Uranium Concentration, Main Sand, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt



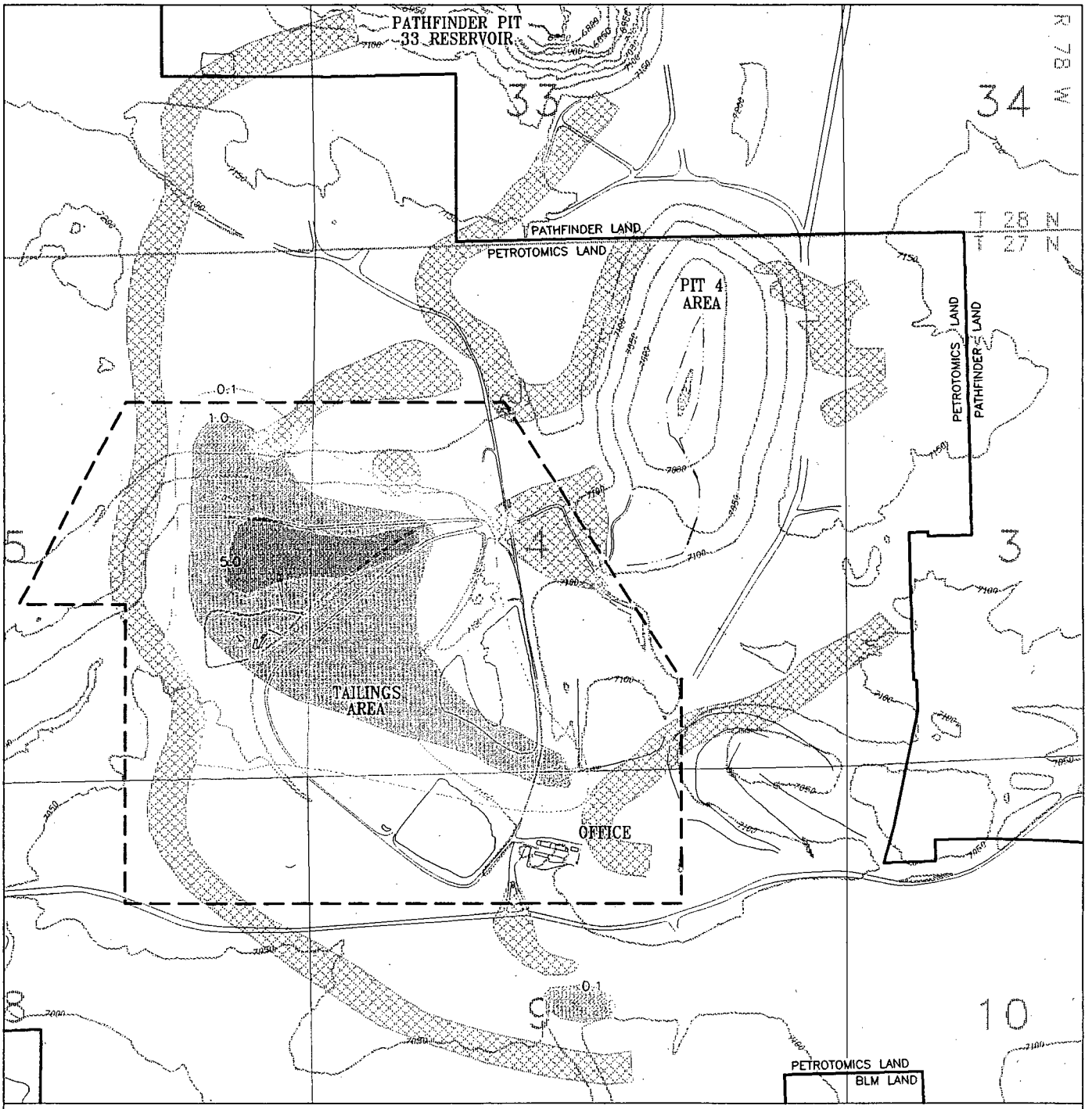
PETROTOMICS COMPANY
Figure 3-9
Simulated Uranium Concentration, Upper Sand, 1995

Date:	March 1998
Project:	100119
File:	form.ppt



PETROTOMICS COMPANY
Figure 3-10
Simulated Uranium Concentration, Main Sand, 1995

Date:	March 1998
Project:	100119
File:	form.ppt



LEGEND

- PETROTOMICS PROPERTY BOUNDARY
- NRC RESTRICED AREA BOUNDARY
- 5.0 mg/l
- 1.0 mg/l
- 0.1 mg/l
- NO FLOW AREAS

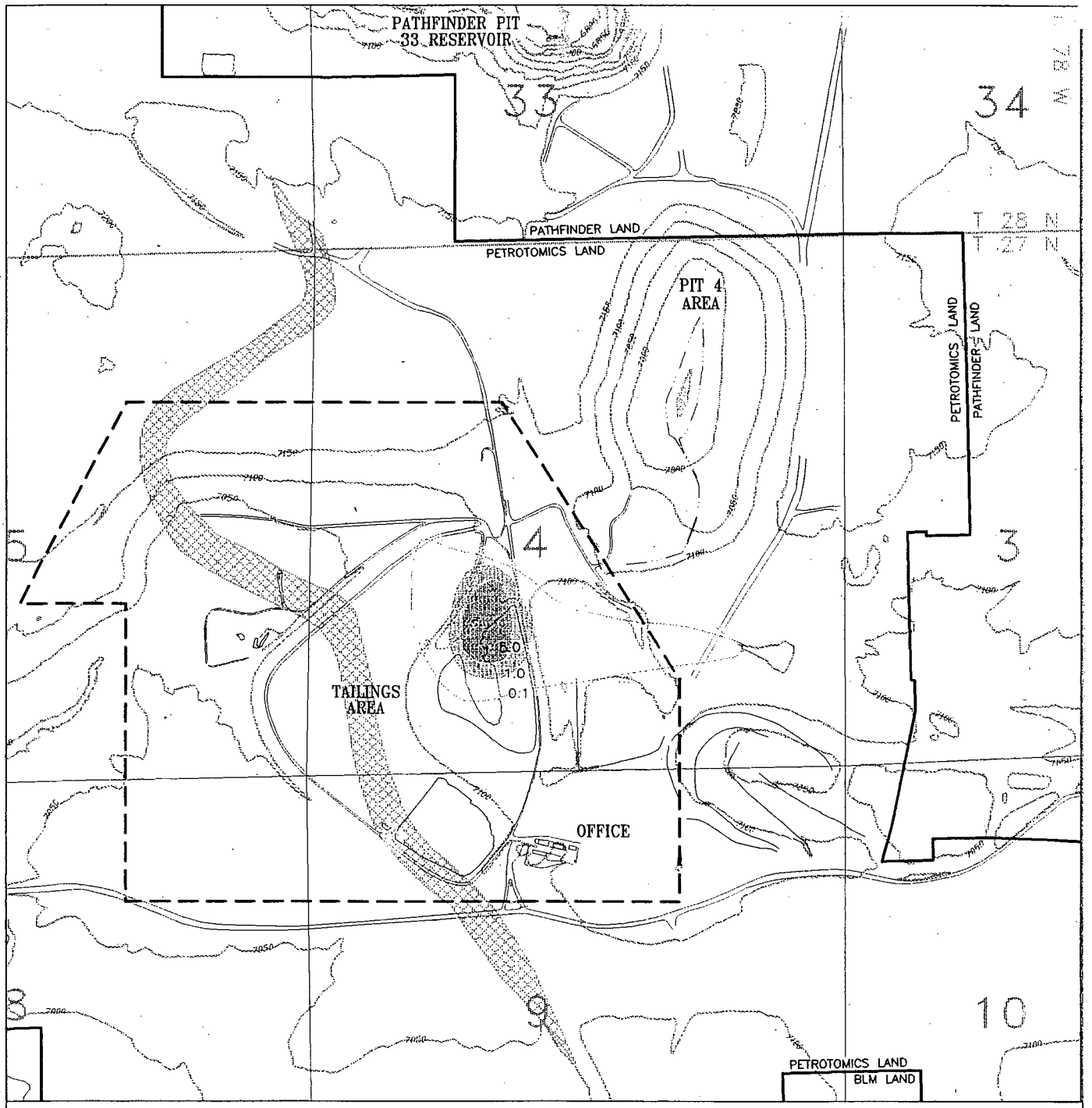
SCALE IN FEET

1500 0 3000

N

PETROTOMICS COMPANY		
OBSERVED URANIUM CONCENTRATION, UPPER SAND, 1995		
FIGURE 3-11	SCALE 1" = 1500'	DATE: MAR.1998

100119\UR-1995



LEGEND

- PETROTOMICS PROPERTY BOUNDARY
- NRC RESTRICED AREA BOUNDARY
- 5.0 mg/l
- 1.0 mg/l
- 0.1 mg/l
- NO FLOW AREAS

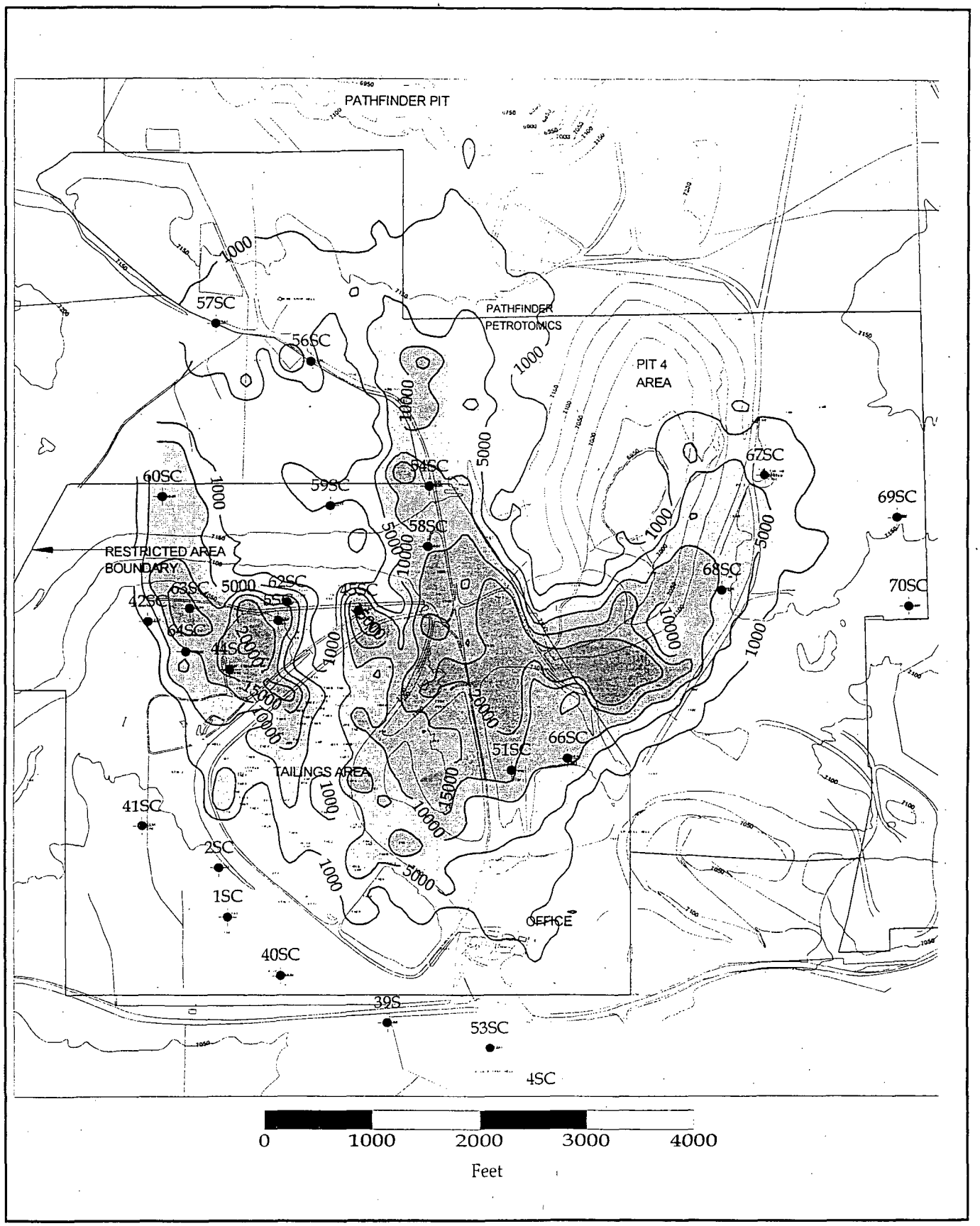
SCALE IN FEET

1500 0 3000

N

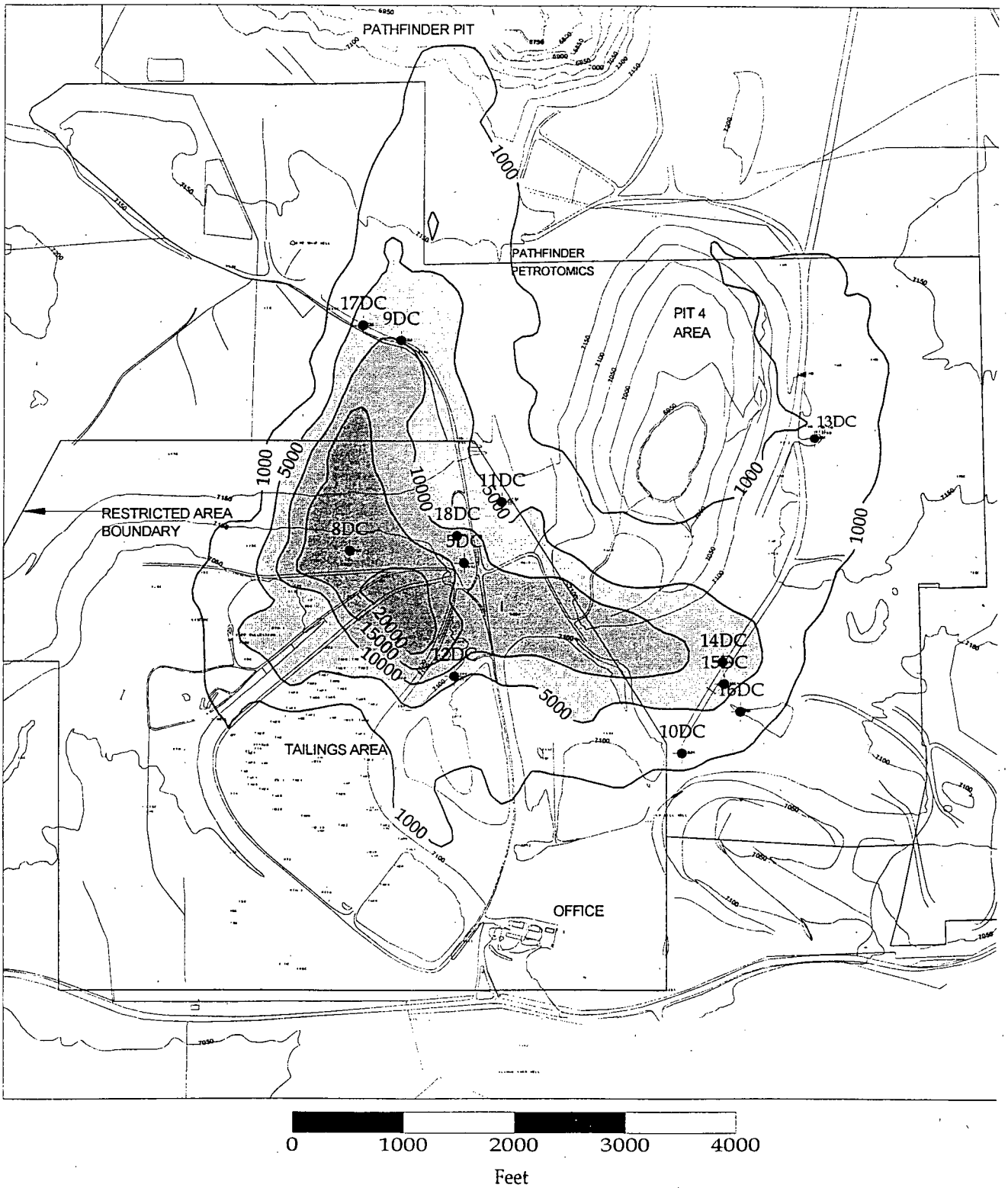
PETROTOMICS COMPANY		
OBSERVED URANIUM CONCENTRATION, MAIN SAND, 1995		
FIGURE 3-12	SCALE 1" = 1500'	DATE: MAR.1998

100119\UR-1995



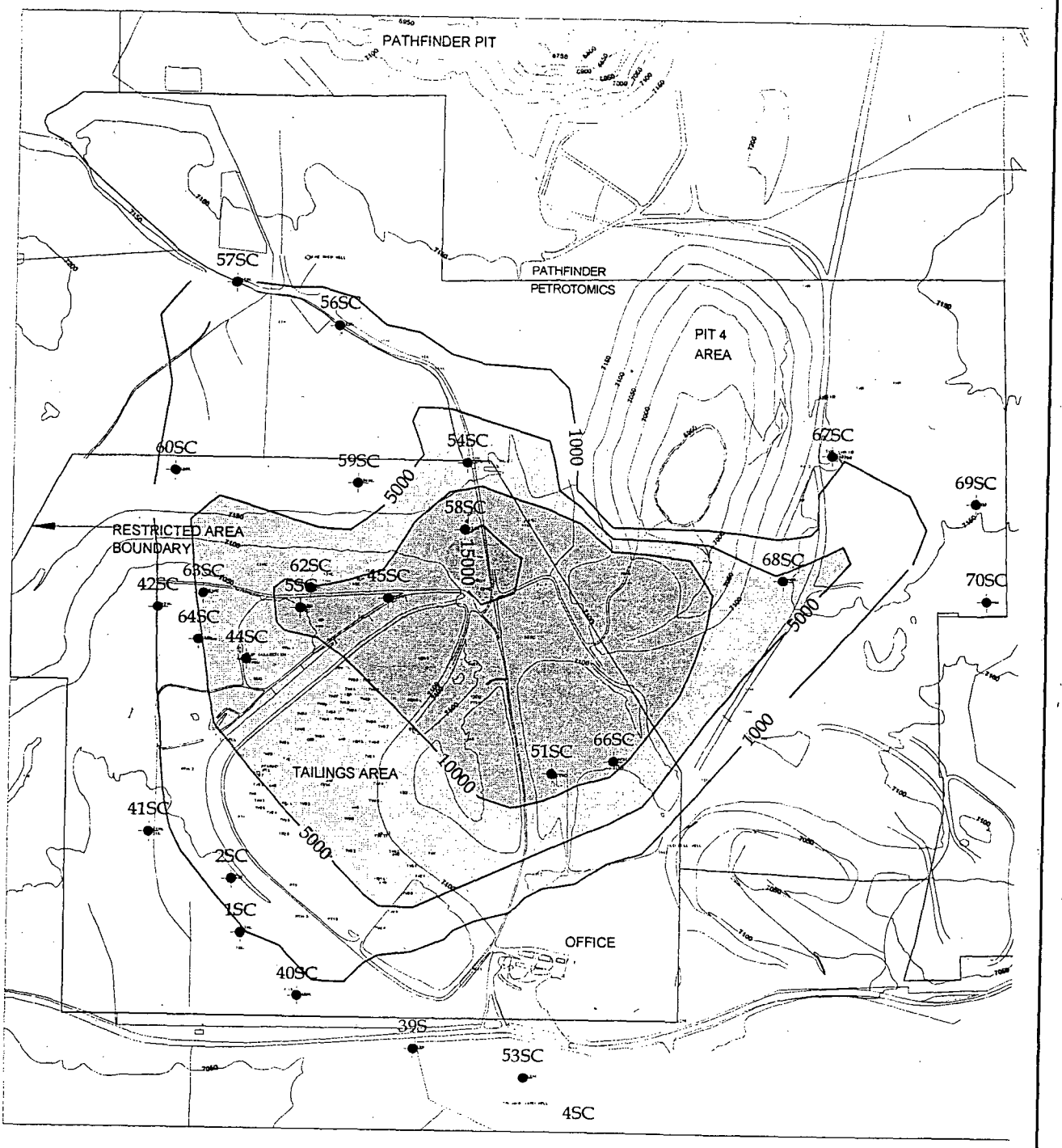
PETROTOMICS COMPANY
Figure 3-13
Simulated Sulfate Concentration, Upper Sand, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt



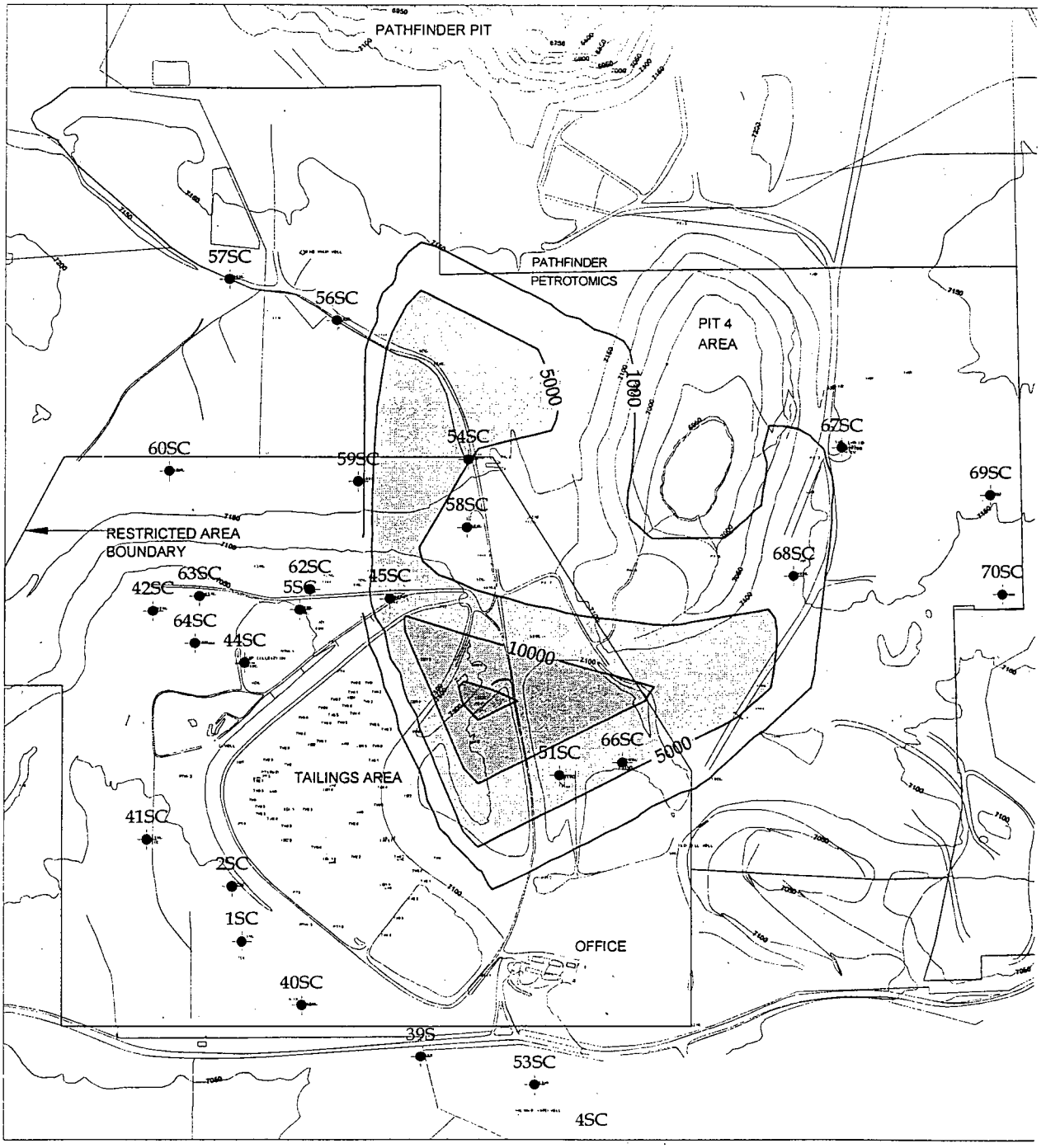
PETROTOMICS COMPANY
Figure 3-14
Simulated Sulfate Concentration, Main Sand, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt



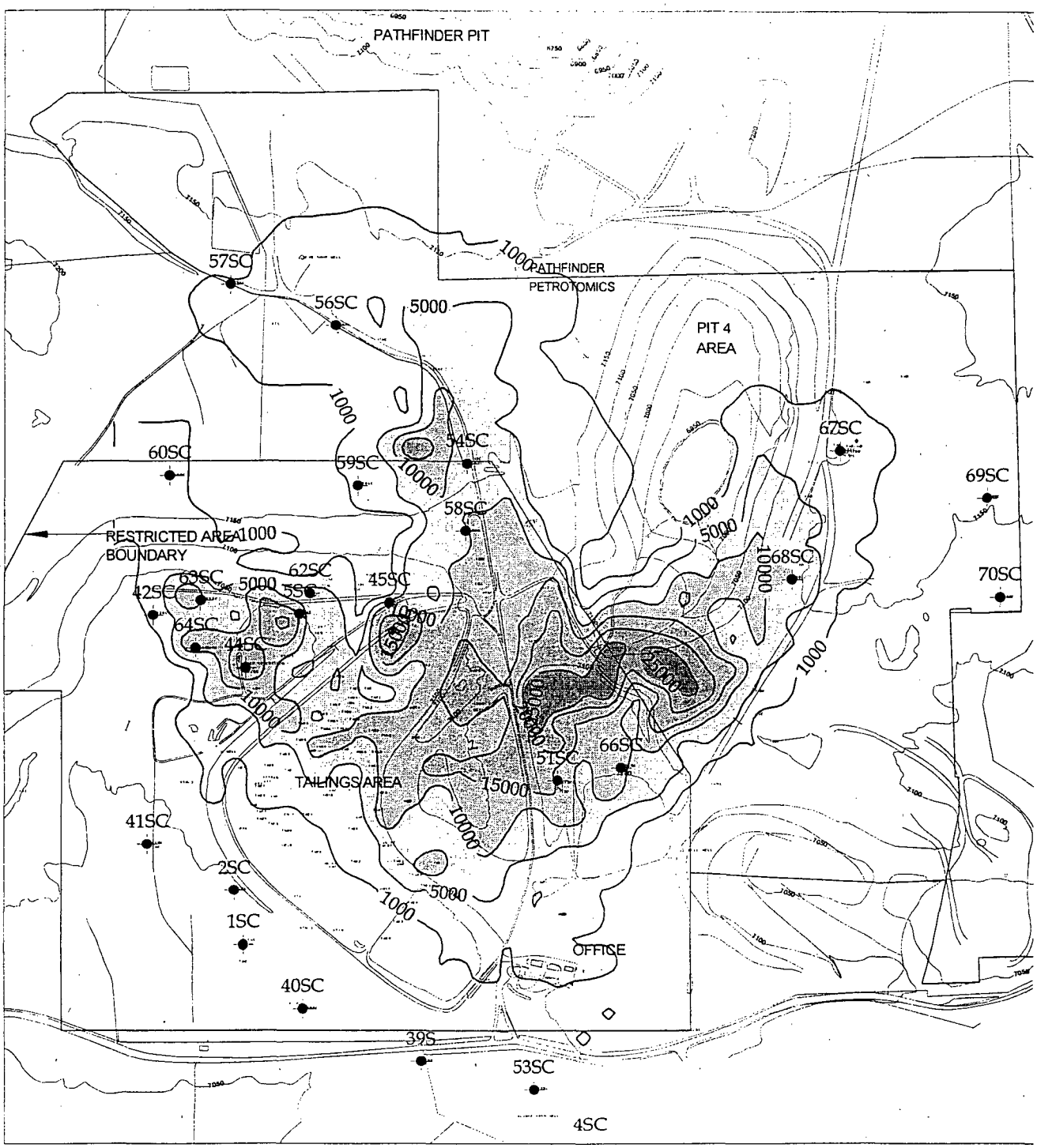
PETROTOMICS COMPANY
Figure 3-15
Observed Sulfate Concentration, Upper Sand, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt



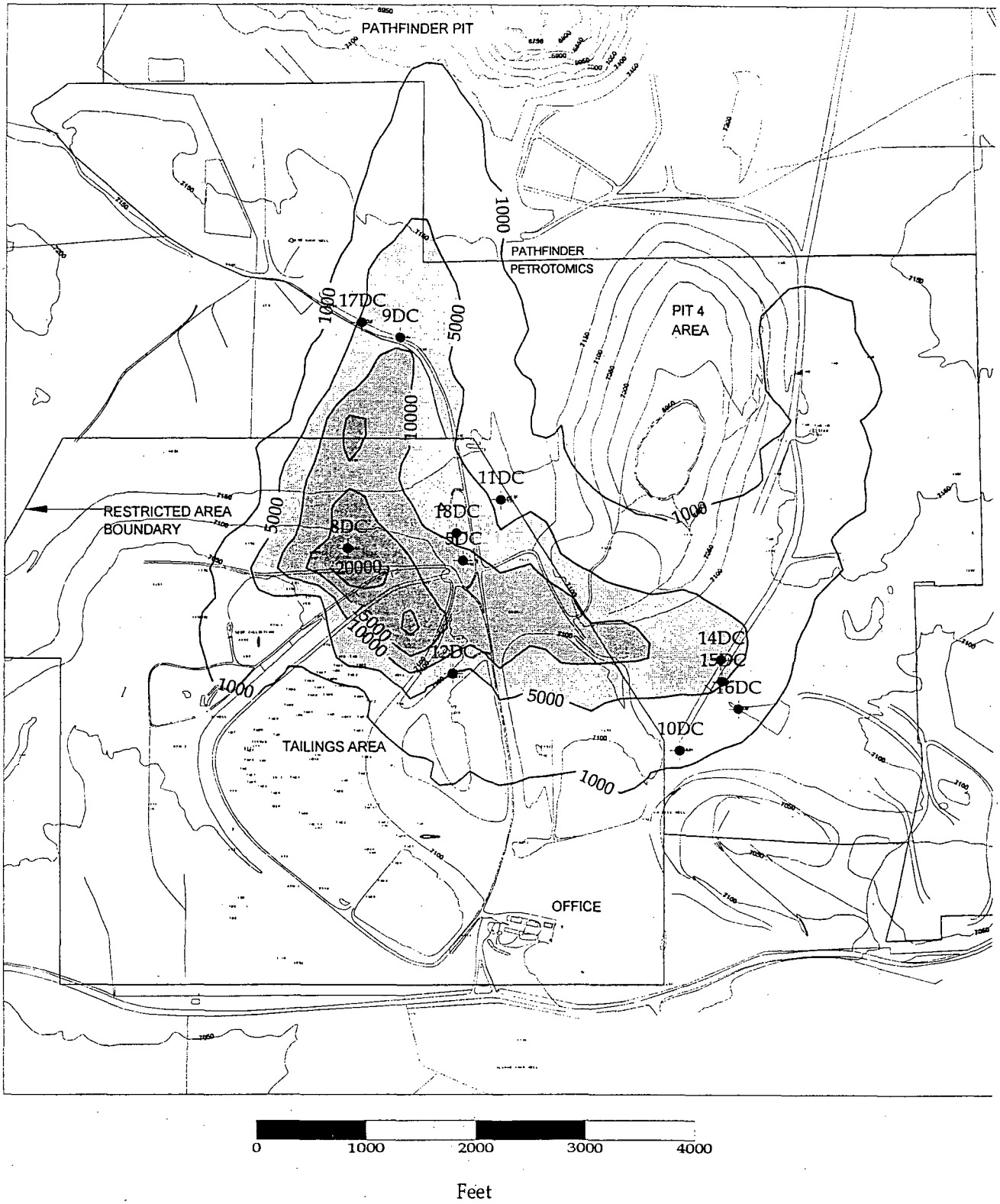
PETROTOMICS COMPANY
Figure 3-16
Observed Sulfate Concentration, Main Sand, End of Verification Period (1997)

Date:	March 1998
Project:	100119
File:	form.ppt



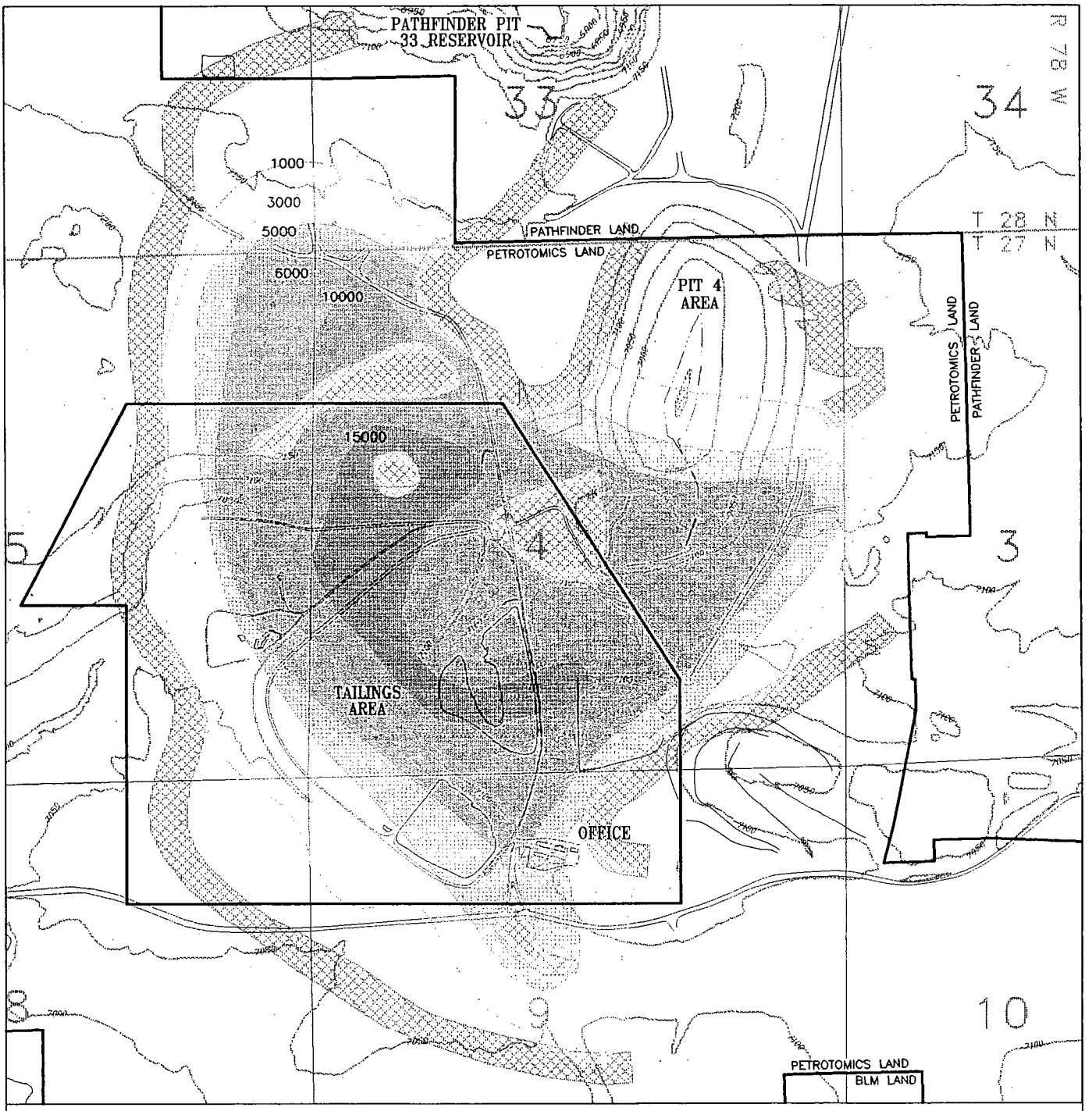
PETROTOMICS COMPANY
Figure 3-17
Simulated Sulfate Concentration, Upper Sand, 1995

Date:	March 1998
Project:	100119
File:	form.ppt



PETROTOMICS COMPANY
Figure 3-18
Simulated Sulfate Concentration, Main Sand, 1995

Date:	March 1998
Project:	100119
File:	form.ppt



LEGEND

PETROTOMICS PROPERTY BOUNDARY

NRC RESTRICED AREA BOUNDARY

15000 mg/l

10000 mg/l

6000 mg/l

5000 mg/l

3000 mg/l

1000 mg/l

NO FLOW AREAS

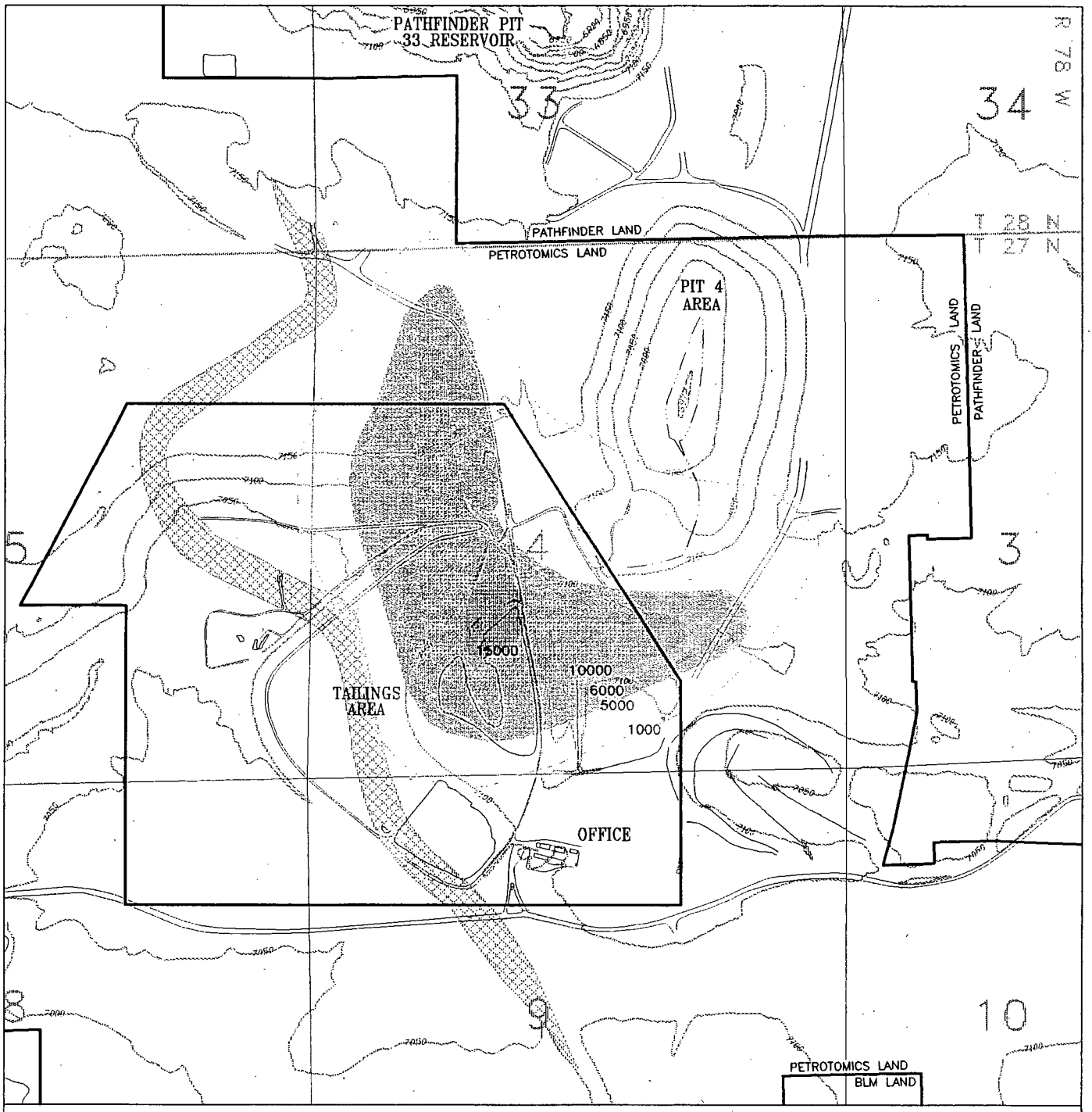
SCALE IN FEET

1500 0 3000

N

PETROTOMICS COMPANY		
OBSERVED SULFATE CONCENTRATION, UPPER SAND, 1995		
FIGURE 3-19	SCALE 1" = 1500'	DATE: MAR.1998

100119\SU-1995



LEGEND

PETROTOMICS PROPERTY BOUNDARY

NRC RESTRICED AREA BOUNDARY

15000 mg/l

10000 mg/l

6000 mg/l

5000 mg/l

1000 mg/l

NO FLOW AREAS

SCALE IN FEET

1500 0 3000

N

PETROTOMICS COMPANY

OBSERVED SULFATE CONCENTRATION, MAIN SAND, 1995

FIGURE 3-20	SCALE 1" = 1500'	DATE: MAR. 1998

100119\SU-1995

4. SUMMARY

Petrotomics has validated the ground water flow and transport models used to predict the fate and transport of site derived constituents in support of Petrotomics ACL application (Petrotomics, 1996). Results of the ground water flow model verification indicate the site flow model is capable of simulating complex hydrologic conditions with a high degree of accuracy, and can be used with confidence to make future predictions. Results of the transport model verification indicate that the concentration of uranium and sulfate is overpredicted in the majority of site monitoring wells, and that the downgradient extent of the plumes are also overestimated. This result supports the conclusion that projected POE concentrations presented in the ACL application (Petrotomics, 1996) are conservative values, and that associated risks have been overestimated. These results support Petrotomics' position that the site models are conservative, and that conclusions drawn from model results are valid.

5. REFERENCES

Petrotomics. 1996. *Petrotomics Tailings Facility Application for Alternate Concentration Limits to Amend USNRC Source Material License SUA 551.* September.

Petrotomics. 1997. *Petrotomics Tailings Facility Application for Alternate Concentration Limits, Source Material License SUA 551, Response to NRC Open Issues 1, 4, and 5.* October.

Koch and Prickett. 1993. User's Manual for PREMOD3D, Engineering Technologies Associates, Inc., Ellicott City, Maryland.

ATTACHMENT A

FLOW MODEL VERIFICATION SCOPE OF WORK

SHEPHERD MILLER
INCORPORATED

COPY

Mr. Mike Franko
Project Manager
Texaco Exploration and Production, Inc.
P.O. Box 2100
4601 DTC Boulevard
Denver, CO 80237

January 27, 1998

RE: Scope of Work for Flow Model Verification

Dear Mike:

As requested, I have prepared a scope of work to verify the Petrotomics ground water flow model over the period 1993 through 1997. As previously discussed in our written response to NRC Open Issue 5, this work is complex and will require some assumptions to account for data gaps. Equally important, numerical instability and/or oscillation associated with aquifer dewatering is a possibility, and there is no guarantee that an acceptable numerical solution can be obtained (e.g. verification may not be possible). With these potential limitations in mind, the following scope of work should resolve remaining NRC concerns related to ground water modeling at the Petrotomics site.

TASK 1 - DATA COLLECTION AND ANALYSIS

This task involves the general compilation and analysis of hydrologic data necessary to run the flow model and assess model results over the period 1993 to 1997. These data include:

- Verification targets, including water level data from monitoring wells and pits. Annual average water level data from monitoring wells will be used as verification targets. Pit water level data and pit dewatering rates over this period is relatively sparse. As a result, significant uncertainty will be associated with pit water level and flux targets.

- Pit geometry, stage-volume relationship, and operational mode (e.g. dewatering vs. recovery, open vs. backfilled) over the simulation period are required to simulate ground water flow correctly. Pathfinder Pit 33 and the Area 3 pit were expanding at various times during the simulation period. Significant assumptions regarding pit geometry and operational mode will be necessary to complete flow model simulations.

Environmental & Engineering Consultants

2460 W. 26th Avenue, Suite 430C
Denver, Colorado 80211
Phone (303) 477-5338
Fax (303) 477-5318

- Hydrologic stresses, primarily pumping rates from wells and dewatering rates of pits. Pumping rates of corrective action wells are highly variable and cyclical. For purposes of model verification, annual average pumping rates will be assumed to be representative. Areal recharge and evaporation rates from the 1981 to 1985 calibration period will be used for the model verification period.

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TASK 2 - FLOW MODEL DEVELOPMENT

This task involves the development of MODFLOW input files necessary to complete verification simulations. Data compiled in Task 1 will be incorporated into the calibrated flow model with the aid of Ground Water Vistas, a popular pre-processing software package for MODFLOW.

TASK 3 - VERIFICATION SIMULATIONS

This task involves the computer simulation of ground water flow over the verification period. Due to the changing geometry and reclamation pattern of pits over the simulation period, it may not be possible to complete the flow model verification in a single transient simulation. Instead, the calibrated flow model would require periodic modification (e.g. every year) to incorporate the changing shape and volume of mine pits. Flow model verification will therefore proceed as a series of individual transient simulations, each initialized from the results of the previous simulation period.

As previously stated, flow model instability and/or oscillation associated with aquifer dewatering and the simulation of very thin aquifers is anticipated. It is possible that a majority of the time required to complete model verification will be devoted to obtaining an acceptable numerical solution (e.g. convergence with an acceptably low water balance error). It is also possible that, after considerable effort, a stable solution cannot be obtained. In this case, the flow model cannot be verified. Sensitivity analyses performed as part of the response to NRC Open Issue 5 should be an adequate substitute for the lack of such verification.

TASK 4 - TRANSPORT MODEL SIMULATIONS

The NRC has suggested that Petrotomics demonstrate the conservativeness of the verified flow model by showing that the model overpredicts the migration of contaminants. This task involves the simulation of uranium and sulfate transport over the period 1993 to 1997 in order to further demonstrate the conservativeness of the site ground water flow and transport models.

The uranium and sulfate distribution for 1993 will be contoured and digitized as an initial starting position for the transport model simulation. In order to simulate transport over the period 1993 to 1997 with RAND3D, ground water velocity files from the verified flow model will be produced on a yearly basis using a Fortran program (PREMOD).

Transport model parameters (e.g. dispersivity, effective porosity, source loading) will be identical to conservative values previously developed for predictive modeling purposes.

Model results will be compared to measured concentrations at monitoring wells over the simulation period in order to assess the adequacy and conservativeness of model predictions.

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TASK 5 - REPORTING

Due to the extreme scheduling limitations required by the NRC, it is anticipated that phone conversations will be held with NRC and their staff to discuss the progress and results of the modeling as it progresses. A limited number of illustrations and exhibits will be prepared for these phone conversations that illustrate the major results of the verification effort. If required by NRC and time permits, a draft technical memorandum will be prepared and submitted to Texaco/Petrotomics that summarizes the methods, results, and conclusions of the verification effort in detail. Comments received from Texaco/ Petrotomics will be incorporated into a final draft technical memo, and submitted to the NRC for review and comment.

SCHEDULE

It is anticipated that the scope of work will require approximately 270 man-hours to complete. Assuming two professional staff members working full time, this work can be accomplished within a one month period.

Please contact me if you have any comments or questions regarding this scope of work. I look forward to the successful completion of this project.

Sincerely,

Robert L. Lewis
SMI Project Manager

ATTACHMENT B

MONITORING WELL WATER QUALITY DATA

Attachment B Monitoring Well Water Quality Data (Page 1 of 15)

Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
01 SC	w	2/21/92	1400	2/21/92	.019
01 SC	w	6/5/92	1560	6/5/92	.007
01 SC	w	8/27/92	1580	8/27/92	.021
01 SC	w	12/3/92	1310	12/3/92	.011
01 SC	w	2/10/93	1420	2/10/93	.02
01 SC	w	5/18/93	1250	5/18/93	.014
01 SC	w	8/9/93	1360	8/9/93	.03
01 SC	w	11/23/93	1800	11/23/93	.024
01 SC	c	3/2/94	2280	3/2/94	.03
01 SC	c	6/6/94	2130	6/6/94	.027
01 SC	c	9/16/94	2090	9/16/94	.004
01 SC	c	12/9/94	2130	12/9/94	
01 SC	c	2/21/95	2020	2/21/95	.029
01 SC	c	5/17/95	1980	5/17/95	
01 SC	c	8/29/95	1830	8/29/95	.026
01 SC	c	11/28/95	2120	11/28/95	
01 SC	c	2/22/96	1860	2/22/96	.028
01 SC	w	2/22/96		2/22/96	.004
01 SC	c	6/3/96	1900	6/3/96	
01 SC	c	8/6/96	1890	8/6/96	.015
01 SC	c	2/19/97	1920	2/19/97	.021
01 SC	w	8/21/97	1600	8/21/97	.02
01 SC	w	11/12/97	1660	11/12/97	
04 SC	w	6/4/92	3000	6/4/92	.143
04 SC	w	8/26/92	3000	8/26/92	.155
04 SC	w	12/2/92	3080	12/2/92	.085
04 SC	w	3/2/93	2860	3/2/93	.123
04 SC	w	5/18/93	2620	5/18/93	.119
04 SC	w	8/9/93	2920	8/9/93	.267
04 SC	w	11/22/93	2620	11/22/93	.156
04 SC	c	3/2/94	3260	3/2/94	.185
04 SC	c	6/7/94	3000	6/7/94	.175
04 SC	c	9/14/94	2680	9/14/94	.191
04 SC	c	12/9/94	2700	12/9/94	
04 SC	c	2/21/95	2440	2/21/95	.2
04 SC	c	2/21/95	2380	2/21/95	.199
04 SC	c	5/18/95	2460	5/18/95	
04 SC	c	8/28/95	2260	8/28/95	.195
04 SC	c	11/27/95	1840	11/27/95	
04 SC	c	2/22/96	2680	2/22/96	.103
04 SC	w	2/22/96		2/22/96	.121
04 SC	c	6/5/96	2700	6/5/96	
04 SC	c	8/5/96	2720	8/5/96	.172
04 SC	c	11/25/96	2460	11/25/96	
04 SC	c	2/19/97	2160	2/19/97	.208
04 SC	w	5/20/97	2020	5/20/97	

Attachment B Monitoring Well Water Quality Data (Page 2 of 15)

Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
04 SC	w	8/20/97	2680	8/20/97	.139
04 SC	w	11/11/97	2040	11/11/97	
05 SC	w	2/18/92	17800	2/18/92	7.52
05 SC	w	6/4/92	17200	6/4/92	15.9
05 SC	w	8/26/92	4480	8/26/92	3.22
05 SC	w	12/2/92	7400	12/2/92	3.31
05 SC	w	3/1/93	10320	3/1/93	3.73
05 SC	w	5/18/93	12080	5/18/93	5.87
05 SC	w	8/9/93	12960	8/9/93	10.7
05 SC	w	11/23/93	15000	11/23/93	8.82
05 SC	c	3/3/94	18600	3/3/94	8.85
05 SC	c	6/6/94	17500	6/6/94	7.96
05 SC	c	9/16/94	15700	9/16/94	3.61
05 SC	c	12/9/94	15900	12/9/94	
05 SC	c	12/9/94	15200	12/9/94	
05 SC	c	2/28/95	16100	2/28/95	7
05 SC	c	5/17/95	15300	5/17/95	
05 SC	c	8/29/95	16000	8/29/95	7.56
05 SC	c	11/29/95	17600	11/29/95	
05 SC	c	2/28/96	16900	2/28/96	1.2
05 SC	w	2/28/96		2/28/96	5.55
05 SC	c	6/5/96	18000	6/5/96	
05 SC	c	8/6/96	15600	8/6/96	14.7
05 SC	c	11/25/96	17500	11/25/96	
05 SC	c	2/19/97	18100	2/19/97	7.35
05 SC	w	5/22/97	14000	5/22/97	
05 SC	w	8/20/97	16100	8/20/97	7.13
05 SC	w	11/11/97	11800	11/11/97	
40 SC	w	2/20/92	1240	2/20/92	.013
40 SC	w	6/4/92	1290	6/4/92	.005
40 SC	w	8/26/92	1470	8/26/92	.003
40 SC	w	12/2/92	1280	12/2/92	**.0005**
40 SC	w	2/9/93	1330	2/9/93	.005
40 SC	w	5/18/93	760	5/18/93	.009
40 SC	w	8/9/93	1020	8/9/93	.002
40 SC	w	11/22/93	1000	11/22/93	.003
40 SC	e	11/22/93	936	11/22/93	**.00015**
40 SC	c	11/22/93	1100	11/22/93	**.0005**
40 SC	c	3/2/94	1150	3/2/94	**.0005**
40 SC	c	6/6/94	1060	6/6/94	.002
40 SC	c	9/14/94	1080	9/14/94	**.0005**
40 SC	c	12/9/94	1170	12/9/94	
40 SC	c	2/21/95	920	2/21/95	.002
40 SC	c	5/17/95	1160	5/17/95	
40 SC	c	8/28/95	1350	8/28/95	**.0005**
40 SC	c	11/28/95	1330	11/28/95	

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
40 SC	c	2/22/96	1360	2/22/96	.0018
40 SC	w	2/22/96		2/22/96	**.0005**
40 SC	c	6/3/96	1430	6/3/96	
40 SC	c	8/6/96	1560	8/6/96	**.0005**
40 SC	c	11/25/96	1520	11/25/96	
40 SC	c	2/19/97	1300	2/19/97	**.0005**
40 SC	w	5/21/97	650	5/21/97	
40 SC	w	8/20/97	893	8/20/97	.008
40 SC	w	11/11/97	1040	11/11/97	
42 SC	w	2/19/92	3120	2/19/92	2.34
42 SC	w	6/4/92	3580	6/4/92	1.71
42 SC	w	8/26/92	3840	8/26/92	1.25
42 SC	w	12/2/92	2840	12/2/92	.631
42 SC	w	3/1/93	3080	3/1/93	1.06
42 SC	w	5/18/93	2820	5/18/93	2.4
42 SC	w	8/9/93	3000	8/9/93	5.31
42 SC	w	11/30/93	2800	11/30/93	1.05
42 SC	c	3/3/94	3540	3/3/94	3.7
42 SC	c	6/6/94	3180	6/6/94	5.32
42 SC	c	9/19/94	3040	9/19/94	3.3
42 SC	c	12/7/94	2910	12/7/94	
42 SC	c	2/28/95	2910	2/28/95	2.87
42 SC	c	5/18/95	3000	5/18/95	
42 SC	c	8/29/95	2760	8/29/95	3.27
42 SC	c	11/29/95	2760	11/29/95	
42 SC	c	2/21/96	2600	2/21/96	1.55
42 SC	w	2/21/96		2/21/96	1.24
42 SC	c	6/6/96	2770	6/6/96	
42 SC	c	8/6/96	2920	8/6/96	1.836
42 SC	c	11/26/96	3100	11/26/96	
42 SC	c	2/18/97	3180	2/18/97	2.04
42 SC	w	5/22/97	2800	5/22/97	
42 SC	w	8/21/97	3440	8/21/97	1.49
42 SC	w	11/11/97	2440	11/11/97	
44 SC	w	2/20/92	14100	2/20/92	4.37
44 SC	w	6/4/92	14600	6/4/92	4.83
44 SC	w	8/26/92	15000	8/26/92	3.56
44 SC	w	12/2/92	14240	12/2/92	3.54
44 SC	w	3/1/93	13920	3/1/93	2.45
44 SC	w	5/18/93	12800	5/18/93	4.03
44 SC	w	8/9/93	12960	8/9/93	6.13
44 SC	w	11/22/93	12000	11/22/93	5.33
44 SC	w	11/22/93	11900	11/22/93	5.16
44 SC	e	11/22/93	10834	11/22/93	6.93
44 SC	c	11/22/93	11600	11/22/93	7.09
44 SC	c	3/3/94	14800	3/3/94	5.2

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
44 SC	c	6/6/94	14400	6/6/94	5.09
44 SC	c	9/16/94	15100	9/16/94	.003
44 SC	c	12/9/94	14600	12/9/94	
44 SC	c	2/22/95	11900	2/22/95	4.12
44 SC	c	5/17/95	12100	5/17/95	
44 SC	c	8/29/95	13200	8/29/95	4.84
44 SC	c	11/28/95	12400	11/28/95	
44 SC	c	2/28/96	12800	2/28/96	5.08
44 SC	w	2/28/96		2/28/96	3.08
44 SC	c	6/5/96	14900	6/5/96	
44 SC	c	8/6/96	10900	8/6/96	3.71
44 SC	c	11/25/96	13800	11/25/96	
44 SC	c	2/19/97	13400	2/19/97	4.35
44 SC	w	5/21/97	12100	5/21/97	
44 SC	w	5/21/97	11600	5/21/97	
44 SC	w	8/20/97	9100	8/20/97	2.5
44 SC	w	11/11/97	7500	11/11/97	
49 SC	w	11/23/93	2400	11/23/93	.01
49 SC	w	3/7/94	2570	3/7/94	.023
49 SC	c	2/21/96	2110	2/21/96	**.0005**
49 SC	w	2/21/96		2/21/96	**.0005**
49 SC	w	5/22/97	1730	5/22/97	
51 SC	w	2/20/92	17800	2/20/92	.039
51 SC	w	6/4/92	18500	6/4/92	.016
51 SC	w	8/26/92	19600	8/26/92	.017
51 SC	w	12/2/92	17400	12/2/92	**.0005**
51 SC	w	3/2/93	16400	3/2/93	.02
51 SC	w	5/18/93	18000	5/18/93	.009
51 SC	w	8/9/93	18200	8/9/93	.022
51 SC	w	11/30/93	18300	11/30/93	.063
51 SC	c	6/7/94	22300	6/7/94	.212
51 SC	c	9/15/94	19300	9/15/94	.063
51 SC	c	12/6/94	18600	12/6/94	
51 SC	c	2/14/95	17800	2/14/95	.03
51 SC	c	5/18/95	16500	5/18/95	
51 SC	c	8/28/95	17500	8/28/95	.022
51 SC	c	11/28/95	16900	11/28/95	
51 SC	c	2/28/96	18900	2/28/96	**.0005**
51 SC	w	2/28/96		2/28/96	.014
51 SC	c	6/5/96	18500	6/5/96	
51 SC	c	8/6/96	16000	8/6/96	.004
51 SC	c	11/26/96	17200	11/26/96	
51 SC	c	2/18/97	17000	2/18/97	.019
51 SC	w	5/22/97	14100	5/22/97	
51 SC	w	8/21/97	17200	8/21/97	.009
51 SC	w	11/12/97	12300	11/12/97	

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
53 SC	w	2/20/92	3060	2/20/92	.082
53 SC	w	6/4/92	3240	6/4/92	.073
53 SC	w	8/26/92	3880	8/26/92	.073
53 SC	w	12/2/92	3040	12/2/92	.074
53 SC	w	3/2/93	3200	3/2/93	.07
53 SC	w	5/18/93	3080	5/18/93	.082
53 SC	w	8/9/93	3200	8/9/93	.099
53 SC	w	11/30/93	2820	11/30/93	.036
53 SC	c	3/2/94	3840	3/2/94	.123
53 SC	c	6/7/94	3440	6/7/94	.114
53 SC	c	9/14/94	2890	9/14/94	.113
53 SC	c	12/6/94	3190	12/6/94	
53 SC	c	2/28/95	3320	2/28/95	**.0005**
53 SC	c	5/19/95	3110	5/19/95	
53 SC	c	8/29/95	3200	8/29/95	.14
53 SC	c	11/29/95	3180	11/29/95	
53 SC	c	2/21/96	3280	2/21/96	.133
53 SC	w	2/21/96		2/21/96	.061
53 SC	c	6/6/96	3640	6/6/96	
53 SC	c	8/6/96	3510	8/6/96	.114
53 SC	c	11/26/96	3440	11/26/96	
53 SC	c	2/19/97	3180	2/19/97	.155
53 SC	w	5/22/97	3200	5/22/97	
53 SC	w	8/21/97	2880	8/21/97	.122
53 SC	w	11/12/97	3000	11/12/97	
54 SC	w	2/20/92	8900	2/20/92	.009
54 SC	w	6/4/92	9000	6/4/92	.013
54 SC	w	8/26/92	8330	8/26/92	.004
54 SC	w	12/2/92	5760	12/2/92	.028
54 SC	w	2/9/93	5920	2/9/93	.043
54 SC	w	5/19/93	5520	5/19/93	.008
54 SC	w	8/10/93	6720	8/10/93	.022
54 SC	w	11/22/93	6440	11/22/93	**.0005**
54 SC	c	3/7/94	9440	3/7/94	.003
54 SC	c	6/6/94	9750	6/6/94	.003
54 SC	c	6/6/94	9100	6/6/94	.002
54 SC	c	9/19/94	9680	9/19/94	.001
54 SC	c	12/6/94	7960	12/6/94	
54 SC	c	2/23/95	7300	2/23/95	.003
54 SC	c	5/18/95	7680	5/18/95	
54 SC	c	8/28/95	8280	8/28/95	**.0005**
54 SC	c	11/27/95	8320	11/27/95	
54 SC	c	2/22/96	9200	2/22/96	.003
54 SC	w	2/22/96		2/22/96	.009
54 SC	c	6/3/96	9000	6/3/96	
54 SC	c	8/6/96	7450	8/6/96	.001

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
54 SC	c	2/17/97	6360	2/17/97	.017
54 SC	w	5/20/97	6880	5/20/97	
54 SC	w	8/20/97	9500	8/20/97	.014
54 SC	w	11/13/97	7500	11/13/97	
56 SC	w	2/20/92	8700	2/20/92	.033
56 SC	w	5/22/92	9100	5/22/92	.028
56 SC	w	6/4/92	8000	6/4/92	.006
56 SC	w	8/24/92	8800	8/24/92	.006
56 SC	w	12/2/92	8880	12/2/92	.058
56 SC	w	3/2/93	8800	3/2/93	.009
56 SC	w	5/19/93	9000	5/19/93	.014
56 SC	w	8/10/93	8200	8/10/93	.013
56 SC	w	11/30/93	9800	11/30/93	.029
56 SC	c	3/7/94	11400	3/7/94	.054
56 SC	c	6/8/94	7800	6/8/94	.016
56 SC	c	9/19/94	7880	9/19/94	.03
56 SC	c	12/6/94	9480	12/6/94	
56 SC	c	2/23/95	10600	2/23/95	.024
56 SC	c	5/19/95	10320	5/19/95	
56 SC	c	8/29/95	9800	8/29/95	.032
56 SC	c	11/29/95	7400	11/29/95	
56 SC	c	2/21/96	4340	2/21/96	**.0005**
56 SC	w	2/21/96		2/21/96	.011
56 SC	c	6/6/96	3140	6/6/96	
56 SC	c	8/6/96	2560	8/6/96	**.0005**
56 SC	c	11/26/96	2420	11/26/96	
56 SC	c	2/24/97	2680	2/24/97	
56 SC	w	8/21/97	2560	8/21/97	.009
57 SC	w	2/20/92	7900	2/20/92	.025
57 SC	w	5/22/92	7200	5/22/92	.004
57 SC	w	6/4/92	7640	6/4/92	.018
57 SC	w	8/24/92	9200	8/24/92	.019
57 SC	w	12/2/92	8480	12/2/92	.002
57 SC	w	3/2/93	8560	3/2/93	.01
57 SC	w	5/19/93	7900	5/19/93	**.0005**
57 SC	w	8/10/93	6800	8/10/93	.005
57 SC	w	11/30/93	8000	11/30/93	.011
57 SC	c	3/7/94	9000	3/7/94	.003
57 SC	c	6/8/94	8040	6/8/94	.002
57 SC	c	9/19/94	8120	9/19/94	.008
57 SC	c	12/8/94	7360	12/8/94	
57 SC	c	2/23/95	5820	2/23/95	.003
57 SC	c	5/18/95	5820	5/18/95	
57 SC	c	8/29/95	5300	8/29/95	.004
57 SC	c	11/29/95	5180	11/29/95	
57 SC	c	2/21/96	4560	2/21/96	**.0005**

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
57 SC	w	2/21/96		2/21/96	.015
57 SC	c	6/6/96	4100	6/6/96	
57 SC	c	8/6/96	3140	8/6/96	**.0005**
57 SC	c	11/26/96	2880	11/26/96	
57 SC	c	2/24/97	3180	2/24/97	
57 SC	w	8/21/97	3000	8/21/97	**.0005**
58 SC	w	2/20/92	17400	2/20/92	.03
58 SC	w	6/4/92	18200	6/4/92	.01
58 SC	w	8/26/92	19400	8/26/92	.061
58 SC	w	12/2/92	17800	12/2/92	.006
58 SC	w	2/9/93	17100	2/9/93	.011
58 SC	w	8/10/93	17600	8/10/93	.036
58 SC	w	11/22/93	18000	11/22/93	.013
58 SC	e	11/22/93	17305	11/22/93	.02
58 SC	c	11/22/93	16500	11/22/93	.015
58 SC	c	3/2/94	21000	3/2/94	.01
58 SC	c	6/6/94	19800	6/6/94	.008
58 SC	c	9/15/94	19900	9/15/94	.011
58 SC	c	12/6/94	19300	12/6/94	
58 SC	c	2/14/95	18400	2/14/95	.02
58 SC	a	2/14/95	16000	2/14/95	.082
58 SC	w	2/14/95	17400	2/14/95	.012
58 SC	c	6/6/95	20700	6/6/95	
58 SC	c	8/28/95	18300	8/28/95	.018
58 SC	c	11/29/95	18500	11/29/95	
58 SC	c	11/29/95	16200	11/29/95	
58 SC	c	2/22/96	22400	2/22/96	.022
58 SC	w	2/22/96		2/22/96	.017
58 SC	c	6/3/96	19200	6/3/96	
58 SC	c	8/5/96	19300	8/5/96	.006
58 SC	c	11/25/96	20400	11/25/96	
58 SC	c	2/17/97	19100	2/17/97	.03
58 SC	w	5/20/97	15400	5/20/97	
58 SC	w	8/20/97	18200	8/20/97	.008
58 SC	w	11/13/97	16600	11/13/97	
62 SC	w	10/31/90	9600	10/31/90	8.38
62 SC	w	2/9/91	14800	2/9/91	5.98
62 SC	w	6/13/91	16100	6/13/91	1.15
62 SC	w	9/26/91	15000	9/26/91	4.92
62 SC	w	11/27/91	18600	11/27/91	2.98
62 SC	w	2/20/92	17900	2/20/92	1.1
62 SC	w	6/4/92	18000	6/4/92	.452
62 SC	w	8/26/92	18500	8/26/92	1.14
62 SC	w	12/2/92	18100	12/2/92	.917
62 SC	w	3/1/93	18000	3/1/93	.588
62 SC	w	5/18/93	17300	5/18/93	.416

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
62 SC	w	8/9/93	16000	8/9/93	.625
62 SC	w	11/22/93	16700	11/22/93	1.17
62 SC	c	3/7/94	21900	3/7/94	.716
62 SC	c	2/16/95	16700	2/16/95	1.77
62 SC	c	6/3/96	15000	6/3/96	.719
62 SC	c	2/18/97	17500	2/18/97	1.63
63 SC	w	11/14/90	11000	11/14/90	2.53
63 SC	w	2/9/91	10200	2/9/91	4.6
63 SC	w	6/12/91	9800	6/12/91	3.45
63 SC	w	9/26/91	10400	9/26/91	2.61
63 SC	w	11/27/91	12800	11/27/91	4.11
63 SC	w	2/20/92	10000	2/20/92	3.33
63 SC	w	6/4/92	10000	6/4/92	2.77
63 SC	w	8/26/92	10200	8/26/92	2.67
63 SC	w	12/2/92	10100	12/2/92	3.04
63 SC	w	3/1/93	9600	3/1/93	2.81
63 SC	w	5/18/93	8800	5/18/93	2.08
63 SC	w	8/9/93	9900	8/9/93	2.78
63 SC	w	11/22/93	9000	11/22/93	4.7
63 SC	c	3/2/94	10900	3/2/94	4.84
63 SC	c	2/16/95	9400	2/16/95	7.68
63 SC	c	2/26/96	8480	2/26/96	7.63
63 SC	w	2/26/96		2/26/96	3.93
63 SC	c	2/18/97	7550	2/18/97	5.01
64 SC	w	11/14/90	12000	11/14/90	3.49
64 SC	w	2/9/91	12000	2/9/91	6.14
64 SC	w	6/12/91	10400	6/12/91	3.89
64 SC	w	9/26/91	10300	9/26/91	4.61
64 SC	w	11/27/91	10600	11/27/91	4.31
64 SC	w	2/20/92	10200	2/20/92	4.81
64 SC	w	6/4/92	9700	6/4/92	5.49
64 SC	w	8/26/92	10800	8/26/92	4.62
64 SC	w	12/2/92	10300	12/2/92	5.84
64 SC	w	2/9/93	10320	2/9/93	5.12
64 SC	w	5/18/93	9760	5/18/93	5.95
64 SC	w	8/9/93	10560	8/9/93	7.45
64 SC	w	11/22/93	10300	11/22/93	6.23
64 SC	c	3/2/94	11500	3/2/94	7.94
64 SC	c	2/16/95	9520	2/16/95	5.36
64 SC	c	2/22/96	5840	2/22/96	5.27
64 SC	w	2/22/96		2/22/96	2.65
64 SC	c	2/18/97	4280	2/18/97	2.65
66 SC	w	3/11/93	15440	3/11/93	.005
66 SC	w	5/11/93	9000	5/11/93	.006
66 SC	w	8/10/93	8640	8/10/93	.01
66 SC	w	11/23/93	14300	11/23/93	.005

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
66 SC	c	3/8/94	15000	3/8/94	.004
66 SC	c	6/7/94	15000	6/7/94	.005
66 SC	c	9/19/94	18000	9/19/94	.002
66 SC	c	12/8/94	15900	12/8/94	
66 SC	c	2/22/95	14600	2/22/95	.003
66 SC	c	6/7/95	16400	6/7/95	
66 SC	c	8/30/95	14400	8/30/95	.006
66 SC	c	11/29/95	17600	11/29/95	
66 SC	c	2/22/96	20000	2/22/96	.004
66 SC	w	2/22/96		2/22/96	.012
66 SC	c	6/5/96	17100	6/5/96	
66 SC	c	8/6/96	14200	8/6/96	**.0005**
66 SC	c	11/25/96	18600	11/25/96	
66 SC	c	2/18/97	14500	2/18/97	**.0005**
66 SC	w	8/21/97	14000	8/21/97	**.0005**
66 SC	w	11/11/97	11600	11/11/97	
67 SC	w	3/10/93	1300	3/10/93	.04
67 SC	w	5/20/93	1480	5/20/93	.022
67 SC	w	8/10/93	1400	8/10/93	.027
67 SC	w	11/30/93	1280	11/30/93	.02
67 SC	w	11/30/93	1210	11/30/93	.025
67 SC	c	3/3/94	1600	3/3/94	.028
67 SC	c	2/22/95	900	2/22/95	.013
67 SC	c	8/8/95	990	8/8/95	.009
67 SC	c	11/26/96	1105	11/26/96	.006
67 SC	c	2/20/97	940	2/20/97	.004
67 SC	w	5/21/97	1020	5/21/97	.007
68 SC	w	3/15/93	3760	3/15/93	.021
68 SC	w	5/20/93	6300	5/20/93	.001
68 SC	w	8/10/93	6133	8/10/93	.013
68 SC	w	11/30/93	8900	11/30/93	.014
68 SC	c	3/8/94	6760	3/8/94	.003
68 SC	c	2/22/95	7480	2/22/95	.004
68SC	c	8/29/95	5760	8/29/95	.004
68SC	c	2/21/96	6500	2/21/96	.006
68SC	w	2/21/96		2/21/96	.012
68 SC	c	2/25/97	8320	2/25/97	**.0005**
69 SC	c	3/10/94	496	3/10/94	.007
69 SC	c	6/14/94	480	6/14/94	.001
69 SC	c	9/20/94	560	9/20/94	.001
69 SC	c	9/20/94	550	9/20/94	.001
69 SC	c	12/7/94	470	12/7/94	**.0005**
69 SC	c	2/23/95	506	2/23/95	.001
69 SC	c	8/28/95	490	8/28/95	**-.0005**
69 SC	c	2/21/96	450	2/21/96	**.0005**
69 SC	w	2/21/96		2/21/96	.011

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
69 SC	c	11/26/96	470	11/26/96	**.0005**
69 SC	c	2/17/97	510	2/17/97	**.0005**
69 SC	w	5/22/97	480	5/22/97	**.0005**
69 SC	w	8/21/97	547	8/21/97	**.0005**
69 SC	w	11/12/97	420	11/12/97	
70 SC	c	3/15/94	588	3/15/94	.026
70 SC	c	6/14/94	570	6/14/94	.054
70 SC	c	9/20/94	590	9/20/94	.027
70 SC	c	12/13/94	667	12/13/94	.031
70 SC	c	2/23/95	596	2/23/95	.027
70 SC	c	8/28/95	560	8/28/95	.023
70 SC	c	2/21/96	538	2/21/96	.015
70 SC	w	2/21/96		2/21/96	.026
70 SC	c	11/26/96	690	11/26/96	.027
70 SC	c	2/17/97	620	2/17/97	.038
70 SC	w	5/21/97	570	5/21/97	.037
70 SC	w	8/20/97	580	8/20/97	.023
70 SC	w	11/11/97	484	11/11/97	
05 DC	w	6/4/92	5800	6/4/92	.204
05 DC	w	8/26/92	9300	8/26/92	.051
05 DC	w	12/2/92	10100	12/2/92	.001
05 DC	w	2/9/93	9600	2/9/93	.004
05 DC	w	5/18/93	7360	5/18/93	.056
05 DC	w	8/10/93	6400	8/10/93	.034
05 DC	w	11/23/93	7100	11/23/93	.01
05 DC	c	3/3/94	7560	3/3/94	.006
05 DC	c	3/3/94	7680	3/3/94	.007
05 DC	c	6/9/94	6250	6/9/94	.002
05 DC	c	6/9/94	6640	6/9/94	.003
05 DC	c	9/16/94	6800	9/16/94	.024
05 DC	c	12/8/94	6480	12/8/94	.002
05 DC	c	2/16/95	6080	2/16/95	.001
05 DC	c	5/19/95	5620	5/19/95	.003
05 DC	c	8/30/95	5580	8/30/95	.007
05 DC	c	11/28/95	5790	11/28/95	.002
05 DC	c	2/29/96	5440	2/29/96	.002
05 DC	w	2/29/96		2/29/96	.006
05 DC	c	6/5/96	5760	6/5/96	.001
05 DC	c	2/19/97	5900	2/19/97	.001
05 DC	w	8/20/97	4840	8/20/97	.001
05 DC	w	11/11/97	4200	11/11/97	
08 DC	w	5/4/92	17800	5/4/92	.013
08 DC	w	8/25/92	19800	8/25/92	.021
08 DC	w	12/15/92	15000	12/15/92	.003
08 DC	w	3/3/93	16000	3/3/93	.066
08 DC	w	5/19/93	14000	5/19/93	.005

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
08 DC	w	8/9/93	15200	8/9/93	.034
08 DC	w	11/23/93	12400	11/23/93	.023
08 DC	c	3/8/94	11400	3/8/94	.025
08 DC	c	12/13/94	8900	12/13/94	.021
08 DC	c	2/28/95	9900	2/28/95	.028
08 DC	c	5/18/95	8600	5/18/95	.029
08 DC	c	8/30/95	9920	8/30/95	.039
08 DC	c	11/28/95	8080	11/28/95	.001
08 DC	c	2/29/96	7750	2/29/96	.009
08 DC	w	2/29/96		2/29/96	.015
08 DC	c	6/5/96	6833	6/5/96	.008
08 DC	c	2/19/97	200	2/19/97	.029
09 DC	w	5/1/92	5640	5/1/92	.016
09 DC	w	8/24/92	6560	8/24/92	.006
09 DC	w	12/15/92	6440	12/15/92	.007
09 DC	w	3/8/93	7120	3/8/93	.007
09 DC	w	5/19/93	6200	5/19/93	.001
09 DC	w	8/10/93	6200	8/10/93	.012
09 DC	w	11/23/93	7216	11/23/93	.001
09 DC	c	3/7/94	9000	3/7/94	.001
09 DC	c	6/9/94	8440	6/9/94	.001
09 DC	c	6/9/94	8280	6/9/94	.001
09 DC	c	9/16/94	9000	9/16/94	.004
09 DC	c	12/7/94	8960	12/7/94	.001
09 DC	c	2/21/95	8440	2/21/95	.001
09 DC	c	6/7/95	9480	6/7/95	.001
09 DC	c	8/29/95	10100	8/29/95	.001
09 DC	c	11/28/95	9990	11/28/95	.002
09 DC	c	2/22/96	10850	2/22/96	.001
09 DC	w	2/22/96		2/22/96	.013
09 DC	c	6/5/96	12867	6/5/96	.001
09 DC	c	2/19/97	11400	2/19/97	.001
10 DC	w	4/28/92	1250	4/28/92	.02
10 DC	w	8/26/92	1200	8/26/92	.029
10 DC	w	12/15/92	1060	12/15/92	.015
10 DC	w	3/8/93	1040	3/8/93	.01
10 DC	w	5/20/93	1000	5/20/93	.001
10 DC	w	6/21/93	1000	6/21/93	.015
10 DC	w	8/10/93	1200	8/10/93	.005
10 DC	w	11/22/93	1050	11/22/93	.011
10 DC	e	11/22/93	1010	11/22/93	.01
10 DC	c	11/22/93	990	11/22/93	.008
10 DC	c	3/3/94	1200	3/3/94	.01
10 DC	c	6/15/94	1070	6/15/94	.007
10 DC	c	9/20/94	1170	9/20/94	.011
10 DC	c	12/6/94	1080	12/6/94	.008

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
10 DC	c	2/14/95	1020	2/14/95	.006
10 DC	a	2/14/95	930	2/14/95	.009
10 DC	w	2/14/95	1010	2/14/95	.008
10 DC	c	6/6/95	1125	6/6/95	.013
10 DC	c	8/28/95	960	8/28/95	.014
10 DC	c	8/28/95	1950	8/28/95	.013
10 DC	c	11/27/95	1100	11/27/95	.011
10 DC	c	2/26/96	1380	2/26/96	.011
10 DC	w	2/26/96		2/26/96	.014
10 DC	c	6/3/96	1075	6/3/96	.014
10 DC	c	8/5/96	1070	8/5/96	
10 DC	c	11/25/96	1210	11/25/96	.013
10 DC	c	2/17/97	1120	2/17/97	.014
10 DC	w	5/20/97	1100	5/20/97	.012
10 DC	w	5/20/97	1110	5/20/97	.014
11 DC	w	4/28/92	1420	4/28/92	.009
11 DC	w	5/20/92	1330	5/20/92	.006
11 DC	w	5/22/92	1080	5/22/92	.02
11 DC	w	5/26/92	650	5/26/92	.006
11 DC	w	5/27/92	486	5/27/92	.008
11 DC	w	8/25/92	1410	8/25/92	.006
11 DC	w	12/15/92	1170	12/15/92	.015
11 DC	w	3/8/93	1180	3/8/93	.009
11 DC	w	5/19/93	1200	5/19/93	.004
11 DC	w	8/10/93	1100	8/10/93	.012
11 DC	w	11/22/93	1140	11/22/93	.001
11 DC	c	3/8/94	1240	3/8/94	.004
11 DC	c	12/7/94	1480	12/7/94	.001
11 DC	c	2/21/95	1370	2/21/95	.002
11 DC	c	6/7/95	1570	6/7/95	.001
11 DC	c	8/29/95	1490	8/29/95	.001
11 DC	c	11/28/95	1650	11/28/95	.002
11 DC	c	2/21/96	1460	2/21/96	.001
11 DC	w	2/21/96		2/21/96	.013
11 DC	c	6/5/96	1520	6/5/96	.001
11 DC	c	8/5/96	1490	8/5/96	
11 DC	c	11/26/96	1380	11/26/96	.001
11 DC	c	2/20/97	1420	2/20/97	.001
11 DC	w	5/21/97	1310	5/21/97	.001
12 DC	w	5/1/92	19300	5/1/92	3.02
12 DC	w	8/26/92	21600	8/26/92	4.14
12 DC	w	12/2/92	19800	12/2/92	5.06
12 DC	w	2/9/93	18200	2/9/93	5.81
12 DC	w	5/18/93	18600	5/18/93	4.28
12 DC	w	8/10/93	19470	8/10/93	5.82
12 DC	w	11/22/93	18600	11/22/93	5.98

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
12 DC	e	11/22/93	17966	11/22/93	7.197
12 DC	c	11/22/93	22400	11/22/93	7.23
12 DC	c	3/2/94	23900	3/2/94	7.22
12 DC	c	6/6/94	19500	6/6/94	6.41
12 DC	c	9/15/94	19900	9/15/94	6.53
12 DC	c	9/15/94	20200	9/15/94	6.61
12 DC	c	12/6/94	18900	12/6/94	7.42
12 DC	c	2/14/95	15900	2/14/95	6.4
12 DC	a	2/14/95	15000	2/14/95	7.4
12 DC	w	2/14/95	17000	2/14/95	6.29
12 DC	c	6/6/95	20400	6/6/95	6.87
12 DC	c	8/28/95	19500	8/28/95	6.77
12 DC	c	11/28/95	20000	11/28/95	6.98
12 DC	c	11/28/95	19700	11/28/95	6.91
12 DC	c	2/22/96	20600	2/22/96	7.
12 DC	c	2/22/96	20000	2/22/96	.617
12 DC	w	2/22/96		2/22/96	3.86
12 DC	w	2/22/96		2/22/96	3.41
12 DC	c	6/3/96	19800	6/3/96	9.15
12 DC	c	2/17/97	18600	2/17/97	7.95
12 DC	w	5/22/97	14700	5/22/97	6.58
12 DC	w	8/20/97	16800	8/20/97	6.86
13 DC	w	3/4/93	644	3/4/93	.009
13 DC	w	5/20/93	636	5/20/93	.001
13 DC	w	6/21/93	620	6/21/93	.009
13 DC	w	8/10/93	620	8/10/93	.009
13 DC	w	11/23/93	660	11/23/93	.001
13 DC	c	3/7/94	840	3/7/94	.003
13 DC	c	12/7/94	490	12/7/94	.001
13 DC	c	2/22/95	670	2/22/95	.001
13 DC	c	6/7/95	800	6/7/95	.001
13 DC	c	8/28/95	785	8/28/95	.006
13 DC	c	11/27/95	647	11/27/95	.003
13 DC	c	2/21/96	650	2/21/96	.001
13 DC	w	2/21/96		2/21/96	.004
13 DC	c	6/3/96	750	6/3/96	.003
13 DC	c	8/5/96	759	8/5/96	.
13 DC	c	11/25/96	830	11/25/96	.003
13 DC	c	2/17/97	1590	2/17/97	.001
13 DC	w	5/21/97	910	5/21/97	.006
14 DC	c	3/2/94	6400	3/2/94	.026
14 DC	c	3/2/94	6640	3/2/94	.032
14 DC	c	6/15/94	6120	6/15/94	.023
14 DC	c	9/14/94		9/14/94	
14 DC	c	9/21/94	6840	9/21/94	.023
14 DC	c	12/6/94	7560	12/6/94	.019

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
14 DC	c	2/23/95	5600	2/23/95	.034
14 DC	c	6/6/95	8160	6/6/95	.026
14 DC	c	8/28/95	6640	8/28/95	.03
14 DC	c	11/27/95	5860	11/27/95	.022
14 DC	c	2/26/96	6460	2/26/96	.024
14 DC	w	2/26/96		2/26/96	.018
14 DC	c	6/4/96	7600	6/4/96	.024
14 DC	c	2/17/97	7950	2/17/97	.019
14 DC	w	8/20/97	8100	8/20/97	.012
14 DC	w	11/12/97	7100	11/12/97	
15 DC	c	3/1/94	11900	3/1/94	.003
15 DC	c	6/15/94	13500	6/15/94	.003
15 DC	c	9/14/94		9/14/94	
15 DC	c	9/21/94	11500	9/21/94	.001
15 DC	c	12/6/94	10880	12/6/94	.002
15 DC	a	12/6/94	9100	12/6/94	.003
15 DC	c	2/14/95	10100	2/14/95	.001
15 DC	a	2/14/95	9200	2/14/95	.005
15 DC	w	2/14/95	10000	2/14/95	.002
15 DC	c	6/6/95	10400	6/6/95	.003
15 DC	c	6/6/95	10760	6/6/95	.002
15 DC	c	8/28/95	9200	8/28/95	.003
15 DC	c	8/28/95	9440	8/28/95	.003
15 DC	c	11/27/95	9410	11/27/95	.002
15 DC	c	2/26/96	9900	2/26/96	.003
15 DC	c	2/26/96	9020	2/26/96	.002
15 DC	w	2/26/96		2/26/96	.005
15 DC	w	2/26/96		2/26/96	.005
15 DC	c	6/3/96	10400	6/3/96	.003
15 DC	c	2/17/97	9050	2/17/97	.001
15 DC	w	8/20/97	8160	8/20/97	.01
15 DC	w	11/12/97	6900	11/12/97	
15 DC	w	11/12/97	7000	11/12/97	
16 DC	c	3/1/94	1530	3/1/94	.082
16 DC	c	6/15/94	1480	6/15/94	.085
16 DC	c	9/21/94	1520	9/21/94	.072
16 DC	c	12/6/94	1420	12/6/94	.083
16 DC	c	12/6/94	1420	12/6/94	.085
16 DC	c	2/22/95	1520	2/22/95	.101
16 DC	c	2/22/95	1430	2/22/95	.106
16 DC	c	5/18/95	1380	5/18/95	.08
16 DC	c	8/28/95	1570	8/28/95	.088
16 DC	c	11/27/95	1230	11/27/95	.085
16 DC	c	2/26/96	1760	2/26/96	.083
16 DC	w	2/26/96		2/26/96	.079
16 DC	c	6/3/96	1475	6/3/96	.087

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Well	Lab	SO4		U	
		Date	mg/L	Date	mg/L
16 DC	c	8/5/96	806	8/5/96	.086
16 DC	c	11/25/96	1610	11/25/96	.076
16 DC	c	2/17/97	1640	2/17/97	.088
16 DC	w	5/20/97	1400	5/20/97	.073
16 DC	w	8/20/97	1600	8/20/97	.064
16 DC	w	11/12/97	1240	11/12/97	
17 DC	c	12/7/94	3540	12/7/94	.001
17 DC	c	2/16/95	3560	2/16/95	.001
17 DC	c	6/7/95	3050	6/7/95	.001
17 DC	c	8/29/95	3440	8/29/95	.001
17 DC	c	11/29/95	3520	11/29/95	.24
17 DC	c	2/22/96	4120	2/22/96	.001
17 DC	w	2/22/96		2/22/96	.004
17 DC	c	6/4/96	3900	6/4/96	.001
17 DC	c	8/5/96	4170	8/5/96	.001
17 DC	c	2/19/97	2960	2/19/97	.088
18 DC	c	12/8/94	19000	12/8/94	.004
18 DC	c	2/16/95	18700	2/16/95	.002
18 DC	c	6/7/95	19300	6/7/95	.004
18 DC	c	8/29/95	16300	8/29/95	.008
18 DC	c	11/27/95	7360	11/27/95	.001
18 DC	c	11/27/95	7230	11/27/95	.002
18 DC	c	2/22/96	9100	2/22/96	.002
18 DC	w	2/22/96		2/22/96	.005
18 DC	c	6/3/96	8867	6/3/96	.001
18 DC	c	2/17/97	6850	2/17/97	.001